Appendix E

RELTAED STUDIES

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City of Hamilton
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Attention: Ms. Janet Haynes

Dear Ms. Haynes::

Reference: Preliminary GUDI Evaluation
Lynden Municipal Well FDL01

The City of Hamilton (City) retained Stantec Consulting Inc. (Stantec) to complete a desktop review to determine the status of the groundwater of Municipal Well FDL01 (FDL01) and to provide recommendations for additional work, if required. The evaluation included a review of the following information:

- Production well and monitoring well logs;
- Historical raw water quality data from FDL01;
- Any consultant reports available with respect to the well field; and
- Regional mapping of the area.

Buildings

Environment

Industrial

Transportation

Urban Land

All information reviewed as part of this evaluation is referenced in the appropriate sections of this letter. A field inspection was completed on December 8, 2003 to verify the precise locations of the nearest surface water features.

Background

The following discussion provides a brief history of the communal water supply in Lynden, Ontario. The production well is located south of Governors Road and southeast of Lynden, as shown on Figure 1. The construction and installation of the Lynden well was completed by Morrison Beatty Ltd. in 1985. The original report detailing the well installation could not be located. However, the MOE well record (MOE, 1984[1]) indicates that the Lynden Production well was installed in 1984 to a total depth of 55 m below ground surface (BGS). The well is screened within a sand and gravel aquifer, which is

[1] MOE (Ministry of the Environment), 1984. Water Well Record, Lynden Well.

Reference: Preliminary GUDI Evaluation
Lynden Municipal Well FDL01

overlain by clay deposits. The MOE well record indicated that at a pumping rate of 19 L/s, the specific capacity of the well was estimated to be 1.4 L/s/m.

Initial production well testing was completed in 1985. The original report could not be located, however Morrison (1987[2]) briefly summarized the findings. The 1985 report concluded that the Lynden well could provide a maximum sustainable rate of 3.8 L/s (330 m^3/day).

Prior to well commissioning, a detailed hydrogeologic evaluation was conducted by Morrison (1987). A thirteen (13) day pumping test was performed at a rate of 3.8 L/s to evaluate groundwater quality and quantity from FDL01. Due to concerns of private well interference, twenty (20) private wells were included in the monitoring program. Morrison indicated that water quality from the well was adequate for municipal purposes. By the end of the pumping test, there was no drawdown observed within any shallow monitoring wells in the vicinity of Lynden. Drawdown was noted in observation wells located within the same deep sand and gravel aquifer as the pumping well. Morrison concluded that only minor interference of groundwater quantity occurred within the deep private wells in the area.

In 1997, International Water Services (IWS) conducted a well assessment and evaluation (IWS, 1997[3]). IWS completed a video log, pump inspection and a variable rate pumping test on FDL01. The well inspection did not indicate any problems with casing integrity or plugging of the well screen. The well was step tested at rates of 2.5 L/s to 7.6 L/s. The resulting specific capacity for FDL01 was estimated at 5.5 L/s/m.

As required by the MOE, the City contracted MacViro Consultants Inc. (MacViro) to complete an Engineers' Report of the Lynden Well System. The report focused on the treatment system, operational procedures and raw water quality (MacViro, 2001[4]). In 2003, Charlesworth and Associates (Charlesworth) completed a 26-hour pumping test to estimate aquifer parameters and the capture zone of the Lynden well (Charlesworth, 2003[5]). In addition to monitoring the pumping well, a shallow and a deep observation well was also monitored. The sand and gravel aquifer responded to pumping FDL01 as a confined system. There was no observed response in the shallow monitoring well due to pumping. The average transmissivity of the aquifer was estimated at about 220 m^2/day.

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[2] Morrison (Morrison Beatty Ltd.), 1987. Well Construction and Testing Program for a Water Supply for the Village of Lynden. Prepared for the Regional Municipality of Hamilton-Wentworth, May 1987.
[3] IWS (International Water Supply Inc.), 1997. Region of Hamilton-Wentworth Well Assessment and Evaluation Study.
[4] MacViro (MacViro Consultants Inc.), 2001. Engineers' Report for the Lynden Well System in the City of Hamilton, January 2001.
[5] Charlesworth (Charlesworth and Associates), 2003. Preliminary Results for Lynden, City Wide Groundwater Study. Prepared for the City of Hamilton.

Reference: Preliminary GUDI Evaluation
Lynden Municipal Well FDL01

Currently, the Lynden well is operated under Certificate of Approval 7753-549JG9 and permitted under PTTW 88-P-2000 (Amended) for a maximum pumping rate of 227 L/min (327,312 L/day).

Well Construction

Production Well FDL01 is located within a concrete brick well house. The well was constructed in 1984 and was completed within the overburden at a total depth of 55 m BGS (MOE, 1984). MacViro (2001) detailed the production well installation. A 305 mm diameter borehole was drilled to 6.0 m BGS. A 200 mm diameter steel outer well casing was installed, extending from approximately 0.6 m above ground surface (AGS) to 50.6 m BGS. The annular space was cement grouted from ground surface to 6.0 m BGS. A 200 mm inner casing extends from 43.9 m BGS to 50.6 m BGS with a stainless steel screen extending 50.6 m to 54.6 m BGS. The screen is composed of 1.5 m lengths of 60 slot, 40 slot and 25 slot screen. The well is equipped with a submersible pump rated for a flow rate of 7.6 L/s at 24 m total dynamic head (TDH).

The construction details suggest that FDL01 complies with the current standards of O. Reg. 903.

Site Setting

Lynden is located within the Grand River Watershed, approximately 15 km north of the Grand River. The land use in the vicinity of Municipal Well FDL01 is agricultural with residential areas located approximately 1,500 m to the west. Surface topography in the vicinity of Lynden and FDL01 is approximately 235 m AMSL and is relatively flat, as shown on Figures 1 and 2. The ground surface gently slopes to the southwest towards the Grand River at an elevation of 200 m AMSL.

The nearest surface water feature in the vicinity of FDL01 is located 250 m to the east and consists of a small unidentified creek approximately 1 m in width flowing in a southerly direction toward the Grand River (Figure 2). Fairchild Creek flows to the southwest towards the Grand River, passing 500 m to the west of FDL01.

Two local drainage areas are situated in the vicinity of the FDL01 well house. To the rear of the well house, a shallow depression was created to ensure that any surface runoff is directed away from the well house. Drainage from sampling lines within the well house is also directed to this depression. The second drainage area is a ditch situated north of Governor’s Rd., approximately 20 m north of FDL01. At the time of the site inspection, some standing water, approximately 0.1 m in depth, was present in the ditch. The ditch and shallow depression likely receive runoff from major precipitation events but would otherwise normally be dry. Therefore, these two drainage areas are not interpreted to be surface water features.

Reference: Preliminary GUDI Evaluation
Lynden Municipal Well FDL01

Geology and Hydrogeology

The surficial quaternary geology in the vicinity of Lynden was mapped by Karrow (1972[6]) and is presented in Figure 2. Deposits of glaciolacustrine silt and sand were mapped within Lynden. These sediments represent the Lake Warren shallow water deposits.

As part of the City Wide Groundwater Study, Charlesworth (2003) installed a deep monitoring well adjacent to FDL01. The stratigraphy encountered within this well indicates silty sand to sandy silt deposits, extending from ground surface to a depth of 5.7 m BGS. Clayey deposits extend from 5.7 m BGS to 33.5 m BGS forming a thick aquitard overlying sandy silt and fine sand deposits to a depth 46.9 m BGS. The sand and gravel aquifer extends from 46.9 m BGS to the bedrock surface at 55.1 m BGS. This interpretation of the geology is similar to the one provided on the MOE WWR for FDC01, which indicated that clay deposits predominated to a depth of 50 m BGS.

Based on MOE Water Well Records for the Lynden area, Morrison (1987) summarized the geology of the area. The report indicated similar stratigraphy to that observed near FDL01. The MOE WWRs indicate surficial deposits of glaciolacustrine deposits of sand and clay extending approximately 3 m BGS underlain by extensive clay till deposits generally greater than 30 m in thickness. Beneath the till are deposits of sand and gravel ranging in thickness from 1.5 m to 20 m.

In the vicinity of Lynden, the bedrock surface was encountered at 43 m to 55 m BGS. The bedrock underlying Lynden consists of dolostone of the Lockport Formation of Middle Silurinan in age (MNDM, 1991[7]). The Lockport Formation is underlain by Ordovician shale. The bedrock elevation decreases from a high of 230 m AMSL to the west of Lynden to 180 m AMSL near FDL01.

Municipal Well FDL01 is installed within the deep sand and gravel aquifer, which directly overlies the bedrock. Based on MOE WWR, groundwater flow within the deep aquifer is to the east following bedrock topography. The potentiometric surface of the bedrock and deep aquifer are similar, averaging 14 m BGS. The static water level within FDL01 at the time of installation was 10.4 m BGS (Morrison, 1987). The water table of the shallow aquifer averages 3 m BGS.

Aquifer Susceptibility

In an effort to quantify the susceptibility of the water supply to contamination, the Intrinsic Susceptibility Index (ISI) was calculated using the method provided in MOE (2001[8]). As

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[6] Karrow, P.F. 1972. Pleistocene Geology of the Brantford Area, Southern Ontario. Ontario Department of Mines and Northern Affairs.
[7] Ministry of Northern Development and Mines (MNDM), 1991. Bedrock Geology of Ontario, Southern Sheet, Map 2544, Scale 1:1,000,000.
[8] Ministry of the Environment (MOE), 2001. Groundwater Studies 2001/2002 Technical Terms of Reference, November 2001.

indicated in MOE (2001), the ISI for a confined aquifer system is based on the thickness and composition of the overburden material above the first significant aquifer. The ISI is categorized into High (<30), Medium (30 to 80) and Low (>80). A high ISI indicates that the water supply is readily susceptible to contamination, whereas a low ISI indicates that the water supply is less likely to be impacted by onsite activity. For this aquifer, the ISI was calculated to be 150, which indicates that the aquifer has a low intrinsic susceptibility to contamination.

Water Quality

Historical microbiological results dating back to 1999 were available for FDL01 and are presented in Table 1. The bacteriological results show excellent raw water quality with approximately 2% of samples having detections of total coliforms (5 out of 328). There was 1 sample (out of 328) that had a detection of *E.coli*. The sample was collected on June 13, 2000 and contained an abnormally high amount of total coliforms, suggesting that it was not a representative sample and may have been contaminated. There were no exceedances of the Ontario Drinking Water Standard (ODWS) for Heterotrophic Plate Count (HPC) analysis (0 out of 64).

Historical raw water quality data for FDL01 from June 1997, December 2000 and February 2001 is presented in Table 2. The water quality has been consistent and is characterized by relatively low concentrations of calcium (10 mg/L), chloride (36 mg/L) and sulphate (36 mg/L). Sodium is slightly elevated at a concentration of about 52 mg/L.

Raw water from production well FDL01 did not exceed the MOE ODWS Maximum Acceptable Concentration (MAC) for any health-related parameters. The concentration of sodium exceeded 20 mg/L, which is only a concern for consumers who may be on a sodium-restricted diet. Hardness and pH did not meet with the ODWS Operational Guidelines (OG) and aesthetic objectives (AO), respectively. These parameters are not a health-related risk under the ODWS.

GUDI Evaluation

O. Reg. 903 Section 2(2) provides seven criteria to determine if a water supply system is considered potentially GUDI, as follows:

1. *A drinking-water system that obtains water from a well that is not a drilled well or from a well that does not have a watertight casing that extends to a depth of six metres below ground level*.
2. A drinking-water system that obtains water from an infiltration gallery.
3. A drinking-water system that is not capable of supplying water at a rate greater than 0.58 L/s and that obtains water from a well, any part of which is within 15 metres of surface water.

Reference: Preliminary GUDI Evaluation
Lynden Municipal Well FDL01

4. *A drinking-water system that is capable of supplying water at a rate greater than 0.58 L/s and that obtains water from an overburden well, any part of which is within 100 metres of surface water*.
5. A drinking-water system that is capable of supplying water at a rate greater than 0.58 L/s and that obtains water from a bedrock well, any part of which is within 500 metres of surface water.
6. *A drinking-water system that exhibits evidence of contamination by surface water*.
7. A drinking-water system in respect of which a written report has been prepared by a professional engineer or professional hydrogeologist that concludes that the system's raw water supply is groundwater under the direct influence of surface water and that includes a statement of his or her reasons for reaching that conclusion.

The evaluation criteria that apply to FDL01 are highlighted in italics above.

Criteria 1

Municipal Well FDL01 is a drilled well that is cased from above ground surface to approximately 50.6 m BGS. A video inspection of the well was completed by IWS in 1997 and the report (IWS, 1997) did not indicate that the casing was cracked or any signs of leakage. Provided that the integrity of the well casing has not changed since 1997, FDL01 likely satisfies Criteria 1 above.

Criteria 4

Municipal well FDL01 is a drilled overburden well that is permitted to supply groundwater at a rate greater than 0.58 L/s (2.3 L/s) and therefore Criteria 4 applies. Criteria 4 states that if a well is located within 100 m of a surface water feature it is considered potentially GUDI. Based on this criterion, FDL01 would not be considered potentially GUDI because the nearest surface water feature is located approximately 250 m to the east of the well.

Criteria 6

The key biological indicators of surface water are fecal bacteria, which includes *E. coli.* Other biological indicators that are not commonly specified in a municipal sampling program include algae, aerobic sporeformers, *Giardia*, *Cryptosporidium* and human enteric viruses. Surface water may also exhibit elevated and/or variable concentrations of organic nitrogen, total organic carbon and pH.

As discussed above, there was one detection of *E. coli* in a sample collected from the raw water supply of FDL01 on June 13, 2001. However, the sample was not considered representative because there was also an abnormally high concentration of total coliforms. Organic nitrogen is equivalent to Total Kjeldahl Nitrogen (TKN) minus

Reference: Preliminary GUDI Evaluation
Lynden Municipal Well FDL01

ammonia. TKN was not detected in a single sample of raw water collected in February 2001 (Table 2). The raw water pH has been relatively stable ranging from 8.06 to 8.59. Dissolved organic carbon was detected in one raw water sample collected in December 2000 at a concentration of 1.1 mg/L; however, concentrations ranging up to 5.0 mg/L are typical of groundwater. No other surface water indicator parameters have been analyzed in the raw samples collected from FDL01.

Conclusions

Based on the results of the desktop review, FDL01 is not considered potentially GUDI, for the following reasons:

- In the vicinity of FDL01, the overburden aquifer is confined by a clay and silt aquitard. Based on the depth to the water table and the composition of the overlying material, the susceptibility of the aquifer to contamination from surface was calculated to be 150, which is considered to be low;
- Results of the 1997 pump testing indicated there was no drawdown observed in the shallow overburden due to pumping of FDL01.
- The nearest surface water feature to FDL01 is located 250 m to the east, which is further than the minimum distance of 100 m specified in the Safe Drinking Water Act for a well completed in the overburden and capable of supplying more than 0.58 L/s; and
- The raw water does not exhibit evidence of surface water impacts.

Recommendations

Based on the desktop review, Municipal Well FDL01 would not be considered potentially GUDI based on the criteria stipulated in the Safe Drinking Water Act and no further investigative work is required.

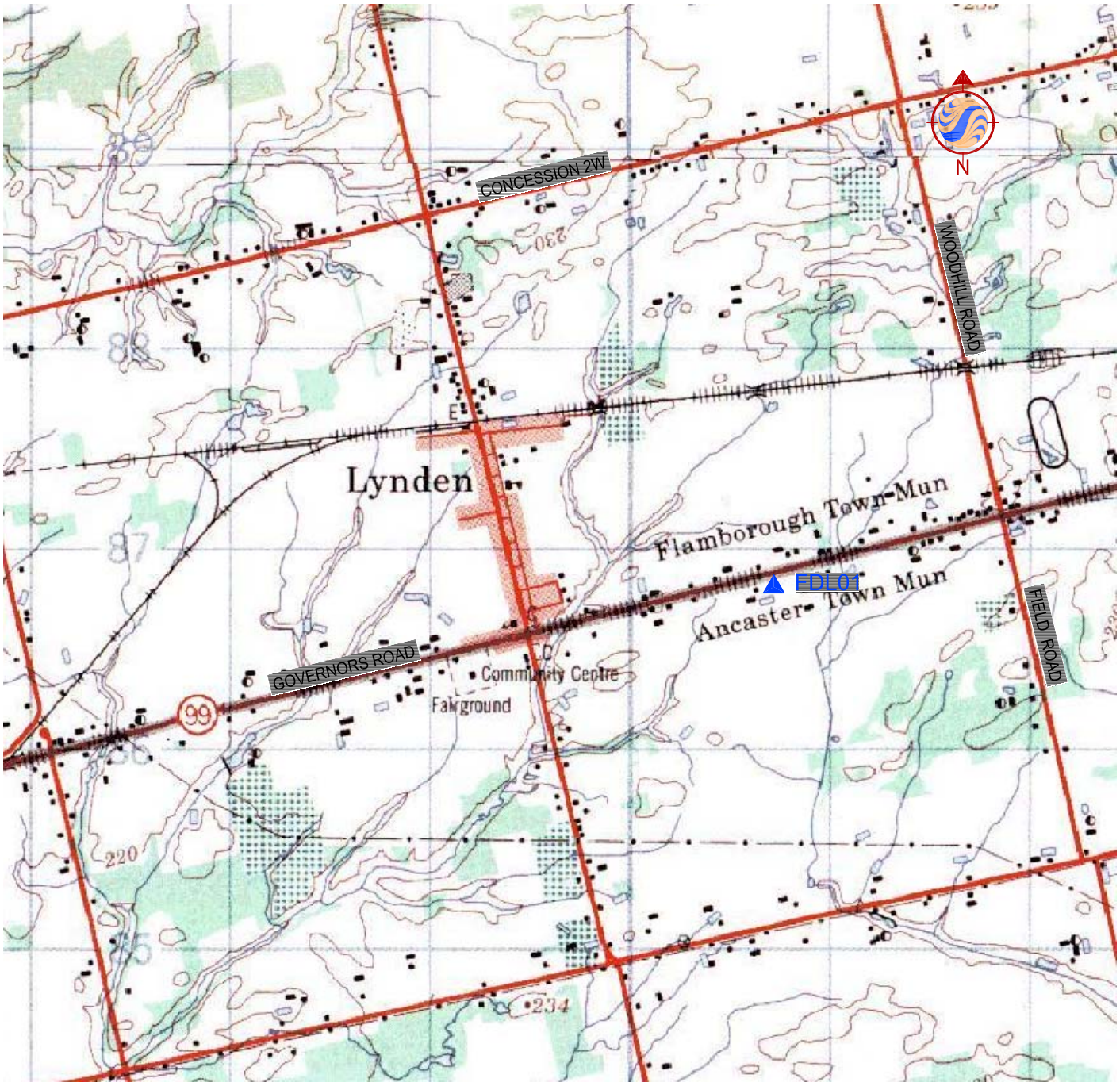
Sincerely,
STANTEC CONSULTING LTD.

Roger Freymond, P.Eng.
Project Manager

Craig Johnston, M.Sc. P.Geo.
Senior Hydrogeologist

Attachment A
Figure 1 – Site Location
Figure 2 – Surficial Geology

Table 1 – Groundwater Bacteriological Results – FDL01
Table 2 – Raw Water Quality General Chemistry Results – FDL01



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December 2003
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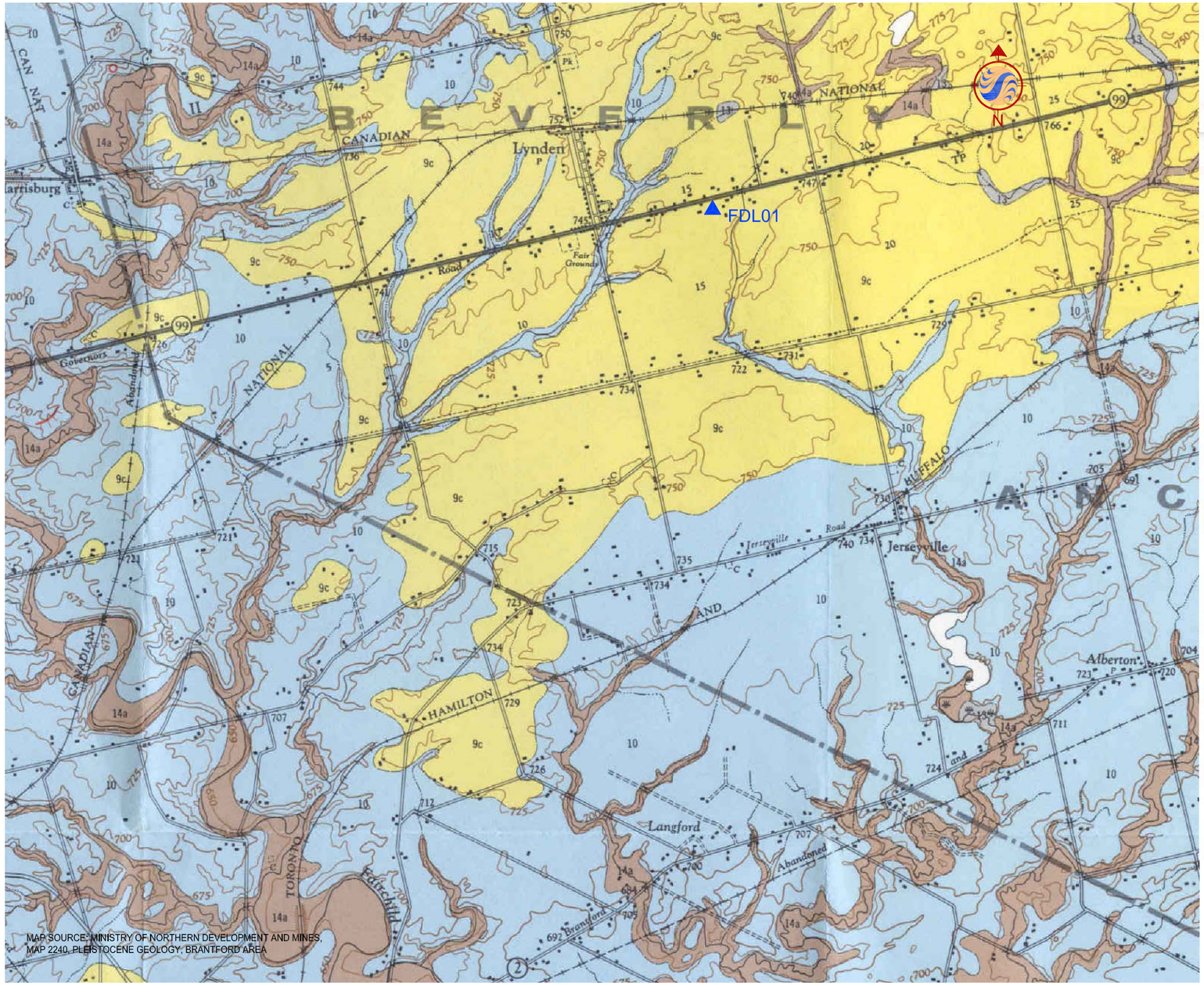
Legend

▲ FDL01 Production Well

Client/Project
City of Hamilton
Preliminary GUDI Evaluation
Lynden Production Well

Figure No.
1

Title
Site Location



LEGEND

CENOZOIC

PLEISTOCENE

RECENT

- 14a Modern alluvium, unsubdivided: silt, sand, gravel, clay, muck.
- 14b Modern alluvium: mainly gravel and gravelly sand.
- 13 Bog deposits: muck, peat, marl.

WISCONSINAN

- 12 Older alluvium in terrace remnants: gravel, sand.
- 11 Glaciolacustrine beach deposits, mainly Lake Warren and younger: gravel, sand, washed till.
- 10 Glaciolacustrine deep water sediments, mainly Lake Warren and younger: stratified to varved silt and clay, minor sand; locally overlain by veneer of sand.
- 9 Sand.
  - 9a Glaciolacustrine shallow water and deltaic sediments, mainly Lake Whittlesey, some silt.
  - 9b Glaciolacustrine sand underlain by patchy deltaic or outwash gravels.
  - 9c Glaciolacustrine shallow water and deltaic sediments, mainly Lake Warren and younger, some silt.
  - 9d Glaciofluvial sand.
- 8 HALTON TILL: calcareous grey to yellowish brown silt till.
- 7 Glaciofluvial outwash and deltaic deposits: gravel, and gravelly sand in many places overlain by several feet of sand.
- 6 Ice-contact deposits: mainly kame gravel.
- 5a WENTWORTH TILL: stony, silty, sand till; in many places modified on surface.
  - 5b WENTWORTH TILL, southeastern facies: loam till.
  - 5c WENTWORTH TILL, fine-grained facies(?): clay till.
  - 5d River or stream section: may include 5, 4, 3, 2 and stratified sediments.
- 4a PORT STANLEY TILL: silt till.
  - 4b River or stream section: may include 4a, 3, 2, associated stratified sediments and some material older than 2.
- 3 CATFISH CREEK TILL: stony silty, sand till.
- 2 CANNING TILL: clayey silt till.

UNCONFORMITY

PALEOZOIC

SILURIAN

- 1a Salina Formation: dolomite, shale, gypsum.
- 1b Lockport Formation: dolomite.

Deposits on this sheet are mapped where they reach three feet or more in thickness. Thinner deposits are not shown.

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December 2003
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Legend

▲ FDL01 Production Well

1:50000 0 500 1500 2500m

Notes

Client/Project
City of Hamilton
Preliminary GUDI Evaluation
Lynden Production Well

Figure No.
2

Title
Surficial Geology

Table 1
Groundwater Bacteriological Results - FDL01

Date Sampled	FDL1 (L-5) (Raw Water)		
	Total	E.Coli	HPC
ODWS*	0**	0**	500**
1999-02-01	0	0	
1999-02-01	0	0	
1999-02-08	0	0	
1999-02-08	0	0	
1999-02-16	0	0	
1999-02-16	0	0	
1999-02-22	0	0	
1999-02-22	0	0	
1999-03-01	0	0	
1999-03-01	0	0	
1999-03-08	0	0	
1999-03-08	0	0	
1999-03-15	0	0	
1999-03-15	0	0	
1999-03-22	0	0	
1999-03-22	0	0	
1999-03-30	0	0	
1999-03-30	0	0	
1999-04-06	0	0	
1999-04-06	0	0	
1999-04-12	0	0	
1999-04-12	0	0	
1999-04-19	0	0	
1999-04-19	0	0	
1999-04-26	0	0	
1999-04-26	0	0	
1999-05-03	0	0	
1999-05-03	0	0	
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1999-05-25	0	0	
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1999-06-21	0	0	
1999-06-30	0	0	
1999-06-30	0	0	
1999-07-09	0	0	
1999-07-09	0	0	
1999-07-12	0	0	
1999-07-12	0	0	
1999-07-20	0	0	
1999-07-20	0	0	
1999-07-27	0	0	
1999-07-27	0	0	

Table 1
Groundwater Bacteriological Results - FDL01

Date Sampled	FDL1 (L-5) (Raw Water)		
	Total	E.Coli	HPC
ODWS*	0**	0**	500**
1999-08-04	0	0	
1999-08-04	0	0	
1999-08-09	0	0	
1999-08-09	0	0	
1999-08-16	0	0	
1999-08-16	0	0	
1999-08-23	0	0	
1999-08-23	0	0	
1999-08-31	0	0	
1999-08-31	0	0	
1999-09-07	0	0	
1999-09-07	3	0	
1999-09-13	0	0	
1999-09-13	0	0	
1999-09-21	0	0	
1999-09-21	0	0	
1999-09-28	0	0	
1999-09-28	0	0	
1999-10-04			
1999-10-04			177
1999-10-12	0	0	
1999-10-12	0	0	
1999-10-18	0	0	
1999-10-18	0	0	
1999-10-25	0	0	
1999-10-25	0	0	
1999-11-01	0	0	
1999-11-01	0	0	
1999-11-08	0	0	
1999-11-08	0	0	
1999-11-15	0	0	
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2000-01-04	0	0	
2000-01-04	0	0	
2000-01-10	0	0	
2000-01-18	0	0	
2000-01-18	0	0	
2000-01-24	0	0	
2000-01-24	0	0	
2000-01-31	0	0	
2000-01-31	0	0	

Table 1
Groundwater Bacteriological Results - FDL01

Date Sampled	FDL1 (L-5) (Raw Water)		
	Total	E.Coli	HPC
ODWS*	0**	0**	500**
2000-02-08	0	0	
2000-02-17	0	0	
2000-02-17	0	0	
2000-02-22	0	0	
2000-02-22	0	0	
2000-02-28	0	0	
2000-02-28	0	0	
2000-03-06	0	0	
2000-03-06	0	0	
2000-03-15	0	0	
2000-03-15	0	0	
2000-03-20	0	0	
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2000-05-23	0	0	
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2000-06-13	0	0	
2000-06-13	**22**	**2**	
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2000-07-11	0	0	
2000-07-11	0	0	
2000-07-18	0	0	
2000-07-18	0	0	
2000-07-25	0	0	
2000-07-25	0	0	
2000-07-27	0	0	
2000-07-27	0	0	
2000-07-27	0	0	

Table 1
Groundwater Bacteriological Results - FDL01

Date Sampled	FDL1 (L-5) (Raw Water)		
	Total	E.Coli	HPC
ODWS*	0**	0**	500**
2000-07-27	0	0	
2000-07-28	2	0	
2000-07-28	0	0	
2000-07-31	0	0	
2000-07-31	0	0	
2000-08-01	0	0	
2000-08-01	0	0	
2000-08-10	0	0	
2000-08-10	0	0	
2000-08-15	0	0	
2000-08-15	0	0	
2000-08-23	0	0	
2000-08-23	0	0	
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2000-09-13	0	0	
2000-09-21	0	0	
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2000-12-05	0	0	
2000-12-05	0	0	
2000-12-13	0	0	
2000-12-13	0	0	
2000-12-20	0	0	
2000-12-20	0	0	

Table 1
Groundwater Bacteriological Results - FDL01

Date Sampled	FDL1 (L-5) (Raw Water)		
	Total	E.Coli	HPC
ODWS*	0**	0**	500**
2000-12-26	0	0	
2000-12-26	0	0	
2001-01-03	0	0	
2001-01-10	0	0	
2001-01-15	0	0	
2001-01-24	0	0	
2001-01-31	0	0	
2001-02-06	0	0	
2001-02-23	0	0	2
2001-03-01	0	0	1
2001-03-07	0	0	1
2001-03-13	0	0	9
2001-03-19	0	0	5
2001-03-26	0	0	5
2001-04-03	0	0	7
2001-04-10	0	0	4
2001-04-18	0	0	0
2001-04-24	0	0	2
2001-05-01	0	0	0
2001-05-08	0	0	1
2001-05-15	0	0	18
2001-05-22	0	0	17
2001-05-28	0	0	7
2001-06-04	0	0	2
2001-06-12	0	0	17
2001-06-19	0	0	1
2001-06-26	0	0	4
2001-07-03	0	0	7
2001-07-09	0	0	3
2001-07-17	0	0	5
2001-07-24	0	0	1
2001-07-31	0	0	42
2001-08-08	0	0	5
2001-08-16	0	0	15
2001-08-21	0	0	12
2001-08-28	0	0	13
2001-09-05	0	0	5
2001-09-11	0	0	7
2001-09-21	0	0	6
2001-09-25	0	0	2
2001-10-02	0	0	1
2001-10-09	0	0	11
2001-10-15	0	0	1
2001-10-22	0	0	6
2001-11-01	0	0	15
2001-11-05	0	0	2
2001-11-14	0	0	1
2001-11-20	0	0	5
2001-11-26	0	0	10
2001-12-04	0	0	11
2001-12-11	0	0	3
2001-12-19	0	0	62
2001-12-26	0	0	4
2002-01-02	0	0	7
2002-01-08	0	0	3
2002-01-15	0	0	0

Table 1
Groundwater Bacteriological Results - FDL01

Date Sampled	FDL1 (L-5) (Raw Water)		
	Total	E.Coli	HPC
ODWS*	0**	0**	500**
2002-01-22	0	0	2
2002-01-31	0	0	3
2002-02-07	0	0	5
2002-02-13	0	0	5
2002-02-19	0	0	2
2002-02-27	0	0	15
2002-03-07	0	0	2
2002-03-12	0	0	15
2002-03-20	0	0	4
2002-03-26	0	0	9
2002-04-03	0	0	6
2002-04-09	0	0	8
2002-04-16	0	0	14
2002-04-24	0	0	
2002-05-01	0	0	
2002-05-07	0	0	
2002-05-14	0	0	0
2002-05-21	0	0	0
2002-05-28	0	0	
2002-06-05	0	0	
2002-06-12	0	0	
2002-06-19	0	0	
2002-06-25	0	0	
2002-07-02	0	0	
2002-07-09	0	0	
2002-07-17	0	0	
2002-07-23	0	0	
2002-07-31	0	0	
2002-08-06	0	0	
2002-08-13	0	0	
2002-08-21	0	0	
2002-08-27	0	0	
2002-09-04	0	0	
2002-09-10	0	0	
2002-09-18	0	0	
2002-09-23	0	0	
2002-10-01	0	0	
2002-10-08	0	0	
2002-10-15	0	0	
2002-10-22	0	0	
2002-10-29	0	0	
2002-11-05	0	0	
2002-11-12	0	0	
2002-11-19	0	0	
2002-11-27	0	0	
2002-12-03	0	0	

Table 1
Groundwater Bacteriological Results - FDL01

Date Sampled	FDL1 (L-5) (Raw Water)		
	Total	E.Coli	HPC
ODWS*	**0****	**0****	**500****
2002-12-11	0	0	
2002-12-17	0	0	
2002-12-23	0	0	
2002-12-30	0	0	
2003-01-08	0	0	
2003-01-14	0	0	
2003-01-22	0	0	
2003-01-29	0	0	
2003-02-04	0	0	
2003-02-11	0	0	
2003-02-18	0	0	
2003-02-25	0	0	
2003-03-04	0	0	
2003-03-11	0	0	
2003-03-18	0	0	
2003-03-25	0	0	
2003-04-02	0	0	
2003-04-09	0	0	
2003-04-14	0	0	
2003-04-23	0	0	
2003-04-30	0	0	
2003-05-08	0	0	
2003-05-13	0	0	
2003-05-20	0	0	
Number of Samples:	328	328	64
Exceedences:	5	1	0
% of Exceedences:	2%	0%	0%
Minimum:	0	0	0
Maximum:	22	2	177

Notes:

*Ministry of Environment, Ontario Drinking Water Objectives, August 2000

** MOE Criteria for Distribution water quality presented for reference purposes only.

Does not apply to raw water samples.

Cells left blank were not analyzed

2	Parameter exceeds ODWS distribution water quality criteria.

Table 2
Raw Water Quality General Chemistry Results - FDL01

Sample Location:	MOE Ontario Drinking Water Standards	Units	FDL01	FDL01	FDL01	FDL01	FDL01
Sample I.D:			Raw			Treaded	
Sampled By:					MOE		
Reference Job Number:							
Sample Date:			10-Jun-97	Dec-00	23-Feb-01	13-Sep-00	23-Feb-01
Metals							
Aluminum	0.1 OG	mg/L	0.03	-	< 0.03	< 0.03	0.03
Antimony	n/v	mg/L	-	-	< 0.001	< 0.001	0.001
Arsenic	0.025 IMAC	mg/L	0.002	-	< 0.001	< 0.001	< 0.001
Barium	1.0 MAC	mg/L	0.4	-	-	0.336	0.35
Beryllium	n/v	mg/L	-	-	-	< 0.0001	< 0.001
Bismuth	n/v	mg/L	-	-	-	< 0.1	< 0.002
Boron	5.0 IMAC	mg/L	-	-	-	0.44	0.5
Cadmium	0.005 MAC	mg/L	0.0001	-	-	< 0.0006	< 0.00007
Calcium	n/v	mg/L	9.6	-	-	9.6	9.7
Chromium	0.05 MAC	mg/L	0.005	-	-	< 0.002	< 0.002
Cobalt	n/v	mg/L	-	-	-	< 0.0006	< 0.001
Copper	1.0 AO	mg/L	0.005	-	-	0.008	0.011
Cyanide - Total	n/v	mg/L	-	-	< 0.002	< 0.002	< 0.002
Iron	0.30 AO	mg/L	< 0.03	-	-	0.02	0.16
Lead	0.01 MAC	mg/L	0.005	-	< 0.005	< 0.005	< 0.005
Magnesium	n/v	mg/L	0.01	-	-	7.83	6.5
Manganese	0.05 AO	mg/L	-	-	-	0.002	0.004
Mercury	n/v	mg/L	0.0004	-	< 0.00001	< 0.0001	< 0.0001
Molybdenum	n/v	mg/L	-	-	-	< 0.01	< 0.002
Nickel	n/v	mg/L	-	-	-	0.008	< 0.002
Potassium	n/v	mg/L	-	-	-	< 0.9	< 0.9
Reactive Silica	n/v	mg/L	-	-	9.28	-	-
Selenium	0.01 MAC	mg/L	-	-	< 0.002	< 0.002	< 0.002
Silver	n/v	mg/L	-	-	-	< 0.002	< 0.002
Sodium	20 MOH/200 AO	mg/L	**52.3**	-	-	**56.1**	**58**
Strontium	n/v	mg/L	-	-	-	0.77	0.79
Thallium	n/v	mg/L	-	-	-	< 0.11	< 0.0002
Tin	n/v	mg/L	-	-	-	< 0.01	< 0.002
Titanium	n/v	mg/L	-	-	-	< 0.002	0.001
Uranium	0.02 MAC	mg/L	-	-	-	< 0.0001	< 0.0002
Vanadium	n/v	mg/L	-	-	-	< 0.005	< 0.002
Zinc	5.0 AO	mg/L	-	-	-	0.01	0.04
General Chemistry							
Alkalinity (as CaCO3)	30-500 OG	mg/L	83	-	86	89	84
Ammonia (as N)	n/v	mg/L	0.1	-	0.08	< 0.02	0.03
Chloride (as Cl)	250 AO	mg/L	36	-	36.4	43	43.6
Nitrate (as N)	10 MAC	mg/L	0.016	-	< 0.15	< 0.03	< 0.03
Nitrite (as N)	1 MAC	mg/L	0.005	-	< 0.15	< 0.03	< 0.03
Total Kjeldahl Nitrogen as N	n/v	mg/L	-	-	< 1	-	-
Sulphate	500 AO	mg/L	36	-	29.5	35	32.8
Fluoride	n/v	mg/L	0.64	-	0.66	0.71	0.67
Dissolved Organic Carbon (DOC)	5.0 AO	mg/L	-	1.1	< 0.7	-	-
Anion Sum	n/v	mg/L	-	-	-	-	-
Bicarbonate(as CaCO3, calculated)	n/v	mg/L	-	-	-	-	-
Carbonate (as CaCO3), calculated)	n/v	mg/L	-	-	-	-	-
Cation Sum	n/v	meq/L	-	-	-	-	-
Hardness (as CaCO3)	80-100 OG	mg/L	**52**	-	98	**56**	**79**
Ion Balance	nv	%	-	-	-	-	-
Langeliers Index at 20°C	nv	na	-	-	-	-	-
Langeliers Index at 4°C	nv	na	-	-	-	-	-
Saturation pH at 20°C	nv	Std. Units	-	-	-	-	-
Saturation pH at 4°C	nv	Std. Units	-	-	-	-	-
Total Dissolved Solids	500 AO	mg/L	-	-	200	-	-
Conductivity @25 ºC	n/v	µS/cm	377	-	-	389	384
pH	6.5-8.5 AO	Std. Units	**8.59**	-	8.06	8.29	7.67
Colour	5 AO	TCU	5	-	< 5	< 5	< 5
Turbidity	1.0(MAC)	NTU	0.05	-	0.14	0.71	-

Notes:

Ministry of the Environment, Ontario Drinking Water Standards (ODWS), (June, 2003)

nv no guideline available

AO Aesthetic Objective that relates to either the taste, odour or appearance of water

IMAC Interim Maximum Acceptable Concentration (IMAC)

MAC Maximum Acceptable Concentration (MAC)

OG Operational Guidelines which usually relates to municipal water treatment

85	Parameter exceeds MOE ODWS
98	Parameter exceeds Medical Officer of Health (MOH)

GENIVAR

TECHNICAL MEMORANDUM

Date: October 4, 2007

To: Chris Shrive, City of Hamilton

Copies: Gary Scott; Muin Husain; Alicia Fraser;

From: Derek Brunner

Project No.: MA-06-633-00-MA

Subject: Evaluation of Alternatives for Potential Well Locations

1. Background

In the summer of 2002 the City of Hamilton developed a Comprehensive Water Servicing Master Plan for the Lynden Rural Settlement Area (Servicing Master Plan). The Plan considered the need for additional water supply to the Rural Settlement Area (RSA) and compared various general methods of meeting the requirement of the future RSA. One of the alternatives identified was to drill a new municipal supply well to provide this extra water and also to provide redundancy when combined with the existing well (FLD01). As such, a Schedule 'C' Class Environmental Assessment (EA) was initiated, part of which is to examine alternative locations for the placement of a new well. This technical memorandum briefly reviews the site locations identified in the XCG (2006) report, and evaluates a sixth alternative based on the same criteria.

2. Geology / Hydrogeology

The regional geology in the Lynden area consists of surficial deposits of glaciolacustrine sands with some silt of variable thickness. MOE well records and borehole logs indicate that there is a thin veneer of sands and silts overlying a clay till aquitard at least 30m thick. Sand and gravel deposits underlie the till and form a regional aquifer. Dolostone bedrock of the Lockport formation lies below the sand and gravel aquifer. It is believed that the bedrock is a source of hydrogen sulphide, which makes it undesirable for a drinking water supply. Locally, the till layer has been estimated at up to 50m in thickness, and the underlying gravel aquifer ranges from less than a meter to 5m thick.

3. Well Location Criteria

Five potential locations for municipal supply wells were investigated by XCG (2006). As part of this study, a number of criteria were provided to determine which location is most suitable for a new well. These criteria include:

- Probability of new well being capable of supplying greater than 5 L/s
- Proximity to Lynden
- Proximity to distribution system
- City owned land

- Potential for GUDI
- Predicted Intrinsic susceptibility index
- Well interference potential
- Physical constraints
- Potential impacts on surface water bodies
- Water quality

A description of each of these criteria is included in Table 3-1 (XCG, 2006).

4. Potential Well Locations

The report by XCG (2006) identified five potential locations for a municipal supply well for the Community of Lynden. In addition to these five locations, a sixth potential location was identified in August 2007 on land that was owned by the City of Hamilton. This location has been designated as Alternative F for the purposes of this report. A brief discussion of the alternatives is presented below. Alternative F is discussed in more detail in the same format as the XCG (2006) report. The available alternatives are summarized in Table 4-1, which has been revised from Table 6 in the XCG (2006) report.

4.1 Existing Alternatives

XCG (2006) described five alternative well locations for potential water supply in the Community of Lynden. They summarized that sites A, B, C, and E were equal in terms of many of the criteria, with site E being preferred due to proximity to Lynden and distance from the existing supply well, which would provide security in the event of aquifer contamination. Location D was ranked the lowest due to physical constraints and lower potential for finding the required 5 L/s. More detailed discussions of each of the alternatives can be found in the hydrogeological investigation by XCG (2006). Locations of the alternatives are shown in Figure 1.

4.2 Alternative F Site

Alternative F is located on the north side of Governor’s Road approximately 500m east of the existing production well (Figure 1). This site was chosen partly because the land was owned by the City of Hamilton, the interpreted thickness of the gravel layer, its proximity to Lynden and the distribution system. However, the following section provides a hydrogeological analysis of the Alternative F site.

4.2.1 Hydrogeological Considerations for Alternative F Site

Based on the available information, the gravel aquifer at the location of Alternative F is expected to be between 0-1m in thickness (XCG, 2006), compared with approximately 4m in the vicinity of the existing well (Figure 2). Therefore, an analysis was conducted to assess whether or not an aquifer of 1m or less thickness could provide a sustainable yield of 5 L/s.

As part of the assessment, the Theis equation was used with the following assumptions:

- The transmissivity of the aquifer varies between 196m^2/day and 244m^2/day based on the range provided by XCG (2006).
- Aquifer thickness varied between 0.5 – 1m as reported by XCG (2006).
- Storativity for a confined aquifer = 1x10^{-4}
- Required pumping rate = 5 L/s as per the requirement of the system.

The maximum drawdown in the pumping well and at distances of 100m and 500m were estimated for a 20-year period (as in the XCG (2006) report). The results are summarized in Table 4-2. The calculations are summarized in Appendix A.

Table 4-2 Drawdowns in Proposed Pumping Well for Different Aquifer Thicknesses

Aquifer Thickness (m)	Transmissivity for 4m Thick Aquifer (m^2/day)	Equivalent Transmissivity for Thinner Aquifer (m^2/day)	Drawdown in Well @ 20 years (m)	Drawdown at 100m @ 20 years (m)	Drawdown at 500m@ 20 years (m)
0.5	196	24.5	37.5	18.1	13.6
0.5	244	30.5	30.4	14.8	11.2
1	196	49	19.2	9.5	7.3
1	244	61	15.6	7.8	6.0

It should be noted that the transmissivity values were only available in areas where the aquifer was approximately 4m thick. In order to make a proper extrapolation of the potential drawdowns in the location of Alternative F, the transmissivity in the area was normalized to the thickness of the aquifer. It did not appear that this was performed by XCG (2006) when estimating the long-term impacts on nearby private wells. It is possible that for the locations where the aquifer is thin, their calculations may have underestimated the drawdowns. It should also be noted that although the predicted thickness of the aquifer in the area was estimated to be between 0-1m, it is possible that these contours are based only on two points on either side of the site location.

Assuming that the proposed production well has a similar available drawdown as the current production well (i.e. between 40-45m), after 20 years an aquifer 0.5 thick would experience drawdowns between 30.4-37.5m, while a 1m thick aquifer would experience drawdowns between 15.6-19.2m at the pumping well. The drawdown levels after 20 years at a distance of 100m from the pumping well are estimated to be between 14.8-18.1m for an aquifer 0.5m thick and between 7.8-9.5m for an aquifer 1.0m thick. The drawdown levels after 20 years at a distance of 500m from the pumping well are estimated to be between 11.2-13.6m for an aquifer 0.5m thick and between 6.0-7.3m for an aquifer 1.0m thick. Based on the information in the XCG (2006) report, most of the private wells screened in the gravel in the area have available drawdowns of over 30m. It should be noted that if the aquifer pinches out in any direction, drawdowns in the pumping well would increase. This should be expected, since two boundaries were encountered during a 24-hour pumping test in December 1984 (Morrison Beatty, 1985).

4.2.2 Evaluation of Alternative F

Four potential concerns were noted for Alternative F. The limited thickness of the aquifer, predicted by XCG (2006), will have a lower transmissivity, which will lead to greater drawdowns for the same pumping volume. There is also the possibility of encountering an

aquifer boundary, which will further increase the drawdowns. The increased drawdowns may cause issues regarding potential interference with private water well users.

Alternative F was also evaluated using the criteria described by XCG (2006) in Table 4-1. The site is approximately 2,000m from Lynden, which is the second furthest location of the alternatives. It is also approximately 140m from the distribution system. The potential for GUDI at this site was estimated to be low based on the distance to the nearest surface water body being greater than 100m and the Intrinsic Susceptibility Index (ISI) of nearby wells being greater than 80 (XCG, 2006). It is also likely that the thick clay till will provide an effective buffer against surface water infiltration. The potential for physical constraints was estimated to be low based on ortho-photography and a site visit (i.e. site access). The potential for impact on nearby wells was also estimated to be manageable, based on the predicted drawdowns calculated in the previous section. The potential for impact on surface water bodies was estimated to be low, based on the ISI of wells in the vicinity of the surface water bodies and the thickness of the intervening clay layer. Based on the limited chemical data available from MOE well records, the water quality has a higher probability of being fresh if screened in the gravel aquifer.

5. Recommendations

Based on the hydrogeological assessment, this site has the potential to provide a sustainable yield of 5 L/sec with the following assumptions:

- The aquifer is 1m thick or greater.
- The aquifer transmissivity and storativity values at the proposed location are similar to those in the thicker portions of the aquifer.
- No boundary effects are encountered.

5.1 Comparison with Other Alternatives

An evaluation was conducted for Alternative F against each of the defined criteria from XCG (2006) and compared with the other wells. Alternative F compares favourably with the other alternatives with respect to potential to meet the required demand, low GUDI potential, low predicted ISI, no physical constraints, low potential impact on surface water bodies, and probability of water quality. This alternative does not compare favourably with the preferred alternatives A and E with respect to distance to Lynden and the distribution system and with potential impacts to nearby wells due to the predicted thickness of the aquifer. However, Alternative F has the strategic advantage of being on land owned by the City of Hamilton. This advantage would allow test well construction immediately without having to undergo the potentially time consuming and expensive process of procuring additional property. In the event that the aquifer in the proposed location is unable to provide the required pumping volumes, it is recommended that the secondary site identified in the XCG (2006) report (Alternative E) be explored further.

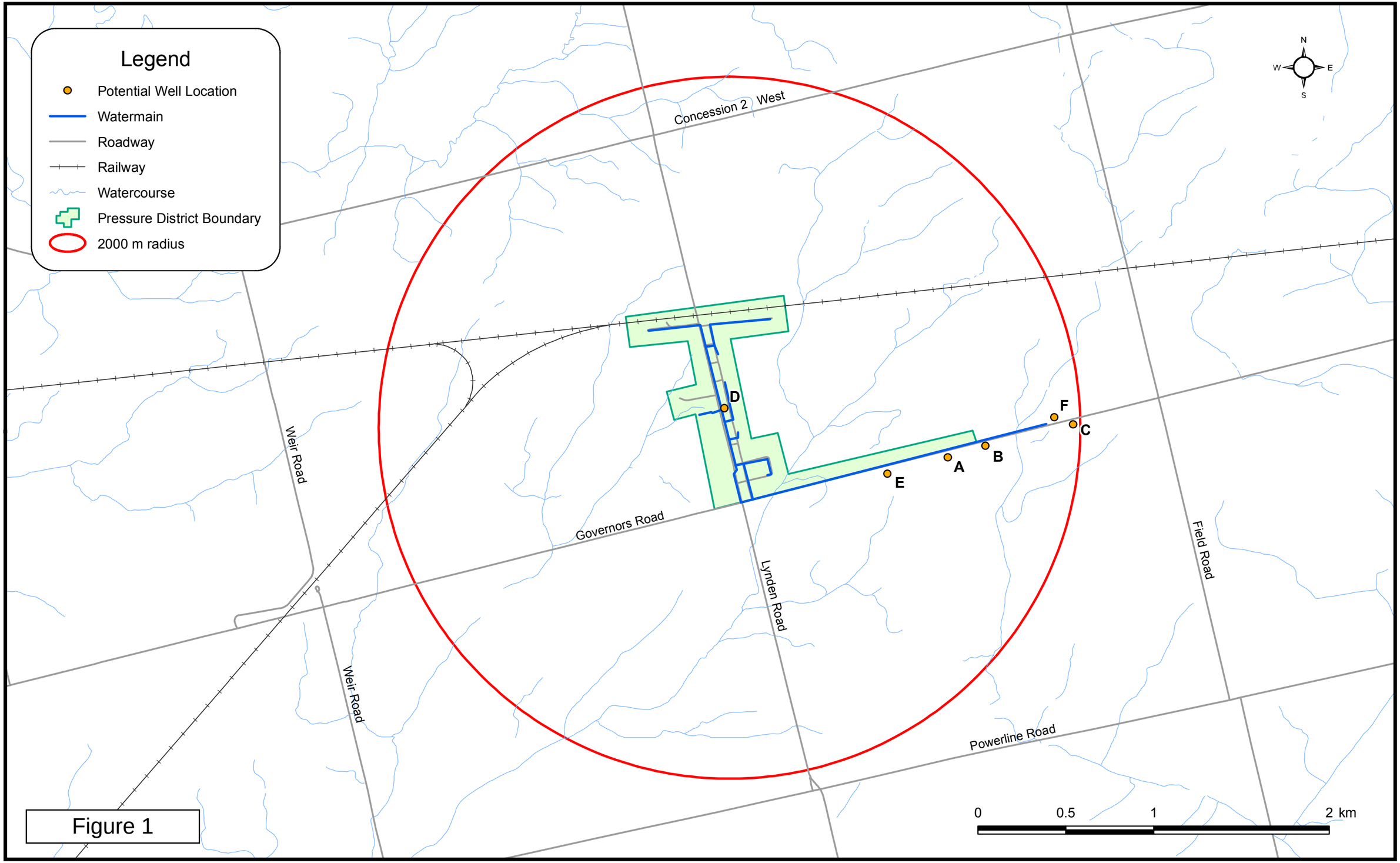
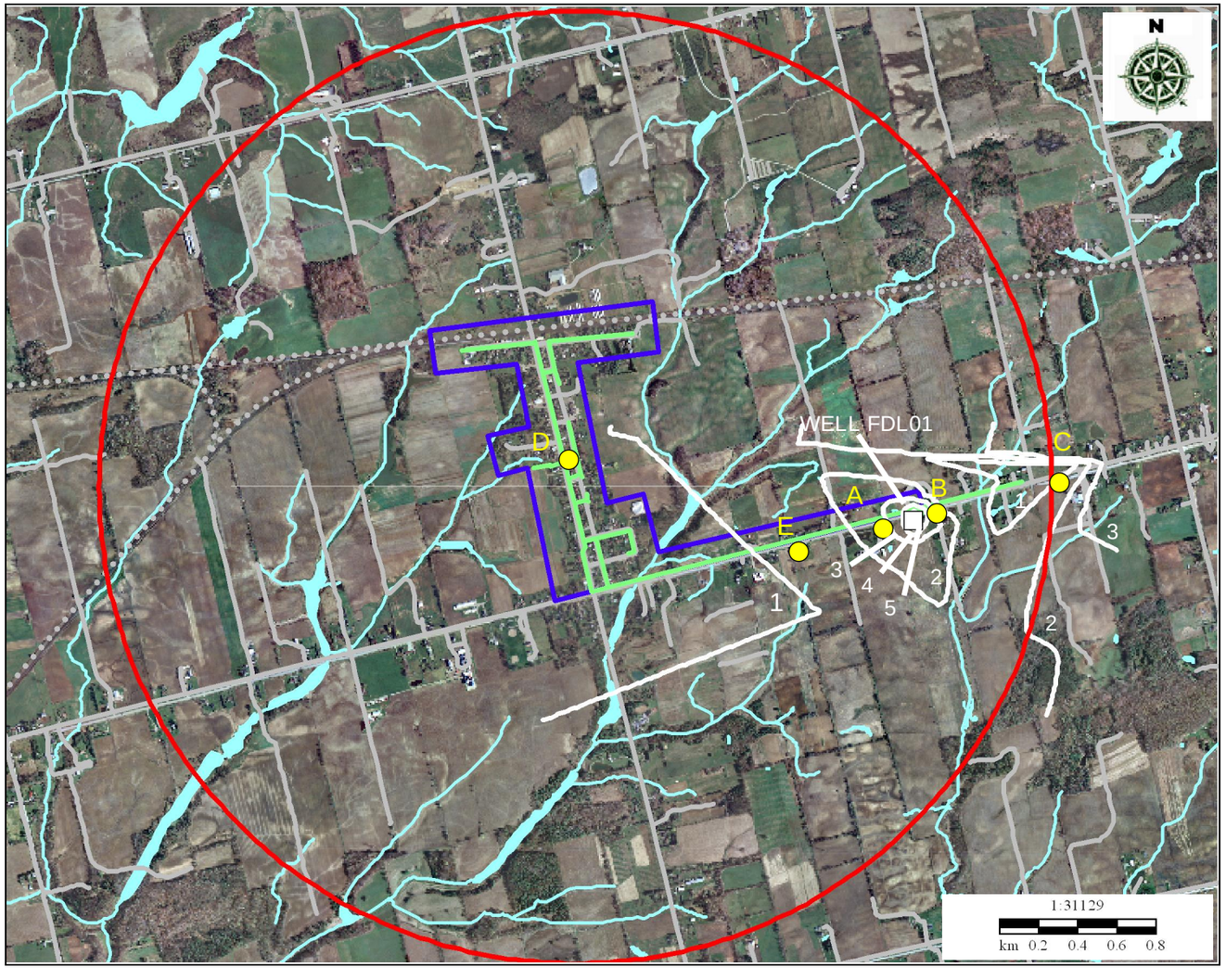

Legend
Potential Well Location
Watermain
Roadway
Railway
Watercourse
Pressure District Boundary
2000 m radius
N
W
E
S
Concession 2 West
Weir Road
Governors Road
Lynden Road
Field Road
Powerline Road
A
B
C
D
E
F
0
0.5
1
2 km

Figure 1



Legend

- Roads
- Railway Line
- Surface Water Body
- Pressure District Boundary
- Watermains
- 2000 m radius
- Potential Well Locations
- Municipal Well FDL01
- 2 — Gravel Unit Thickness (m)

ALL POTENTIAL WELL LOCATIONS FOR A NEW MUNICIPAL WELL

LYNDEN WELL SITING STUDY

CITY OF HAMILTON

XCG CONSULTANTS LTD.

DATE	JOB NO.	FIGURE NO.
JULY 2005	5-866-15-01	2

Table 3-1 ***Well Siting Criteria and Evaluation Protocol***

Criteria	Possible Rank	Definition of Ranks	Desired Rank	Ranking Process	Rationale
Probability of new well being capable of supplying >5 L/sec	Low-Medium-High	Low = Pumping rate in surrounding wells is <2.5 L/s Medium = Pumping rate in surrounding wells is 2.5-5 L/s High = Pumping rate in surrounding wells is >5 L/s	High	Probability assessed qualitatively based on pumping rate from MOE well records in nearby wells and aquifer geology	Satisfy anticipated demand of >5 L/sec.
Proximity to Lynden	Measured distance	-	<2,000 metres	Measured distance from geographical centre of Lynden	Minimize capital, operational and maintenance expenditures.
Proximity to distribution system	Measured distance	-	<2,000 metres	Measured distance to distribution system	Minimize capital, operational and maintenance expenditures.
City owned land	Yes/No	Yes = Land is currently owned by the City No = Land is not currently owned by the City	Yes	Assessed based on map supplied by City of Hamilton	Minimize capital expenditures associated with purchase/lease of new land.
Potential for GUDI[1]	Low-High	Low = >100 m from surface water body High = <100 m from surface water body	Low	Potential GUDI zones mapped in Figure 29 based on Terms of Reference[1]	Drill well in location that is not potentially GUDI to source best possible raw water quality and minimize treatment requirements and costs.
Predicted Intrinsic susceptibility index[2]	Low-Medium-High	Low = >80 Medium = 30-80 High = <30	Low	ISI for each well shown in Figure 28 calculated based on Terms of Reference[2]	Drill well in location with low ISI to source best possible raw water quality and minimize treatment requirements and costs.
Well interference potential	Low-Medium-High	Low = >5 m standing water left in closest well assuming maximum predicted drawdown Medium = 1 to 5 m standing water left in closest well assuming maximum predicted drawdown High = <1 m standing water left in closest well assuming maximum predicted drawdown	Low	Based on predicted drawdown calculated for each well. The predicted drawdown was based on transmissivity values reported in SNC Lavalin Study and the amount of standing water column is reported in MOE well records.	Ideal well should have little to no impact on the yield or storage of surrounding wells.
Physical constraints	Low-Medium-High	Low = no apparent physical constraints Medium = possible physical constraints present High = known physical constraints	Low	Interpretations made based on air photos and site visits. Constraints include visible evidence of buildings, roads, utilities, wetlands, etc.	Minimize capital expenditures and minimal disturbance of the natural environment.
Potential impacts on surface water bodies	Low-Medium-High	Low = ISI >80 Medium = ISI 30-80 High = ISI <30	Low	Based on intrinsic susceptibility index in wells nearest to the surface water body and predicted drawdown potential	Drill well in locations where geology provides protection against direct hydraulic connection to surface water.
Water quality	Sulphurous-Mixed-Fresh	Wells screened in bedrock unit are assumed to be sulphurous Wells screened potentially in overburden/gravel and bedrock units are assumed to have a mixture of fresh and sulphurous water Wells screened in overburden and gravel units are assumed to be fresh	Fresh	Based on water type listed in MOE well records of nearby wells with low quality being sulphurous and high quality being fresh. Wells partially screened in bedrock and overburden or gravel units were considered of mixed water quality, as there is potential for sulphurous water being derived from the bedrock.	Drill well in location where water has the highest probability of being fresh with the objective of minimizing treatment requirements and costs.

Notes:
1 - GUDI - Groundwater under direct influence of surface water, delineated based on MOE document entitled "Terms of Reference, Hydrogeological Study to Examine Groundwater Sources Potentially under the Direct Influence of Surface Water", dated October 2001
2 - Intrinsic susceptibility index - Low, medium and high values calculated based on method outlined in MOE Document entitled "Groundwater Studies 2001/2002 Technical Terms of Reference", dated November 2002

From XCG, 2006.

Table 4-1. Evaluation of Possible Well Locations

Evaluation Criteria			Potential for Supplying > 5 L/sec	Distance to Lynden (m)	Distance to Distribution System (m)	City Owned Land	GUDI Potential	Predicted ISI	Potential Impact on Nearby Wells	Physical Constraints	Potential Impact on Surface Water Bodies	Probable Water Quality
Evaluation Factor			Low / Medium / High	< 2000	< 2000	Yes / No	Low/High	Low / Medium / High	Low / Medium / High	Low / Medium / High	Low / Medium / High	Low / Medium / High
Site	**Location Description**	**Ranking**										
A	South side of Governor's Road, approximately 200 metres west of well FDL01	3	Medium: existing surrounding wells pumping rate = 2.5 - 5 L/sec	1400	30	No	Low: > 100m from nearest surface water body	Low: >80	Low: standing water left in all surrounding wells after preditced drawdown >=5m	Low: no physical constraints observed on air photo or during site visits	Low: predicted ISI is Low, drawdwon effect on surface water bodies is predicted to be minimal (1.7m or less)	High: screened in gravel unit
B	South side of Governor's Road, approximately 100 metres east of well FDL01	4	Medium: existing surrounding wells pumping rate = 2.5 - 5 L/sec	1500	30	No	Low: > 100m from nearest surface water body	Low: >80	Low: standing water left in all surrounding wells after preditced drawdown >=5m	Low: no physical constraints observed on air photo or during site visits	Low: predicted ISI is Low, drawdwon effect on surface water bodies is predicted to be minimal (1.7m or less)	High: screened in gravel unit
C	South side of Governor's Road, approximately 800 metres east of well FDL01	5	Low: existing surrounding wells pumping rate = < 2.5 L/sec	2080	220	No	Low: > 100m from nearest surface water body	Low: >80	Medium: standing water left in some surrounding wells after preditced drawdown > 1-5m	Low: no physical constraints observed on air photo or during site visits	Low: predicted ISI is Low, drawdwon effect on surface water bodies is predicted to be minimal (1.7m or less)	High: screened in gravel unit
D	Along east side of Lynden Road, approximately 750 metres north of Governor's Road	6	Low: existing surrounding wells pumping rate = < 2.5 L/sec	<100	<100	No	Low: > 100m from nearest surface water body	Medium: 30-80	Medium: standing water left in some surrounding wells after preditced drawdown > 1-5m	Low: no physical constraints observed on air photo or during site visits	Medium: ISI is predicted to be Medium drawdown effect on surface water bodies is predicted to be minimal (1.7m or less)	High: screened in gravel unit
E	South side of Governor's Road, approximately 750 metres west of well FDL01	2	Medium: existing surrounding wells pumping rate = 2.5 - 5 L/sec	1120	20	No	Low: > 100m from nearest surface water body	Low: >80	Low: standing water left in all surrounding wells after preditced drawdown >=5m	Low: no physical constraints observed on air photo or during site visits	Low: predicted ISI is Low, drawdwon effect on surface water bodies is predicted to be minimal (1.7m or less)	High: screened in gravel unit
F	South side of Governor's Road, approximately 500 metres east of well FDL01	1	Medium: existing surrounding wells pumping rate = 2.5 - 5 L/sec	2000	140	Yes	Low: > 100m from nearest surface water body	Low: >80	Manageable	Low: no physical constraints observed on air photo or during site visits	Low: predicted ISI is Low, drawdwon effect on surface water bodies is predicted to be minimal	High: screened in gravel unit

modified from XCG (2006)

GENIVAR

MEMORANDUM

Date: September 19, 2007

To: Chris Shrive, City of Hamilton

Copies:

From: Alicia Fraser, GENIVAR

Project No.: 6333

Subject: Lynden Communal Water Supply
Future Demand and Alternative Water Source

1. Background

The Lynden RSA is a rural community situated 20 km to the west of the Hamilton City Centre. It is bounded by Governors Road to the south and the railroad tracks to the north, with Main Street/Lynden Road running through the middle of the community. The Lynden RSA is currently composed of 163 lots.

It is the City of Hamilton's policy that anyone within the bounds of the current RSA has the option of connecting to the communal water systems. In addition, any property that fronts a water main has the option to connect.

In the summer of 2002 the City of Hamilton developed a Comprehensive Water Servicing Master Plan for the Lynden Rural Settlement Area (Servicing Master Plan). The Plan considered the need for additional water supply to the RSA and compared various general methods of meeting the requirement of the future RSA.

This report summarises the current and projected demands, as well as, the general water supply alternatives for the meeting water demands of the future Lynden water servicing area. The following information was used to compile this memorandum:

- *Comprehensive Water Servicing Master Plan for the Lynden Rural Settlement*, Totten Sims Hubicki Associates Inc., August 2002.
- Lynden Communal Well Systems Permit to Take Water No. 88-P-2000, April 19, 2001.
- Lynden Communal Well Systems Amended Certificate of Approval No. 8235-6UHJBC, October 31, 2006.
- Lynden Communal Well Systems Pumping Records from 2005 – 2007, supplied by the City of Hamilton.
- Lynden Rural Settlement Area Servicing Categories Map, supplied by the City of Hamilton.

2. Existing Water Supply Facilities

Currently, municipal water servicing is supplied by a single groundwater well located to the east of the community on Governors Road. In addition to the well, the municipal system includes a

storage and treatment reservoir, air stripping, pumping station and associated distribution system. The existing wells operate under the Ministry of the Environment, Permit to Take Water No. 88-2000, which limits the maximum flow rate to 227 L/min or 327 m^3/day.

3. Water Demand

3.1 Current Demand

The Lynden RSA is composed of 163 lots, of those lots 117 are connected to the communal water system. There are also 11 lots that are not part of the RSA but front the watermain that are also connected to the system. Currently there are a total of 128 connections to the existing system.

The following table summaries the average and maximum monthly water demands on the Lynden communal water systems between 2005 and 2007.

Table 1: Average and Maximum Day Demands (m^3/day)

	2005		2006		2007		Average Monthly
	Average Day	Maximum Day	Average Day	Maximum Day	Average Day	Maximum Day	
January	89.77	114.05	70.91	86.4	83.84	105.32	81.51
February	93.65	114.91	66.96	83.81	84.78	105.72	81.80
March	92.45	114.91	71.44	107.14	78.03	83.77	80.64
April	95.36	127.87	73.27	90.72	85.94	103.79	84.86
May	106.41	139.1	85.12	117.5	108.51	152.01	100.01
June	140.23	192.67	116.47	154.66	125.63	170.14	127.44
July	141.42	219.46	84.61	139.97			113.02
August	123.61	166.75	87.51	134.78			105.56
September	111.69	147.74	76.75	235.01			94.22
October	97.46	144.29	69.00	88.99			83.23
November	75.6	124.42	71.34	88.13			73.47
December	71.38	89.86	73.92	89.86			72.65
Annual	**103.3**	**219.5**	**78.9**	**235.0**	**94.5**	**170.1**	**91.53**

Based on the information presented above the average day demand is 91.53 m^3/day with a maximum day of 235 m^3/day or 1.8 m^3/day/connection. The Servicing Master Plan reported a maximum day of 244.9 m^3/day during the 2000 and 2001 period. The reduction in maximum day between the past three years and the value used in the Servicing Master Plan could be a result of increased prevalence of high efficiency appliances and water conservation initiatives.

Given the maximum day demand of 1.8 m^3/day/connection and the permitted pumping capacity of 327 m^3/day, the existing station can support a total of 181 connections or 53 additional connections.

3.2 Projected Demand

The City of Hamilton is proposing to expand the existing RSA, Figure 1 shows the existing and proposed RSA boundaries, as well as the current connections. The future drinking water source

and associated facility will have to be able to meet the demands assuming all potential connections are made. The long-term total connections would include the connection of all lots within the current RSA, the lots within the proposed RSA expansion and all the lots fronting the water main on Governors Road, in total 225 connections.

Based on the historic demands presented in Table 1, it is estimated that each lots uses an average of 0.66 m^3/day. A maximum day peaking factor of 2.6 was used to determine the maximum day demand, this peaking factor is consistent with the MOE Design guidelines, as well as the historic records demand for the Lynden RAS. The following table summarises the long-term demands.

Table 2: Long Term Average and Maximum Day Demands (m^3/day)

Long-Term Connections	195
Average Day Demand per Connection	0.72 m^3/day
Average Day Demand	139 m^3/day
Maximum Peaking Factor	2.6
Maximum Day Demand per Connection	1.86 m^3/day
Long-Term Max Day Demand	**358 m^3/day**

4. Project Rational

This project addresses water supply and treatment issues arising out of the need to provide drinking water to meet the demands of the future water servicing area and comply with current provincial guidelines, which recommend redundancy within the system. A full analysis of water demand was conducted during the study to confirm water supply and storage requirements as well as treatment requirements.

5. Alternatives Assessment

5.1 Screening Criteria

Considering the potential effects arising from the alternative solutions and the nature of the Lynden project, the following evaluation criteria were used in assessing alternative solutions:

1. **Socio-Economic Environment**. Involving noise, traffic obstruction, existing services and activities, private wells, cultural and heritage sites, aesthetics, adjacent land use and community growth.
2. **Natural Environment**. Involving the natural environment including natural features, wildlife and aquatic habitats, vegetation and groundwater resources.
3. **Drinking Water**. Involving water quality, public health water resources, treatability and source water protection.
4. **Technical Factors**. Involving feasibility, property requirements and restrictions, ease of operations and maintenance, timing and utility conflicts.
5. **Legislative Issues**. Involving compliance with regional provincial and federal legislation.
6. **Costs**. Involving lifecycle costs and long-term sustainability of constructed entities.

5.2 Review of General Alternative Solutions

The following table details the general alternatives under consideration for upgrading the Lynden communal water supply system to meet the demands of the future service and a improve the security of supply.

Table 3: General Alternative Solutions

Alternative	Description
Alternative 1 – Do Nothing	The "Do Nothing" alternative represents what would occur if none of the alternatives were selected
Alternative 2 - Water Conservation/Demand	By continuing to implement water conservation measures such as flow metering, encouraging the use of low flush toilets in existing and new developments, toilet replacement, leak detection and undertaking rehabilitation activities.
Alternative 3 – Limit the Growth of the RSA	Reduce future water supply needs by limiting the extent, density, type and/or location of future growth.
Alternative 4 – Upgrade the Existing Well System	This would involve upgrading the existing facility to from 327m^3/day to 358 m^3/day to handle the increased demand, improving the existing water quality and increasing the maximum allowable pumping limit. It has been estimated that the aquifer has a capacity of 560 m^3/day.
Alternative 5 – New Groundwater Supply	Develop a new groundwater well in the Lynden area and construct a new treatment facility. The existing facility would be maintained to provide the system with redundancy, as well as additional capacity.
Alternative 6 – Connect to an Adjacent System	Build a new transmission main and booster station that would connect the Lynden RSA to the adjacent City of Hamilton lake based system. The closest connection is in Dundas, approximately 15km away.

5.3 Summary of the Evaluation of Alternatives

The alternatives for upgrading the Lynden communal water supply system were assessed using the criteria presented above. The evaluation of the alternatives is shown in Table 4.

6. Preferred Solution

The preferred alternative is to develop and construct a new groundwater supply with associated treatment facility. The following summarises the advantages of this alternative:

- Fully addresses problem statement.
- Meets MOE Guidelines by providing redundancy in the water system.
- Allows for proposed 18-lot expansion the RSA south on Governors Road
- Allows the connection of 23 additional lots resulting from lot severance within the RSA.
- Allows for the connection of all lots front the water mains.
- Provides flexibility and allows for future growth

Further study is required to select the best location for siting the new groundwater well and facility, this study in detailed in *Evaluation of Alternatives for Potential Well Locations*, GENIVAR 2007.

7. Next Steps

The following outlines the next steps in the preferred alternative selection:

- Select the preferred location,
- Commence the drilling program,
- Perform the hydrogeological testing in concert with the natural science and archaeological evaluation,
- Once a well site is selected:
  - → The evaluation process will be complete,
  - → Mitigation measures will be developed,
  - → The preferred alternative will be confirmed,
  - → Design Options for the treatment facility will be developed based on the site location, topography and water quality from the new well.

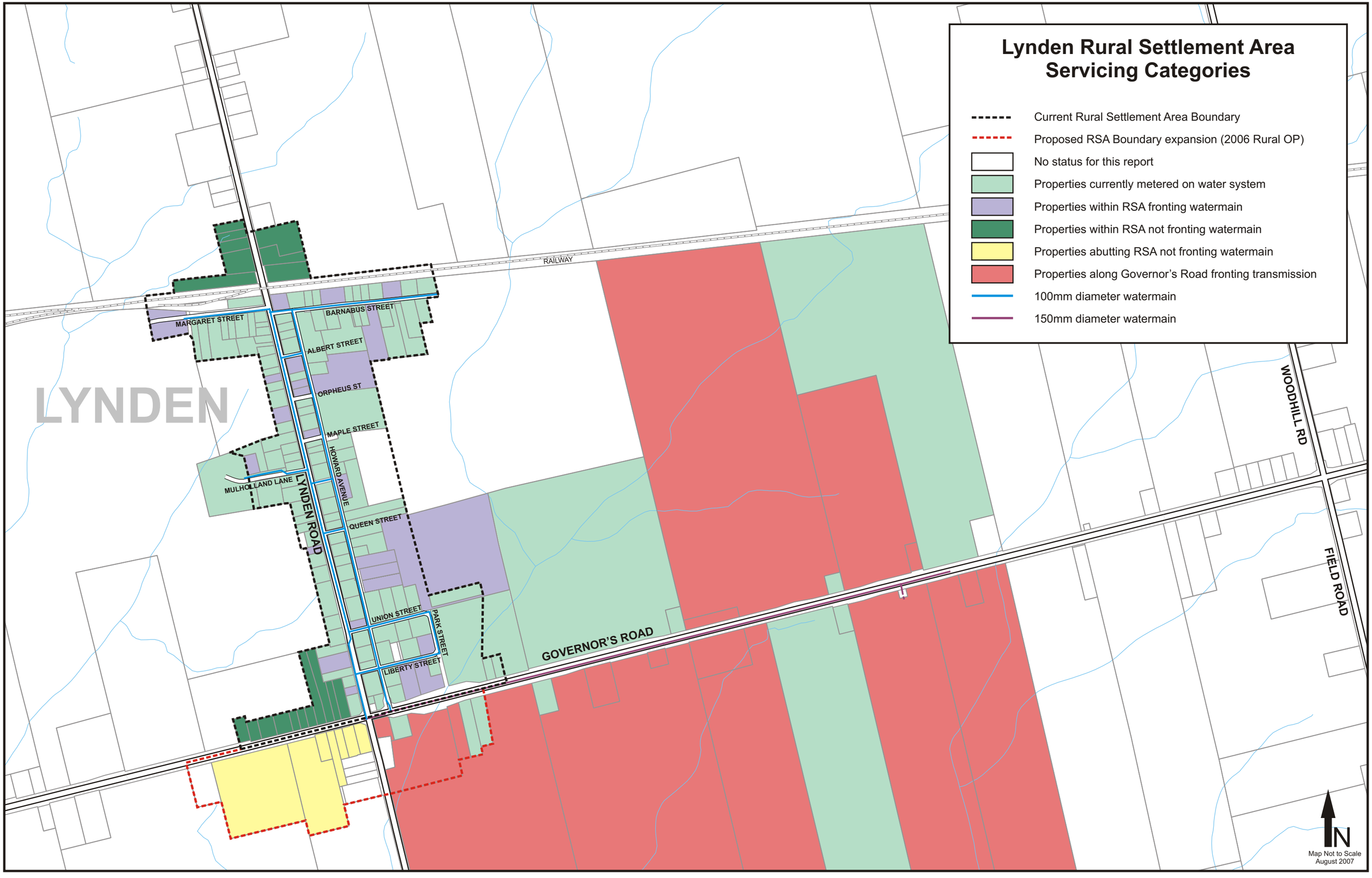

Lynden Rural Settlement Area
Servicing Categories
Current Rural Settlement Area Boundary
Proposed RSA Boundary expansion (2006 Rural OP)
No status for this report
Properties currently metered on water system
Properties within RSA fronting watermain
Properties within RSA not fronting watermain
Properties abutting RSA not fronting watermain
Properties along Governor's Road fronting transmission
100mm diameter watermain
150mm diameter watermain
LYNDEN
RAILWAY
MARGARET STREET
BARNABUS STREET
ALBERT STREET
ORPHEUS ST
MAPLE STREET
HOWARD AVENUE
MULHOLLAND LANE
LYNDEN ROAD
QUEEN STREET
UNION STREET
PARK STREET
LIBERTY STREET
GOVERNOR'S ROAD
WOODHILL RD
FIELD ROAD
N
Map Not to Scale
August 2007

Table 4: Comparison of General Alternatives

Consideration	Do Nothing	Water Conservation	Upgrade Existing Well Supply	New Groundwater Supply	Connection to an Hamilton System
Socio-Economic Environment	The service area could not be expanded by more than 49 connections	No Impacts	Increased pumping at existing well could effect Private Wells	Service area could be expanded Could produce noise during construction and exploration Further archaeological investigation would be required	Ability to grow service area Traffic Obstructions during construction of the main Further archaeological investigation would be required
Natural Environment	No Impacts	Reducing demand preserves the water resource	Increased demand on groundwater resources	Increased demand on groundwater resources Further field Investigation would be required	Further Field Investigation would be required
Drinking Water	No improvement to water quality	No improvement to water quality	Would require upgrades to the treatment system to improve water quality	Potential for improved water quality based on the aquifer	Improved water quality
Technical Factors	In the event the existing aquifer was compromised an emergency water supply would have to be found or a boil water advisory would be required.	In the event the existing aquifer was compromised an emergency water supply would have to be found or a boil water advisory would be required.	Existing property would not support an additional well on the property or the expansion of the existing facility. In the event the existing aquifer was compromised an emergency water supply would have to be found or a boil water advisory would be required. The capacity of the hydrogen sulphide removal system must be increased	Could require the purchase of land to house the well and treatment facility A new transmission main may be required depending on the location of the new well Would require additional O&M to maintain the two stations	Construction of a 15km transmission main through Greenbelt Protected Land The booster station would need to boost the water 115.2 up the Escarpment
Legislative Issues	Does not conform with City' policy to provide water service to all RSA lots as well as all lots fronting a distribution main Does not conform with Provincial Guideline requiring multiple groundwater wells	Does not conform with Provincial Guideline requiring multiple groundwater wells	Does not conform with Provincial Guideline requiring multiple groundwater wells	Conforms	Does not conform with the Greenbelt Plan 2005, which does not permit extension of Great Lake based water systems into Protected Areas
Cost Impacts	No Cost Impacts $0	Minimal Cost $20,000	Moderate Cost $100,000	High Cost $1,500,000	High Cost $5,000,000
Summary and Rating of Option Analysis	**- Minimum Expansion of the Water Service Area** **- No system redundancy**	**- Limits future growth of Water Service Area** **- No system redundancy**	**- No system redundancy**	**- Provides redundancy** **- Allows for growth of the water service area**	**- Cannot extend Great Lake based water system**
Rating of Option Analysis	○	◔	◐	●	○

GENIVAR

MEMORANDUM

Date: March 10, 2008

To: Chris Shrive, City of Hamilton

Copies: Gary Scott, GENIVAR

From: Alicia Fraser, GENIVAR

Project No.: 6333

Subject: Class Environmental Assessment for the Lynden Communal Water Supply Update to the 2002 Comprehensive Water Servicing Master Plan

1. Introduction

The Lynden RSA is a rural community situated 20 km west of Hamilton City Centre. It is bounded by Governors Road to the south and the CN railroad tracks to the north with Main Street/Lynden Road running through the middle of the community. The Lynden Rural Settlement Area (RSA) is currently composed of 163 lots as designated by the approved community plan.

In the summer of 2002, the City of Hamilton developed a Comprehensive Water Servicing Master Plan for the Lynden RSA (2002 Master Plan). The purpose of the 2002 Master Plan was to ensure the following:

- The water system could service those connected to the system, as well as those that could petition to connect based on City of Hamilton Policy;
- Compliance with Ministry of the Environment Guidelines and City of Hamilton standards; and,
- Optimization of the security of supply.

This memo provides an overview of the 2002 Master Plan, reviews the selected alternative for security of supply and reassesses the current and projected demands for the Lynden water servicing area. The following information was used to compile this memorandum:

- *Comprehensive Water Servicing Master Plan for the Lynden Rural Settlement*, Totten Sims Hubicki Associates Inc., August 2002.
- Lynden Communal Well Systems Permit to Take Water No. 88-P-2000, April 19, 2001.
- Lynden Communal Well Systems Amended Certificate of Approval No. 8235-6UHJBC, October 31, 2006.
- Lynden Communal Well Systems Pumping Records from 2005 – 2007, supplied by the City of Hamilton.
- Lynden Rural Settlement Area Servicing Categories Map, supplied by the City of Hamilton.

2. Existing Water Supply Facilities

Currently, the municipal water system is supplied by a single groundwater well located to the east of the community on Governors Road. In addition to the well, the municipal water system includes a storage and treatment reservoir, pumping station, and associated distribution system. The existing well operates under the Ministry of the Environment, Permit to Take Water No. 88-2000, which limits the maximum flow rate to 227 L/min or 327 m^3/day (50 IGPM).

3. 2002 Master Plan

The 2002 Master Plan considered the existing water servicing area and the present water demand as well as additional future connections. Two scenarios were developed:

- An interim expansion of the water service area to meet the current permitted capacity of 327 m^3/day or an estimated 154 connections.
- The future expansion of the water servicing area to meet the capacity of the aquifer, estimated as 560 m^3/day or an estimated 260 connections.

The 2002 Master Plan considered the following alternatives for the Water Supply and Water Distribution System for the existing Lynden communal water system.

- Water Supply Alternatives

  - Do Nothing

  - Water Conservation /Demand

  - **Upgrade the Existing Well System** (Preferred Alternative)

  - New Groundwater Supply

  - Connect to an Adjacent System

- Water Distribution System Alternatives

  - Do Nothing

  - **Upgrade to Improve Operation/Looping** (Preferred Alternative)

  - Upgrade to Fire Protection

  - System storage for pressure control

The 2002 Master Plan recommended preferred alternatives included upgrading of the existing well system and the distribution system to improve operation of the distribution system through looping.

The 2002 Master Plan recommended the following specific upgrades to the Lynden communal water system:

- Upgrade the existing facility

  - Replace the well discharge pipe. (Completed)

  - Replace the well pump. (Completed)

- Recalibrate the well sensor. (Completed)
- Implement turbidity treatment to reduce raw water turbidity levels. (Completed)
- Upgrade well cap and install measuring port. (Completed)
- Construct a backup well (Subject of this Assessment)

- Water efficiency public education. (On Going)
- Looping of water distribution system. (Completed)
- Undertake hydrogeological investigation to determine aquifer capacity and local well interference. (Partially the Subject of this Assessment and Partially Future Work)
- Further assess ability to supply water from the Dundas system. (No longer considered due to the policies within the Greenbelt Act, 2005)
- Develop wellhead protection strategy. (In Progress)

The 2002 Master Plan also recommended that if the water service area were to grow beyond 154 connections and exceed the current permitted capacity of the existing well, further consideration should be given to extending the City of Hamilton system and connecting Lynden. Since 2002 when the Master Plan was developed, the Greenbelt Act (2005) was passed. The Greenbelt Act and the associated Greenbelt Plan identified an area around the Golden Horseshoe and designated it the Greenbelt. The Greenbelt Act ensures the permanent protection of the agricultural land base and the ecological features and functions occurring on this Greenbelt. Lynden is located within the Greenbelt, therefore is subject to the policies included with the Act.

In order to limit development in the Greenbelt and protect the Greenbelt from urban sprawl, the policy outlined in Section 4.2.2 of the Greenbelt Plan prohibits the connection of settlements within the Greenbelt to a Great Lake based water system.

> "Where settlements do not currently have Great Lake or Lake Simcoe based water and sewage services, extensions to or expansions of existing Great Lake or Lake Simcoe based services to such settlements is not permitted, unless such servicing is required to address failed individual on-site sewage or water services or to ensure the protection of public health where it has been determined by a medical officer of health (or health authority) that there is a public health concern associated with existing services within the settlement. The capacity of the services provided in these circumstances will be restricted to that required to service the affected existing settlement plus the capacity for potential *development* within the approved settlement boundary as it existed on the date this Plan came into effect."
>
> *Reference: http://www.mah.gov.on.ca/Page189.aspx#3.4*

The City of Hamilton currently obtains its drinking water from the Great Lakes; therefore, the extension of the City system is not permitted. Given this change in policy, the City of Hamilton is proposing the exploration and construction of a backup well and facility to meet the current and future demands of the Lynden water service area as the preferred alternative.

4. Project Rationale

This project addresses the need to construct a backup well and associated treatment facility as outlined in the recommendations of the 2002 Master Plan. The new well and associated facility

will provide the system with redundancy to ensure a secure supply and will meet the needs of the potential ultimate water servicing areas, which would include all properties able to petition for connection based on the City of Hamilton By-Law No. 01-039.

5. Update to the 2002 Master Plan

5.1 Water Servicing Area

The City of Hamilton is proposing to expand the existing RSA, and Figure 1 shows the existing and proposed RSA boundaries. The 2002 Master Plan accounted of the connection of all the lots within the RSA, as well as those abutting the RSA along Governors Road. Since the completion of the Master Plan, the City of Hamilton water servicing policy has been expanded to include the potential connection of the lots along Governors Road abutting the water main.

The new backup well and associated treatment facility will be designed to meet the needs of the ultimate potential service area. The ultimate number of connections was calculated by the City of Hamilton and was based on the existing number of lots currently within the RSA in the proposed RSA expansion and fronting the existing water main. The ultimate water servicing area could include a total of 224 connections.

- 163 properties currently in the RSA, 118 are connected and metered, and 45 are not connected or not metered.
- 17 properties in the proposed RSA expansion, 3 of which are already connected and metered.
- 21 properties outside the future RSA boundary but fronting a water main, of which 8 are already connected.
- 23 severances are allowed for within the RSA or the proposed RSA. The number of severances was estimated based on the number of lots in excess of one acre that could be divided.

5.2 Reassessment of Alternatives

The following table summarises the alternatives considered in the 2002 Master Plan for upgrading the Lynden communal water supply system, as well as the updated reason for the selection or rejection of the alternatives based on the current conditions and requirements.

Alternative	Description	2007 Revised Conclusion
Do Nothing	The "Do Nothing" alternative represents what would occur if none of the alternatives were selected.	***Did not meet the requirements of the RSA and considered in Master Plan***
Water Conservation /Demand	Implement water conservation measures such as flow metering, encouraging the use of low flush toilets in existing and new developments, toilet replacement, leak detection, undertaking rehabilitation activities.	***Did not meet the requirements of the RSA and considered in Master Plan***
Upgrade the Existing Well System	Upgrading the existing facility to meet the Ministry of the Environment requirements. The upgrades would include treatment to reduce the treated water turbidity, replacement of the pump and well cap and construction of a backup well with increased capacity.	***Selected Alternative in Master Plan and remains Selected Alternative with increased capacity***
New Groundwater Supply	Develop a new groundwater supply from an alternate groundwater source in the Lynden area and construct a new treatment facility.	***As in the 2002 Master Plan still found to be not economic and provided greater disruption during construction***
Connect to an Adjacent System	Build a new transmission main and booster station that would connect the Lynden RSA to the adjacent City of Hamilton lake based system. The closest connection is in Dundas, approximately 15km away.	***Considered for Long-term Expansion but no longer feasible due to the restriction of the Greenbelt Act, 2005.***

5.3 Water Demand

5.3.1 2002 Master Plan Demands

The 2002 Master Plan based the water system demands on the 2000 and 2001 metered water readings; the following figure from the Master Plan compares the sum of the metered readings to the pumping records from the station.

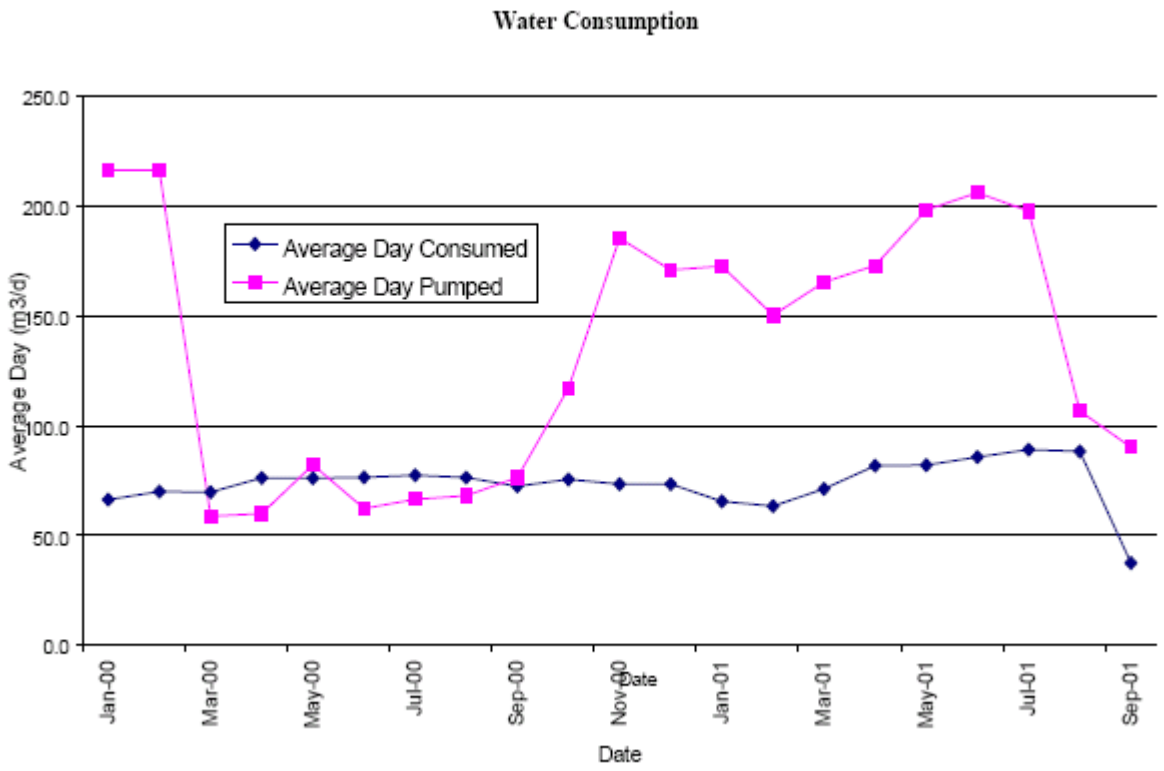


Figure 1: Water Consumption: Average Day Consumed and Average Day Pumped (Ref: 2002 Master Plan Figure 2.1)

The metered readings did not correlate to the amount pumped from the station. One recommendation of the 2002 Master Plan was to further investigate this discrepancy. Since this time, the City of Hamilton has recalibrated the flow meter and the pumping records more closely correlate to the meter readings collected in 2000 and 2001.

The Master Plan estimated the maximum day demand based on the pumping records as 244.9 m^3/day, and the average and maximum day demand based on the meter readings as 177 m^3/day and 222 m^3/day, respectively.

5.3.2 Current Demand

Since 2002, seven new connections have been made to the system, totalling 128 connections. Based on an estimated 3.2 people per household, there are 410 people currently connected to the water system.

This assessment considered the average and daily pumping rates from the station for the last seven years. The monthly average day pumping rates from the station were plotted for each year from 2000 to 2006 shown in Figure 2. The monthly average day demands for 2000 and 2001 do not correspond to the demands from 2002 to 2006. The demands from 2002 to 2006 do show a similar trend to the average day meter readings presented in Figure 1 and recorded in the 2002 Master Plan. The pumping records from 2002 to 2006 do show higher demands than the metered readings of 2000 and 2001, this is most likely a result of leaks in the system that are not recorded as part of the meter readings and additional connections being made over time.

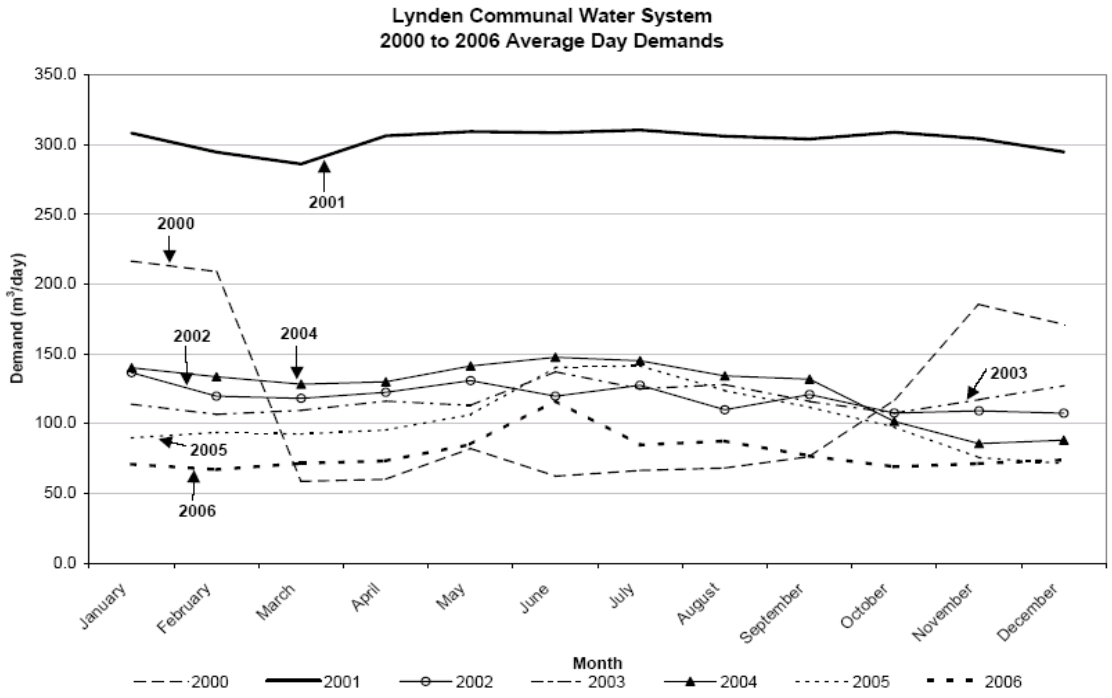


Figure 2: Average Day Demands 2000 to 2006

Industry standards suggest using the last three full year of record for calculating the existing system demand, in this case, 2004 to 2006 were used to calculate the average day demand and the maximum day demand. The following table summaries the average and maximum monthly water demands on the Lynden communal water systems between 2004 and 2006.

Table 2: Average and Maximum Day Demands (m^3/day)

	2004		2005		2006		Average Monthly
	Average Day	Maximum Day	Average Day	Maximum Day	Average Day	Maximum Day	
January	139.94	164.16	89.77	114.05	70.91	86.4	100.20
February	133.56	152.93	93.65	114.91	66.96	83.81	98.06
March	128.20	151.2	92.45	114.91	71.44	107.14	97.36
April	129.95	165.89	95.36	127.87	73.27	90.72	99.52
May	141.29	168.48	106.41	139.1	85.12	117.5	110.94
June	147.48	191.81	140.23	192.67	116.47	154.66	134.73
July	145.04	173.66	141.42	219.46	84.61	139.97	123.69
August	134.16	159.84	123.61	166.75	87.51	134.78	115.09
September	131.79	196.13	111.69	147.74	76.75	235.01	106.74
October	101.51	131.33	97.46	144.29	69.00	88.99	89.32
November	85.62	110.59	75.6	124.42	71.34	88.13	77.52
December	88.13	115.78	71.38	89.86	73.92	89.86	90.14
Annual	**125.6**	**196.1**	**103.3**	**219.5**	**78.9**	**235.0**	**103.6**

Based on the information presented above, the average day demand is 103.6 m^3/day or 252 L/cap/day with a maximum day of 235 m^3/day or 573 L/cap/day.

5.3.3 Projected Demand

It is the City of Hamilton's policy that anyone within the bounds of the current RSA has the option of connecting to a communal water system. In addition, any property that fronts a water main has the option to connect.

Given the maximum day demand of 1.8 m^3/day/connection and the permitted pumping capacity of the existing well of 327 m^3/day, the existing system can support a total of 181 connections or 53 additional connections.

The proposed well supply and associated facility will have to be able to meet the demands of all potential connections permitted under the existing City policy, assuming no additional expansion to the RSA. The long-term total connections would include the connection of all lots within the current RSA, the lots within the proposed RSA expansion and all the lots fronting the water main on Governors Road, in total 224 connections.

Based on the current demands, it is estimated that each lot uses 252 L/cap/day, with a maximum day of 573 L/cap/day. The following table summarises the long-term demands assuming a total of 224 connections.

Table 2: Long Term Average and Maximum Day Demands

Long-Term Connections	224
Total Population Served	717
Average Day Demand per Capital	252 L/cap/day
Average Day Demand	181 m^3/day
Maximum Day Demand per Capital	573 L/cap/day
Long-Term Maximum Day Demand	**411 m^3/day**

6. Conclusion

Upon review of the 2002 Master Plan existing conditions and the projected demands, it was found that there have been no significant changes that would change the recommendations of the 2002 Master Plan. The 2002 Master Plan recommendation to upgrade the existing well system is still the preferred alternative.

Further study is required to select the best location for siting the new groundwater well and facility, this study in detailed in *Evaluation of Alternatives for Potential Well Locations,* GENIVAR 2007.

7. Next Steps

The following outlines the next steps in the preferred alternative selection:

- Select the preferred location.
- Commence the drilling program.
- Perform the hydrogeological testing in concert with the natural science and archaeological evaluation.
- Once a well site is selected:
  - The evaluation process will be complete.
  - Mitigation measures will be developed.
  - The preferred alternative will be confirmed.
  - Design options for the treatment facility will be developed based on the site location, topography, and water quality from the new well.

CITY OF HAMILTON
HAMILTON, ONTARIO

REPORT ON INSPECTION AND REPAIRS TO THE LYNDEN WATER TREATMENT FACILITY AERATION AND DISINFECTION RESERVOIR CELLS

ASI Group Project E20279

Submitted

July 9, 2009

ASI Group Ltd.
St. Catharines, Ontario, Canada

ASI Group

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 BACKGROUND 2
- 2.1 System Design 3

3.0 PRELIMINARY SITE INVESTIGATION 5

4.0 CLEANING, INSPECTION, REPAIR AND DISINFECTION 5
- 4.1 General Site 5
- 4.2 Aeration Cell 6
  - *4.2.1 Cleaning & Inspection 7*
  - 4.2.1.1 Cleaning 7
  - 4.2.1.2 Inspection 7
  - *4.2.2 Aeration Cell Valves, Headers and Pipes 10*
- 4.3 Disinfection Cell 12
  - *4.3.1 Cleaning & Inspection 12*
  - 4.3.1.1 Cleaning 12
  - 4.3.1.2 Inspection 13
  - *4.3.2 Disinfection Cell Valves, Headers and Pipes 13*
- 4.3 Pump Wells 14
- 4.4 Repairs 15
  - *4.4.1 Baffle Curtains 15*
  - *4.4.2 Vertical Turbine Pump Casing 16*
  - *4.4.3 Valve Extension Rods 17*
  - *4.4.4 Pipe Hanger 18*
  - *4.4.5 Concrete Repair 19*
- 4.5 Disinfection and Decontamination 19

5.0 RECOMMENDATIONS 21

6.0 FOLLOW UP DIVE INSPECTION 23

7.0 LIMITATIONS 24

LIST OF FIGURES

Figure 1: Lynden WTF 2
Figure 2 Layout of the Lynden WTF..... 4
Figure 3: Exterior access to the aeration cell. Note residue under gasket material (bottom left corner), possible seepage (behind ladder) and corrosion (staining) of the exposed rebar 6
Figure 4: Concrete erosion along the edge of the pump well outer wall in the aeration cell by the baffle support hardware. 8
Figure 5: Porous concrete in wall separating pump well from aeration cell. 9
Figure 6: Tear in a baffle curtain removed from the aeration cell..... 10
Figure 7: Aeration header and baffle curtain support. Note the erosion spots in the floor located below the aeration nozzles 11
Figure 8: Isolation Butterfly valve from adjacent pump well. Note valve stem extension has now been replaced with stainless steel. 12
Figure 9: Pump No. 1 casing; note the two holes and surface texture of the casing. 15
Figure 10: Vertical pump casing repair using clamp on sealing collar. 17
Figure 11: Pipe clamp support, showing the delaminating carbon steel 18
Figure 12: New stainless steel support detail..... 19
Figure 13: Disinfection Cell Hatch Riser and Flashing..... 22

LIST OF APPENDICES

APPENDIX I: Drawings

APPENDIX II: Confined Space Entry Inspection Sheets

APPENDIX III: Baffle Curtain Specifications

APPENDIX IV: Video Inspection Work Sheets and DVDs

CITY OF HAMILTON
HAMILTON, ONTARIO
REPORT ON INSPECTION AND REPAIRS TO THE LYNDEN
WATER TREATMENT FACILITY AERATION AND DISINFECTION RESERVOIR CELLS
ASI Group Project E20279
July 9, 2009

1.0 INTRODUCTION

ASI Group Ltd. (ASI) was retained by the City of Hamilton, Ontario (Hamilton) in early May 2009 to perform a detailed survey and infrastructure assessment of, replace the aging baffle curtain in, and clean and disinfect the two (2) reservoir cells (aeration and disinfection) at the Lynden Water Treatment Facility (WTF).

Work to be completed included a preliminary condition assessment and repairs to each of the two (2) cells, with one (1) cell taken out of service at any time. The second cell was to function as a reservoir to distribute trucked (municipal) potable water to the users of the Lynden WTF.

The City provided drawings of the existing facility for review prior to the start of work at the site, and allowed for a maximum of two (2) weeks (fourteen (14) working days) to complete all tasks.

The specific scope of work proposed included,

< Dewater, enter and inspect the cell(s);
< Remove the aging baffle curtains and hardware. Inspect all hardware for wear and replace as necessary;
< Provide and install new baffle curtains, consistent with the original design;
< Wash/clean the reservoir cell and remove all debris and residual water for disposal at a municipal wastewater treatment plant (WTTP, Dundas and/or Woodward Ave.);
< Survey and assess the condition of the infrastructure in each cell, including the concrete, seals, hardware, piping, aerator header pipes and nozzles, valves, pumps, chlorine solution line piping, etc.
< Disinfect the reservoir cell following cleaning and installation of new baffle curtains; and,
< Complete and submit a report on the findings of the site inspection and reservoir rehabilitation program.

The present report presents a summary of the findings of the site work, an assessment of the condition of the system, and

recommendations for future work to improve the reliability and operability of the Lynden WTF.

2.0 BACKGROUND

The Lynden WTF provides water from a single well supply to approximately one hundred and sixteen (116) user connections in the nearby village of Lynden. The WTF is located at 3630 Highway #99 (Old Governors Road) in the City of Hamilton.

Figure 1: Lynden WTF

The City previously identified a need to enter, clean and inspect the condition of the two (2) reservoir cells, and replace the aging baffle curtains.

The condition of the existing valves, pumps, aeration headers and disinfection solution lines was unknown, and ASI was requested to inspect and assess the condition and report any findings to the City.

The City provided an outage window of fourteen (14) days, beginning on May 25, 2009 at 0800h, for the completion of all tasks. The City provided a Certified and Licensed Operator at all times during the outage to monitor the level of potable water in the pump reservoir(s) and the free chlorine disinfectant residual in the system and feed water.

Potable water for the users of the Lynden system was provided by two (2) water haulers contracted directly by the City. One (1) truck was on “stand by” at all times on site.

2.1 System Design

The Lynden WTP consists of a single well feeding a dual reservoir system piped for operation in series to provide aeration (oxidation) for removal of hydrogen sulphide (H_2S) and other contaminants, and disinfection of the aerated water (using free available chlorine, FAC).

The two (2) cells are below grade with the top partially covered by the floor of the treatment facility. Access to the reservoir cells is through two (2) raised access hatches located outside of the building and fitted with locking lids sealed with an elastomeric gasket. Each hatch is secured using a bolted down checker plate on top to further prevent unauthorized access as well as aid in preventing rain water from entering the cells via the hatch lid. (See Figure 1)

The reservoir cells are identical in size, but mirror images in layout. Water from the well may be directed to either cell by proper valve arrangement, and both cells are fitted with submerged aeration header pipes and nozzles. The WTF is normally operated with the western cell (cell 1) providing aeration while disinfection is completed in cell 2. It was anecdotally noted the valves have been more or less left in the same position for the majority of the time since the retrofitted station was commissioned.

Each cell has baffle curtains of identical dimensions (one (1) narrow and two (2) wider fabric baffles) anchored at the top and bottom edges, and along one (1) side. The cells are hydraulically connected by a single valve (356 mm, or 14 inch).

There are two (2) pump wells located below the floor of the treatment building. Access to the pump wells is by two (2) hatches located in the main pump room covered with checker plate fixed by hex bolts. The facility is kept locked at all times to prevent unauthorized access.

A single vertical turbine pump is provided in each pump well, and feed to the pump wells is controlled by three (3) 300 mm (12 inch) butterfly valves – one (1) feeding into each pump well from the adjacent reservoir, and one (1) connecting the two pump wells to each other.

The general arrangement is shown in Figure 2 (taken from City of Hamilton Lynden Governor's Road Pump Floor Plan Drawing M1, prepared by Thorburn Penny Consulting Engineers (1994)).

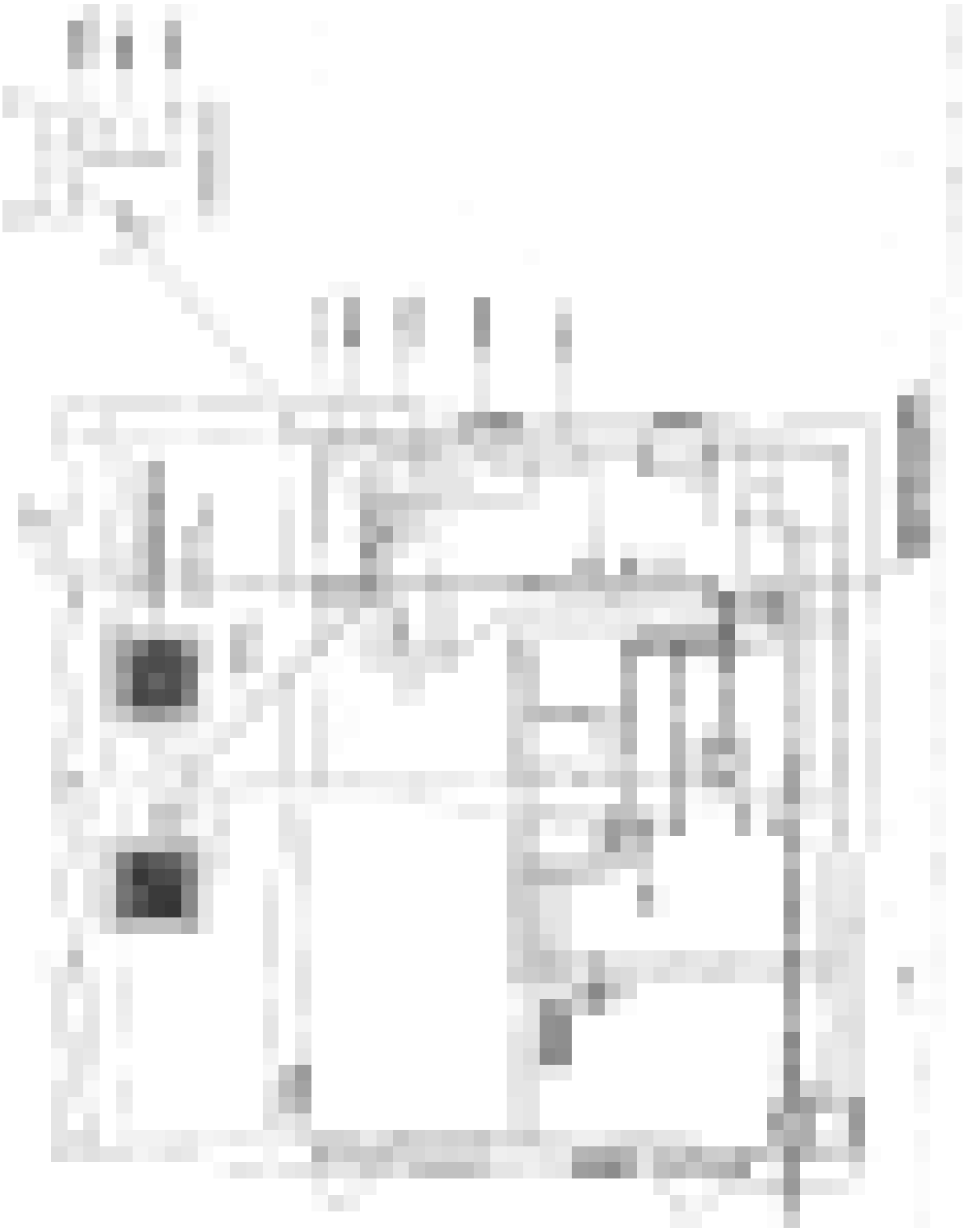


Figure 2 Layout of the Lynden WTF.

3.0 PRELIMINARY SITE INVESTIGATION

A preliminary site visit took place on April 28, 2009. Four (4) staff members from ASI visited the Lynden facility to conduct a preliminary site review and assess the access, equipment condition and state of repair prior to completing the site work.

A pole-mounted camera was used to take a look inside the two (2) reservoir cells and make preliminary observations as to the anchoring method for the existing baffle curtains, and the condition of the FAC solution lines and interconnecting valve between the cells.

The camera assembly was disinfected using a 200 mg/l solution of FAC consistent with the requirements of AWWA Standard C-652.

The site visit was led by Mr. Walter Furry of the City, and lasted approximately two and one half (2½) hours.

4.0 CLEANING, INSPECTION, REPAIR AND DISINFECTION

4.1 General Site

The facility was kept locked and in a state of generally good repair. There was evidence of corrosion of metallic piping and valves as a result of the corrosive atmosphere prevalent at the site, and it was expected that corrosion would be commonly found during the inspection of the two (2) reservoir cells.

The gasket material under the reservoir cell access hatches was found to be worn and compacted, with evidence of dirt and debris beneath the gasket material (see Figure 3).

There was evidence of seepage, and potential infiltration of surface water/runoff, at the seam where the raised hatches meet the original reservoir top slab (see Figure 3). The ends of the steel rebar exposed during the installation of the hatches showed evidence of corrosion and local staining of the concrete.

4.2 Aeration Cell

The site work commenced at 0800h on May 25th 2009. The aeration cell work was to be completed first, allowing the treated water in the disinfection cell to supply the residents of Lynden before trucked water was brought in from another system.

The water in the aeration cell was untreated, and contained no residual disinfectant. The water was pumped using two (2) submersible trash pumps (two (2) inch discharge) to the municipal ditch along Hwy #99.

When the water level was reduced to the point where the pumps could no longer operate, the air quality was checked using a portable MSA gas detector and ASI staff entered the cell to begin the physical work.

Figure 3: Exterior access to the aeration cell. Note residue under gasket material (bottom left corner), possible seepage (behind ladder) and corrosion (staining) of the exposed rebar.

4.2.1 Cleaning & Inspection

4.2.1.1 Cleaning

The aeration cell contained very little sediment. The sediment present was primarily white or gray with a fluffy appearance.

A sample (dilute) of sediment was collected in a one (1) litre polyethylene sample bottle and handed over to the City for analysis, as requested. The results of the analysis performed on this sample, if any, were not available for inclusion in this report.

The aeration cell was cleaned following removal of the existing baffle curtains and hardware. A high pressure water spray (potable water) was used to clean and scour all exposed surfaces, including pipes, valves and walls. The accumulated wash water, debris and residual sediment were removed by a vacuum truck and crew.

All aqueous waste and waste solids collected were disposed of at the Dundas Wastewater Treatment Plant (WWTP) or the Woodward Avenue WWTP in Hamilton.

4.2.1.2 Inspection

The concrete walls of the cell were heavily stained (reddish-brown) and discoloured, with a small amount of erosion near to and underneath the corners of the vertical anchor of the baffle curtains (see Figure 4).

Figure 4: Concrete erosion along the edge of the pump well outer wall in the aeration cell by the baffle support hardware.

The concrete floor area immediately below the aeration nozzles closest to the access hatch appeared to have worn unevenly. It is possible the combination of aeration/abrasion leading to a belief the air and high sulphur content are eroding the concrete in this area.

The concrete wall separating the adjacent pump well from the aeration cell was observed to be leaking a substantial amount of water from the pump well to the aeration cell as a result of the hydrostatic differential pressure. This situation may be reversed at certain times, leading to the possible infiltration of untreated water to the distribution system (see Figure 5, and refer to the video provided in the appendices).

Approximately 200 mm to 250 mm of treated water collected in the aeration cell overnight following the initial pressure washing and vacuum cleaning of the cell.

Figure 5: Porous concrete in wall separating pump well from aeration cell.

The baffle curtains were in relatively good condition; however, there was wearing damage noted on all baffle curtains, particularly adjacent to the anchored sides. The narrow baffle curtain had two (2) large tears in the fabric, making its operational effectiveness questionable (see Figure 6).

All three (3) curtains were removed from the cell, and accurate measurements taken for fabricating the replacement curtains. All three (3) curtains were anchored at the ceiling and along the floor using 50 mm stainless steel flat bar and hardware, including wedge-style anchors set into the concrete of the reservoir walls.

Figure 6: Tear in a baffle curtain removed from the aeration cell.

The final dimensions of the baffle curtains, and material specifications, are provided in the appendices.

4.2.2 Aeration Cell Valves, Headers and Pipes

All piping in the aeration cell was found to be in good repair and condition. The stainless steel air headers exhibited only a small amount of surface corrosion.

Figure 7: Aeration header and baffle curtain support. Note the erosion spots in the floor located below the aeration nozzles

The air nozzles appeared to be slightly occluded with particulate matter prior to washing, but the material was removed during the cleaning and the nozzles appeared to be in good condition.

The valve connecting the two (2) reservoir cells was heavily corroded on the surface of the face, but the butterfly disc itself and the seats were clear of debris. The valve closed with a little effort, and sealed well – it did not leak or permit water to transfer between the cells throughout the site work.

The valve connecting the aeration cell to the pump well was corroded on the face of the flange, and the stem extension. The face of the butterfly valve and seat were free and clear of any large debris, corrosion, marks, etc. Once repairs and disinfection were completed the valve was operated (closed) to begin work on the adjacent disinfection cell; however, upon closing the valve extension rod fractured making repairs necessary.

Figure 8: Isolation Butterfly valve from adjacent pump well. Note valve stem extension has now been replaced with stainless steel.

4.3 Disinfection Cell

Work on the disinfection cell began at 0800h on June 2nd after the aeration cell was returned to duty and was used to supply potable water for the system users, and the disinfection cell was taken out of service.

A large portion of the water in the disinfection cell was pumped over to the aeration cell, and the remaining volume was de-chlorinated using sodium bi-sulphite (aqueous solution of 38wt% bisulphite) prior to discharge to the municipal ditch using a submersible trash pump.

4.3.1 Cleaning & Inspection

4.3.1.1 Cleaning

There was considerably more sediment found in the disinfection cell compared to the aeration cell. Approximately 10mm of material was dispersed more or less evenly over the concrete floor of the cell, consisting of clumps and flakes of black material. A sample was collected in a one (1) litre polyethylene taken and handed over to the City of Hamilton for analysis, as requested.

The disinfection cell was cleaned following removal of the existing baffle curtains and hardware. A high pressure water spray (potable water) was used to clean and scour all exposed surfaces, including pipes, valves and walls. The accumulated wash water, debris and residual sediment were removed by a vacuum truck and crew.

All aqueous waste and waste solids collected were disposed of at the Dundas Wastewater Treatment Plant (WWTP) or the Woodward Avenue WWTP in Hamilton.

4.3.1.2 Inspection

The disinfection cell has a small 50mm channel cut into the floor leading from a small sump located below the access hatch in the North Western corner of the cell to the middle. The channel was coated with what appeared to be an epoxy based coating and appeared to be in good condition (no cracks noted, and the material was not peeling away from the concrete substrate).

The interior concrete surfaces of the cell were generally in good condition. No infiltration of water was noted during the inspection.

The condition of the concrete in the disinfection cell appeared better than that in the aeration cell – less local erosion, and no wearing near to the edges of the baffle curtain supports were evident in the disinfection cell.

A small area where the surface of the concrete had eroded away exposing a section with a heavy aggregate concentration - similar to the area found to be seeping in the aeration cell - was located just below the cross connection pipe on the disinfection reservoir side.

The finding indicates an area in the cell structure which may have an inherent weakness; however, this area was not noted to be seeping at the time of the inspection.

4.3.2 Disinfection Cell Valves, Headers and Pipes

Little to no corrosion was found on the aeration pipe headers, and only minor surface discolouration was noted. The majority of the PVC tubes from the aeration headers were undisturbed from their original locations, with the exception of two (2) pipes found off of their mounts.

The existing PVC pipes were replaced easily on their mounts to address the issue.

The cast iron butterfly isolating valve located at the back of the cell was corroded heavily on the face of the flange and the valve stem extension. The face of the disc and seals were found more or less free of debris and corrosion, very similar to the identical valve in the aeration cell. The valve seated firmly and did not permit passage of any water from the working pump well adjacent to the disinfection cell for the duration of the site work.

The original baffle curtains in the disinfection cell did not have any tears/rips, and there was very little of the wearing damage of the kind observed on the curtains from the aeration cell.

The difference in the condition of the baffles between the two (2) cells was attributed to the comparatively small amount of turbulence present in the disinfection cell (no aeration, laminar flow).

One (1) main pipe support for the 100mm main discharge pipe was severely corroded, with pieces of the support easily removed by hand like the layers of an onion.

The chlorine solution line headers and injection point were found to be in a good state of repair. The line and injector were cleaned by hand during the outage.

4.3 Pump Wells

ASI was informed by the City that one (1) of the main pumps was not providing sufficient pressure at normal water flows. The lack of back up for distribution pumping introduced a complication in one pump well could not be taken out of service for physical inspection and cleaning during the outage.

A three (3) person crew of commercial divers entered the pump well on May 28 2009 to inspect the pump and pump well; the other pump well remained in service.

The diver and all associated equipment were disinfected following the requirements of AWWA Standard C-652 prior to entering the wet well. The notes from the dive inspection indicate a hole in the casing of at least 18mm was discovered, with the heavily corroded condition of the casing implying the existence of more holes was “possible”.

On June 3rd the water level in the pump well was pumped down, and a closer inspection of the damaged casing was performed. Heavy scaling was found on the submersed side of the pump casing; however, this was easily removed using a putty scraper.

A second (6mm) hole was found approximately 10cm from the first hole once the encrustation of scale was removed. The surface of the casing was heavily pitted and corroded over a large area, but noted to be more or less intact apart from the two (2) penetrations already identified.

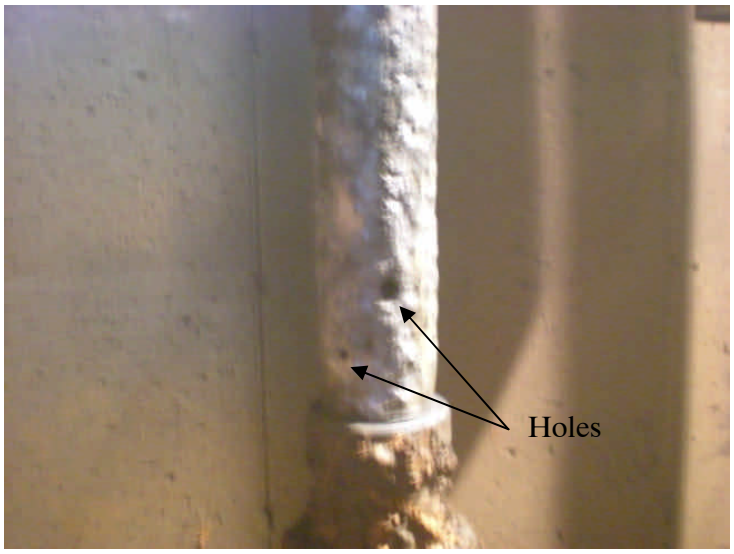


Figure 9: Pump No. 1 casing; note the two holes and surface texture of the casing.

The valve connecting the two (2) pump wells was visually inspected. The valve body is located in the adjoining pump well; however, when the valve was firmly closed it was observed the valve was leaking water around the seat at a rate of approximately 0.5 l/s.

4.4 Repairs

4.4.1 Baffle Curtains

All baffle curtains were removed from the two (2) cells under the approved scope of work. New curtains for both cells were fabricated by R.L. Sopers Inc. based on dimensions taken from the curtains removed from the aeration cell.

No dimensional drawings of the older curtains were located during the planning of the work, and direct measurements were the most expedient means of accurately determining the size of the curtains.

All fabric baffle curtains were manufactured of 8130 XR-3 vinyl coated canvas material, certified and tested to NSF Standard 61 for use in drinking water systems. The curtains were installed using 50mm stainless steel flat-bars and anchors in the same manner as the original baffles.

The newer curtains, which include perimeter seams fitted with rope inserts to provide better grip and handling, are made of a heavier material than the old curtains, and substantially more robust.

Three (3) new baffle curtains were installed in each of the two (2) reservoir cells.

4.4.2 Vertical Turbine Pump Casing

A stainless steel sealing collar was installed over the two (2) holes to repair the defects found in the pump casing. A wheel brush was used to clean the surface around the two (2) holes prior to installing the collar.

The surface of the casing was heavily pitted and corroded, and the entire assembly should be replaced in the near future.

The chamber was then pressure washed following the installation of the collar, and the accumulated wash water and debris was removed using a vacuum truck in a manner visually to that employed for cleaning the reservoir cells.

The pump and well chamber were disinfected using a methodology consistent with the requirements of AWWA Std. C-652 prior to returning the pump to full operation status.

Figure 10: Vertical pump casing repair using clamp on sealing collar.

4.4.3 Valve Extension Rods

The valve stem extension rods for both of the isolating butterfly valves that connect the treatment cells and their respective pump wells failed when they were operated by the City.

The fractures occurred around the same location for each valve stems, approximately where the top of the water met the rod.

The valve on the aeration side was actuated using a two (2) inch nut secured to the valve stem via three (3) or four (4) set screws. These screws had come loose following the connecting rod failure, and the entire assembly including the nut, rod and socket were removed as one (1) complete unit.

The nut on the valve stem in the disinfection cell remained in place when the rod failed and was not removed.

No key way could be found on either valve stem, which makes reliable future operation of the valve difficult.

The two (2) valve extensions were repaired, replacing the existing carbon steel rods (1¼" thin walled tubing) with thicker walled stainless steel. The two (2) inch square nuts on both the valve stem and on the top end of the extension, as well as the mating socket(s), were found to be in good shape and were reused.

4.4.4 Pipe Hanger

A new stainless steel pipe hanger was installed on the main discharge inside the disinfection cell. The hanger consisted of a stainless steel U-Bolt and angle iron.

Figure 11: Pipe clamp support, showing the delaminating carbon steel

Figure 12: New stainless steel support detail.

4.4.5 Concrete Repair

The erosion and subsequent leaking noted in the wall separating the aeration cell and the adjacent pump well was repaired by a contractor hired directly by the City.

The repair was effected using a combination of NSF Std. 61 certified epoxy and hydraulic cement. A copy of the material safety data sheets for the grout and accelerant are provided in the appendices.

The repair appears to have worked. No further seepage could be seen coming from the repair.

The entire area around the repaired section was washed, all residual material on the floor around the repair was scraped by hand, and the area cleaned using a vacuum truck prior to disinfection of the cell.

4.5 Disinfection and Decontamination

A boot tray filled with a disinfectant solution (minimum concentration 200 mg/l as free available chlorine) was used to safeguard against contamination of the reservoir cells. Any person entering the cells was required to disinfect their footwear using this tray before entering the cell.

All disinfection was performed following the cleaning and repair work completed in each cell. Disinfection followed the methodology as stated under AWWA Std. C-652-02, which reads,

> "a solution of 200 mg/l available chlorine shall be applied directly to the surfaces of all parts of the storage facility that would be in contact with water when the storage facility is full to the overflow elevation",

and where,

> "the chlorine solution may be applied with suitable brushes or spray equipment. The solution shall thoroughly coat all surfaces to be treated, including the inlet and outlet piping, and shall be applied to any separate drain piping such that it will have available chlorine of not less than 10 mg/L when filled with water. Overflow piping need not be disinfected."

and

> "The disinfected surfaces shall remain in contact with the strong chlorine solution for at least 30 min, after which potable water shall be admitted, the drain piping purged of the 10mg/L chlorinated water, and the storage facility then filled to its overflow level. Following this procedure and subject to satisfactory bacteriological testing and acceptable aesthetic quality, the water may be delivered to the distribution system."

ASI used only sodium hypochlorite tested and certified to NSF Std. 60 in preparing of the 200mg/l solution. The solution was prepared in batches using a 320 l (72 IG) vessel, and was applied using a small pump and garden hose.

Personal protection equipment for the entrant performing the disinfection duties consisted of a rain suit, rubber boots, gloves, and a full Niosh face mask designed for use with chlorine gas. A

All disinfection equipment (hoses and nozzles) was allowed to sit in the solution for a minimum of thirty (30) minutes before being lowered into the cells.

All surfaces, including all piping and the newly installed baffle curtains inside each cell, were thoroughly sprayed with the chlorine solution. Over 640 litres (144 IG) of the disinfectant solution was

consumed in the disinfection process of each cell; a further 320 litres (72 IG) was used in disinfecting the pump well.

Thirty (30) to ninety (90) minutes following the initial spraying the cells were filled with trucked potable (municipal) water. Samples were taken by the City for analysis.

Once the samples were analyzed and found to be clear of any bacteriological contamination, the cells were brought back into service.

All microbiological samples were tested and reported by laboratories operated by the City. Reports were provided to the City's contact, who informed the ASI Project Manager of the results and the path forward.

There were no samples collected following disinfection of any component which did not meet acceptable microbiological standards.

5.0 RECOMMENDATIONS

The butterfly valves in each of the cells that isolate the cells from their respective pump well seem to be in fairly good condition. It seemed to take little effort to actuate the valves once the extensions had been replaced.

The 300 mm (12 inch) butterfly valve that connects the two cells took a considerable amount of effort to close, as did the smaller valve that connects the two (2) pump wells.

This may be attributed to the fact that these valves are rarely exercised in the normal operating process for the WTF. This was apparent with the four (4) inch butterfly isolating valve on the inlet line from the well to the aeration cell, which had to be replaced at the start of the site work due to the valve having completely seized.

The air quality around and inside the facility consists of high H_2S concentration and there is a significant amount of condensation on and around the process piping inside the facility. ASI recommends the City implement and adhere to an aggressive valve exercise program where the valves are actuated at least once every six (6) months to prevent further valve seizing.

Staining evident where the rebar had penetrated out from the concrete may be indicative of some surface water seeping through the flashing located around the exterior of the riser sections that make up the hatch. The flashing around the hatches has separated from the risers, and it appears this separation is providing a flow path into the reservoirs. (See Figure 13)

ASI recommends the flashing be repaired immediately to prevent the possibility of contamination of the reservoir. ASI also recommends the City replace the gaskets on the underside of the chequered plates to help prevent any infiltration into the cells.

Figure 13: Disinfection Cell Hatch Riser and Flashing

The existing patch repair on the pump casing seems to be holding. ASI stresses this repair is a temporary fix, and recommends the City replace the pump casing (or pump) at its earliest convenience.

ASI recommends the City increase the cleaning frequency of the disinfection cell while closely monitoring the condition of the aeration cell. The constant agitation generated in the aeration cell prevents the majority of the solids from settling in the aeration cell; however, they accumulate in the disinfection cell. A more stringent cleaning schedule will reduce the probability of accumulated solids in the disinfection cell entering and contaminating the drinking water

distribution system, such as if the blower in the disinfection cell was inadvertently switched on.

The baffle curtains in the cells reduce the mobility and access of a conventional vacuum truck; whereas a more stringent cleaning schedule will allow the use of smaller hand held wet/dry shop vacs capable to remove any settled solids.

The baffle curtains should not be subjected to increased wear, and should remain viable and operable for a period of not less than ten (10) to fifteen (15) years if operation of the WTF is stable and flows do not fluctuate significantly.

6.0 FOLLOW UP DIVE INSPECTION

A second inspection by a three (3) person commercial dive crew was completed on June 22, 2009. The purpose of the inspection was to determine if the valve which connects the two (2) pump wells was leaking and/or damaged as suspected by the City based on a combination of residual chlorine concentration and wet well level fluctuations.

The divers entered the reservoir cell at 09:30h following standard disinfection practices (AWWA Std. C-652) to inspect the condition of the valve in question. The valve was manually closed by the diver, and the set screws connecting the valve stem extension to the actuating arm were tightened. The action of the valve was confirmed by visual observation, and a fine sediment test was used to monitor for any leakage around the valve seat.

The valve was found to be in good working order, with no leakage detected by the diver.

The diver exited the reservoir cell and entered the pump well at approximately 09:50h. The diver inspected the connecting valve between the two (2) pump chambers, and used hand tools to ensure the valve was fully closed and seated. The action of the valve was confirmed by visual observation, and a fine sediment test was used to monitor for any leakage around the valve seat

The valve was found to be in good working order, with no leakage detected by the diver.

The pump well water level was pumped down below the invert to confirm the ability of the valve to hold water at 10:30h. No leakage was observed, and the valve was found to be in good working order.

7.0 LIMITATIONS

The conclusions and recommendations (where offered) presented in this assessment report are based, in part, on visual observations of the site and attendant structures, interviews conducted and records reviewed. Our conclusions cannot and are not extended to include those portions of the site, structures or records which were not reasonably available, in ASI's opinion, for direct observation. Only those areas which were capable of being observed and were reasonably obvious to ASI personnel, or which have been identified to ASI by the City of Hamilton or other parties can be reported on.

It should be noted that ASI is an engineering and operational organization and, therefore, the contents of this report should not be interpreted as providing legal advice, opinions or interpretations.

No other warranties or representations, either expressed or implied, are made as to the professional services provided under the terms of our Contract, or the conclusions presented.
The conditions at the site were assessed, within the limitations set out above, having due regard for applicable Regulations and procedures as of the date of the inspection, as well as original design drawings and reports where available.

The site history included obtaining information from third parties and employees or agents of the City. No attempt has been made to verify the accuracy of any information provided, unless specifically noted in our report.

This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or contract. Any use which any third party makes of the report, in whole or the part, or any reliance thereon or decisions made based on any information or conclusions in the report is the sole responsibility of such third party. ASI accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on the report or anything set out therein.

APPENDIX I

MSDS SHEETS

ASI Group

APPENDIX II

DIVE LOGS AND FIELD REPORTS

ASI Group

APPENDIX III

BAFFLE CURTAIN SPECIFICATIONS

ASI Group

APPENDIX IV

VIDEO OF WATER SEEPING
THROUGH PUMP WELL WALL

ASI Group

ESTIMATION OF WELL YIELD
PROPOSED MUNICIPAL WELL
3618 GOVERNORS ROAD
LYNDEN, ONTARIO

Submitted to:
City of Hamilton
Public Works Department
Infrastructure and Source Water Planning Section
Environment and Sustainable Infrastructure Division
77 James Street North, Suite 400
Hamilton, ON, L8R 2K3

Submitted by:
AMEC Environmental & Infrastructure
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September 30, 2011

Project Number: TB111049

TABLE OF CONTENTS

PAGE

1.0 INTRODUCTION 1
2.0 WORK PROGRAM 1
3.0 SITE DESCRIPTION 1
3.1 Topography 2
3.2 Drainage 2
3.3 Physiography 2
3.4 Soils 2
4.0 GEOLOGY 3
5.0 HYDROGEOLOGY 3
7.0 WATER SUPPLY 3
7.1 Pumping Test 4
7.2 Monitoring Well Response to Pumping ..... **Error! Bookmark not defined.**
8.0 WATER QUALITY ANALYSES 6
9.0 CONCLUSIONS 7
12.0 CLOSURE 8

LIST OF TABLES

Table 1 – Summary of Bacteriological and Chemical Analyses

LIST OF FIGURES

Figure 1 – Site Location
Figure 2 – Aerial Photograph showing Well Locations and Site Features
Figure 3 – Hydrograph of Groundwater Levels at FDL 02 (Temporary Casing)
Figure 4 – Semi-log Plot of Drawdown and Recovery at FDL 02 (Temporary Casing)
Figure 5 – Hydrograph of Groundwater Levels during Constant RateTesting (Final Well FDL 02 & Monitoring Well LM-09)
Figure 6 – Semi-log Plot of Drawdown and Recovery during Constant Rate Testing (Final Well FDL 02 & Monitoring Well LM-09)

LIST OF APPENDICES

Appendix A – Bacteriological and Chemical Analyses
Appendix B – Water well records and borehole logs
Appendix C – AMEC Statement of Limitations

1.0 INTRODUCTION

AMEC Earth & Environmental, a division of AMEC Americas Limited ("AMEC"), was retained by the City of Hamilton (the "Client") to conduct a hydrogeological investigation to estimate the yield of a new water supply well which, if found suitable, will be used as a source of potable municipal water for the Rural Settlement Area of Lynden. The water well is to be located at 3618 Governors Road, Lynden, Ontario (hereafter referred to as the "Site") (Figure 1). The site is approximately 41 acres (16.7 Ha) and is primarily agricultural field with an existing pump house facility, located on the south side of Governors Road (Figure 2). The purpose of this hydrogeological investigation is to assess the capacity of the newly constructed water well.

The work carried out for the investigation was completed in accordance with AMEC's proposal (ref. no. TB-P11061E), dated July 7, 2011. Authorization to proceed with the work was provided by Mr. Mike Bingham via email on July 15, 2011.

2.0 WORK PROGRAM

The work program for this investigation comprised the following tasks:

- Clearing of underground locates;
- Monitoring of drilling and completion of the water well FDL 02 (TW-1);
- A step test carried out at FDL 02, at two pump rates of 2 L/sec; 4 L/sec, including recording of water levels using an automatic pressure transducer and manual water level readings;
- Chemical and microbiological analysis of water obtained from the subject well;
- Preparation of a report presenting the findings of the drilling and installation of FDL 02, step testing, and chemical analyses.

Prior to the completion of the water well, three test boreholes were drilled by the City of Hamilton with one of the test boreholes completed as a monitoring well (LM-09), which were supervised by Mike Bingham of the City. In addition Mike Bingham performed the final step test at 6 L/sec on the completed water well.

3.0 SITE DESCRIPTION

The Site is located in the Rural Settlement Area of Lynden, as part of the amalgamated City of Hamilton (Figure 1), on the south side of Governors Road. Lynden Road is situated approximately 1.4 km to the west of the site and Field Road is situated 1 km to the east. The surrounding area is primarily agricultural, with residential and farming properties located along Governors Road and in the settlement of Lynden. Currently, the site consists primarily of fallow field an existing pump house building at the entrance to

the Site. The existing pump well is on the west side of the pump house, with two existing monitoring wells installed to the west of the entrance driveway. The newly constructed FDL 02 is located approximately 115 meters to the rear (south) of the existing building (Figure 2).

3.1 Topography

The site is located within the Norfolk Sand Plain (Chapman and Putnam, 1984), characterized as a flat-lying area above and to the west of the Niagara Escarpment. In the vicinity of the site, the topography is low-lying in the northern half of the property, with a bedrock high forming a low ridge, rising several meters above the surrounding plain. Elevation in the vicinity of the site is on the order of 225 to 230 masl (National Topographic Database (Canvec) data, 2010).

3.2 Drainage

Based on a review of topographic maps and air photographs, and direct observation at the site, the drainage in the vicinity of the site is generally south and east towards the Niagara Escarpment. An unnamed creek flows along the eastern edge of the site property, draining into Dunmark Lake approximately 6 km to the south.

3.3 Physiography

The area of the present study is situated within the Norfolk Sand Plain Physiographic Region of Chapman and Putnam (1984). Within the Norfolk Sand Plain, the highest elevations are generally found adjoining the Niagara Escarpment where recessional moraines have been deposited by the ice lobe occupying the Lake Ontario basin. A portion of the Waterdown Moraine forms a low ridge, roughly parallel to the Niagara Escarpment which rises to the south.

3.4 Soils

The soils within the vicinity of the site are a fine-textured mixture of Grimsby sandy loam and Alberton silty clay loam (Presant, *et al.*, 1965). Overburden on the rock near the Niagara Escarpment is generally less than 50 feet (15 m) thick, increasing in thickness towards the southwest (Chapman and Putnam, 1984). In the vicinity of the site, the overburden thickness is generally on the order of 50 to 55 meters thick. According to borehole logs from LM-01-03 and LM-02-03 (the existing onsite monitoring wells), the overburden consists of predominantly clay and silt down to a depth of approximately 40 m, followed by an upward fining sequence of fine sand, sand and gravel of approximately 15 m thick, with dolostone bedrock at approximately 55 meter below ground surface (mbgs) (borehole logs, SNC Lavalin, 2003).

4.0 GEOLOGY

Bedrock in the vicinity of the site is composed of Middle to Lower Silurian age dolostone of the Guelph and Lockport-Amabel Formations. The southern half of the site property overlies the dolomite of the Guelph Formation, with the northern half of the site overlying the Lockport-Amabel (OGS, 2011), which forms the cap rock of the Niagara Escarpment. This formation is primarily dolostone, with minor limestone, chert and shale (AquaResource, 2009). The Lockport Formation is considered to be a relatively good aquifer, with variable permeability due to the presence of higher porosity vugs and chemical dissolution leading to karstification. FDL 02 possibly lies within a local bedrock high (bedrock was not proven at 52.1 mbgs), in comparison to the deeper bedrock encountered at LM-01-03 at 55 mbgs.

Overburden encountered at the site is composed of fine textured sand to silty sand, and clays with varying degrees of silt. As noted, the site property falls within the Norfolk Sand Plains, which consists of high permeability glaciolacustrine shallow water and deltaic sediments deposited during the Late Wisonsinan glaciation. The area is also influenced by lower permeability clays and silts of glaciolacustrine deep water sediments, and the silty Halton Till extending to the east of the site (OGS, 2003).

5.0 HYDROGEOLOGY

In southwestern Ontario, groundwater is found in both overburden and bedrock sources. The Lockport-Amabel aand Guelph Formations provide an important regional aquifer of good quality fresh water for both rural and municipal water supplies. Wells completed in the overburden often draw water from deposits such as the sands and gravels of glaciolacustrine outwash materials (Singer, *et al.*, 2003).

The pump well FDL-02 penetrates lower permeability fine-grained silts and clays which act as aquitard in the area. The well is completed in a sand and gravel unit, likely outwash material, which is the likely water producing zone. Later sections discuss the well's capacity and quality of water produced by this layer.

6.0 WATER SUPPLY

Three 2" (50 mm) trial boreholes were drilled by Durl Hopper Ltd. ("Hopper") in July, 2011 (Figure 2). The supervision of the test boreholes were undertaken by Mike Bingham of the City of Hamilton. The trial borehole at location TW-1 (depth of 51.2 mbgl (168')) was selected as the new water supply well FDL-02, and was increased to a temporary 6" (150 mm) casing installation for step testing. The screened interval extended from 50.1 mbgs to 48.9 mbgs (164.5 to 160.5 feet). The well was developed

by air lifting and flushing for a total of 6 hours, with return water remaining brown-grey in colour. Hopper estimated the well's production rate at 50 US GPM. Following step testing with the temporary casing, the well was reamed out to a diameter of 12" and advanced a further three foot to 52.1 mbgs (171') with permanent steel screen emplaced at a depth of 51.5 mbgs to 48.4 mbgs (169 to 159 feet) with an internal diameter of 8". The well was subsequently developed for just under eight hours with the water running clear on completion. The second trial borehole (TW2) was selected for the installation of a piezometer (Well LM-09), with the screen set at 54.6 mbgs to 51.5 mbgs (179 to 169 feet), the installation of which was supervised by Mike Bingham from the City of Hamilton. The well records for both boreholes are given in Appendix B. A drilling log for the pumping well based on the records of Mike Bingham of the City of Hamilton is given in Appendix B.

6.1 Step Testing – Temporary casing

In order to assess the potential water supply capacity from FDL 02, a step test was carried out on the subject well on July 28, 2011. The test consisted of two steps; the first step was conducted at a rate of 2 litres per second (L/sec, or 32 US GPM) for a duration of 30 minutes, followed by 30 minutes of recovery. The second step started at 4 L/sec (63 US GPM), but reduced to approximately 3.2 to 3.4 L/sec (51 to 54 US GPM) for a total of 106 minutes, with recovery to static levels recorded for approximately 10 minutes. A third step of 6 L/sec (95 US GPM) was not attempted.

A submersible Grundfös 5 horsepower pump, rated for 60 US GPM in a 2" well at 142' depth, was set with the intake at 48.8 mbgs (160 ft bgs). At the time of initiation of the step test the static water level was at 15.2 meters below top of casing (mbTOC).

Water levels were monitored automatically at 30 second intervals by a transducer in the pumping well, and manual readings were collected using a water level meter in order to monitor the progress of the test. Flow rates were monitored by Hopper using an orifice weir during pumping in order to monitor the rate of pumping, as well as to determine that the total water takings remained below 50,000 litres.

As noted, the static water level was measured at 15.2 mbTOC prior to starting the pump. During the initial step at 2 L/sec, the water level drew down to 22.6 mbTOC within 3 minutes, and then stabilized in the range of 22.6 to 22.8 mbTOC for the remainder of the step period. From the flow monitoring results, the flow rates measured during the step were 1.96 to 2.02 L/sec (31 to 32 US GPM). Recovery to static levels after the first step took approximately 2 minutes. The second step proceeded following recovery of the first step with an initial target of reaching 4 L/sec (63 US GPM). Water levels drew down to 32 mbTOC within 3 minutes of the pump being turned on and drew down to 48.2 mbTOC by approximately 10 minutes. To prevent the water level dropping below the

pump intake, the rate of drawdown was reduced to around 3.2 to 3.4 L/sec (51 to 54 US GPM). For the remainder of the step, the flow rate was adjusted to maintain an average rate of 3.3 L/sec. At this rate drawdown was close to stabilising, reaching a level of 47.7 mbTOC, or a maximum drawdown of 32.5 meters at the end of the step. In total, less than approximately 35,700 litres of water were pumped from the well during the step test.

Water levels at FDL 02 during the step test period are displayed graphically in Figure 3. Figure 4 shows drawdown and recovery (plotted as drawdown) for the pump well on a semi-logarithmic scale. Of note is the slight recovery in the second step at around 10 minutes. This is a response the pumping rate being reduced from 4 to around 3.3 L/sec. The difference of the recovery and drawdown phase of the second step test (Figure 4) is likely due to this change in pumping rate. Analysis of the second test drawdown data of the pumped well suggests a transmissivity of the order of 50-100 m^2/d using Jacob's approximation for a single well test (Kruseman, G.P. & de Ridder, N.A., 1991). The step testing indicates that with the temporary borehole construction, pumping rates of 3 to possibly 3.5 L/sec are attainable.

6.2 Constant Rate Test – Permanent Casing

A final constant rate test was undertaken by Mike Bingham of the City of Hamilton on the completed pumping well on the 16th August. The test was run for two hours at an average rate of 6.6 L/s (104 US GPM) with a total volume pumped of approximately 48,000 L. The test was monitored by two loggers, one in the pumping well and another in the new monitoring well (LM-09). A slight adjustment of the pump rate occurred approximately at 1½ hours into the test. The results of the constant rate test are shown in Figures 5 and 6.

At the time of initiation of the test the static water level was at 15.76 mbTOC in the pumping well. Following the adjustment in the pumping rate, the drawdown in the test well stabilised at 17.36 mbTOC (a drawdown of 1.6m). Drawdown in the well was recorded at just under 0.5 (from a static water level 12.87 mbTOC to a stabilized level of 13.35 mbTOC). In both pumping well and monitoring well, the drawdown is relatively rapid, but modest in magnitude. The early time of both the drawdown and recovery curves (Figure 6) are irregular (the recovery reversal suggests flow back from the pump after switch off). An analysis of the aquifer test is difficult because the test does not show a typical smooth drawdown curve. However, a rough analysis using the Jacob approximation (Kruseman, G.P. & de Ridder, N.A., 1991) on the data from the monitoring well suggests the transmissivity of the sands and gravels at the base of the clay being of the order of 100s m^2/d.

The dramatic increase in performance relative to the well with the temporary casing can be attributed to:

- increase in diameter of the well;
- improved borehole development;
- improved screen on the borehole;
- an increase of length of screened section of the well open to the sands and gravels from 4' to 10'.

The results from the constant rate test show that the new pumping well is capable of pumping at a rate of 6 L/s.

7.0 WATER QUALITY ANALYSES

Water samples were obtained from the pumped well during Step 2 (temporary casing installed), after approximately 30 minutes of pumping and at approximately 10 minutes prior to terminating the step. The samples were obtained from the end of the discharge line. The samples were submitted for analysis to Exova Accutest in Ottawa. The samples were analyzed for the parameters listed in Schedules 23 and 24 of O. Reg. 170/03 and for standard microbial parameters E coli and Total Coliforms, nitrate, nitrite, lead, sodium, fluoride, chloride, sulphide and DOC. AMEC also measured the pH, temperature, conductivity, turbidity and ORP of the groundwater prior to each sampling event, using a Horiba U22 water analyzer. Results of the analyses are summarized in Tables 1 and 2 below, with full results presented in Appendix A.

During well development, it was noted that initially the water was cloudy, but during step testing and sampling, the water remained clear. The water was noted to have a fairly strong odour of sulphide gas, which persisted throughout the pumping period.

Table 1: Summary of Water Quality Parameters

	Parameters				
	Temperature (˚C)	pH	Conductivity (µS/cm)	Turbidity (NTU)	ORP (mV)
Step 2: 30 minutes Elapsed Time	12.12	8.42	0.308	303	-160
Step 2: 95 minutes Elapsed Time	12.28	8.29	0.310	236	-168
Step 2: 105 minutes Elapsed Time	12.29	8.08	0.307	198	-180

Table 2: Summary of Bacteriological and Chemical Analyses

Parameter	Units	ODWQS[a]	FDL 02 (Temporary Casing)	
			TB111049-1	TB111049-2
			28-Jul-2011 1:30 PM	28-Jul-2011 2:45 PM
Microbiology				
E. coli	CFU/100 ml	ND	0	0
Total Coliforms	CFU/100 ml	ND	2	2
O. Reg. 170 Schedule 23 - Inorganic				
Antimony	mg/L	0.006	<0.0005	<0.0005
Arsenic	mg/L	0.025	<0.005	0.002
Barium	mg/L	1	**2.3**	**2.4**
Boron	mg/L	5	0.48	0.49
Cadmium	mg/L	0.005	<0.0001	<0.0001
Chromium	mg/L	0.05	0.001	0.002
Mercury	mg/L	0.001	<0.0001	<0.0001
Selenium	mg/L	0.01	NR	NR
Uranium	mg/L	0.02	<0.001	<0.001
O. Reg. 170 Schedule 24 (Selected Results)				
Benzene	mg/L	0.005	<0.0005	<0.0005
Chloride	mg/L	250	48	48
Dissolved Organic Carbon	mg/L	5	1.2	1.2
Fluoride	mg/L	1.5	0.73	0.72
Hydrogen Sulphide	mg/L	0.05	**0.3**	**0.3**
Lead	mg/L	0.01	<0.001	<0.001
$N\text{-}NO_2$ (Nitrite)	mg/L	1.0	<0.10	<0.10
$N\text{-}NO_3$ (Nitrate)	mg/L	10.0	<0.10	<0.10
$NO_2 + NO_3$ as N	mg/L	10.0	<0.10	<0.10
Sodium	mg/L	200	56	59
Trichloroethylene	mg/L	0.005	<0.0003	<0.0003

[a] O. Reg. 169/03 Ontario Drinking Water Quality Standards
"<" means less than the MRL (method reporting limit); guideline exceedances are noted in **RED**.

Exceedances were noted for hydrogen sulphide and barium, and bacteria (as Total Coliforms) were detected. Other parameters showed no further exceedances.

8.0 CONCLUSIONS

A new pumping well was installed at Lynden Road, completed in the basal sands and gravels Step testing was undertaken on a new pumping well (Well FDL 02). Two of the steps were undertaken with the well at 6" diameter and temporary casing. For the temporary borehole completion, drawdown was of the order of 7.5 m during the first step (2 L/sec) and during the second step (3.3 L/sec average) increased to 16.8 m within the first several minutes of the pump being turned on, and continued dropping to a maximum drawdown of 32.5 m. Recovery was also relatively quick, reaching pre-pumping static levels within ten minutes of the pump being shut off. The results from the final step test (6.6 L/sec average) with the completed 8" well extended further into the sands and gravel show that the well is easily capable of sustaining pumping rates at 6 L/sec as stabilised drawdowns are approximately 1.5 m after 2 hours of pumping.

Bacteria were detected in the well when sampled with the temporary completion. However, other parameters such as Nitrates and Nitrites and all tested anthropogenic organic compounds did not exceed Ontario Drinking Water Quality (ODWQ) guidelines, suggesting little anthropogenic contamination of the site. Hydrogen sulphide and Barium also exceeded the ODWS. It is possible that the detect for bacteria is associated with cross-contamination from the temporary casing. Further chemical testing is recommended on the completed 8" production well.

9.0 CLOSURE

We trust that the information provided in this report is sufficient for your purposes. Should you should have any questions regarding this submission, please contact the undersigned at 905-312-0700. The report is subject to AMEC's standard terms and conditions that are provided in Appendix C.

Prepared by:	Reviewed by:
Rachel McLean, B.Sc., P.Geo. Project Geoscientist	Martin Shepley, D.Phil., P.Geo. Senior Hydrogeologist

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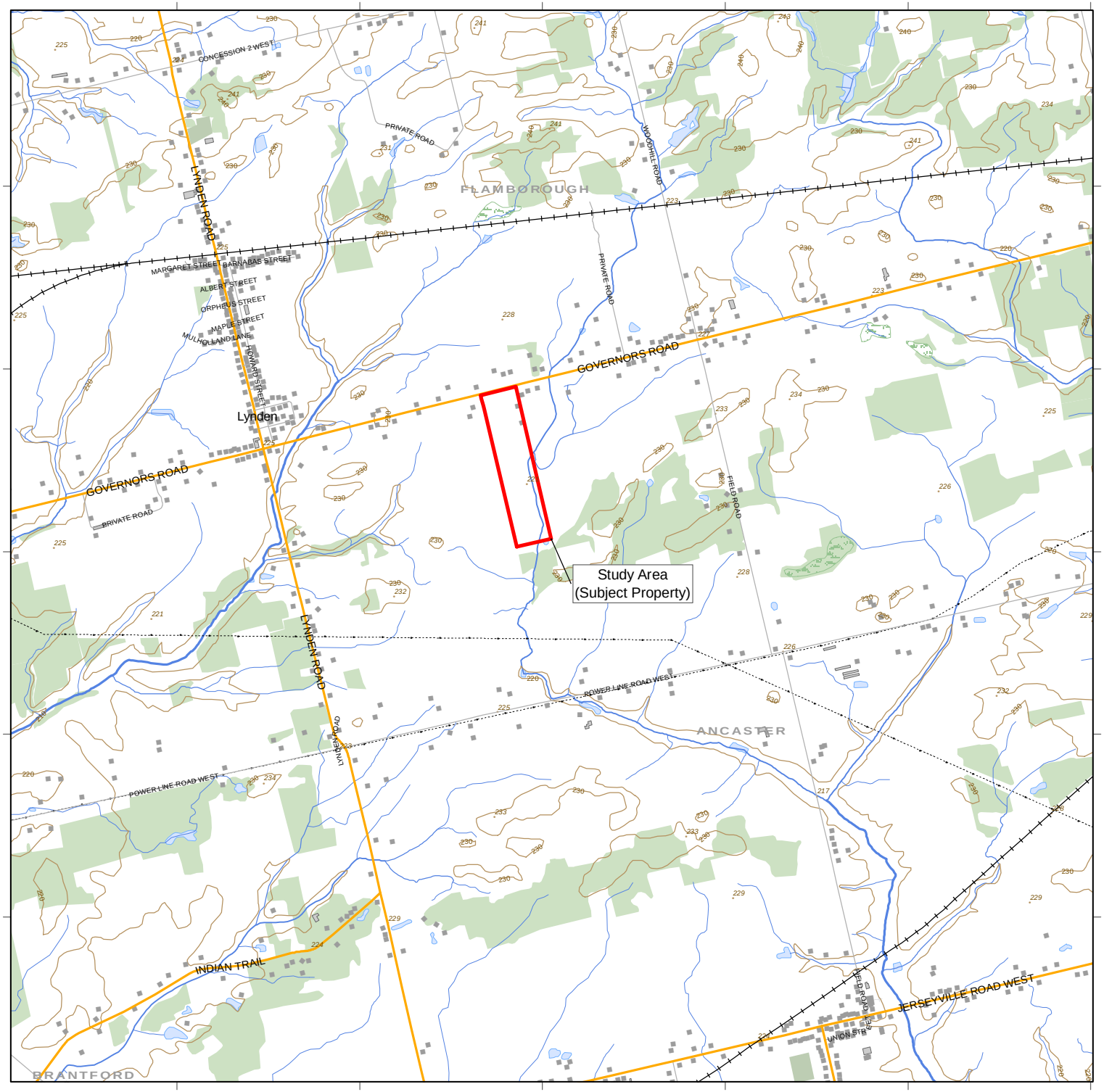
HYDROGEOLOGICAL INVESTIGATION
LYNDEN WATER PLANT
3618 Governors Road,
Lynden, Ontario

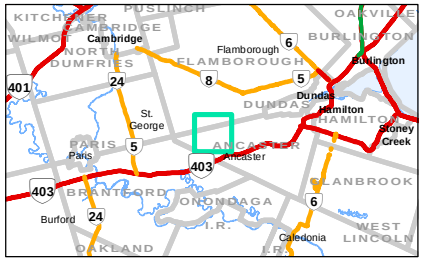
Figure 1

Site Location



Legend

- Railway
- U.G. Gas line
- Power Transmission Line
- Building Footprint
- Waterbody
- Wetlands
- Vegetation
- Park / Sportsfield
- Golf Course



Source: National Topographic Database Canvec Data, 040P01 tile, 1:10 000 nominal scale.

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project # TB111049
Date: August 2011
Client: City of Hamilton

Drawn by: RM
Checked by: SG
Revision No.: 2

N
W E
S

Meters
0 300 600 900 1,200

UTM NAD 83
Zone 17N
1:30,000

amec

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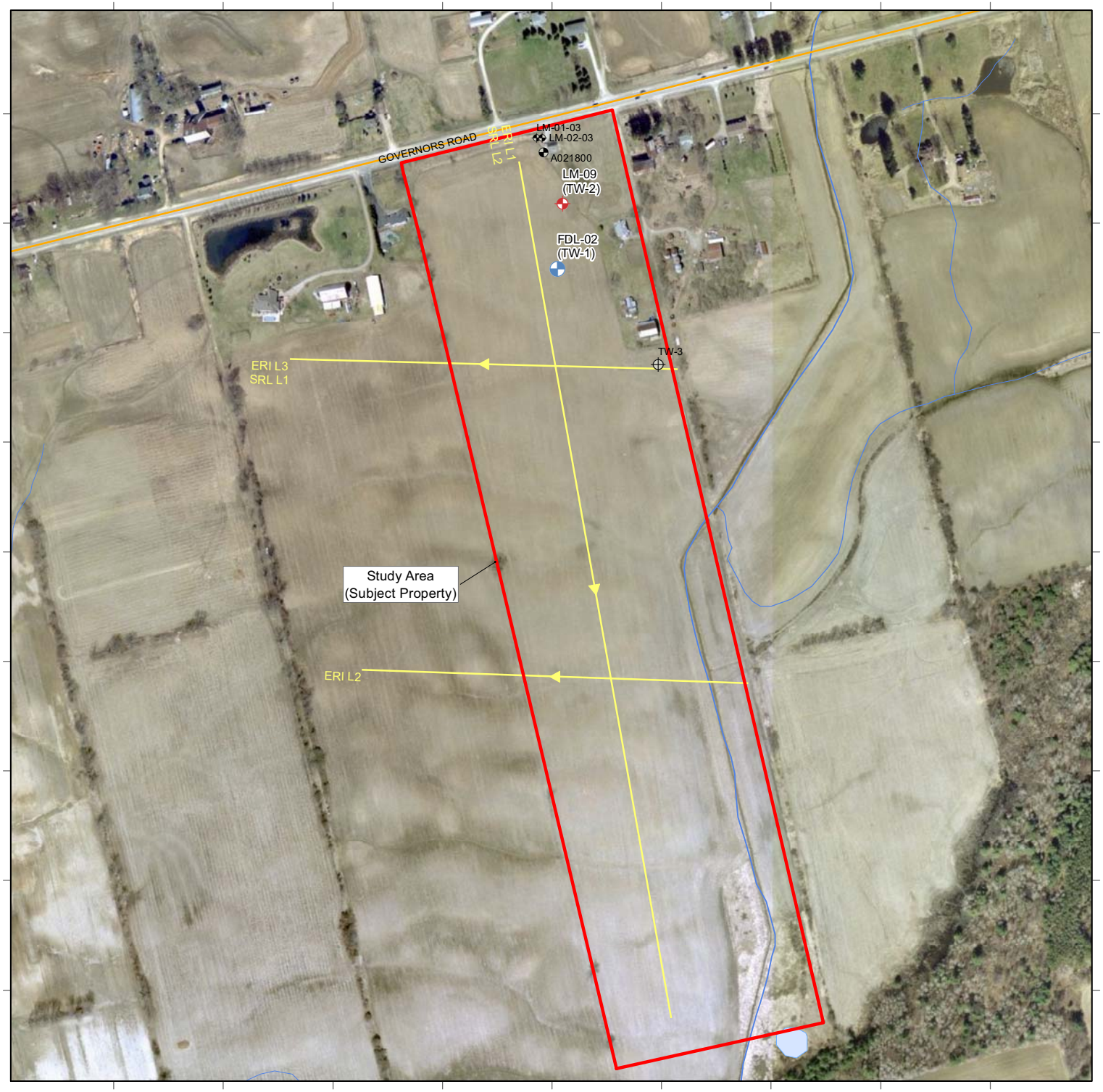
a Division of AMEC Americas Limited
505 Woodward Ave.
Hamilton, ON L8H 6N6

04 August 2011 C:\Documents and Settings\rachel.mclean\Desktop\GIS_Work\TB111049 - Lynden Water Plant_MAPS\Figure 1 Site Location.mxd



HYDROGEOLOGICAL INVESTIGATION
LYNDEN WATER PLANT
3618 Governors Road,
Lynden, Ontario

Figure 2
Aerial Photograph showing
Well Locations and Site Features

Legend

Wells
- Existing Pump Well
- Existing Monitoring Well
- Pump Well
- Monitoring Well
- Test Well
- Seismic Survey Lines
- Study Area
- Railway
- U.G. Gas line
- Power Transmission Line
- Waterbody

Source: National Topographic Database Canvec Data, 040P01 tile, 1:10 000 nominal scale.

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project # TB111049
Date: September 2011
Client: City of Hamilton

Drawn by: RM
Checked by: SG
Revision No.: 2

UTM NAD 83
Zone 17N
1:5,000

N
W E
S

Meters
0 50 100 150 200

amec

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Hamilton, ON L8H 6N6

30 September 2011 C:\Documents and Settings\rachel.mclean\Desktop\GIS_Work\TB111049 - Lynden Water Plant_MAPS\Figure 2 Aerial Photo showing Site Property.mxd

Figure 3: Hydrograph of Groundwater Levels at FDL 02 during Step Testing (Temporary Casing)

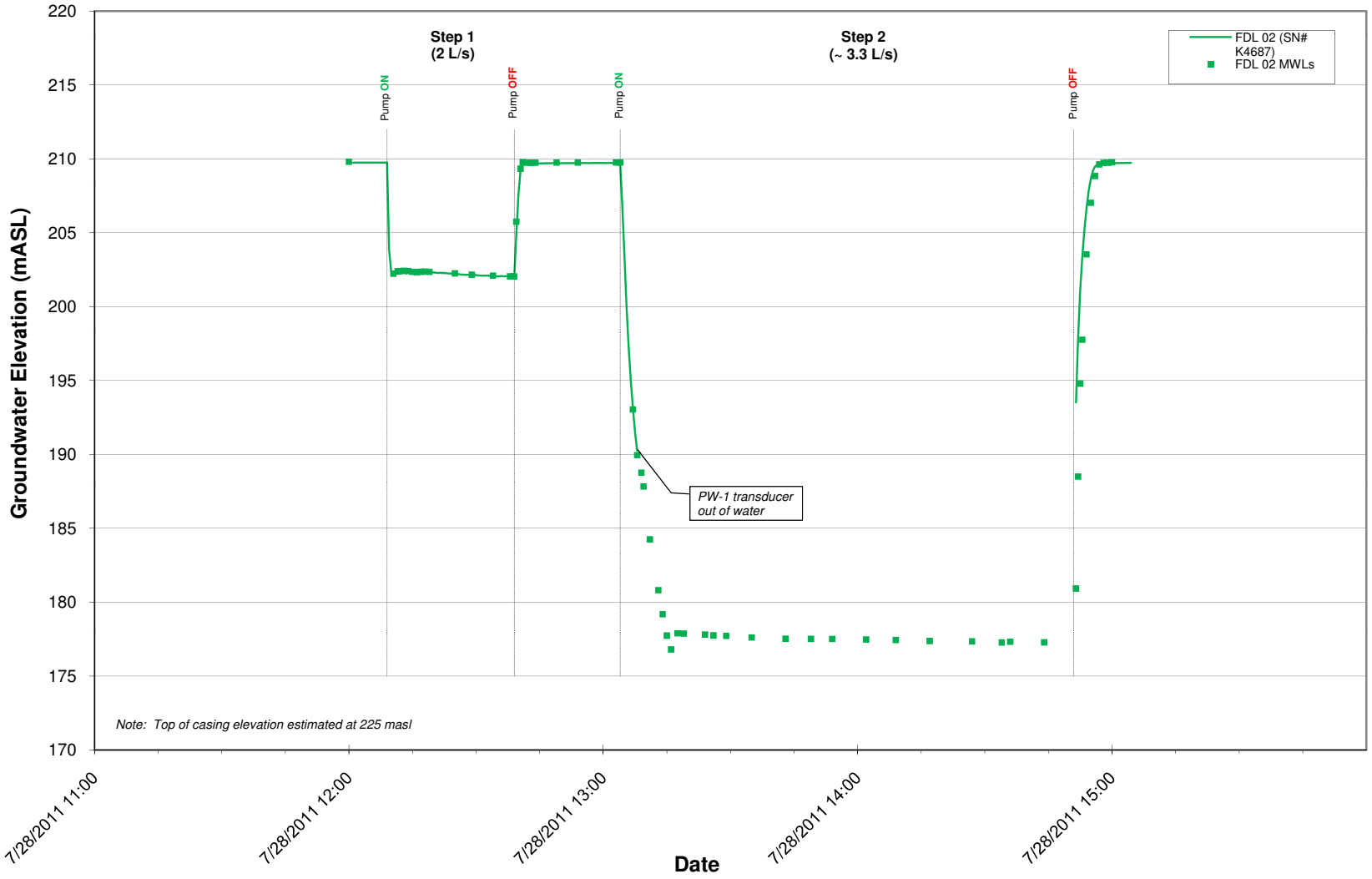


Figure 4: Semi-log Plot of Drawdown and Recovery at FDL 02 during Step Testing (Temporary Casing)

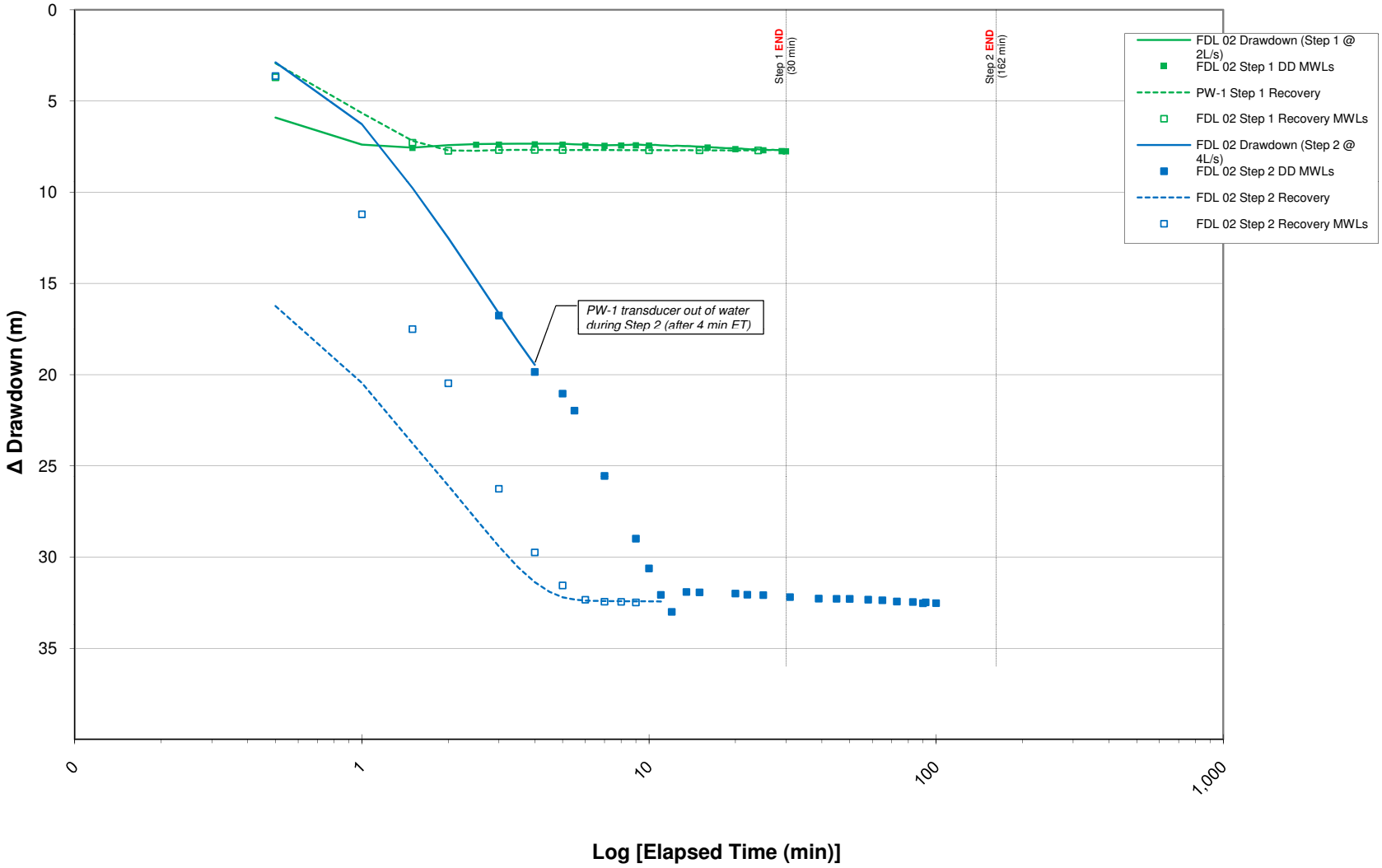


Figure 5: Hydrograph of Groundwater Levels during Constant RateTesting (Final Well FDL 02 & Monitoring Well LM-09)

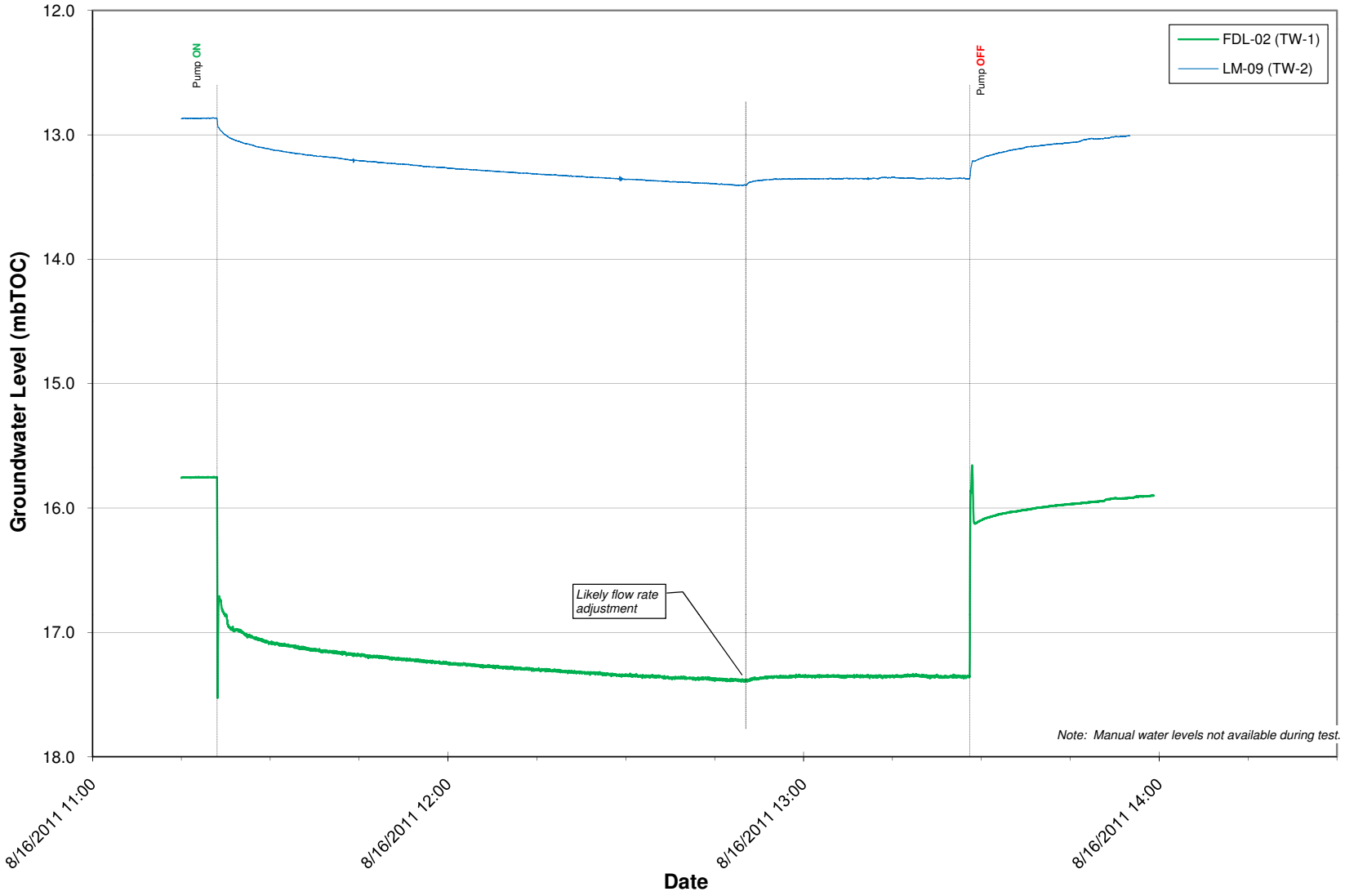
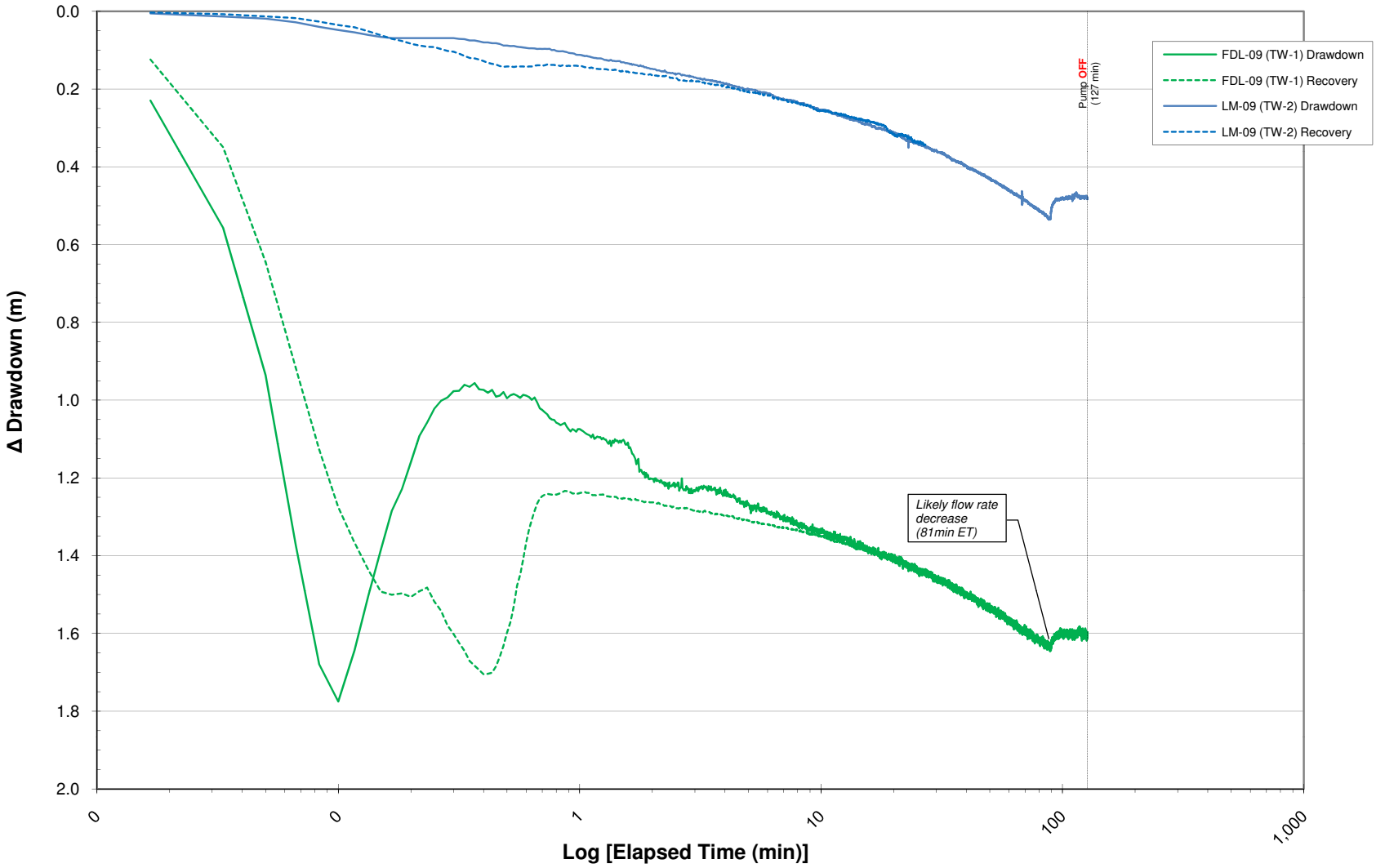


Figure 6: Semi-log Plot of Drawdown and Recovery during Constant Rate Testing (Final Well FDL 02 & Monitoring Well LM-09)



APPENDIX A

BACTERIAL AND CHEMICAL ANALYSES

Table A1: Summary of Microbiological, Organic and Inorganic Parameters

Parameter	Units	ODWQS[a]	FDL 02 (Temporary Casing)	
			TB111049-1	TB111049-2
			28-Jul-2011 1:30 PM	28-Jul-2011 2:45 PM
Microbiology				
E. coli	CFU/100 ml	ND	0	0
Total Coliforms	CFU/100 ml	ND	**2**	**2**
O. Reg. 170 Schedule 23 - Inorganic				
Antimony	mg/L	0.006	<0.0005	<0.0005
Arsenic	mg/L	0.025	<0.005	0.002
Barium	mg/L	1	**2.3**	**2.4**
Boron	mg/L	5	0.48	0.49
Cadmium	mg/L	0.005	<0.0001	<0.0001
Chromium	mg/L	0.05	0.001	0.002
Mercury	mg/L	0.001	<0.0001	<0.0001
Selenium	mg/L	0.01	<0.01	<0.01
Uranium	mg/L	0.02	<0.001	<0.001
O. Reg. 170 Schedule 24 - Inorganic				
Chloride	mg/L	250	48	48
Dissolved Organic Carbon	mg/L	5	1.2	1.2
Fluoride	mg/L	1.5	0.73	0.72
Hydrogen Sulphide	mg/L	0.05	**0.3**	**0.3**
Lead	mg/L	0.01	<0.001	<0.001
$N\text{-}NO_2$ (Nitrite)	mg/L	1.0	<0.10	<0.10
$N\text{-}NO_3$ (Nitrate)	mg/L	10.0	<0.10	<0.10
$NO_2 + NO_3$ as N	mg/L	10.0	<0.10	<0.10
Sodium	mg/L	200	56	59
O. Reg. 170 Schedule 24 - Organic				
Alachlor	mg/L	0.005	<0.0005	<0.0005
Aldicarb	mg/L	0.009	<0.005	<0.005
Aldrin + Dieldrin	mg/L	0.0007	<0.000012	<0.000012
Atrazine + N-dealkylated metabolites	mg/L	0.005	<0.00001	<0.00001
Azinphos-methyl	mg/L	0.02	<0.002	<0.002
Bendiocarb	mg/L	0.04	<0.002	<0.002
Benzene	mg/L	0.005	<0.0005	<0.0005
Benzo(a)pyrene	mg/L	0.00001	<0.00001	<0.00001
Bromoxynil	mg/L	0.005	<0.0005	<0.0005
Carbaryl	mg/L	0.09	<0.005	<0.005
Carbofuran	mg/L	0.09	<0.005	<0.005
Carbon Tetrachloride	mg/L	0.005	<0.0005	<0.0005
Chlordane (Total)	mg/L	0.007	<0.000018	<0.000018
Chlorpyrifos	mg/L	0.09	<0.001	<0.001
Cyanazine	mg/L	0.01	<0.00003	<0.00003
Diazinon	mg/L	0.02	<0.001	<0.001
Dicamba	mg/L	0.12	<0.001	<0.001
1,2-Dichlorobenzene	mg/L	0.2	<0.0004	<0.0004
1,4-Dichlorobenzene	mg/L	0.005	<0.0004	<0.0004
Dichlorodiphenyltrichloroethane (DDT) + metabolites	mg/L	0.03	<0.000024	<0.000024
1,2-dichloroethane	mg/L	0.005	<0.0002	<0.0002

Table A1: Summary of Microbiological, Organic and Inorganic Parameters

Parameter	Units	ODWQS[a]	FDL 02 (Temporary Casing)	
			TB111049-1	TB111049-2
			28-Jul-2011 1:30 PM	28-Jul-2011 2:45 PM
1,1-Dichloroethylene (vinylidene chloride)	mg/L	0.014	<0.0005	<0.0005
Dichloromethane	mg/L	0.05	<0.004	<0.004
2,4-Dichlorophenol	mg/L	0.9	<0.0005	<0.0005
2,4-Dichlorophenoxy acetic acid (2,4-D)	mg/L	0.1	<0.001	<0.001
Diclofop-methyl	mg/L	0.009	<0.0009	<0.0009
Dimethoate	mg/L	0.02	<0.0025	<0.0025
Dinoseb	mg/L	0.01	<0.001	<0.001
Diquat	mg/L	0.07	<0.005	<0.005
Diuron	mg/L	0.15	<0.01	<0.01
Fluoride	mg/L	1.5	0.73	0.72
Glyphosate	mg/L	0.28	<0.01	<0.01
Heptachlor + Heptachlor Epoxide	mg/L	0.003	<0.000012	<0.000012
Lead	mg/L	0.01	<0.001	<0.001
Lindane (Total)	mg/L	0.004	<0.000005	<0.000005
Malathion	mg/L	0.19	<0.005	<0.005
Methoxychlor	mg/L	0.9	<0.000024	<0.000024
Metolachlor	mg/L	0.05	<0.00001	<0.00001
Metribuzin	mg/L	0.08	<0.00002	<0.00002
Monochlorobenzene	mg/L	0.08	<0.0002	<0.0002
Nitrate (as nitrogen)	mg/L	10	<0.1	<0.1
Nitrite (as nitrogen)	mg/L	1	<0.1	<0.1
Nitrate + Nitrite (as nitrogen)	mg/L	10	<0.1	<0.1
Paraquat	mg/L	0.01	<0.005	<0.005
Parathion	mg/L	0.05	<0.001	<0.001
Pentachlorophenol	mg/L	0.06	<0.0005	<0.0005
Phorate	mg/L	0.002	<0.0005	<0.0005
Picloram	mg/L	0.19	<0.005	<0.005
Polychlorinated Biphenyls (PCB)	mg/L	0.003	<0.0001	<0.0001
Prometryne	mg/L	0.001	<0.00025	<0.00025
Simazine	mg/L	0.01	<0.00001	<0.00001
Temephos	mg/L	0.28	<0.01	<0.01
Terbufos	mg/L	0.001	<0.0004	<0.0004
Tetrachloroethylene (perchloroethylene)	mg/L	0.03	<0.0003	<0.0003
2,3,4,6-Tetrachlorophenol	mg/L	0.1	<0.0005	<0.0005
Triallate	mg/L	0.23	<0.001	<0.001
Trichloroethylene	mg/L	0.005	<0.0003	<0.0003
2,4,6-Trichlorophenol	mg/L	0.005	<0.0005	<0.0005
2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	mg/L	0.28	<0.001	<0.001
Trifluralin	mg/L	0.045	<0.00002	<0.00002
Vinyl Chloride	mg/L	0.002	<0.0002	<0.0002

[a] *Total toxic equivalents when compared with 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin).*

[b] *This standard is expressed as a running annual average.*

Tables show results received as of date of issuance of report.

EXOVA ACCUTEST

REPORT OF ANALYSIS

Exova Accutest

Client: **AMEC Earth & Environmental**
3300 Merrittville Hwy, Unit 5

Thorold, ON
L2V 4Y6
Attention: **Mr. Randall Secord**

Niagara Report: N11-1426
Report Number: 1117363
Date: 2011-08-18
Date Submitted: 2011-07-29

Project: Lynden

P.O. Number:
Matrix: Groundwater

Chain of Custody Number: **143495**

		LAB ID:	900011	900012				**GUIDELINE**		
		Sample Date:	2011-07-28	2011-07-28				ODWQS O. Reg. 170 - Schedule 23/24		
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
Chloride	mg/L	1	48	48				AO	250	mg/L
Dissolved Organic Carbon	mg/L	0.5	1.2	1.2				AO	5	mg/L
Fluoride	mg/L	0.1	0.73	0.72				MAC	1.5	mg/L
Hydrogen Sulphide	mg/L	0.1	**0.3**	**0.3**				AO	0.05	mg/L
N-NO2 (Nitrite)	mg/L	0.1	<0.10	<0.10				MAC	1.0	mg/L
N-NO3 (Nitrate)	mg/L	0.1	<0.10	<0.10				MAC	10.0	mg/L
NO2 + NO3 as N	mg/L	0.1	<0.10	<0.10				MAC	10.0	mg/L
Sodium	mg/L	2	56	59				AO	200	mg/L
Antimony	mg/L	0.0005	<0.0005	<0.0005				IMAC	0.006	mg/L
Arsenic	mg/L	0.005	<0.005	<0.005				IMAC	0.025	mg/L
Barium	mg/L	0.1	**2.3**	**2.4**				MAC	1	mg/L
Boron	mg/L	0.01	0.48	0.49				IMAC	5	mg/L
Cadmium	mg/L	0.0001	<0.0001	<0.0001				MAC	0.005	mg/L
Chromium	mg/L	0.001	0.001	0.002				MAC	0.05	mg/L
Mercury	mg/L	0.0001	<0.0001	<0.0001				MAC	0.001	mg/L
Selenium	mg/L	0.01	<0.01	<0.01				MAC	0.01	mg/L
Uranium	mg/L	0.001	<0.001	<0.001				MAC	0.02	mg/L

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:
900011: H2S MRL elevated due to turbidity of sample. Arsenic MRL elevated due to matrix interference.
Samples were subcontracted for Se analysis
900012: H2S MRL elevated due to turbidity of sample.

APPROVAL: _____
Lorna Wilson
Inorganic Lab Supervisor

Methods references and/or additional QA/QC information available on request.

Results relate only to the parameters tested on the samples submitted.

EXOVA ACCUTEST

REPORT OF ANALYSIS

Exova Accutest

Client: **AMEC Earth & Environmental**
3300 Merrittville Hwy, Unit 5

Thorold, ON
L2V 4Y6
Attention: **Mr. Randall Secord**

Niagara Report: N11-1426
Report Number: 1117363
Date: 2011-08-18
Date Submitted: 2011-07-29

Project: Lynden

P.O. Number:
Matrix: Groundwater

Chain of Custody Number: **143495**

		LAB ID:	900011	900012				**GUIDELINE**		
		Sample Date:	2011-07-28	2011-07-28						
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
Organochlorine Pesticides (OCPs) & PCBs										
Aldrin	ug/L	0.006	<0.006	<0.006						
Dieldrin	ug/L	0.006	<0.006	<0.006						
Aldrin + Dieldrin	ug/L	0.012	<0.012	<0.012						
a-chlordane	ug/L	0.006	<0.006	<0.006						
g-chlordane	ug/L	0.006	<0.006	<0.006						
Oxychlordane	ug/L	0.006	<0.006	<0.006						
Chlordane (Total)	ug/L	0.018	<0.018	<0.018						
op-DDT	ug/L	0.006	<0.006	<0.006						
pp-DDD	ug/L	0.006	<0.006	<0.006						
pp-DDE	ug/L	0.006	<0.006	<0.006						
pp-DDT	ug/L	0.006	<0.006	<0.006						
Dichlorodiphenyltrichloroethane (DDT) + Metabolites	ug/L	0.024	<0.024	<0.024						
alpha-BHC	ug/L	0.006	<0.006	<0.006						
beta-BHC	ug/L	0.006	<0.006	<0.006						
delta-BHC	ug/L	0.006	<0.006	<0.006						
Endosulfan I	ug/L	0.006	<0.006	<0.006						
Endosulfan II	ug/L	0.02	<0.02	<0.02						
Endrin	ug/L	0.006	<0.006	<0.006						
gamma-BHC (Lindane)	ug/L	0.006	<0.006	<0.006						
Heptachlor	ug/L	0.006	<0.006	<0.006						
Heptachlor epoxide	ug/L	0.006	<0.006	<0.006						
Heptachlor + Heptachlor Epoxide	ug/L	0.012	<0.012	<0.012						
Lindane (Total)	ug/L	0.005	<0.005	<0.005						
Methoxychlor	ug/L	0.024	<0.024	<0.024						
Polychlorinated Biphenyls (PCBs)	ug/L	0.1	<0.1	<0.1						
CHLOROPHENOLS										
2,3,4,6-tetrachlorophenol	ug/L	0.5	<0.5	<0.5						
2,4,6-trichlorophenol	ug/L	0.5	<0.5	<0.5						
2,4-dichlorophenol	ug/L	0.5	<0.5	<0.5						

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:
Samples were subcontracted for Triazine analysis.

APPROVAL: _____
Mina Nasirai
Organic Lab Supervisor

Methods references and/or additional QA/QC information available on request.

Results relate only to the parameters tested on the samples submitted.

EXOVA ACCUTEST

REPORT OF ANALYSIS

Exova Accutest

Client: **AMEC Earth & Environmental**
3300 Merrittville Hwy, Unit 5

Thorold, ON
L2V 4Y6
Attention: **Mr. Randall Secord**

Niagara Report: N11-1426
Report Number: 1117363
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Project: Lynden

P.O. Number:
Matrix: Groundwater

Chain of Custody Number: **143495**

		LAB ID:	900011	900012				**GUIDELINE**		
		Sample Date:	2011-07-28	2011-07-28						
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
Pentachlorophenol	ug/L	0.5	<0.5	<0.5						
PHENOXYACID HERBICIDES										
2,4,5-trichlorophenoxyacetic acid (2,4,5-T)	ug/L	1	<1	<1						
2,4-dichlorophenoxyacetic acid (2,4-D)	ug/L	1	<1	<1						
Bromoxynil	ug/L	0.5	<0.5	<0.5						
Dicamba	ug/L	1	<1	<1						
Dinoseb	ug/L	1	<1	<1						
Picloram	ug/L	5	<5	<5						
CARBAMATES										
Aldicarb	ug/L	5	<5	<5						
Bendiocarb	ug/L	2	<2	<2						
Carbaryl	ug/L	5	<5	<5						
Carbofuran	ug/L	5	<5	<5						
TRIAZINE & RELATED HERBICIDES										
Alachlor	ug/L	0.5	<0.5	<0.5						
Atrazine	ug/L	0.01	<0.01	<0.01						
De-ethylated atrazine	ug/L	0.01	<0.01	<0.01						
Atrazine + N-dealkylated metabolites	ug/L	0.01	<0.01	<0.01						
Cyanazine	ug/L	0.03	<0.03	<0.03						
Metolachlor	ug/L	0.01	<0.01	<0.01						
Metribuzin	ug/L	0.02	<0.02	<0.02						
Prometryne	ug/L	0.25	<0.25	<0.25						
Simazine	ug/L	0.01	<0.01	<0.01						
ORGANOPHOSPHOROUS PESTICIDES										
Azinphos-methyl	ug/L	2	<2	<2						
Chlorpyrifos	ug/L	1	<1	<1						
Diazinon	ug/L	1	<1	<1						
Diclofop-methyl	ug/L	0.9	<0.9	<0.9						
Dimethoate	ug/L	2.5	<2.5	<2.5						
Malathion	ug/L	5	<5	<5						

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:

APPROVAL: _____
Mina Nasirai
Organic Lab Supervisor

Methods references and/or additional QA/QC information available on request.

Results relate only to the parameters tested on the samples submitted.

EXOVA ACCUTEST

REPORT OF ANALYSIS

Exova Accutest

Client: **AMEC Earth & Environmental**
3300 Merrittville Hwy, Unit 5

Thorold, ON
L2V 4Y6
Attention: **Mr. Randall Secord**

Niagara Report: N11-1426
Report Number: 1117363
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Project: Lynden

P.O. Number:
Matrix: Groundwater

Chain of Custody Number: **143495**

		LAB ID:	900011	900012				**GUIDELINE**		
		Sample Date:	2011-07-28	2011-07-28						
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
Parathion	ug/L	1	<1	<1						
Phorate	ug/L	0.5	<0.5	<0.5						
Temephos	ug/L	10	<10	<10						
Terbufos	ug/L	0.4	<0.4	<0.4						
Triallate	ug/L	1	<1	<1						
Trifluralin	ug/L	0.02	<0.02	<0.02						
DIURON & GLYPHOSATE										
Diuron	ug/L	10	<10	<10						
Glyphosate	ug/L	10	<10	<10						
DIQUAT & PARAQUAT										
Diquat	ug/L	5	<5	<5						
Paraquat	ug/L	5	<5	<5						
BENZO (a) PYRENE										
Benzo(a)pyrene	ug/L	0.01	<0.01	<0.01						

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Comment:

APPROVAL: _____
Mina Nasirai
Organic Lab Supervisor

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Chain of Custody Number: **143495**

		LAB ID:	900011	900012				**GUIDELINE**		
		Sample Date:	2011-07-28	2011-07-28				ODWQS O. Reg. 170 - Schedule 23/24		
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
TABLE B COMPOUNDS (VOCs)										
1,1-dichloroethylene	mg/L	0.0005	<0.0005	<0.0005				MAC	0.014	mg/L
1,2-dichlorobenzene	mg/L	0.0004	<0.0004	<0.0004				MAC	0.2	mg/L
1,2-dichloroethane	mg/L	0.0002	<0.0002	<0.0002				IMAC	0.005	mg/L
1,4-dichlorobenzene	mg/L	0.0004	<0.0004	<0.0004				MAC	0.005	mg/L
Benzene	mg/L	0.0005	<0.0005	<0.0005				MAC	0.005	mg/L
Carbon Tetrachloride	mg/L	0.0005	<0.0005	<0.0005				MAC	0.005	mg/L
Dichloromethane	mg/L	0.004	<0.004	<0.004				MAC	0.05	mg/L
Monochlorobenzene	mg/L	0.0002	<0.0002	<0.0002				MAC	0.08	mg/L
Tetrachloroethylene	mg/L	0.0003	<0.0003	<0.0003				MAC	0.03	mg/L
Trichloroethylene	mg/L	0.0003	<0.0003	<0.0003				MAC	0.005	mg/L
Vinyl Chloride	mg/L	0.0002	<0.0002	<0.0002				MAC	0.002	mg/L
TABLE B SURROGATES										
Toluene-d8	%		100	99						
4-bromofluorobenzene	%		118	113						
1,2-dichloroethane-d4	%		111	107						

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:

APPROVAL: _____
Mina Nasirai
Organic Lab Supervisor

Methods references and/or additional QA/QC information available on request.

Results relate only to the parameters tested on the samples submitted.

APPENDIX B

WATER WELL RECORDS AND

BOREHOLE LOGS

RECORD OF BOREHOLE No FDL-02

PROJECT	Proposed Municipal Well, Lynden, ON	LOCATION	3618 Governors Road, Lynden, Ontario	ORIGINATED BY	MB
CLIENT	City of Hamilton		570803,4786739 (+/-4m)	COMPILED BY	RM
JOB NO.	TB111049 DATE 8/16/2011	EQUIPMENT	Mud Rotary	CHECKED BY	MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
0.0	Brown **TOPSOIL**										
0.9	Grey **SILT** with thick (~10cm) CLAY layers; increasing clay with depth							1, 2, 3, 4, 5, 6, 7, 8, 9			
9.1	Grey **CLAY**, hard; high plasticity							10, 11, 12			
12.5	Grey **CLAY**, soft, with red clay, silt and very fine sand							13, 14			

Continued Next Page

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049 DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES					STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)			
							16			Static water level on 16 August 2011 was at 15.54 mbTOC.
16.2	Grey **CLAY**, fining downward sequences very fine SAND to SILT to grey CLAY to red CLAY; repeating with increasing thickness downward						17			
							18			
							19			
							20			
							21			
							22			
							23			
							24			
							25			
							26			
							27			
							28			
							29			
29.3	**CLAY**, hard, mottled red and grey; trace fine sand									

Continued Next Page

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049
DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✠ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
							31			
							32			
							33			
							34			
							35			
							36			
36.6	Grey-brown **SILT**, loose, with thin clay layer						37			
							38			Very low sample return.
39.0	Grey-brown fine **SAND and SILT**, stiff						39			
							40			
							41			
41.2	Grey-brown fine **SAND and SILT**, soft						42			
42.1	Grey-brown fine **SAND and SILT**, stiff									
42.7	Grey-brown fine **SAND and SILT**, soft						43			
							44			

Continued Next Page

amec

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049 DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
45.1	Brown **SILT**, trace fine SAND, stiff									
45.7	Brown **SILT**, trace CLAY, soft						46			
46.6	Brown **SILT**, trace fine SAND, stiff						47			
47.9	Brown **SILT**, trace CLAY, soft						48			
48.0	Brown **SILT**, trace fine SAND, stiff									Water found at 48.46 mbTOC.
48.5	Grey-brown medium coarse **SAND** coarsening down to pea **GRAVEL**						49			
50.1	Dense **TILL** diamicton						50			
50.8	Green **COBBLES**, shaley, rounded						51			
50.9	Grey-green **GRAVEL**, black shale **COBBLES**						52			
52.1	**BOREHOLE TERMINATED**									**Well Details:** Casing: 206 mm I.D. steel riser (+2.6-48.5 m). Screen: 219mm I.D. stainless steel Slot 25 (48.5-49.1m), Slot 45 (49.1-50.1m), TW (Slot 10) (50.1-50.6m), and Slot 20 (50.6-51.5m). Annular Space: silica sand pack #2 (44.2-52.1 m), bentonite gravel (0-2.74 m) and neat cement grout (2.74-44.2 m) above sand pack, filling 311 mm I.D. hole. Locking well cap.

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. *(Place Sticker and/or Print Below)*: A100758

Well Record

Regulation 903 Ontario Water Resources Act

Page ___ of ___

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	CITY OF HAMILTON		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
71 MAIN STREET WEST	HAMILTON	ON	L8P4Y5	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 GOVERNOR'S ROAD	ANCASTER	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570803	4786739		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BROWN	TOPSOIL			0	3
GREY	SILT			3	30
GREY	CLAY		HARD	30	41
GREY	CLAY	SILT LAYERS	SOFT	41	53
GREY	CLAY	FINE SILT SAND LRS		53	96
GRY-RED	CLAY	TRACE SAND		96	120
GREY-BRN	FINE SAND SILT			120	159
GREY-BRN	SAND	GRAVEL	GRADES DOWN	159	167
GREY-GRN	GRAVEL	BLACK SHALE COBBLES		167	171

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used *(Material and Type)*	Volume Placed *(m³/ft³)*
0	9	BENTONITE GRAVEL	
9	145	NEAT CEMENT GROUT	
145	171	SILICA SAND PACK #2,1,1/4X1/8	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify*

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify*

Construction Record - Casing

Inside Diameter *(cm/in)*	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness *(cm/in)*	Depth (m/ft) From	To
8.125	STEEL	.219	+3	159

Construction Record - Screen

Outside Diameter *(cm/in)*	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
8.625	S STEEL	25,45	159	164
		TW,20	164	169

Status of Well

☒ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth	Kind of Water	
159 *(m/ft)* ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	

Hole Diameter

Depth (m/ft) From	To	Diameter *(cm/in)*
0	171	12.25

Results of Well Yield Testing

After test of well yield, water was:
☒ Clear and sand free
☐ Other, *specify*

If pumping discontinued, give reason: STEP TEST ONLY

Pump intake set at *(m/ft)*: 147

Pumping rate *(l/min / GPM)*: 250 IGPM

Duration of pumping: 3 hrs + ___ min

Final water level end of pumping *(m/ft)*: 67

If flowing give rate *(l/min / GPM)*:

Recommended pump depth *(m/ft)*: 100

Recommended pump rate *(l/min / GPM)*: 150 IGPM

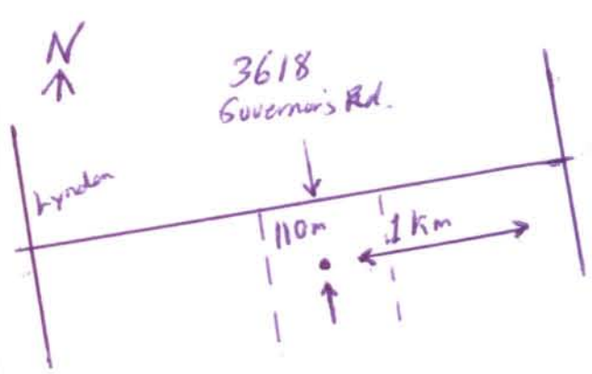
Well production *(l/min / GPM)*: 350

Disinfected? ☒ Yes ☐ No

Draw Down Time *(min)*	Water Level *(m/ft)*	Recovery Time *(min)*	Water Level *(m/ft)*
Static Level	51		
1	67	1	53
2		2	52
3		3	51
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60	67	60	51

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Durl Hopper Ltd.	2644

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont.	N4X1C9	hopper@cyg.net

Bus Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
5192717860	HOPPER, DOUGLAS

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
2323		Y Y Y Y M M D D 8/22/2011

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No	Y Y Y Y M M D D	Y Y Y Y M M D D 8/16/2011

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Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. *(Place Sticker and/or Print Below)* A100757

Well Record

Regulation 903 Ontario Water Resources Act

Page ___ of ___

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	
	CITY OF HAMILTON		☐ Well Constructed by Well Owner

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
71 MAIN STREET WEST	HAMILTON	ON	L8P4Y5	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 GOVERNOR'S ROAD	ANCASTER	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570810	4786818		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BROWN	TOPSOIL			0	3
GREY	SILT			3	30
GREY	CLAY		HARD	30	41
GREY	CLAY	SILT LAYERS	SOFT	41	53
GREY	CLAY	FINE SILT SAND LRS		53	96
GRY-RED	CLAY	TRACE SAND		96	120
GREY-BRN	FINE SAND SILT			120	159
GREY-BRN	SAND	GRAVEL	GRADES DOWN	159	167
GREY-GRN	GRAVEL	BLACK SHALE COBBLES		167	179

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	9	BENTONITE GRAVEL	
9	145	NEAT CEMENT GROUT	
145	171	SILICA SAND PACK #2,1,1/4X1/8	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify*

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify*

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
2	PVC	SCH40	+2	169

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
10	PVC	10	169	179

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth	Kind of Water	
169 (m/ft) ☐ Gas	☑ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	179	6 1/8

Results of Well Yield Testing

After test of well yield, water was:
☑ Clear and sand free
☐ Other, *specify*

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ___ hrs + ___ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

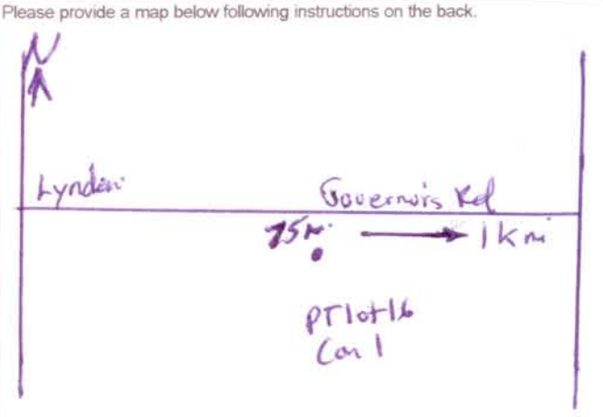
Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level	11		
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Durl Hopper Ltd.	2644

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont.	N4X1C9	hopper@cyg.net

Bus. Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
5192717860	HOPPER, DOUGLAS

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
2323		9/8/2011

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No		7/27/2011

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APPENDIX C

AMEC STATEMENT OF LIMITATIONS

AMEC EARTH & ENVIRONMENTAL, A DIVISION OF AMEC AMERICAS LIMITED
STANDARD TERMS AND CONDITIONS

1) **ENTIRE AGREEMENT.** Upon authorization by the CLIENT and commencement of performance hereunder, these terms constitute the entire agreement between the parties concerning its subject matter. Any changes or additional conditions proposed by CLIENT are hereby rejected, unless expressly stated in the Agreement or incorporated by a change order.
2) **CHANGES.** Upon receipt of notice from CLIENT of a change in the scope of the work hereunder, AMEC will promptly notify the CLIENT if there is an impact on the schedule, price or terms of the Agreement. Thereafter, an estimate of any impact on the Agreement will be prepared and submitted to the CLIENT. The parties agree to promptly negotiate and implement changes to the Agreement. CLIENT acknowledges and agrees that its use of any purchase order or other form to procure services is solely for administrative purposes and in no event shall AMEC be bound to any terms and conditions on such form regardless of reference to or signature. CLIENT shall endeavor to reference this Agreement on any purchase order (or any other form), but CLIENT's failure to do so shall not operate to modify this Agreement.
3) **SITE INFORMATION AND ACCESS.** The CLIENT shall make available to AMEC all relevant information and documents under his control regarding past, present and proposed conditions of the site. The information shall include, but not be limited to, plot plans, topographic surveys, hydrologic data and previous soil and geologic data including borings, field or laboratory tests and written reports. The CLIENT shall immediately transmit to AMEC any new information that becomes available or any change in plans. The CLIENT shall also ensure uninterrupted site access for AMEC throughout performance of this Agreement.
4) **PERMITS AND UTILITIES.** Unless otherwise stated elsewhere, the CLIENT shall apply for and obtain all required permits and licenses and shall make all necessary arrangements for right of entry to provide AMEC access to the site for all equipment and personnel at no charge to AMEC. The CLIENT shall also provide AMEC with the location of all underground utilities and structures in the exploration area. AMEC is not responsible for location or identification of utilities.
5) **PAYMENT AND SUSPENSION.** Unless otherwise stated in the Proposal, invoices will be submitted by AMEC either at the completion of the work or on a monthly basis and will be due and payable on the invoice date. Invoices not paid within thirty (30) days of the invoice date shall be subject to a late fee of one and one-half percent (1.5%) per month computed at 31 days from the date of invoice. In addition, any collection fees, legal fees, court costs, and other related expenses incurred by AMEC in the collection of delinquent invoice amounts shall be paid by CLIENT. **IN THE EVENT CLIENT DISPUTES ALL OR PART OF AN INVOICE, CLIENT MUST ADVISE AMEC IN WRITING WITHIN FIFTEEN (15) DAYS FROM INVOICE DATE**. **UNDISPUTED PORTIONS ARE SUBJECT TO PAYMENT WITHIN THIRTY (30) DAYS.** AMEC may suspend performance of services under this Agreement if: 1) CLIENT fails to make payment in accordance with the terms hereof, 2) CLIENT becomes insolvent, enters bankruptcy, receivership, or other like proceeding (voluntary or involuntary) or makes an assignment for the benefit of creditors, or 3) AMEC reasonably believes that CLIENT will be unable to pay AMEC in accordance with the terms hereof and notifies CLIENT in writing prior to such suspension of services. If any such suspension causes an increase in the time required for AMEC's performance, the performance schedule and/or period for performance shall be extended for a period of time equal to the suspension period. **OWNERSHIP RIGHTS.** Any documents produced by AMEC shall be the sole property of AMEC. At the request and expense of the CLIENT, AMEC shall provide the CLIENT with copies of any or all drawings, specifications and other documents prepared by AMEC.
6) **STANDARD OF CARE.** In the performance of professional services, AMEC will use that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same or similar localities. No warranty, either express or implied, is made or intended by this Agreement or by furnishing oral or written reports of the findings. AMEC is to be liable only for damage proximately caused by the negligence of AMEC. The CLIENT recognizes that subsurface conditions may vary from those encountered at the location where borings, surveys or explorations are made by AMEC and that the data, interpretations and recommendation of AMEC are based solely on the information available to him. AMEC will not be responsible for the interpretation by others of the information developed.
7) **INSURANCE.** AMEC will maintain insurance for this Agreement in the following types: 1) worker's compensation insurance at statutorily required levels, 2) comprehensive general liability (CGL) insurance and 3) automobile liability insurance for bodily injury and property damage.
8) **ENVIRONMENTAL LIABILITY.** Because CLIENT owns and/or operates the site where work is being performed, CLIENT has and shall retain all responsibility and liability associated with the environmental conditions at the site. Unless specifically identified elsewhere, CLIENT'S responsibility and liability includes the handling and disposal of any samples or hazardous materials generated on the site as a result of AMEC's performance hereunder.
9) **CONSEQUENTIAL DAMAGES.** AMEC shall NOT be responsible for any consequential, incidental or indirect damages.
10) **LIMITATION OF LIABILITY.** ***Notwithstanding any other provision of this Agreement, the total liability of AMEC, its officers, directors and employees for liabilities, claims, judgments, demands and causes of action arising under or related to this Agreement, whether based in contract or tort, shall be limited to the total compensation actually paid to AMEC for the services hereunder or $50,000, whichever is less. All claims by CLIENT shall be deemed relinquished unless filed within one (1) year after substantial completion of the services hereunder.***
11) **DISPUTES.** Any dispute arising hereunder shall first be resolved by taking the following steps, where a successive step is taken if the issue is not resolved at the preceding step: 1) by the technical and contractual personnel for each party performing this Agreement, 2) by executive management of each party, 3) by mediation or 4) through the court system of the jurisdiction of the AMEC office that entered into this Agreement. CLIENT hereby waives the right to trial by jury for any disputes arising out of this Agreement. Except as otherwise provided herein, each party shall be responsible for its own legal fees and costs.
12) **AUTHORIZATION TO SIGN.** The person signing this Agreement warrants that he has authority to sign as, or on behalf of, the CLIENT for whom or for whose benefit AMEC's services are rendered. If such a person does not have such authority, he agrees that he is personally liable for all breaches of this Agreement, and that in any such action against him for breach of such warranty, reasonable legal fees and costs shall be included in a judgment rendered.
13) **ASSIGNMENT.** Neither party shall assign its interest in this Agreement without the written consent of the other except that AMEC may assign its interest in the Agreement to related or affiliated companies of AMEC without the consent of CLIENT.
14) **CHOICE OF LAWS.** This Agreement shall be governed by the laws of the province of the AMEC office performing the work.
15) **FORCE MAJEURE.** Should performance of services by AMEC be affected by causes beyond its reasonable control, including but not limited to: acts of God; acts of a legislative, administrative or judicial entity; acts of contractors other than contractors engaged by AMEC; fires; floods; labor disturbances; unusually severe weather and/or an epidemic; then CLIENT will grant AMEC a time extension and the parties will negotiate an equitable adjustment to the price of any affected services, where appropriate.
16) **FIELD REPRESENTATION.** Unless otherwise expressly agreed in writing, AMEC shall not be responsible for the safety or direction of the means and methods at the CLIENT's site of contractors or their employees or agents that are not hired by AMEC, and the presence of AMEC at the CLIENT's site will not relieve the contractor of its responsibilities for performing the work in accordance with applicable regulations, or in accordance with project plans and specifications. If necessary, CLIENT will advise any contractors that AMEC's services are so limited. AMEC will not assume the role of "prime contractor", "principal contractor", "constructor", "controlling employer", or their equivalents unless the scope of such services are expressly agreed in writing.
17) **TERMINATION.** This Agreement may be terminated by either party upon ten (10) days written notice to the other. In the event of a termination, Client shall pay for all reasonable charges for work performed and demobilization by AMEC to date of notice of termination. The limitation of liability and indemnity obligations of this Agreement shall be binding notwithstanding any termination of this Agreement.

XCG CONSULTANTS LTD.
T 905 829 8880 F 905 829 8890 | toronto@xcg.com
2620 Bristol Circle, Suite 300, Oakville, Ontario, Canada L6H 6Z7

XCG File No.: 3-866-30-01
May 4, 2012

INVESTIGATION OF LEAD DETECTIONS AT THE LYNDEN DRINKING WATER SYSTEM

Prepared for:

CITY OF HAMILTON
700 Woodward Avenue
Hamilton, Ontario
L8H 6P4

Attention: Andrew Grice

Prepared by:

XCG CONSULTANTS LTD.
2620 Bristol Circle, Suite 300
Oakville, Ontario
L6H 6Z7

TABLE OF CONTENTS

1. INTRODUCTION 1

2. STUDY BACKGROUND 1
2.1 Existing Conditions 1
2.2 Background Information 2
2.2.1 Lead in Drinking Water 2
2.2.2 Chemistry of Lead in Drinking Water 3
2.3 Hydrogen Sulphide 3
2.3.1 Review of Hydrogen Sulphide Treatment Processes 4

3. PRELIMINARY DATA REVIEW 4
3.1 Historical Water Quality Data 4
3.1.1 pH, Alkalinity and Hardness 4
3.1.2 Sulphate/Sulphide 5
3.1.3 Turbidity 5
3.1.4 Lead 6
3.1.5 Corrosion indices 8
3.2 Review of Engineer's Report 9
3.3 Review of Maintenance Data 9
3.4 Preliminary Monitoring Program 9
3.5 Monitoring Program Results 12
3.5.1 pH, Alkalinity and Hardness 12
3.5.2 Sulphate/Sulphide 12
3.5.3 Turbidity 12
3.5.4 Metals 12

4. DISCUSSION 12

5. RECOMMENDATIONS 13

6. REFERENCES 14

TABLE

Table 3.1 Treated Water Turbidity (NTU), 2008 to 2011 5
Table 3.2 Summary of Lead Samples, 2006 to 2011 7
Table 4.1 Monitoring Program Results 10

FIGURE

Figure 3.1 Treated Water Turbidity 6
Figure 3.2 Treated Water Metals 8

APPENDICES

Appendix A Layne Pump Specifications
Appendix B Historical Water Quality Data
Appendix C Monitoring Program Laboratory Reports

1. INTRODUCTION

XCG Consultants Ltd. (XCG) was retained by the City of Hamilton (City) to undertake a study to investigate the source of intermittent lead detections in the Lynden drinking water system.

High levels of lead in drinking waters arise primarily from corrosion of materials containing lead. There are many different types of corrosion and the form can range from uniform to intense localized attack. Corrosion of water distribution systems leads to two major problems:

- The failure of the distribution system pipes, resulting in water leakage, and/or loss of hydraulic capacity caused by corrosion by-product build-up; and
- Undesired water quality changes caused by release of corrosion products into the water, resulting in an increase in metals concentration such as lead and copper, which are released from well pumps, pipes, valves and fittings.

The O. Reg. 169/03 maximum acceptable concentration (MAC) for lead in drinking water is 0.010 mg/L at the point of consumption. Lead sampling must be carried out in accordance with O. Reg. 170/03 under the Safe Drinking Water Act, 2002. The regulation outlines sampling requirements for lead based on the residential population served by the drinking water system.

Typically lead corrosion tends to be worst in waters with a low pH and low alkalinity. For systems with elevated lead levels, the best approach is replacement of lead-containing materials with non-leaded alternatives or implementation of treatment to reduce lead corrosion.

2. STUDY BACKGROUND

2.1 Existing Conditions

The community of Lynden is located approximately 20 km west of the Hamilton downtown core at the junction of Governor's Road and Lynden Road. The water source for the community is groundwater and the serviced population is approximately 375.

The Lynden drinking water source consists of one 200 mm diameter, 54.6 meter deep well (FDL01) drilled in 1984. The well is located in Part Lot 16, Concession 1, Ancaster at 3630 Governors Road in Lynden. A 200 mm steel casing extends to a depth of 56.6 m and the void space between the steel casing and soil contains cement grout. The well is equipped with a submersible well pump rated at a flow rate of 5.4 L/s at 24 meters TDH. The City has indicated that a Layne well pump was replaced in 2008. Reviews of the pump specifications show that pump materials include stainless steel, bronze, and cast iron. Appendix A presents information on Layne pump specifications. The well is located at approximately an elevation of 20.1 meters below grade.

Raw water is pumped into the underground plastic dual-cell chamber. The raw water from the well enters the first cell, in which compressed air is diffused to strip and reduce hydrogen sulphide levels. Disinfection is carried out in the second cell. Each cell contains baffles to provide the required contact time. The water is delivered to the distribution system by two high lift pumps. A second chlorination point is provided at the discharge header to maintain adequate chlorine residual in the distribution system. A turbidity meter is installed on the discharge header to sample and analyze the treated water continuously.

2.2 Background Information

2.2.1 Lead in Drinking Water

High levels of lead in drinking waters are primarily from corrosion of materials containing lead, such as lead pipes and fittings. In addition to leaching of lead from piping, lead may also enter drinking water through the use of lead pipe jointing compounds and solder joints, the dissolution of lead in brass and bronze plumbing fixtures and the use of lead for valve parts, and fittings in the water treatment plant or distribution system. Brasses are typically metal alloys of copper and zinc, with other minor constituents such as lead. Bronze is a metal alloy consisting mainly of copper however it may contain other alloying agents such as lead, zinc, nickel, and iron.

Lead was a common component of distribution systems for many years. The National Plumbing Code of Canada (NPC) allowed lead as an acceptable material for pipes until 1975. In 1986, the content of solder was limited to contain 0.2 percent lead under the NPC. In 1990, the NPC officially prohibited lead solders from being used in new plumbing or in repairs to plumbing for drinking water supplies (Health Canada, 2009).

The U.S. Safe Drinking Water Act requires that after June 19, 1986 only "lead free" pipe, solder or flux may be used in the installation or repair of public water systems, or any plumbing in a residential or non-residential facility providing water for human consumption, which is connected to a public water system. Under the Act, "lead free" means that solders and flux may not contain more than 0.2 percent lead, and pipes, pipe fittings, and well pumps may not contain more than 8.0 percent lead.

An additional source of lead could be the impurities in the coatings on galvanized pipe. Galvanized pipes will release zinc, and can also be sources of cadmium and lead. The NPC permitted the use of galvanized steel for plumbing systems until 1980 (Health Canada, 2009).

The amount of lead attributable to corrosion by-products in the water depends on a number of factors, including the amount and age of lead bearing materials susceptible to corrosion, the way they were manufactured, how long the water is in contact with the lead-containing surfaces, and how corrosive the water is towards these materials. The corrosivity of water is influenced by a number of factors, including acidity, alkalinity, dissolved solids and hardness. In general, soft acidic waters are more corrosive to lead than hard waters.

2.2.2 Chemistry of Lead in Drinking Water

There are several oxidizing agents present in drinking water that can transform metallic lead into one of its oxidized forms. The most common forms are Pb(II) and Pb(IV). The solids of Pb(II) and Pb(IV) that can form vary with the chemical composition of the water and can also have considerable differences in crystallinity, compactness and adherability that will affect oxidation rates and particulate erosion (AWWARF, 1996).

Oxygen is one of the most prevalent agents of corrosion. Oxygen enables the formation of Pb(II) and Pb(IV) ions (MOE, 2009). The main drivers of lead corrosion are an increase in dissolved oxygen, a decrease in pH and the complexation of the dissolved plumbic ion ($Pb^{2+)}$ by carbonate and sulphate. These reactions may also vary with temperature.

Free chlorine residual may also have an effect on lead corrosion by acting as the primary oxidant, accelerating the conversion of metallic lead to Pb(II) or Pb(IV). In 2011, the free chlorine ranged from 0.64 to 2.70 mg/L in the treated water and from 0.28 to 2.11 mg/L in the distribution water for the Lynden system.

The passivation – reduction in corrosion tendency – of lead usually results from the formation of a surface film composed of lead carbonate or cerussite ($PbCO_3$), hydroxycarbonate or hydrocerussite [$Pb_3(OH)_2(CO_3)_2$], plumbacronite [$Pb_{10}(CO_3)_6(OH)_6O$] or hydroxide [$Pb(OH)_2$], or some combination of these forms (AWWA, 1990). The formation of these compounds depends primarily on pH and dissolved inorganic carbonate (DIC) concentrations. For example, $PbCO_3$ is favoured at pH near neutral, while $Pb_3(OH)_2(CO_3)_2$ and $Pb(OH)_2$ are favoured at higher pHs. Because the equilibrium between Pb^{2+} and $PbCO_3$ tends to govern the distribution of oxidized forms of lead, the solubility of lead increases dramatically as pH decreases below pH 8 (MWH, 2005).

The leaching of lead from soldered joints, unlike lead pipe dissolution, has a strong galvanic corrosion component and the effect of water chemistry and treatment strategies on lead uptake from solder is not necessarily the same as for the pipe (AWWA, 1990).

2.3 Hydrogen Sulphide

Sulphate occurs naturally in most waters, and the principal forms of sulphur that are of special significance with respect to water quality are organic sulphur, hydrogen sulphide, elemental sulphur and sulphate (AWWA, 1990).

Odours associated with water usually result from the presence of decaying organic matter or, in the case of groundwater, the reduction of sulfates by a small group of anaerobic bacteria known collectively as sulfate-reducing bacteria to hydrogen sulphide (H_2S). The ODWS aesthetic objective (AO) for sulphide in drinking water is 0.05 mg/L as H_2S. Hydrogen sulphide has a distinct odour similar to rotten eggs, and ingestion of large quantities of hydrogen sulphide gas can produce toxic effects on humans, however it is unlikely to occur due to the unpleasant odour and taste of drinking water containing hydrogen sulphide (MOE, 2006).

Hydrogen sulphide can also combine and precipitate heavy metals (Tchobanoglour & Schroeder, 1985).

2.3.1 Review of Hydrogen Sulphide Treatment Processes

Hydrogen Sulphide can be removed by aeration or other chemical oxidation processes. The effectiveness of aeration for the removal of hydrogen sulphide depends on the degree of solubility of the gas in the water and is therefore site-specific. Chemical oxidants that can be used for the removal of hydrogen sulphide include chlorine, potassium permanganate, hydrogen peroxide and ozone. These oxidants may also precipitate other compounds present in the water.

One of the main operating challenges associated with hydrogen sulphide removal, particularly when the raw water concentrations are elevated above 1 mg/L, are the presences of elevated levels of turbidity in the finished water due to the formation of elemental sulphur, and the high chlorine dosages needed for hydrogen sulphide oxidation under certain pH conditions. The Lynden raw water data for 2006 to 2011 indicates an average raw water sulphide concentration of 1.9 mg/L with levels ranging from < 0.02 to 3.8 mg/L. In addition, turbidity spikes have been observed at the Lynden facility as outlined in Section 3.1.3 indicating that elemental sulphur is likely causing elevated turbidity in the finished water. Given that the sulphur particles are generally colloidal in nature, filtration using catalytic media may be required to address the treated water turbidity issues.

3. PRELIMINARY DATA REVIEW

3.1 Historical Water Quality Data

Historical water quality data was provided by the City for review. Appendix B contains the raw, treated and distribution water quality data.

3.1.1 pH, Alkalinity and Hardness

Treated water pH ranged from 8.0 to 8.3 with an average treated water pH of 8.2 between 2006 and 2011. The ODWS operational guideline (OG) recommended drinking water pH is between 6.5 and 8.5. The treated water pH at Lynden is within the recommended ODWS OG. The principal objective in controlling pH is to produce a water that in neither corrosive nor produces incrustation. At pH levels below 6.5, corrosion can occur resulting in elevated levels of metals from corrosion of specific types of pipe. At pH levels above 8.5, mineral incrustation and bitter tastes can occur.

Based on the data provided by the City, the treated water alkalinity ranged from 91 to 97 mg/L from 2006 to 2011. Low alkaline water may accelerate natural corrosion leading to coloured water while high alkaline water may produce scale incrustations on pipes. Alkalinity measurement or adjustment is not required for water treatment systems that do not use coagulation. The hardness in the Lynden system ranged from 46 to 59 mg/L during 2006 and 2011. The Lynden water is below the ODQWS OG for hardness between 80 to 100 mg/L. Soft water may result in accelerated corrosion of water pipes.

3.1.2 Sulphate/Sulphide

The odour related ODWS AO for sulfide in drinking water is 0.05 mg/L as hydrogen sulphide. Hydrogen sulphide is highly corrosive and undesirable in water supplies because, in addition to the taste and odour issues, it can react with metals and produce black stains on laundered items and black deposits on pipes and fixtures.

From the data provided the average raw water sulphide concentration was 1.9 mg/L and the levels ranged from < 0.02 to 3.8 mg/L. Between 2006 and 2011 treated water sulphide levels were typically below 0.02 mg/L, with the exception of sulphide concentrations of 0.9 mg/L and 2.6 mg/L observed on February 5, 2008 and August 14, 2008, respectively. The data indicates that the treatment process at Lynden has a hydrogen sulphide removal efficiency of above 90 percent.

Aeration of waters with low levels of hydrogen sulphide, cause the sulfide to oxidize to sulphate. Sulphate levels in the treated water ranged from 24 to 29 mg/L with an average of 27 mg/L. Information regarding sulphate concentrations in the raw water was not provided.

3.1.3 Turbidity

Table 3.1 presents the monthly average and maximum treated water turbidities observed between 2008 and 2011. Treated water turbidity daily averages are also shown graphically in Figure 3.1.

Table 3.1 Treated Water Turbidity (NTU), 2008 to 2011

	2008		2009		2010		2011	
Month	**Average**	**Max.**	**Average**	**Max.**	**Average**	**Max.**	**Average**	**Max.**
January	1.11	4.67	1.86	5.10	1.59	5.11	/	/
February	1.17	5.10	1.73	5.10	1.44	2.01	1.37	2.76
March	1.21	1.65	1.52	5.10	1.51	4.36	1.42	5.11
April	1.42	2.64	1.51	5.15	1.35	5.11	1.99	5.11
May	1.32	2.62	1.44	5.10	1.41	5.11	2.34	5.11
June	1.32	5.10	1.73	5.10	1.44	5.11	2.39	5.11
July	1.14	5.10	1.56	5.11	1.41	5.00	2.56	5.12
August	1.08	3.95	1.10	5.11	1.46	5.11	2.76	5.12
September	1.20	5.10	1.28	5.11	1.54	5.11	2.86	5.11
October	1.17	5.10	1.49	5.11	2.35	5.11	/	/
November	1.36	5.10	1.63	5.10	1.26	2.30	/	/
December	1.44	5.10	1.46	5.08	1.27	1.56	/	/

Notes:
"/" denotes data not obtained

Treated water turbidity is continuously monitored at the Lynden system. Treated water turbidity ranged from approximately 1.08 to 1.44 NTU in 2008, 1.10 to 1.86 NTU in 2009, and 1.26 to 2.35 NTU in 2010. In 2011, the turbidity ranged from 1.37 to 2.86 NTU for the months reviewed. Turbidity spikes of 5 NTU were regularly observed in the treated water. The data presented in Figure 3.1 show an increasing trend for treated water turbidity over the period of 2008 to 2011.

The O. Reg. 170/03 Annual Report for the Lynden Drinking Water System, 2010 indicated that a total of 52 raw water grab samples were collected and analyzed for turbidity, the results ranged from 0.08 to 0.59 NTU. The raw water turbidity is lower than treated water turbidity.

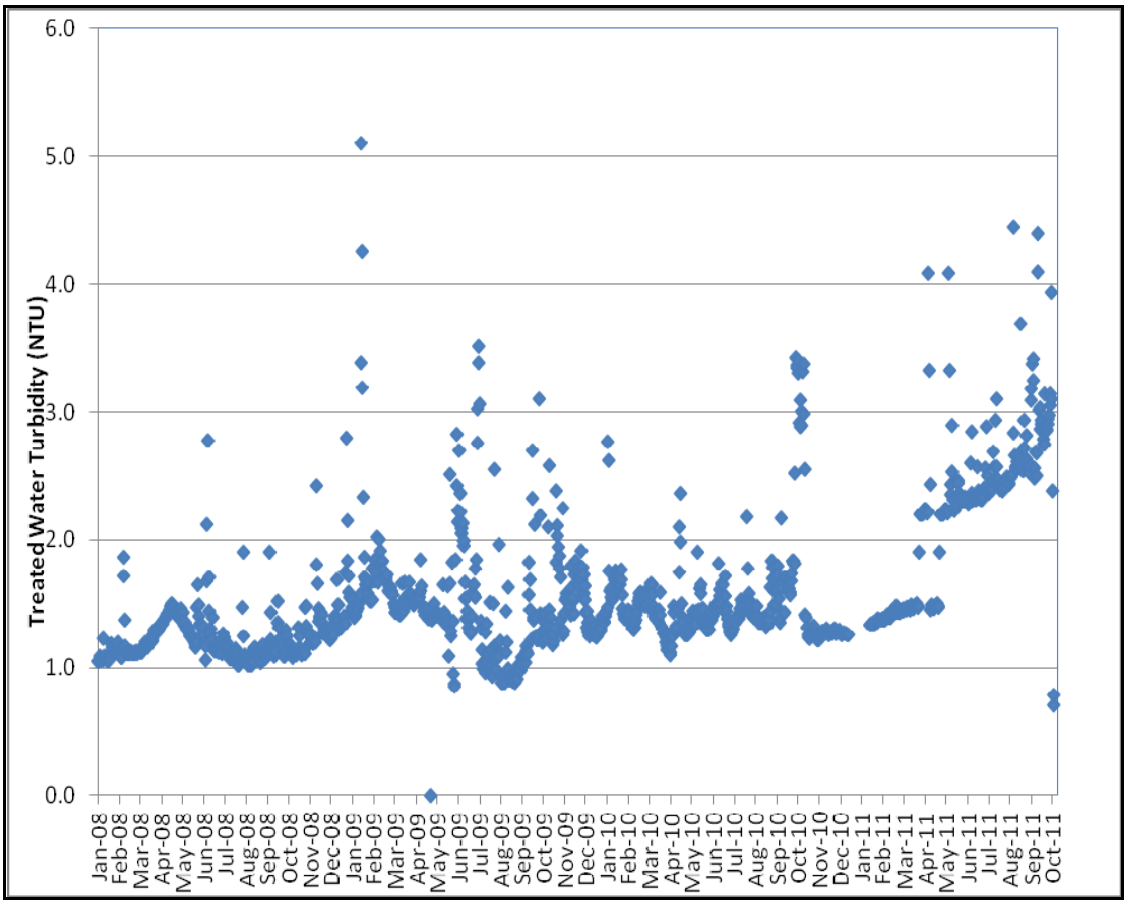


Figure 3.1 Treated Water Turbidity

3.1.4 Lead

The raw water lead concentrations were typically below 0.001 mg/L, with the exception of a sample collected in March 2009 which showed 0.005 mg/L of lead. Based on the limited data, raw water lead concentrations are below the ODWS MAC of 0.01 mg/L.

Treated water lead levels were observed above the ODWS MAC, ranging from < 0.001 to 0.049 mg/L during 2006 to 2011. Samples collected in the distribution system during the same time period showed lead concentrations ranged from < 0.001 to 0.097 mg/L. Exceedances of lead were observed above the ODWS MAC of 0. 01 mg/L during 2008, 2009 and 2011. Although below the ODWS MAC, increased lead concentrations were observed during 2007 and 2010. The City's extensive lead sampling program from 2006 to 2011 is summarized in the Table 3.2. Appendix B also presents the locations of elevated lead detections in the distribution system between 2007 and 2011.

Table 3.2 Summary of Lead Samples, 2006 to 2011

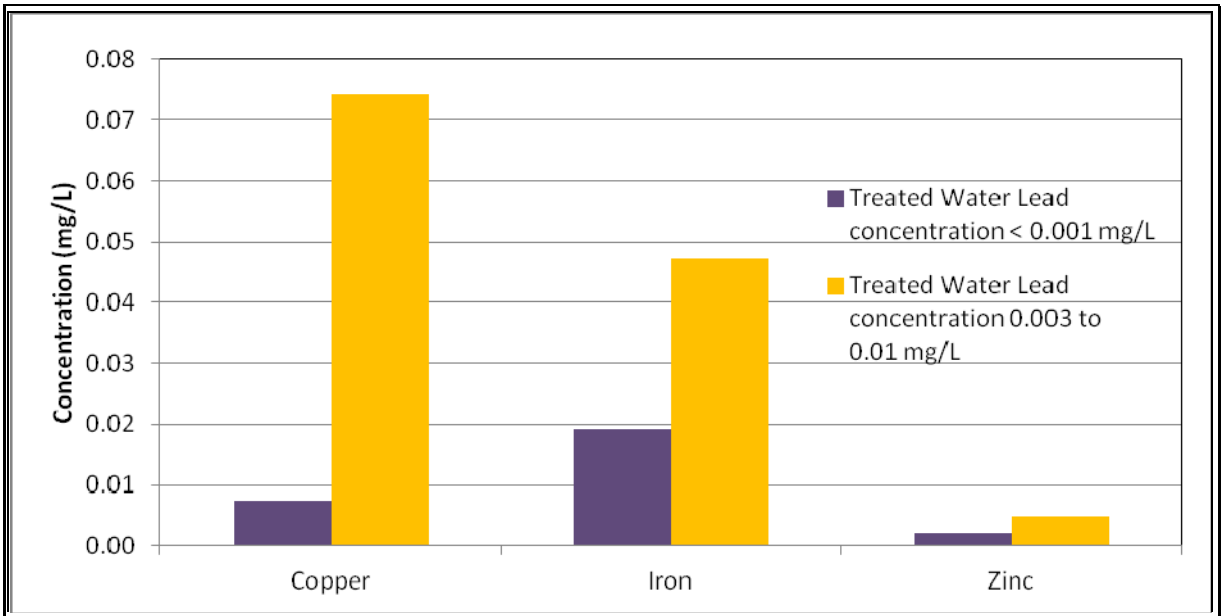
	# of Samples Collected			# of Samples Above the ODWS MAC (1)			# of Samples Lead Detections below ODWQS MAC (2)		
Year	**Raw**	**Treated**	**Distribution(3)**	**Raw**	**Treated**	**Distribution(3)**	**Raw**	**Treated**	**Distribution(3)**
2006	0	5	5	/	0	0	/	0	0
2007	0	6	3	/	0	0	/	**3 (50%)**	**1 (33%)**
2008	0	5	50	/	**0**	0	/	**3 (60%)**	1 (20%)
2009	6	24	117	0	**4 (17%)**	**6 (5%)**	**1 (17%)**	**11 (46%)**	**56 (47%)**
2010	0	31	77	/	0	0	0	**2 (6%)**	**3 (4%)**
2011	1	21	81	0%	**2 (10%)**	**6 (7%)**	0	**1 (5%)**	**12 (15%)**

Notes:
1. ODWS MAC of 0.01 mg/L for lead.
2. Lead detection between 0.001 - 0.009 mg/L.
3. Distribution locations are show in Appendix B.

The City's Lynden Well Operating Procedures No.PW-WW-PO-P-011-LWT-1001-001 outlines a process for collecting treated water samples for lead analysis when turbidity levels above 4.9 NTU occur for more than two hours. A review of the data completed by XCG, indicate that at times, elevated treated water turbidity levels correspond with elevated lead levels in the treated and distribution water.

Generally, no additional water quality information was collected by the City during lead sampling with the exception of several samples collected between November 2007 and November 2009. The data indicated that elevated lead concentrations correspond with slightly elevated concentrations of copper, iron and zinc detected in the treated water. Figure 3.2 compares the average treated water copper, iron and zinc concentrations during periods with elevated lead concentrations versus periods when lead levels were below the detection limits of 0.002 mg/L. Treated water copper, iron and zinc concentrations were well below the ODWS AO for each parameter.

No raw water metals analysis was provided with the exception of lead.



Note:

1. Treated water lead concentration < 0.001 mg/L data based on samples collected between 2006 to 2011.
2. Treated water lead concentration 0.003 to 0.01 mg/L data based on samples collected during November 2007 to November 2009.

Figure 3.2 Treated Water Metals

3.1.5 Corrosion indices

The Langelier Saturation Index (LSI) has been historically used an indicator of the corrosivity of water. The LSI is the most common of the $CaCO_3$ saturation indices used to predict corrosion in drinking water systems. The corrosion index is based on the assumption that water will be less corrosive if it has a tendency to deposit a $CaCO_3$ scale on metal surfaces; There are several limitations to the use of corrosion indices and typically they are not recommended as the primary method for determining the corrosivity of water; however they can be used as a tool to predict water corrosivity. A positive LSI has been widely believed to indicate that the water has a tendency to deposit $CaCO_3$, suggesting non-corrosive water. While a negative LSI indicated under saturation with $CaCO_3$, or corrosive water. A value of zero indicated saturation with $CaCO_3$ resulting in a neutral water.

The LSI for the Lynden treated water was calculated from the treated water quality data provided by the City. The LSI for the Lynden treated water ranged from -0.33 to +0.02, with an average LSI of -0.14, indicating that the water is slightly corrosive. Based on the data reviewed there was no relationship observed between the LSI and metal concentrations observed in the treated water.

3.2 Review of Engineer's Report

A review of The Engineer's Report for the Lynden Well System, 2001 was conducted. The report outlines that in 1997, a video inspection conducted by IWS indicated that the well was obstructed by black material in the well but the screen appeared to be clean. The study indicated that impeller wear was present. Physical examination indicated there was corrosion pitting on the surface of the discharge pipe and signs of interior softening at the pump bowl castings. The report recommended that the discharge pipe and pump bowl be replaced. The City indicated that the pump was replaced in 2005.

The report also indicated that treated water quality met the requirements of O. Reg. 169/03 at the time with the exception of turbidity. The current treatment process increased the turbidity in the finished water to levels that exceed the Ontario Drinking Water Standards.

3.3 Review of Maintenance Data

A review of maintenance data provided by the City was conducted. XCG was unable to establish a relationship between elevated lead concentrations and maintenance activities at the Lynden facility.

It is recommended that all underground cells be completely covered and sealed to prevent contamination. According to the City all underground cells are completely covered and properly sealed.

3.4 Preliminary Monitoring Program

A monitoring program was developed as the first step towards addressing the elevated lead concentrations detected in the City’s treated and distribution water. The program was designed to obtain additional water quality information and to evaluate the effects of particulates and flushing times on metal levels. Samples were collected by XCG staff at the pump house and at the existing distribution water sampling taps used by the City located on Liberty Street, Barnabus Street and Margaret Street.

For each location, a standard sampling approach was used to minimize the possibility of sampling error. For two of the distribution sampling location, a "first draw" sample and a ten minute flush sample were collected. For the remaining locations, approximately threeminute flushed samples were collected. In addition, treated water and distribution water samples were collected and processed at the XCG laboratory in Oakville to prepare two sets of samples for each location: one unfiltered sample and one filtered sample (using a 0.45 µm filter). All samples were analyzed at an accredited laboratory. On-site analysis for free and total chlorine residual was also conducted.

The results for each site are shown in Figures 4.1. Laboratory results are provided in Appendix C.

Table 3.3 Monitoring Program Results

Parameters	Units	Raw	Treated			Distribution System					
			CELL	TREATED	TREATED FILTERED(1) (5)	LIBERTY	BARNABUS-1(2)	BARNABUS-2(3)	MARGARET-1(2)	MARGARET-2 (3)	MARGARET-2 FILTERED(1) (5)
Calculated Parameters											
Calculated TDS	mg/L	202	210	207	/	208	220	213	210	212	/
Hardness (CaCO3)	mg/L	53	53	51	/	52	58	55	54	55	/
Inorganics											
Total Chlorine (4)	mg/L		2.0	1.9	/	1.6	1.0	1.3	1.4	1.3	/
pH	pH	8.00	8.13	8.14	/	8.28	8.65	8.42	8.45	8.47	/
Dissolved Sulphate (SO4)	mg/L	24	24	24	/	24	26	24	25	24	/
Sulphide	mg/L	2.6	< 0.02	< 0.02	/	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	/
Turbidity	NTU	< 0.2	0.7	0.7	/	0.9	0.5	0.9	0.4	0.7	/
Alkalinity (Total as CaCO3)	mg/L	92	93	95	/	96	101	97	98	99	/
Dissolved Chloride (Cl)	mg/L	37	40	40	/	40	40	40	40	40	/
Nitrite (N)	mg/L	< 0.01	< 0.01	< 0.01	/	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	/
Nitrate (N)	mg/L	< 0.1	< 0.1	< 0.1	/	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	/
Nitrate + Nitrite	mg/L	< 0.1	< 0.1	< 0.1	/	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	/
Metals											
Aluminium (Al)	mg/L	< 0.005	0.01	0.006	0.009	0.007	0.006	0.006	0.005	0.005	0.006
Antimony (Sb)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Arsenic (As)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Barium (Ba)	mg/L	0.50	0.46	0.46	0.43	0.43	0.40	0.41	0.40	0.40	0.39
Beryllium (Be)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Bismuth (Bi)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron (B)	mg/L	0.49	0.47	0.48	0.46	0.46	0.48	0.46	0.46	0.45	0.46
Cadmium (Cd)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Calcium (Ca)	mg/L	9.4	9.4	9.2	10	9.9	12	11	11	11	11
Chromium (Cr)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cobalt (Co)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Copper (Cu)	mg/L	< 0.001	0.007	0.007	0.006	0.021	0.014	0.012	0.014	0.012	0.009
Iron (Fe)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Lead (Pb)	mg/L	< 0.0005	< 0.0005	< 0.0005	0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0007	0.0007
Lithium (Li)	mg/L	0.007	< 0.005	0.006	0.007	0.005	0.005	< 0.005	0.006	0.005	0.007
Magnesium (Mg)	mg/L	7.2	7.1	6.8	6.8	6.7	6.9	6.9	6.5	6.6	6.8
Manganese (Mn)	mg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

Molybdenum (Mo)	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Nickel (Ni)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Phosphorus (P)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Potassium (K)	mg/L	1.00	1.00	0.95	1.00	0.97	1.00	0.98	0.97	0.96	1.00
Selenium (Se)	mg/L	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Silicon (Si)	mg/L	4.9	4.8	4.6	4.6	4.7	4.8	4.8	4.6	4.6	4.7
Silver (Ag)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sodium (Na)	mg/L	58	62	59	60	59	63	62	58	59	60
Strontium (Sr)	mg/L	0.81	0.85	0.78	0.78	0.77	0.85	0.83	0.76	0.77	0.77
Tellurium (Te)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thallium (Tl)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Tin (Sn)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Titanium (Ti)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Tungsten (W)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium (U)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Vanadium (V)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Zinc (Zn)	mg/L	< 0.005	0.008	< 0.005	< 0.005	0.005	0.01	< 0.005	< 0.005	< 0.005	< 0.005
Zirconium (Zr)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Notes:

1. Samples were collected and filtered using a 0.45 µm filter, filtrate was submitted to laboratory for analysis.
2. Samples were collected following 1 minute of flushing.
3. Samples were collected following 10 minutes of flushing.
4. On-site analysis for free and total chlorine results showed free chlorine ranged from 1.14 to 1.91 mg/L and total chlorine ranged from 1.22 to 2.08 mg/L.
5. Denotes not analyzed.

3.5 Monitoring Program Results

3.5.1 pH, Alkalinity and Hardness

Based on the sample collected on December 1, 2011 the raw water pH was approximately 8.0. The treated water samples collected showed a pH of approximately 8.14. The pH in the distribution system ranged from 8.28 to 8.65. The water pH at Lynden is within the recommended ODQWS OG between 6.5 and 8.5.

The alkalinity in the Lynden system ranged from 92 to 101 mg/L.

The hardness ranged between 53 to 58 mg/L in the Lynden system. Hardness at Lynden is below the ODQWS OG of 80 to 100 mg/L.

3.5.2 Sulphate/Sulphide

The raw water sulphide concentration was approximately 2.6 mg/L and treated water sulphide levels were below 0.02 mg/L, indicating that the treatment system is effective for removal of hydrogen sulphide. Sulphate levels in the Lynden system ranged from 24 to 26 mg/L.

3.5.3 Turbidity

Based on the sample collected, the raw water turbidity was below the detection limit of 0.2 NTU. The treated and distribution water turbidities ranged from 0.4 to 0.9 NTU, indicating that the treatment system slightly increases finished water turbidity.

3.5.4 Metals

Raw and treated water metal concentrations were below the ODWS guidelines. Raw water copper concentrations were below the detection limit of 0.001 mg/L. Copper concentrations ranged from 0.006 to 0.21 mg/L in the treated and distribution water samples, well below the ODWS OG of 1 mg/L. The raw water sample showed an aluminum level below the detection limit of 0.005 mg/L. Aluminum concentrations in the treated and distribution samples ranged from 0.005 to 0.01 mg/L. All other metals concentrations in the raw and treated water were negligible.

4. DISCUSSION

The results of the water quality review and monitoring program indicate that:

- Elevated lead concentration in the Lynden system is not a regular occurrence. The elevated lead incidents have been linked by the City to elevated turbidity present in the treated water. Lead levels above the ODWS MAC of 0.1 mg/L have occurred only sporadically since 2006.
- Turbidity levels are increased by the treatment process for hydrogen sulphide. Raw water turbidity levels are lower than treated water turbidity levels.

- It is suspected that the elevated turbidities in the Lynden treated water are caused by the formation of elemental sulphur in the treated water after chlorine disinfection. It is recommended that the composition of particles causing the ongoing elevated turbidities be identified/confirmed; these "turbidities" are not the ones referred to in the sporadic high turbidity incidents.
- Hydrogen sulphide, a highly corrosive constituent, is effectively removed by the process of aeration at the Lynden system. Hydrogen sulphide is undesirable in water supplied because, in addition to the taste and odours issues, it can react with metals and produce black stains and black deposits on pipes and fixtures.
- Based on limited water quality data, elevated lead levels correspond to elevated concentrations of copper, iron and zinc indicating that the source of metals in the treated water may be due to corrosion. All other metals with the exception of lead meet ODWS.
- Raw and treated water pH is within the ODWQ OG guideline of 6.5 to 8.5.
- The Langelier Saturation Index for the Lynden treated water ranged from -0.33 to +0.02, with an average LSI of -0.14, indicating that the water is slightly corrosive.

5. RECOMMENDATIONS

Based on the information presented above, the following measures are recommended:

- During a high turbidity incident, it is recommended that water samples from both cells in addition to raw and treated water samples be collected. All samples should be split, and an unfiltered sample and filtered sample should be prepared and submitted to an accredited laboratory and analyzed for a full water quality scan. The suggested parameters for analysis include, but are not limited to turbidity, pH, alkalinity, hardness, sulphate, sulphide, and metals.
- During upgrades or new installations, consideration should be given to replace well pump, booster pumps, fittings, and valves containing brass and/or bronze with equivalent stainless steel components in the water treatment plant. In addition, solder containing less than 0.2 percent of lead must be used.
- A review of well pumps used prior to 2008, including information on well pump impeller condition, reasons for pump replacement, pump material and evidence of corrosion should be carried out.
- Consider a condition assessment of the existing well pump, including examination of the impeller and any components containing brass or bronze for evidence of corrosion.
- Regular cleaning of cells to reduce the potential for any settled precipitates to be disturbed and introduced into the treated and distribution water.

6. REFERENCES

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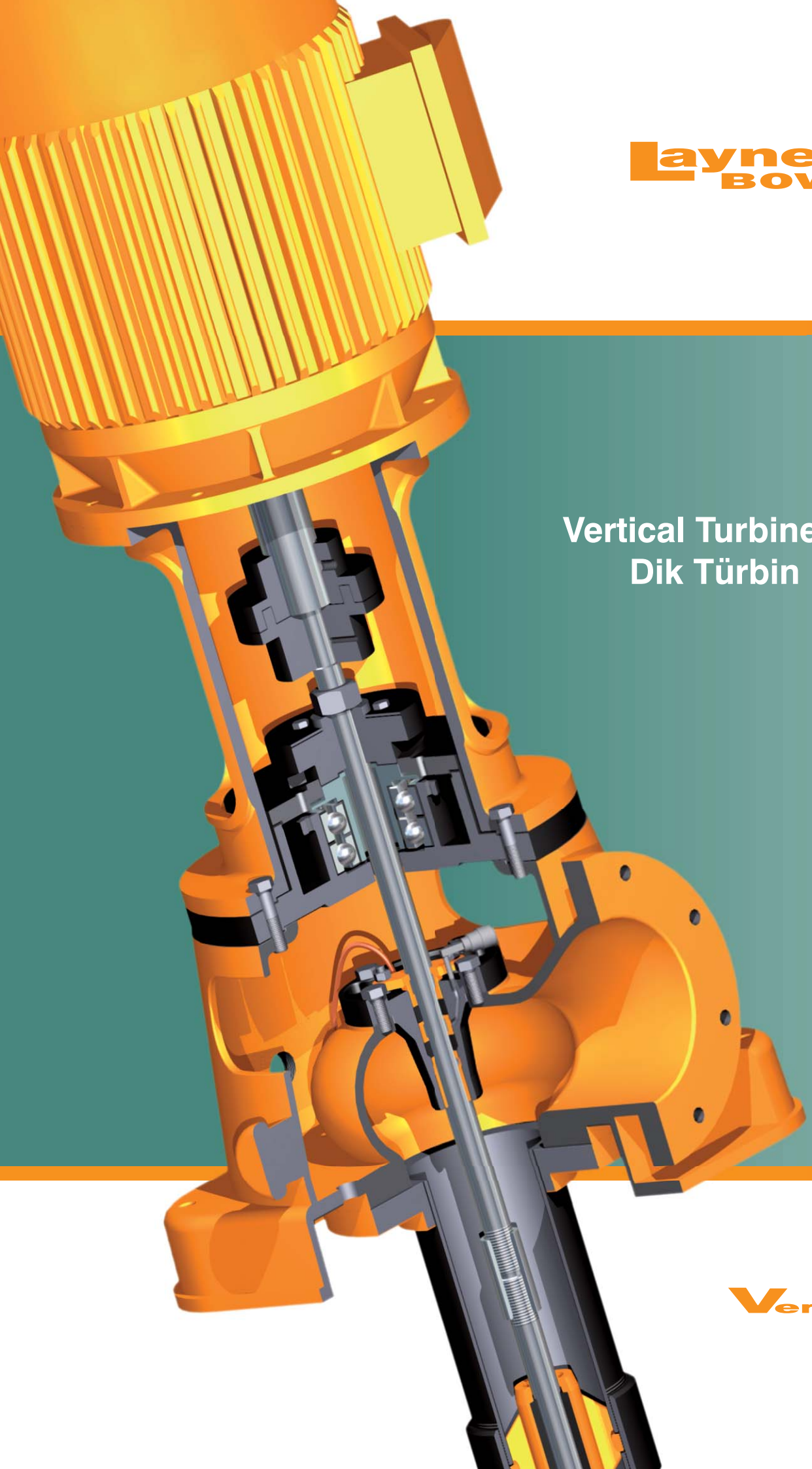
APPENDIX A
LAYNE PUMP SPECIFICATIONS

Layne Bowler

Vertical Turbine Pump
Dik Türbin Pompa



VertiLine

Layne Bowler Pump Company Inc.

Layne Bowler history can be traced back to 1882, when the inventor, Mr. Mahlon Layne drilled his first well and found himself in need of a different pump to get the water out from his drilled well. He understood that the pump, which he should invent, must be different from all the existing pumps of that time. In 1903 Mr. M. Layne and the entrepreneur Mr. P. D. Bowler joined in a manufacturing venture called “Layne Bowler”, which had spread from the Mississippi basin to all over the world.

Layne Bowler Pump Company Inc. was established in 1965 and domiciled in the capital city of Turkey, Ankara. In Layne Bowler the innovations and the engineering studies never stop. In addition to the innovation of the existing pumps, Layne Bowler is always working on introducing new pump ranges and categories. Hoping that, our products would play a positive role in helping the constantly growing world population who is relying on a very small amount of fresh water to survive. People are in need of Layne Bowler pumps in order to get the cold or hot fresh water from underground, to boost big quantities to higher elevations and sometimes to get rid off waste water problems.

On a 42.000 m^2 facility, groups of qualified engineers and experienced technicians are serving to all over the world Layne Bowler high class engineering pumps. Throughout the years, they proved to energy, industrial, municipal and agricultural sectors that Layne Bowler is producing reliable and leader brands.

Layne Bowler is supplying a distinguished After Sales Services, by having a special database for every produced pump, a comprehensive stock of spare parts and an experienced group of technicians and trainers, who are ready to support you wherever you are in the world.

Layne Bowler High Class Engineering can be tasted from the high performance, the high efficiency and the long lasting reliability.
Today, Layne Bowler Pump Company Inc. Products are almost everywhere. In addition to America, Australia and Europe, we are one of the leader pump suppliers in the Middle East and North Africa.

Future export growth is directly depending on your intelligent choice, so let us invite you to Taste the Engineering by using Layne Bowler Pumps.

Layne Bowler Pompa Sanayi A.Ş.

Layne Bowler'in öyküsü, 1882'de, Mahlon Layne'nin ilk su kuyusunu kazması ve kuyudaki suyu çıkarabilmek için değişik bir pompaya ihtiyaç duymasıyla başladı. Bu durum karşısında, zamanın tüm pompalarından daha farklı bir pompayı tasarlaması gerektiğinin farkına vardı. 1903'te, M. Layne ve girişimci P. D. Bowler, Mississippi'den tüm dünyaya yayılan “Layne Bowler” adıyla üretime başladılar.

Layne Bowler Pompa Sanayi A.Ş. 1965'te Türkiye'nin başkenti Ankara'da kuruldu. Layne Bowler'de AR-GE, yenilik ve mühendislik çalışmaları, süreklilik arzeder. Var olan pompaların geliştirilmesine ek olarak, yeni kapasitelere ve katagorilere sahip pompaları piyasaya kazandırma uğraşındadır. Artan nufüs ile birlikte yaşam için çok önemli hale gelen içme ve kullanma suyuna olan ihtiyaç artmakta, ihtiyaçlara yönelik geliştirilen çözümler için önemli roller almaktadır. Soğuk veya sıcak suları yer yüzüne çıkarmak, büyük su kütlelerini yüksek irtifalara basmak kimi zamanda atık suları uzaklaştırmak için Layne Bowler ürünleri kullanılmaktadır.

42.000 m^2 alana kurulu olan Layne Bowler bünyesinde, tecrübeli mühendisler ve teknisyenler yüksek kalitede mühendislik ürünü olan Layne Bowler pompalarını üretmek için çaba sarfetmekte ve bu ürünler ile bütün dünyaya hizmet vermektedirler. Yılların tecrübesi ve mühendisliği ile ürünlerimiz enerji, endüstri, kentsel ve tarımsal alanda güvenilir ve sınıfında birinci kalite olduğunu kanıtlamışır.

Layne Bowler, ürettiği her bir pompanın kaydını kendine has bilgi havuzunda toparlayarak, geniş kapsamda yedek parçayı elinde bulundurarak ve tecrübeli elemanları sayesinde siz dünyanın neresinde olursanız olun, farkı hissedeceğiniz bir satış sonrası hizmeti sağlamaktadır.

Layne Bowler'in kaliteli mühendisliği ürünlerin yüksek performansından, elde edilen yüksek verimlilikten ve uzun süreli sorunsuz çalışmasından anlaşılabilmektedir. Bugün, Layne Bowler Pompa Sanayi A.Ş. ürünleri dünyanın her yerindedir. Amerika, Avustralya ve Avrupa'ya ek olarak Orta Doğu ve Kuzey Afrika'da pompa tedarikçisi olarak lider bir kuruluştur.

Yılların birikimi ile üretilen bir pompanın farkını anlamak, mühendisliğin tadına varmak için sizin de Layne Bowler 'iniz olsun.

Vertical Turbine Pump

Vertical turbine pumps are firstly invented by Mr. M. Layne and adapted for use in cased wells or where the water surface is below the practical limits, where other pumps cannot do the same job. Vertical turbine pump efficiencies are comparable to or greater than most centrifugal pumps.

The vertical turbine pumps have three main parts: the head assembly, column assembly and the pump bowl assembly.

The shaft and column assembly provides a connection between the head and pump bowls. The line shaft transfers the power from the motor to the impellers and the column carries the water to the surface. The line shaft of a turbine pump may be either water lubricated or oil lubricated.

The oil lubricated pump has an enclosed tube in which oil is lubricating the bearings. The water-lubricated pump has an open shaft. The bearings are lubricated by the pumped water. If there is a possibility of fine sand being pumped, select the oil lubricated pump because it will keep the sand out of the bearings. If the water is for domestic or livestock use, it must be free of oil and a water lubricated pump must be used.

Other Features:

- Capacity with no limit
- Drive options
  - -Electric motors with variable speed
  - -Engines with right angle gearbox
  - -Belt and pulley
- Provides high Total Dynamic Head (TDH) and flow rates with high efficiency

Dik Türbin Pompa

Dik türbin pompaları ilk defa M. Layne tarafından icat edilmiş ve derin sondaj kuyularında ya da diğer pompalarca çekilmesinin mümkün olmadığı su seviyesine sahip kuyularda görev alacak şekilde ayarlanmıştır. Dik türbin pompaları çoğu santrifüj pompalardan daha yüksek verime sahiptir.

Dik türbin pompaları üç ana parçadan oluşur: pompa asamblesi, kolon asamblesi ve çıkış başlığı asamblesi.

Mil ve kolon asamblesi, çıkış başlığı ile pompa asamblesi arasındaki bağlantıyı sağlar. Ara milleri motorun gücünü fanlara aktarır ve kolon boruları suyu yüzeye taşır. Bir dik türbin pompanın ara milleri su veya yağ yağlamalı olabilir.

Yağ yağlamalı yatağa sahip pompalar, ara mil ve yatakları çevreleyen , içinde sıvı yağ bulunduran boruya sahiptir. Su yağlamalı yatağa sahip pompalarda ise açık mil vardır. Yataklar pompalanan su ile yağlanır. Eğer çok miktarda kumlu suyun pompalanma olasılığı varsa, yağ yağlamalı pompa tercih edilmelidir. Çünkü yağ, kumu yataklardan uzak tutacaktır. Eğer su, evsel veya tarımsal kullanım içinse, pompalanacak su yağ içermemelidir ve su yağlamalı pompa kullanılmalıdır.

Diğer Özellikler:

- *Sınırsız Debi*
- *Tahrik seçenekleri*
  - *-Elektrik motorları ile farklı hızlarda*
  - *-Dişli kutuları ile*
  - *- Kayış ve kasnak ile*
- *Yüksek verimde yüksek dinamik basma yüksekliği ve debi sağlaması*

1. Adjusting Nut - *Ayar Somunu*
Permits the axial positioning of the impellers in the bowls at the end of the installation.
Montaj işleminin ardından, çanaklar içinde yer alan çarkların eksenel olarak pozisyonlanmasını sağlar.

2. Head Shaft - *Başlık Mili*
The upper shaft, that transfers the power from the motor to the lineshafts.
Motordan aldığı gücü aramillerine ileten en üst mildir.

3. Thrust Assembly - *Eksenel Yük Asamblesi*
The axial loads are taken by bearings fitted in this assembly. VHS motors have this in itself but for VSS motors, a special assembly is used which is designed by Layne Bowler.
Oluşan eksenel yükler bu asamble içindeki rulmanlar aracılığı ile taşınır. VHS motorlar kendi yapıları içinde bu asambleye sahipken, VSS motorlar için Layne bowler tasarımı özel bir asamble kullanılır.

4. VHS / VSS Electric Motor - *Elektrik Motoru*
Electric motor supplies the needed power, and has various speeds and protection classes.
Farklı hız ve koruma sınıflarında elektrik motorları pompa için gereken gücü sağlar.

5.1 Intermediate Part - *Araparça*
It is used with VSS motors only for the thrust assembly.
Yalnızca eksenel yük asamblesi uygulamaları için VSS motorlara özel bir parçadır.

5.2 Elastic Coupling Pair - *Elastik Kaplin Yarıları*
To transfer the power from the motor to the head shaft, couplings are used for VSS motor applications.
VSS motor uygulamalarında, motordan başlık miline güç aktarımı için elastik kaplin çiftleri kullanılır.

6. Discharge Head - *Çıkış Başlığı*
The discharge head dimensions are directly related to pump capacity and column pipe.
Debiye göre ölçülendirilen çıkış başlıkları akışkanı yönlendirirken diğer asambleleri de taşırlar.

7. Prelube Pipe - *Ön Yağlama Borusu*
To avoid the dry working of the lineshafts in the first run, pre-lubrication can be done through this pipe from an outer source.
Dış bir depoya bağlanan boru, ön yağlama yaparak ilk çalıştırmalarda aramillerinin kuruya çalışmasını önler.

8. Stuffing Box Assembly - *Salmastra Kutusu Asamblesi*

9. Column Assembly - *Kolon Asamblesi*

10. Discharge Case Cap - *Çıkış Haznesi Yatak Başlığı*

11. Discharge Case - *Çıkış Haznesi*
Threaded or flanged discharge cases connect the pump assembly to the column assembly.
Manşonlu ya da flanşlı çıkış hazneleri, pompa asamblesini kolon asamblesine bağlar.

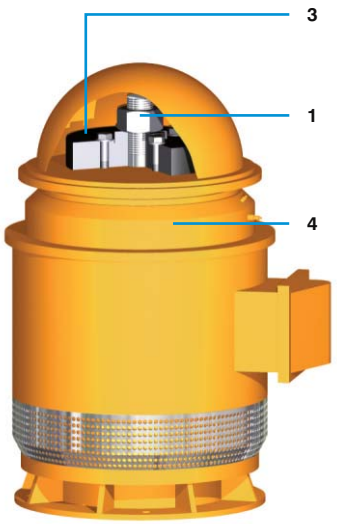
12. Slide Bearings - *Kaymalı Yataklar*
In the pump assembly, bowls, suction and discharge cases have slide bearings. Bearings are sized according to the shaft diameter, speed and the pumped fluid. Metal-Rubber, only metal or only rubber designs can be applied.
Pompa asamblesi içinde, emiş ve çıkış haznelerinde yataklar bulunur. Pompa mil çapına, hıza ve akışkan özelliklerine göre ölçülendirilirler. Metal-kauçuk, sadece metal ya da sadece kauçuk gibi tasarımlar uygulanabilir.

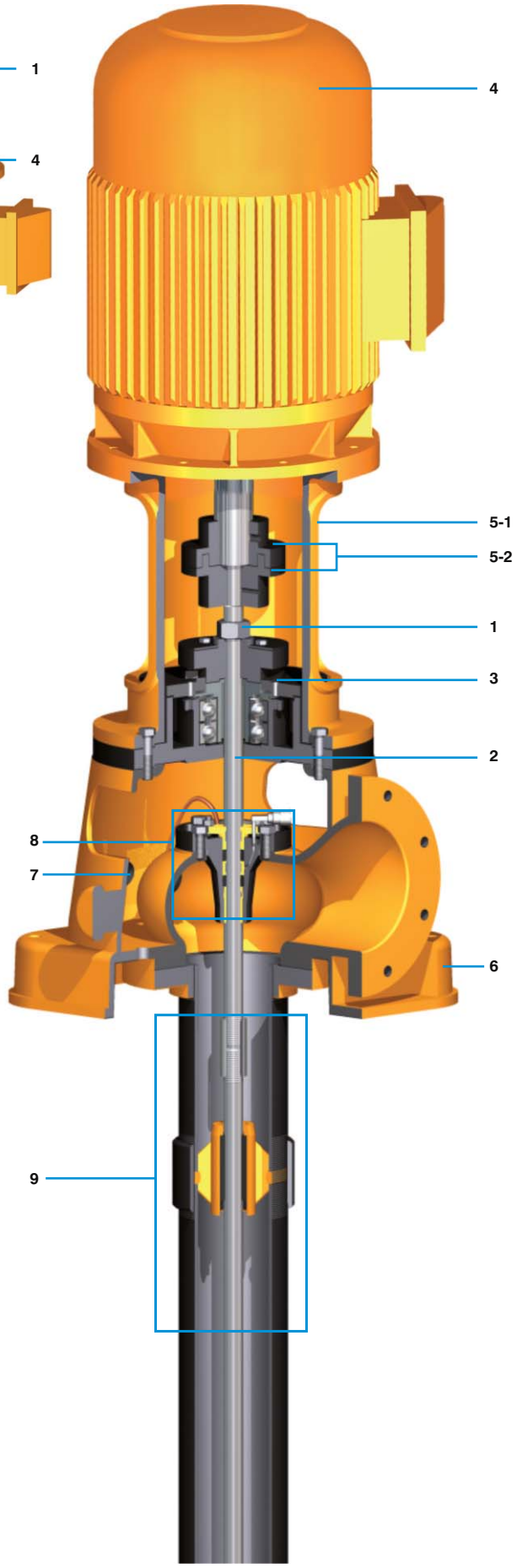
13. Bowl - *Araçanak*

14. Pump Shaft - *Pompa Mili*

15. Impeller - *Çark*

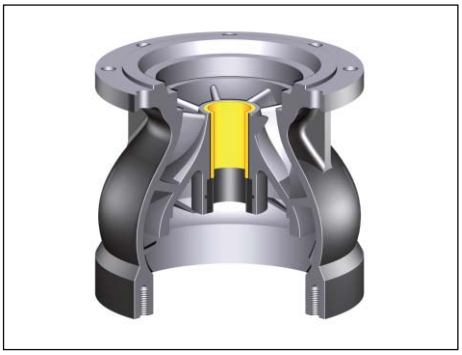
16. Impeller Lock Collet - *Çark Tespit Burcu*
Conical collets are used to fix the impellers on the pump shaft. Key fixing application is optional.
Çarkları pompa miline sabitlemek için konik burçlar kullanılır. Kama sabitlemesi de bir opsiyondur.





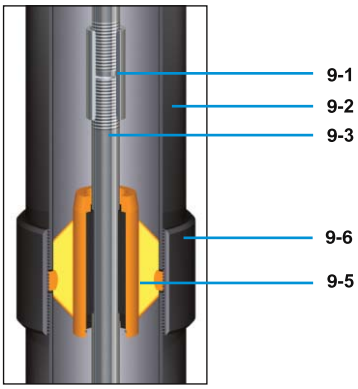
Stuffing Box Assembly Detail
Salmastra Kutusu Asamblesi Detayı

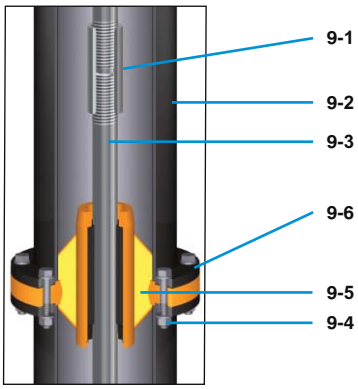
Soft seal and an effective stuffing box assembly is used for sealing. According to the application conditions, also mechanical seal applications are possible.
Yumuşak salmastra, salmastra kutusu asamblesi içerisinde sızdırmazlık sağlar. Uygulama gerekliliklerine göre mekanik salmastra uygulamaları da yapılabilir.



Bowl Assembly Detail / ***Çanak Asamblesi Detayı***

Impeller and pump shaft as rotor, suction and discharge cases with bowls as stator, parts are accurately machined then assembled to each other to get an efficent performance.
Pompada verimli bir performans sağlanması için, dönen parçalar (çark ve pompa mili) ile dönmeyen parçalar (emiş, çıkış, çanak) hassas olarak işlenir ve toplanır.





Flanged & Coupling Assembly Detail
Flanşlı ve Manşonlu Asamble Detayı

9-1 Lineshaft couplings - ***Aramili manşonları***

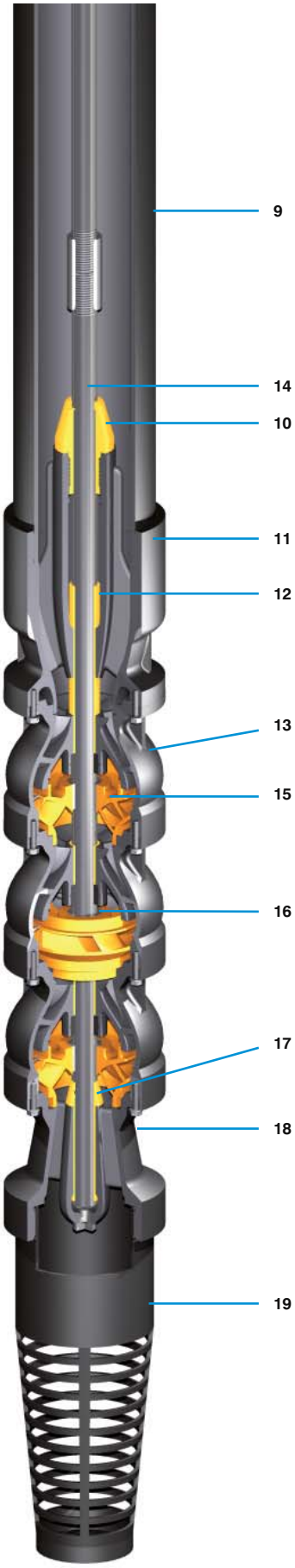
9-2 Column pipes - ***Kolon boruları***

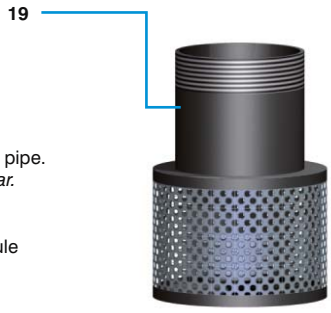
9-3 Lineshafts - ***Aramilleri***

9-4 Bolts & nuts - ***Cıvata somunlar***

9-5 Bearing retainers - ***Yatak tutucular***

9-6 Couplings or flanges - ***Boru manşonları veya flanşlar***





17. Sand Collar - ***Kumluk***

18. Suction Case - ***Emiş Haznesi***
Threaded or flanged suction cases connect the pump assembly to the suction pipe.
Manşonlu ya da flanşlı emiş hazneleri, pompa asamblesini emiş borusuna bağlar.

19. Strainer with Suction Pipe - ***Süzgeç ve Emiş Borusu***
Conical or basket types are used to prevent the pump from the big size particule substances.
Konik ve basket tipleri ile pompaya istenmeyen parçaların girişini engeller.

1. Adjusting Nut - *Ayar Somunu*
Permits the axial positioning of the impellers in the bowls at the end of the installation.
Montaj işleminin ardından, çanaklar içinde yer alan çarkların eksenel olarak pozisyonlanmasını sağlar.

2. Head Shaft - *Başlık Mili*
The upper shaft, that transfers the power from the motor to the lineshafts.
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Electric motor supplies the needed power, and has various speeds and protection classes.
Farklı hız ve koruma sınıflarında elektrik motorları pompa için gereken gücü sağlar.

5.1 Intermediate Part - *Araparça*
It is used with VSS motors only for the thrust assembly.
Yalnızca eksenel yük asamblesi uygulamaları için VSS motorlara özel bir parçadır.

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VSS motor uygulamalarında, motordan başlık miline güç aktarımı için elastik kaplin çiftleri kullanılır.

6. Discharge Head - *Çıkış Başlığı*
The discharge head dimensions are directly related to pump capacity and column pipe.
Debiye göre ölçülendirilen çıkış başlıkları akışkanı yönlendirirken diğer asambleleri de taşırlar.

7. Oil Reservoir - *Yağ Deposu*
To avoid the dry working oil is supplied.
Aramillerinin yağsız çalışması önlenir.

8. Tube Tension Assembly - *Gergi Asamblesi*

9. Column Assembly - *Kolon Asamblesi*

10. Tube Adaptor - *Mil Muhafaza Adaptörü*

11. Discharge Case - *Çıkış Haznesi*
Threaded or flanged discharge cases connect the pump assembly to the column assembly.
Manşonlu ya da flanşlı çıkış hazneleri, pompa asamblesini kolon asamblesine bağlar.

12. Slide Bearings - *Kaymalı Yataklar*
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13. Bowl - *Araçanak*

14. Pump Shaft - *Pompa Mili*

15. Impeller - *Çark*

16. Impeller Lock Collet - *Çark Tespit Burcu*
Conical collets are used to fix the impellers on the pump shaft. Key fixing application is optional.
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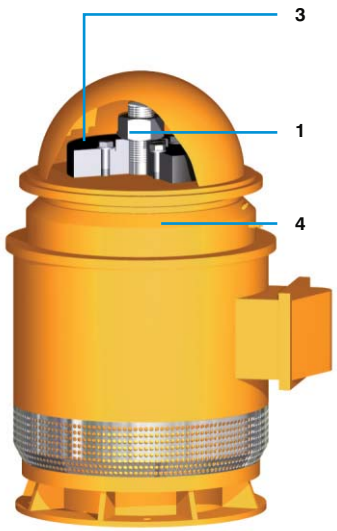
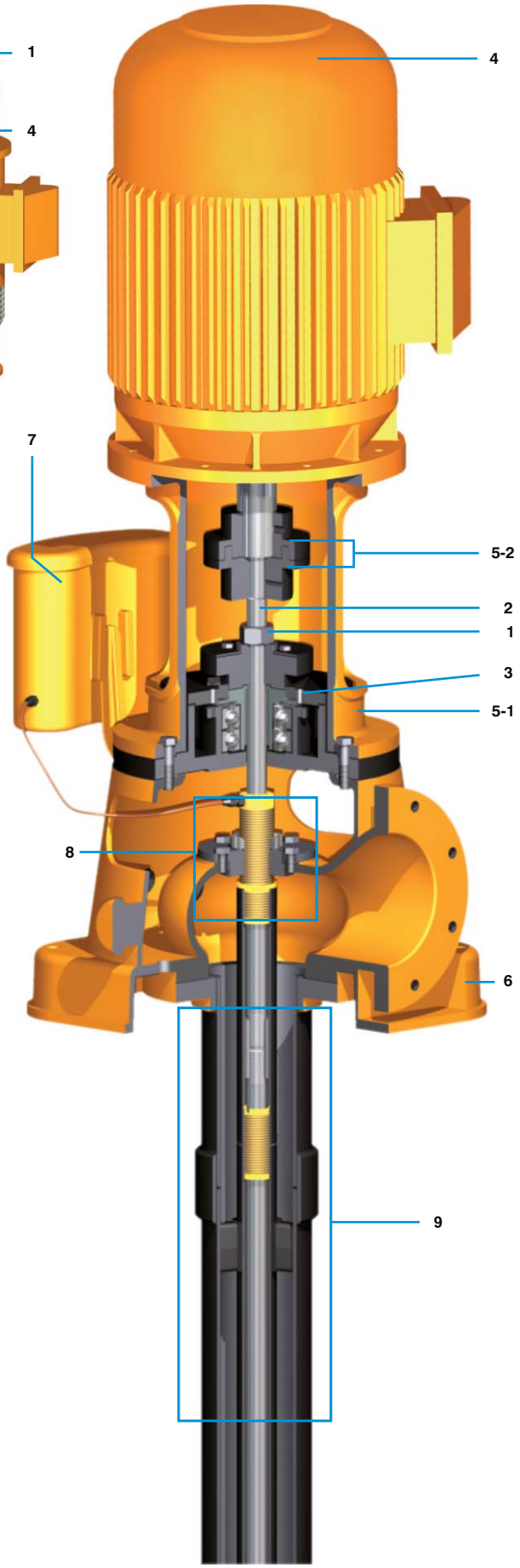
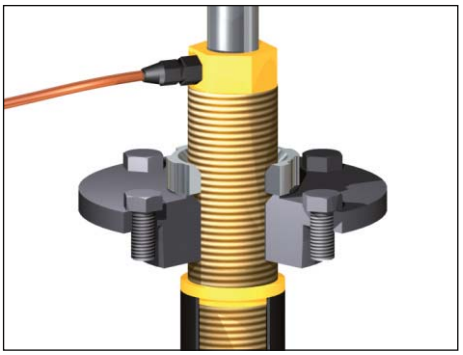
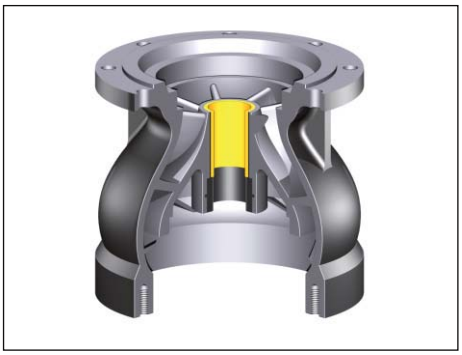






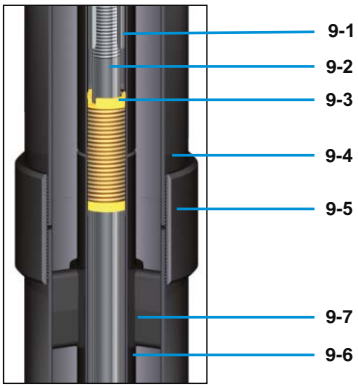
Tubing Tension Assembly Detail
Gergi Asamblesi Detayı

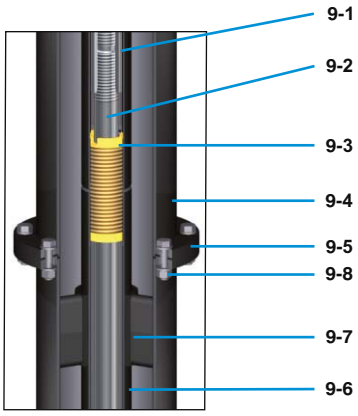
Used after installation to tension the shaft enclosing tubes and the sealing.
Montaj sonrasında mil muhafaza borularının gerdirilmesi için kullanılır.



Bowl Assembly Detail / Çanak Asamblesi Detayı

Impeller and pump shaft as rotor and suction and discharge cases with bowls as stator, parts are accurately machined then assembled to each other to get the efficent performance.
Pompada verimli bir performans sağlanması için, dönen parçalar (çark ve pompa mili) ile dönmeyen parçalar (emiş, çıkış, çanak) hassas olarak işlenir ve toplanır.





Flanged & Coupling Assembly Detail
Flanşlı ve Manşonlu Asamble Detayı

9-1 Lineshaft couplings - *Aramili manşonları*

9-2 Lineshafts - *Aramilleri*

9-3 Lineshaft bearings - *Aramili yatakları*

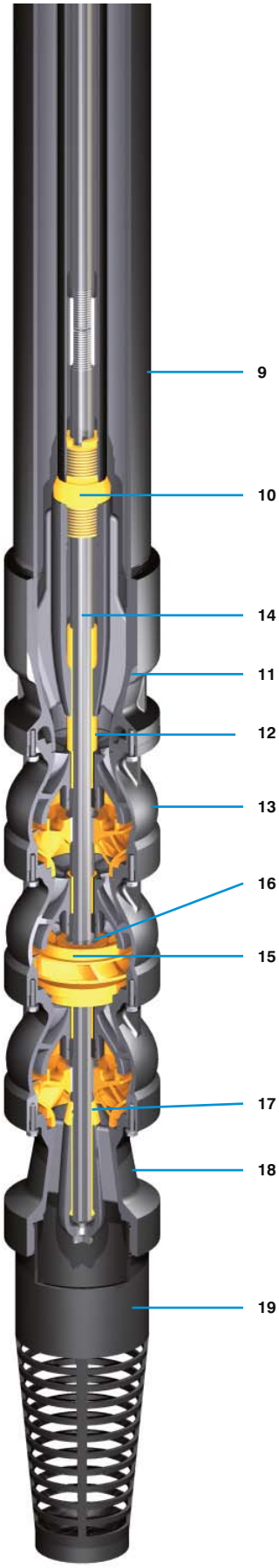
9-4 Column pipes - *Kolon boruları*

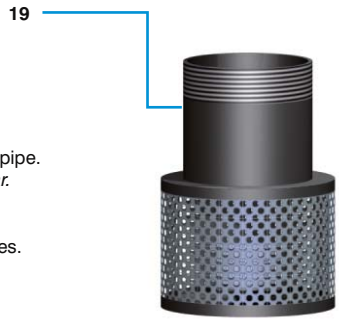
9-5 Couplings or flanges - *Boru manşonları veya flanşlar*

9-6 Enclosing tubes - *Muhafaza boruları*

9-7 Enclosing tube supports - *Merkezleme yatakları*

9-8 Bolts & nuts - *Cıvata somunlar*





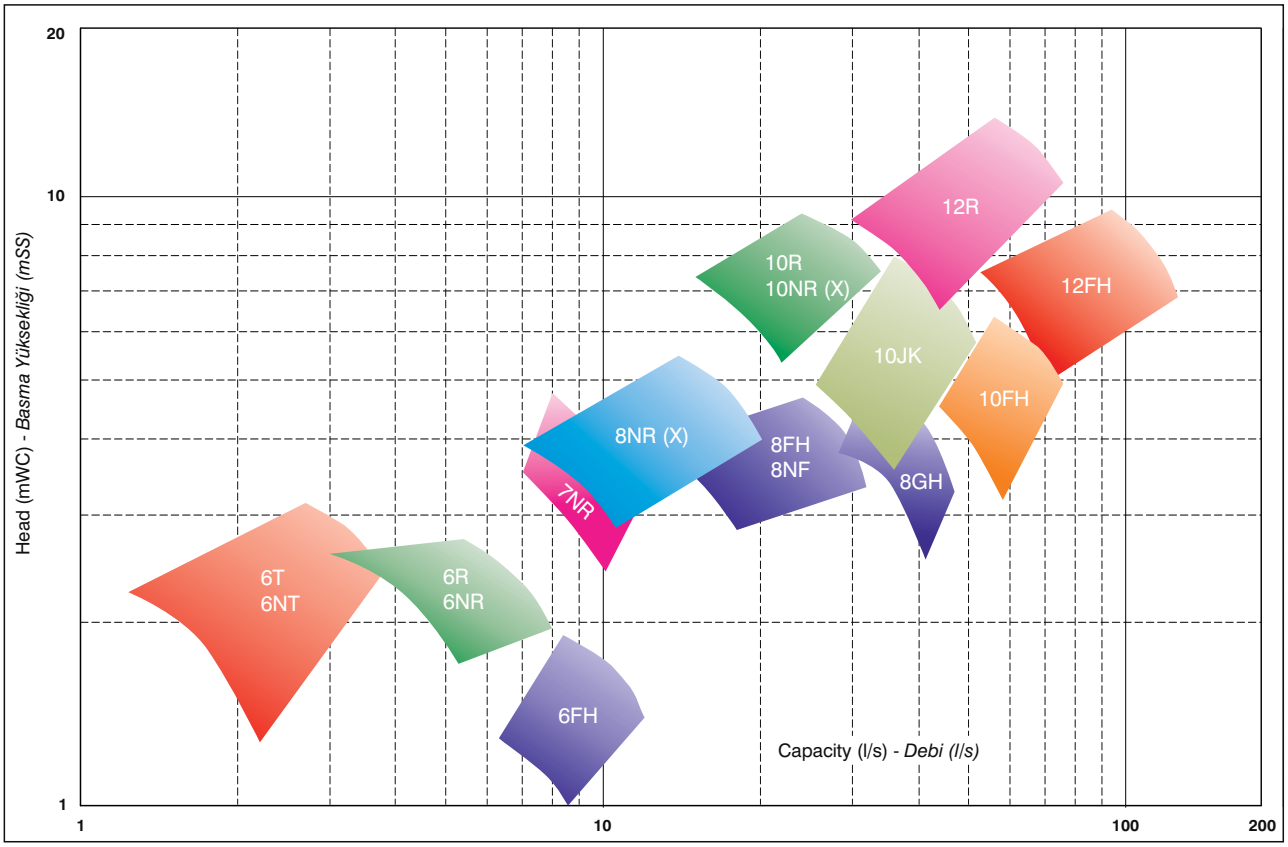
17. Sand Collar - *Kumluk*

18. Suction Case - *Emiş Haznesi*
Threaded or flanged suction cases connect the pump assembly to the suction pipe.
Manşonlu ya da flanşlı emiş hazneleri, pompa asamblesini emiş borusuna bağlar.

19. Strainer with Suction Pipe - *Süzgeç ve Emiş Borusu*
Conical or basket types are used to prevent the pump from the sized substances.
Konik ve basket tipleri ile pompaya istenmeyen parçaların girişini engeller.

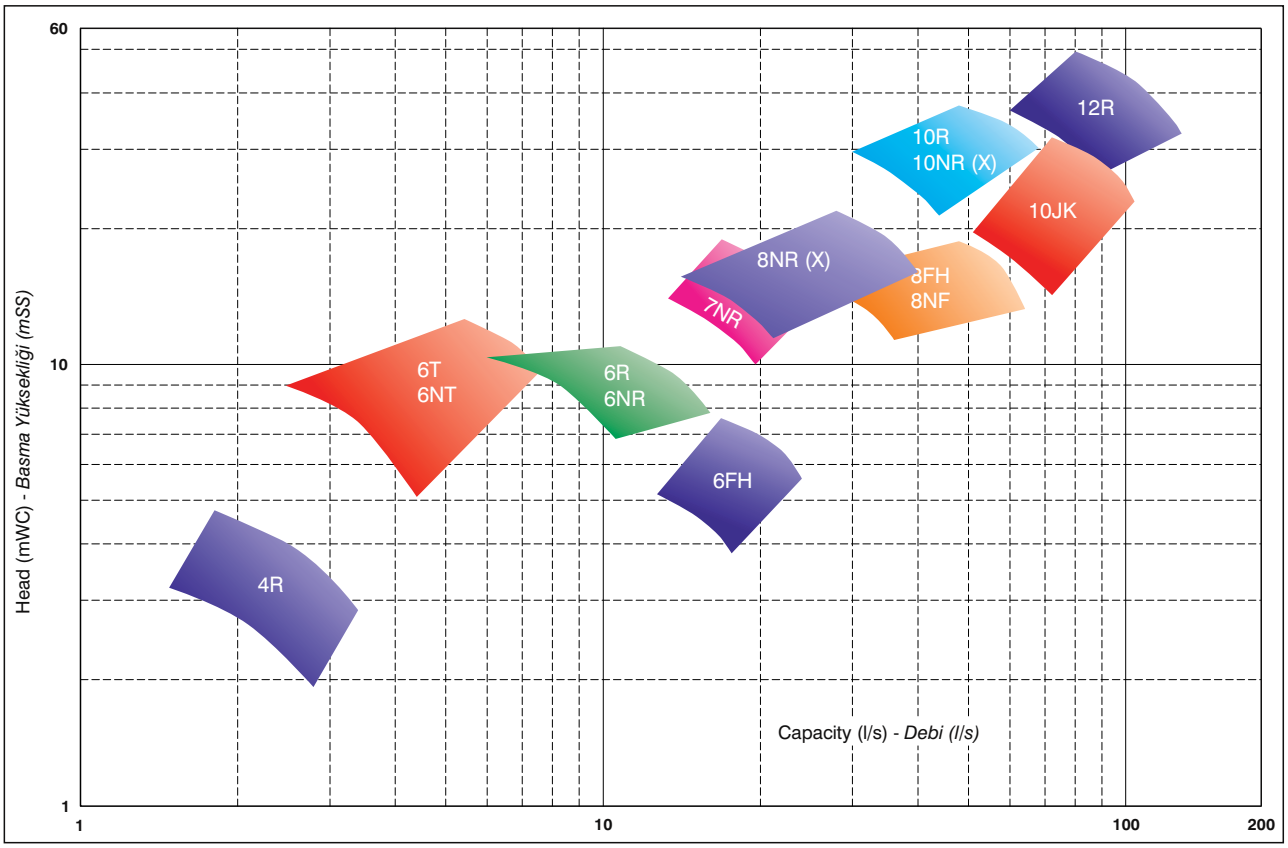
50 Hz, 1500 rpm

50 Hz, 1500 d/d



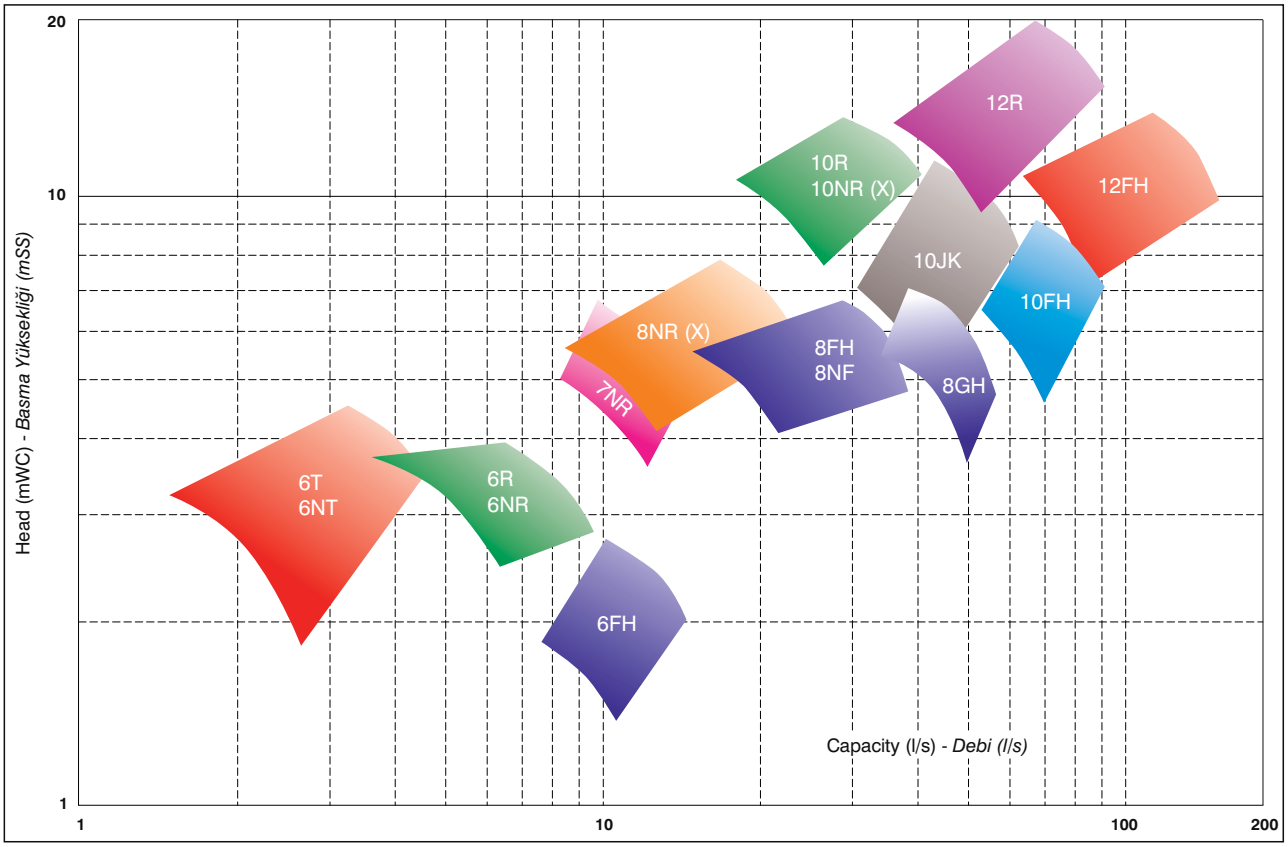
50 Hz, 3000 rpm

50 Hz, 3000 d/d



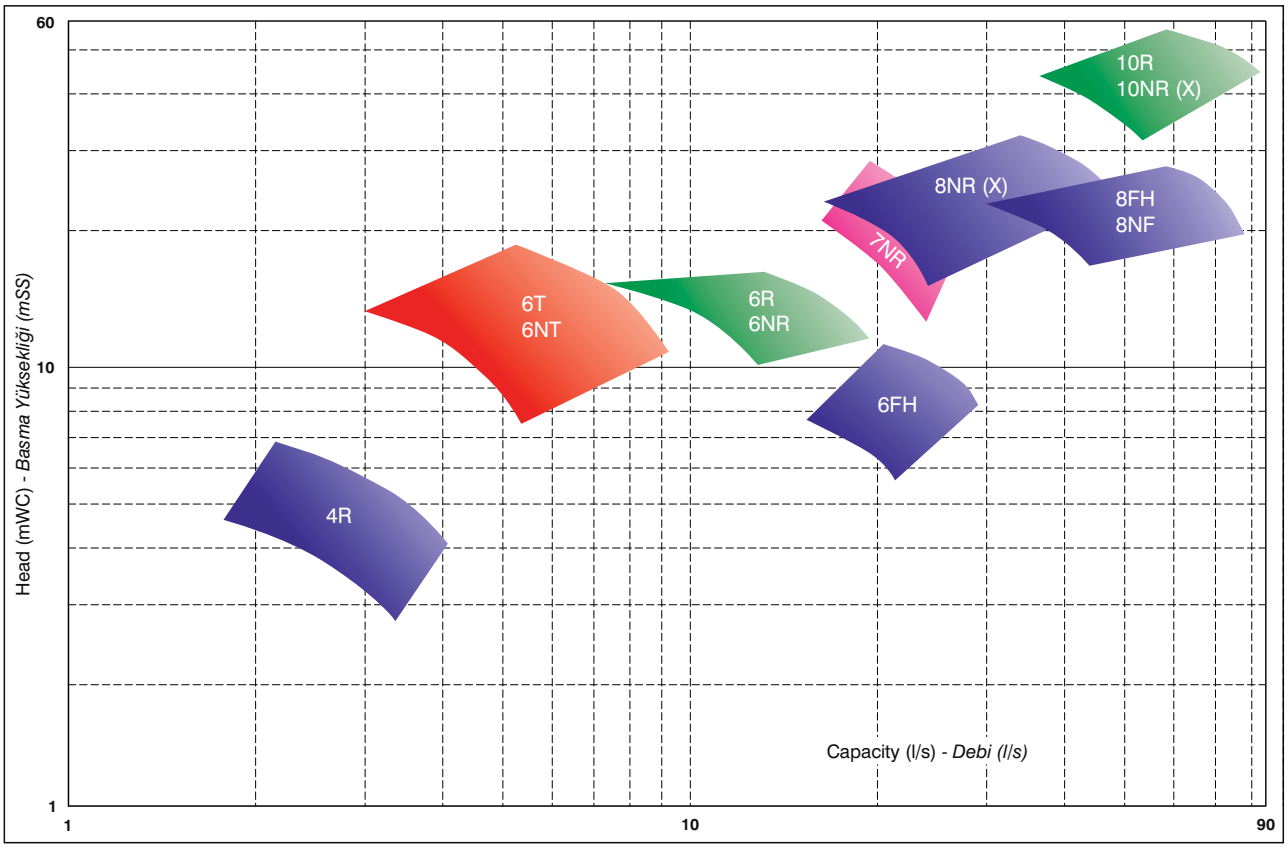
60 Hz, 1800 rpm

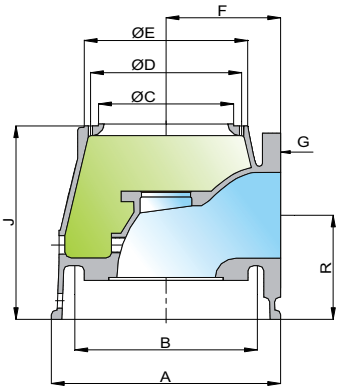
60 Hz, 1800 d/d



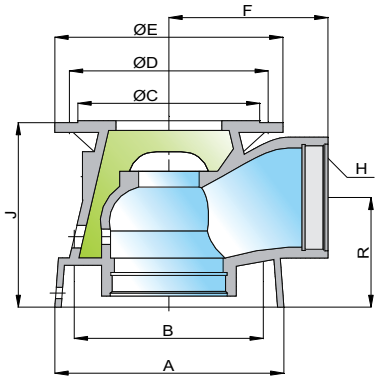
60 Hz, 3600 rpm

60 Hz, 3600 d/d





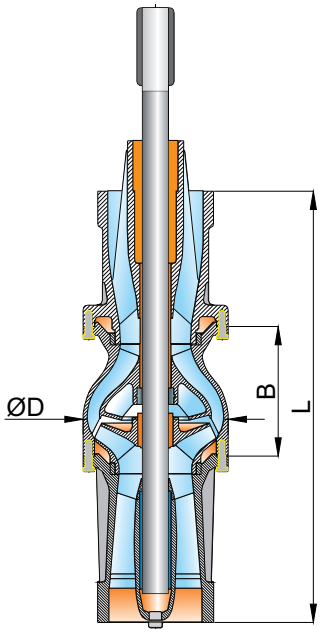
AC Type (flanged) Discharge Head
AC (flanşlı) Tip Çıkış Başlığı

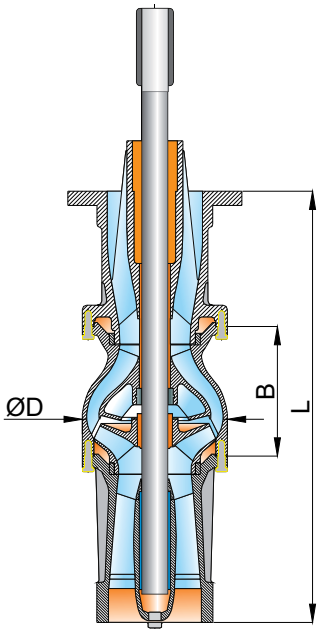


X Type (threaded) Discharge Head
X (dişli) Tip Çıkış Başlığı

Discharge Head *Çıkış Başlığı*	MAIN DIMENSIONS / *ANA ÖLÇÜLER*										Column & Discharge Dia. *Kolon & Çıkış Çapı*
	ØA mm	ØB mm	ØC mm	ØD mm	ØE mm	F mm	G * max.	H	J mm	R mm	inch / *inç*
10X3	330	254	209,4	232	254	152	—	3"- 8 UNC-2B	254	89	3
10x4-10	356	266	209,4	232	254	218	—	4"-8 UNC-2B	331	178	4
10x4-17			342,8	375	432		—				
10x5-10	356	266	209,4	232	254	218	—	5"-8 UNC-2B	331	178	5
10x5-17			342,8	375	432		—				
10x6-10	356	266	209,4	232	254	218	—	6"-8 UNC-2B	331	178	6
10x6-17			342,8	375	432		—				
17x6-10	559	432	209,4	232	254	290	—	6"-8 UNC-2B	381	203	6
17x6-17			342,8	375	432		—				
17x-8-10	432	330	209,4	232	254	300	—	8"-8 UNC-2B	386	227	8
17x-8-17			342,8	375	432		—				
10AC6	356	266	209,4	232	254	178	PN16-DN150	—	331	178	4-5-6
17AC8	559	432	342,8	375	432	280	PN16-DN200	—	381	203	4-5-6-8
20AC12	670	510	342,8	375/48	508	330	PN25-DN300	—	575	305	8-10-12
25AC14	820	635	342,8	375/480/600	640	450	PN25-DN350	—	635	325	10-12-14

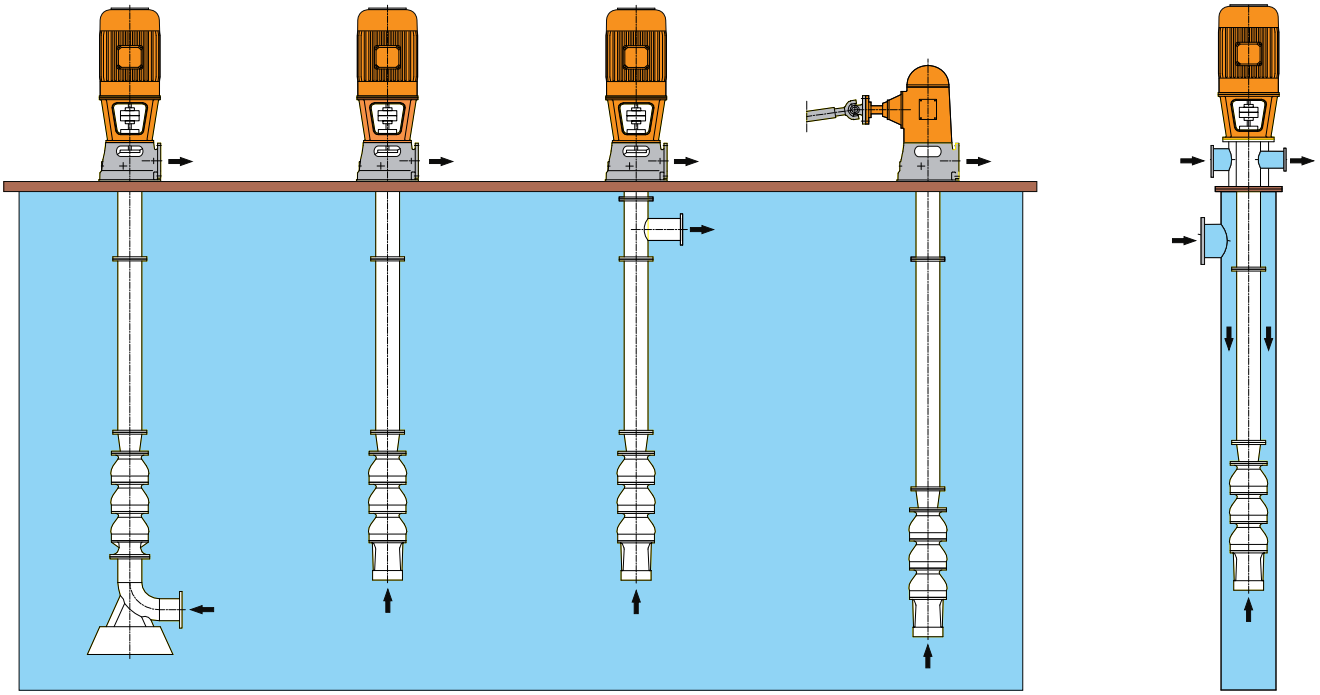
Pump Type *Pompa Tipi*	Bowl Diameter *Çanak Çapı* D (mm)	Single Stage Pump Length *Tek Kademe Pompa Boyu* L (mm)	Additional Stage Length *Ek Kademe Pompa Boyu* B (mm)
4R	92	254	76
6T	137	350	89
6NT	140	353	92
6NR	137	421	116
6R	140	435	130
6FH	140	435	121
7NR	175	513	158
8NR(X)	190	520	165
8R	191	520	165
8NF	200	572	178
8FH	191	585	191
8GH	198	620	185
10NR(X)	235	651	199
10R	238	662	210
10JK	238	610	194
10FH	245	685	222
12R	286	756	254
12FH	289	775	279





*Subject to change without any notice. *Her türlü değişiklik hakkı saklıdır.*

*Other applications up on request. *Özel uygulamalar için firmamıza başvurulmalıdır.*



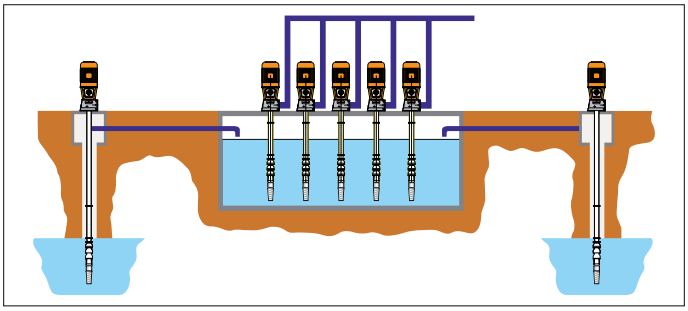
Dry Type Installation
Kuru Tip Pompa Montajı

Wet Type Installation
Islak Tip Pompa Montajı

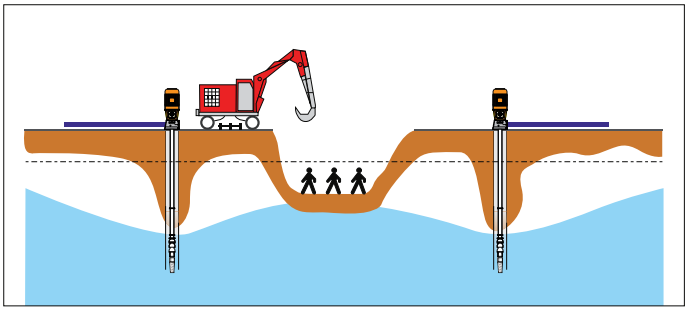
Discharge Below Ground Level
Zemin Altı Deşarjlı Pompa Montajı

Wet Type Diesel Installation
Islak Tip Dizel Montajı

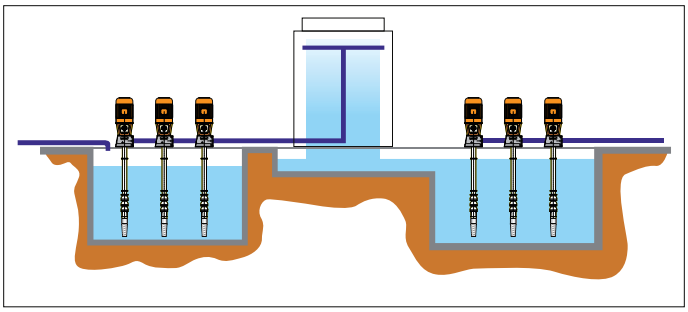
Canned Type Installation
Zarflı Tip Pompa Montajı



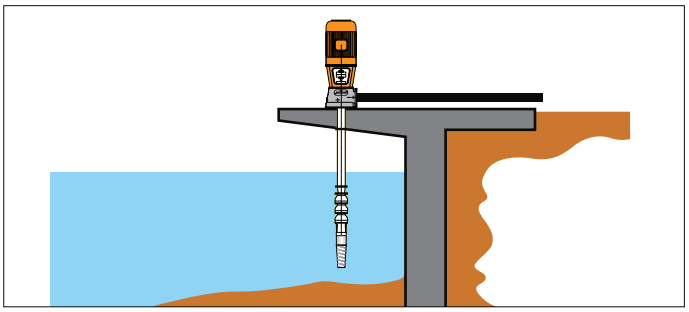
Service Water Storage and Boosting / *Servis Suyu Depolama ve Pompajı*



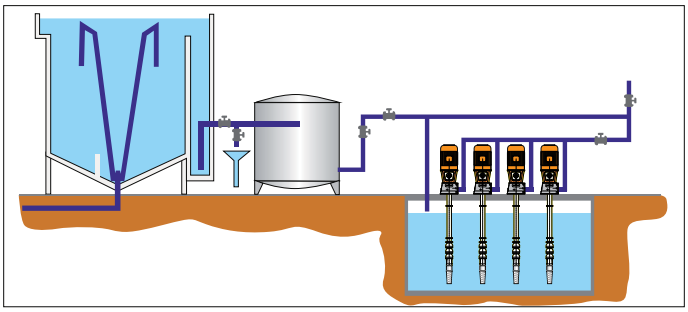
Excavation Draining / *Hafriyat Drenajı*



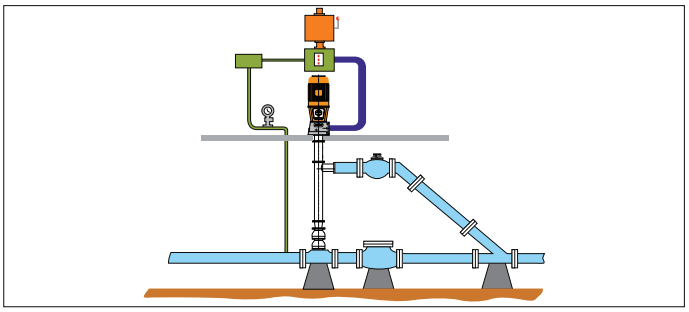
Cooling Tower Water Recyling / *Soğutma Kulesi Çevrimi*



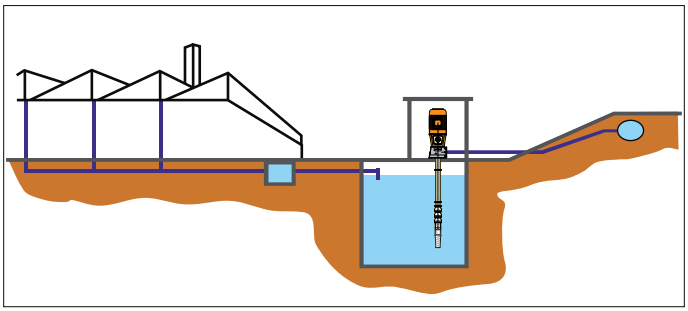
Water Pumping from Canal, River, Sea or Lake / *Nehir, Göl, Denizden Su Alma*



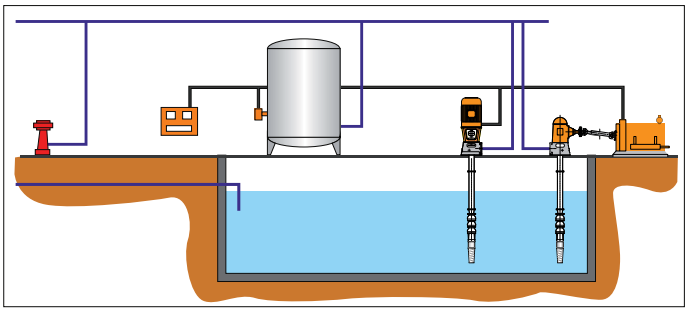
Water Treatment Plant Recycling / *Su Tasfiye Tesisi Çevrimi*



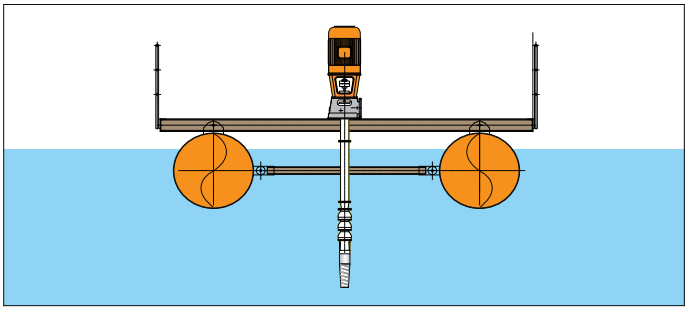
Pipeline Boosting / *Boru Hattı Hat Üstü Pompajı (Buster)*



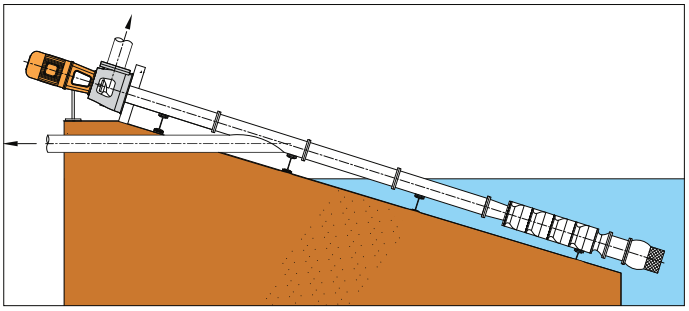
Storm Water Pumping / *Yağmur Suyu Drenajı*



Fire Fighting / *Yangınla Mücadele Sistemi*



Floating Station / *Sal Üstü Uygulama*

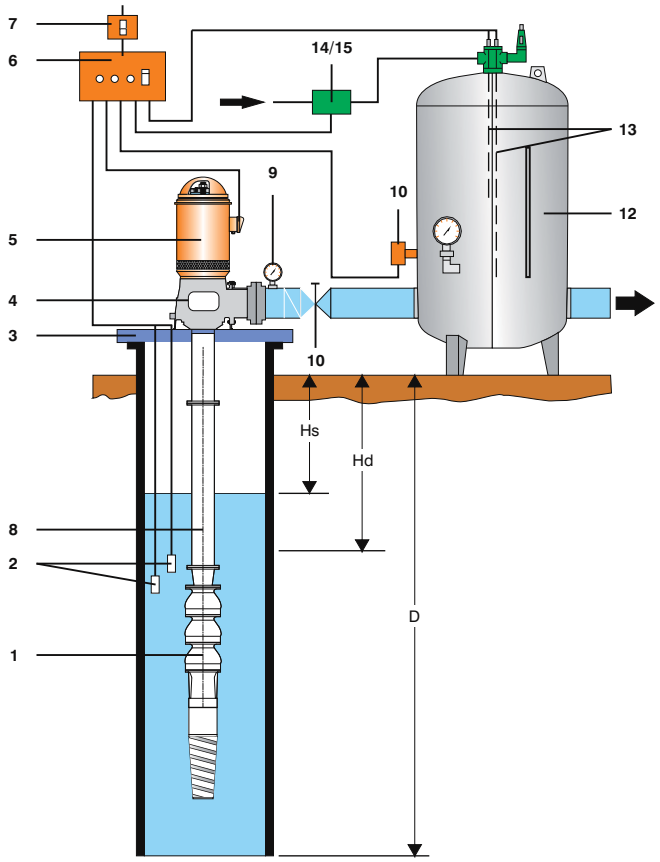


Slant mounted lift pump app. / *Eğik Montajlı Rezervuar Uygulaması*

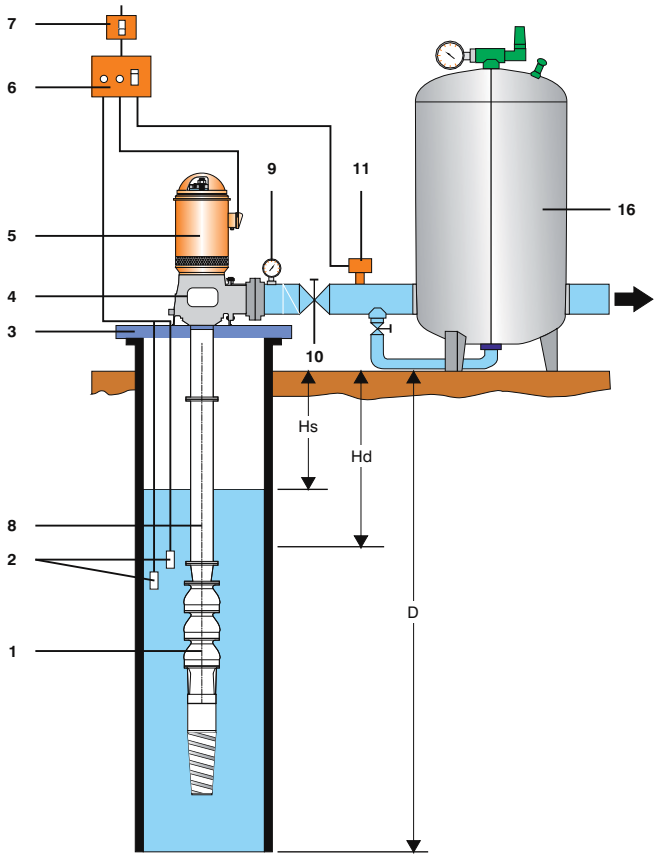
No	Part Name - *Parça Adı*	Part Description - *Parça Tanımı*	Materials Description - *Malzeme Standardı*
1	Adjusting nut - *Ayar somunu*		Carbon steel - *Karbon çelik* - ASTM A108 (1040)
2	Drive key - *Tahrik kaması*		Steel - *Çelik* - ASTM A29 (1049)
3	Headshaft - *Başlık mili*		Stainless steel - *Paslanmaz çelik* - ASTM A582 Type 420
4	Deflector ring - *Su dağıtma rondelası*	Water lube only - *Su yağlamalı*	Carbon steel - *Karbon çelik* - ASTM A108 (1040)
5	Discharge head - *Çıkış başlığı*		Cast iron - *Pik döküm* - ASTM A48 Class 30B
6	Discharge flange - *Çıkış flanşı*		Cast iron - *Pik döküm* - ASTM A48 Class 30B
7	Discharge pipe - *Çıkış borusu*		Pipe - *Çelik boru* - ASTM A53
8	Top column flange - *Kolon borusu flanşı*		Cast iron - *Pik döküm* - ASTM A48 Class 30B
9	Drain - *Yağ boşaltma borusu*	Water lube only - *Su yağlamalı*	Copper pipe - *Bakır boru* - ASTM B75 - 61
10	Packing - *Salmastra*	Water lube only - *Su yağlamalı*	Graphited soft seal - *Grafitli yumusak salmastra*
11	Stuffing box - *Salmastra kutusu*	Water lube only - *Su yağlamalı*	Cast iron - *Pik döküm* - ASTM A48 Class 30B
12	Lantern ring - *Fener halkası*	Water lube only - *Su yağlamalı*	Leaded red bronze - *Kalaylı bronz* G 83600
13	Packing gland - *Salmastra baskısı*	Water lube only - *Su yağlamalı*	Leaded red bronze - *Kalaylı bronz* G 83600
14	Stuffing box bushing - *Salmastra burcu*	Water lube only - *Su yağlamalı*	Leaded red bronze - *Kalaylı bronz* G 83600
15	Lubricator - *Yağ deposu*	Oil lube only - *Yağ yağlamalı*	Cast iron - *Pik döküm* - ASTM A48 Class 30B
16	Lubricator feed - *Yağ damlalığı*	Oil lube only - *Yağ yağlamalı*	Brass - *Prinç* - SAE 72
17	Tubing locknut - *Yağ borusu emniyet somunu*	Oil lube only - *Yağ yağlamalı*	Cast iron - *Pik döküm* - ASTM A48 Class 30B
18	Tubing tension nut - *Yağ borusu gergi somunu*	Oil lube only - *Yağ yağlamalı*	Cast iron - *Pik döküm* - ASTM A48 Class 30B
19	Seat ring - *Sızdırmazlık halkası*	Oil lube only - *Yağ yağlamalı*	Rubber O - ring - *Kauçuk oring*
20	Tubing connector - *Konnektör*	Oil lube only - *Yağ yağlamalı*	Leaded red bronze - *Kalaylı bronz* G 83600
21	Column pipe - *Kolon borusu*		Pipe - *Çelik boru* - ASTM A53
22	Column pipe coupling - *Kolon borusu manşonu*		Pipe - *Çelik boru* - ASTM A53
23	Lineshaft - *Aramili*	Water and oil lube *Su ve yağ yağlamalı*	Stainless steel - *Paslanmaz çelik* - ASTM A582 Type 420 *veya Carbon* Steel *Karbon çelik* - ASTM A108 (1040)
24	Lineshaft coupling - *Aramili manşonu*	Water lube only- *Su yağlamalı*	Stainless *Paslanmaz* - ASTM A582 Type 420 veya Carbon steel *Karbon çelik* - ASTM A108 (1040)
25	Bearing retainer - *Yatak Tutucu*	Water lube only - *Su yağlamalı*	Leaded red bronze - *Kalaylı bronz* - G 83600
26	Rubber bearing - *Lastik yatak*	Water lube only - *Su yağlamalı, oluklu*	Rubber - *Kauçuk* - shore 70 - *Shore 70 sertlik*
27	Retaining ring - *Tespit bileziği*	Water lube only - *Su yağlamalı*	Leaded red bronze - *Kalaylı bronz* G 83600
28	Shaft sleeve - *Mil gömleği*	Water lube only - *Su yağlamalı*	Stainless steel - *Paslanmaz çelik* - ASTM A582 Type 420
29	Sleeve collet - *Gömlek tespit bileziği*	Water lube only - *Su yağlamalı*	Stainless steel - *Paslanmaz çelik* - ASTM A582 Type 420
30	Discharge bowl cap - *Çıkış haznesi başlığı*	Water lube only - *Su yağlamalı*	Leaded red bronze *Kalaylı bronz* G 83600
31	Lineshaft enclosing tube - *Mil muhafaza borusu*	Oil lube only - *Yağ yağlamalı*	Pipe - *Çelik boru* - ASTM A53
32	Lineshaft bearing - *Aramili yatağı*	Oil lube only - *Yağ yağlamalı*	Leaded red bronze - *Kalaylı bronz* G 83600
33	Enclosing tube support - *Merkezleme lastiği*	Oil lube only - *Yağ yağlamalı*	Rubber - *Kauçuk* - shore 70 - *Shore 70 sertlik*
34	Tube adapter - *Adaptör*	Oil lube only - *Yağ yağlamalı*	Leaded red bronze - *Kalaylı bronz* G 83600
35	Discharge bowl- *Çıkış haznesi*		Cast iron - *Pik döküm* - ASTM A48 Class 30B
36	Discharge bowl coupling - *Çıkış haznesi manşonu*		Cast iron - *Pik döküm* - ASTM A48 Class 30B
37	Discharge bowl bearing - *Çıkış hazinesi yatağı*		Leaded red bronze - *Kalaylı bronz* G 83600
38	Pump shaft - *Pompa mili*		Stainless steel - *Paslanmaz çelik* - ASTM A582 Type 420
39	Intermediate bowl - *Ara çanak*		Cast iron - *Pik döküm* - ASTM A48 Class 30B
40	Intermediate bowl bearing - *Ara çanak yatağı*	Bronze with or without flutted rubber *Bronz yatak oluklu kauçuklu veya oluklu kauçuksuz*	Leaded red bronze - *Kalaylı bronz* G 83600 (B145 - 61 4A)(B145 - 61 4A) / *Rubber Kauçuk* shore 70 - *Shore 70 sertlik*
41	Bowl wear ring - *Aşınma Bileziği*		Leaded red bronze - *Kalaylı bronz* G 83600
42	Impeller - *Çark*		Leaded red bronze - *Kalaylı bronz* G 83600
43	Impeller lock collet -*Çark tespit bilezigi*		Stainless steel - *Paslanmaz çelik* ASTM A582 Type 420
44	Suction bowl - *Emiş haznesi*		Cast iron - *Pik döküm* ASTM A48 Class 30B
45	Suction bowl bearing - *Emiş haznesi yatağı*		Leaded red bronze - *Kalaylı bronz* G 83600
46	Suction pipe - *Emiş borusu*		Pipe - *Çelik boru* ASTM A120
47	Strainer - *Süzgeç*	Basket or cone type *Sepet ya da konik tip*	Stell construction - *Çelik konstrüksiyon - Paslanmaz veya galvanizli*
48	Studs - *Saplamalar*	For bolted types - *saplamalı tipler için*	Steel - *Çelik* ASTM A108 - 61 Gr. B1113
49	Bolts and nuts - *Cıvata ve somunlar*		Steel - *Çelik* ASTM A 307 - 61 Gr. A

*Subject to change without any notice / *Her türlü değişiklik hakkı saklıdır.*

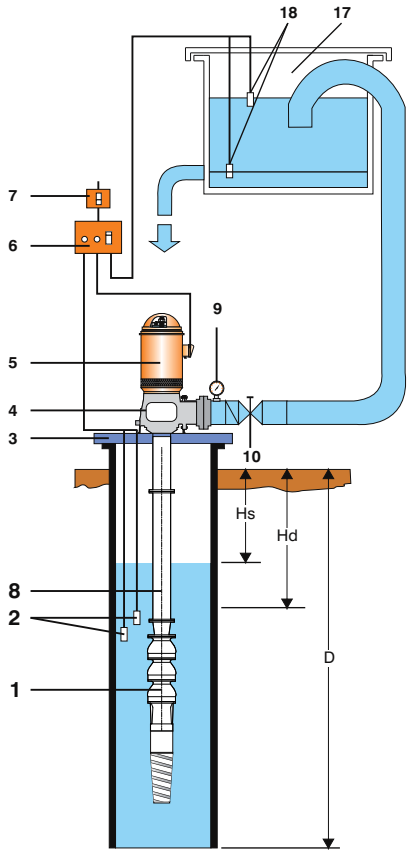
*Other material can be provided up on request / *Farklı malzeme uygulamaları yapılabilir.*



Pumping to Hydro - Pneumatic Pressure Tank
Hidrofor Tankına Pompaj



Pumping to Membrane Tank
Membranlı Tanka Pompaj



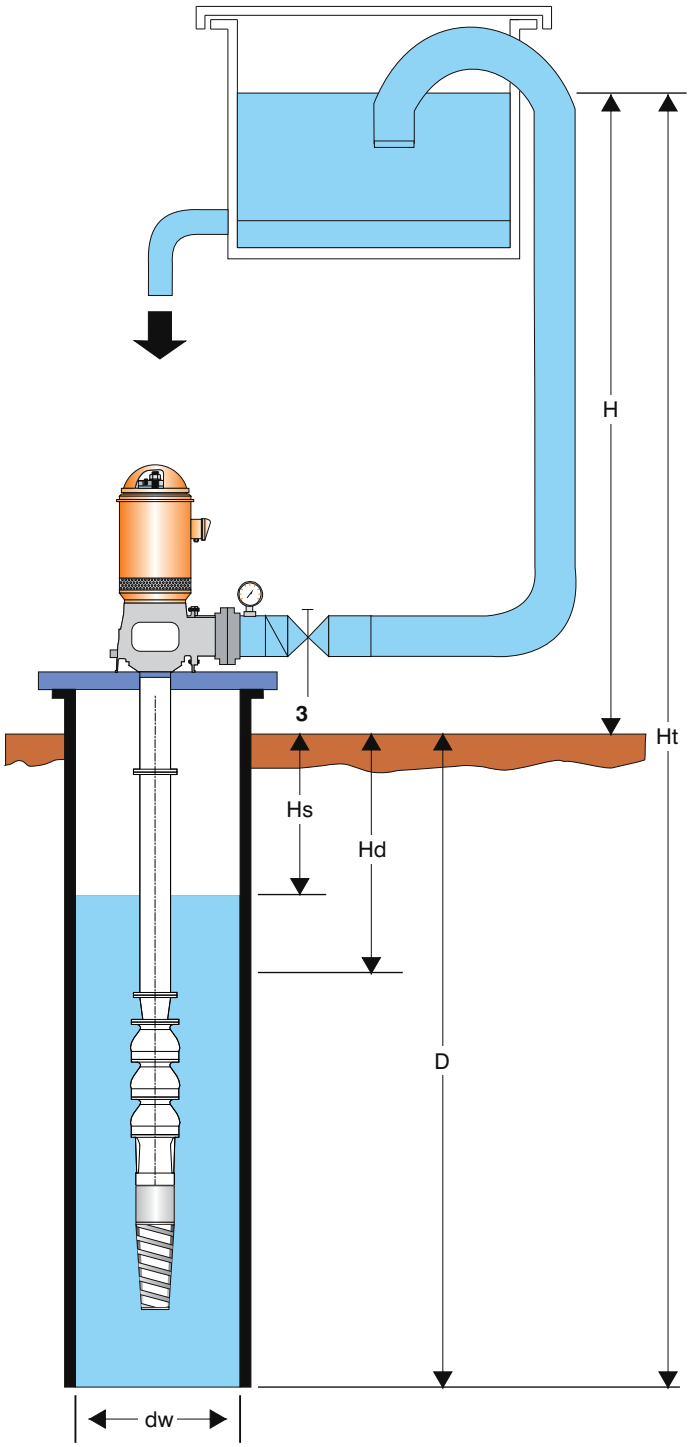
Pumping to Storage Tank or Reservoir
Depolama Tankına Pompaj

1. Deep Well Turbine Pump
   Derinkuyu Pompası
2. Column Pipe
   Kolon Borusu
3. Support Plate
   Destek Plakası
4. Discharge Head
   Çıkış Başlığı
5. VHS Electric Motor
   Dik Delik Milli "VHS" Elektrik Motoru
6. Electric Control Board
   Elektrik Panosu
7. Circuit Breaker
   Ana Şalter
8. Well Level Probes
   Kuyu Seviye Elektrodları
9. Pressure Gauge
   Manometre
10. Gate Valve
    Sürgülü Vana
11. Pressure Switch
    Basınç Şalteri
12. Pressure Tank
    Basınçlı Tank
13. Air Inlet Control Probes
    Hava Girişi Kontrol Elektrodları
14. Electric Valve
    Elektrikli Vana
15. Compressor
    Kompresör
16. Membrane Tank
    Membranlı Tank
17. Storage Tank
    Depolama Tankı
18. Start - Stop Probes
    Pompa Çalıştırma Elektrodları

Hs - Static Head
Statik Seviye

Hd - Dynamic Head
Dinamik Seviye

D - Well Depth
Kuyu Derinliği



Data to be supplied in requests for proposal.
Başvurunun aşağıdaki bilgilerle yapılması ile en uygun pompa seçimi mümkün olacaktır.

Water Characteristics
Su Bilgileri

Usage (potable, industrial etc.)
Sand content in water (gr/m³)
Temperature of water (°C)
pH value
Others
Kullanım amacı
Sudaki kum miktarı (gr/m³)
Su sıcaklığı (°C)
pH değeri
Varsa diğer

Well Data
(Supplied by driller)
Kuyu Bilgileri
(Sondajcıdan Alınmalıdır)

Drilling year
Well Capacity (l/s)
Altitude of well (m)
Depth of well, D (m)
Casing diameter of well, dw (inch)
Static water level in well, Hs (m)
Dynamic water level, Hd (m)
Kuyu açılma tarihi
Kuyu verimi (l/s)
Kuyu başı rakımı (m)
Kuyu derinliği, D (m)
Kuyu teçhiz çapı, dw (inç)
Statik su seviyesi, Hs (m)
Dinamik su seviyesi, Hd (m)

Pump Data
Pompa Bilgileri

Required capacity, Q (l/s)
Required total manometric head, Hm (m)
İstenilen debi, Q (l/s)
Gereken toplam manometrik yükseklik, Hm (m)

In Case Hm is not known
Toplam Manometrik Yüksekliğin Bilinmediği Durumlarda Gereken Bilgiler

Height of water in reservoir from the datum, H (m)
Length of pipe from well head to reservoir, L (m)
Diameter of pipe (inch)
Material and pressure class of pipe
Number of valves and bends along the piping
Kuyu başından depodaki su seviyesine kadar yükseklik, H (m)
Kuyu başından su deposuna kadar ulaşan boru boyu, L (m)
Boru Çapı, dp (mm)
Boru hattındaki vana, dirsek ve dönüş sayısı

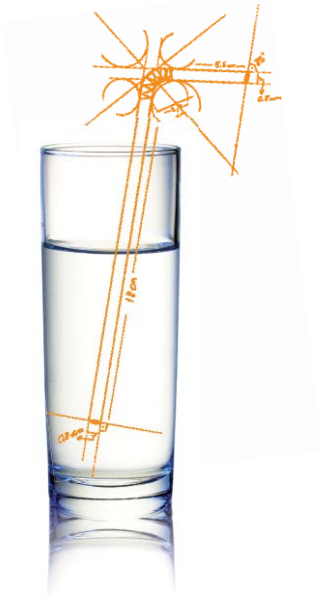
Diesel or gasoline engine
(speed and power at optimum duty, if possible)
Dizel veya Benzinli Motor *(mümkünse en iyi çalışma noktasında hızı ve gücü)*
Belt and pulley system
Kayış Kasnak

Drive Types
Tahrik Tipleri

Vertical hollow shaft (VHS) or vertical solid shaft (VSS, V1) electrical motor
Voltage
Frequency
Transformer Power (kVA)
Dik Delik Milli (VHS) veya dik dolu milli (VSS) Elektrik Motoru
Voltaj
Frekans
Trafo Gücü (kVA)

Taste the Engineering

MÜHENDİSLİĞİN tadına varın



Layne Bowler Pompa Sanayi A.Ş. / Layne Bowler Pump Company Inc.
İstanbul Karayolu 16.Km, P.K.3, 06930, Etimesgut, Ankara, Türkiye
Tel: (90 312) 255 96 51 • Fax: (90 312) 255 96 50
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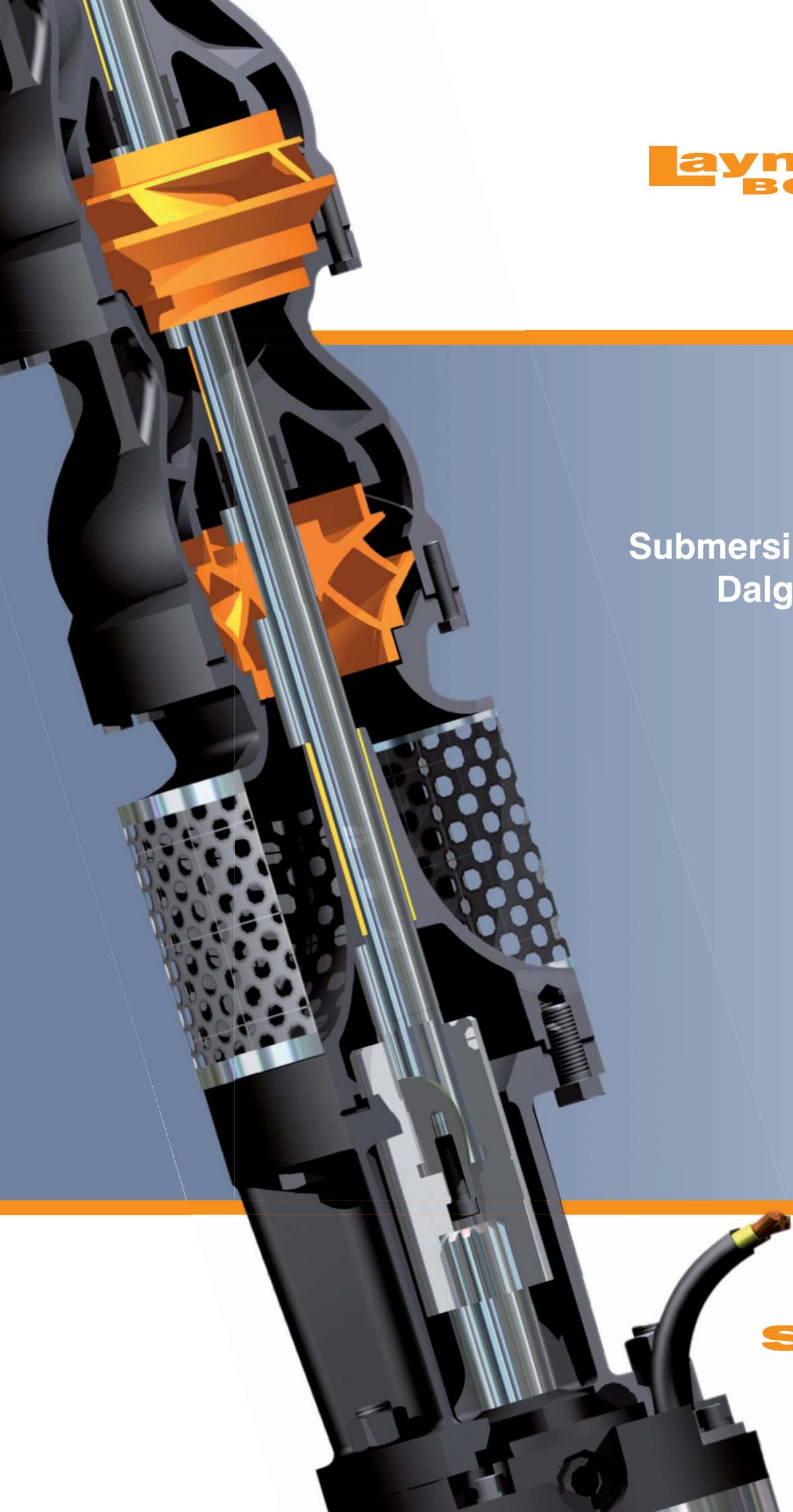


Layne Bowler

Submersible Pump
Dalgıç Pompa

SubLine

Layne Bowler Pump Company Inc.

Layne Bowler history can be traced back to 1882, when the inventor, Mr. Mahlon Layne drilled his first well and found himself in need of a different pump to get the water out from his drilled well. He understood that the pump, which he should invent, must be different from all the existing pumps of that time. In 1903 Mr. M. Layne and the entrepreneur Mr. P. D. Bowler joined in a manufacturing venture called “Layne Bowler”, which had spread from the Mississippi basin to all over the world.

Layne Bowler Pump Company Inc. was established in 1965 and domiciled in the capital city of Turkey, Ankara. In Layne Bowler the innovations and the engineering studies never stop. In addition to the innovation of the existing pumps, Layne Bowler is always working on introducing new pump ranges and categories. Hoping that, our products would play a positive role in helping the constantly growing world population who is relying on a very small amount of fresh water to survive. People are in need of Layne Bowler pumps in order to get the cold or hot fresh water from underground, to boost big quantities to higher elevations and sometimes to get rid off waste water problems.

On a 42.000 m^2 facility, groups of qualified engineers and experienced technicians are serving to all over the world Layne Bowler high class engineering pumps. Throughout the years, they proved to energy, industrial, municipal and agricultural sectors that Layne Bowler is producing reliable and leader brands.

Layne Bowler is supplying a distinguished After Sales Services, by having a special database for every produced pump, a comprehensive stock of spare parts and an experienced group of technicians and trainers, who are ready to support you wherever you are in the world.

Layne Bowler High Class Engineering can be tasted from the high performance, the high efficiency and the long lasting reliability.
Today, Layne Bowler Pump Company Inc. Products are almost everywhere. In addition to America, Australia and Europe, we are one of the leader pump suppliers in the Middle East and North Africa.

Future export growth is directly depending on your intelligent choice, so let us invite you to Taste the Engineering by using Layne Bowler Pumps.

Layne Bowler Pompa Sanayi A.Ş.

Layne Bowler'in öyküsü, 1882'de, Mahlon Layne'nin ilk su kuyusunu kazması ve kuyudaki suyu çıkarabilmek için değişik bir pompaya ihtiyaç duymasıyla başladı. Bu durum karşısında, zamanın tüm pompalarından daha farklı bir pompayı tasarlaması gerektiğinin farkına vardı. 1903'te, M. Layne ve girişimci P. D. Bowler, Mississippi'den tüm dünyaya yayılan “Layne Bowler” adıyla üretime başladılar.

Layne Bowler Pompa Sanayi A.Ş. 1965'te Türkiye'nin başkenti Ankara'da kuruldu. Layne Bowler'de AR-GE, yenilik ve mühendislik çalışmaları, süreklilik arzeder. Var olan pompaların geliştirilmesine ek olarak, yeni kapasitelere ve katagorilere sahip pompaları piyasaya kazandırma uğraşındadır. Artan nufüs ile birlikte yaşam için çok önemli hale gelen içme ve kullanma suyuna olan ihtiyaç artmakta, ihtiyaçlara yönelik geliştirilen çözümler için önemli roller almaktadır. Soğuk veya sıcak suları yer yüzüne çıkarmak, büyük su kütlelerini yüksek irtifalara basmak kimi zamanda atık suları uzaklaştırmak için Layne Bowler ürünleri kullanılmaktadır.

42.000 m^2 alana kurulu olan Layne Bowler bünyesinde, tecrübeli mühendisler ve teknisyenler yüksek kalitede mühendislik ürünü olan Layne Bowler pompalarını üretmek için çaba sarfetmekte ve bu ürünler ile bütün dünyaya hizmet vermektedirler. Yılların tecrübesi ve mühendisliği ile ürünlerimiz enerji, endüstri, kentsel ve tarımsal alanda güvenilir ve sınıfında birinci kalite olduğunu kanıtlamışır.

Layne Bowler, ürettiği her bir pompanın kaydını kendine has bilgi havuzunda toparlayarak, geniş kapsamda yedek parçayı elinde bulundurarak ve tecrübeli elemanları sayesinde siz dünyanın neresinde olursanız olun, farkı hissedeceğiniz bir satış sonrası hizmeti sağlamaktadır.

Layne Bowler'in kaliteli mühendisliği ürünlerin yüksek performansından, elde edilen yüksek verimlilikten ve uzun süreli sorunsuz çalışmasından anlaşılabilmektedir. Bugün, Layne Bowler Pompa Sanayi A.Ş. ürünleri dünyanın her yerindedir. Amerika, Avustralya ve Avrupa'ya ek olarak Orta Doğu ve Kuzey Afrika'da pompa tedarikçisi olarak lider bir kuruluştur.

Yılların birikimi ile üretilen bir pompanın farkını anlamak, mühendisliğin tadına varmak için sizin de Layne Bowler 'iniz olsun.

Submersible Pump
Dalgıç Pompa

A submersible pump is turbine pump close-coupled to a submersible electric motor. Both pump and motor are suspended in the water, thereby eliminating the long drive shafts and bearing retainers required for a deep well turbine pump. Because the pump is located above the motor, water enters the pump through a screen located between the pump and motor. The pump curve for a submersible pump is very similar to a vertical turbine pump.

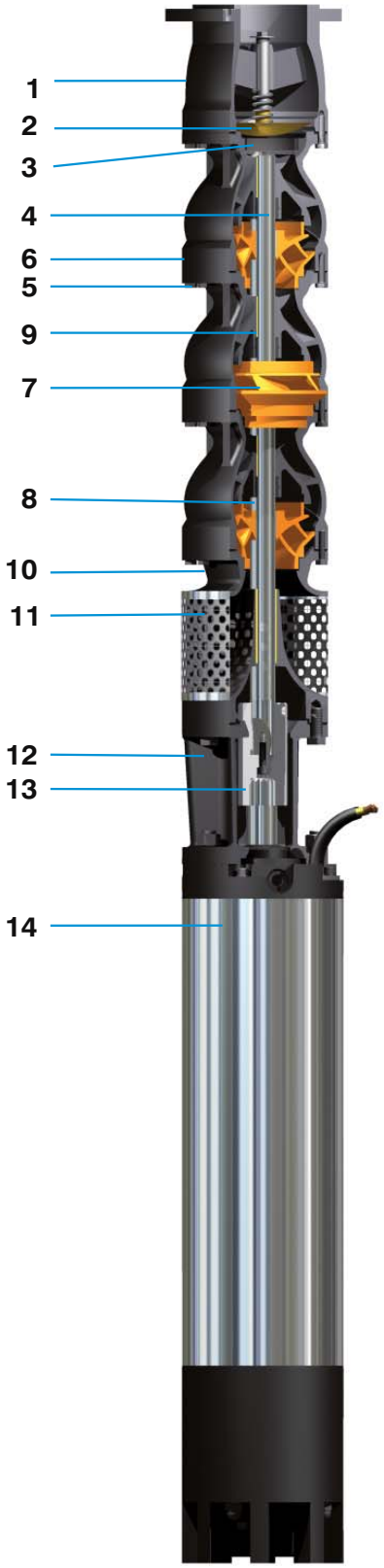
Other Features:

- Produced from;
  - -Casting
  - -Sheet metal
- Used in deep wells
  - -Easy to install
  - -Can be used in crooked wells
- Pump speed is usually 3000-3600 rpm and it is available as 1500-1800 rpm as well.

Dalgıç pompa, dalgıç elektrik motoru ile dik türbin pompanın bağlanması ile oluşmuş bir çeşit pompadır. Hem pompa hem de motor suyun içinde asılı konumdadır. Böylelikle, dik türbin pompalarında olan uzun hareket miline ve yatak tutuculara gerek yoktur. Çünkü, motor pompanın hemen altında yer alır ve su pompa ile motor arasındaki açıklıktan içeri girer. Dalgıç pompa, yapı itibariyle dik türbin pompaya benzerlik göstermektedir.

Diğer Özellikler:

- *Üretim malzemeleri*
  - *-Döküm*
  - *-Sac*
- *Derin kuyularda kullanım*
  - *-Kolay montaj imkanı*
  - *-Eğri kuyularda kullanabilme olanağı*
- *Pompa devir hızı genellikle 3000-3600 d/d'dır. Ancak 1500-1800 d/d hızında da kullanılabilir.*



1. **Discharge Case** / ***Çıkış Haznesi***
   Cast iron (ASTM A48 Class 30B)
   Pik döküm (ASTM A48 Sınıf 30B)

2. **Check Valve** / **Klape**
   Stainless steel sheet / Bronze
   Paslanmaz çelik sac / Bronz

3. **Rubber Seat** / ***Klape Lastiği***
   Rubber (Shore 70) / *Kauçuk (Shore 70)*

4. **Pump Shaft** / ***Pompa Mili***
   Stainless steel (ASTM A582 Type 420)
   Paslanmaz çelik (ASTM A582 Tip 420)

5. **Bolts and Nuts** / ***Civatalar ve Somunlar***
   Steel (ASTM A307-61 Gr. A)
   Çelik (ASTM A307-61 Gr. A)

6. **Intermediate Bowl** / ***Araçanak***
   Cast iron (ASTM A48 Class 30B)
   Pik döküm (ASTM A48 Sınıf 30B)

7. **Impeller** / ***Çark***

   Leaded bronze (G 83600)
   Kalaylı bronz (G 83600)

8. **Impeller Lock Collet** / ***Çark Tespit Burcu***
   Stainless steel (ASTM A582 Type 420)
   Paslanmaz çelik (ASTM A582 Tip 420)

9. **Intermediate Bowl Bearing** / ***Araçanak Yatağı***
   Leaded bronze (G 83600)
   Kalaylı bronz (G 83600)

10. **Suction Case** / ***Emiş Haznesi***
    Cast iron (ASTM A48 Class 30B)
    Pik döküm (ASTM A48 Sınıf 30B)

11. **Strainer** / ***Süzgeç***
    Stainless steel sheet
    Paslanmaz çelik sac

12. **Intermediate Part** / ***Araparça***

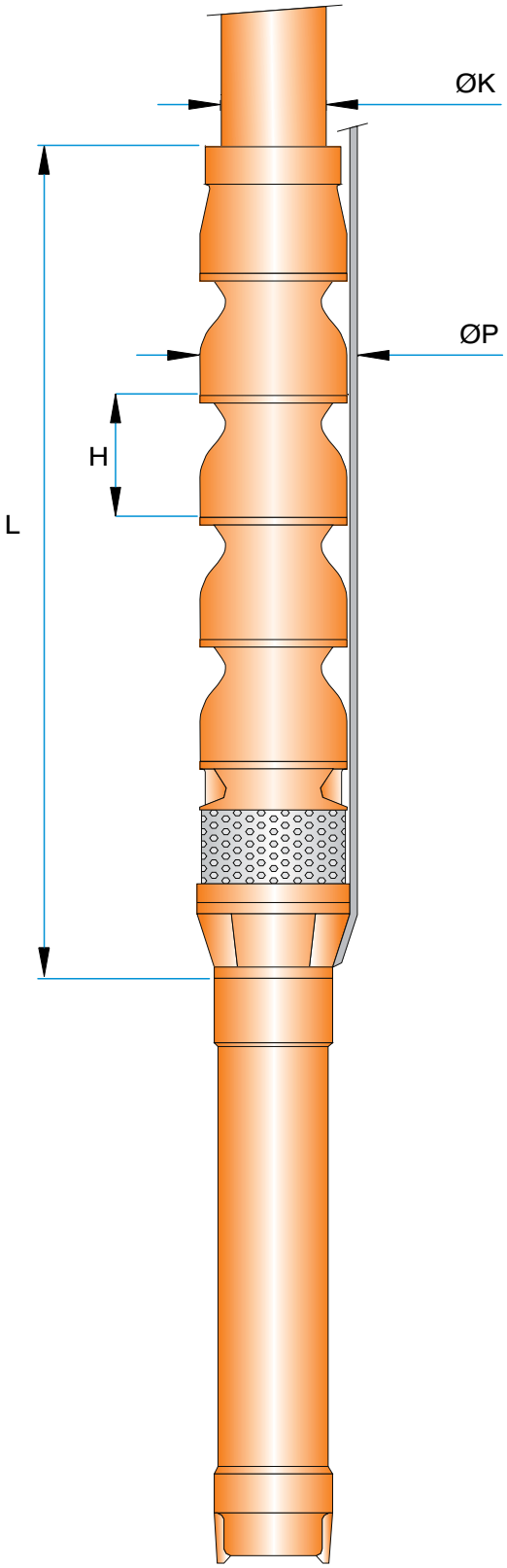
13. **Coupling** / ***Kaplin***
    Stainless steel (ASTM A582 Type 420)
    Paslanmaz çelik (ASTM A582 Tip 420)

14. **Submersible Motor** / ***Dalgıç Motor***

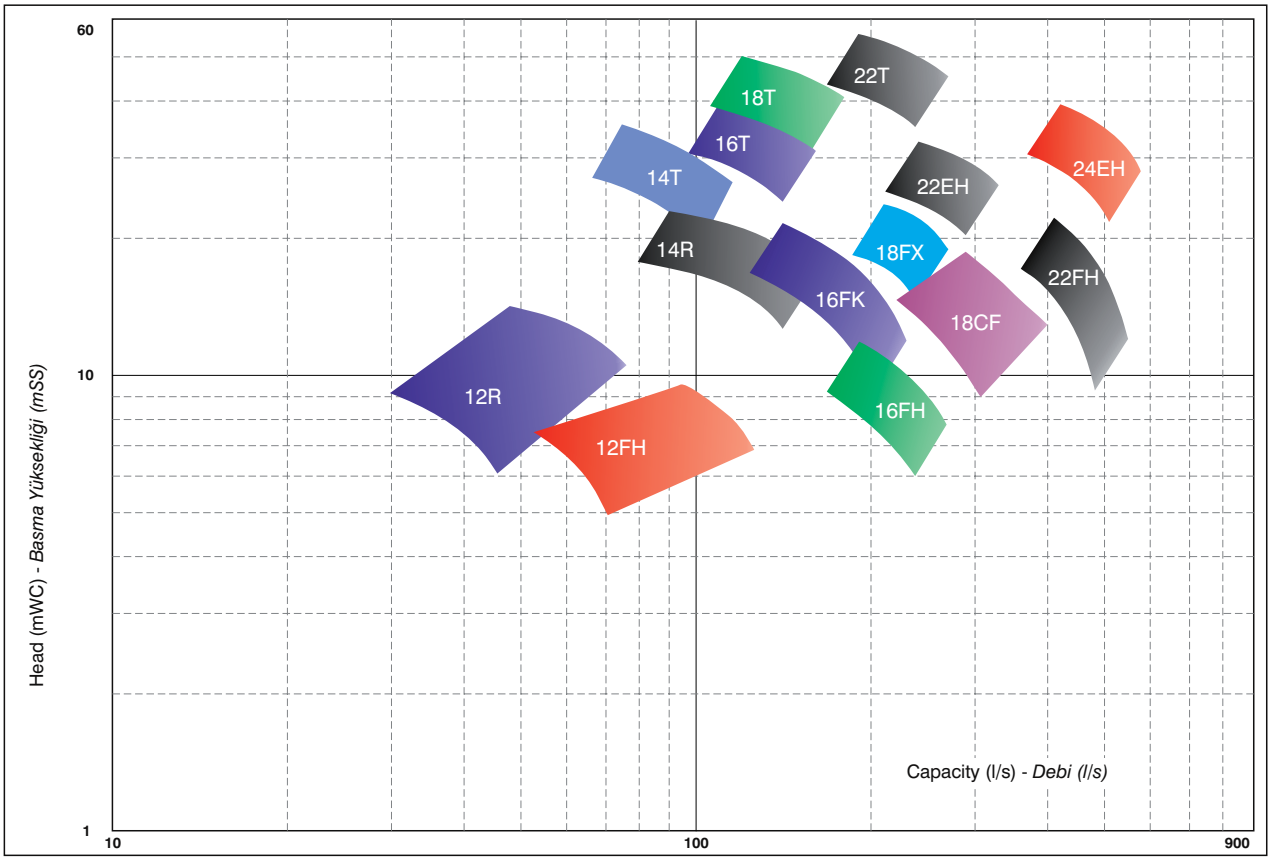
* Other material can be provided up on request / *Farklı malzeme uygulamaları yapılabilir.*

Pump Type *Pompa Tipi*	Single Stage Pump Length *Tek Kademe Pompa Boyu* L (mm)	Additional Stage Length *Ek Kademe Boyu* H (mm)	Maximum Diameter *Maksimum Çap* ØP (mm)	Discharge Diameter *Çıkış Çapı* ØK (inch)
6T	440	89	152	3-4
6NT	442	91	152	3-4
6NR	455	116	152	3-4
6R	470	130	155	3-4
6FH	460	121	155	3-4-5
7NR	745	158	193	4-5
8NR(X)	750	165	195	4-5-6
8NF	770	178	205	4-5-6
8FH	780	190	205	4-5-6
10NR(X)	845	199	255	5-6-8
10R	845	210	258	5-6-8
10JK	785	193	258	6-8-10
12R	1050	254	311	8-10
12FH	1130	279	314	8-10
14T	1315	365	450	8-10
14R	1265	340	381	10-12
16FK	1450	361	431	10-12
16FH	1530	424	421	12-14
16T	1500	394	490	10-12
18FX	1550	359	460	12-14
18CF	1575	375	460	12-14-16
18T	1575	428	530	10-12-14
22EH	1650	406	523	12-14-16
22FH	1750	557	585	16-18-20
22T	1675	478	590	14-16
24EH	1900	458	565	18-20

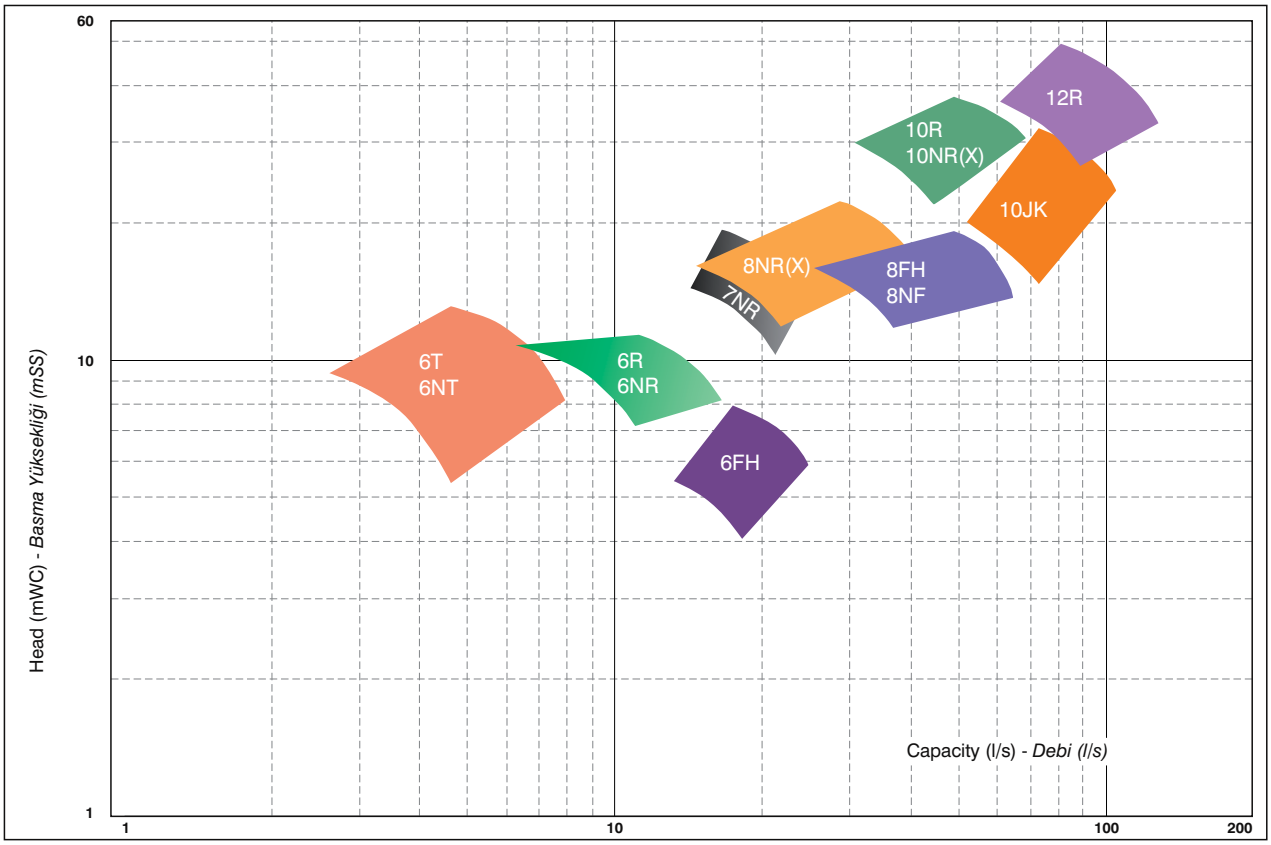
*Subject to change without any notice. *Her türlü değişiklik hakkı saklıdır.*



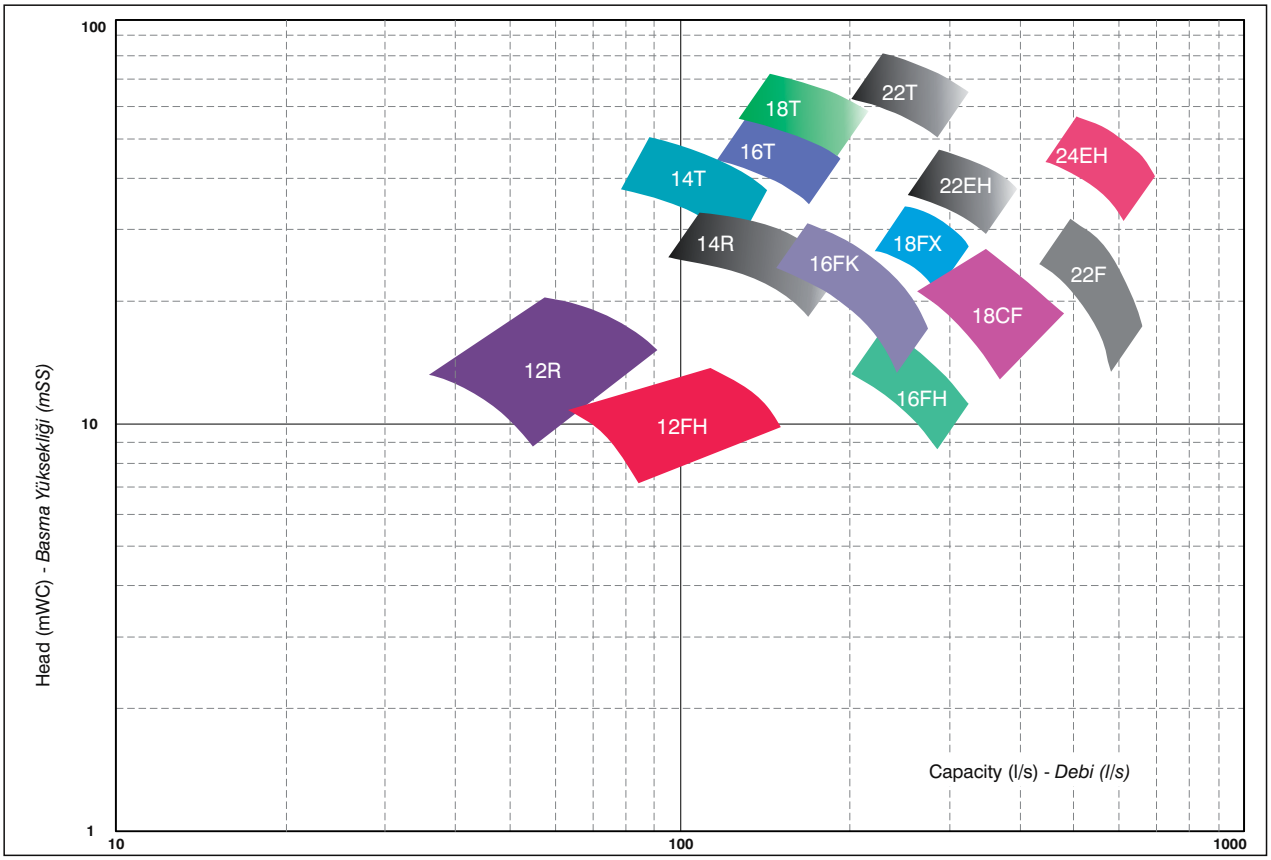
50 Hz, 1500 rpm *50 Hz, 1500 d/d*



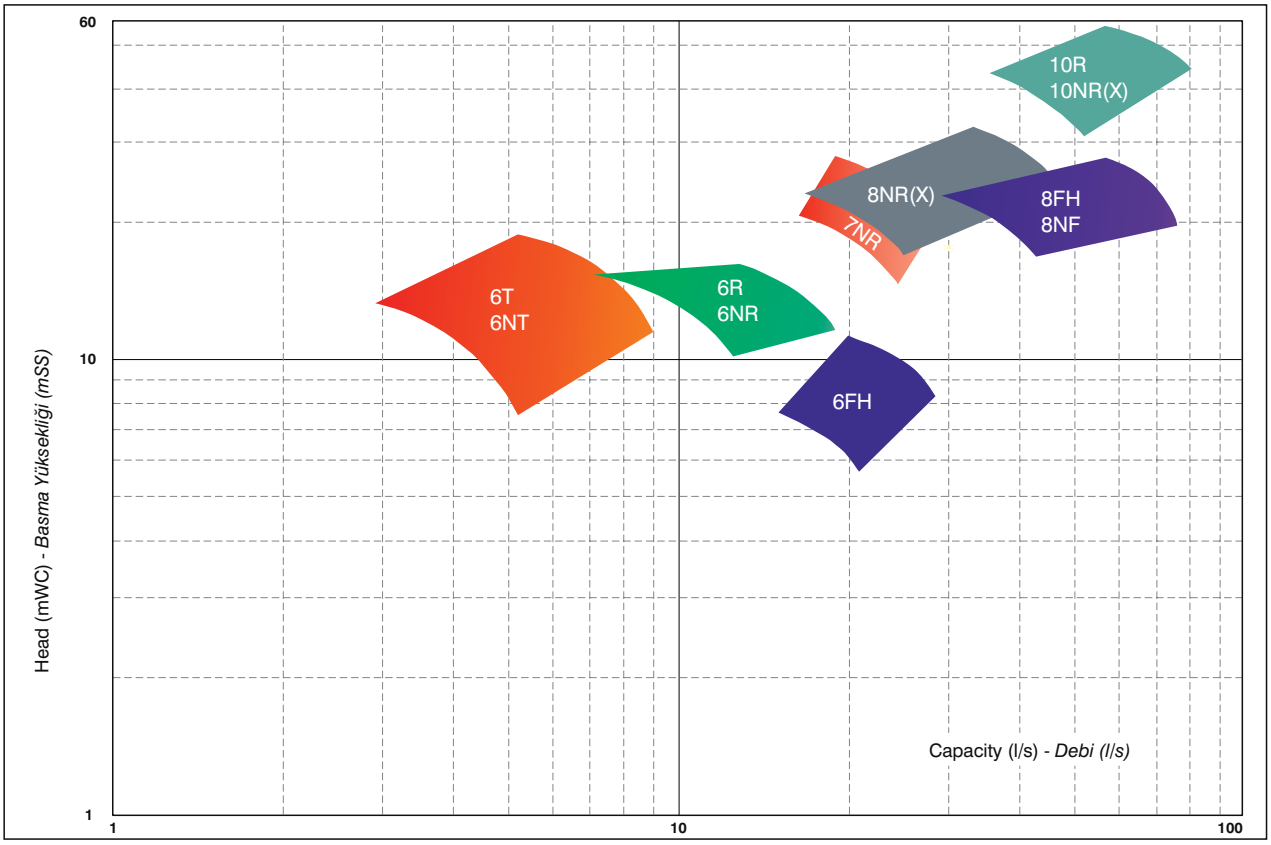
50 Hz, 3000 rpm *50 Hz, 3000 d/d*



60 Hz, 1800 rpm *60 Hz, 1800 d/d*



60 Hz, 3600 rpm *60 Hz, 3600 d/d*

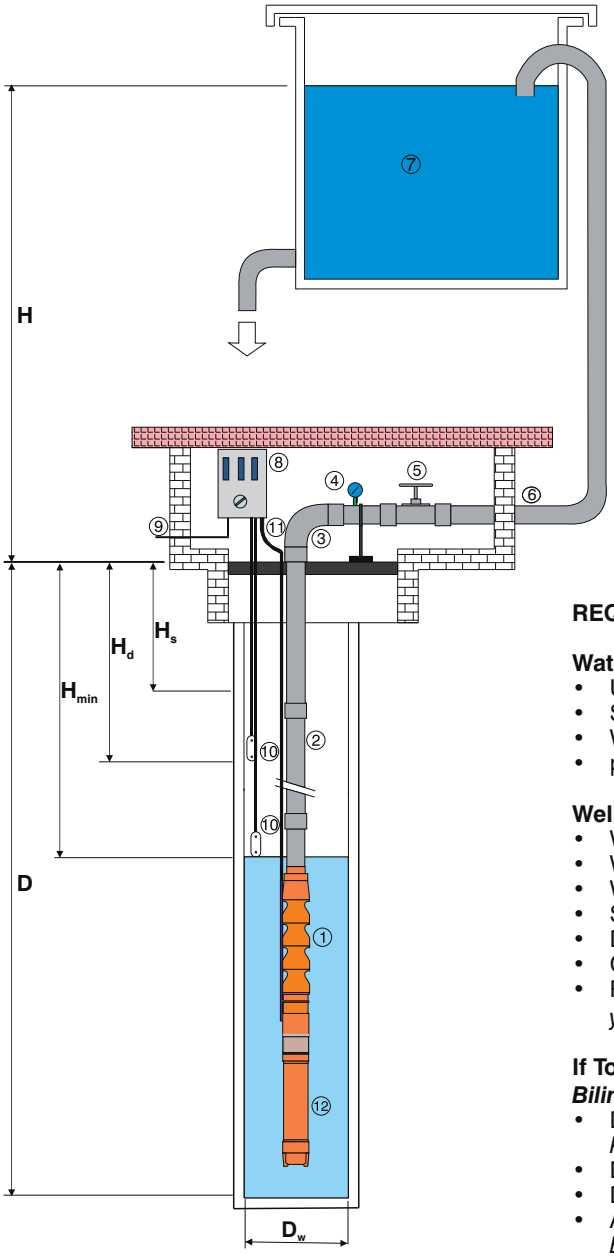


Current *Akım*	Motor Power *Motor Gücü*	Cable Cross - Section (mm²)/*Kablo Kesiti (mm²)*															
		1	1,5	2,5	4	6	10	16	25	35	50	70	95	120	150	185	240
A	HP	Maximum Cable Lenght (m)/*Maksimum Kablo Boyu (m)*															
7	4	73	109	181	290	436	710										
10	5,5	53	79	132	211	318	518	811									
13	7,5		58	96	154	231	377	591	914								
17	10			74	119	179	291	457	706	961							
21	12,5			59	95	143	234	367	567	772	1010						
25	15				81	122	198	311	481	655	858						
28	17,5				70	105	172	270	416	567	742	1024					
32	20					92	150	236	355	497	652	901					
40	25						120	189	292	398	522	720	947				
47	30						102	151	248	338	444	613	806	966			
54	35							140	216	295	386	534	701	841	983		
64	40							118	182	249	326	450	592	709	830	974	
78	50							100	154	210	273	376	491	586	682	797	944
94	60							82	127	172	225	310	405	485	565	662	786
108	70							71	109	149	195	268	352	421	492	576	686
124	80								95	129	169	234	306	367	428	502	598
138	90								85	116	152	210	275	330	385	451	537
155	100								76	104	136	187	245	293	343	402	478
186	125									86	113	156	204	245	286	335	399
225	150										93	128	168	202	236	277	331
264	180											109	143	172	201	236	282
306	200											94	124	148	174	204	243
370	250												102	123	143	168	201
440	300													103	121	142	169
515	350														103	121	144
590	400															106	126

Cable selection according to the length for Star/Delta (⅄/△) starting (3 Phases - 380 V - 50 Hz)
Yıldız/Üçgen (⅄/△) yol vermede uzunluğa göre kablo seçimi (3 Faz - 380V - 50 Hz)

Current *Akım*	Motor Power *Motor Gücü*	Cable Cross - Section (mm²)/*Kablo Kesiti (mm²)*															
		1	1,5	2,5	4	6	10	16	25	35	50	70	95	120	150	185	240
A	HP	Maximum Cable Length (m)/*Maksimum Kablo Boyu (m)*															
7	4	85	126	209	336	504	821										
10	5,5	62	92	152	244	367	598	938									
13	7,5		67	111	178	267	436	884	1056								
17	10		52	86	137	206	337	528	816								
21	12,5			69	110	166	270	424	655	892							
25	15				94	141	229	360	556	757	991						
28	17,5				81	122	199	312	481	656	858						
32	20				71	107	174	273	422	575	754	1041					
40	25					85	139	218	337	460	603	833	1094				
47	30						118	186	287	391	515	712	935				
54	35						103	162	250	341	447	617	811	972			
64	40							135	211	287	377	521	684	820	959		
78	50							112	173	236	309	427	561	673	787	924	
94	60								142	194	255	353	464	557	653	768	919
108	70								124	169	222	307	404	485	568	689	800
124	80									148	195	269	353	423	495	581	694
138	90										175	241	317	380	445	522	623
155	100										157	216	283	339	396	464	553
186	125											179	235	282	330	384	462
225	150												194	233	273	321	384
264	180													196	232	273	327
306	200														201	236	284
370	250															196	235
440	300																196
515	350																
590	400																

Cable selection according to the lenght for direct or auto - transformer starting (3 Phases - 380 V - 50 Hz)
Direkt veya trafo ile yol vermede uzunluğa göre kablo seçimi (3 Faz - 380 V - 50 Hz)



REQUIRED DATA FOR OFFER / *TEKLİF İÇİN GEREKLİ BİLGİLER*

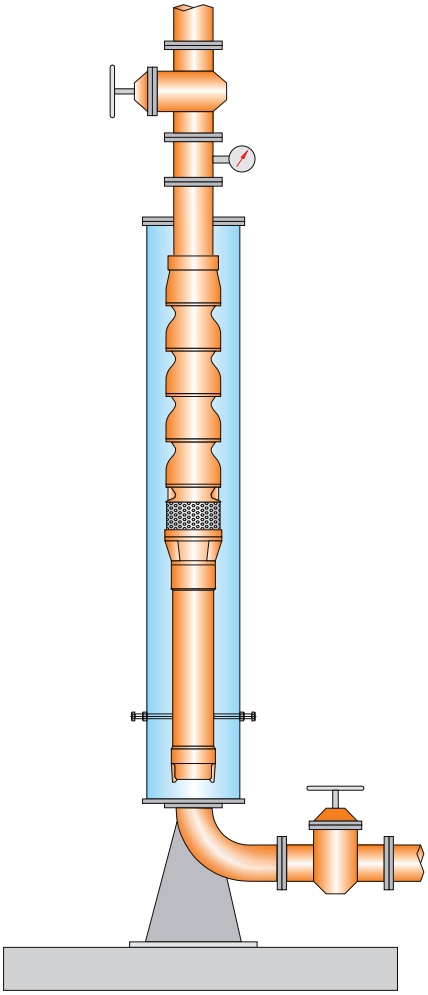
Water Properties / Su Özellikleri
- Usage / *Kullanım amacı*
- Sand content in water / *Sudaki kum miktarı (g/m³)*
- Water temperature / *Su sıcaklığı (°C)*
- pH value / *pH değeri*

Well Properties / *Kuyu Özellikleri*
- Well head altitude from sea level / *Kuyu başı rakımı (m)*
- Well depth / *Kuyu derinliği (m)*
- Well casing diameter / *Kuyu techiz çapı (mm/inch/pouce)*
- Static water level / *Statik su seviyesi (m)*
- Dynamic water level / *Dinamik su seviyesi (m)*
- Capacity / *Debi (l/s)*
- Required total manometric head / *Gereken toplam manometrik yükseklik (m)*

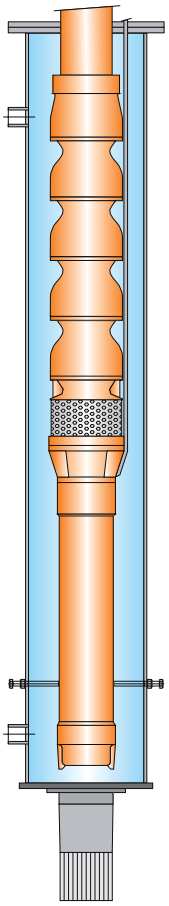
If Total Head Can Not Be Given / *Toplam Manometrik Yüksekliğin Bilinmediği Durumlarda*
- Distance between well head and water level in reservoir / *Kuyu başından depodaki su seviyesine kadar yükseklik (m)*
- Discharge line length / *Basma borusu boyu (m)*
- Discharge line diameter / *Basma borusu çapı (mm)*
- Accessories through the pipeline like valve, elbow etc. / *Basma borusu üzerindeki vana, dirsek dönüş sayısı vb.*

1. Submersible pump / *Dalgıç pompa*
2. Column pipe / *Kolon borusu*
3. Discharge elbow / *Çıkış dirseği*
4. Pressure gauge / *Manometre*
5. Discharge valve / *Ayar vanası*
6. Discharge line / *Basma borusu*
7. Reservoir / *Depo*
8. Control panel / *Elektrik panosu*
9. Power supply / *Şebeke girişi*
10. Level electrode / *Seviye elektrodları*
11. Motor cable / *Motor kablosu*
12. Submersible motor / *Dalgıç motor*

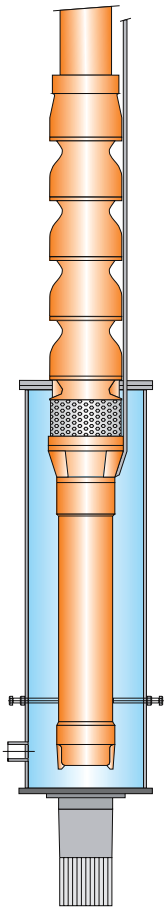
H_s Static water level / *Statik su seviyesi*
H_d Dynamic water level / *Dinamik su seviyesi*
H_{min} Minumum water level / *Minimum su seviyesi*
D Well depth / *Kuyu derinliği*
D_w Well casing diameter / *Kuyu çapı*



Suction Through Pipeline
Boru Hattı Beslemeli Emiş

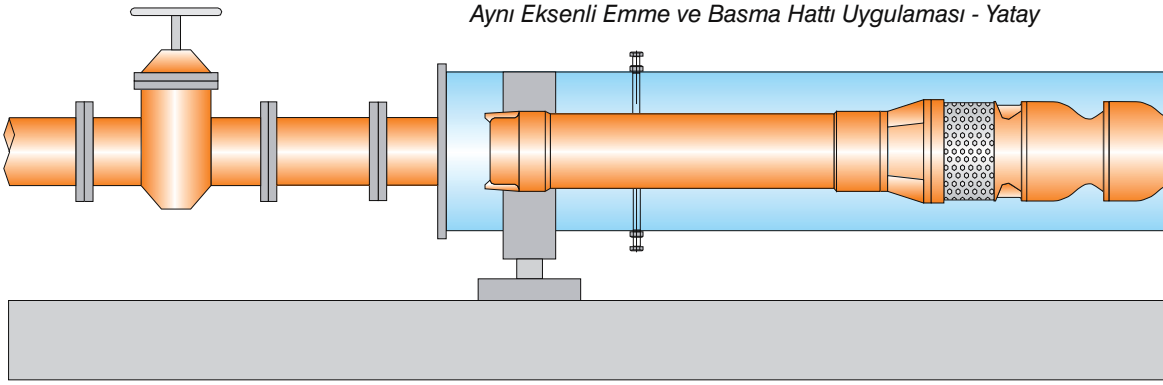


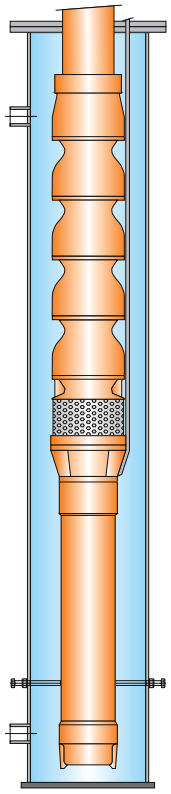
Suction Through Reservoir
Rezervuardan Beslemeli Emiş



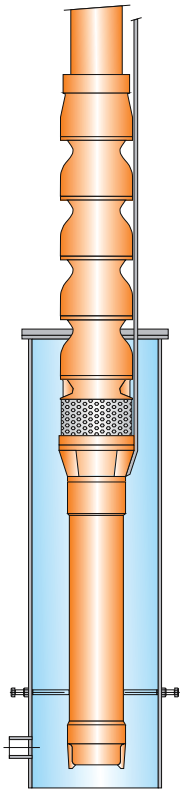
Suction Through Reservoir
Rezervuardan Beslemeli Emiş

Serial Suction and Delivery Example - Horizontal
Aynı Eksenli Emme ve Basma Hattı Uygulaması - Yatay

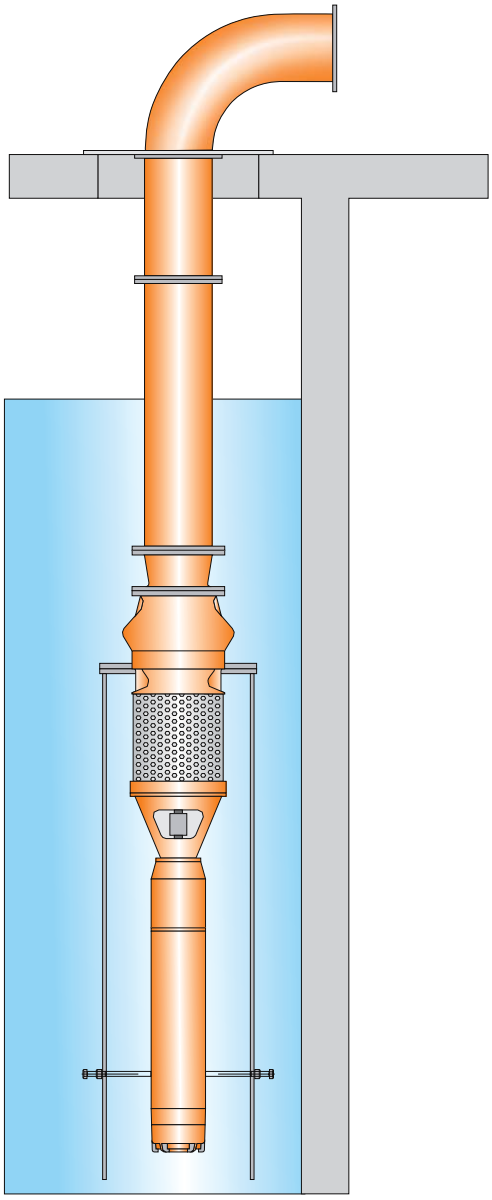


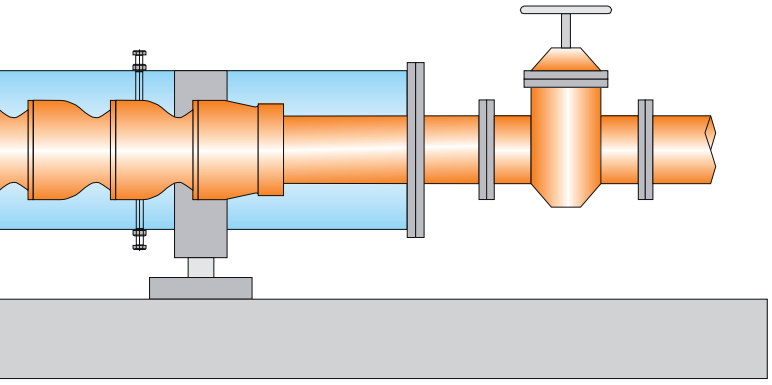


Suction Through a Reservoir - Cooling Shell
Rezervuardan Beslemeli Emiş - Soğutma Ceketli



Suction Through a Reservoir - Cooling Shell
Rezervuardan Beslemeli Emiş - Soğutma Ceketli

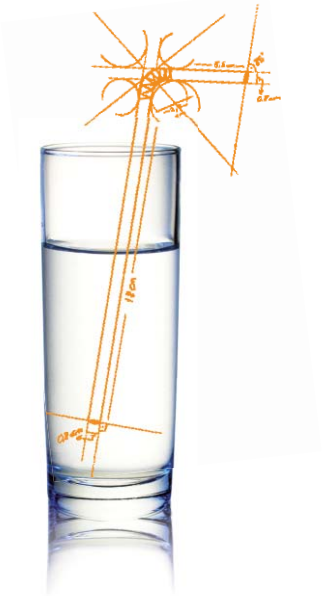




Suction Through a Reservoir - Flanged Delivery Line - Cooling Jacket
Rezervuardan Beslemeli Emiş - Flanşlı Basma Hattı - Soğutma Ceketli

Taste the Engineering

MÜHENDİSLİĞİN tadına varın



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APPENDIX B
HISTORICAL WATER QUALITY DATA

Table B1 - Lynden Raw Water Quality Data

	Units	07-Feb-06	03-May-06	09-Aug-06	02-Nov-06	07-Feb-07	09-May-07	15-Aug-07	07-Nov-07	05-Feb-08	07-May-08	14-Aug-08	05-Nov-08	18-Feb-09	07-May-09	12-Aug-09	03-Nov-09	09-Feb-10	28-May-10	17-Aug-10	25-Nov-10	16-Feb-11	19-May-11	24-Aug-11
General Parameters																								
Alkalinity	mg/L																							
Colour (apparent)	CU																							
Colour (true)	CU																							
Conductivity	umhos/cm																							
Dissolved Organic Carbon	mg/L																							
pH	pH																							
Hardness	mg/L																							
Temperature - Field	C																							
Total Dissolved Solids	mg/L																							
Total Organic Carbon	mg/L	0.8	0.7	0.6	<0.4	<0.4	0.5	<0.4	<0.4	0.7	0.5	0.5	0.6	1	0.5	1.1	0.5	0.5	0.7	0.7	0.8	0.7	0.5	1.1
Nutrients																								
Ammonia + Ammonium as N	mg/L																							
Nitrate as N	mg/L																							
Nitrate+Nitrite as N	mg/L																							
Nitrite as N	mg/L																							
Other																								
Mercury	µg/L																							
Chloride	mg/L																							
Fluoride	mg/L																							
Sulphate	mg/L																							
Sulphide	mg/L	1.43	2.24	1.92	2.65	1.66	1.33	1.04	0.99	<0.02	2.01	<0.02	3.79	3.4	0.49	3.1	0.48	2.6	2.7	2.1	2.7	2.3	2.7	2.4
Total Trihalomethanes	µg/L																							
Metals																								
Aluminum	mg/L																							
Antimony	mg/L																							
Arsenic	mg/L																							
Barium	mg/L																							
Beryllium	mg/L																							
Bismuth	mg/L																							
Boron	mg/L																							
Cadmium	mg/L																							
Calcium	mg/L																							
Chromium	mg/L																							
Cobalt	mg/L																							
Copper	mg/L																							
Iron	mg/L																							
Lead	mg/L																							
Magnesium	mg/L																							
Manganese	mg/L																							
Molybdenum	mg/L																							
Nickel	mg/L																							
Potassium	mg/L																							
Selenium	mg/L																							
Silver	mg/L																							
Sodium	mg/L																							
Strontium	mg/L																							
Thallium	mg/L																							
Tin	mg/L																							
Titanium	mg/L																							
Uranium	mg/L																							
Vanadium	mg/L																							
Zinc	µg/L																							

Table B2 - Lynden Treated Water Quality Data

		2006				2007					2008					2009				2010					2011		
	Units	07-Feb-06	03-May-06	09-Aug-06	02-Nov-06	07-Feb-07	09-May-07	11-May-07	15-Aug-07	07-Nov-07	05-Feb-08	07-May-08	14-Aug-08	20-Aug-08	05-Nov-08	18-Feb-09	07-May-09	12-Aug-09	03-Nov-09	09-Feb-10	28-May-10	08-Jun-10	17-Aug-10	25-Nov-10	16-Feb-11	19-May-11	24-Aug-11
General Parameters																											
Alkalinity	mg/L	94	97	94	92	95	93		94	94	94	91		92	93	92	92	94	93	92	94		93	92	94	91	92
Colour (apparent)	CU	<2	<2	3	4	2	2		4	<2	<2	4	4		<2	4	5	5	<2	<2	2		7	2	<2	<2	3
Colour (true)	CU	<2	<2	<2	2	<2	<2		<2	<2	<2	<2	4		<2	<2	4	<2	<2	<2	<2		<2	<2	<2	<2	<2
Conductivity	umhos/cm	391	406	402	401	404	371		388	381	376	367	387		389	364	374	359	386	382	363		376	367	371	374	378
Dissolved Organic Carbon	mg/L																										
pH	pH	8.26	8.29	8.3	8.27	8.23	8.25		8.16	8.05	8.09	8.03		8.17	8.12	8.08	8.21	8.2	8.24	8.23	8.23		8.25	8.24	8.23	8.2	8.27
Hardness	mg/L	55.2	58.8	50	49.2	52.1	50.5		50.7	50.8	52.1	50.5	49		50.3	50.5	50.8	50.1	49	45.9	50		48.5	49.8	51.3	49.7	51
Temperature - Field	C																									16.3	
Total Dissolved Solids	mg/L	230	272	228	240	238	220		212	256	210	230	233		204	235	198	194	239	206	230		202	196	204	207	209
Total Organic Carbon	mg/L	0.8					0.6		<0.4	0.5	0.7	0.4	0.5		0.6	0.7	0.6	1.1	0.5	<0.4	0.8		0.6	0.8	0.7	0.6	0.8
Nutrients																											
Ammonia + Ammonium as N	mg/L	<0.01	<0.01	<0.01	<0.1	<0.01	<0.01		<0.01	<0.01	0.01	0.03	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.02	0.02	0.02	0.02	0.02	<0.1		0.02	0.03	0.02	0.03	0.03		0.03	0.02	0.02	0.02	0.05	0.03	0.01		0.02	0.02	0.02	0.02	0.02
Nitrate+Nitrite as N	mg/L	0.02	0.02	0.02	0.02	0.02	<0.1		0.02	0.03	0.02	0.03	0.03		0.03	0.02	0.02	0.02	0.05	0.03	<0.02		0.02	0.02	0.02	0.02	0.02
Nitrite as N	mg/L	<0.01	<0.1	<0.1	<0.1	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01
Other																											
Mercury	µg/L	<0.1				<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05
Chloride	mg/L	42.8	44.1	46.7	46.2	42.8	46		44.8	45.6	45.4	41	44.2		44.2	41.8	41.3	41	43.4	42.1	43.9		42.4	41.7	40.9	38.8	41.3
Fluoride	mg/L	0.62	0.64	0.63	0.63	0.64	0.62		0.62	0.57	0.61	0.61	0.64		0.61	0.66	0.69	0.69	0.68	0.68	0.64		0.64	0.65	0.64	0.64	0.67
Sulphate	mg/L	29.3	26.8	26.1	26.7	26.4	24		27.2	27.6	28.4	26.4	27.2		29.3	28.2	25.2	27.8	28.7	27.1	27.2		27.2	27.1	27	26.7	27.2
Sulphide	mg/L	<0.02					<0.02		<0.02	<0.02	0.94	<0.02	2.59		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02
Total Trihalomethanes	µg/L	27.9	29.3	26.9	31	27.5	28.5		31	30.9	29.5	29	32.7		31.4	33.4	34	34	37	35.5	25.3		35.5	32.8	33.2	32.5	24.3
Metals																											
Aluminum	mg/L	<0.05	<0.005	0.024	0.009	0.003	<0.002		0.009	0.008	0.005	0.006	0.002		0.005	0.009	0.008	0.009	0.006	0.003	0.005		0.004	0.003	0.003	0.002	0.004
Antimony	mg/L	<0.0006	<0.001	<0.0006	<0.0006	<0.0006	<0.0006		<0.0006	<0.0006	<0.0006	<0.0006	<0.0006		<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006		<0.0006	<0.0006	<0.0006	<0.0006	<0.0006
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	0.385	0.41	0.397	0.394	0.391	0.43		0.433	0.421	0.432	0.431	0.429		0.434	0.424	0.433	0.463	0.447	0.434	0.463		0.472	0.444	0.455	0.465	0.474
Beryllium	mg/L	<0.001	<0.0005	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	mg/L	<0.10	<0.001	<0.020	<0.020	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020
Boron	mg/L	0.469	0.45	0.524	0.481	0.465	0.48		0.476	0.465	0.487	0.479	0.473		0.472	0.489	0.493	0.48	0.458	0.441	0.476		0.48	0.447	0.47	0.468	0.475
Cadmium	mg/L	<0.001	<0.0001	<0.0005	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Calcium	mg/L	9.4	11	9.32	9.13	9.72	9.3		9.34	9.36	9.68	9.41	8.96		9.41	9.35	9.57	9.29	9.15	8.5	9.32		9.1	9.35	9.67	9.17	9.41
Chromium	mg/L	<0.002	<0.005	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	0.002	<0.001	<0.001	0.002		<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	<0.0009	<0.0005	<0.0009	<0.0009	<0.0009	<0.0009		<0.0009	<0.0009	<0.0009	<0.0009	<0.0009		<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009		<0.0009	<0.0009	<0.0009	<0.0009	<0.0009
Copper	mg/L	<0.005	0.002	<0.002	<0.005	<0.002	0.020		0.013	0.055	0.083	0.005	0.004		0.054	0.108	0.114	0.031	0.074	0.020	<0.002		0.018	<0.002	<0.002	0.009	0.009
Iron	mg/L	<0.020	<0.05	<0.010	0.013	0.012	<0.010		0.037	0.018	0.018	0.018	0.011		0.024	0.042	0.023	0.027	0.179	0.029	0.015		0.053	<0.010	<0.010	0.013	0.012
Lead	mg/L	<0.001	<0.0005	<0.001	<0.001	<0.001	0.002	0.002	<0.001	0.003	0.006	<0.001	<0.001		0.004	0.010	0.009	<0.0010	<0.0010	<0.0010	<0.0010		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Magnesium	mg/L	7.7	7.6	6.49	6.42	6.75	6.63		6.65	6.65	6.78	6.55	6.47		6.5	6.6	6.53	6.54	6.36	5.98	6.49		6.26	6.43	6.6	6.52	6.68
Manganese	mg/L	0.002	<0.002	0.002	0.001	0.002	0.002		0.002	0.002	0.002	0.002	0.002		0.002	0.002	0.002	0.002	0.004	0.002	0.002		0.004	0.002	0.002	0.002	0.002
Molybdenum	mg/L	<0.010	0.002	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005
Nickel	mg/L	<0.010	<0.001	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005
Potassium	mg/L	1	1	1.46	1.37	1.14	1.14		1.31	1.05	1.08	1.05	1		1.02	1	1.08	1.07	1.01	1	1.02		1.03	1.02	1.08	1.06	1.03
Selenium	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002
Silver	mg/L	<0.005	<0.0001	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005
Sodium	mg/L	58.9	67	64.9	63	61.2	60.2		61.4	59.9	61.3	58.8	63		58.8	62.2	58.5	57.7	57.5	54.8	58	55.4	57.5	57	56.6	56.8	57.2
Strontium	mg/L	0.808	0.75	0.791	0.81	0.778	0.816		0.809	0.804	0.815	0.801	0.767		0.798	0.787	0.8	0.792	0.764	0.753	0.785		0.809	0.762	0.769	0.784	0.781
Thallium	mg/L	<0.10	<0.00005	<>0.010	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010		<0.010	<0.010	<0.010	<0.010	<0.010
Tin	mg/L	<0.02	<0.001	<0.020	<0.020	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020
Titanium	mg/L	<0.002	<0.005	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L		<0.0001				<0.0001					<0.0001					<0.0001				<0.0001					<0.0001	
Vanadium	mg/L	<0.010	<0001	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002
Zinc	mg/L	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	0.020	<0.005	<0.005	<0.005		<0.005	0.046	0.009	<0.005	0.006	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005
Calculated Langelier Index	LSI	-0.05	0.02	-0.05	-0.10	-0.10	-0.10	0.00	-0.18	-0.30	-0.24	-0.33	0.00	0.00	-0.23	-0.28	-0.14	-0.14	-0.13	-0.16	-0.12	0.00	-0.11	-0.11	-0.10	-0.16	-0.08

Table B3 - Lynden Distribtuion Water Quality Data - Sampling Station Lynden A Margaret Street

	Units	07-Feb-06	03-May-06	09-Aug-06	02-Nov-06	07-Feb-07	13-Aug-07	07-Nov-07	05-Feb-08	07-May-08	14-Aug-08	05-Nov-08	18-Feb-09	07-May-09	11-Aug-09	05-Nov-09	09-Feb-10	26-May-10	17-Aug-10	25-Nov-10	16-Feb-11	19-May-11	23-Aug-11
General Parameters																							
Alkalinity (mg/L)	mg/L																						
Colour (apparent) (CU)	CU																						
Colour (true) (CU)	CU																						
Conductivity (umhos/cm)	umhos/cm																						
Dissolved Organic Carbon (mg/L)	mg/L					0.4	0.9	1.4	0.6	0.9	0.7	0.8	0.8	0.6	0.7	0.4	0.4	0.9	0.8	0.4	0.8	0.8	1
pH (pH)	pH																						
Hardness (mg/L)	mg/L																						
Temperature - Field (C)	C																					8.7	
Total Dissolved Solids (mg/L)	mg/L																						
Total Organic Carbon (mg/L)	mg/L																						
Nutrients																							
Ammonia + Ammonium as N (mg/L)	mg/L																						
Nitrate as N (mg/L)	mg/L																						
Nitrate+Nitrite as N (mg/L)	mg/L																						
Nitrite as N (mg/L)	mg/L																						
Other																							
Mercury (ug/L)	µg/L																						
Chloride (mg/L)	mg/L																						
Fluoride (mg/L)	mg/L																						
Sulphate (mg/L)	mg/L																						
Sulphide (mg/L)	mg/L																						
Total Trihalomethanes (ug/L)	µg/L						105	80.5	44.5	49.7	90.8	61	46	56	95	78	49	63	144	57	47	55	79
Metals																							
Aluminum (mg/L)	mg/L																						
Antimony (mg/L)	mg/L																						
Arsenic (mg/L)	mg/L																						
Barium (mg/L)	mg/L																						
Beryllium (mg/L)	mg/L																						
Bismuth (mg/L)	mg/L																						
Boron (mg/L)	mg/L																						
Cadmium (mg/L)	mg/L																						
Calcium (mg/L)	mg/L																						
Chromium (mg/L)	mg/L																						
Cobalt (mg/L)	mg/L																						
Copper (mg/L)	mg/L																						
Iron (mg/L)	mg/L																						
Lead (mg/L)	mg/L					<0.001	0.001																
Magnesium (mg/L)	mg/L																						
Manganese (mg/L)	mg/L																						
Molybdenum (mg/L)	mg/L																						
Nickel (mg/L)	mg/L																						
Potassium (mg/L)	mg/L																						
Selenium (mg/L)	mg/L																						
Silver (mg/L)	mg/L																						
Sodium (mg/L)	mg/L																						
Strontium (mg/L)	mg/L																						
Thallium (mg/L)	mg/L																						
Tin (mg/L)	mg/L																						
Titanium (mg/L)	mg/L																						
Uranium (mg/L)	mg/L																						
Vanadium (mg/L)	mg/L																						
Zinc (mg/L)	mg/L																						

Table B4 - Lynden Water Quality Results, Lead (mg/L)

			Distribution																																																	
					Barnabus Street (Street No.)										Governors Road		Howard Street				Lynden Road																Margaret Street			Park Street	Union Street			Hydrant		Blow off valve					
	Raw	Treated	Sampling Station A	Sampling Station B	8	9	15	17	26	27	30	43	47	50	3977	3989	59	61	63	79	26	27	36	55	60	61	65	66	75	79	85	86	88	89	95	128	7	20	26	25	6	7	12	FY01 WS02	FY02 WS02	FY01 V003	FY02 V005	FY02 V008	FY02 V014	FY02 WS02	FY03 V014
7-Feb-06		<0.001	<0.001																																																	
21-Feb-06		<0.001	<0.001																																																	
3-May-06		<0.0005	<0.001																																																	
9-Aug-06		<0.001	<0.001																																																	
2-Nov-06		<0.001	<0.001																																																	
7-Feb-07		<0.001	<0.001																																																	
22-Feb-07		<0.001																																																		
9-May-07		0.002	<0.001																																																	
11-May-07		0.002	0.001																																																	
15-Aug-07		<0.001																																																		
7-Nov-07		0.003																																																		
31-Jan-08		0.006		0.004												<0.001	<0.001	<0.001	<0.001	<0.001				<0.001		<0.001		<0.001												<0.001												
5-Feb-08		0.006																																																		
31-Mar-08									<0.001			<0.001										<0.001			<0.001				<0.001								<0.001							<0.001	<0.001						
31-Mar-08									<0.001			<0.001										<0.001			<0.001				<0.001								<0.001														
3-Apr-08																											<0.001																									
3-Apr-08																											<0.001																									
7-May-08		<0.001																																																		
14-Aug-08		<0.001																																																		
7-Oct-08									<0.001								<0.001					<0.001																													
7-Oct-08									<0.001								<0.001					<0.001																													
8-Oct-08																<0.001		<0.001	<0.001	<0.001				<0.001				<0.001												<0.001			<0.001	<0.001						
8-Oct-08																<0.001		<0.001	<0.001	<0.001				<0.001				<0.001												<0.001											
14-Oct-08																										<0.001																										
14-Oct-08																										<0.001																										
5-Nov-08		0.004																																																		
11-Feb-09		0.009		0.004																																								0.010							
18-Feb-09		0.010	0.005																																																	
24-Feb-09			0.005	0.016			0.005	0.005			0.005	0.005												0.007	0.007	0.007	0.097				0.006						0.006		0.005												
24-Feb-09							0.005	0.005			0.005	0.004												0.006	0.006	0.006	0.008				0.006						0.006		0.005												
26-Feb-09																																												0.010							
27-Feb-09																											0.006																									
27-Feb-09																											0.005																									
2-Mar-09	0.005	0.007		<0.001																							0.007																									
9-Apr-09		0.009		0.007																																																
5-May-09		0.009		0.069																																																
7-May-09		0.009																																																		
11-May-09		0.006		0.006																																																
17-Jun-09	<0.001	0.004	0.003	0.004																																																
30-Jun-09	<0.001	0.014	0.003	0.003																																																
6-Jul-09		0.022	0.011	0.007																																																
8-Jul-09	<0.001	0.049																																																		
9-Jul-09	<0.001																																																			
15-Jul-09	<0.001	0.002	0.003	0.004																																																
5-Aug-09			0.001	0.001																																																
12-Aug-09		<0.001																																																		
19-Aug-09			0.005	0.005																																																
28-Aug-09		<0.001	0.001	0.002																																																
2-Sep-09		0.001	<0.001	<0.001																																																
17-Sep-09		<0.001	0.006	0.001																																																
30-Sep-09		0.002	0.001	0.002																																																
14-Oct-09		0.001	<0.001	<0.001																																																
15-Oct-09			<0.001	<0.001		<0.001						<0.001	<0.001				<0.001							0.002								<0.001	<0.001	0.003			<0.001	<0.001		<0.001			0.001								
15-Oct-09						<0.001						0.001	<0.001				<0.001							0.002								0.003	<0.001	0.003			<0.001	<0.001		<0.001			<0.001								
28-Oct-09		<0.001	<0.001	<0.001																																																
3-Nov-09		<0.001																																																		
11-Nov-09		<0.001	<0.001	<0.001																																																
25-Nov-09		<0.001	<0.001	<0.001																																																
9-Dec-09		<0.001	<0.001	<0.001																																																
16-Dec-09			0.001	<0.001		<0.001				<0.001		<0.001			<0.001						0.018			<0.001			<0.001						<0.001		<0.001	<0.001							<0.001								
16-Dec-09						0.001				<0.001		<0.001			<0.001						0.003			<0.001			<0.001						<0.001		<0.001	<0.001							<0.001								
23-Dec-09		<0.001	<0.001	<0.001																																																
6-Jan-10		<0.001	<0.001	<0.001																																																
20-Jan-10		<0.001	<0.001	<0.001																																																
3-Feb-10		<0.001	<0.001	<0.001																																																
9-Feb-10		<0.001																																																		
17-Feb-10			<0.001																																																	
19-Feb-10		0.001	<0.001	<0.001																																																
5-Mar-10		<0.001	<0.001	<0.001																																																
17-Mar-10		<0.001	<0.001	<0.001																																																
1-Apr-10		<0.001	<0.001	<0.001																																																
15-Apr-10		<0.001	<0.001	0.002																																																
29-Apr-10		<0.001	<0.001	<0.001																																																
13-May-10		<0.001	<0.001	<0.001																																																
28-May-10		<0.001	<0.001	<0.001																																																
11-Jun-10		<0.001	<0.001	<0.001																																																
16-Jun-10		<0.001	<0.001	<0.001																																																
30-Jun-10		<0.001	<0.001	<0.001																																																

Table B4 - Lynden Water Quality Results, Lead (mg/L)

			Distribution																																																			
					Barnabus Street (Street No.)										Governors Road		Howard Street				Lynden Road																	Margaret Street			Park Street	Union Street			Hydrant		Blow off valve					
	Raw	Treated	Sampling Station A	Sampling Station B	8	9	15	17	26	27	30	43	47	50	3977	3989	59	61	63	79	26	27	36	55	60	61	65	66	75	79	85	86	88	89	95	128	7	20	26	25	6	7	12	FY01 WS02	FY02 WS02	FY01 V003	FY02 V005	FY02 V008	FY02 V014	FY02 WS02	FY03 V014
14-Jul-10		<0.001	<0.001	<0.001																																																		
28-Jul-10		<0.001	<0.001	<0.001																																																	
17-Aug-10		<0.001																																																				
18-Aug-10		<0.001	<0.001	<0.001																																																		
31-Aug-10		<0.001	<0.001	<0.001																																																		
3-Sep-10		<0.001			<0.001	<0.001			<0.001				<0.001	<0.001									<0.001	<0.001								<0.001	<0.001		<0.001					<0.001				<0.001	<0.001							
3-Sep-10		<0.001			<0.001	<0.001			<0.001				<0.001	<0.001									<0.001	<0.001								<0.001	<0.001		<0.001					<0.001												
8-Sep-10		<0.001	<0.001	<0.001																																																	
24-Sep-10		0.001	0.003	0.006																																																	
6-Oct-10		<0.001	<0.001	<0.001																																																	
20-Oct-10		<0.001	<0.001	<0.001																																																	
3-Nov-10		<0.001	<0.001	<0.001																																																	
17-Nov-10		<0.001	<0.001	<0.001																																																	
25-Nov-10		<0.001																																																				
1-Dec-10		<0.001	<0.001	<0.001																																																	
15-Dec-10		<0.001	<0.001	<0.001																																																	
5-Jan-11		<0.001	<0.001	<0.001																																																	
18-Jan-11		<0.001	<0.001	<0.001																																																	
3-Feb-11		<0.001	<0.001	<0.001																																																	
16-Feb-11		<0.001	<0.001	<0.001																																																	
22-Feb-11			<0.001																																																			
2-Mar-11		<0.001	<0.001	0.001																																																		
16-Mar-11		<0.001	<0.001	<0.001																																																		
31-Mar-11					<0.001			<0.001							<0.001		<0.001							<0.001						<0.001		<0.001				<0.001				<0.001		<0.001	<0.001	<0.001	<0.001							
31-Mar-11					<0.001			<0.001							<0.001		<0.001							<0.001						<0.001		<0.001				<0.001				<0.001		<0.001	<0.001									
6-Apr-11		<0.001	<0.001	<0.001																																																		
20-Apr-11		<0.001	<0.001	<0.001																																																		
4-May-11		<0.001	<0.001	<0.001																																																		
19-May-11		<0.001	<0.001	<0.001																																																		
1-Jun-11		<0.001	<0.001	<0.001																																																		
15-Jun-11		<0.001	<0.001	<0.001																																																		
6-Jul-11		<0.001	0.002	0.001																																																		
20-Jul-11		0.003	<0.001	<0.001																																																		
5-Aug-11		<0.001	<0.001	<0.001																																																		
17-Aug-11		0.018	<0.001	<0.001																																																		
18-Aug-11		<0.001	<0.001	<0.001																																																		
19-Aug-11	<0.001	<0.001	<0.001	<0.001																																																		
4-Sep-11																																												0.002	0.006	0.002	0.006	0.010	0.028	0.015	0.009
6-Sep-11		0.012																																												0.001	0.012	0.002		<0.001	0.019
7-Sep-11		0.002	<0.001	<0.001																																										0.006		0.027		0.016
21-Sep-11		<0.001	<0.001	<0.001																																																		

Notes:

1. Sampling Station A - Margaret Street, Sampling Station B - Barnabus Street
2. Red denotes samples at or above ODWS MAC of 0.1 mg/L for lead, Green and Yellow denotes lad concentrations between 0.001 to 0.009 mg/L, Grey denots lead concentratios below the detection limit of 0.001 mg/L

Figure B1
Lynden Distribution System
Water Quality, Lead
2007-08

Water Sampling Locations

- Lead Levels Elevated (0.001 to 0.009 mg/L)
- Lead Levels Exceed ODWS MAC of 0.01 mg/L)

N

XCG
Environmental Engineers & Scientists

0 100 200 300
Meters

Figure B2
Lynden Distribution System
Water Quality, Lead
2009

Water Sampling Locations

- Lead Levels Elevated (0.001 to 0.009 mg/L)
- Lead Levels Exceed ODWS MAC of 0.01 mg/L)

N

XCG
Environmental Engineers & Scientists

0 100 200 300
Meters

Figure B3
Lynden Distribution System
Water Quality, Lead
2010

Water Sampling Locations

- Lead Levels Elevated (0.001 to 0.009 mg/L)
- Lead Levels Exceed ODWS MAC of 0.01 mg/L)

N

XCG
Environmental Engineers & Scientists

0 100 200 300
Meters

Figure B4
Lynden Distribution System
Water Quality, Lead
2011

Water Sampling Locations

- Lead Levels Elevated (0.001 to 0.009 mg/L)
- Lead Levels Exceed ODWS MAC of 0.01 mg/L)

N

XCG
Environmental Engineers & Scientists

0 100 200 300
Meters

APPENDIX C

MONITORING PROGRAM LABORATORY REPORTS

Maxxam

Success Through Science®

Your C.O.C. #: 0057343

Attention: Kasia Piskorz
XCG Consultants Ltd
2620 Bristol Cir
Suite 300
Oakville, ON
L6H 6Z7

Report Date: 2011/12/08

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B1I9571
Received: 2011/12/01, 14:35

Sample Matrix: Water
Samples Received: 8

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Alkalinity	8	N/A	2011/12/05	CAM SOP-00448	SM 2320B
Total Chlorine	7	2011/12/01	2011/12/01	CAM SOP 00425	SM4500CL-G
Chloride by Automated Colourimetry	3	N/A	2011/12/05	CAM SOP-00463	SM 4500 Cl E
Chloride by Automated Colourimetry	5	N/A	2011/12/06	CAM SOP-00463	SM 4500 Cl E
Hardness (calculated as CaCO3)	8	N/A	2011/12/07	CAM SOP 00102	SM 2340 B
Metals Analysis by ICPMS (as received) (1)	5	2011/12/05	2011/12/06	CAM SOP-00447	EPA 6020
Metals Analysis by ICPMS (as received) (1)	3	2011/12/06	2011/12/07	CAM SOP-00447	EPA 6020
Nitrate (NO3) and Nitrite (NO2) in Water (2)	8	N/A	2011/12/05	CAM SOP-00440	SM 4500 NO3I/NO2B
pH	8	N/A	2011/12/05	CAM SOP-00448	SM 4500H
Sulphate by Automated Colourimetry	3	N/A	2011/12/05	CAM SOP-00464	EPA 375.4
Sulphate by Automated Colourimetry	5	N/A	2011/12/06	CAM SOP-00464	EPA 375.4
Sulphide	8	N/A	2011/12/05	CAM SOP-00455	SM 4500-S G
Total Dissolved Solids (TDS calc)	8	N/A	2011/12/07		
Turbidity	8	N/A	2011/12/03	CAM SOP-00417	APHA 2130B

Remarks:

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act.

The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following the 'Alberta Environment Draft Addenda to the CWS-PHC, Appendix 6, Validation of Alternate Methods'. Documentation is available upon request. Maxxam has made the following improvements to the CWS-PHC reference benchmark method: (i) Headspace for F1; and, (ii) Mechanical extraction for F2-F4. Note: F4G cannot be added to the C6 to C50 hydrocarbons. The extraction date for samples field preserved with methanol for F1 and Volatile Organic Compounds is considered to be the date sampled.

Maxxam Analytics is accredited by SCC (Lab ID 97) for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

(1) Metals analysis was performed on the sample 'as received'.
(2) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

../2

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

XCG Consultants Ltd

Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MARIJANE CRUZ, Project Manager
Email: MCruz@maxxam.ca
Phone# (905) 817-5756

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

Total cover pages: 2

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

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Success Through Science®

XCG Consultants Ltd

Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

RESULTS OF ANALYSES OF WATER

Maxxam ID		LV4513		LV4514	LV4515		LV4516		
Sampling Date		2011/12/01		2011/12/01	2011/12/01		2011/12/01		
	Units	**RAW**	**QC Batch**	**CELL**	**TREATED**	**QC Batch**	**LIBERTY**	**RDL**	**QC Batch**
Calculated Parameters									
Calculated TDS	mg/L	202	2699472	210	207	2699472	208	1	2699472
Hardness (CaCO3)	mg/L	53	2699392	53	51	2699392	52	1	2699392
Inorganics									
Total Chlorine	mg/L			2.0	1.9	2700446	1.6	0.1	2700446
pH	pH	8.00	2701556	8.13	8.14	2701556	8.28		2701556
Dissolved Sulphate (SO4)	mg/L	24	2701476	24	24	2703012	24	1	2703012
Sulphide	mg/L	2.6	2700899	ND	ND	2700899	ND	0.02	2700899
Turbidity	NTU	ND	2700985	0.7	0.7	2701521	0.9	0.2	2701521
Alkalinity (Total as CaCO3)	mg/L	92	2701528	93	95	2701528	96	1	2701528
Dissolved Chloride (Cl)	mg/L	37	2701468	40	40	2702999	40	1	2702999
Nitrite (N)	mg/L	ND	2702323	ND	ND	2702323	ND	0.01	2701201
Nitrate (N)	mg/L	ND	2702323	ND	ND	2702323	ND	0.1	2701201
Nitrate + Nitrite	mg/L	ND	2702323	ND	ND	2702323	ND	0.1	2701201

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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

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XCG Consultants Ltd

Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

RESULTS OF ANALYSES OF WATER

Maxxam ID		LV4517	LV4518		LV4519		LV4520		
Sampling Date		2011/12/01	2011/12/01		2011/12/01		2011/12/01		
	Units	**BARNABUS-1**	**BARNABUS-2**	**QC Batch**	**MARGARET-1**	**QC Batch**	**MARGARET-2**	**RDL**	**QC Batch**
Calculated Parameters									
Calculated TDS	mg/L	220	213	2699472	210	2699472	212	1	2699472
Hardness (CaCO3)	mg/L	58	55	2699392	54	2699392	55	1	2699392
Inorganics									
Total Chlorine	mg/L	1.0	1.3	2700446	1.4	2700446	1.3	0.1	2700446
pH	pH	8.65	8.42	2701556	8.45	2701556	8.47		2701556
Dissolved Sulphate (SO4)	mg/L	26	24	2703012	25	2701476	24	1	2701476
Sulphide	mg/L	ND	ND	2700899	ND	2700899	ND	0.02	2700899
Turbidity	NTU	0.5	0.9	2701521	0.4	2700985	0.7	0.2	2700985
Alkalinity (Total as CaCO3)	mg/L	101	97	2701528	98	2701528	99	1	2701528
Dissolved Chloride (Cl)	mg/L	40	40	2702999	40	2701468	40	1	2701468
Nitrite (N)	mg/L	ND	ND	2702323	ND	2701201	ND	0.01	2702323
Nitrate (N)	mg/L	ND	ND	2702323	ND	2701201	ND	0.1	2702323
Nitrate + Nitrite	mg/L	ND	ND	2702323	ND	2701201	ND	0.1	2702323

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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

XCG Consultants Ltd

Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		LV4513		LV4514		LV4515	LV4516		
Sampling Date		2011/12/01		2011/12/01		2011/12/01	2011/12/01		
	Units	**RAW**	**QC Batch**	**CELL**	**QC Batch**	**TREATED**	**LIBERTY**	**RDL**	**QC Batch**
Metals									
. Aluminum (Al)	ug/L	ND	2703328	10	2703819	6	7	5	2703328
. Antimony (Sb)	ug/L	ND	2703328	ND	2703819	ND	ND	0.5	2703328
. Arsenic (As)	ug/L	ND	2703328	ND	2703819	ND	ND	1	2703328
. Barium (Ba)	ug/L	500	2703328	460	2703819	460	430	2	2703328
. Beryllium (Be)	ug/L	ND	2703328	ND	2703819	ND	ND	0.5	2703328
. Bismuth (Bi)	ug/L	ND	2703328	ND	2703819	ND	ND	1	2703328
. Boron (B)	ug/L	490	2703328	470	2703819	480	460	10	2703328
. Cadmium (Cd)	ug/L	ND	2703328	ND	2703819	ND	ND	0.1	2703328
. Calcium (Ca)	ug/L	9400	2703328	9400	2703819	9200	9900	200	2703328
. Chromium (Cr)	ug/L	ND	2703328	ND	2703819	ND	ND	5	2703328
. Cobalt (Co)	ug/L	ND	2703328	ND	2703819	ND	ND	0.5	2703328
. Copper (Cu)	ug/L	ND	2703328	7	2703819	7	21	1	2703328
. Iron (Fe)	ug/L	ND	2703328	ND	2703819	ND	ND	100	2703328
. Lead (Pb)	ug/L	ND	2703328	ND	2703819	ND	ND	0.5	2703328
. Lithium (Li)	ug/L	7	2703328	ND	2703819	6	5	5	2703328
. Magnesium (Mg)	ug/L	7200	2703328	7100	2703819	6800	6700	50	2703328
. Manganese (Mn)	ug/L	ND	2703328	ND	2703819	ND	ND	2	2703328
. Molybdenum (Mo)	ug/L	1.8	2703328	1.8	2703819	1.7	1.7	0.5	2703328
. Nickel (Ni)	ug/L	ND	2703328	ND	2703819	ND	ND	1	2703328
. Phosphorus (P)	ug/L	ND	2703328	ND	2703819	ND	ND	100	2703328
. Potassium (K)	ug/L	1000	2703328	1000	2703819	950	970	200	2703328
. Selenium (Se)	ug/L	ND	2703328	ND	2703819	ND	ND	2	2703328
. Silicon (Si)	ug/L	4900	2703328	4800	2703819	4600	4700	50	2703328
. Silver (Ag)	ug/L	ND	2703328	ND	2703819	ND	ND	0.1	2703328
. Sodium (Na)	ug/L	58000	2703328	62000	2703819	59000	59000	100	2703328
. Strontium (Sr)	ug/L	810	2703328	850	2703819	780	770	1	2703328
. Tellurium (Te)	ug/L	ND	2703328	ND	2703819	ND	ND	1	2703328
. Thallium (Tl)	ug/L	ND	2703328	ND	2703819	ND	ND	0.05	2703328
. Tin (Sn)	ug/L	ND	2703328	ND	2703819	ND	ND	1	2703328
. Titanium (Ti)	ug/L	ND	2703328	ND	2703819	ND	ND	5	2703328
. Tungsten (W)	ug/L	ND	2703328	ND	2703819	ND	ND	1	2703328
. Uranium (U)	ug/L	ND	2703328	ND	2703819	ND	ND	0.1	2703328
. Vanadium (V)	ug/L	ND	2703328	ND	2703819	ND	ND	0.5	2703328
. Zinc (Zn)	ug/L	ND	2703328	8	2703819	ND	5	5	2703328

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B1I9571
Report Date: 2011/12/08

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Sampler Initials: KP

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		LV4513		LV4514		LV4515	LV4516		
Sampling Date		2011/12/01		2011/12/01		2011/12/01	2011/12/01		
	Units	**RAW**	**QC Batch**	**CELL**	**QC Batch**	**TREATED**	**LIBERTY**	**RDL**	**QC Batch**
. Zirconium (Zr)	ug/L	ND	2703328	ND	2703819	ND	ND	1	2703328

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		LV4517	LV4518		LV4519	LV4520		
Sampling Date		2011/12/01	2011/12/01		2011/12/01	2011/12/01		
	Units	**BARNABUS-1**	**BARNABUS-2**	**QC Batch**	**MARGARET-1**	**MARGARET-2**	**RDL**	**QC Batch**
Metals								
. Aluminum (Al)	ug/L	6	6	2703819	5	5	5	2703328
. Antimony (Sb)	ug/L	ND	ND	2703819	ND	ND	0.5	2703328
. Arsenic (As)	ug/L	ND	ND	2703819	ND	ND	1	2703328
. Barium (Ba)	ug/L	400	410	2703819	400	400	2	2703328
. Beryllium (Be)	ug/L	ND	ND	2703819	ND	ND	0.5	2703328
. Bismuth (Bi)	ug/L	ND	ND	2703819	ND	ND	1	2703328
. Boron (B)	ug/L	480	460	2703819	460	450	10	2703328
. Cadmium (Cd)	ug/L	ND	ND	2703819	ND	ND	0.1	2703328
. Calcium (Ca)	ug/L	12000	11000	2703819	11000	11000	200	2703328
. Chromium (Cr)	ug/L	ND	ND	2703819	ND	ND	5	2703328
. Cobalt (Co)	ug/L	ND	ND	2703819	ND	ND	0.5	2703328
. Copper (Cu)	ug/L	14	12	2703819	14	12	1	2703328
. Iron (Fe)	ug/L	ND	ND	2703819	ND	ND	100	2703328
. Lead (Pb)	ug/L	ND	ND	2703819	ND	0.7	0.5	2703328
. Lithium (Li)	ug/L	5	ND	2703819	6	5	5	2703328
. Magnesium (Mg)	ug/L	6900	6900	2703819	6500	6600	50	2703328
. Manganese (Mn)	ug/L	ND	ND	2703819	ND	ND	2	2703328
. Molybdenum (Mo)	ug/L	1.8	1.7	2703819	1.7	1.6	0.5	2703328
. Nickel (Ni)	ug/L	ND	ND	2703819	ND	ND	1	2703328
. Phosphorus (P)	ug/L	ND	ND	2703819	ND	ND	100	2703328
. Potassium (K)	ug/L	1000	980	2703819	970	960	200	2703328
. Selenium (Se)	ug/L	ND	ND	2703819	ND	ND	2	2703328
. Silicon (Si)	ug/L	4800	4800	2703819	4600	4600	50	2703328
. Silver (Ag)	ug/L	ND	ND	2703819	ND	ND	0.1	2703328
. Sodium (Na)	ug/L	63000	62000	2703819	58000	59000	100	2703328
. Strontium (Sr)	ug/L	850	830	2703819	760	770	1	2703328
. Tellurium (Te)	ug/L	ND	ND	2703819	ND	ND	1	2703328
. Thallium (Tl)	ug/L	ND	ND	2703819	ND	ND	0.05	2703328
. Tin (Sn)	ug/L	ND	ND	2703819	ND	ND	1	2703328
. Titanium (Ti)	ug/L	ND	ND	2703819	ND	ND	5	2703328
. Tungsten (W)	ug/L	ND	ND	2703819	ND	ND	1	2703328
. Uranium (U)	ug/L	ND	ND	2703819	ND	ND	0.1	2703328
. Vanadium (V)	ug/L	ND	ND	2703819	ND	ND	0.5	2703328
. Zinc (Zn)	ug/L	10	ND	2703819	ND	ND	5	2703328

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Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		LV4517	LV4518		LV4519	LV4520		
Sampling Date		2011/12/01	2011/12/01		2011/12/01	2011/12/01		
	Units	**BARNABUS-1**	**BARNABUS-2**	**QC Batch**	**MARGARET-1**	**MARGARET-2**	**RDL**	**QC Batch**
. Zirconium (Zr)	ug/L	ND	ND	2703819	ND	ND	1	2703328

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RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B1I9571
Report Date: 2011/12/08

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Sampler Initials: KP

Test Summary

Maxxam ID LV4513
Sample ID RAW
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2701528	N/A	2011/12/05	YOGESH PATEL
Chloride by Automated Colourimetry	AC	2701468	N/A	2011/12/05	DEONARINE RAMNARINE
Hardness (calculated as CaCO3)		2699392	N/A	2011/12/07	AUTOMATED STATCHK
Metals Analysis by ICPMS (as received)	ICP/MS	2703328	2011/12/05	2011/12/06	JOHN BOWMAN
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2702323	N/A	2011/12/05	HELEN HE
pH	PH	2701556	N/A	2011/12/05	YOGESH PATEL
Sulphate by Automated Colourimetry	AC	2701476	N/A	2011/12/05	DEONARINE RAMNARINE
Sulphide	ISE/S	2700899	N/A	2011/12/05	XUANHONG QIU
Total Dissolved Solids (TDS calc)	CALC	2699472	N/A	2011/12/07	AUTOMATED STATCHK
Turbidity	TURB	2700985	N/A	2011/12/03	NEIL DASSANAYAKE

Maxxam ID LV4514
Sample ID CELL
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2701528	N/A	2011/12/05	YOGESH PATEL
Total Chlorine	COL	2700446	2011/12/01	2011/12/01	LEMENEH ADDIS
Chloride by Automated Colourimetry	AC	2702999	N/A	2011/12/06	DEONARINE RAMNARINE
Hardness (calculated as CaCO3)		2699392	N/A	2011/12/07	AUTOMATED STATCHK
Metals Analysis by ICPMS (as received)	ICP/MS	2703819	2011/12/06	2011/12/07	JOHN BOWMAN
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2702323	N/A	2011/12/05	HELEN HE
pH	PH	2701556	N/A	2011/12/05	YOGESH PATEL
Sulphate by Automated Colourimetry	AC	2703012	N/A	2011/12/06	DEONARINE RAMNARINE
Sulphide	ISE/S	2700899	N/A	2011/12/05	XUANHONG QIU
Total Dissolved Solids (TDS calc)	CALC	2699472	N/A	2011/12/07	AUTOMATED STATCHK
Turbidity	TURB	2701521	N/A	2011/12/03	NEIL DASSANAYAKE

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Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

Test Summary

Maxxam ID LV4514 Dup
Sample ID CELL
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Total Chlorine	COL	2700446	2011/12/01	2011/12/01	LEMENEH ADDIS

Maxxam ID LV4515
Sample ID TREATED
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2701528	N/A	2011/12/05	YOGESH PATEL
Total Chlorine	COL	2700446	2011/12/01	2011/12/01	LEMENEH ADDIS
Chloride by Automated Colourimetry	AC	2702999	N/A	2011/12/06	DEONARINE RAMNARINE
Hardness (calculated as CaCO3)		2699392	N/A	2011/12/07	AUTOMATED STATCHK
Metals Analysis by ICPMS (as received)	ICP/MS	2703328	2011/12/05	2011/12/06	JOHN BOWMAN
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2702323	N/A	2011/12/05	HELEN HE
pH	PH	2701556	N/A	2011/12/05	YOGESH PATEL
Sulphate by Automated Colourimetry	AC	2703012	N/A	2011/12/06	DEONARINE RAMNARINE
Sulphide	ISE/S	2700899	N/A	2011/12/05	XUANHONG QIU
Total Dissolved Solids (TDS calc)	CALC	2699472	N/A	2011/12/07	AUTOMATED STATCHK
Turbidity	TURB	2701521	N/A	2011/12/03	NEIL DASSANAYAKE

Maxxam ID LV4516
Sample ID LIBERTY
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2701528	N/A	2011/12/05	YOGESH PATEL
Total Chlorine	COL	2700446	2011/12/01	2011/12/01	LEMENEH ADDIS
Chloride by Automated Colourimetry	AC	2702999	N/A	2011/12/06	DEONARINE RAMNARINE
Hardness (calculated as CaCO3)		2699392	N/A	2011/12/07	AUTOMATED STATCHK
Metals Analysis by ICPMS (as received)	ICP/MS	2703328	2011/12/05	2011/12/06	JOHN BOWMAN
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2701201	N/A	2011/12/05	HELEN HE
pH	PH	2701556	N/A	2011/12/05	YOGESH PATEL
Sulphate by Automated Colourimetry	AC	2703012	N/A	2011/12/06	DEONARINE RAMNARINE

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Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

Test Summary

Sulphide	ISE/S	2700899	N/A	2011/12/05	XUANHONG QIU
Total Dissolved Solids (TDS calc)	CALC	2699472	N/A	2011/12/07	AUTOMATED STATCHK
Turbidity	TURB	2701521	N/A	2011/12/03	NEIL DASSANAYAKE

Maxxam ID LV4517 **Collected** 2011/12/01
Sample ID BARNABUS-1 **Shipped**
Matrix Water **Received** 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2701528	N/A	2011/12/05	YOGESH PATEL
Total Chlorine	COL	2700446	2011/12/01	2011/12/01	LEMENEH ADDIS
Chloride by Automated Colourimetry	AC	2702999	N/A	2011/12/06	DEONARINE RAMNARINE
Hardness (calculated as CaCO3)		2699392	N/A	2011/12/07	AUTOMATED STATCHK
Metals Analysis by ICPMS (as received)	ICP/MS	2703819	2011/12/06	2011/12/07	JOHN BOWMAN
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2702323	N/A	2011/12/05	HELEN HE
pH	PH	2701556	N/A	2011/12/05	YOGESH PATEL
Sulphate by Automated Colourimetry	AC	2703012	N/A	2011/12/06	DEONARINE RAMNARINE
Sulphide	ISE/S	2700899	N/A	2011/12/05	XUANHONG QIU
Total Dissolved Solids (TDS calc)	CALC	2699472	N/A	2011/12/07	AUTOMATED STATCHK
Turbidity	TURB	2701521	N/A	2011/12/03	NEIL DASSANAYAKE

Maxxam ID LV4517 Dup **Collected** 2011/12/01
Sample ID BARNABUS-1 **Shipped**
Matrix Water **Received** 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride by Automated Colourimetry	AC	2702999	N/A	2011/12/06	DEONARINE RAMNARINE
Sulphate by Automated Colourimetry	AC	2703012	N/A	2011/12/06	DEONARINE RAMNARINE

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Report Date: 2011/12/08

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Sampler Initials: KP

Test Summary

Maxxam ID LV4518
Sample ID BARNABUS-2
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2701528	N/A	2011/12/05	YOGESH PATEL
Total Chlorine	COL	2700446	2011/12/01	2011/12/01	LEMENEH ADDIS
Chloride by Automated Colourimetry	AC	2702999	N/A	2011/12/06	DEONARINE RAMNARINE
Hardness (calculated as CaCO3)		2699392	N/A	2011/12/07	AUTOMATED STATCHK
Metals Analysis by ICPMS (as received)	ICP/MS	2703819	2011/12/06	2011/12/07	JOHN BOWMAN
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2702323	N/A	2011/12/05	HELEN HE
pH	PH	2701556	N/A	2011/12/05	YOGESH PATEL
Sulphate by Automated Colourimetry	AC	2703012	N/A	2011/12/06	DEONARINE RAMNARINE
Sulphide	ISE/S	2700899	N/A	2011/12/05	XUANHONG QIU
Total Dissolved Solids (TDS calc)	CALC	2699472	N/A	2011/12/07	AUTOMATED STATCHK
Turbidity	TURB	2701521	N/A	2011/12/03	NEIL DASSANAYAKE

Maxxam ID LV4518 Dup
Sample ID BARNABUS-2
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Turbidity	TURB	2701521	N/A	2011/12/03	NEIL DASSANAYAKE

Maxxam ID LV4519
Sample ID MARGARET-1
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2701528	N/A	2011/12/05	YOGESH PATEL
Total Chlorine	COL	2700446	2011/12/01	2011/12/01	LEMENEH ADDIS
Chloride by Automated Colourimetry	AC	2701468	N/A	2011/12/05	DEONARINE RAMNARINE
Hardness (calculated as CaCO3)		2699392	N/A	2011/12/07	AUTOMATED STATCHK
Metals Analysis by ICPMS (as received)	ICP/MS	2703328	2011/12/05	2011/12/06	JOHN BOWMAN
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2701201	N/A	2011/12/05	HELEN HE
pH	PH	2701556	N/A	2011/12/05	YOGESH PATEL
Sulphate by Automated Colourimetry	AC	2701476	N/A	2011/12/05	DEONARINE RAMNARINE

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Report Date: 2011/12/08

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Test Summary

Sulphide	ISE/S	2700899	N/A	2011/12/05	XUANHONG QIU
Total Dissolved Solids (TDS calc)	CALC	2699472	N/A	2011/12/07	AUTOMATED STATCHK
Turbidity	TURB	2700985	N/A	2011/12/03	NEIL DASSANAYAKE

Maxxam ID LV4519 Dup
Sample ID MARGARET-1
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2701201	N/A	2011/12/05	HELEN HE

Maxxam ID LV4520
Sample ID MARGARET-2
Matrix Water

Collected 2011/12/01
Shipped
Received 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2701528	N/A	2011/12/05	YOGESH PATEL
Total Chlorine	COL	2700446	2011/12/01	2011/12/01	LEMENEH ADDIS
Chloride by Automated Colourimetry	AC	2701468	N/A	2011/12/05	DEONARINE RAMNARINE
Hardness (calculated as CaCO3)		2699392	N/A	2011/12/07	AUTOMATED STATCHK
Metals Analysis by ICPMS (as received)	ICP/MS	2703328	2011/12/05	2011/12/06	JOHN BOWMAN
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2702323	N/A	2011/12/05	HELEN HE
pH	PH	2701556	N/A	2011/12/05	YOGESH PATEL
Sulphate by Automated Colourimetry	AC	2701476	N/A	2011/12/05	DEONARINE RAMNARINE
Sulphide	ISE/S	2700899	N/A	2011/12/05	XUANHONG QIU
Total Dissolved Solids (TDS calc)	CALC	2699472	N/A	2011/12/07	AUTOMATED STATCHK
Turbidity	TURB	2700985	N/A	2011/12/03	NEIL DASSANAYAKE

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Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2700446	Total Chlorine	2011/12/01	NC	85 - 115	99	85 - 115	ND, RDL=0.1	mg/L	0.5	25		
2700899	Sulphide	2011/12/05	94	80 - 120	102	80 - 120	ND, RDL=0.02	mg/L	NC	20		
2700985	Turbidity	2011/12/03					ND, RDL=0.2	NTU	0.7	20	96	85 - 115
2701201	Nitrite (N)	2011/12/05	98	80 - 120	100	85 - 115	ND, RDL=0.01	mg/L	NC	25		
2701201	Nitrate (N)	2011/12/05	102	80 - 120	95	85 - 115	ND, RDL=0.1	mg/L	NC	25		
2701468	Dissolved Chloride (Cl)	2011/12/05	NC	75 - 125	106	80 - 120	ND, RDL=1	mg/L	1.1	20		
2701476	Dissolved Sulphate (SO4)	2011/12/05	NC	75 - 125	104	80 - 120	ND, RDL=1	mg/L	1.8	20		
2701521	Turbidity	2011/12/03					ND, RDL=0.2	NTU	NC	20	106	85 - 115
2701528	Alkalinity (Total as CaCO3)	2011/12/05					ND, RDL=1	mg/L	1.2	25	95	85 - 115
2702323	Nitrite (N)	2011/12/05	101	80 - 120	101	85 - 115	ND, RDL=0.01	mg/L	NC	25		
2702323	Nitrate (N)	2011/12/05	NC(1)	80 - 120	98	85 - 115	ND, RDL=0.1	mg/L	0.4	25		
2702999	Dissolved Chloride (Cl)	2011/12/06	NC	75 - 125	104	80 - 120	ND, RDL=1	mg/L	0.2	20		
2703012	Dissolved Sulphate (SO4)	2011/12/06	NC	75 - 125	104	80 - 120	ND, RDL=1	mg/L	8.2	20		
2703328	. Aluminum (Al)	2011/12/06	98	80 - 120	99	80 - 120	ND, RDL=5	ug/L				
2703328	. Antimony (Sb)	2011/12/06	99	80 - 120	95	80 - 120	ND, RDL=0.5	ug/L	NC	20		
2703328	. Arsenic (As)	2011/12/06	98	80 - 120	96	80 - 120	ND, RDL=1	ug/L	NC	20		
2703328	. Barium (Ba)	2011/12/06	96	80 - 120	97	80 - 120	ND, RDL=2	ug/L	0.8	20		
2703328	. Beryllium (Be)	2011/12/06	99	80 - 120	98	80 - 120	ND, RDL=0.5	ug/L				
2703328	. Bismuth (Bi)	2011/12/06	96	80 - 120	96	80 - 120	ND, RDL=1	ug/L				
2703328	. Boron (B)	2011/12/06	98	80 - 120	102	80 - 120	ND, RDL=10	ug/L	NC	20		
2703328	. Cadmium (Cd)	2011/12/06	98	80 - 120	96	80 - 120	ND, RDL=0.1	ug/L	NC	20		
2703328	. Calcium (Ca)	2011/12/06	NC	80 - 120	96	80 - 120	ND, RDL=200	ug/L				
2703328	. Chromium (Cr)	2011/12/06	99	80 - 120	98	80 - 120	ND, RDL=5	ug/L	NC	20		
2703328	. Cobalt (Co)	2011/12/06	96	80 - 120	98	80 - 120	ND, RDL=0.5	ug/L				
2703328	. Copper (Cu)	2011/12/06	94	80 - 120	97	80 - 120	ND, RDL=1	ug/L				
2703328	. Iron (Fe)	2011/12/06	97	80 - 120	98	80 - 120	ND, RDL=100	ug/L				
2703328	. Lead (Pb)	2011/12/06	95	80 - 120	97	80 - 120	ND, RDL=0.5	ug/L				
2703328	. Lithium (Li)	2011/12/06	97	80 - 120	97	80 - 120	ND, RDL=5	ug/L				
2703328	. Magnesium (Mg)	2011/12/06	NC	80 - 120	98	80 - 120	ND, RDL=50	ug/L				
2703328	. Manganese (Mn)	2011/12/06	96	80 - 120	97	80 - 120	ND, RDL=2	ug/L				
2703328	. Molybdenum (Mo)	2011/12/06	101	80 - 120	99	80 - 120	ND, RDL=0.5	ug/L				
2703328	. Nickel (Ni)	2011/12/06	95	80 - 120	96	80 - 120	ND, RDL=1	ug/L				
2703328	. Phosphorus (P)	2011/12/06	96	80 - 120	101	80 - 120	ND, RDL=100	ug/L				
2703328	. Potassium (K)	2011/12/06	98	80 - 120	97	80 - 120	ND, RDL=200	ug/L				
2703328	. Selenium (Se)	2011/12/06	98	80 - 120	98	80 - 120	ND, RDL=2	ug/L	NC	20		
2703328	. Silicon (Si)	2011/12/06	98	80 - 120	99	80 - 120	ND, RDL=50	ug/L				
2703328	. Silver (Ag)	2011/12/06	95	80 - 120	96	80 - 120	ND, RDL=0.1	ug/L				
2703328	. Sodium (Na)	2011/12/06	NC	80 - 120	100	80 - 120	ND, RDL=100	ug/L	2.1(2)	20		
2703328	. Strontium (Sr)	2011/12/06	NC	80 - 120	100	80 - 120	ND, RDL=1	ug/L				
2703328	. Tellurium (Te)	2011/12/06	96	80 - 120	96	80 - 120	ND, RDL=1	ug/L				

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XCG Consultants Ltd

Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2703328	. Thallium (Tl)	2011/12/06	94	80 - 120	96	80 - 120	ND, RDL=0.05	ug/L				
2703328	. Tin (Sn)	2011/12/06	99	80 - 120	97	80 - 120	ND, RDL=1	ug/L				
2703328	. Titanium (Ti)	2011/12/06	96	80 - 120	96	80 - 120	ND, RDL=5	ug/L				
2703328	. Tungsten (W)	2011/12/06	99	80 - 120	100	80 - 120	ND, RDL=1	ug/L				
2703328	. Uranium (U)	2011/12/06	97	80 - 120	98	80 - 120	ND, RDL=0.1	ug/L	NC	20		
2703328	. Vanadium (V)	2011/12/06	101	80 - 120	99	80 - 120	ND, RDL=0.5	ug/L				
2703328	. Zinc (Zn)	2011/12/06	94	80 - 120	99	80 - 120	ND, RDL=5	ug/L				
2703328	. Zirconium (Zr)	2011/12/06	103	80 - 120	102	80 - 120	ND, RDL=1	ug/L				
2703819	. Aluminum (Al)	2011/12/07	105	80 - 120	107	80 - 120	ND, RDL=5	ug/L	NC	20		
2703819	. Antimony (Sb)	2011/12/07	111	80 - 120	101	80 - 120	ND, RDL=0.5	ug/L	NC	20		
2703819	. Arsenic (As)	2011/12/07	99	80 - 120	99	80 - 120	ND, RDL=1	ug/L	NC	20		
2703819	. Barium (Ba)	2011/12/07	NC	80 - 120	101	80 - 120	ND, RDL=2	ug/L	0.3	20		
2703819	. Beryllium (Be)	2011/12/07	98	80 - 120	101	80 - 120	ND, RDL=0.5	ug/L	NC	20		
2703819	. Bismuth (Bi)	2011/12/07	94	80 - 120	98	80 - 120	ND, RDL=1	ug/L	NC	20		
2703819	. Boron (B)	2011/12/07	102	80 - 120	104	80 - 120	ND, RDL=10	ug/L	NC	20		
2703819	. Cadmium (Cd)	2011/12/07	102	80 - 120	104	80 - 120	ND, RDL=0.1	ug/L	NC	20		
2703819	. Calcium (Ca)	2011/12/07	NC	80 - 120	98	80 - 120	ND, RDL=200	ug/L	0.4	20		
2703819	. Chromium (Cr)	2011/12/07	103	80 - 120	102	80 - 120	ND, RDL=5	ug/L	NC	20		
2703819	. Cobalt (Co)	2011/12/07	99	80 - 120	101	80 - 120	ND, RDL=0.5	ug/L	NC	20		
2703819	. Copper (Cu)	2011/12/07	93	80 - 120	98	80 - 120	ND, RDL=1	ug/L	NC	20		
2703819	. Iron (Fe)	2011/12/07	100	80 - 120	102	80 - 120	ND, RDL=100	ug/L	1.7	20		
2703819	. Lead (Pb)	2011/12/07	93	80 - 120	99	80 - 120	ND, RDL=0.5	ug/L	NC	20		
2703819	. Lithium (Li)	2011/12/07	100	80 - 120	100	80 - 120	ND, RDL=5	ug/L	NC	20		
2703819	. Magnesium (Mg)	2011/12/07	NC	80 - 120	103	80 - 120	ND, RDL=50	ug/L	1.6	20		
2703819	. Manganese (Mn)	2011/12/07	101	80 - 120	102	80 - 120	ND, RDL=2	ug/L	1.1	20		
2703819	. Molybdenum (Mo)	2011/12/07	110	80 - 120	102	80 - 120	ND, RDL=0.5	ug/L	NC	20		
2703819	. Nickel (Ni)	2011/12/07	95	80 - 120	98	80 - 120	ND, RDL=1	ug/L	NC	20		
2703819	. Phosphorus (P)	2011/12/07	107	80 - 120	104	80 - 120	ND, RDL=100	ug/L	NC	20		
2703819	. Potassium (K)	2011/12/07	101	80 - 120	101	80 - 120	ND, RDL=200	ug/L	0.2	20		
2703819	. Selenium (Se)	2011/12/07	102	80 - 120	104	80 - 120	ND, RDL=2	ug/L	NC	20		
2703819	. Silicon (Si)	2011/12/07	104	80 - 120	104	80 - 120	ND, RDL=50	ug/L	1.1	20		
2703819	. Silver (Ag)	2011/12/07	80	80 - 120	99	80 - 120	ND, RDL=0.1	ug/L	NC	20		
2703819	. Sodium (Na)	2011/12/07	NC	80 - 120	105	80 - 120	ND, RDL=100	ug/L	0.6	20		
2703819	. Strontium (Sr)	2011/12/07	NC	80 - 120	106	80 - 120	ND, RDL=1	ug/L	1.1	20		
2703819	. Tellurium (Te)	2011/12/07	95	80 - 120	102	80 - 120	ND, RDL=1	ug/L	NC	20		
2703819	. Thallium (Tl)	2011/12/07	93	80 - 120	98	80 - 120	ND, RDL=0.05	ug/L	NC	20		
2703819	. Tin (Sn)	2011/12/07	107	80 - 120	104	80 - 120	ND, RDL=1	ug/L	NC	20		
2703819	. Titanium (Ti)	2011/12/07	103	80 - 120	101	80 - 120	ND, RDL=5	ug/L	NC	20		
2703819	. Tungsten (W)	2011/12/07	102	80 - 120	99	80 - 120	ND, RDL=1	ug/L	NC	20		
2703819	. Uranium (U)	2011/12/07	102	80 - 120	103	80 - 120	ND, RDL=0.1	ug/L	NC	20		

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XCG Consultants Ltd

Maxxam Job #: B1I9571
Report Date: 2011/12/08

Sampler Initials: KP

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2703819	. Vanadium (V)	2011/12/07	105	80 - 120	102	80 - 120	ND, RDL=0.5	ug/L	NC	20		
2703819	. Zinc (Zn)	2011/12/07	95	80 - 120	102	80 - 120	ND, RDL=5	ug/L	NC	20		
2703819	. Zirconium (Zr)	2011/12/07	111	80 - 120	103	80 - 120	ND, RDL=1	ug/L	NC	20		

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - NITRATE:The recovery in the matrix spike was not calculated (NC). Spiked concentration was less than 2x that native to the sample.
(2) - POTENTIAL EXCEEDENCE FOR PARAMETER

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Validation Signature Page

Maxxam Job #: B1I9571

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

BRAD NEWMAN, Scientific Specialist

==========

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Site Location: LYNDEN
Your C.O.C. #: 57344

Attention: Kasia Piskorz
XCG Consultants Ltd
2620 Bristol Cir
Suite 300
Oakville, ON
L6H 6Z7

Report Date: 2011/12/09

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B1I9785
Received: 2011/12/01, 18:10

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Analysis by ICPMS (as received) (1)	2	2011/12/06	2011/12/07	CAM SOP-00447	EPA 6020

Remarks:

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act.

The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following the 'Alberta Environment Draft Addenda to the CWS-PHC, Appendix 6, Validation of Alternate Methods'. Documentation is available upon request. Maxxam has made the following improvements to the CWS-PHC reference benchmark method: (i) Headspace for F1; and, (ii) Mechanical extraction for F2-F4. Note: F4G cannot be added to the C6 to C50 hydrocarbons. The extraction date for samples field preserved with methanol for F1 and Volatile Organic Compounds is considered to be the date sampled.

Maxxam Analytics is accredited by SCC (Lab ID 97) for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

(1) Metals analysis was performed on the sample 'as received'.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MARIJANE CRUZ, Project Manager
Email: MCruz@maxxam.ca
Phone# (905) 817-5756

==========

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XCG Consultants Ltd

Maxxam Job #: B1I9785
Report Date: 2011/12/09

Site Location: LYNDEN
Sampler Initials: KP

-2-

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Total cover pages: 2

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Maxxam Job #: B1I9785
Report Date: 2011/12/09

XCG Consultants Ltd

Site Location: LYNDEN
Sampler Initials: KP

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		LV5397	LV5398		
Sampling Date		2011/12/01	2011/12/01		
	Units	**TREATED FILTERED**	**MARGARET-2 FILTERED**	**RDL**	**QC Batch**
Metals					
. Aluminum (Al)	ug/L	9	6	5	2704324
. Antimony (Sb)	ug/L	ND	ND	0.5	2704324
. Arsenic (As)	ug/L	ND	ND	1	2704324
. Barium (Ba)	ug/L	430	390	2	2704324
. Beryllium (Be)	ug/L	ND	ND	0.5	2704324
. Bismuth (Bi)	ug/L	ND	ND	1	2704324
. Boron (B)	ug/L	460	460	10	2704324
. Cadmium (Cd)	ug/L	ND	ND	0.1	2704324
. Calcium (Ca)	ug/L	10000	11000	200	2704324
. Chromium (Cr)	ug/L	ND	ND	5	2704324
. Cobalt (Co)	ug/L	ND	ND	0.5	2704324
. Copper (Cu)	ug/L	6	9	1	2704324
. Iron (Fe)	ug/L	ND	ND	100	2704324
. Lead (Pb)	ug/L	0.5	0.7	0.5	2704324
. Lithium (Li)	ug/L	7	7	5	2704324
. Magnesium (Mg)	ug/L	6800	6800	50	2704324
. Manganese (Mn)	ug/L	ND	ND	2	2704324
. Molybdenum (Mo)	ug/L	1.7	1.7	0.5	2704324
. Nickel (Ni)	ug/L	ND	ND	1	2704324
. Phosphorus (P)	ug/L	ND	ND	100	2704324
. Potassium (K)	ug/L	1000	1000	200	2704324
. Selenium (Se)	ug/L	ND	ND	2	2704324
. Silicon (Si)	ug/L	4600	4700	50	2704324
. Silver (Ag)	ug/L	ND	ND	0.1	2704324
. Sodium (Na)	ug/L	60000	60000	100	2704324
. Strontium (Sr)	ug/L	780	770	1	2704324
. Tellurium (Te)	ug/L	ND	ND	1	2704324
. Thallium (Tl)	ug/L	ND	ND	0.05	2704324
. Tin (Sn)	ug/L	ND	ND	1	2704324
. Titanium (Ti)	ug/L	ND	ND	5	2704324
. Tungsten (W)	ug/L	ND	ND	1	2704324
. Uranium (U)	ug/L	ND	ND	0.1	2704324
. Vanadium (V)	ug/L	ND	ND	0.5	2704324
. Zinc (Zn)	ug/L	ND	ND	5	2704324

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B1I9785
Report Date: 2011/12/09

XCG Consultants Ltd

Site Location: LYNDEN
Sampler Initials: KP

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		LV5397	LV5398		
Sampling Date		2011/12/01	2011/12/01		
	Units	**TREATED FILTERED**	**MARGARET-2 FILTERED**	**RDL**	**QC Batch**
. Zirconium (Zr)	ug/L	ND	ND	1	2704324

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B1I9785
Report Date: 2011/12/09

XCG Consultants Ltd

Site Location: LYNDEN
Sampler Initials: KP

Test Summary

Maxxam ID LV5397 **Collected** 2011/12/01
Sample ID TREATED FILTERED **Shipped**
Matrix Water **Received** 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Metals Analysis by ICPMS (as received)	ICP/MS	2704324	2011/12/06	2011/12/07	JOHN BOWMAN

Maxxam ID LV5397 Dup **Collected** 2011/12/01
Sample ID TREATED FILTERED **Shipped**
Matrix Water **Received** 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Metals Analysis by ICPMS (as received)	ICP/MS	2704324	2011/12/06	2011/12/07	JOHN BOWMAN

Maxxam ID LV5398 **Collected** 2011/12/01
Sample ID MARGARET-2 FILTERED **Shipped**
Matrix Water **Received** 2011/12/01

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Metals Analysis by ICPMS (as received)	ICP/MS	2704324	2011/12/06	2011/12/07	JOHN BOWMAN

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Maxxam Job #: B1I9785
Report Date: 2011/12/09

XCG Consultants Ltd

Site Location: LYNDEN
Sampler Initials: KP

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
2704324	. Aluminum (Al)	2011/12/07	101	80 - 120	103	80 - 120	ND, RDL=5	ug/L	NC	20
2704324	. Antimony (Sb)	2011/12/07	103	80 - 120	99	80 - 120	0.9, RDL=0.5	ug/L	NC	20
2704324	. Arsenic (As)	2011/12/07	97	80 - 120	96	80 - 120	ND, RDL=1	ug/L	NC	20
2704324	. Barium (Ba)	2011/12/07	NC	80 - 120	97	80 - 120	ND, RDL=2	ug/L	1.4	20
2704324	. Beryllium (Be)	2011/12/07	102	80 - 120	103	80 - 120	ND, RDL=0.5	ug/L	NC	20
2704324	. Bismuth (Bi)	2011/12/07	95	80 - 120	94	80 - 120	ND, RDL=1	ug/L	NC	20
2704324	. Boron (B)	2011/12/07	NC	80 - 120	103	80 - 120	ND, RDL=10	ug/L	0.8	20
2704324	. Cadmium (Cd)	2011/12/07	101	80 - 120	101	80 - 120	ND, RDL=0.1	ug/L	NC	20
2704324	. Calcium (Ca)	2011/12/07	93	80 - 120	96	80 - 120	ND, RDL=200	ug/L	0.08	20
2704324	. Chromium (Cr)	2011/12/07	98	80 - 120	98	80 - 120	ND, RDL=5	ug/L	NC	20
2704324	. Cobalt (Co)	2011/12/07	96	80 - 120	98	80 - 120	ND, RDL=0.5	ug/L	NC	20
2704324	. Copper (Cu)	2011/12/07	94	80 - 120	96	80 - 120	ND, RDL=1	ug/L	7.1	20
2704324	. Iron (Fe)	2011/12/07	98	80 - 120	99	80 - 120	ND, RDL=100	ug/L	NC	20
2704324	. Lead (Pb)	2011/12/07	95	80 - 120	97	80 - 120	ND, RDL=0.5	ug/L	NC	20
2704324	. Lithium (Li)	2011/12/07	100	80 - 120	99	80 - 120	ND, RDL=5	ug/L	NC	20
2704324	. Magnesium (Mg)	2011/12/07	98	80 - 120	102	80 - 120	ND, RDL=50	ug/L	0.1	20
2704324	. Manganese (Mn)	2011/12/07	97	80 - 120	99	80 - 120	ND, RDL=2	ug/L	NC	20
2704324	. Molybdenum (Mo)	2011/12/07	102	80 - 120	101	80 - 120	ND, RDL=0.5	ug/L	NC	20
2704324	. Nickel (Ni)	2011/12/07	93	80 - 120	95	80 - 120	ND, RDL=1	ug/L	NC	20
2704324	. Phosphorus (P)	2011/12/07	102	80 - 120	104	80 - 120	ND, RDL=100	ug/L	NC	20
2704324	. Potassium (K)	2011/12/07	96	80 - 120	98	80 - 120	ND, RDL=200	ug/L	0.8	20
2704324	. Selenium (Se)	2011/12/07	97	80 - 120	96	80 - 120	ND, RDL=2	ug/L	NC	20
2704324	. Silicon (Si)	2011/12/07	98	80 - 120	99	80 - 120	ND, RDL=50	ug/L	0.5	20
2704324	. Silver (Ag)	2011/12/07	95	80 - 120	96	80 - 120	ND, RDL=0.1	ug/L	NC	20
2704324	. Sodium (Na)	2011/12/07	NC	80 - 120	102	80 - 120	ND, RDL=100	ug/L	1.0	20
2704324	. Strontium (Sr)	2011/12/07	NC	80 - 120	100	80 - 120	ND, RDL=1	ug/L	1	20
2704324	. Tellurium (Te)	2011/12/07	100	80 - 120	100	80 - 120	ND, RDL=1	ug/L	NC	20
2704324	. Thallium (Tl)	2011/12/07	94	80 - 120	97	80 - 120	ND, RDL=0.05	ug/L	NC	20
2704324	. Tin (Sn)	2011/12/07	101	80 - 120	100	80 - 120	ND, RDL=1	ug/L	NC	20
2704324	. Titanium (Ti)	2011/12/07	98	80 - 120	100	80 - 120	ND, RDL=5	ug/L	NC	20
2704324	. Tungsten (W)	2011/12/07	98	80 - 120	99	80 - 120	ND, RDL=1	ug/L	NC	20
2704324	. Uranium (U)	2011/12/07	96	80 - 120	98	80 - 120	0.1, RDL=0.1	ug/L	NC	20
2704324	. Vanadium (V)	2011/12/07	98	80 - 120	99	80 - 120	ND, RDL=0.5	ug/L	NC	20

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

Maxxam Job #: B1I9785
Report Date: 2011/12/09

XCG Consultants Ltd

Site Location: LYNDEN
Sampler Initials: KP

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
2704324	. Zinc (Zn)	2011/12/07	96	80 - 120	98	80 - 120	ND, RDL=5	ug/L	NC	20
2704324	. Zirconium (Zr)	2011/12/07	104	80 - 120	102	80 - 120	ND, RDL=1	ug/L	NC	20

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

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Validation Signature Page

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

BRAD NEWMAN, Scientific Specialist

==========

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Testing Program for Lynden Supply Well FDL-02
Community of Lynden

February 2013

Prepared for:
City of Hamilton
400-77 James Street North
Hamilton, Ontario L6M 3L1

Prepared by:
GENIVAR Inc.
1425 Cormorant Road
Ancaster, Ontario L9G 4V5

Project No. 071-11885-00

Distribution:
3 c Client
1 c File

071-11885-00

February 1, 2013

Carmen Ches
Acting Senior Project Manager, Infrastructure and Source Water Planning
Water and Wastewater Division, Public Works
City of Hamilton
400-77 James Street North
Hamilton, ON L8R 2K3

Re: Lynden Water Supply Class Environmental Assessment
Testing Program for Lynden Supply Well FDL-02

Dear Ms. Ches:

GENIVAR Inc. (GENIVAR) is pleased to provide this report describing the process and results of the testing of the water supply well designated FDL-02 in the community of Lynden. The test results show that this proposed standby well yields 284.3 L/min (75 USgpm) and that the raw water requires treatment prior to connection to the Lynden system.

This report will serve as supporting documentation for the Category 3 amendment application to the Lynden Permit to Take Water (PTTW).

Yours truly,
GENIVAR Inc.

Derek S. Brunner, M.Sc., P.Geo.
Hydrogeologist / Project Manager

/db

600 Cochrane Drive, 5th Floor, Markham, Ontario L3R 5K3
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Table of Contents

Transmittal Letter
Table of Contents

1. INTRODUCTION 1
   - 1.1 Background 1
   - 1.2 Lynden's Existing Water Supply System 1
   - 1.3 Site Selection 1
   - 1.4 Scope of Work 1
2. PHYSICAL SETTING 3
   - 2.1 Physiography and Drainage 3
   - 2.2 Regional Geology 3
     - 2.2.1 Quaternary Geology 3
     - 2.2.2 Bedrock Geology 3
   - 2.3 Hydrostratigraphy of the Lynden Area 4
     - 2.3.1 Upper Unconfined Aquifer 4
     - 2.3.2 Aquitard 5
     - 2.3.3 Lower Confined Aquifer 5
     - 2.3.4 Bedrock Aquifer 5
   - 2.4 Local Water Supplies 5
3. WELL CONSTRUCTION 8
4. AQUIFER TESTING 9
   - 4.1 Background 9
   - 4.2 Monitoring Network 9
   - 4.3 Step Test 9
   - 4.4 Constant Rate Test 10
     - 4.4.1 Well Yield 11
     - 4.4.2 Aquifer Parameters 11
5. GROUNDWATER INTERFERENCE 13
   - 5.1 Observed Interference 13
   - 5.2 Well Complaints 13
   - 5.3 Predicted Interference 13
6. WATER QUALITY 15
7. GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER (GUDI) 16
8. CONCLUSIONS AND RECOMMENDATIONS 17
   - 8.1 Conclusions 17
   - 8.2 Recommendations 18
9. REFERENCES 19

List of Tables

Table 1 – Details of the Lynden Municipal Water Supply Permit to Take Water 1
Table 2 – Summary of Private Water Well Survey 6
Table 3 – Monitoring Network 9
Table 4 – Summary of Step Test Data for FDL-02 10

Table 5 – Drawdowns in Deep Aquifer 10
Table 6 – GUDI Criteria and Classification 16

Table C-1 – MOE Water Well Records

Table E-1 - Water Quality Results - Lynden Private Water Well Survey

Table G-1 – Step Test Pumping Data, Lynden Well FDL-02

Table H-1 – Pumping Test Data, Lynden Well FDL-02

Table H-2 – Pumping Test Data, Monitoring Well LM-01-11-D

Table H-3 – Pumping Test Data, Monitoring Well LM-01-12-D

Table H-4 – Pumping Test Data, Monitoring Well LM-01-03-D

Table H-5 – Pumping Test Data, Monitoring Well LM-01-08-OB

Table H-6 – Pumping Test Data, Private Well – 3606 Governors Road

Table H-7 – Pumping Test Data, Private Well – 8725 Governors Road

Table H-8 – Pumping Test Data, Private Well – 3830 Governors Road

Table K-1 – General Inorganic Water Quality – Lynden Well FDL-02

Table K-2 – General Organic Water Quality – Lynden Well FDL-02

Table K-3 – General Organic Water Quality – Lynden Well FDL-02

List of Figures

Figure 1 – Site Location Plan

Figure 2 – FDL-02 and Surrounding Area

Figure 3 – Surficial Geology

Figure 4 – Bedrock Topography

Figure 5 – MOE Water Wells

Figure 6 – Hydrostratigraphic Cross-Section

Figure 7 – Zone of Influence

Figure G-1 – Record of Step Test Data – Lynden Well FDL-02

Figure G-2 – Observed Drawdown vs Discharge FDL-01 1985 and FDL-02 2012

Figure H-1 – Pumping Test Data, Lynden Well FDL-02

Figure H-2 – Pumping Test Data, Monitoring Well LM-01-11-D

Figure H-3 – Pumping Test Data, Monitoring Well LM-01-12-D

Figure H-4 – Pumping Test Data, Monitoring Well LM-01-03-D

Figure H-5 – Pumping Test Data, Monitoring Well LM-01-08-OB

Figure H-6 – Pumping Test Data, Private Well – 3606 Governors Road

Figure H-7 – Pumping Test Data, Private Well – 3725 Governors Road

Figure H-8 – Pumping Test Data, Private Well – 3830 Governors Road

Figure H-9 – 20-Year Projection for FDL-02

Figure H-10 – Theis Analysis – FDL-02

Figure H-11 – Agarwal Recovery Analysis – FDL-02

Figure H-12 – Theis Analysis – LM-01-11-D

Figure H-13 – Agarwal Recovery Analysis – LM-01-11-D

Figure H-14 – Theis Analysis – LM-01-12-D

Figure H-15 – Agarwal Recovery Analysis – LM-01-12-D

Figure H-16 – Theis Analysis – LM-01-03-D

Figure H-17 – Agarwal Recovery Analysis – LM-01-03-D

Figure H-18 – Theis Analysis – 3606 Governors Road

Figure H-19 – Agarwal Recovery Analysis – 3606 Governors Road

Figure H-20 – Theis Analysis – 3725 Governors Road

Figure H-21 – Agarwal Recovery Analysis – 3725 Governors Road

Figure H-22 – Theis Analysis – LM-01-08-OB

Figure H-23 – Agarwal Recovery Analysis – LM-01-08-OB

Figure H-24 – Theis Analysis – 3830 Governors Road

Figure H-25 – Agarwal Recovery Analysis – 3830 Governors Road

Figure J-1 – Groundwater Levels – 3606 Governors Road

Figure J-1a – Groundwater Levels – 3606 Governors Road Scaled for Depth

Figure J-2 – Groundwater Levels – 3725 Governor’s Road

Figure J-2a – Groundwater Levels – 3725 Governor’s Road Scaled for Depth

Figure J-3 – Groundwater Levels – 3830 Governor’s Road

Figure J-3a – Groundwater Levels – 3830 Governor’s Road Scaled for Depth

Figure J-4 – Groundwater Levels – 3431 Governor’s Road

Figure J-4a – Groundwater Levels – 3431 Governor’s Road Scaled for Depth

Figure J-5 – Groundwater Levels – 3586 Governor’s Road

Figure J-5a – Groundwater Levels – 3586 Governor’s Road Scaled for Depth

Figure J-6 – Groundwater Levels – 3826 Governor’s Road

Figure J-6a – Groundwater Levels – 3826 Governor’s Road Scaled for Depth

Appendices

Appendix A Certificate of Approval

Appendix B Existing Lynden PTTW

Appendix C MOE Water Well Records

Appendix D Borehole Logs

Appendix E Private Water Well Survey Results

Appendix F FDL-02 Well Construction Report

Appendix G Step Test Data

Appendix H Pumping Test Data

Appendix I Category 2 PTTW for Pumping Test

Appendix J Private Water Well Monitoring Results

Appendix K Water Quality Results - FDL-02

1. Introduction

1.1 Background

Lynden is a small community (population of approximately 400) located within the City of Hamilton (the City). Lynden obtains its drinking water from a communal well located approximately 1.5 km to the east of the community. In the summer of 2002, the City of Hamilton developed a Comprehensive Water Servicing Master Plan for the Lynden Rural Settlement Area (Totten-Sims-Hubicki, 2002). The Plan considered the need for additional water supply to the Rural Settlement Area (RSA) and outlined various options of meeting the requirement for the future RSA. One of the alternatives identified was to drill a new municipal supply well to provide this extra water and also to provide redundancy when combined with the existing well (FDL-01). Accordingly, a Schedule 'C' Class Environmental Assessment (EA) was initiated by the City, part of which was to examine alternatives for the location of a new well (the Notice of Completion is still pending).

1.2 Lynden's Existing Water Supply System

The existing Lynden municipal water supply system consists of a production well located to the east of the community (Figure 1). The well is housed outside its own pump house, which contains treatment and control facilities. The rated capacity for the municipal well is set out in the Certificate of Approval issued on October 30, 2006 (Appendix A) and the Permit to Take Water (PTTW) #2331-826QBK dated December 16, 2009 (Appendix B). The details of the existing municipal supply well are summarized in Table 1.

Table 1 – Details of the Lynden Municipal Water Supply Permit to Take Water

Provincial Instrument	Reference Number	System	Rated Pump Capacity (L/s)	Max Flow Rate (L/min)	Max Daily Volume (m^3/day)
PTTW	2331-826QBK	Well FDL-01	7.6	227	327.312
C of A	8235-6UHJBC	Well FDL-01			

Projected future maximum daily demands are expected to reach 411 m^3/day. FDL-02 was designed and constructed with this volume of water in mind.

1.3 Site Selection

Based on a number of factors, including proximity to the community, anticipated pumping capacity, potential for Groundwater Under the Direct Influence of Surface Water (GUDI), possible well interference, and potential impacts on surface water bodies and water quality, a number of test holes were drilled to identify a preferred location for further testing. The preferred well location for FDL-02 was identified on the south side of Governor's Road approximately 100 m south of the existing production well FDL-01 on land recently acquired by the City (Figure 2). Land use in the vicinity of the well is predominantly agricultural with some scattered residences. The well site was selected for a number of reasons:

- The land is owned by the City;
- The interpreted thickness of the gravel aquifer in the area was favourable; and
- Close proximity to Lynden and the distribution system.

The exploration program and well construction were conducted under the direction of the City. Although the exploration program was not conducted as part of this assignment, some details are presented in Section 3.This report discusses the hydraulic testing of the new well.

1.4 Scope of Work

The scope of work for the testing of the backup supply well at Lynden consisted of the following tasks:

- Private Water Well Survey and Implementation of Monitoring Program

- Step Drawdown Test
- 72-hour Constant Rate Aquifer Test
- Regulation 170/03 Chemical Analysis
- GUDI evaluation
- Analysis and Reporting

A private water well survey was conducted for all residents within 500 m of the proposed well. This included the completion of a questionnaire, baseline water quality sampling, and requests to participate in a monitoring program. The monitoring included installation of dataloggers in residential wells and occasional hand-measurement of water levels. Upon completion of the survey, tests were carried out in order to assess the capacity of the well and water quality.

Step drawdown and 72-hour constant rate tests were carried out to assess the capacity of the well. During the constant rate pumping test, the groundwater was sampled at four intervals (i.e. after 1 hour, 24 hours, 48 hours and 72 hours of pumping) and sent for chemical analysis to assess groundwater quality with respect to the requirements of Regulation 170/03. An evaluation of groundwater under the direct influence of surface water (GUDI) was carried out for raw water quality.

The details of this work program are presented in the following sections of this report.

2. Physical Setting

2.1 Physiography and Drainage

The Community of Lynden is located within the Norfolk Sand Plain physiographic region, which consists of relatively flat to gently rolling terrain that slopes gently towards Lake Erie to the southwest (Chapman and Putnam, 1984).). The plain is wedge shaped with a broad base near Lake Erie, tapering to a point near Brantford and Lynden. The sands and silts characteristic of the region were deposited as part of a delta into Glacial Lakes Whittlesey and Warren. The maximum relief in the Lynden area is approximately 10 m, with drainage towards the south and southwest. A tributary of Fairchild Creek drains the Village of Lynden, which enters the Grand River at Onondaga. A tributary of Big Creek drains the lands east of Lynden, and enters the Grand River east of Middleport (Cowan, 1972). The major surficial feature to the east is the Dundas Valley, a re-entrant in the Niagara Escarpment, which has been traced inland as far as Copetown. Lands to the east near Copetown drain towards the Dundas Valley and Lake Ontario.

2.2 Regional Geology

2.2.1 Quaternary Geology

The Quaternary geology in the vicinity of Lynden is dominated by shallow lake and deltaic sediments, consisting mainly of sands and silts deposited during the Lake Warren stage and more recent periods (Cowan, 1972). These deposits are fairly extensive, being found as far east as Waterdown and Ancaster and mantle the top of the Niagara Escarpment (SNC Lavalin and Charlesworth and Associates, 2006). According to Cowan (1972), the area of sand near Lynden and Copetown resulted from sedimentation into glacial Lake Warren, which spread southwards as water levels receded. Near Lynden, the sand deposits are relatively thin and the underlying silt and clay outcrops in most of the valley walls. Surficial geology in the vicinity of Lynden is shown in Figure 3.

The sediments beneath the surficial sands consist of deep-lake deposited silts and clays, which vary from laminated/stratified to varved (Cowan, 1972). Extensive clay layers have been identified in the water well records that extend to great depths. In the Lynden area, the clay layer is up to 50 m in thickness.

Below the clay is a layer of sand and gravel that overlies the bedrock. This sand and gravel unit varies in thickness, extent and composition and appears to be a valley fill deposit associated with the Dundas buried valley and its tributaries, which are located to the south and east of Lynden. In the south, north, and west directions, the aquifer consists mainly of sand, with isolated pockets of gravel. To the east of Lynden, the base of the sand and gravel aquifer was found to consist of a thick gravel layer of greater lateral extent. The deep aquifer is discontinuous towards the north and west of Lynden. The Dundas buried valley is shown using bedrock contours in Figure 4.

2.2.2 Bedrock Geology

The Lynden area is predominantly underlain by dolostone of the Guelph Formation, which dip gently to the southwest towards the Michigan Basin at 4-5 m/km (Cowan, 1972; Morrison Beatty, 1985). The elevation of the top of bedrock ranges between 190 masl to 170 masl above the Dundas Valley. To the south and east, the Dundas Valley erodes into several underlying bedrock units as described below (from the top down):

- The Eramosa member of the Guelph Formation, which is a bituminous dolostone that extends to the southeast of Lynden.
- The Lockport Formation consisting of argillaceous dolostone and shale
- The Clinton and Cataract groups consisting of sandstones, shales, dolostones and limestones.
- The red shales of the Queenston Formation, which is the oldest bedrock unit in the area.

The Dundas Buried Valley is described in more detail below.

Dundas Buried Valley

The major surficial feature in this area is the Niagara Escarpment, which extends around the western end of Lake Ontario near Hamilton. The Dundas Valley is a major re-entrant into the escarpment that extends westward for some distance before being buried under Quaternary aged sediments. Borings into the Burlington Bar have extended down 137 m without encountering bedrock (Karrow, 1987), which is believed to lie approximately 180 m below the level of Lake Ontario based on gravity data (Greenhouse and Monier-Williams, 1986). This corresponds to an elevation of 105 m below mean sea level. The re-entrant terminates beneath Copetown, where it is described as being analogous to a buried Niagara gorge by Greenhouse and Monier-Williams (1986). The portion of the buried valley at Copetown and to the east has been studied extensively and has had constraints placed on its lateral and vertical extent (Greenhouse and Monier-Williams, 1986; Sinha, 1990; MacCormack et al., 2005). However, a recent test well was installed to a depth of 195 m below ground surface (bgs) without reaching bedrock in Copetown (Stantec, 2010), suggesting that there may be deeper areas that have not yet been fully characterized.

West of Copetown, the valley extends south of Lynden, where it splits. The main channel is believed to extend west and north and passes south of Scotland and Glen Morris before running beneath the Village of Ayr and may extend as far as Lake Huron (Karrow, 1987). The secondary tributary was traced southwest to the Brantford area, where it is found to connect with the Grand River valley. Karrow (1987) postulated that this extension was likely cut by an earlier Grand River and deepened by glacial action. The valley has been interpreted as far north as the Kitchener-Waterloo area and beyond (AquaResource Inc., 2007). A small tributary to this valley connects with the main valley just east of Lynden (Figure 4), which was the target location for the new well.

2.3 Hydrostratigraphy of the Lynden Area

The subsurface stratigraphy in the Lynden area as identified from borehole and water well records can be conceptualized in terms of their hydrogeological properties into a regional framework. Existing deep wells from the MOE database were plotted (Figure 5) and a conceptual cross-section was prepared (Figure 6). Based on the descriptions, the sediments can be simplified into an upper unconfined aquifer, an aquitard, a lower confined aquifer, and a bedrock aquifer. These hydrogeological units are described in more detail below. MOE water well records in the project area are summarized in Table C-1 in Appendix C. Additional well logs are provided in Appendix D.

2.3.1 Upper Unconfined Aquifer

A discontinuous unconfined aquifer of variable thickness is located at ground surface over much of the area. The aquifer consists of sands and silts with some clay and is associated with saturated portions of the Norfolk Sand Plain. The well records shown in the section suggest thicknesses of up to 20 m near Woodhill Road east of the site. In addition, the records suggest that the aquifer is not continuous at ground surface as would be expected from the description in Chapman and Putnam (1984). This can possibly be attributed to the quality of interpretation in the MOE database, particularly for deeper wells, where sampling at ground surface may not have been as thorough. Previous investigations have suggested the aquifer is thin (up to about 7 m) in the Lynden area and vulnerable to surface contamination, particularly from domestic septic systems and agricultural practices.

The surficial sands and silts in the Lynden and surrounding areas provide domestic groundwater supplies for a number of residents. The water levels fluctuate seasonally, leading to potential water shortages in the dry season and a high water table in the wet season. Wells within this aquifer have been noted to have marginal success as a water supply for domestic purposes (Morrison Beatty, 1978). These wells do not produce more than 4.8 to 24 L/min (Morrison Beatty, 1985). Groundwater flow direction within the shallow aquifer is interpreted to be towards the nearest tributary, with a component in the downstream direction.

2.3.2 Aquitard

Below the upper unconfined aquifer lies a thick layer of clay that is up to 50 m thick in the Lynden area. The unit acts as an aquitard, retarding groundwater flow from the surficial aquifer into underlying units. Near the Lynden well site, the unit appears to be approximately 20 m in thickness.

Previous investigations have reported that the unit has very low permeability (Morrison Beatty, 1978) although it does contain isolated sand pockets. Like the shallow wells in the area, wells screened within these pockets tend to produce only enough water for domestic supply (Morrison Beatty, 1978; Morrison Beatty, 1985; Morrison Beatty, 1987).

2.3.3 Lower Confined Aquifer

Beneath the aquitard is a discontinuous sand and gravel aquifer of variable thickness, extent and composition overlying the bedrock. In the vicinity of the Lynden well site, the aquifer appears to exhibit a pattern of fining upwards and may be up to 20 m thick. The coarsest material appears to lie where the bedrock surface is deepest, and consists of sand and gravel at thicknesses of up to 10 m. The aquifer extends to the east and west along the top of the bedrock and thins out. It appears to be discontinuous towards Lynden, with localized areas of medium to fine sand.

Previous investigations suggest that the aquifer tends to be thicker and contains greater amounts of gravel closer to the Dundas buried valley, which is located to the south and east of Lynden. Aquifer thickness was estimated to be 10-20 m by SNC Lavalin and Charlesworth and Associates (2006). Hydrogeologic cross-sections prepared in previous studies indicate that the highest proportion of continuous gravel is located to the east of Lynden (Morrison Beatty, 1978; Morrison Beatty, 1987; XCG, 2006), with thicker deposits of sand to the south along Lynden Road (Morrison Beatty, 1978). The deep aquifer was also noted to be present to the west and north of Lynden, but available data indicates that it contains higher proportions of silt and is discontinuous (i.e. generally absent) (Morrison Beatty, 1978; Morrison Beatty, 1987).

The gravel unit is believed to outcrop approximately 10 km northeast of Lynden, where it is exposed at ground surface (SNC-Lavalin and Charlesworth and Associates, 2006). Groundwater flow within this unit is interpreted to be in a southerly direction towards the Dundas buried valley (XCG, 2006). This aquifer has considerable storage and likely recharges the underlying bedrock aquifer.

Wells constructed within this aquifer tend to have higher specific capacities than those in the surficial or bedrock aquifers, with pumping rates generally greater than 45 L/min and occasionally up to 454 L/min, as determined from existing MOE well records (XCG, 2006). However, private wells are not expected to be representative of the potential for the deeper aquifer, since they are tested at lower rates for domestic demand. The static water level in this aquifer has ranged between approximately 9-12 m bgs.

2.3.4 Bedrock Aquifer

Bedrock in the area lies beneath the overburden at depths of 50 – 60 m bgs. The bedrock surface dips from approximately 185 masl near Lynden to about 170 masl in the vicinity of the well site, before rising slightly to above 175 masl to the east. This suggests that the bedrock valley that enters the Dundas Valley to the south is shallow and wide (Figure 4). It is not clear if any deeper gorges exist within this area.

The bedrock is capacity highly productive aquifer in several areas north of Lynden, such as Cambridge, Aberfoyle and Guelph (Morrison Beatty, 1978). In areas where it is more crystalline, well yields are lower. Bedrock wells in the Lynden area generally can produce from 45 – 90 L/min (Morrison Beatty, 1978). Regional groundwater flow within the bedrock is difficult to ascertain based on the limited amount of data.

2.4 Local Water Supplies

Between August 27 and September 12, 2012, a private well survey was conducted at residences located within 500 m of the proposed new Lynden well to collect background water quality information and interview the residents to ensure that any pertinent information was recorded prior to the completion of

the pumping test and the transition to the new well. As part of the survey, fourteen property owners were contacted (by phone and mailed letter) and were informed of the purpose of the survey. Eight of the fourteen residents completed the survey.

At each of the eight residences, water quality samples were collected and submitted to the City of Hamilton Laboratory for analysis. Sampled parameters included:

- colour
- hardness
- nitrates / nitrites
- turbidity
- metals
- hydrogen sulphide
- microbiological parameters (Total Colifom, e.Coli., Heterotrophic Plate Count, Background).

All analytical results were reviewed and compared to the Ontario Drinking Water Quality Standards (ODWQS) and health related exceedances are shown in Table 2. The water quality results for four properties were non-compliant with the ODWQS for microbiological parameters. One of the wells was also in exceedance of the ODWQS for nitrates. Two of these wells were bored wells, which are susceptible to contamination from surface sources. The other two wells with bacteriological exceedances were both drilled. The first well has no cap, a small stickup, poor accessibility and is located in a barn less than 5 m from livestock. It is likely that the location and condition of the wellhead contributed to the presence of bacteria. It also creates a potential contaminant pathway into the aquifer. It is not known why the other drilled well tested positive. Letters were sent to these properties identifying the exceedances and recommendations were provided in accordance with the Local Public Health Department.

Table 2 – Summary of Private Water Well Survey

	Well Type	Well Depth	Health Based Exceedances	Monitoring Program	Additional Comments
Property 1	Drilled	N/A	None	No	Well head not accessible. Pump test in 1985 caused well to go dry.
Property 2	Drilled	Approx. 180 feet	E.Coli., Total Coliform	Yes	Previous positive E.Coli. results. Wellhead location is in a barn and is susceptible to contamination from animal waste.
Property 3	Bored - 2 wells	60 feet and 40 feet	Nitrate, E.Coli., Total Coliform	Yes	If used too much, can go dry.
Property 4	Drilled	Approx. 200 feet	E.Coli., Total Coliform	Yes	None.
Property 5	Drilled	170 feet	None	Yes	None.
Property 6	Bored	55 feet	Total Coliform	Yes	Well has not gone dry for 30 years.
Property 7	Dug	Approx. 25 to 30 feet	None	Yes	Dries up frequently. Frequent E.Coli. exceedances in raw water. Requires frequent water delivery.
Property 8	Drilled	Approx. 185 feet	None	Yes	None.

Non-health related exceedances were also noted in the groundwater. Hydrogen sulphide exceeded the ODWQS aesthetic objectives (AO) of 0.05 mg/L in two wells, iron exceeded the AO of 0.3 mg/L in five

wells, colour exceeded in six wells, and turbidity in three. While sodium was within the AO of 200 mg/L in all wells, it exceeded the value of 20 mg/L for people on sodium restricted diets in seven of the eight locations.

While barium did not exceed the interim maximum acceptable concentration of 1 mg/L, two domestic wells had levels just below this (0.98 mg/L), suggesting that this parameter is also locally elevated. Hardness values exceeded the operational guideline range of 80 – 100 mg/L in all wells. All of the drilled wells exhibited naturally soft water (< 80 mg/L) lower in calcium and magnesium than we would expect from wells screened in materials that apparently derive from limestone / dolostone bedrock. The water in the bored wells was hard (> 100 mg/L), which is common for groundwater in Southern Ontario.

In addition to water quality sampling, the field technician interviewed the residents and inspected the wellhead. General comments on the well head quality were recorded on field sheets. Questions posed to the residents included any known water quality history, any general concerns, well depths, and whether they would allow for the installation of a data logger into their well and allow manual monitoring of the water levels during the pumping test. Seven residences agreed to participate in the monitoring program. However, one of the residents had water delivered to their well on a regular basis, so it was determined that monitoring this well would not provide any meaningful information. A summary of the survey and water quality sampling results from these properties is provided in Table 2.

A summary of water quality results from the private well survey is provided in Table E-1 of Appendix E. Laboratory certificates of analysis are also provided in Appendix E.

3. Well Construction

A test drilling and hydrogeological investigation were conducted at the preferred site by AMEC. The program involved the drilling of three 2-inch diameter test boreholes designated TW-1, TW-2 and TW-3. Of the three test boreholes, TW-1 was completed as a temporary 6-inch test well, TW-2 was completed as a 2-inch monitoring well and renamed LM-09 by AMEC (subsequently renamed LM-01-11-D by the City), and the third was properly abandoned.

The stratigraphy encountered during drilling was found to consist of approximately 9 metres of silt at ground surface (likely corresponding to the Norfolk Sand Plain), overlying clay with sand and silt layers to a depth of 36.6 m bgs. Beneath the clay was a layer of silt and fine sand to 48.5 m bgs. A sand and gravel aquifer was identified between 48.5 m and 50.9 m bgs, with gravel with black shale cobbles to 54.6 m bgs. It is possible that this unit is fractured bedrock. TW-1 underwent step testing, which was followed by the hole being reamed out and replaced with a permanent 8” casing and screen set between 48.4 m and 51.5 m bgs and designated as FDL-02. The static water level in the well was measured to be 15.2 m, suggesting an available drawdown of approximately 33 m. A full description of the well installation process, testing and logs for FDL-02 and LM-09 (LM-01-11-D) are provided in the AMEC report in Appendix F.

4. Aquifer Testing

4.1 Background

In preparation for the aquifer testing, Lynden well FDL-01 was shut down for one week between the morning of October 14, 2012 to provide at least 24 hours of recovery. FDL-01 was turned back on October 21, 2012. In the interim, water was temporarily supplied to the community through the use of water trucks, which continuously delivered water to the existing pump house for distribution. The expense of bringing in this supply constrained the amount of time that FDL-01 was shut down for the testing of FDL-02 and limited the amount of pre- and post-test recovery unaffected by pumping.

4.2 Monitoring Network

A combination of observation wells and private wells were selected to be monitored during the aquifer testing. A total of six (6) observation wells and six (6) private wells were chosen as summarized in Table 3.

Table 3 – Monitoring Network

Monitoring Location	Well Type	Distance from FDL-02 (m)	Hydrostratigraphic Unit	Measurements
LM-01-11-D	Observation	79	Deep Aquifer	Manual, Logger
LM-01-12-D	Observation	92	Deep Aquifer	Manual, Logger
LM-01-03-D	Observation	140	Deep Aquifer	Manual, Logger
LM-01-03-S	Observation	140	Shallow Aquifer	Manual
3606 Governors Road	Private	177	Deep Aquifer	Manual, Logger
3586 Governors Road	Private	227	Shallow Aquifer	Manual, Logger
3725 Governors Road	Private	365	Deep Aquifer	Logger
LM-01-08-OB	Observation	550	Deep Aquifer	Manual, Logger
LM-01-08-D	Observation	550	Bedrock	Manual, Logger
3826 Governors Road	Private	665	Shallow Aquifer	Manual, Logger
3830 Governors Road	Private	743	Deep Aquifer	Manual, Logger
3431 Governors Road	Private	826	Deep Aquifer	Manual, Logger

4.3 Step Test

On October 15, 2012, a step test was conducted on FDL-02 to determine whether the well could sustain the proposed 72-hour test pumping rate of 4.7 L/s and to provide baseline data with which to assess future well performance and to compare to past performance of existing Lynden well FDL-01. The step test was conducted at three discharge rates (1.6 L/s, 3.2 L/s and 4.7 L/s). The steps were 60 minutes in length, with 60 minute interruptions between pumping stages to allow the well to recover. However, due to almost complete recovery of the well during the first step, the delay before the start of the second step was only 30 minutes. The water levels were monitored manually and with a datalogger. The data is presented graphically in Figure G-1 and tabulated results are shown in Table G-1 of Appendix G. The results of the step test are summarized below in Table 4.

Specific capacity is the pumping rate divided by the drawdown. As shown in Table 4, there is essentially no change in the specific capacity of the well during the step test. As discharge rates rise, well losses due to turbulent flow through the well screen do not appear to cause reduced well efficiency or higher drawdown. The relationship between drawdown and discharge is illustrated in Figure G-2 of Appendix G. This baseline information can be used for comparisons with future step tests to assess the need for periodic maintenance of the well.

Table 4 – Summary of Step Test Data for FDL-02

Discharge Rate		Cumulative Drawdown	Drawdown per Step	Specific Capacity
(L/s)	(USgpm)	(m)	(m)	(L/s/m)
1.6	25	0.34	0.34	4.64
3.2	50	0.69	0.35	4.57
4.7	75	1.03	0.34	4.59

The results compare favourably with the data collected for FDL-01 by Morrison Beatty (1985), following an almost identical trend (Figure G-2, Appendix G).

The step test data provides sufficient information to proceed with a 72-hour aquifer test at a discharge rate of 4.7 L/s (75 USgpm).

4.4 Constant Rate Test

On October 16, 2012, a 72-hour constant rate pumping test was conducted on FDL-02 to evaluate aquifer parameters and assess the long-term performance of the well at a constant discharge rate of 4.7 L/s (75 USgpm). Water levels were monitored in the pumping well over the course of the test manually and through the use of dataloggers, during both the pumping/drawdown and recovery phases and until about 74% recovery was achieved when FDL-01 resumed supplying water to the community. Drawdown in FDL-02 after 72 hours was measured at 2.37 m below the static level of 15.02 m below the top of the well. The drawdowns in each of the deep monitoring wells are provided in Table 5. No measureable drawdowns attributable to the pumping test were observed in wells screened in the shallow aquifer or the deep bedrock well.

Table 5 – Drawdowns in Deep Aquifer

Location	Well Type	Distance from FDL-02 (m)	Maximum Drawdown (m)
FDL-02	Pumping	0	2.37
LM-01-11-D	Observation	79	1.73
LM-01-12-D	Observation	92	1.67
LM-01-03-D	Observation	140	1.66
3606 Governors Road	Private	177	1.61
3725 Governors Road	Private	365	1.61
LM-01-08-OB	Observation	550	1.20
3830 Governors Road	Private	743	0.85
3431 Governors Road	Private	826	0.31

The distribution of drawdowns tends to decrease with increasing distance from the pumping well, although there are some irregularities that are apparent. These irregularities can likely be attributed to the boundaries represented by the variability of the bedrock surface and the variability in thickness and anisotropy of the aquifer in different directions. The cone of depression is fairly shallow, indicating a high transmissivity in the aquifer.

The drawdown and recovery data for FDL-02 and the monitoring network is provided in Tables H-1 to H-8 and Figures H-1 to H-8 in Appendix H. The Category 2 Permit to Take Water for the testing is provided in Appendix I.

4.4.1 Well Yield

In an ideal confined aquifer, the time-drawdown and time-recovery data from a constant rate test will follow a straight line trend on a semi-log plot. Additionally, the recovery data should mirror the rate of drawdown. In other words, the recovery data for the pumping well should superimpose onto the drawdown data on a semi-logarithmic plot.

As shown in Figure H-1 in Appendix H, the drawdown and recovery data for the FDL-02 generally follow a linear trend for approximately the first 100 minutes, after which drawdown increases, likely indicating a negative boundary condition. Other increases in drawdown occur at approximately 700 and 2000 minutes into the test, suggesting multiple boundaries have been encountered. The hydraulic response compares well with the testing done on FDL-01 by Morrison Beatty in 1985 (24-hour test at 250 Igpm) and 1987 (13.2 day test at 50 igpm). The recovery data superimposes on the drawdown data reasonably well at early time, but starts to lag after approximately 1 day, likely due to a combination of boundary effects and the renewed pumping of FDL-01. Steady-state conditions have not been reached by the end of the pumping test. Similar trends were observed in the other wells monitored during the pumping test (Figures H-2 to H-8 in Appendix H).

With a pumping rate of 4.7 L/s (75 USgpm) applied during the 72-hour constant rate test, the drawdown in the pumping well after 20 years was estimated to determine the effects of long-term pumping at the maximum rate. The drawdown after 20 years in FDL-02 is estimated to be about 7.4 metres assuming no additional boundaries are encountered (Figure H-9 in Appendix H). This predicted 20-year drawdown is lower than the available drawdown of about 33 metres (discussed in Section 3.1), which indicates that the pumping rate of 4.7 L/s (75 USgpm) appears sustainable.

Given that the well will not be pumped constantly at the maximum rate of 4.7 L/s, but rather periodically at lower rates, it is likely that the well will not have any long-term negative impacts to the aquifer. Further, Morrison Beatty (1985) estimated a long-term recharge rate of 13 L/s to this aquifer, suggesting that the rate may be sustainable.

As part of the wellhead protection study completed by SNC Lavalin and Charlesworth and Associates (2006), a steady-state capture zone was generated for FDL-01 at its maximum pumping rate. The capture zone water budget was estimated to have a surplus of 1,164.2 m^3/day, or 13.5 L/s, which corresponds to the estimates provided by Morrison Beatty. Since the increased taking from FDL-02 is proposed to be 1.1 L/s greater than FDL-01, it is expected that the new rate will be sustainable.

4.4.2 Aquifer Parameters

The pumping test drawdown and recovery data for FDL-02 and wells screened in the deep aquifer were analyzed using AquiferTest software version 4.0 for FDL-02. The following assumptions were applied during the analysis:

- Aquifer is assumed to be confined.
- Theis solution was used for drawdown.
- Agarwal solution (after Theis) was used for recovery.
- Wells were screened across the entire aquifer.
- Drawdowns as a result of well use in private wells were removed.

The data were analyzed for transmissivity and storativity (Table H-9, Appendix H). Given the presence of negative boundaries, early time data was used in the calculations using Theis and Agarwal. The transmissivity results fell into two ranges. The first included the wells screened in the aquifer in the immediate vicinity of FDL-02. In these wells, transmissivity ranged from 530 – 830 m^2/day. These wells were all located within about 140 m of the pumping well and are expected to be within the bedrock valley. The wells that were further away from FDL-02 had much lower transmissivities, estimated between 50 – 200 m^2/day. The changes in transmissivity are likely due to several factors, including:

- Drawdown encounters a physical boundary (i.e. bedrock).
- Aquifer becomes finer grained at a distance from FDL-02.
- Aquifer changes in thickness.

The trends are also consistent with the shallow nature of the drawdown cone.

Storativity values ranged between 1.0×10^{-5} to 3.0×10^{-4}. These are generally within the range of expected values for confined systems. Analysis plots are provided in H-10 to H-25 of Appendix H.

5. Groundwater Interference

5.1 Observed Interference

The effects of pumping a well must be evaluated so that potential groundwater interference with local wells can be addressed. Since the pumping requirements for FDL-02 are slightly higher than for FDL-01 (411 m^3/day vs. 327 m^3/day), there may be additional interference with nearby private wells. To quantify the amount of interference from the pumping test, loggers were installed within selected private wells as discussed in Sections 2.4 and 4.2. The loggers were installed a week prior to the start of testing to provide baseline water use data, and were removed a week after the test was completed. Loggers were installed above the pump intake in all cases. Manual levels were taken after installation, several times a day during testing, and again prior to removal. Plots showing logger trends in private wells are included in Figures J-1 to J-6 in Appendix J.

Two types of trends were noticed in the logger data recorded prior to the start of the pumping test:

- Instantaneous changes in water level resulting in drawdown and recovery as represented by daily residential use (tens of centimetres to metres).
- Short term drops in water level likely caused by the pumping of FDL-01 (tens of centimetres). These variations were most notable in the deep private wells closest to the site.

The use of FDL-01 did not appear to have a long-term affect on any private wells. In particular, the well at 3606 Governor's Road exhibited clear disturbances of approximately 0.3 metres each time FDL-01 was used. However, once municipal pumping ceased, water levels recovered to pre-pumping levels. It is apparent that this pumping pattern may be sustainable in the long term.

During the pumping test, interference was detected in private wells screened in the deep aquifer as listed in Table 5. None of the wells experienced loss of water during the pumping test, although the level in the well at 3725 Governor's Road dropped below the level of the logger, on several occasions during periods of high use. This drilled well utilizes a jet pump with a foot valve installed at a depth of approximately 90 – 100 feet bgs rather than a submersible pump. Neither of the shallow wells that were monitored exhibited detectable interference due to the pumping test.

Once the pumping test was completed, water levels recovered to within 0.2 to 0.4 metres of their original levels, which corresponds to 75 to 78 percent recovery. The recovery was interrupted by the pumping of FDL-01.

5.2 Well Complaints

No well complaints were received during the duration of the testing of FDL-02.

5.3 Predicted Interference

Monitoring during the pumping test indicated that water levels in nearby wells screened in the same aquifer were influenced by the testing. The trend of the drawdown was measured to be shallow and extensive, with the 1 m drawdown contour between 550 and 750 m distant at the end of the test (Figure 7). Since steady-state has not been achieved, it is expected that drawdown will increase with additional pumping. The long-term trend in drawdown is expected to increase in a similar manner, with a shallow but expansive drawdown in the aquifer close to FDL-02. Given the proposed increase in pumping rates for FDL-02 compared to FDL-01, it is expected that nearby private dwellings will experience increased drawdown in their wells. However, water level changes in the nearest private wells were monitored to be only about 0.2 m as a result of pumping from FDL-01, so additional impacts due to a slight increase in pumping is generally not expected to be significant given the available drawdown in nearby wells of over 30 metres.

The well at 3725 Governors Road is a high-use well (livestock) with a jet pump and shallow intake (90 – 100 feet bgs). The water level in this well declined below the level of the datalogger during the pumping

test on several occasions, suggesting that the well was close to experiencing a shortage. As such, it is possible that the proposed increase in water taking may cause shortages in this well, particularly during periods of high demand. Consideration should be given to replacing the existing jet pump with a submersible pump, which will allow the resident to utilize more of the available drawdown in the well and avoid water quantity issues.

Long Term Interference

Longer term interference was predicted in for two scenarios:

- Four (4) months constant pumping at the maximum requested rate (high demand)
- Twelve (12) months constant pumping at the average daily rate (regular demand)

The rationale for examining effects from these two scenarios is that maximum day demand is a stress that is applied to a well during periods of high demand including drought. The assumption that drought conditions will persist for four continuous months and require non-stop pumping of FDL-02 at this maximum rate is considered unlikely to arise. To assess the long-term effects of pumping, average day demand for 365 days without consideration of recharge to the aquifer was considered in the second scenario. Since FDL-01 has operated for many years at average daily demand without stressing the aquifer, the assumption that there is enough recharge to the aquifer on an annual basis seems reasonable to conclude that a 365 day average daily demand scenario should represent long-term effects in the aquifer.

The analysis and results are provided in the following sections.

High Demand Zone of Influence

Drawdown in the wells monitored during the test period was estimated at a period of four months using a semi-log plot for each. These values were subsequently plotted on a distance-drawdown curve. Based on this plot, the projected 1-m drawdown zone of influence (ZOI) for four months of pumping at the maximum rate is approximately 900 m (Figure 7).

Average Demand Zone of Influence

Similarly, drawdown was estimated at a period of one year using the same semi-log plots. However, since the existing plots were created at the maximum rate, a correction factor is required to estimate drawdown at the lower rate assuming a maximum day factor of 2.5. Based on this calculation, the projected 1-m drawdown ZOI for one year of pumping at the average daily rate is approximately 800 m (Figure 7).

6. Water Quality

Proposed public groundwater supplies are subject to groundwater quality characterization to demonstrate that these supplies are potable. Water samples were collected from FDL-02 after 1 hour, 24 hours, 48 hours and 72 hours of pumping. These samples were submitted for analytical testing for general inorganic chemistry and for the chemical parameters listed in Schedule 23 and Schedule 24 of O.Reg. 170/03. All samples were preserved as required at the time of collection and stored in coolers for delivery to the City of Hamilton's laboratory.

A summary of the general inorganic chemistry results and the organic chemistry results are provided in Tables K-1 to K-3 of Appendix K. The laboratory certificates of analysis for all chemical and physical parameters tested are also provided in Appendix K.

General chemistry parameters include both chemical and physical parameters that relate to the general quality of a water sample such as cations, anions, nutrients, pH, conductivity, turbidity, dissolved organic carbon and metals. Chemical characteristics of drinking water refer to both organic and inorganic chemicals that may be potentially hazardous to human health, aesthetically objectionable or interfere with the operational requirements of the treatment or distribution system. Physical characteristics of groundwater refer to characteristics such as colour, clarity, odour and taste. While these characteristics directly relate to aesthetics, some may also negatively affect the treatment process or be precursors to potentially harmful chemicals.

All chemical and physical parameters tested meet the Ontario Drinking Water Quality Standards, Objectives and Guidelines, except for barium, hydrogen sulphide and hardness.

Barium levels in the samples were measured to be between 2.61 and 2.64 mg/L, which exceeds the Maximum Acceptable Concentration (MAC) of 1 mg/L. It is commonly found in dolostone (Ministry of the Environment, 2006), which is the bedrock underlying the overburden at the wellsite. Since barium did not exceed the ODWQS criteria for FDL-01, it is expected that the concentrations are high locally.

Hydrogen sulphide levels in the groundwater were measured to be 2.4 to 2.5 mg/L, which is well above the aesthetic objective of 0.05 mg/L. It is common in deep wells in the Lynden area, including FDL-01, where treatment systems are in place.

The total hardness in the water ranged between 33.5 and 36.2 mg/L as $CaCO_3$. These levels are below the recommended Operational Guideline of 80 to 100 mg/L as $CaCO_3$, indicating naturally soft water with lower calcium and magnesium values than are expected for sources derived from limestone and dolostone.Water softness can cause corrosion of water pipes.

Sodium levels in the samples, which are in the range of 54.4 to 55.2 mg/L, are below the Aesthetic Objective of 200 mg/L. However, the MOE requires that the Medical Officer of Health be notified when concentrations of sodium exceed 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium-restricted diets.

Levels for pH were measured to be 8.42 at 72-hours. This is within the Operational Guideline of 6.5 – 8.5 pH units. However, pH has been measured to exceed this level in FDL-01, so this parameter should be monitored to ensure that it remains within this range.

In summary, groundwater quality is considered to require treatment of barium and hydrogen sulphide in order for it to be potable and palatable.

7. Groundwater Under the Direct Influence of Surface Water (GUDI)

Filtration and disinfection requirements for drinking-water systems are dependent upon the type of raw water (e.g. groundwater or surface water) that is supplying the system These requirements are set out in Ontario Regulation 170/03 (O.Reg. 170/03) for Drinking-Water Systems, made under the Safe Drinking Water Act, 2002 (SDWA).

Where the raw water supply is being drawn from groundwater, the Ministry of the Environment requires an evaluation of whether or not the water supply is 'groundwater under the direct influence of surface water' (GUDI). If a drinking-water system is considered to be GUDI, the raw water supply for the system must be considered to be surface water and must receive the appropriate level of treatment.

Table 2 summarizes the O.Reg. 170/03 criteria that define which systems are drinking-water systems that obtain water from a raw water supply that is GUDI, and demonstrates the applicability of the criteria with respect to LC 9B. The hydrogeologic cross-section in Figure 5 provides an illustration in support of the GUDI evaluation. Appendix F can be referred to for well construction details.

Table 6 – GUDI Criteria and Classification

O.Reg. 170/03 Criteria for Drinking-Water Systems Whose Raw Water Supply is GUDI	Applicability of Criteria
1 - Obtains water from a well that is not a drilled well or from a well that does not have a watertight casing that extends to a depth of six metres below ground level.	N/A – The new well is a drilled well, with a watertight casing that extends 48.5 metres below ground surface.
2 - Obtains water from an infiltration gallery.	N/A – The water is not obtained from an infiltration gallery.
3 - Is not capable of supplying water at a rate greater than 0.58 litres per second and that obtains water from a well, any part of which is within 15 metres of surface water.	N/A – The long-term capacity of the new well is 4.7 L/s (75 USgpm) and the well is not within 15 metres of surface water.
4 - Is capable of supplying water at a rate greater than 0.58 litres per second and that obtains water from an overburden well, any part of which is within 100 metres of surface water.	N/A – The new well is an overburden well with a capacity greater than 0.58 L/s, but it is located more than 100 metres from surface water.
5 - Is capable of supplying water at a rate greater than 0.58 litres per second and that obtains water from a bedrock well, any part of which is within 500 metres of surface water.	N/A –The new well is an overburden well, not a bedrock well.
6 - Exhibits evidence of contamination by surface water.	N/A – recent water quality results for FDL-02 and historical water quality results for FDL-01 well located approximately 100 metres away do not provide an indication of surface water contamination.
7 - In respect of which, a written report has been prepared by a professional engineer or professional hydrogeologist that concludes that the system's raw water supply is groundwater under the direct influence of surface water and that includes a statement of his or her reasons for reaching that conclusion. O. Reg. 170/03, s. 2 (2).	N/A – a preliminary GUDI assessment by a Professional Engineer and Professional Geoscientist suggests that FDL-01, which is screened in the same aquifer, is not GUDI (Stantec, 2004)

Notes:
N/A – Not applicable

Based on the evaluation of the above criteria, the well water from FDL-02 is considered to be "characteristic of groundwater"1 (not GUDI). Additionally, the aquifer is confined below more than 20 metres of low permeability soil and microbiologic quality at the existing FDL-01 well remains satisfactory, which further supports the evaluation that the well water at FDL-02 is not GUDI.

8. Conclusions and Recommendations

8.1 Conclusions

The following conclusions are presented based on the test data collected during this study:

- FDL-02 is completed in a confined overburden aquifer within a buried valley, which trends north to south towards the Dundas Buried Valley.
- A number of residences along Governors Road near the well site rely on groundwater as a source of supply.
- Four private wells had health related exceedances (microbiology – 4, nitrates – 1).
- One of the drilled wells was located in a barn next to livestock. The well had no cap and a short stickup, making it a potential risk for contamination of the aquifer. The City should encourage the well owner to secure the well or offer to provide a proper well lid to protect the aquifer.
- Step testing indicated constant specific capacity across steps with minimal losses due to turbulent flow.
- The measured 1-m drawdown ZOI was measured to be between 550 and 750 m distant at the end of the test.
- The projected 1-m drawdown ZOI for four months of pumping at the maximum rate is approximately 900 m.
- The projected 1-m drawdown ZOI for one year of pumping at the average daily rate is approximately 800 m.
- Recovery in the aquifer was found to lag behind the drawdown on data plots, possibly due to interference from FDL-01 or nearby boundaries.
- Aquifer transmissivities ranged from 530 – 830 m^2/day for wells within 150 m of the pumping well and 50 – 200 m^2/day for wells further away. The variation may be due to the bedrock valley boundary, change in aquifer thickness and/or a change is soil composition.
- Storativity values were estimated to range between 1.0×10^{-5} to 3.0×10^{-4}
- Although steady-state conditions were not achieved during the pumping test, FDL-02 should be capable of sustained operation at a discharge rate of 4.7 L/s (75 USgpm).
- No well complaints were received during the pumping test.
- No adverse effects were detected in shallow wells as a result of the pumping test.
- Groundwater quality in the well water meets the Ontario Drinking Water Standards, Objectives and Guidelines for all parameters listed in Schedule 23 and 24 of O.Reg. 170/03, except for barium, hydrogen sulphide and hardness. Barium levels were measured to range between 2.61 and 2.64 mg/L, which exceeds the MAC of 1 mg/L. Hydrogen sulphide levels were measured to range between 2.4 and 2.5 mg/L, which exceeds the aesthetic objective of 0.05 mg/L. The hardness levels in the samples were measured to range from 33.5 to 36.2 mg/L as $CaCO_3$, which is below the Operational Guideline range of 80 to 100 mg/L as $CaCO_3$.
- The groundwater requires treatment for barium and hydrogen sulphide. The water is considered to be soft.
- Sodium levels in the samples, which are in the range of 54.4 to 55.2 mg/L, are below the Aesthetic Objective of 200 mg/L. However, the MOE requires that the Medical Officer of Health

be notified when concentrations of sodium exceed 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium-restricted diets.

- FDL-02 is designed to pump at a higher discharge rate than FDL-01. Based on analysis of the pumping test data and water balance calculations, additional interference with nearby private wells is expected to be minor.
- The well at 3725 Governors Road is a high use well and may experience water shortages due to interference during high use periods.
- The raw water from FDL-02 is characteristic of groundwater and “not GUDI”.

8.2 Recommendations

The following recommendations are provided based on the conclusions of the testing of FDL-02:

- Lynden well FDL-02 can be operated in place of the existing FDL-01 municipal well.
- Lynden well FDL-02 should be added to the existing systems PTTW and permitted for a maximum taking of 4.7 L/s (75 USgpm).
- A contingency plan should be prepared to replace the jet pump at 3725 Governors Road with a submersible pump to reduce the potential for water shortages as a result of pumping of FDL-02.
- FDL-02 will require treatment for barium and hydrogen sulphide before being connected to the local supply.

Respectfully submitted

GENIVAR Inc.

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Report reviewed by

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Consulting Engineer

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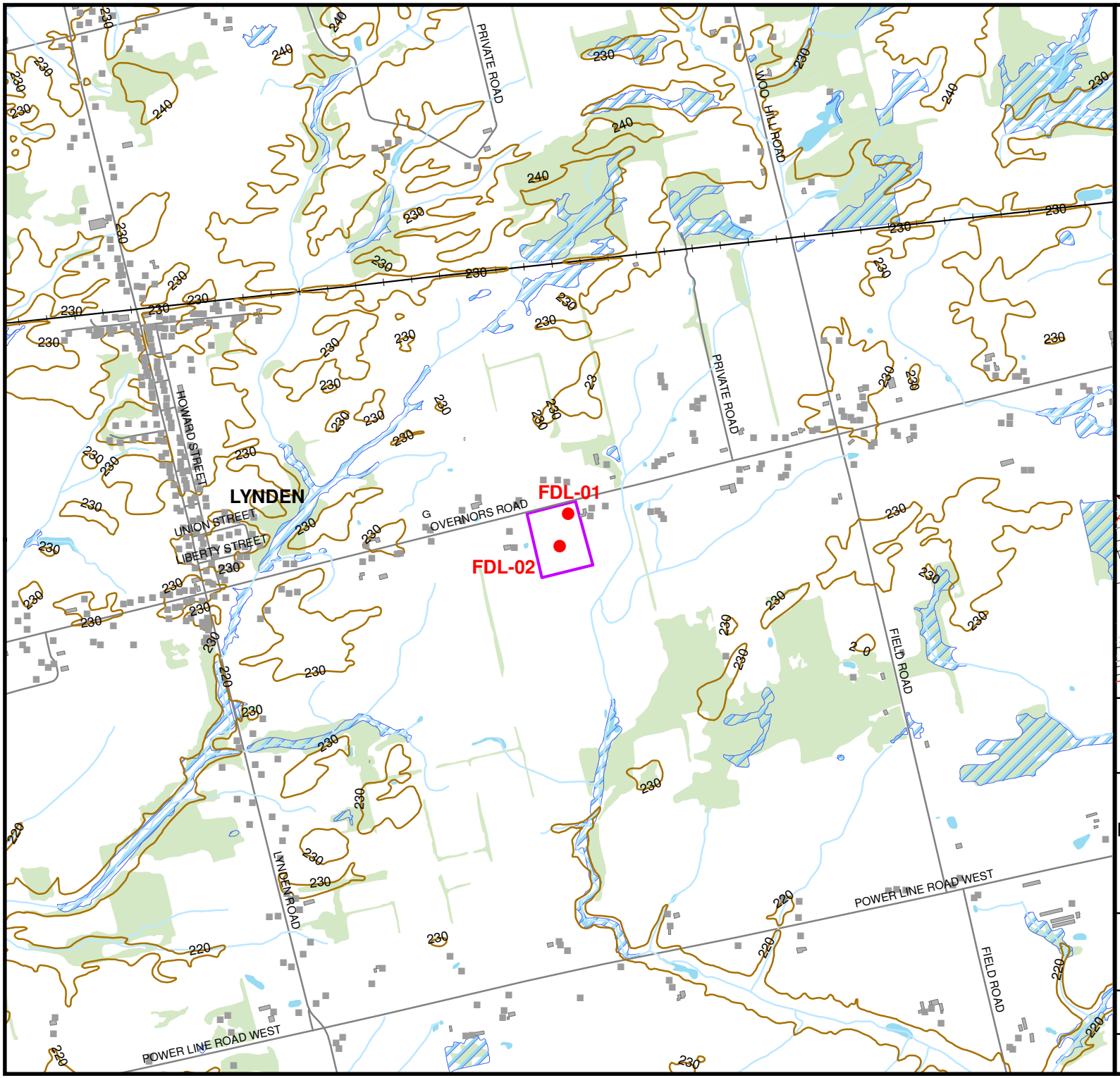
Figures



Legend

- FDL-01 and FDL-02
- Building Symbols
- Contours - 10 metre Intervals (mASL)
- Railway
- Watercourses
- Roads
- Buildings
- Wetlands
- Wooded Area
- Waterbodies
- Site Location

Data Source: Ministry of Natural Resources, Ontario Base Mapping, July 2012.

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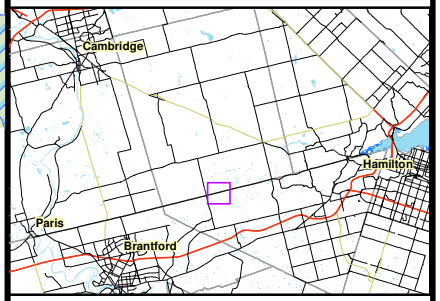
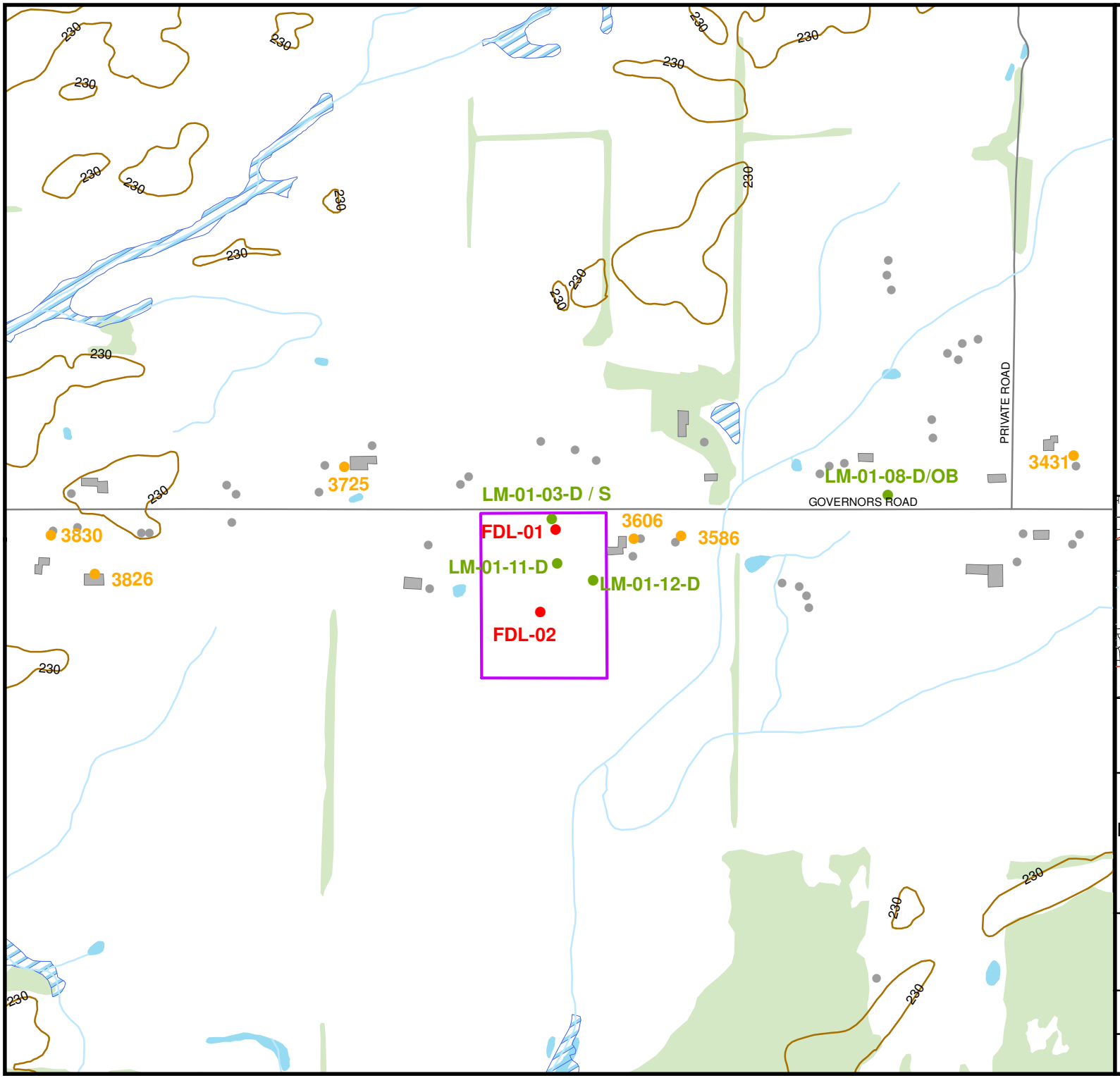


GENIVAR

Project:
LYNDEN WATER SUPPLY CLASS ENIVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-02
For: City of Hamilton

Title:
SITE LOCATION

Project No.:	Date:
071-11885-00	DECEMBER 2012
Scale:	Figure No:
1:20,000	1

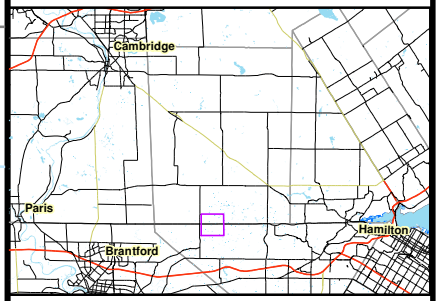


Legend

- Municipal Wells
- Monitoring Wells
- Private Wells
- Building Symbols
- Contours - 10 metre Intervals (mASL)
- Watercourses
- Roads
- Buildings
- Wetlands
- Wooded Area
- Waterbodies
- Site Location

Data Source: Ministry of Natural Resources, Ontario Base Mapping, July 2012.

150 75 0 150 Metres

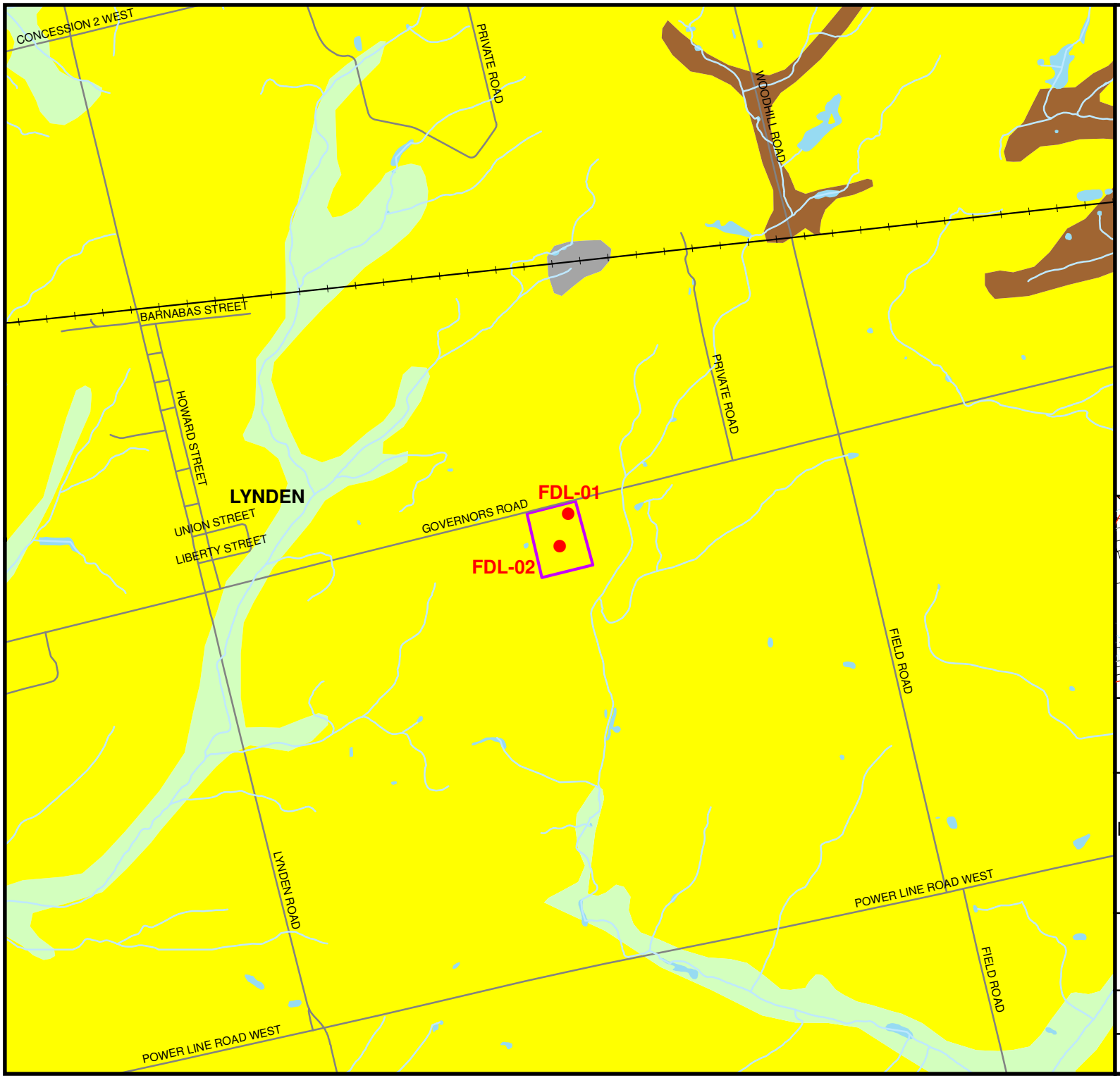


GENIVAR

Project:
LYNDEN WATER SUPPLY CLASS ENIVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-02
For: City of Hamilton

Title:
FDL-02 AND THE SURROUNDING AREA

Project No.:	Date:
071-11885-00	DECEMBER 2012
Scale:	Figure No:
1:8,000	2

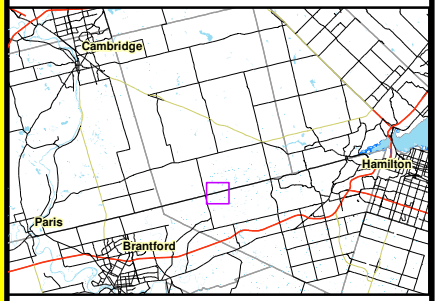


Legend

- FDL-01 and FDL-02
- Railway
- Watercourses
- Roads
- Site Location
- Waterbodies
- Massive-well laminated
- Coarse-textured glaciolacustrine deposits
- Modern alluvial deposits
- Organic deposits

Data Source: Ministry of Natural Resources, Ontario Base Mapping, July 2012. Surficial Geology of Southern Ontario, MRD 128, Ministry of Northern Development and Mines.

400 200 0 400 Metres

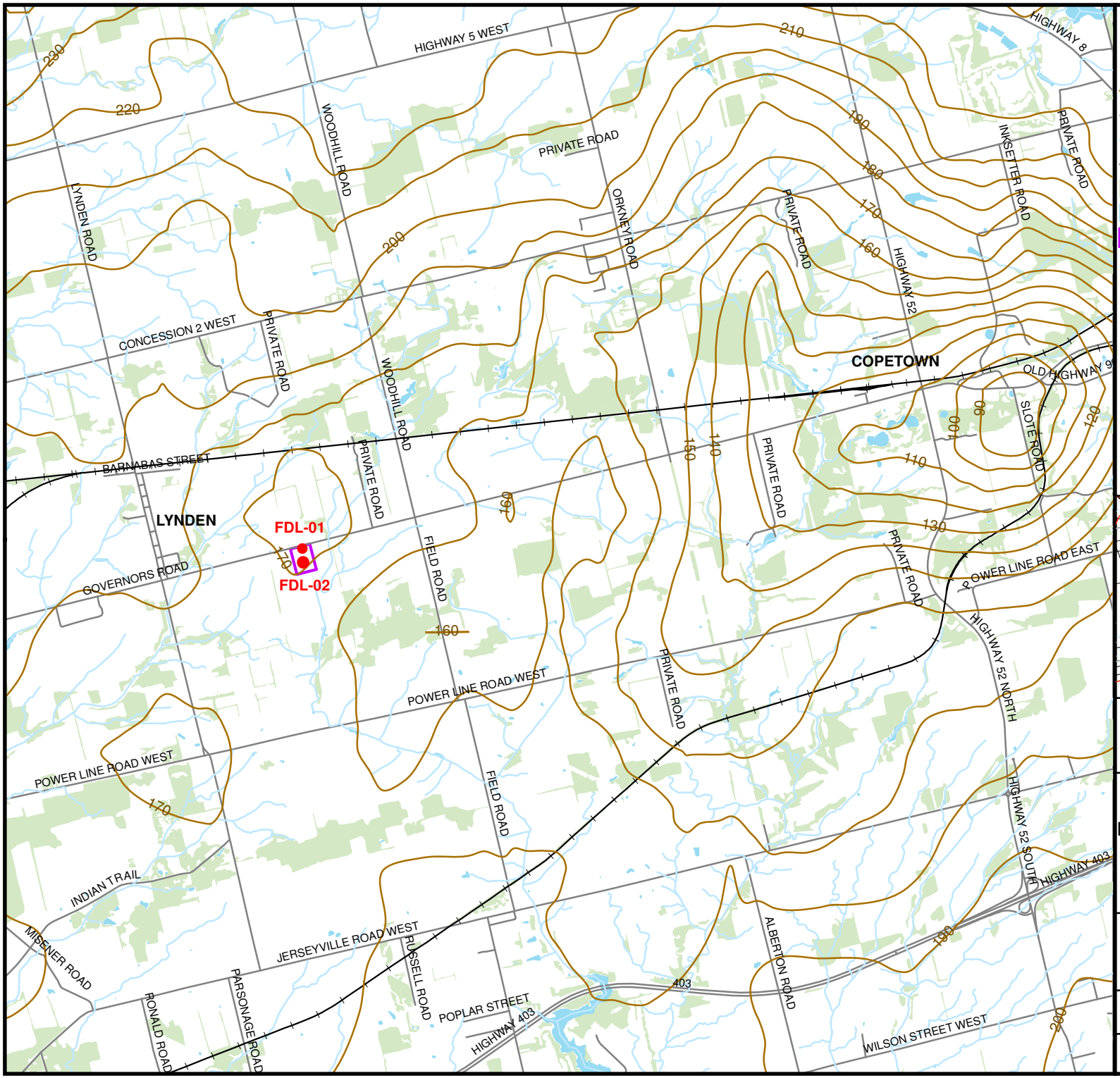


GENIVAR

Project:
LYNDEN WATER SUPPLY CLASS ENIVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-02
For: City of Hamilton

Title:
SURFICIAL GEOLOGY

Project No.:	Date:
071-11885-00	DECEMBER 2012
Scale:	Figure No:
1:20,000	3

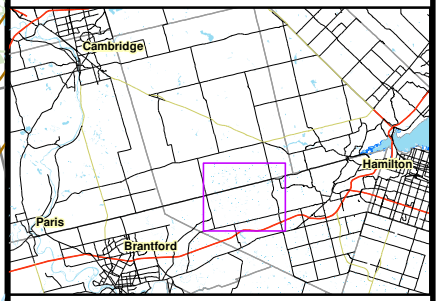


Legend

- Municipal Wells
- Bedrock Elevation (mASL) (10 m Interval)
- Railway
- Watercourses
- Roads
- Wooded Area
- Waterbodies
- Site Location

Data Source: Ministry of Natural Resources, Ontario Base Mapping, July 2012. Bedrock Topography and Overburden Thickness Mapping, Southern Ontario, MRD 207, Ministry of Northern Development and Mines.

1,000 500 0 1,000 Metres

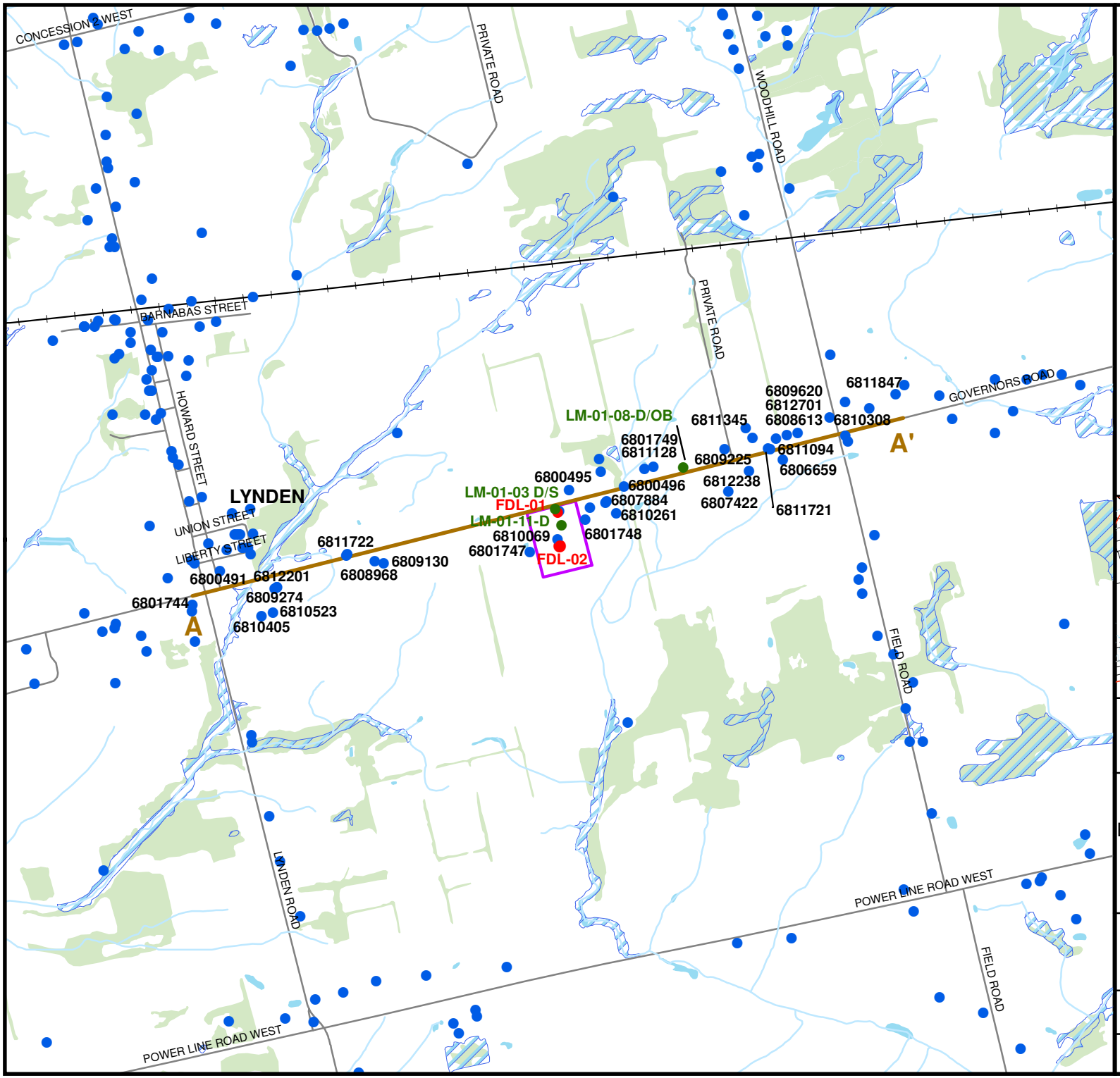


GENIVAR

Project:
LYNDEN WATER SUPPLY CLASS ENIVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-02
For: City of Hamilton

Title:
BEDROCK TOPOGRAPHY

Project No.:	Date:
071-11885-00	JANUARY 2013
Scale:	Figure No:
1:50,000	4

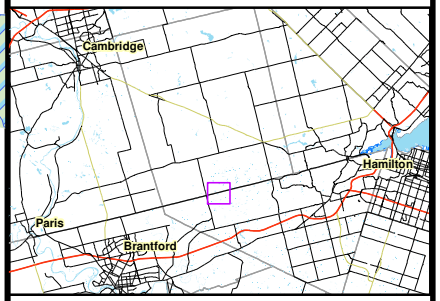


Legend

- Monitoring Wells
- Municipal Wells
- Water Well Locations
- A — A' Cross Section Location
- Railway
- Watercourses
- Roads
- Wetlands
- Wooded Area
- Waterbodies
- Site Location

Data Source: Ministry of Natural Resources, Ontario Base Mapping, July 2012.

400 200 0 400 Metres

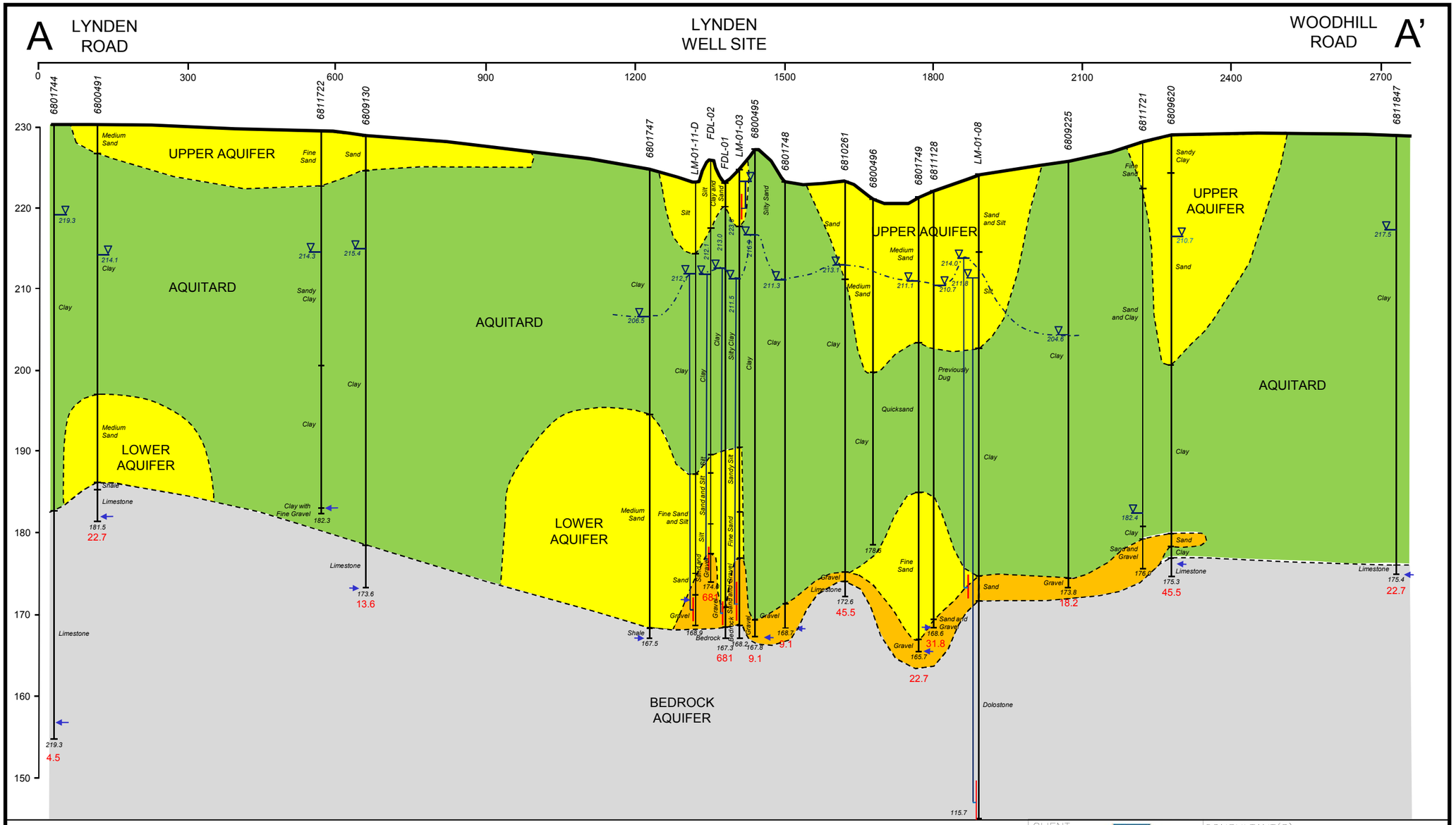


GENIVAR

Project:
LYNDEN WATER SUPPLY CLASS ENIVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-02
For: City of Hamilton

Title:
MOE WATER WELLS

Project No.:	Date:
071-11885-00	DECEMBER 2012
Scale: 1:20,000	Figure No: 5



Legend

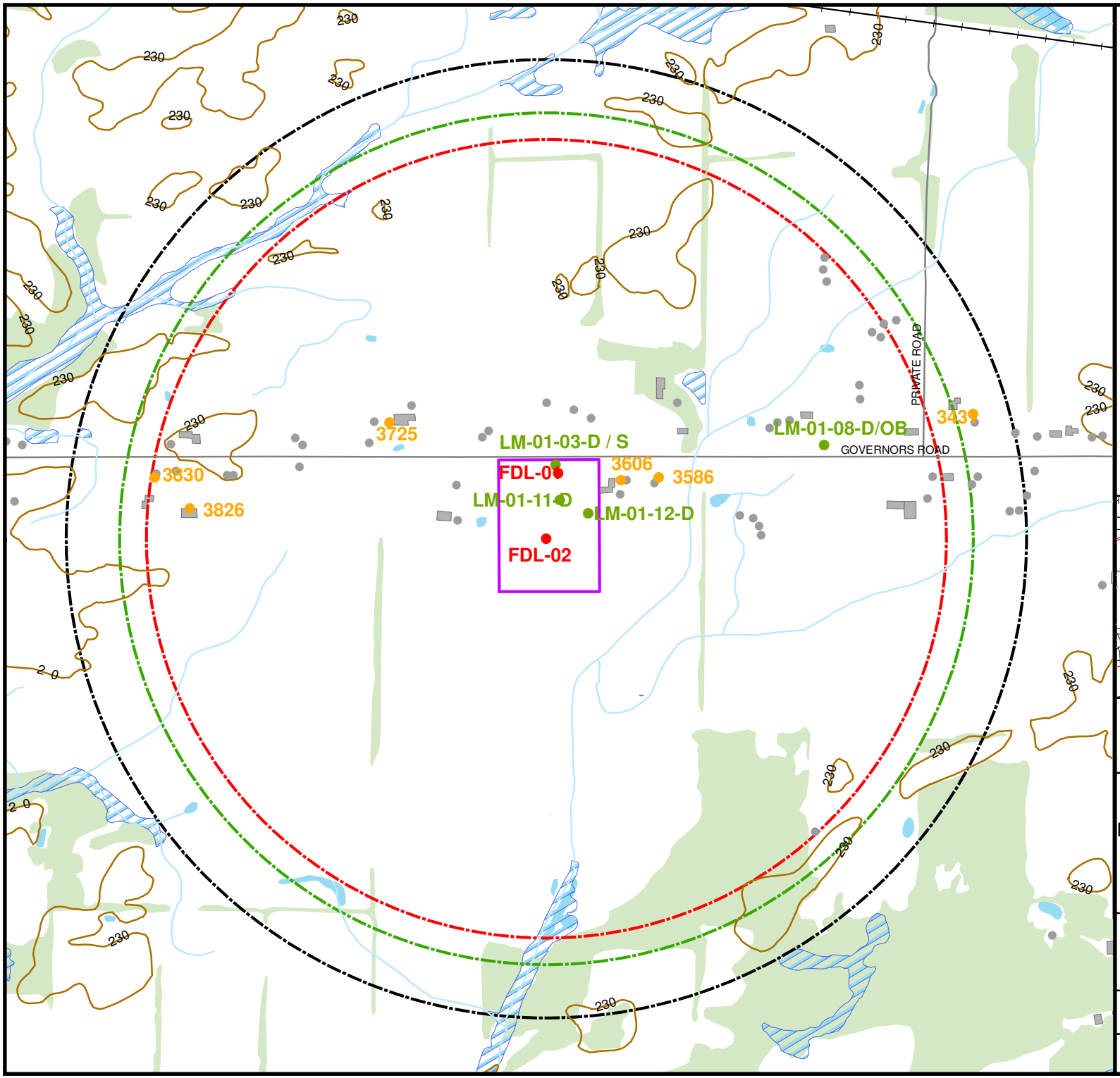
- Aquitard
- Sand and Gravel Aquifer
- Sand Aquifer
- Bedrock Aquifer

LM-01-03 — Location and Designation

Surface
Stratigraphic Change
Potentiometric Surface
Static Water Level
Water Found
Screened Interval

167.3 — Bottom of Hole (masl)
681 — Q = Litres / Minute

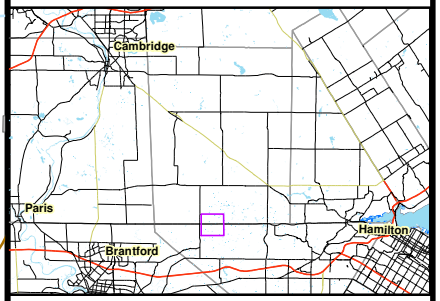
CLIENT	Hamilton
CONSULTANT(S)	GENIVAR
PROJECT TITLE	LYNDEN ENVIRONMENTAL ASSESSMENT
DRAWING TITLE	HYDROSTRATIGRAPHIC CROSS-SECTION
SCALE	AS SHOWN
DATE	JANUARY 2013
PROJECT NO.	071-11885-00
DRAWING NO.	FIG. 6



Municipal Wells
Monitoring Wells
Private Wells
Building Symbols
Contours - 10 metre Intervals (mASL)
Railway
Watercourses
Roads
Approximate ZOI (1m drawdown) – 72-hours pumping (750 m)
Approximate ZOI (1m drawdown) – Average Daily Rate for 12 months (800 m)
Approximate ZOI (1m drawdown) - Maximum Daily Rate for 4 months (900 m)
Buildings
Wetlands
Wooded Area
Waterbodies
Site Location

Data Source: Ministry of Natural Resources, Ontario Base Mapping, July 2012.

150 75 0 150 Metres



GENIVAR

Project:
LYNDEN WATER SUPPLY CLASS ENIVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-02
For: City of Hamilton

Title:
ZONE OF INFLUENCE

Project No.:	Date:
071-11885-00	JANUARY 2013
Scale:	Figure No:
1:10,000	7

Appendix A

Certificate of Approval

copy to Dan

Ministry of the Environment
Safe Drinking Water Branch
Floor 19
2 St Clair Ave W
Toronto ON M4V 1L5
Fax: (416)314-1037
Telephone: (416) 314-4625

Ministère de l'Environnement
Direction du contrôle de la qualité de l'eau potable
Étage 19
2 av St Clair Ouest
Toronto ON M4V 1L5
Télécopieur: (416)314-1037
Téléphone : (416) 314-4625

Ontario

October 30, 2006

NOV 1 0 2006

Dan Chauvin, Manager
City of Hamilton
55 John St N 6th Floor
Hamilton, Ontario
L8R 3M8

Dear Sir:

Re: Application for Approval of Municipal Drinking Water Systems
Update Description of Works
Hamilton City
MOE Reference Number 4757-6U4KDJ

We have enclosed a new Certificate of Approval in accordance with Part V, of the SDWA. This Certificate revokes and replaces Certificate of Approval No. 5475-6D5MFN dated August 25, 2006. As requested, the certificate has been amended to reflect the existing works.

Should you have any questions, please do not hesitate to contact Mrs. Ranee Mahalingam, P.Eng., at (416) 314 8184.

Yours truly,

A. Ahmed

Aziz Ahmed, P.Eng.,
Director, Part V SDWA

c: Supervisor, DWI, MOE Hamilton - District
Robert Poisson, R.E. Poisson Engineering

Ministry of the Environment | Ministère de l'Environnement

Ontario

AMENDED CERTIFICATE OF APPROVAL
MUNICIPAL DRINKING WATER SYSTEMS
NUMBER 8235-6UHJBC
Issue Date: October 31, 2006

City of Hamilton
55 John St N 6th Floor
Hamilton, Ontario
L8R 3M8

Site Location: Lynden Communal Well System
3630 Governors Rd Lot 16, Concession 1
Hamilton City,

Pursuant to the Safe Drinking Water Act, 2002, S.O. 2002, c. 32, and the regulations made thereunder and subject to the limitations thereof, this approval is issued under Part V of the Safe Drinking Water Act, 2002, S.O. 2002, c. 32 to:

City of Hamilton
71 Main Street West
Hamilton, Ontario
L8P 4Y5

PART 1 - DRINKING-WATER SYSTEM DESCRIPTION

1.1 for a drinking-water system serving the community of Lynden, rated as set out in Part 4, consisting of the following:

Completed Works
(as per email dated October 20, 2006)

i. modifications to the piping system that would ensure discharges from the well only pump into one reservoir cell; and

ii. locking out of the interconnection between the pump wells and the reservoir cells.

Proposed Works
(as per letter dated August 4, 2005)

Modifications to the Supervisory Control and Data Acquisition System (SCADA)

Existing Works
(As per Engineers' Report prepared by MacViro Consultants Inc. and dated January 31, 2001, and amended by R.E.Poisson Engineering Inc's report dated September 28, 2006)

a ground water supply consisting of one (1) deep well, and a water storage and treatment building, serving community of Lynden, located at the junction of Governors Road and Lynden Road, approximately 20 km west of the City of Hamilton, as follows:

Water Supply Well No. FDL01

- a 200 mm diameter casing, 54.56 m deep, located in part Lot 16, Concession 1, Ancaster, at 3630 Governors Road, 1.5 km east of Lynden Road, (NAD83: UTM Zone 17: 4786865.00 m N, 570797.00 m E), equipped with a 3.75 kW deep well submersible pump rated at 7.6 L/sec at 24.0 m TDH.

Water Storage and Treatment Building:

- a 9.1 x 6.9 m building over a 9.1 x 9.1 m underground reservoir, located besides the water supply well (NAD83: UTM Zone 17: 4786869.00 m N, 570802.00 m E), chemical storage and feed system, an aeration system, a stand-by diesel-generator set, motor control center, control equipment, heating and ventilation system, and other accessories:

  - a 9.1 x 9.1 m water storage reservoir, divided into two (2) equal cells, interconnected via a 400 mm Ø pipe complete with valve, and complete with cloth baffles;

  - two (2) 3.8 x 1.9 m high lift pump wells, one in each cell of the reservoir, interconnected between themselves and the reservoir cells with 300 mm diameter valves;

  - two (2) multi-stage vertical turbine high lift pumps, each capable of providing 11.4 L/s;

  - an aeration system for removal of sulfides, consisting of two (2) blowers, each with a 18.75 kW motor, manually adjustable start/stop and run times to optimize hydrogen sulphide removal and distribution headers and diffuser located in the reservoir cells, three (3) headers per cell;

  - a primary disinfection facility consisting of sodium hypochlorite storage and feed system, including a 220 L storage tank, two (2) metering pumps with a rated capacity of 3.6 L/hr @ 145 psi backpressure, and including, solution pipes, fittings, valves and accessories, with sodium hypochlorite solution injected into a 400 mm diameter pipe connection between the two storage cells;

- a secondary disinfection facility consisting of sodium hypochlorite storage and feed system, including a 220 L storage tank, two (2) metering pumps, each with a rated capacity of 3.6 L/hr at 145 psi backpressure, and including, solution pipes, fittings, valves and accessories, with sodium hypochlorite solution injected into the high lift pumps' discharge header;

- a cell outlet free chlorine analyzer, which measures free chlorine residual at the discharge of the highlift pumps prior to the secondary chlorination application point;

- a station discharge free chlorine analyzer, which measures the free chlorine residual at the entrance to the distribution system, after the secondary chlorination application point;

- miscellaneouos chlorine analyzers, turbidity meters and instrumentation required for process control;

- a raw water and a treated water flowmeters;

- an emergency stand-by power facility, consisting of one (1) 54 kW diesel-generator set to provide power to well pump and high lift pumps, chemical storage and feed facilities, complete with diesel accessories, a 910 L fuel oil storage tank inside a containment wall, fuel oil pipes, fittings, valves and accessories;

- a motor control center, consisting of main station breaker, controls for all station equipment and lighting, and a transfer switch for diesel-generator set;

- a control system to control operation of well pump and high lift pumps, and to pace chemical feed pumps;

- gravity discharge piping to collect and divert well pump seal water and in-line total chlorine residual analyzers water to a natural swale; and

- miscellaneous accessories including heaters, louvers, fans etc.

1.2 all in accordance with the applications and plans and other supporting documents listed in Schedule "A", and all other Schedules, which are attached to, and form part of this approval, except as specified in the conditions contained herein.

PART 2 - DEFINITIONS AND INFORMATION

2.1 Words and phrases not defined in this approval shall be given the same meaning as those set out in the *Safe Drinking Water Act, 2002*, S.O. 2002, c. 32 and any regulations made in accordance

with that act, unless the context requires otherwise.

2.2 In this approval

"adverse effect", "contaminant", "impairment" and "natural environment" shall have the same meanings as in the *Environmental Protection Act*, R.S.O.1990, c. E.19 and the *Ontario Water Resources Act,* R.S.O.1990, c. O.40;

"approval" means this entire approval document, issued in accordance with section 36 of the *SDWA,* and includes any schedules to it;

"Director" means a Director appointed pursuant to s. 6 of the *SDWA* for the purposes of Part V of the *SDWA*;

"drinking-water system" includes the works set out in Part 1;

"operating authority" and "owner" mean, in addition to the respective meanings given in the Act, City of Hamilton;

"provincial officer" means a provincial officer appointed pursuant to s. 8 of the *SDWA*;

"rated capacity" means the maximum flow rate of water which can be treated when operating the drinking-water system under design conditions;

"*SDWA*" means the *Safe Drinking Water Act, 2002, S.O. 2002, c. 32,* as amended.

PART 3 - GENERAL

Compliance

3.1 The owner and operating authority shall operate the drinking-water system in accordance with the *SDWA*, any applicable regulations made thereunder, and this approval.

3.2 Despite any condition of this approval to the contrary, the owner and operating authority set out in Part 2 are jointly and severally liable to comply with all conditions of this approval.

3.3 The owner and operating authority shall ensure that any person authorized to carry out work on or operate any aspect of the drinking-water system has been informed of the *SDWA*, all applicable regulations made in accordance with that act, and this approval and shall take all reasonable measures to ensure any such person complies with the same.

3.4 A copy of this approval shall be kept in a conspicuous place so that it is available for reference by

the *Environmental Protection Act* , and any regulations made thereunder; or

(b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

(a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or

(b) acceptance by the Ministry of the information's completeness or accuracy.

2.4 Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5 Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6 Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

3. Water Takings Authorized by This Permit

3.1 Expiry

This Permit expires on **May 31, 2019**. No water shall be taken under authority of this Permit after the expiry date.

3.2 Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

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Table A

	Source Name / Description:	Source Type:	Taking Specific Purpose:	Taking Major Category:	Max. Taken per Minute (litres):	Max. Num. of Hrs Taken per Day:	Max. Taken per Day (litres):	Max. Num. of Days Taken per Year:	Zone/ Easting/ Northing:
1	Well (FDL01)	Well Drilled	Municipal	Water Supply	227	24	327,312	365	17 570797 4786865
						Total Taking:	327,312		

4. Monitoring

4.1 Under section 9 of O. Reg. 387/04, and as authorized by subsection 34(6) of the *Ontario Water Resources Act* , the Permit Holder shall, on each day water is taken under the authorization of this Permit, record the date, the volume of water taken on that date and the rate at which it was taken. The daily volume of water taken shall be measured by a flow meter or calculated in accordance with the method described in the application for this Permit, or as otherwise accepted by the Director. The Permit Holder shall keep all records required by this condition current and available at or near the site of the taking and shall produce the records immediately for inspection by a Provincial Officer upon his or her request. The Permit Holder, unless otherwise required by the Director, shall submit, on or before March 31st in every year, the records required by this condition to the ministry's Water Taking Reporting System.

5. Impacts of the Water Taking

5.1 Notification

The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

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5.2 For Groundwater Takings

If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so.

If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected.

6. Director May Amend Permit

The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the *Ontario Water Resources Act* , Section 100 (4).

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.

2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.

3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing, conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

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In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, you may by written Notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, as amended, provides that the Notice requiring the hearing shall state:

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these legal requirements, the Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Permit to Take Water number;
6. The date of the Permit to Take Water;
7. The name of the Director;
8. The municipality within which the works are located;

This notice must be served upon:

The Secretary
Environmental Review Tribunal
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5

AND

The Director, Section 34
Ministry of the Environment
12th Floor
119 King St W
Hamilton ON L8P 4Y7
Fax: (905)521-7820

Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal:

by telephone at (416) 314-4600 ***by fax at (416) 314-4506*** ***by e-mail at www.ert.gov.on.ca***

This Permit cancels and replaces Permit Number 88-P-2000, issued on 2001/04/19 12:00:00 AM.

Dated at Hamilton this 23 rd day of March, 2010.

Carl Slater

Carl Slater
Director, Section 34
Ontario Water Resources Act , R.S.O. 1990

CONTROLLED DOCUMENT
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Schedule A

This Schedule "A" forms part of Permit To Take Water 2331-826QBK, dated March 23, 2010.

CONTROLLED DOCUMENT
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Appendix C

MOE Water Well Records

Table C-1 - MOE Water Well Records

Well ID	Color	Material	Material 2	Material 3	Depth (m)	Original Depth	Unit	Final Status	Use 1	Use 2	Static WL			Water Found (m)		Casing	Surface Elevation	Layer Elevation
											(ft)	(m)	(masl)	(m)	(masl)		(masl)	(masl)
6800491		MEDIUM SAND	SILT		3.66	12	ft	Water Supply	Domestic		52	15.85	214.08	48.158	181.77	STEEL	229.93	226.27
		CLAY	MEDIUM SAND		33.53	110	ft										229.93	196.40
		MEDIUM SAND	SILT	CLAY	43.89	144	ft										229.93	186.03
	GREY	SHALE			44.50	146	ft									OPEN HOLE	229.93	185.42
	GREY	LIMESTONE			48.46	159	ft										229.93	181.46
6800495	BROWN	CLAY			3.05	10	ft	Water Supply	Livestock	Domestic	35	10.67	216.87	59.74	167.80	STEEL	227.54	224.49
	BLUE	CLAY			57.91	190	ft										227.54	169.63
		GRAVEL			59.74	196	ft										227.54	167.80
6800496		TOPSOIL			1.52	5	ft	Abandoned Supply								STEEL	221.32	219.79
		MEDIUM SAND			21.34	70	ft										221.32	199.98
		CLAY			42.67	140	ft										221.32	178.64
6801744	BROWN	CLAY			1.8288	6	ft	Water Supply	Domestic		35	10.67	219.30	73.15	156.82	STEEL	229.97	228.14
	BLUE	CLAY			48.768	160	ft										229.97	181.20
		LIMESTONE			75.2856	247	ft									OPEN HOLE	229.97	154.68
6801747		TOPSOIL			1.22	4	ft	Water Supply	Livestock	Domestic	60	18.29	206.49	57.30	167.47	STEEL	224.77	223.56
	BLUE	CLAY			30.48	100	ft										224.77	194.29
		MEDIUM SAND			56.39	185	ft										224.77	168.39
		SHALE			57.30	188	ft									OPEN HOLE	224.77	167.47
6801748	BROWN	CLAY			2.44	8	ft	Water Supply	Livestock	Domestic	40	12.19	211.34	54.86	168.66	STEEL	223.53	221.09
	BLUE	CLAY			51.82	170	ft										223.53	171.71
		GRAVEL			54.86	180	ft										223.53	168.66
		GRAVEL			54.86	180	ft									OPEN HOLE	223.53	168.66
6801749		TOPSOIL	MEDIUM SAND		1.52	5	ft	Water Supply	Livestock	Domestic	35	10.67	211.13	56.08	165.72	STEEL	221.80	220.28
	BROWN	MEDIUM SAND			18.29	60	ft										221.80	203.51
		QUICKSAND			36.58	120	ft										221.80	185.23
		FINE SAND			54.86	180	ft										221.80	166.94
		GRAVEL			56.08	184	ft										221.80	165.72
6806659	BROWN	CLAY			1.83	6	ft	Water Supply	Livestock	Domestic	7	2.13	224.89	2.13	224.89	CONCRETE	227.02	225.19
	GREY	SILT	MEDIUM SAND		6.40	21	ft										227.02	220.62
6807422	BROWN	TOPSOIL			0.61	2	ft	Water Supply	Domestic		6			6.71	218.53	CONCRETE	225.24	224.63
	RED	CLAY			1.83	6	ft										225.24	223.41
	GREY	SILT	MEDIUM SAND		10.67	35	ft							9.14	216.10		225.24	214.57
	GREY	CLAY			12.19	40	ft									OPEN HOLE	225.24	213.04
6807884	BROWN	TOPSOIL			0.91	3	ft	Water Supply	Domestic		10	3.05	221.31	3.05	221.31	CONCRETE	224.36	223.45
	BROWN	CLAY	MEDIUM SAND		3.05	10	ft										224.36	221.31
		CLAY	SILT	MEDIUM SAND	5.18	17	ft										224.36	219.18
	BLUE	CLAY	SILT		10.67	35	ft										224.36	213.69
	GREY	MEDIUM SAND	SILT		14.94	49	ft							9.75	214.61		224.36	209.43
	BLUE	CLAY			15.24	50	ft										224.36	209.12
6808613	BROWN	CLAY	SAND		2.13	7	ft	Water Supply	Domestic		7	2.13	227.11	2.13	227.11	CONCRETE	229.25	227.11
	GREY	SILT	SAND		4.57	15	ft										229.25	224.68
	GREY	SILT			8.84	29	ft							7.62	221.63		229.25	220.41
	BLUE	CLAY			10.06	33	ft										229.25	219.19
6808968	YELLOW	SAND			0.61	2	ft	Water Supply	Domestic					3.05	225.22	CONCRETE	228.27	227.66
	BROWN	CLAY	SANDY		3.05	10	ft							4.57	223.70		228.27	225.22
	GREY	SILT			4.57	15	ft										228.27	223.70
	BLUE	CLAY			6.10	20	ft							10.67	217.60		228.27	222.17
	GREY	SILT	SAND	LAYERED	12.19	40	ft										228.27	216.08

Table C-1 - MOE Water Well Records

Well ID	Color	Material	Material 2	Material 3	Depth (m)	Original Depth	Unit	Final Status	Use 1	Use 2	Static WL			Water Found (m)		Casing	Surface Elevation	Layer Elevation
											(ft)	(m)	(masl)	(m)	(masl)		(masl)	(masl)
6809130	BROWN	SAND			4.27	14	ft	Water Supply	Livestock	Domestic	44	13.41	215.36	54.86	173.91	STEEL	228.77	224.50
	GREY	CLAY			30.48	100	ft										228.77	198.29
	GREY	CLAY	SILT		50.60	166	ft										228.77	178.18
	GREY	LIMESTONE			55.17	181	ft									OPEN HOLE	228.77	173.60
6809225		TOPSOIL			1.83	6	ft	Water Supply	Domestic		70	21.34	204.59	52.12	173.81	STEEL	225.93	224.10
	BROWN	CLAY			8.23	27	ft										225.93	217.70
	BLUE	CLAY			51.82	170	ft										225.93	174.11
	GREY	GRAVEL			52.12	171	ft										225.93	173.81
6809274	BROWN	SAND	CLAY		2.44	8	ft	Water Supply	Domestic					5.49	224.16	CONCRETE	229.65	227.21
	GREY	SAND	SILT		10.67	35	ft										229.65	218.98
	GREY	SILT	CLAY		12.19	40	ft										229.65	217.46
6809620	BROWN	CLAY	SANDY	LOOSE	4.27	14	ft	Water Supply	Domestic		40	12.19	216.71	52.73	176.18	STEEL	228.91	224.64
	BROWN	SAND	LOOSE		27.43	90	ft										228.91	201.47
	BROWN	CLAY	SANDY	LOOSE	34.75	114	ft										228.91	194.16
	GREY	CLAY	LOOSE		48.77	160	ft										228.91	180.14
	BROWN	SAND	LOOSE		50.29	165	ft										228.91	178.61
	BROWN	CLAY	SANDY		51.82	170	ft										228.91	177.09
	GREY	LIMESTONE	HARD		53.64	176	ft									OPEN HOLE	228.91	175.26
6810069		TOPSOIL			1.83	6	ft	Water Supply	Livestock		40	12.19		52.73		STEEL	227.24	225.41
	BROWN	CLAY			6.71	22	ft										227.24	220.53
	BLUE	CLAY			30.48	100	ft										227.24	196.76
	BROWN	QUICKSAND			49.99	164	ft										227.24	177.25
	GREY	GRAVEL			52.73	173	ft										227.24	174.51
6810261	BROWN	SAND	LOOSE		3.05	10	ft	Water Supply	Domestic		35	10.67	213.14	50.60	173.21	STEEL	223.81	220.76
	GREY	SAND	LOOSE		12.19	40	ft										223.81	211.61
	GREY	CLAY	LOOSE		17.68	58	ft										223.81	206.13
	GREY	CLAY	SANDY	LOOSE	22.86	75	ft										223.81	200.95
	GREY	CLAY	LOOSE		48.16	158	ft										223.81	175.65
	BROWN	GRAVEL			49.38	162	ft										223.81	174.43
	GREY	LIMESTONE	HARD		51.21	168	ft									OPEN HOLE	223.81	172.60
6810308	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		15	4.57	225.86	4.57	225.86	CONCRETE	230.43	230.12
	BROWN	CLAY	SANDY		4.57	15	ft							7.62	222.81		230.43	225.86
	GREY	SILT			6.10	20	ft							10.67	219.76		230.43	224.33
		UNKNOWN			12.19	40	ft										230.43	218.24
6810405	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		15	4.57	224.50	4.57	224.50	CONCRETE	229.08	228.77
	BROWN	CLAY	SANDY		4.57	15	ft							7.62	221.46		229.08	224.50
	GREY	SILT			11.89	39	ft							10.67	218.41		229.08	217.19
	BLUE	CLAY	SILT	LAYERED	15.24	50	ft							13.72	215.36		229.08	213.84
6810523	BROWN	SAND			6.10	20	ft	Water Supply	Domestic		12	3.66	227.59	3.66	227.59	CONCRETE	231.25	225.15
	BLUE	CLAY			9.14	30	ft									GALVANIZED	231.25	222.11
6811094	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		4	1.22	225.65	1.22	225.65	CONCRETE	226.87	226.57
	BROWN	SAND			1.22	4	ft										226.87	225.65
	BROWN	SAND	WATER-BEARING		4.57	15	ft										226.87	222.30
	GREY	SAND	SILT	LAYERED	9.14	30	ft										226.87	217.73
6811128		PREV. DRILLED			53.0352	174	ft	Water Supply	Domestic		38	11.58	210.69	53.645	168.63	STEEL	222.27	169.24
	GREY	SAND	GRAVEL		53.6448	176	ft										222.27	168.63
6811345	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		10	3.05	222.29	3.05	222.29	CONCRETE	225.34	225.03
	BROWN	CLAY	SANDY		3.05	10	ft										225.34	222.29
	GREY	SILT	SAND	LAYERED	6.10	20	ft										225.34	219.24
	BLUE	CLAY			9.14	30	ft										225.34	216.19

Table C-1 - MOE Water Well Records

Well ID	Color	Material	Material 2	Material 3	Depth (m)	Original Depth	Unit	Final Status	Use 1	Use 2	Static WL			Water Found (m)		Casing	Surface Elevation	Layer Elevation
											(ft)	(m)	(masl)	(m)	(masl)		(masl)	(masl)
6811721	BROWN	FINE SAND			4.88	16	ft	Observation Wells	Municipal		150	45.72	182.44			STEEL	228.16	223.28
	GREY	SAND			7.62	25	ft										228.16	220.54
	GREY	SAND	CLAY		39.62	130	ft										228.16	188.53
	BROWN	SAND	CLAY		45.11	148	ft										228.16	183.05
	BROWN	SAND	CLAY	GRAVEL	47.24	155	ft										228.16	180.91
	BROWN	CLAY	SILTY	FINE GRAVEL	48.46	159	ft										228.16	179.69
	BROWN	GRAVEL	SAND	CLAY	51.21	168	ft										228.16	176.95
	BROWN	SAND	GRAVEL	CLAY	52.12	171	ft										228.16	176.04
6811722	BROWN	FINE SAND			6.40	21	ft	Observation Wells	Municipal		49	14.94	214.28	46.33	182.89	STEEL	229.22	222.82
	GREY	CLAY	SANDY		28.96	95	ft										229.22	200.26
	BROWN	CLAY			46.33	152	ft										229.22	182.89
	BROWN	CLAY	FINE GRAVEL		46.94	154	ft										229.22	182.28
6811847		TOPSOIL			1.83	6	ft	Water Supply	Livestock		38	11.58	217.50	53.645	175.43	STEEL	229.08	227.25
	BROWN	CLAY	SANDY		5.49	18	ft										229.08	223.59
	BLUE	CLAY	SANDY		19.51	64	ft										229.08	209.57
	BLUE	CLAY			53.04	174	ft										229.08	176.04
	GREY	LIMESTONE			53.64	176	ft										229.08	175.43
6812201		PREVIOUSLY DUG			12.19	40	ft	Water Supply	Domestic					13.72	216.37	CONCRETE	230.09	217.90
	GREY	SAND	SILT		18.29	60	ft										230.09	211.80
6812238	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		5	1.52	224.40	1.52	224.40		225.93	225.62
	BROWN	SAND			2.74	9	ft							2.74	223.18		225.93	223.18
	GREY	SAND	SILT		10.67	35	ft							7.62	218.31		225.93	215.26
	BLUE	CLAY			11.58	38	ft							9.75	216.17		225.93	214.34
6812701		UNKNOWN TYPE			6.71	22	ft	Water Supply	Domestic		20	6.10	222.82	6.71	222.21	CONCRETE	228.92	222.21
	GREY	SILT	CLAY	LAYERED	10.67	35	ft										228.92	218.25

Appendix D

Borehole Logs

morrison beatty limited
consulting engineers and hydrogeologists
4500 dixie road, unit 12a, mississauga, ontario L4W 1V7 (416-624-9308)

TEST WELL
FDL-01

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON. BLOCK, TRACT, SURVEY, ETC.	LOT
Region of Hamilton-Wentworth	Ancaster	Conc. I	16

OWNER (SURNAME FIRST)	ADDRESS	DATE COMPLETED
Region of Hamilton-Wentworth	71 Main St.W. Hamilton,Ont.	DAY 21 MO Dec YR 84

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
Brown	clay	sand stones	layered	0	12
Grey	clay		dense (soft)	12	84
Grey	clay	stones	hard	84	140
Grey	clay	sand	layered	142	164
Grey-Black	Gravel	some clay streaks	layered	164	168
Grey-Black	Gravel	more clay streaks	layered	168	172
Grey-Black	gravel	sand,particles clay	layered,loose	172	180
Grey	rock		dense	180	184

K packer+22' leader on top

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
170-179	☒ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL
	☐ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL
	☐ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL
	☐ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL
	☐ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL

CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
8	☒ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE	.279	+1	166
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE			
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET
5'-60 5'-40 5'-25	7 7/8	13
MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN FEET	
Sta.St. wire wd.	166	

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

PUMPING TEST

PUMPING TEST METHOD	PUMPING RATE	DURATION OF PUMPING
☒ PUMP ☐ BAILER	250 GPM	24 HOURS 0 MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING ☒ PUMPING ☐ RECOVERY			
		15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
34'-11/2" FEET	Drawdown 57 FEET	12-1/2" FEET	12'3/4" FEET	13' FEET	13'-5/8" FEET

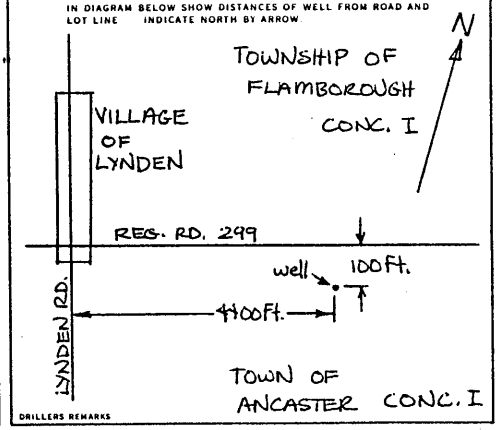
IF FLOWING, GIVE RATE	PUMP INTAKE SET AT	WATER AT END OF TEST
GPM	140 FEET	☒ CLEAR ☐ CLOUDY

RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING	RECOMMENDED PUMPING RATE
☐ SHALLOW ☒ DEEP	140 FEET	150 GPM

FINAL STATUS OF WELL	☒ WATER SUPPLY ☐ OBSERVATION WELL ☐ TEST HOLE ☐ RECHARGE WELL ☐ ABANDONED, INSUFFICIENT SUPPLY ☐ ABANDONED, POOR QUALITY ☐ UNFINISHED
WATER USE	☐ DOMESTIC ☐ STOCK ☐ IRRIGATION ☐ INDUSTRIAL ☐ OTHER ☐ COMMERCIAL ☒ MUNICIPAL ☐ PUBLIC SUPPLY ☐ COOLING OR AIR CONDITIONING ☐ NOT USED
METHOD OF DRILLING	☐ CABLE TOOL ☒ ROTARY (CONVENTIONAL) ☐ ROTARY (REVERSE) ☐ ROTARY (AIR) ☐ AIR PERCUSSION ☐ BORING ☐ DIAMOND ☐ JETTING ☐ DRIVING

6450 LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS

CONTRACTOR

NAME OF WELL CONTRACTOR	LICENCE NUMBER
Northern Well Drilling Limited	3903
ADDRESS: P.O. Box 358 Unionville,Ontario.	
NAME OF DRILLER OR BORER: Jerry W. Renwick	LICENCE NUMBER: 4508
SIGNATURE OF CONTRACTOR	SUBMISSION DATE: DAY ___ MO ___ YR ___

OFFICE USE ONLY

FORM NO. 0506—4—77 FORM 7

RECORD OF BOREHOLE No FDL-02

PROJECT	Proposed Municipal Well, Lynden, ON	LOCATION	3618 Governors Road, Lynden, Ontario	ORIGINATED BY	MB
CLIENT	City of Hamilton		570803,4786739 (+/-4m)	COMPILED BY	RM
JOB NO.	TB111049 DATE 8/16/2011	EQUIPMENT	Mud Rotary	CHECKED BY	MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
0.0	Brown **TOPSOIL**										
0.9	Grey **SILT** with thick (~10cm) CLAY layers; increasing clay with depth							1, 2, 3, 4, 5, 6, 7, 8, 9			
9.1	Grey **CLAY**, hard; high plasticity							10, 11, 12			
12.5	Grey **CLAY**, soft, with red clay, silt and very fine sand							13, 14			

Continued Next Page

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049 DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES					STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)			
							16			Static water level on 16 August 2011 was at 15.54 mbTOC.
16.2	Grey **CLAY**, fining downward sequences very fine SAND to SILT to grey CLAY to red CLAY; repeating with increasing thickness downward						17			
							18			
							19			
							20			
							21			
							22			
							23			
							24			
							25			
							26			
							27			
							28			
							29			
29.3	**CLAY**, hard, mottled red and grey; trace fine sand									

Continued Next Page

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049
DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✠ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
							31			
							32			
							33			
							34			
							35			
							36			
36.6	Grey-brown **SILT**, loose, with thin clay layer						37			
							38			Very low sample return.
39.0	Grey-brown fine **SAND and SILT**, stiff						39			
							40			
							41			
41.2	Grey-brown fine **SAND and SILT**, soft						42			
42.1	Grey-brown fine **SAND and SILT**, stiff									
42.7	Grey-brown fine **SAND and SILT**, soft						43			
							44			

Continued Next Page

amec

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049 DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
45.1	Brown **SILT**, trace fine SAND, stiff									
45.7	Brown **SILT**, trace CLAY, soft						46			
46.6	Brown **SILT**, trace fine SAND, stiff						47			
47.9	Brown **SILT**, trace CLAY, soft						48			
48.0	Brown **SILT**, trace fine SAND, stiff									Water found at 48.46 mbTOC.
48.5	Grey-brown medium coarse **SAND** coarsening down to pea **GRAVEL**						49			
50.1	Dense **TILL** diamicton						50			
50.8	Green **COBBLES**, shaley, rounded						51			
50.9	Grey-green **GRAVEL**, black shale **COBBLES**						52			
52.1	**BOREHOLE TERMINATED**									**Well Details:** Casing: 206 mm I.D. steel riser (+2.6-48.5 m). Screen: 219mm I.D. stainless steel Slot 25 (48.5-49.1m), Slot 45 (49.1-50.1m), TW (Slot 10) (50.1-50.6m), and Slot 20 (50.6-51.5m). Annular Space: silica sand pack #2 (44.2-52.1 m), bentonite gravel (0-2.74 m) and neat cement grout (2.74-44.2 m) above sand pack, filling 311 mm I.D. hole. Locking well cap.

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. *(Place Sticker and/or Print Below)*: A100758

Well Record

Regulation 903 Ontario Water Resources Act

Page ___ of ___

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	CITY OF HAMILTON		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
71 MAIN STREET WEST	HAMILTON	ON	L8P4Y5	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 GOVERNOR'S ROAD	ANCASTER	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570803	4786739		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BROWN	TOPSOIL			0	3
GREY	SILT			3	30
GREY	CLAY		HARD	30	41
GREY	CLAY	SILT LAYERS	SOFT	41	53
GREY	CLAY	FINE SILT SAND LRS		53	96
GRY-RED	CLAY	TRACE SAND		96	120
GREY-BRN	FINE SAND SILT			120	159
GREY-BRN	SAND	GRAVEL	GRADES DOWN	159	167
GREY-GRN	GRAVEL	BLACK SHALE COBBLES		167	171

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used *(Material and Type)*	Volume Placed *(m³/ft³)*
0	9	BENTONITE GRAVEL	
9	145	NEAT CEMENT GROUT	
145	171	SILICA SAND PACK #2,1,1/4X1/8	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify*

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify*

Construction Record - Casing

Inside Diameter *(cm/in)*	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness *(cm/in)*	Depth (m/ft) From	To
8.125	STEEL	.219	+3	159

Construction Record - Screen

Outside Diameter *(cm/in)*	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
8.625	S STEEL	25,45	159	164
		TW,20	164	169

Status of Well

☒ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth	Kind of Water	
159 *(m/ft)* ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	

Hole Diameter

Depth (m/ft) From	To	Diameter *(cm/in)*
0	171	12.25

Results of Well Yield Testing

After test of well yield, water was:
☒ Clear and sand free
☐ Other, *specify*

If pumping discontinued, give reason: STEP TEST ONLY

Pump intake set at *(m/ft)*: 147

Pumping rate *(l/min / GPM)*: 250 IGPM

Duration of pumping: 3 hrs + ___ min

Final water level end of pumping *(m/ft)*: 67

If flowing give rate *(l/min / GPM)*:

Recommended pump depth *(m/ft)*: 100

Recommended pump rate *(l/min / GPM)*: 150 IGPM

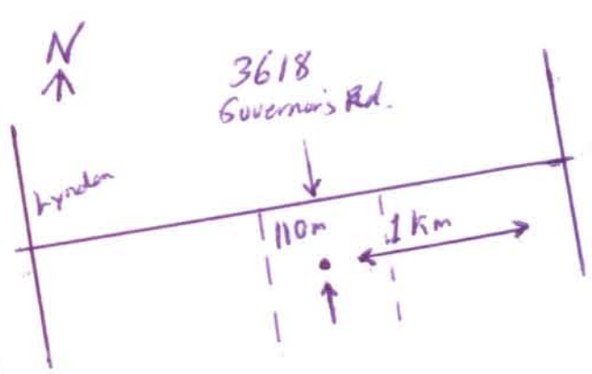
Well production *(l/min / GPM)*: 350

Disinfected? ☒ Yes ☐ No

Draw Down Time *(min)*	Water Level *(m/ft)*	Recovery Time *(min)*	Water Level *(m/ft)*
Static Level	51		
1	67	1	53
2		2	52
3		3	51
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60	67	60	51

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Durl Hopper Ltd.	2644

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont.	N4X1C9	hopper@cyg.net

Bus Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
5192717860	HOPPER, DOUGLAS

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
2323		Y Y Y Y M M D D 8/22/2011

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No	Y Y Y Y M M D D	Y Y Y Y M M D D 8/16/2011

Ministry Use Only

Audit No. z131638

Received

Ministry's Copy

LM-01-03-V LINDEN

BOREHOLE LOG

Logged By:	Reviewed By:	Sheet Number:	Borehole Number:
H.Sangam	H. Jackson	1 of 3	LM-01-03

Drilling Company:	Drilling Equipment:	Drilling Method:	Start Date:	End Date:
Lantech Drilling Services	CM-75		01 Apr 03	05 Apr 03

Final Hole Depth (m):	Final Well Depth (m):	Hole Diameter (m):	Well Diameter (m):	Pipe Stickup (m):
56.67	56.67	0.1	0.051	0.85

Ground Elevation (m):	TOC Elevation (m):	Depth to Water BTOC (m):	Depth to Water BGS (m):	Groundwater Elevation (m):
224.89	Not Surveyed	13.35	12.50	211.54 (05 Apr 03)

Sample Type Legend:

- SS Split Spoon Sample
- PS Pistar Sample
- GR Grab Sample
- RX Core Sample
- AU Auger Sample
- VA Vane Test Interval
- SP Standard Penetration Test
- SH Shelby Tube Sample

Borehole Location Description/Notes:

Northing: 4766878
Easting: 570786 Zone 17T

Sample Type, No., and Interval	Blow Counts (N/15 cm)	N-Value	Sample Recovery	Elevation (m) / Depth (m)	Depth Scale (m)	Material	Stratigraphic Description	Well Materials	Well Construction Details
SS-1		92		224.79 / 0.10			TOPSOIL		Concrete Seal
					1–5		SILTY SAND -brown -becoming wet and saturated with depth -some gravel		
SS-2		20							
				219.17 / 5.72	6		CLAY -brown-greyish -plastic		
RX-3		n.a.			7				
RX-4		n.a.			8				
				216.05 / 8.84	9		SILTY CLAY -brown -soft -layered		
RX-5		n.a.			10				
				214.27 / 10.62	11		CLAYEY SILT -light brown to brwon-greyish -interlayered clay, plastic		
RX-6		n.a.			12				
RX-7		n.a.			13				
RX-8		n.a.			14				
					15				
RX-9		n.a.			16				
				208.13 / 16.76	17		CLAY -grey, soft -plastic		
RX-10		n.a.			18				
RX-11		n.a.			19				
				205.38 / 19.51			SILTY CLAY		

SNC·LAVALIN
Engineers & Constructors

Project Name: Hamilton Grounwater Study
Project Location: Lynden

LM-01-03-D LYNDEN

BOREHOLE LOG

Logged By:	Reviewed By:	Sheet Number:	Borehole Number:
H.Sangam	H. Jackson	2 of 3	LM-01-03

Sample Type Legend:

- SS Split Spoon Sample
- PS Piontar Sample
- GR Grab Sample
- RX Core Sample
- AU Auger Sample
- VA Vane Test Interval
- SP Standard Penetration Test
- SH Shelby Tube Sample

Borehole Location Description/Notes:

Northing: 4788878
Easting: 570786 Zone 17T

Sample Type, No., and Interval	Blow Counts (N/15 cm)	N-Value	Sample Recovery	Elevation (m) Depth (m)	Depth Scale (m)	Material	Stratigraphic Description	Well Materials	Well Construction Details
RX-1		n.a.			21		-brwon-greyish -layered -stiff, becoming soft at about 32 mbgs		
RX-1		n.a.			22				
					23				
RX-1		n.a.			24				
RX-1		n.a.			25				Bentonite Grout
					26				
RX-1		n.a.			27				
RX-1		n.a.			28				
					29				
RX-1		n.a.			30				
					31				
RX-1		n.a.			32				
RX-2		n.a.			33				
				191.38 33.53	34		SANDY SILT -brown-greyish, damp -fine sand -some gravel		
RX-2		n.a.			35				
RX-2		n.a.			36				
					37				
RX-2		n.a.			38				
RX-2		n.a.			39				
					40				
RX-2		n.a.			41				
				163.74 41.15	42		FINE SAND -brown -some silt and clay		
RX-2		n.a.							

SNC·LAVALIN
Engineers & Constructors

Project Name: Hamilton Groundwater Study
Project Location: Lynden

LM-01-03-D LYNDEN

BOREHOLE LOG

Logged By:	Reviewed By:	Sheet Number:	Borehole Number:
H.Sangam	H. Jackson	3 of 3	LM-01-03

Sample Type Legend:

- SS Split Spoon Sample
- PS Piezjer Sample
- GR Grab Sample
- RX Core Sample
- AU Auger Sample
- VA Vane Test Interval
- SP Standard Penetration Test
- SH Shelby Tube Sample

Borehole Location Description/Notes:

Northing: 4786878
Easting: 570768 Zone 17T

Sample Type, No., and Interval	Blow Counts (N/15 cm)	N-Value	Sample Recovery	Elevation (m) Depth (m)	Depth Scale (m)	Material	Stratigraphic Description	Well Materials	Well Construction Details
RX-2		n.a.			43				
RX-2		n.a.			44				
RX-2		n.a.			45				
RX-2		n.a.			46				
				177.95-46.94	47		SAND and GRAVEL		
RX-3		n.a.			48		-brown-greyish, damp		
RX-3		n.a.			49		-fine sand becoming coarser with depth -subrounded gravel		Bentonite Plug
RX-3		n.a.			50				Sand Pack
RX-3		n.a.			51				
RX-3		n.a.			52				
RX-3		n.a.			53				Slotted screen
RX-3		n.a.			54				
				169.82-55.07	55		BEDROCK - DOLOMITE		
RX-3		n.a.			56		-dark grey -massive, smooth core -ocasional dissolution cavities -secondary very low permeability		
				168.22-56.67			End of Borehole		

SNC•LAVALIN

Project Name: Hamilton Grounwater Study
Project Location: Lynden

LYNDEN

BOREHOLE LOG

Logged By:	Reviewed By:	Sheet Number:	Borehole Number:
H.Sangam	H. Jackson	1 of 1	LM-02-03

Drilling Company:	Drilling Equipment:	Drilling Method:	Start Date:	End Date:
Lantech Drilling Services	CM-75		04 Apr 03	04 Apr 03

Final Hole Depth (m):	Final Well Depth (m):	Hole Diameter (m):	Well Diameter (m):	Pipe Stickup (m):
6.07	6.07	0.1	0.051	0.70

Ground Elevation (m):	TOC Elevation (m):	Depth to Water BTOC (m):	Depth to Water BGS (m):	Groundwater Elevation (m):
224.73	Not Surveyed	1.10	0.40	223.63 (05 Apr 03)

Sample Type Legend:

- SS Split Spoon Sample
- PS Pionjer Sample
- GR Grab Sample
- RX Core Sample
- AU Auger Sample
- VA Vane Test Interval
- SP Standard Penetration Test
- SH Shelby Tube Sample

Borehole Location Description/Notes:

Northing: 4766878
Easting: 570791 Zone 17T

Sample Type, No., and Interval	Blow Counts (N/15 cm)	N-Value	Sample Recovery	Elevation (m) Depth (m)	Depth Scale (m)	Material	Stratigraphic Description	Well Materials	Well Construction Details
				224.63 / 0.10			TOPSOIL		Concrete Seal
							SILTY SAND -brown -becoming wet and saturated with depth -some gravel		Bentonite Grout
					1				
					2				Bentonite Plug
									Sand Pack
					3				
					4				Slotted screen
					5				
				219.01 / 5.72			CLAY -brown-greyish -plastic		
				218.66 / 6.07	6		End of Borehole		

SNC·LAVALIN
Engineers & Constructors

Project Name: Hamilton Groundwater Study
Project Location: Lynden

Monitoring Well: MW-OGS-08 S/D

Project:	Copetown Test Hole	**Drillrig:**	CME 75	**Casing Diameter:**	102 mm (overburden), 100 mm (bedrock)	**Ground surface elevation:**	n/a
Client:	City of Hamilton	**Bit Type:**	Diamond	**Inclination:**	90 °	**Top of casing elevation:**	n/a
Location:	Copetown, Ontario	**Flush:**	Potable water - Brethren Water Service	**Azimuth:**	n/a	**Easting:**	571266
Number:	1609-00519	**Feed:**	Potable water - Brethren Water Service	**Date Started:**	Sep-15-2008	**Northing:**	4787035
Field investigator:	R.Dong	**Core Diameter:**	PQ-85 mm(overburden), HQ-63.5 mm (bedrock)	**Date Completed:**	Oct-14-2008	**Stick up:**	n/a
Contractor:	ProCore Drilling Ltd.						

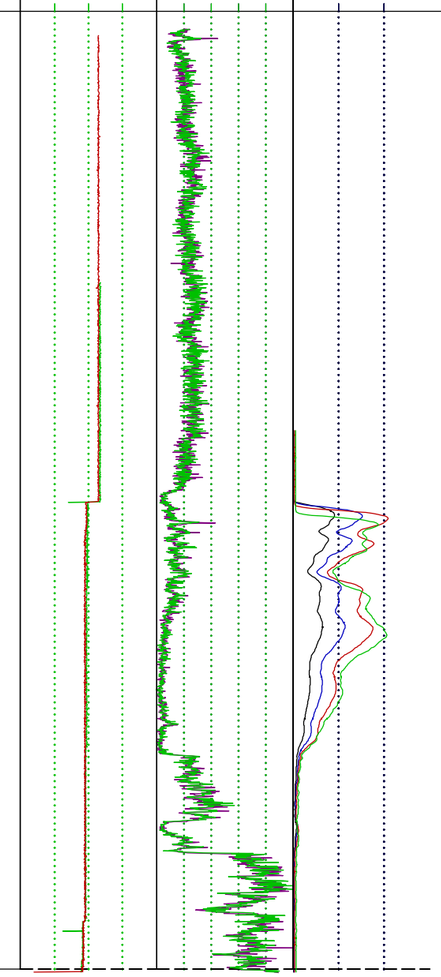
SUBSURFACE PROFILE

Depth (m)	Lithologic Description	Elevation (m AMSL) Depth (m BGS)
0	Ground Surface	0.00
0	TOPSOIL organic, brown, very moist	0.00
4	SAND trace fines, organics, rootlets, brown and grey mottled, rusty colour, very moist	0.91
8	fine grained, brown, homogeneous, very moist	1.22
10	some silt, fine grained, browny grey, homogeneous, wet	3.53
14	SILT little sand, browny grey, wet	4.82
16	SANDY SILT lenses of grey silty clay, browny grey, wet	5.94
20	CLAYEY SILT trace fine sand, lenses of clayey silt, little sand, browny grey, wet	6.35
22	SILT trace sand, trace grey clay pockets, browny grey, homogeneous, wet	7.87
26	SILT AND SAND fine grained, browny grey, very stiff, wet	9.40
30	some clay, reddy brown	16.89
32	CLAY/SAND/SILT light to dark grey, grey mottled, moist	20.06
34	SAND AND SILT grey, fine grained, moist	20.40
36	SAND/SILT AND CLAY fine grained, reddy brown, browny grey, grey, soft, stiff	21.59
38	SAND fine grained, reddy brown/browny grey, varved, moist	50.54
40	SAND AND SILT trace fine to coarse gravel, little medium to coarse sand	52.37
42	ERAMOSA FORMATION (REFORMATORY QUARRY MEMBER) dolostone, light to dark grey	53.39
44	ERAMOSA FORMATION (VINEMOUNT MEMBER) dolostone, light to dark grey, petroleum odour	57.20
48	GOAT ISLAND FORMATION (ANCASTER MEMBER) dolostone, light to medium dark grey, trace soft white clasts, fine bedding plans	66.75
50	GASPORT FORMATION dolostone, light grey to grey, sinewy bedding planes, trace chert clasts	80.14
52	ROCHESTER FORMATION shale and limestone, grey to black	83.57
54	IRONDEQUOIT FORMATION limestone, light grey, porous	91.11
56	ROCKWAY FORMATION dolostone, light grey	92.38
58	MERRITTON FORMATION	94.18
60	CABOT HEAD FORMATION shale and limestone, green and red	95.79
66	End of Borehole	108.80

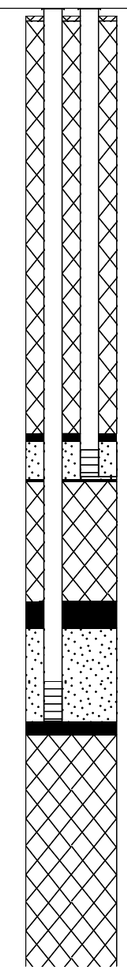
CORE RECOVERY DATA

Run Number	TCR	SCR	RQD	Fractures per 1.52 m	Surface Description	Rock Strength
37	69%	53%	50%	1	irregular/rough	
38	85%	46%	28%	8	irregular/rough	
39	100%	91%	90%	5	irregular/rough	
40	100%	89%	89%	4	irregular/rough	
41	87%	87%	85%	1	irregular/rough	
42	98%	98%	90%	1	irregular/rough	
43	100%	98%	98%	2		
44	100%	100%	100%	1		
45	100%	99%	NA	0	irregular/rough	
46	100%	96%	93%	2		
47	100%	NA	NA	0		
48	100%	98%	99%	1		
49	100%	98%	98%	1	irregular/rough	
50	100%	99%	99%	1	irregular/rough	
51	100%	99%	99%	1		
52	100%	98%	99%	0		
53	100%	96%	96%	4		
54	100%	94%	94%	4	irregular/rough	
55	100%	94%	89%	5	irregular/rough	
56	100%	94%	94%	2		
57	100%	92%	93%	0		
58	100%	100%	100%	0		
59	100%	95%	95%	2		
60	100%	100%	100%	0		
61	100%	98%	98%	0		
62	100%	97%	98%	0	irregular/rough	
63	100%	96%	97%	1		
64	100%	97%	91%	5		
65	100%	100%	100%	0		
66	100%	100%	100%	0		
67	100%	NA	NA	0		
68	100%	23%	NA	1		
69	100%	100%	100%	1		
70	100%	100%	100%	0		
71	100%	29.69%	100%	0		
72	NA	NA	NA	2		
73	100%	NA	NA	5		

GEOPHYSICS



WELL DETAILS



NOTES:

TCR - Total Core Recovery

SCR - Solid Core Recovery

RQD - Rock Quality Designation

mAMSL - metres above mean sea level

mBGS - metres below ground surface

Electrode spread

- No.8
- No.16
- No.32
- No.64

Stantec

Lm-11-01

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. *(Place Sticker and/or Print Below)* A100757

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	CITY OF HAMILTON		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
71 MAIN STREET WEST	HAMILTON	ON	L8P4Y5	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3818 GOVERNOR'S ROAD	ANCASTER	18	1

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570819	4786818		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BROWN	TOPSOIL			0	3
GREY	SILT			3	30
GREY	CLAY		HARD	30	41
GREY	CLAY	SILT LAYERS	SOFT	41	53
GREY	CLAY	FINE SILT SAND LRS		53	96
GRY-RED	CLAY	TRACE SAND		96	120
GREY-BRN	FINE SAND SILT			120	159
GREY-BRN	SAND	GRAVEL	GRADES DOWN	159	167
GREY-GRN	GRAVEL	BLACK SHALE COBBLES		167	179

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used *(Material and Type)*	Volume Placed *(m³/ft³)*
0	9	BENTONITE GRAVEL	
9	145	NEAT CEMENT GROUT	
145	171	SILICA SAND PACK #2.1,1/4X1/8	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify* ____

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify* ____

Construction Record - Casing

Inside Diameter *(cm/in)*	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness *(cm/in)*	Depth (m/ft) From	To
2	PVC	SCH40	+2	169

Construction Record - Screen

Outside Diameter *(cm/in)*	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
10	PVC	10	169	179

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify* ____
☐ Other, *specify* ____

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, *specify* ____

If pumping discontinued, give reason:

Pump intake set at *(m/ft)*

Pumping rate *(l/min / GPM)*

Duration of pumping ____ hrs + ____ min

Final water level end of pumping *(m/ft)*

If flowing give rate *(l/min / GPM)*

Recommended pump depth *(m/ft)*

Recommended pump rate *(l/min / GPM)*

Well production *(l/min / GPM)*

Disinfected? ☐ Yes ☐ No

Draw Down Time *(min)*	Water Level *(m/ft)*	Recovery Time *(min)*	Water Level *(m/ft)*
Static Level	11		
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Water Details

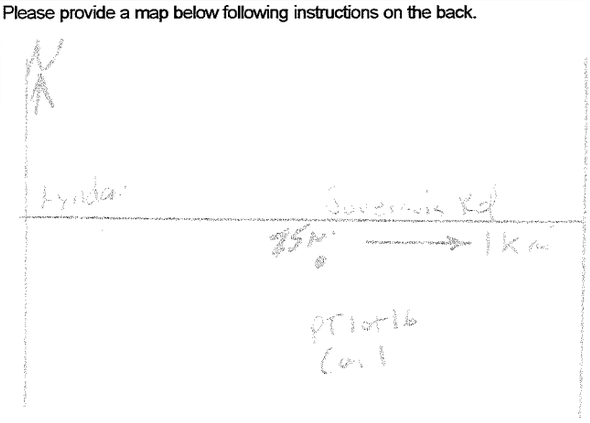
Water found at Depth *(m/ft)*	Kind of Water	
169	☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify* ____
	☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify* ____
	☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify* ____

Hole Diameter

Depth (m/ft) From	To	Diameter *(cm/in)*
0	179	8 1/8

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Durl Hopper Ltd.	2644

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont	N4X1C9	hopper@oyg.net

Bus.Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
519-271-7300	HOPPER, DOUGLAS

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
2323		Y Y Y Y M M D D

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No	Y Y Y Y M M D D	Y Y Y Y M M D D

Ministry Use Only

Audit No. z131640

Received

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. *(Place Sticker and/or Print Below)* A115331

Well Record

Regulation 903 Ontario Water Resources Act

Page _____ of _____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	CITY OF HAMILTON		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
77 JAMES STREET NORTH	HAMILTON	ON	L8R2K3	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
1618 GOVERNORS ROAD	ANCASTER	16	

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON - WENTWORTH	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570958	4786204		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
			NO PREVIOUS RECORD FOUND		
			EXISTING DRILLED WELL	0	171
			WELL WAS CLEANED AND NEW 2"		
			PVC MONITOR WAS INSTALLED		

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used *(Material and Type)*	Volume Placed (m^3/ft^3)
0	150	BENTONITE CHIPS	
150	171	SILICA SAND	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify* _____

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify* _____

Construction Record - Casing

Inside Diameter *(cm/in)*	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness *(cm/in)*	Depth (m/ft) From	Depth (m/ft) To
2	PVC SCH 40		+2	151

Construction Record - Screen

Outside Diameter *(cm/in)*	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To
2	PVC SCH 40	10	151	171

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify* _____
☐ Other, *specify* _____

Water Details

Water found at Depth *(m/ft)*	Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, *specify* _____
Water found at Depth *(m/ft)*	Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, *specify* _____
Water found at Depth *(m/ft)*	Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, *specify* _____

Hole Diameter

Depth (m/ft) From	Depth (m/ft) To	Diameter *(cm/in)*

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, *specify* _____

If pumping discontinued, give reason: NOT TESTED

Pump intake set at *(m/ft)*

Pumping rate *(l/min / GPM)*

Duration of pumping _____ hrs + _____ min

Final water level end of pumping *(m/ft)*

If flowing give rate *(l/min / GPM)*

Recommended pump depth *(m/ft)*

Recommended pump rate *(l/min / GPM)*

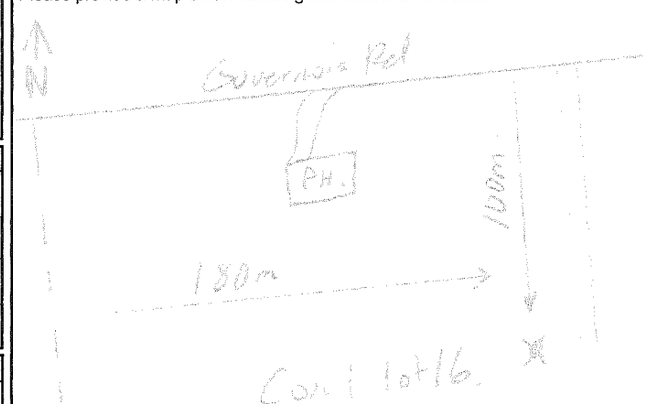
Well production *(l/min / GPM)*

Disinfected? ☐ Yes ☐ No

Draw Down Time *(min)*	Draw Down Water Level *(m/ft)*	Recovery Time *(min)*	Recovery Water Level *(m/ft)*
Static Level	45		
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Dun Hopper Ltd.	2044

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont.	N4X1C9	hopper@cyg.net

Bus.Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
519-271-7240	HOPPER, SIMON

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
3051		2014-04-16

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No	Y Y Y Y M M D D	2014-04-16

Ministry Use Only

Audit No. Z140523

Received

Appendix E

Private Water Well Survey Results

Table E-1 - Water Quality Results - Lynden Private Water Well Survey

	Units	ODWQS Heath Based Guidelines	ODWQS Aesthetic Objective	ODWQS Operational Guideline	Property 1	Property 2	Property 3	Property 4	Property 5	Property 6	Property 7	Property 8
Well Type					**Drilled**	**Drilled**	**Bored**	**Drilled**	**Drilled**	**Bored**	**Dug**	**Drilled**
Approx. Well Depth					**Unknown**	**57.9m**	**18.3m**	**61.0m**	**51.8m**	**16.8m**	**7.6-9.1m**	**56.4m**
Colour	**TCU**	**-**	**5**	**-**	**22**	4	**111**	**64**	**6**	<2	**90**	**25**
Hardness	**mg/L**	**-**	**-**	**80-100**	**62.7**	**23**	**623**	**44.3**	**70.6**	**376**	**<0.7**	**63.4**
Nitrate	**mg/L**	**10**	**-**	**-**	<0.01	<0.01	**17.4**	0.02	<0.01	0.63	0.55	<0.01
Nitrite	**mg/L**	**1**	**-**	**-**	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.019	<0.01
Turbidity	**NTU**	**-**	**5**		2.15	0.22	13.6	**5.54**	0.5	<0.05	**8.68**	3.56
E.Coli.	**TCU/100ml**	**0**	**-**	**-**	0	**40**	**<10**	**<10**	0	0	0	0
HPC	**TCU/100ml**	**-**	**-**	**-**	0	99	32	107	81	240	239	84
Total Coliform	**TCU/100ml**	**0**	**-**	**-**	0	**100**	**10**	**50**	0	**4**	0	0
Background	**TCU/ml**	**-**	**-**	**-**	1	n/a	330	n/a	12	83	800	15
Antinomy	**mg/L**	**0.006**	**-**	**-**	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006
Arsenic	**mg/L**	**0.025**	**-**	**-**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009
Barium	**mg/L**	**1**	**-**	**-**	0.978	0.641	0.072	0.501	0.982	0.057	<0.002	0.074
Beryllium	**mg/L**	**-**	**-**	**-**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	**mg/L**	**-**	**-**	**-**	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Boron	**mg/L**	**5**	**-**	**-**	0.538	0.553	0.068	0.547	0.555	0.041	0.033	0.401
Cadmium	**mg/L**	**0.005**	**-**	**-**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Calcium	**mg/L**	**-**	**-**	**-**	12.4	4.5	184	8.81	11.3	108	<0.10	12.9
Chromium	**mg/L**	**-**	**-**	**-**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	**mg/L**	**-**	**-**	**-**	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009
Copper	**mg/L**	**1**	**-**	**-**	0.008	<0.002	0.002	0.064	<0.002	0.008	0.007	0.004
Iron	**mg/L**	**0.3**	**-**	**-**	**0.455**	0.069	**0.562**	**2.34**	0.052	0.019	**0.427**	**0.312**
Lead	**mg/L**	**0.01**	**-**	**-**	<0.0010	<0.0010	<0.0010	0.0013	<0.0010	<0.0010	<0.0010	<0.0010
Magnesium	**mg/L**	**-**	**-**	**-**	7.71	2.85	39.6	5.42	10.3	25.7	<0.10	7.58
Manganeese	**mg/L**	**0.05**	**-**	**-**	0.008	0.006	0.029	0.015	0.004	0.003	0.01	0.008
Molybdenum	**mg/L**	**-**	**-**	**-**	<0.005	0.006	<0.005	<0.005	0.005	<0.005	<0.005	0.007
Nickel	**mg/L**	**-**	**-**	**-**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Potassium	**mg/L**	**-**	**-**	**-**	1.24	0.91	10.6	1.06	1.37	1.28	0.42	1.05
Selenium	**mg/L**	**0.01**	**-**	**-**	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Silver	**mg/L**	**-**	**-**	**-**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium	**mg/L**	**-**	**200** (1)	**-**	81.7	48.6	70	68.8	80	19.8	71.6	31.3
Strontium	**mg/L**	**-**	**-**	**-**	1.18	0.508	0.507	0.719	0.993	0.26	<0.005	0.0848
Thallium	**mg/L**	**-**	**-**	**-**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin	**mg/L**	**-**	**-**	**-**	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Titanium	**mg/L**	**-**	**-**	**-**	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	0.018	<0.001
Vanadium	**mg/L**	**-**	**-**	**-**	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Zinc	**mg/L**	**-**	**5**	**-**	0.017	0.017	0.012	0.01	<0.005	0.006	0.008	<0.005
Hydrogen Sulphide	**mg/L**	**-**	**0.05**	**-**	<0.021	**1.48**	<0.021	**0.201**	<0.021	<0.021	<0.021	<0.021

Notes:

Bolded entries were in exceedance of ODWQS Guidelines

Highlighted, bolded and underlined entries are in exceedance of ODWQS Health Based Guidelines

(1) - The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets

Certificate of Analysis

City of Hamilton
Environmental Laboratory
700 Woodward Avenue, Hamilton, ON L8H 6P4
P. (905) 546-2424 F. (905)545-0234

CLIENT INFORMATION

Client Name: INFRASTRUCTURE AND SOURCE WATER PLANNING
Attention: CHRIS SHRIVE

Address: 77 JAMES STREET NORTH
HAMILTON
L8R 2K3

LABORATORY INFORMATION

Sample Date: 2012-09-06
Date Submitted: 2012-09-07

Laboratory Work Order Number: 304206

Samples analysed in this work order were analysed using the following methods:

Bacteria Membrane Filtration DC agar	Bacteria Membrane Filtration-HPC	Metals Hydrides-Hydride AA	Lead Graphite Furnace AA
Metals ICP	Anions IC	Turbidity Turbimeter	Cadmium Graphite Furnace AA
Colour Spectrophotometric	LIMS Calculation	Subcontract	

NOTES: '<' = less than the Method Detection Limit (MDL), 'NS' = No Sample, 'IS' = Insufficient Sample, '>' = greater than the reported result, " * " indicates result is outside of the applied guideline/objective
Methods used by the City of Hamilton's Environmental Laboratory (CHEL) are based upon or modified from those found in the following sources: Standard Methods for the Examination of Water and Wastewater, 22nd Edition, United States Environmental Protection Agency (EPA), Ministry of the Environment (MOE), Association of Official Analytical Chemists (AOAC) and American Oil Chemists Society (AOCS).
All analytical work performed at the CHEL is done according to accepted quality assurance and quality control procedures. Quality and other related data as well as uncertainty values are available upon request.

The results on this Chemical Analysis Report relate only to the items tested.

Final Report Approval by:

Digitally signed by Rosemary Eszes
Date: 2012.10.03 12:29:12 -04'00'

Rosemary Eszes-Wegner, Supervisor Quality Assurance

Digitally signed by Pamela Thomas
Date: 2012.10.05 10:46:15 -04'00'

Pamela M. Thomas, Superintendent Environmental Laboratory

Infrastructure and Source Water Planning

Lynden Well Study - Genivar

3531 Governor's Road 2012-08-27 09:30:00

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)		
Colour (apparent)	22	CU	2			
Hardness	62.7	mg/L	0.7			
Nitrate as N	<0.01	mg/L	0.01	10.0		MAC
Nitrite as N	<0.01	mg/L	0.01	1.0		MAC
Turbidity	2.15	NTU	0.05			
Escherichia coli	0	CFU/100mL	0	0		MAC
Heterotrophic Plate Count	0	CFU/1mL	0			
Total Coliform	0	CFU/100mL	0	0		MAC
Total Coliform Background	1	CFU/100mL	0			MAC
Antimony	<0.0006	mg/L	0.0006	0.006		MAC
Arsenic	<0.001	mg/L	0.001	0.025		MAC
Barium	0.978	mg/L	0.002	1.0		MAC
Beryllium	<0.0001	mg/L	0.0001			
Bismuth	<0.020	mg/L	0.020			
Boron	0.538	mg/L	0.010	5.0		MAC
Cadmium	<0.0001	mg/L	0.0001	0.005		MAC
Calcium	12.4	mg/L	0.10			
Chromium	<0.001	mg/L	0.001	0.05		MAC
Cobalt	<0.0009	mg/L	0.0009			
Copper	0.008	mg/L	0.002			
Iron	0.455	mg/L	0.010			
Lead	<0.0010	mg/L	0.0010	0.010		MAC
Magnesium	7.71	mg/L	0.10			
Manganese	0.008	mg/L	0.001			
Molybdenum	<0.005	mg/L	0.005			
Nickel	<0.005	mg/L	0.005			
Potassium	1.24	mg/L	0.10			
Selenium	<0.002	mg/L	0.002	0.01		MAC
Silver	<0.005	mg/L	0.005			
Sodium	81.7	mg/L	0.50			
Strontium	1.18	mg/L	0.005			
Thallium	<0.010	mg/L	0.010			
Tin	<0.020	mg/L	0.020			
Titanium	<0.001	mg/L	0.001			
Vanadium	<0.002	mg/L	0.002			
Zinc	0.017	mg/L	0.005			
Sulphide (Subcontract)	<0.020	mg/L	0.020			

Note: Hydrogen Sulphide result is calculated to be <0.021 mg/L

3725 Governor's 2012-08-28 10:00:00

Colour (apparent)	4	CU	2			
Hardness	23.0	mg/L	0.7			
Nitrate as N	<0.01	mg/L	0.01	10.0		MAC
Nitrite as N	<0.01	mg/L	0.01	1.0		MAC
Turbidity	0.22	NTU	0.05			
Escherichia coli	40	CFU/100mL	0	0	*	MAC
Heterotrophic Plate Count	99	CFU/1mL	0			
Total Coliform	100	CFU/100mL	0	0	*	MAC

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)		
Total Coliform Background	Note	CFU/100mL	0			**MAC**
Antimony	<0.0006	mg/L	0.0006	0.006		**MAC**
Arsenic	<0.001	mg/L	0.001	0.025		**MAC**
Barium	0.641	mg/L	0.002	1.0		**MAC**
Beryllium	<0.0001	mg/L	0.0001			
Bismuth	<0.020	mg/L	0.020			
Boron	0.553	mg/L	0.010	5.0		**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005		**MAC**
Calcium	4.50	mg/L	0.10			
Chromium	<0.001	mg/L	0.001	0.05		**MAC**
Cobalt	<0.0009	mg/L	0.0009			
Copper	<0.002	mg/L	0.002			
Iron	0.069	mg/L	0.010			
Lead	<0.0010	mg/L	0.0010	0.010		**MAC**
Magnesium	2.85	mg/L	0.10			
Manganese	0.006	mg/L	0.001			
Molybdenum	0.006	mg/L	0.005			
Nickel	<0.005	mg/L	0.005			
Potassium	0.91	mg/L	0.10			
Selenium	<0.002	mg/L	0.002	0.01		**MAC**
Silver	<0.005	mg/L	0.005			
Sodium	48.6	mg/L	0.50			
Strontium	0.508	mg/L	0.005			
Thallium	<0.010	mg/L	0.010			
Tin	<0.020	mg/L	0.020			
Titanium	<0.001	mg/L	0.001			
Vanadium	<0.002	mg/L	0.002			
Zinc	<0.005	mg/L	0.005			
Sulphide (Subcontract)	1.40	mg/L	0.020			

Note: Hydrogen Sulphide result is calculated to be 1.48 mg/L. Total Coliform and Escherichia coli results obtained on diluted sample due to smearing of background bacterial growth.

3826 Governor's - Barn 2012-08-28 09:00:00

Colour (apparent)	111	CU	2			
Hardness	623	mg/L	0.7			
Nitrate as N	17.4	mg/L	0.01	10.0	*	**MAC**
Nitrite as N	<0.01	mg/L	0.01	1.0		**MAC**
Turbidity	13.6	NTU	0.05			
Escherichia coli	<10	CFU/100mL	0	0		**MAC**
Heterotrophic Plate Count	32	CFU/1mL	0			
Total Coliform	10	CFU/100mL	0	0	*	**MAC**
Total Coliform Background	330	CFU/100mL	0			**MAC**
Antimony	<0.0006	mg/L	0.0006	0.006		**MAC**
Arsenic	<0.001	mg/L	0.001	0.025		**MAC**
Barium	0.072	mg/L	0.002	1.0		**MAC**
Beryllium	<0.0001	mg/L	0.0001			
Bismuth	<0.020	mg/L	0.020			
Boron	0.068	mg/L	0.010	5.0		**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005		**MAC**
Calcium	184	mg/L	0.10			
Chromium	<0.001	mg/L	0.001	0.05		**MAC**
Cobalt	<0.0009	mg/L	0.0009			

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)		
Copper	0.002	mg/L	0.002			
Iron	0.562	mg/L	0.010			
Lead	<0.0010	mg/L	0.0010	0.010		**MAC**
Magnesium	39.6	mg/L	0.10			
Manganese	0.029	mg/L	0.001			
Molybdenum	<0.005	mg/L	0.005			
Nickel	<0.005	mg/L	0.005			
Potassium	10.6	mg/L	0.10			
Selenium	<0.002	mg/L	0.002	0.01		**MAC**
Silver	<0.005	mg/L	0.005			
Sodium	70.0	mg/L	0.50			
Strontium	0.507	mg/L	0.005			
Thallium	<0.010	mg/L	0.010			
Tin	<0.020	mg/L	0.020			
Titanium	0.008	mg/L	0.001			
Vanadium	<0.002	mg/L	0.002			
Zinc	0.012	mg/L	0.005			
Sulphide (Subcontract)	<0.020	mg/L	0.020			

Note: Hydrogen Sulphide result is calculated to be <0.021 mg/L. Total Coliform and Escherichia coli results obtained on a diluted sample due to smearing of background bacterial growth.

3606 Governors Road 2012-08-29 09:30:00

Colour (apparent)	64	CU	2			
Hardness	44.3	mg/L	0.7			
Nitrate as N	0.02	mg/L	0.01	10.0		**MAC**
Nitrite as N	<0.01	mg/L	0.01	1.0		**MAC**
Turbidity	5.54	NTU	0.05			
Escherichia coli	<10	CFU/100mL	0	0		**MAC**
Heterotrophic Plate Count	107	CFU/1mL	0			
Total Coliform	50	CFU/100mL	0	0	*	**MAC**
Total Coliform Background	Note	CFU/100mL	0			**MAC**
Antimony	<0.0006	mg/L	0.0006	0.006		**MAC**
Arsenic	<0.001	mg/L	0.001	0.025		**MAC**
Barium	0.501	mg/L	0.002	1.0		**MAC**
Beryllium	<0.0001	mg/L	0.0001			
Bismuth	<0.020	mg/L	0.020			
Boron	0.547	mg/L	0.010	5.0		**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005		**MAC**
Calcium	8.81	mg/L	0.10			
Chromium	<0.001	mg/L	0.001	0.05		**MAC**
Cobalt	<0.0009	mg/L	0.0009			
Copper	0.064	mg/L	0.002			
Iron	2.34	mg/L	0.010			
Lead	0.0013	mg/L	0.0010	0.010		**MAC**
Magnesium	5.42	mg/L	0.10			
Manganese	0.015	mg/L	0.001			
Molybdenum	<0.005	mg/L	0.005			
Nickel	<0.005	mg/L	0.005			
Potassium	1.06	mg/L	0.10			
Selenium	<0.002	mg/L	0.002	0.01		**MAC**
Silver	<0.005	mg/L	0.005			
Sodium	66.8	mg/L	0.50			

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)	
Strontium	0.719	mg/L	0.005		
Thallium	<0.010	mg/L	0.010		
Tin	<0.020	mg/L	0.020		
Titanium	<0.001	mg/L	0.001		
Vanadium	<0.002	mg/L	0.002		
Zinc	0.010	mg/L	0.005		
Sulphide (Subcontract)	0.190	mg/L	0.020		

Note: Hydrogen Sulphide result is calculated to be 0.201 mg/L. Sample contained very fine particles. Total Coliform and Escherichia coli results obtained on a diluted sample due to smearing of background bacterial growth.

3431 Governors Road 2012-08-29 10:00:00

Colour (apparent)	6	CU	2		
Hardness	70.6	mg/L	0.7		
Nitrate as N	<0.01	mg/L	0.01	10.0	**MAC**
Nitrite as N	<0.01	mg/L	0.01	1.0	**MAC**
Turbidity	0.50	NTU	0.05		
Escherichia coli	0	CFU/100mL	0	0	**MAC**
Heterotrophic Plate Count	81	CFU/1mL	0		
Total Coliform	0	CFU/100mL	0	0	**MAC**
Total Coliform Background	12	CFU/100mL	0		**MAC**
Antimony	<0.0006	mg/L	0.0006	0.006	**MAC**
Arsenic	<0.001	mg/L	0.001	0.025	**MAC**
Barium	0.982	mg/L	0.002	1.0	**MAC**
Beryllium	<0.0001	mg/L	0.0001		
Bismuth	<0.020	mg/L	0.020		
Boron	0.555	mg/L	0.010	5.0	**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005	**MAC**
Calcium	11.3	mg/L	0.10		
Chromium	<0.001	mg/L	0.001	0.05	**MAC**
Cobalt	<0.0009	mg/L	0.0009		
Copper	<0.002	mg/L	0.002		
Iron	0.052	mg/L	0.010		
Lead	<0.0010	mg/L	0.0010	0.010	**MAC**
Magnesium	10.3	mg/L	0.10		
Manganese	0.004	mg/L	0.001		
Molybdenum	0.005	mg/L	0.005		
Nickel	<0.005	mg/L	0.005		
Potassium	1.37	mg/L	0.10		
Selenium	<0.002	mg/L	0.002	0.01	**MAC**
Silver	<0.005	mg/L	0.005		
Sodium	80.0	mg/L	0.50		
Strontium	0.993	mg/L	0.005		
Thallium	<0.010	mg/L	0.010		
Tin	<0.020	mg/L	0.020		
Titanium	<0.001	mg/L	0.001		
Vanadium	<0.002	mg/L	0.002		
Zinc	<0.005	mg/L	0.005		
Sulphide (Subcontract)	<0.020	mg/L	0.020		

Note: Hydrogen Sulphide result is calculated to be <0.021 mg/L

3586 Governors Road 2012-09-04 11:00:00

Colour (apparent)	<2	CU	2		

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)		
Hardness	376	mg/L	0.7			
Nitrate as N	0.63	mg/L	0.01	10.0		**MAC**
Nitrite as N	0.01	mg/L	0.01	1.0		**MAC**
Turbidity	<0.05	NTU	0.05			
Escherichia coli	0	CFU/100mL	0	0		**MAC**
Heterotrophic Plate Count	240	CFU/1mL	0			
Total Coliform	4	CFU/100mL	0	0	*	**MAC**
Total Coliform Background	83	CFU/100mL	0			**MAC**
Antimony	<0.0006	mg/L	0.0006	0.006		**MAC**
Arsenic	<0.001	mg/L	0.001	0.025		**MAC**
Barium	0.057	mg/L	0.002	1.0		**MAC**
Beryllium	<0.0001	mg/L	0.0001			
Bismuth	<0.020	mg/L	0.020			
Boron	0.041	mg/L	0.010	5.0		**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005		**MAC**
Calcium	108	mg/L	0.10			
Chromium	<0.001	mg/L	0.001	0.05		**MAC**
Cobalt	<0.0009	mg/L	0.0009			
Copper	0.008	mg/L	0.002			
Iron	0.019	mg/L	0.010			
Lead	<0.0010	mg/L	0.0010	0.010		**MAC**
Magnesium	25.7	mg/L	0.10			
Manganese	0.003	mg/L	0.001			
Molybdenum	<0.005	mg/L	0.005			
Nickel	<0.005	mg/L	0.005			
Potassium	1.28	mg/L	0.10			
Selenium	<0.002	mg/L	0.002	0.01		**MAC**
Silver	<0.005	mg/L	0.005			
Sodium	19.8	mg/L	0.50			
Strontium	0.260	mg/L	0.005			
Thallium	<0.010	mg/L	0.010			
Tin	<0.020	mg/L	0.020			
Titanium	<0.001	mg/L	0.001			
Vanadium	<0.002	mg/L	0.002			
Zinc	0.006	mg/L	0.005			
Sulphide (Subcontract)	<0.020	mg/L	0.020			

Note: Hydrogen Sulphide result is calculated to be <0.021 mg/L

3757 Governor's Road 2012-09-06 17:30:00

Colour (apparent)	90	CU	2			
Hardness	<0.7	mg/L	0.7			
Nitrate as N	0.55	mg/L	0.01	10.0		**MAC**
Nitrite as N	0.19	mg/L	0.01	1.0		**MAC**
Turbidity	8.68	NTU	0.05			
Escherichia coli	0	CFU/100mL	0	0		**MAC**
Heterotrophic Plate Count	239	CFU/1mL	0			
Total Coliform	0	CFU/100mL	0	0		**MAC**
Total Coliform Background	800	CFU/100mL	0			**MAC**
Antimony	<0.0006	mg/L	0.0006	0.006		**MAC**
Arsenic	<0.001	mg/L	0.001	0.025		**MAC**
Barium	<0.002	mg/L	0.002	1.0		**MAC**
Beryllium	<0.0001	mg/L	0.0001			

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)	
Bismuth	<0.020	mg/L	0.020		
Boron	0.033	mg/L	0.010	5.0	**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005	**MAC**
Calcium	<0.10	mg/L	0.10		
Chromium	<0.001	mg/L	0.001	0.05	**MAC**
Cobalt	<0.0009	mg/L	0.0009		
Copper	0.007	mg/L	0.002		
Iron	0.427	mg/L	0.010		
Lead	<0.0010	mg/L	0.0010	0.010	**MAC**
Magnesium	<0.10	mg/L	0.10		
Manganese	0.010	mg/L	0.001		
Molybdenum	<0.005	mg/L	0.005		
Nickel	<0.005	mg/L	0.005		
Potassium	0.42	mg/L	0.10		
Selenium	<0.002	mg/L	0.002	0.01	**MAC**
Silver	<0.005	mg/L	0.005		
Sodium	71.6	mg/L	0.50		
Strontium	<0.005	mg/L	0.005		
Thallium	<0.010	mg/L	0.010		
Tin	<0.020	mg/L	0.020		
Titanium	0.018	mg/L	0.001		
Vanadium	<0.002	mg/L	0.002		
Zinc	0.008	mg/L	0.005		
Sulphide (Subcontract)	<0.020	mg/L	0.020		

Note: Hydrogen Sulphide result is calculated to be <0.021 mg/L. Total Coliform Background result is an estimate.

3830 Governor's Road 2012-09-06 14:20:00

Colour (apparent)	25	CU	2		
Hardness	63.4	mg/L	0.7		
Nitrate as N	<0.01	mg/L	0.01	10.0	**MAC**
Nitrite as N	<0.01	mg/L	0.01	1.0	**MAC**
Turbidity	3.56	NTU	0.05		
Escherichia coli	0	CFU/100mL	0	0	**MAC**
Heterotrophic Plate Count	84	CFU/1mL	0		
Total Coliform	0	CFU/100mL	0	0	**MAC**
Total Coliform Background	15	CFU/100mL	0		**MAC**
Antimony	<0.0006	mg/L	0.0006	0.006	**MAC**
Arsenic	0.009	mg/L	0.001	0.025	**MAC**
Barium	0.074	mg/L	0.002	1.0	**MAC**
Beryllium	<0.0001	mg/L	0.0001		
Bismuth	<0.020	mg/L	0.020		
Boron	0.401	mg/L	0.010	5.0	**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005	**MAC**
Calcium	12.9	mg/L	0.10		
Chromium	<0.001	mg/L	0.001	0.05	**MAC**
Cobalt	<0.0009	mg/L	0.0009		
Copper	0.004	mg/L	0.002		
Iron	0.312	mg/L	0.010		
Lead	<0.0010	mg/L	0.0010	0.010	**MAC**
Magnesium	7.58	mg/L	0.10		
Manganese	0.008	mg/L	0.001		
Molybdenum	0.007	mg/L	0.005		

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)	
Nickel	<0.005	mg/L	0.005		
Potassium	1.05	mg/L	0.10		
Selenium	<0.002	mg/L	0.002	0.01	**MAC**
Silver	<0.005	mg/L	0.005		
Sodium	31.3	mg/L	0.50		
Strontium	0.848	mg/L	0.005		
Thallium	<0.010	mg/L	0.010		
Tin	<0.020	mg/L	0.020		
Titanium	<0.001	mg/L	0.001		
Vanadium	<0.002	mg/L	0.002		
Zinc	<0.005	mg/L	0.005		
Sulphide (Subcontract)	<0.020	mg/L	0.020		

Note: Hydrogen Sulphide result is calculated to be <0.021 mg/L

Appendix F

FDL-02 Well Construction Report

ESTIMATION OF WELL YIELD
PROPOSED MUNICIPAL WELL
3618 GOVERNORS ROAD
LYNDEN, ONTARIO

Submitted to:
City of Hamilton
Public Works Department
Infrastructure and Source Water Planning Section
Environment and Sustainable Infrastructure Division
77 James Street North, Suite 400
Hamilton, ON, L8R 2K3

Submitted by:
AMEC Environmental & Infrastructure
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September 30, 2011

Project Number: TB111049

TABLE OF CONTENTS

PAGE

1.0 INTRODUCTION 1
2.0 WORK PROGRAM 1
3.0 SITE DESCRIPTION 1
3.1 Topography 2
3.2 Drainage 2
3.3 Physiography 2
3.4 Soils 2
4.0 GEOLOGY 3
5.0 HYDROGEOLOGY 3
7.0 WATER SUPPLY 3
7.1 Pumping Test 4
7.2 Monitoring Well Response to Pumping ..... **Error! Bookmark not defined.**
8.0 WATER QUALITY ANALYSES 6
9.0 CONCLUSIONS 7
12.0 CLOSURE 8

LIST OF TABLES

Table 1 – Summary of Bacteriological and Chemical Analyses

LIST OF FIGURES

Figure 1 – Site Location
Figure 2 – Aerial Photograph showing Well Locations and Site Features
Figure 3 – Hydrograph of Groundwater Levels at FDL 02 (Temporary Casing)
Figure 4 – Semi-log Plot of Drawdown and Recovery at FDL 02 (Temporary Casing)
Figure 5 – Hydrograph of Groundwater Levels during Constant RateTesting (Final Well FDL 02 & Monitoring Well LM-09)
Figure 6 – Semi-log Plot of Drawdown and Recovery during Constant Rate Testing (Final Well FDL 02 & Monitoring Well LM-09)

LIST OF APPENDICES

Appendix A – Bacteriological and Chemical Analyses
Appendix B – Water well records and borehole logs
Appendix C – AMEC Statement of Limitations

1.0 INTRODUCTION

AMEC Earth & Environmental, a division of AMEC Americas Limited ("AMEC"), was retained by the City of Hamilton (the "Client") to conduct a hydrogeological investigation to estimate the yield of a new water supply well which, if found suitable, will be used as a source of potable municipal water for the Rural Settlement Area of Lynden. The water well is to be located at 3618 Governors Road, Lynden, Ontario (hereafter referred to as the "Site") (Figure 1). The site is approximately 41 acres (16.7 Ha) and is primarily agricultural field with an existing pump house facility, located on the south side of Governors Road (Figure 2). The purpose of this hydrogeological investigation is to assess the capacity of the newly constructed water well.

The work carried out for the investigation was completed in accordance with AMEC's proposal (ref. no. TB-P11061E), dated July 7, 2011. Authorization to proceed with the work was provided by Mr. Mike Bingham via email on July 15, 2011.

2.0 WORK PROGRAM

The work program for this investigation comprised the following tasks:

- Clearing of underground locates;
- Monitoring of drilling and completion of the water well FDL 02 (TW-1);
- A step test carried out at FDL 02, at two pump rates of 2 L/sec; 4 L/sec, including recording of water levels using an automatic pressure transducer and manual water level readings;
- Chemical and microbiological analysis of water obtained from the subject well;
- Preparation of a report presenting the findings of the drilling and installation of FDL 02, step testing, and chemical analyses.

Prior to the completion of the water well, three test boreholes were drilled by the City of Hamilton with one of the test boreholes completed as a monitoring well (LM-09), which were supervised by Mike Bingham of the City. In addition Mike Bingham performed the final step test at 6 L/sec on the completed water well.

3.0 SITE DESCRIPTION

The Site is located in the Rural Settlement Area of Lynden, as part of the amalgamated City of Hamilton (Figure 1), on the south side of Governors Road. Lynden Road is situated approximately 1.4 km to the west of the site and Field Road is situated 1 km to the east. The surrounding area is primarily agricultural, with residential and farming properties located along Governors Road and in the settlement of Lynden. Currently, the site consists primarily of fallow field an existing pump house building at the entrance to

the Site. The existing pump well is on the west side of the pump house, with two existing monitoring wells installed to the west of the entrance driveway. The newly constructed FDL 02 is located approximately 115 meters to the rear (south) of the existing building (Figure 2).

3.1 Topography

The site is located within the Norfolk Sand Plain (Chapman and Putnam, 1984), characterized as a flat-lying area above and to the west of the Niagara Escarpment. In the vicinity of the site, the topography is low-lying in the northern half of the property, with a bedrock high forming a low ridge, rising several meters above the surrounding plain. Elevation in the vicinity of the site is on the order of 225 to 230 masl (National Topographic Database (Canvec) data, 2010).

3.2 Drainage

Based on a review of topographic maps and air photographs, and direct observation at the site, the drainage in the vicinity of the site is generally south and east towards the Niagara Escarpment. An unnamed creek flows along the eastern edge of the site property, draining into Dunmark Lake approximately 6 km to the south.

3.3 Physiography

The area of the present study is situated within the Norfolk Sand Plain Physiographic Region of Chapman and Putnam (1984). Within the Norfolk Sand Plain, the highest elevations are generally found adjoining the Niagara Escarpment where recessional moraines have been deposited by the ice lobe occupying the Lake Ontario basin. A portion of the Waterdown Moraine forms a low ridge, roughly parallel to the Niagara Escarpment which rises to the south.

3.4 Soils

The soils within the vicinity of the site are a fine-textured mixture of Grimsby sandy loam and Alberton silty clay loam (Presant, *et al.*, 1965). Overburden on the rock near the Niagara Escarpment is generally less than 50 feet (15 m) thick, increasing in thickness towards the southwest (Chapman and Putnam, 1984). In the vicinity of the site, the overburden thickness is generally on the order of 50 to 55 meters thick. According to borehole logs from LM-01-03 and LM-02-03 (the existing onsite monitoring wells), the overburden consists of predominantly clay and silt down to a depth of approximately 40 m, followed by an upward fining sequence of fine sand, sand and gravel of approximately 15 m thick, with dolostone bedrock at approximately 55 meter below ground surface (mbgs) (borehole logs, SNC Lavalin, 2003).

4.0 GEOLOGY

Bedrock in the vicinity of the site is composed of Middle to Lower Silurian age dolostone of the Guelph and Lockport-Amabel Formations. The southern half of the site property overlies the dolomite of the Guelph Formation, with the northern half of the site overlying the Lockport-Amabel (OGS, 2011), which forms the cap rock of the Niagara Escarpment. This formation is primarily dolostone, with minor limestone, chert and shale (AquaResource, 2009). The Lockport Formation is considered to be a relatively good aquifer, with variable permeability due to the presence of higher porosity vugs and chemical dissolution leading to karstification. FDL 02 possibly lies within a local bedrock high (bedrock was not proven at 52.1 mbgs), in comparison to the deeper bedrock encountered at LM-01-03 at 55 mbgs.

Overburden encountered at the site is composed of fine textured sand to silty sand, and clays with varying degrees of silt. As noted, the site property falls within the Norfolk Sand Plains, which consists of high permeability glaciolacustrine shallow water and deltaic sediments deposited during the Late Wisonsinan glaciation. The area is also influenced by lower permeability clays and silts of glaciolacustrine deep water sediments, and the silty Halton Till extending to the east of the site (OGS, 2003).

5.0 HYDROGEOLOGY

In southwestern Ontario, groundwater is found in both overburden and bedrock sources. The Lockport-Amabel aand Guelph Formations provide an important regional aquifer of good quality fresh water for both rural and municipal water supplies. Wells completed in the overburden often draw water from deposits such as the sands and gravels of glaciolacustrine outwash materials (Singer, *et al.*, 2003).

The pump well FDL-02 penetrates lower permeability fine-grained silts and clays which act as aquitard in the area. The well is completed in a sand and gravel unit, likely outwash material, which is the likely water producing zone. Later sections discuss the well's capacity and quality of water produced by this layer.

6.0 WATER SUPPLY

Three 2" (50 mm) trial boreholes were drilled by Durl Hopper Ltd. ("Hopper") in July, 2011 (Figure 2). The supervision of the test boreholes were undertaken by Mike Bingham of the City of Hamilton. The trial borehole at location TW-1 (depth of 51.2 mbgl (168')) was selected as the new water supply well FDL-02, and was increased to a temporary 6" (150 mm) casing installation for step testing. The screened interval extended from 50.1 mbgs to 48.9 mbgs (164.5 to 160.5 feet). The well was developed

by air lifting and flushing for a total of 6 hours, with return water remaining brown-grey in colour. Hopper estimated the well's production rate at 50 US GPM. Following step testing with the temporary casing, the well was reamed out to a diameter of 12" and advanced a further three foot to 52.1 mbgs (171') with permanent steel screen emplaced at a depth of 51.5 mbgs to 48.4 mbgs (169 to 159 feet) with an internal diameter of 8". The well was subsequently developed for just under eight hours with the water running clear on completion. The second trial borehole (TW2) was selected for the installation of a piezometer (Well LM-09), with the screen set at 54.6 mbgs to 51.5 mbgs (179 to 169 feet), the installation of which was supervised by Mike Bingham from the City of Hamilton. The well records for both boreholes are given in Appendix B. A drilling log for the pumping well based on the records of Mike Bingham of the City of Hamilton is given in Appendix B.

6.1 Step Testing – Temporary casing

In order to assess the potential water supply capacity from FDL 02, a step test was carried out on the subject well on July 28, 2011. The test consisted of two steps; the first step was conducted at a rate of 2 litres per second (L/sec, or 32 US GPM) for a duration of 30 minutes, followed by 30 minutes of recovery. The second step started at 4 L/sec (63 US GPM), but reduced to approximately 3.2 to 3.4 L/sec (51 to 54 US GPM) for a total of 106 minutes, with recovery to static levels recorded for approximately 10 minutes. A third step of 6 L/sec (95 US GPM) was not attempted.

A submersible Grundfös 5 horsepower pump, rated for 60 US GPM in a 2" well at 142' depth, was set with the intake at 48.8 mbgs (160 ft bgs). At the time of initiation of the step test the static water level was at 15.2 meters below top of casing (mbTOC).

Water levels were monitored automatically at 30 second intervals by a transducer in the pumping well, and manual readings were collected using a water level meter in order to monitor the progress of the test. Flow rates were monitored by Hopper using an orifice weir during pumping in order to monitor the rate of pumping, as well as to determine that the total water takings remained below 50,000 litres.

As noted, the static water level was measured at 15.2 mbTOC prior to starting the pump. During the initial step at 2 L/sec, the water level drew down to 22.6 mbTOC within 3 minutes, and then stabilized in the range of 22.6 to 22.8 mbTOC for the remainder of the step period. From the flow monitoring results, the flow rates measured during the step were 1.96 to 2.02 L/sec (31 to 32 US GPM). Recovery to static levels after the first step took approximately 2 minutes. The second step proceeded following recovery of the first step with an initial target of reaching 4 L/sec (63 US GPM). Water levels drew down to 32 mbTOC within 3 minutes of the pump being turned on and drew down to 48.2 mbTOC by approximately 10 minutes. To prevent the water level dropping below the

pump intake, the rate of drawdown was reduced to around 3.2 to 3.4 L/sec (51 to 54 US GPM). For the remainder of the step, the flow rate was adjusted to maintain an average rate of 3.3 L/sec. At this rate drawdown was close to stabilising, reaching a level of 47.7 mbTOC, or a maximum drawdown of 32.5 meters at the end of the step. In total, less than approximately 35,700 litres of water were pumped from the well during the step test.

Water levels at FDL 02 during the step test period are displayed graphically in Figure 3. Figure 4 shows drawdown and recovery (plotted as drawdown) for the pump well on a semi-logarithmic scale. Of note is the slight recovery in the second step at around 10 minutes. This is a response the pumping rate being reduced from 4 to around 3.3 L/sec. The difference of the recovery and drawdown phase of the second step test (Figure 4) is likely due to this change in pumping rate. Analysis of the second test drawdown data of the pumped well suggests a transmissivity of the order of 50-100 m^2/d using Jacob's approximation for a single well test (Kruseman, G.P. & de Ridder, N.A., 1991). The step testing indicates that with the temporary borehole construction, pumping rates of 3 to possibly 3.5 L/sec are attainable.

6.2 Constant Rate Test – Permanent Casing

A final constant rate test was undertaken by Mike Bingham of the City of Hamilton on the completed pumping well on the 16th August. The test was run for two hours at an average rate of 6.6 L/s (104 US GPM) with a total volume pumped of approximately 48,000 L. The test was monitored by two loggers, one in the pumping well and another in the new monitoring well (LM-09). A slight adjustment of the pump rate occurred approximately at 1½ hours into the test. The results of the constant rate test are shown in Figures 5 and 6.

At the time of initiation of the test the static water level was at 15.76 mbTOC in the pumping well. Following the adjustment in the pumping rate, the drawdown in the test well stabilised at 17.36 mbTOC (a drawdown of 1.6m). Drawdown in the well was recorded at just under 0.5 (from a static water level 12.87 mbTOC to a stabilized level of 13.35 mbTOC). In both pumping well and monitoring well, the drawdown is relatively rapid, but modest in magnitude. The early time of both the drawdown and recovery curves (Figure 6) are irregular (the recovery reversal suggests flow back from the pump after switch off). An analysis of the aquifer test is difficult because the test does not show a typical smooth drawdown curve. However, a rough analysis using the Jacob approximation (Kruseman, G.P. & de Ridder, N.A., 1991) on the data from the monitoring well suggests the transmissivity of the sands and gravels at the base of the clay being of the order of 100s m^2/d.

The dramatic increase in performance relative to the well with the temporary casing can be attributed to:

- increase in diameter of the well;
- improved borehole development;
- improved screen on the borehole;
- an increase of length of screened section of the well open to the sands and gravels from 4' to 10'.

The results from the constant rate test show that the new pumping well is capable of pumping at a rate of 6 L/s.

7.0 WATER QUALITY ANALYSES

Water samples were obtained from the pumped well during Step 2 (temporary casing installed), after approximately 30 minutes of pumping and at approximately 10 minutes prior to terminating the step. The samples were obtained from the end of the discharge line. The samples were submitted for analysis to Exova Accutest in Ottawa. The samples were analyzed for the parameters listed in Schedules 23 and 24 of O. Reg. 170/03 and for standard microbial parameters E coli and Total Coliforms, nitrate, nitrite, lead, sodium, fluoride, chloride, sulphide and DOC. AMEC also measured the pH, temperature, conductivity, turbidity and ORP of the groundwater prior to each sampling event, using a Horiba U22 water analyzer. Results of the analyses are summarized in Tables 1 and 2 below, with full results presented in Appendix A.

During well development, it was noted that initially the water was cloudy, but during step testing and sampling, the water remained clear. The water was noted to have a fairly strong odour of sulphide gas, which persisted throughout the pumping period.

Table 1: Summary of Water Quality Parameters

	Parameters				
	Temperature (˚C)	pH	Conductivity (µS/cm)	Turbidity (NTU)	ORP (mV)
Step 2: 30 minutes Elapsed Time	12.12	8.42	0.308	303	-160
Step 2: 95 minutes Elapsed Time	12.28	8.29	0.310	236	-168
Step 2: 105 minutes Elapsed Time	12.29	8.08	0.307	198	-180

Table 2: Summary of Bacteriological and Chemical Analyses

Parameter	Units	ODWQS[a]	FDL 02 (Temporary Casing)	
			TB111049-1	TB111049-2
			28-Jul-2011 1:30 PM	28-Jul-2011 2:45 PM
Microbiology				
E. coli	CFU/100 ml	ND	0	0
Total Coliforms	CFU/100 ml	ND	2	2
O. Reg. 170 Schedule 23 - Inorganic				
Antimony	mg/L	0.006	<0.0005	<0.0005
Arsenic	mg/L	0.025	<0.005	0.002
Barium	mg/L	1	**2.3**	**2.4**
Boron	mg/L	5	0.48	0.49
Cadmium	mg/L	0.005	<0.0001	<0.0001
Chromium	mg/L	0.05	0.001	0.002
Mercury	mg/L	0.001	<0.0001	<0.0001
Selenium	mg/L	0.01	NR	NR
Uranium	mg/L	0.02	<0.001	<0.001
O. Reg. 170 Schedule 24 (Selected Results)				
Benzene	mg/L	0.005	<0.0005	<0.0005
Chloride	mg/L	250	48	48
Dissolved Organic Carbon	mg/L	5	1.2	1.2
Fluoride	mg/L	1.5	0.73	0.72
Hydrogen Sulphide	mg/L	0.05	**0.3**	**0.3**
Lead	mg/L	0.01	<0.001	<0.001
$N\text{-}NO_2$ (Nitrite)	mg/L	1.0	<0.10	<0.10
$N\text{-}NO_3$ (Nitrate)	mg/L	10.0	<0.10	<0.10
$NO_2 + NO_3$ as N	mg/L	10.0	<0.10	<0.10
Sodium	mg/L	200	56	59
Trichloroethylene	mg/L	0.005	<0.0003	<0.0003

[a] O. Reg. 169/03 Ontario Drinking Water Quality Standards
"<" means less than the MRL (method reporting limit); guideline exceedances are noted in **RED**.

Exceedances were noted for hydrogen sulphide and barium, and bacteria (as Total Coliforms) were detected. Other parameters showed no further exceedances.

8.0 CONCLUSIONS

A new pumping well was installed at Lynden Road, completed in the basal sands and gravels Step testing was undertaken on a new pumping well (Well FDL 02). Two of the steps were undertaken with the well at 6" diameter and temporary casing. For the temporary borehole completion, drawdown was of the order of 7.5 m during the first step (2 L/sec) and during the second step (3.3 L/sec average) increased to 16.8 m within the first several minutes of the pump being turned on, and continued dropping to a maximum drawdown of 32.5 m. Recovery was also relatively quick, reaching pre-pumping static levels within ten minutes of the pump being shut off. The results from the final step test (6.6 L/sec average) with the completed 8" well extended further into the sands and gravel show that the well is easily capable of sustaining pumping rates at 6 L/sec as stabilised drawdowns are approximately 1.5 m after 2 hours of pumping.

Bacteria were detected in the well when sampled with the temporary completion. However, other parameters such as Nitrates and Nitrites and all tested anthropogenic organic compounds did not exceed Ontario Drinking Water Quality (ODWQ) guidelines, suggesting little anthropogenic contamination of the site. Hydrogen sulphide and Barium also exceeded the ODWS. It is possible that the detect for bacteria is associated with cross-contamination from the temporary casing. Further chemical testing is recommended on the completed 8" production well.

9.0 CLOSURE

We trust that the information provided in this report is sufficient for your purposes. Should you should have any questions regarding this submission, please contact the undersigned at 905-312-0700. The report is subject to AMEC's standard terms and conditions that are provided in Appendix C.

Prepared by:	Reviewed by:
Rachel McLean, B.Sc., P.Geo. Project Geoscientist	Martin Shepley, D.Phil., P.Geo. Senior Hydrogeologist

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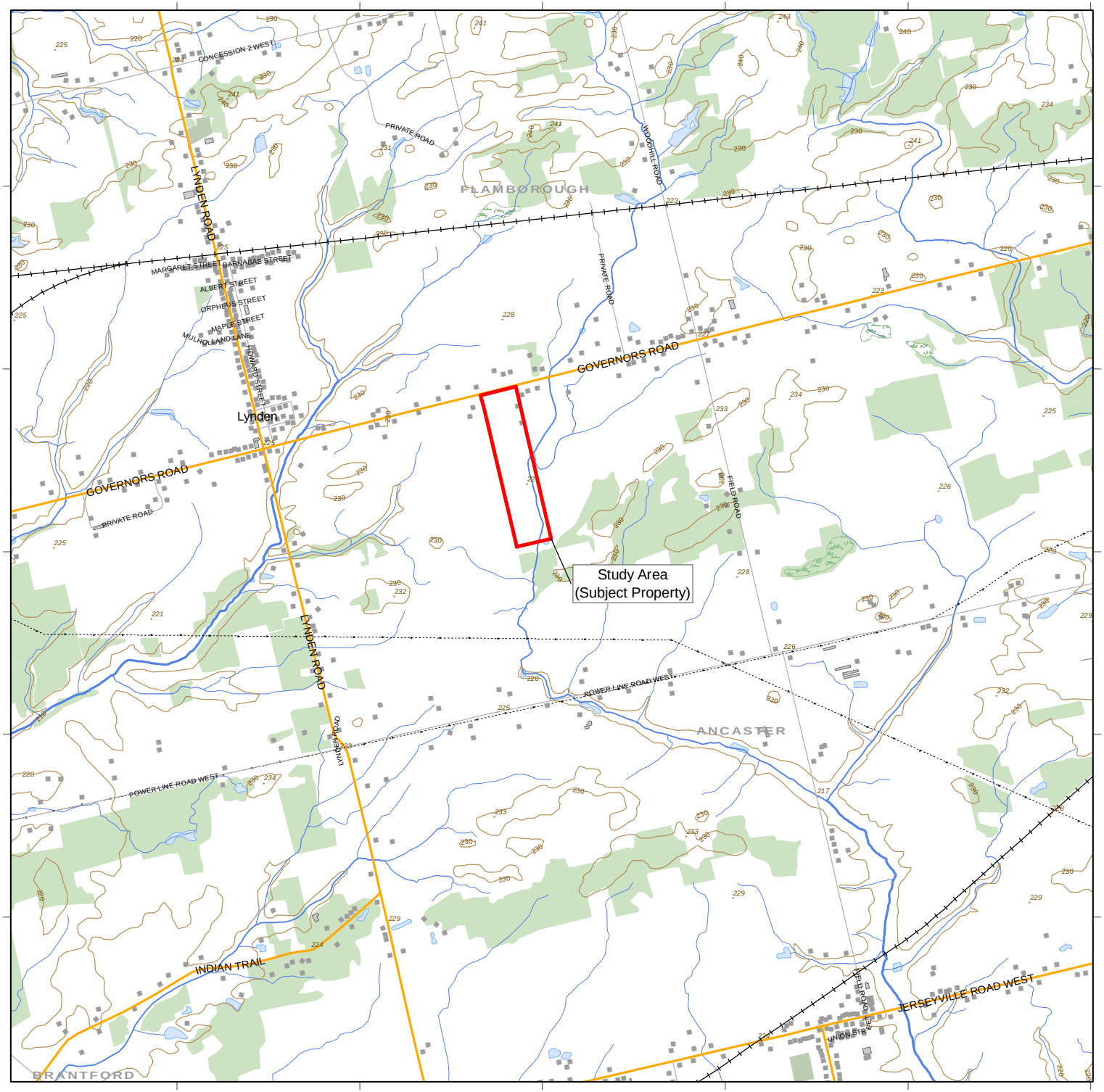
HYDROGEOLOGICAL INVESTIGATION
LYNDEN WATER PLANT
3618 Governors Road,
Lynden, Ontario

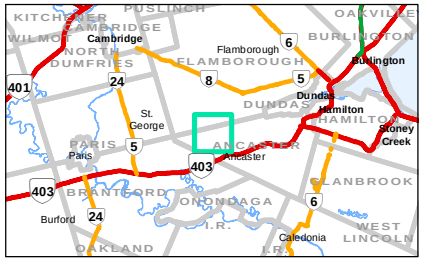
Figure 1

Site Location



Legend

- Railway
- U.G. Gas line
- Power Transmission Line
- Building Footprint
- Waterbody
- Wetlands
- Vegetation
- Park / Sportsfield
- Golf Course



Source: National Topographic Database Canvec Data, 040P01 tile, 1:10 000 nominal scale.

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project # TB111049
Date: August 2011
Client: City of Hamilton

Drawn by: RM
Checked by: SG
Revision No.: 2

N
W E
S

Meters
0 300 600 900 1,200

UTM NAD 83
Zone 17N
1:30,000

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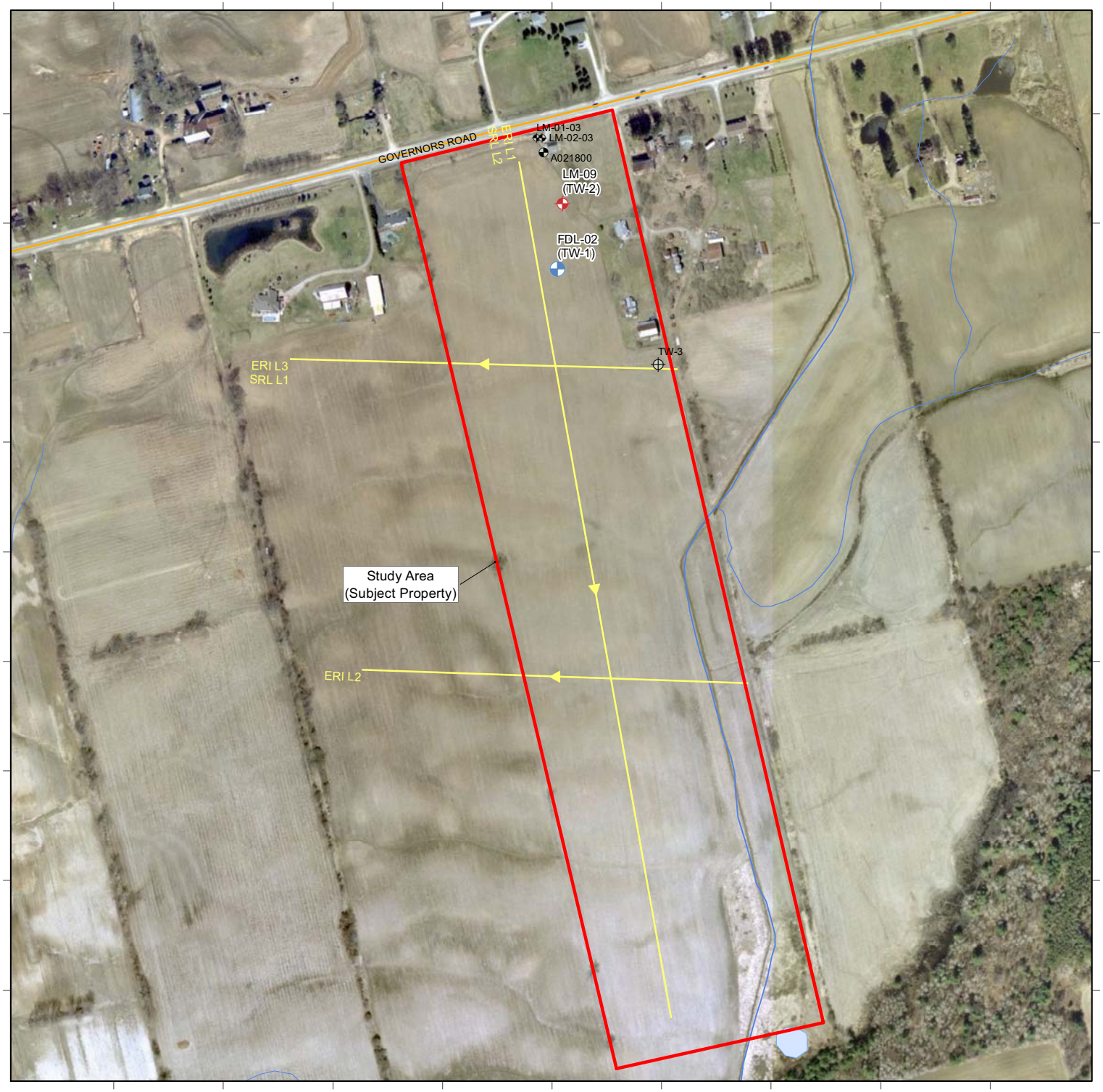
04 August 2011 C:\Documents and Settings\rachel.mclean\Desktop\GIS_Work\TB111049 - Lynden Water Plant_MAPS\Figure 1 Site Location.mxd



HYDROGEOLOGICAL INVESTIGATION
LYNDEN WATER PLANT
3618 Governors Road,
Lynden, Ontario

Figure 2
Aerial Photograph showing
Well Locations and Site Features

Legend

Wells
- Existing Pump Well
- Existing Monitoring Well
- Pump Well
- Monitoring Well
- Test Well
- Seismic Survey Lines
- Study Area
- Railway
- U.G. Gas line
- Power Transmission Line
- Waterbody

Source: National Topographic Database Canvec Data, 040P01 tile, 1:10 000 nominal scale.

Conditions encountered in the field may be different from the interpreted information presented on this figure.

Project # TB111049
Date: September 2011
Client: City of Hamilton

Drawn by: RM
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Revision No.: 2

UTM NAD 83
Zone 17N
1:5,000

N
W E
S

Meters
0 50 100 150 200

amec

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Hamilton, ON L8H 6N6

30 September 2011 C:\Documents and Settings\rachel.mclean\Desktop\GIS_Work\TB111049 - Lynden Water Plant_MAPS\Figure 2 Aerial Photo showing Site Property.mxd

Figure 3: Hydrograph of Groundwater Levels at FDL 02 during Step Testing (Temporary Casing)

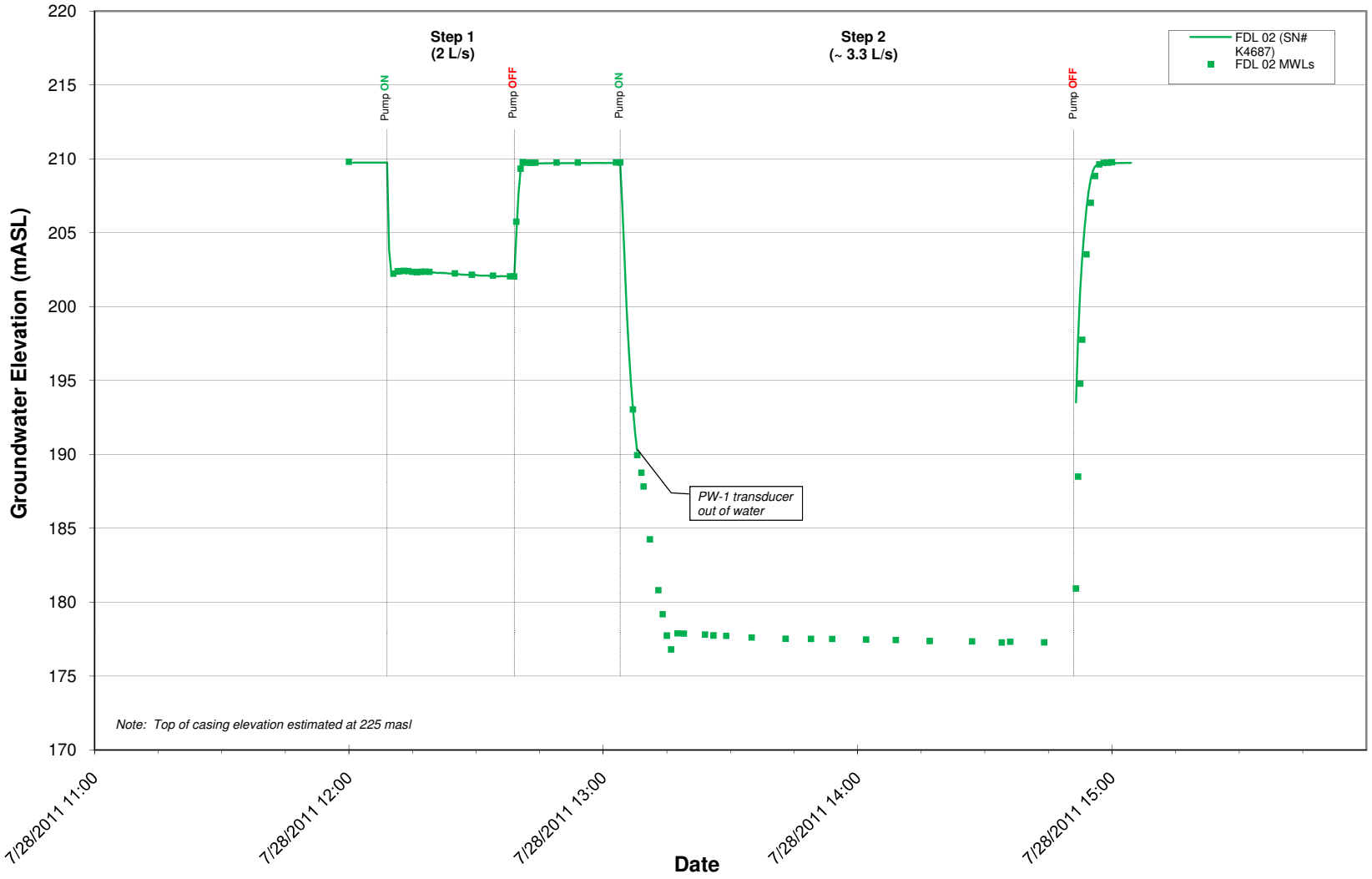


Figure 4: Semi-log Plot of Drawdown and Recovery at FDL 02 during Step Testing (Temporary Casing)

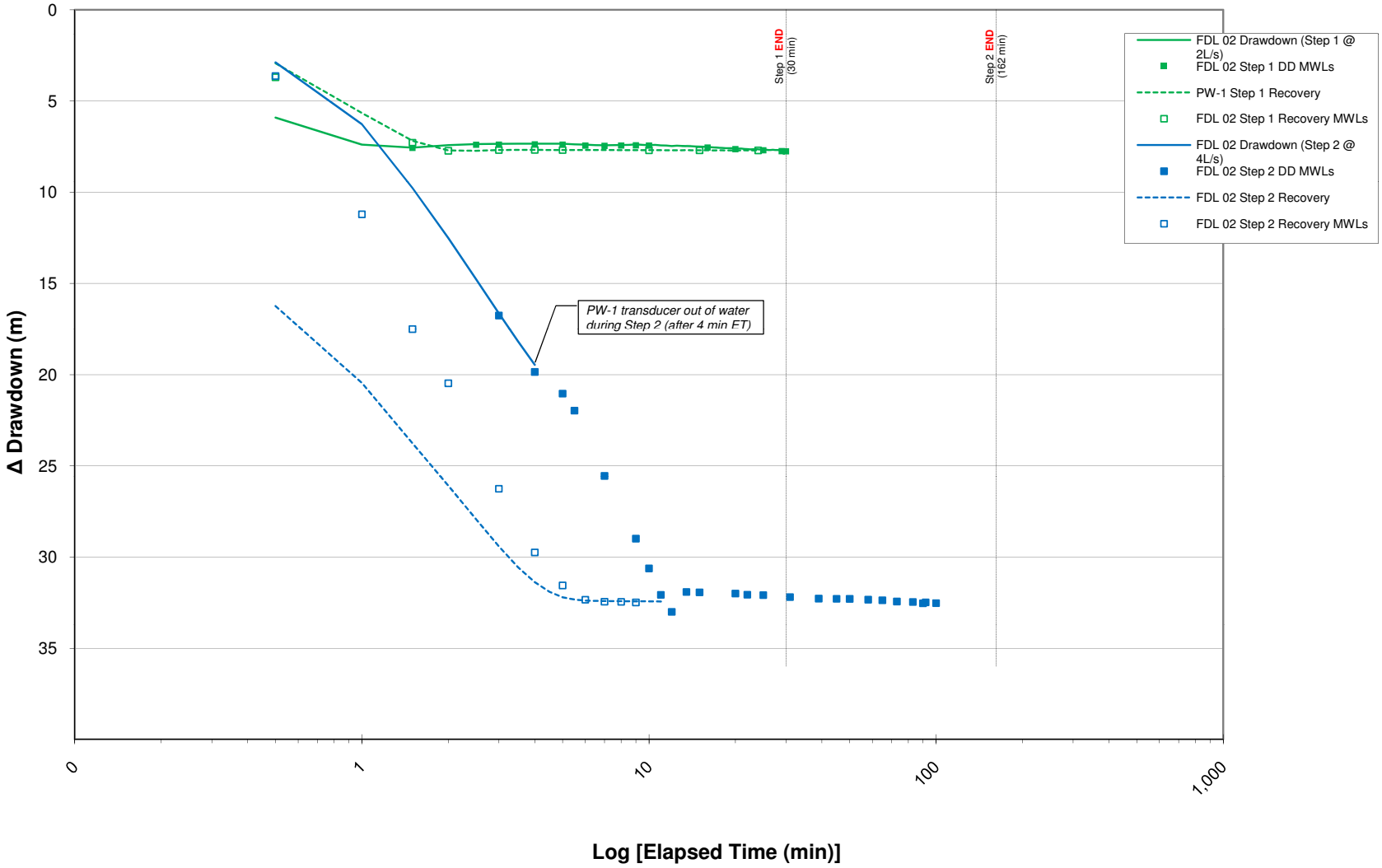


Figure 5: Hydrograph of Groundwater Levels during Constant RateTesting (Final Well FDL 02 & Monitoring Well LM-09)

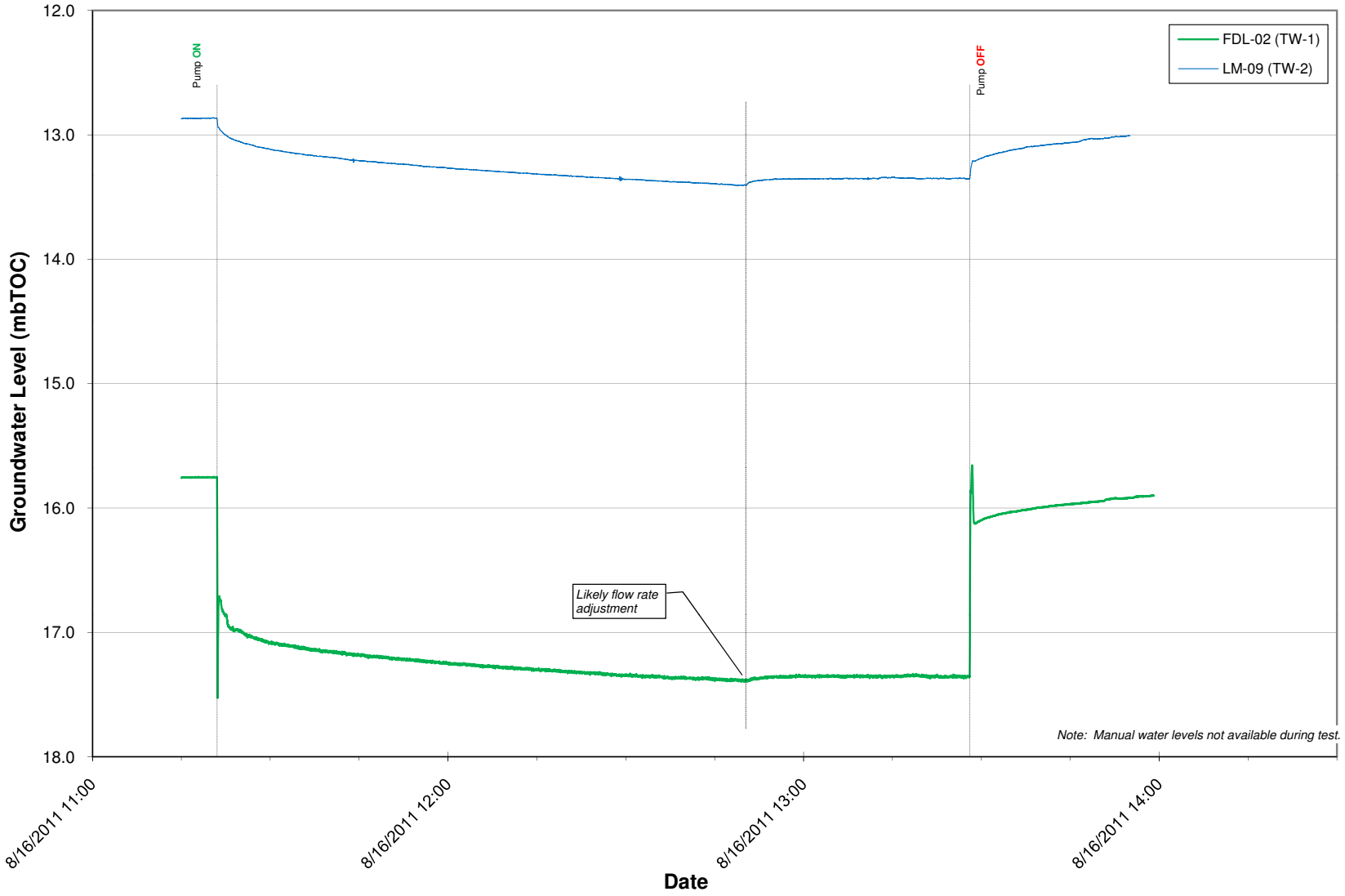
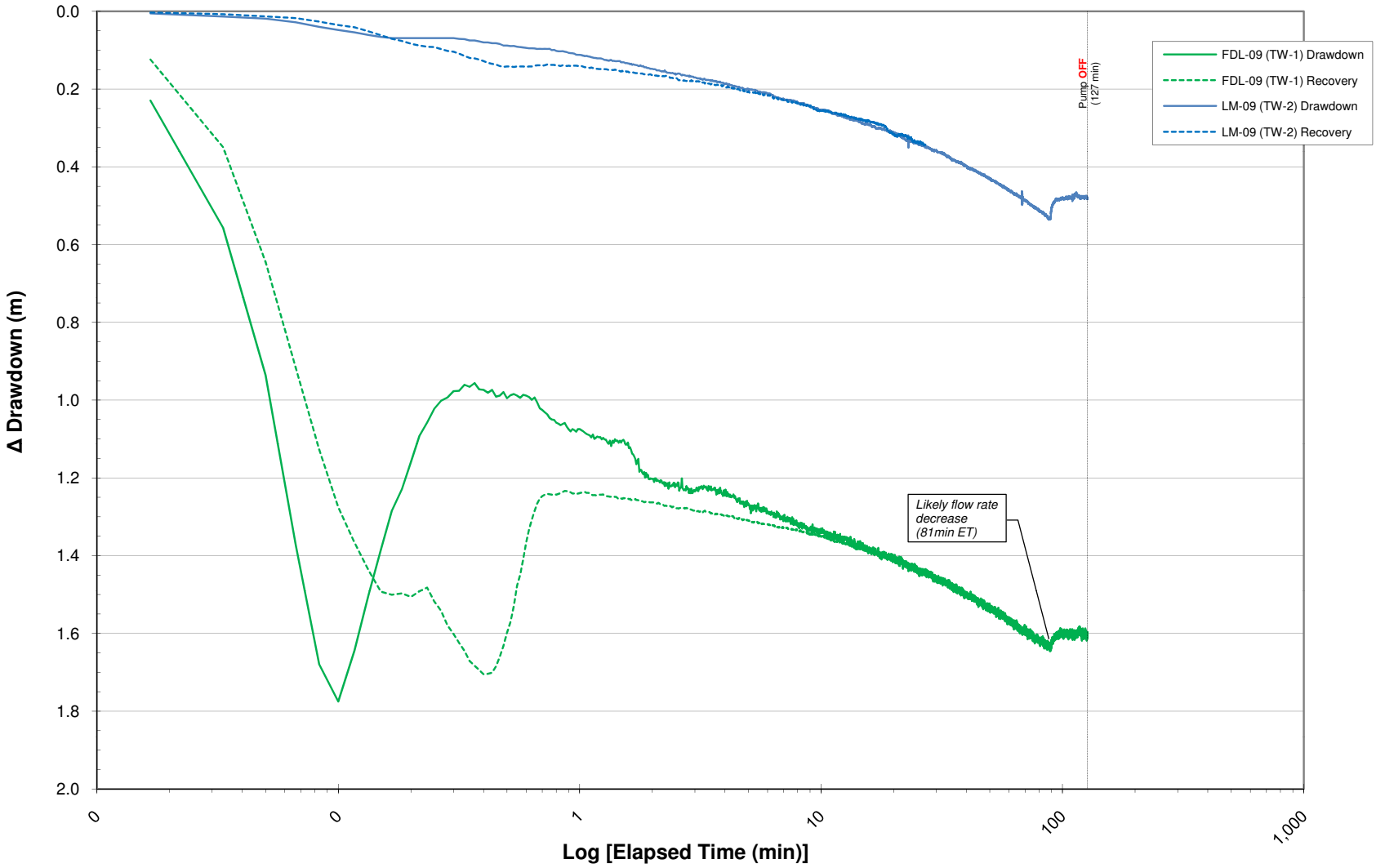


Figure 6: Semi-log Plot of Drawdown and Recovery during Constant Rate Testing (Final Well FDL 02 & Monitoring Well LM-09)



APPENDIX A

BACTERIAL AND CHEMICAL ANALYSES

Table A1: Summary of Microbiological, Organic and Inorganic Parameters

Parameter	Units	ODWQS[a]	FDL 02 (Temporary Casing)	
			TB111049-1	TB111049-2
			28-Jul-2011 1:30 PM	28-Jul-2011 2:45 PM
Microbiology				
E. coli	CFU/100 ml	ND	0	0
Total Coliforms	CFU/100 ml	ND	**2**	**2**
O. Reg. 170 Schedule 23 - Inorganic				
Antimony	mg/L	0.006	<0.0005	<0.0005
Arsenic	mg/L	0.025	<0.005	0.002
Barium	mg/L	1	**2.3**	**2.4**
Boron	mg/L	5	0.48	0.49
Cadmium	mg/L	0.005	<0.0001	<0.0001
Chromium	mg/L	0.05	0.001	0.002
Mercury	mg/L	0.001	<0.0001	<0.0001
Selenium	mg/L	0.01	<0.01	<0.01
Uranium	mg/L	0.02	<0.001	<0.001
O. Reg. 170 Schedule 24 - Inorganic				
Chloride	mg/L	250	48	48
Dissolved Organic Carbon	mg/L	5	1.2	1.2
Fluoride	mg/L	1.5	0.73	0.72
Hydrogen Sulphide	mg/L	0.05	**0.3**	**0.3**
Lead	mg/L	0.01	<0.001	<0.001
$N\text{-}NO_2$ (Nitrite)	mg/L	1.0	<0.10	<0.10
$N\text{-}NO_3$ (Nitrate)	mg/L	10.0	<0.10	<0.10
$NO_2 + NO_3$ as N	mg/L	10.0	<0.10	<0.10
Sodium	mg/L	200	56	59
O. Reg. 170 Schedule 24 - Organic				
Alachlor	mg/L	0.005	<0.0005	<0.0005
Aldicarb	mg/L	0.009	<0.005	<0.005
Aldrin + Dieldrin	mg/L	0.0007	<0.000012	<0.000012
Atrazine + N-dealkylated metabolites	mg/L	0.005	<0.00001	<0.00001
Azinphos-methyl	mg/L	0.02	<0.002	<0.002
Bendiocarb	mg/L	0.04	<0.002	<0.002
Benzene	mg/L	0.005	<0.0005	<0.0005
Benzo(a)pyrene	mg/L	0.00001	<0.00001	<0.00001
Bromoxynil	mg/L	0.005	<0.0005	<0.0005
Carbaryl	mg/L	0.09	<0.005	<0.005
Carbofuran	mg/L	0.09	<0.005	<0.005
Carbon Tetrachloride	mg/L	0.005	<0.0005	<0.0005
Chlordane (Total)	mg/L	0.007	<0.000018	<0.000018
Chlorpyrifos	mg/L	0.09	<0.001	<0.001
Cyanazine	mg/L	0.01	<0.00003	<0.00003
Diazinon	mg/L	0.02	<0.001	<0.001
Dicamba	mg/L	0.12	<0.001	<0.001
1,2-Dichlorobenzene	mg/L	0.2	<0.0004	<0.0004
1,4-Dichlorobenzene	mg/L	0.005	<0.0004	<0.0004
Dichlorodiphenyltrichloroethane (DDT) + metabolites	mg/L	0.03	<0.000024	<0.000024
1,2-dichloroethane	mg/L	0.005	<0.0002	<0.0002

Table A1: Summary of Microbiological, Organic and Inorganic Parameters

Parameter	Units	ODWQS[a]	FDL 02 (Temporary Casing)	
			TB111049-1	TB111049-2
			28-Jul-2011 1:30 PM	28-Jul-2011 2:45 PM
1,1-Dichloroethylene (vinylidene chloride)	mg/L	0.014	<0.0005	<0.0005
Dichloromethane	mg/L	0.05	<0.004	<0.004
2,4-Dichlorophenol	mg/L	0.9	<0.0005	<0.0005
2,4-Dichlorophenoxy acetic acid (2,4-D)	mg/L	0.1	<0.001	<0.001
Diclofop-methyl	mg/L	0.009	<0.0009	<0.0009
Dimethoate	mg/L	0.02	<0.0025	<0.0025
Dinoseb	mg/L	0.01	<0.001	<0.001
Diquat	mg/L	0.07	<0.005	<0.005
Diuron	mg/L	0.15	<0.01	<0.01
Fluoride	mg/L	1.5	0.73	0.72
Glyphosate	mg/L	0.28	<0.01	<0.01
Heptachlor + Heptachlor Epoxide	mg/L	0.003	<0.000012	<0.000012
Lead	mg/L	0.01	<0.001	<0.001
Lindane (Total)	mg/L	0.004	<0.000005	<0.000005
Malathion	mg/L	0.19	<0.005	<0.005
Methoxychlor	mg/L	0.9	<0.000024	<0.000024
Metolachlor	mg/L	0.05	<0.00001	<0.00001
Metribuzin	mg/L	0.08	<0.00002	<0.00002
Monochlorobenzene	mg/L	0.08	<0.0002	<0.0002
Nitrate (as nitrogen)	mg/L	10	<0.1	<0.1
Nitrite (as nitrogen)	mg/L	1	<0.1	<0.1
Nitrate + Nitrite (as nitrogen)	mg/L	10	<0.1	<0.1
Paraquat	mg/L	0.01	<0.005	<0.005
Parathion	mg/L	0.05	<0.001	<0.001
Pentachlorophenol	mg/L	0.06	<0.0005	<0.0005
Phorate	mg/L	0.002	<0.0005	<0.0005
Picloram	mg/L	0.19	<0.005	<0.005
Polychlorinated Biphenyls (PCB)	mg/L	0.003	<0.0001	<0.0001
Prometryne	mg/L	0.001	<0.00025	<0.00025
Simazine	mg/L	0.01	<0.00001	<0.00001
Temephos	mg/L	0.28	<0.01	<0.01
Terbufos	mg/L	0.001	<0.0004	<0.0004
Tetrachloroethylene (perchloroethylene)	mg/L	0.03	<0.0003	<0.0003
2,3,4,6-Tetrachlorophenol	mg/L	0.1	<0.0005	<0.0005
Triallate	mg/L	0.23	<0.001	<0.001
Trichloroethylene	mg/L	0.005	<0.0003	<0.0003
2,4,6-Trichlorophenol	mg/L	0.005	<0.0005	<0.0005
2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	mg/L	0.28	<0.001	<0.001
Trifluralin	mg/L	0.045	<0.00002	<0.00002
Vinyl Chloride	mg/L	0.002	<0.0002	<0.0002

[a] *Total toxic equivalents when compared with 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin).*

[b] *This standard is expressed as a running annual average.*

Tables show results received as of date of issuance of report.

EXOVA ACCUTEST

REPORT OF ANALYSIS

Exova Accutest

Client: **AMEC Earth & Environmental**
3300 Merrittville Hwy, Unit 5

Thorold, ON
L2V 4Y6
Attention: **Mr. Randall Secord**

Niagara Report: N11-1426
Report Number: 1117363
Date: 2011-08-18
Date Submitted: 2011-07-29

Project: Lynden

P.O. Number:
Matrix: Groundwater

Chain of Custody Number: **143495**

		LAB ID:	900011	900012				**GUIDELINE**		
		Sample Date:	2011-07-28	2011-07-28				ODWQS O. Reg. 170 - Schedule 23/24		
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
Chloride	mg/L	1	48	48				AO	250	mg/L
Dissolved Organic Carbon	mg/L	0.5	1.2	1.2				AO	5	mg/L
Fluoride	mg/L	0.1	0.73	0.72				MAC	1.5	mg/L
Hydrogen Sulphide	mg/L	0.1	**0.3**	**0.3**				AO	0.05	mg/L
N-NO2 (Nitrite)	mg/L	0.1	<0.10	<0.10				MAC	1.0	mg/L
N-NO3 (Nitrate)	mg/L	0.1	<0.10	<0.10				MAC	10.0	mg/L
NO2 + NO3 as N	mg/L	0.1	<0.10	<0.10				MAC	10.0	mg/L
Sodium	mg/L	2	56	59				AO	200	mg/L
Antimony	mg/L	0.0005	<0.0005	<0.0005				IMAC	0.006	mg/L
Arsenic	mg/L	0.005	<0.005	<0.005				IMAC	0.025	mg/L
Barium	mg/L	0.1	**2.3**	**2.4**				MAC	1	mg/L
Boron	mg/L	0.01	0.48	0.49				IMAC	5	mg/L
Cadmium	mg/L	0.0001	<0.0001	<0.0001				MAC	0.005	mg/L
Chromium	mg/L	0.001	0.001	0.002				MAC	0.05	mg/L
Mercury	mg/L	0.0001	<0.0001	<0.0001				MAC	0.001	mg/L
Selenium	mg/L	0.01	<0.01	<0.01				MAC	0.01	mg/L
Uranium	mg/L	0.001	<0.001	<0.001				MAC	0.02	mg/L

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:
900011: H2S MRL elevated due to turbidity of sample. Arsenic MRL elevated due to matrix interference.
Samples were subcontracted for Se analysis
900012: H2S MRL elevated due to turbidity of sample.

APPROVAL: _____
Lorna Wilson
Inorganic Lab Supervisor

Methods references and/or additional QA/QC information available on request.

Results relate only to the parameters tested on the samples submitted.

EXOVA ACCUTEST

REPORT OF ANALYSIS

Exova Accutest

Client: **AMEC Earth & Environmental**
3300 Merrittville Hwy, Unit 5

Thorold, ON
L2V 4Y6
Attention: **Mr. Randall Secord**

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Date Submitted: 2011-07-29

Project: Lynden

P.O. Number:
Matrix: Groundwater

Chain of Custody Number: **143495**

		LAB ID:	900011	900012				**GUIDELINE**		
		Sample Date:	2011-07-28	2011-07-28						
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
Organochlorine Pesticides (OCPs) & PCBs										
Aldrin	ug/L	0.006	<0.006	<0.006						
Dieldrin	ug/L	0.006	<0.006	<0.006						
Aldrin + Dieldrin	ug/L	0.012	<0.012	<0.012						
a-chlordane	ug/L	0.006	<0.006	<0.006						
g-chlordane	ug/L	0.006	<0.006	<0.006						
Oxychlordane	ug/L	0.006	<0.006	<0.006						
Chlordane (Total)	ug/L	0.018	<0.018	<0.018						
op-DDT	ug/L	0.006	<0.006	<0.006						
pp-DDD	ug/L	0.006	<0.006	<0.006						
pp-DDE	ug/L	0.006	<0.006	<0.006						
pp-DDT	ug/L	0.006	<0.006	<0.006						
Dichlorodiphenyltrichloroethane (DDT) + Metabolites	ug/L	0.024	<0.024	<0.024						
alpha-BHC	ug/L	0.006	<0.006	<0.006						
beta-BHC	ug/L	0.006	<0.006	<0.006						
delta-BHC	ug/L	0.006	<0.006	<0.006						
Endosulfan I	ug/L	0.006	<0.006	<0.006						
Endosulfan II	ug/L	0.02	<0.02	<0.02						
Endrin	ug/L	0.006	<0.006	<0.006						
gamma-BHC (Lindane)	ug/L	0.006	<0.006	<0.006						
Heptachlor	ug/L	0.006	<0.006	<0.006						
Heptachlor epoxide	ug/L	0.006	<0.006	<0.006						
Heptachlor + Heptachlor Epoxide	ug/L	0.012	<0.012	<0.012						
Lindane (Total)	ug/L	0.005	<0.005	<0.005						
Methoxychlor	ug/L	0.024	<0.024	<0.024						
Polychlorinated Biphenyls (PCBs)	ug/L	0.1	<0.1	<0.1						
CHLOROPHENOLS										
2,3,4,6-tetrachlorophenol	ug/L	0.5	<0.5	<0.5						
2,4,6-trichlorophenol	ug/L	0.5	<0.5	<0.5						
2,4-dichlorophenol	ug/L	0.5	<0.5	<0.5						

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:
Samples were subcontracted for Triazine analysis.

APPROVAL: _____
Mina Nasirai
Organic Lab Supervisor

Methods references and/or additional QA/QC information available on request.

Results relate only to the parameters tested on the samples submitted.

EXOVA ACCUTEST

REPORT OF ANALYSIS

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		Sample Date:	2011-07-28	2011-07-28						
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
Pentachlorophenol	ug/L	0.5	<0.5	<0.5						
PHENOXYACID HERBICIDES										
2,4,5-trichlorophenoxyacetic acid (2,4,5-T)	ug/L	1	<1	<1						
2,4-dichlorophenoxyacetic acid (2,4-D)	ug/L	1	<1	<1						
Bromoxynil	ug/L	0.5	<0.5	<0.5						
Dicamba	ug/L	1	<1	<1						
Dinoseb	ug/L	1	<1	<1						
Picloram	ug/L	5	<5	<5						
CARBAMATES										
Aldicarb	ug/L	5	<5	<5						
Bendiocarb	ug/L	2	<2	<2						
Carbaryl	ug/L	5	<5	<5						
Carbofuran	ug/L	5	<5	<5						
TRIAZINE & RELATED HERBICIDES										
Alachlor	ug/L	0.5	<0.5	<0.5						
Atrazine	ug/L	0.01	<0.01	<0.01						
De-ethylated atrazine	ug/L	0.01	<0.01	<0.01						
Atrazine + N-dealkylated metabolites	ug/L	0.01	<0.01	<0.01						
Cyanazine	ug/L	0.03	<0.03	<0.03						
Metolachlor	ug/L	0.01	<0.01	<0.01						
Metribuzin	ug/L	0.02	<0.02	<0.02						
Prometryne	ug/L	0.25	<0.25	<0.25						
Simazine	ug/L	0.01	<0.01	<0.01						
ORGANOPHOSPHOROUS PESTICIDES										
Azinphos-methyl	ug/L	2	<2	<2						
Chlorpyrifos	ug/L	1	<1	<1						
Diazinon	ug/L	1	<1	<1						
Diclofop-methyl	ug/L	0.9	<0.9	<0.9						
Dimethoate	ug/L	2.5	<2.5	<2.5						
Malathion	ug/L	5	<5	<5						

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:

APPROVAL: _____
Mina Nasirai
Organic Lab Supervisor

Methods references and/or additional QA/QC information available on request.

Results relate only to the parameters tested on the samples submitted.

EXOVA ACCUTEST

REPORT OF ANALYSIS

Exova Accutest

Client: **AMEC Earth & Environmental**
3300 Merrittville Hwy, Unit 5

Thorold, ON
L2V 4Y6
Attention: **Mr. Randall Secord**

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Report Number: 1117363
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P.O. Number:
Matrix: Groundwater

Chain of Custody Number: **143495**

		LAB ID:	900011	900012				**GUIDELINE**		
		Sample Date:	2011-07-28	2011-07-28						
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
Parathion	ug/L	1	<1	<1						
Phorate	ug/L	0.5	<0.5	<0.5						
Temephos	ug/L	10	<10	<10						
Terbufos	ug/L	0.4	<0.4	<0.4						
Triallate	ug/L	1	<1	<1						
Trifluralin	ug/L	0.02	<0.02	<0.02						
DIURON & GLYPHOSATE										
Diuron	ug/L	10	<10	<10						
Glyphosate	ug/L	10	<10	<10						
DIQUAT & PARAQUAT										
Diquat	ug/L	5	<5	<5						
Paraquat	ug/L	5	<5	<5						
BENZO (a) PYRENE										
Benzo(a)pyrene	ug/L	0.01	<0.01	<0.01						

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:

APPROVAL: _____
Mina Nasirai
Organic Lab Supervisor

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Chain of Custody Number: **143495**

		LAB ID:	900011	900012				**GUIDELINE**		
		Sample Date:	2011-07-28	2011-07-28				ODWQS O. Reg. 170 - Schedule 23/24		
		Sample ID:	TB111049-1	TB111049-2						
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
TABLE B COMPOUNDS (VOCs)										
1,1-dichloroethylene	mg/L	0.0005	<0.0005	<0.0005				MAC	0.014	mg/L
1,2-dichlorobenzene	mg/L	0.0004	<0.0004	<0.0004				MAC	0.2	mg/L
1,2-dichloroethane	mg/L	0.0002	<0.0002	<0.0002				IMAC	0.005	mg/L
1,4-dichlorobenzene	mg/L	0.0004	<0.0004	<0.0004				MAC	0.005	mg/L
Benzene	mg/L	0.0005	<0.0005	<0.0005				MAC	0.005	mg/L
Carbon Tetrachloride	mg/L	0.0005	<0.0005	<0.0005				MAC	0.005	mg/L
Dichloromethane	mg/L	0.004	<0.004	<0.004				MAC	0.05	mg/L
Monochlorobenzene	mg/L	0.0002	<0.0002	<0.0002				MAC	0.08	mg/L
Tetrachloroethylene	mg/L	0.0003	<0.0003	<0.0003				MAC	0.03	mg/L
Trichloroethylene	mg/L	0.0003	<0.0003	<0.0003				MAC	0.005	mg/L
Vinyl Chloride	mg/L	0.0002	<0.0002	<0.0002				MAC	0.002	mg/L
TABLE B SURROGATES										
Toluene-d8	%		100	99						
4-bromofluorobenzene	%		118	113						
1,2-dichloroethane-d4	%		111	107						

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:

APPROVAL: _____
Mina Nasirai
Organic Lab Supervisor

Methods references and/or additional QA/QC information available on request.

Results relate only to the parameters tested on the samples submitted.

APPENDIX B

WATER WELL RECORDS AND

BOREHOLE LOGS

RECORD OF BOREHOLE No FDL-02

PROJECT	Proposed Municipal Well, Lynden, ON	LOCATION	3618 Governors Road, Lynden, Ontario	ORIGINATED BY	MB
CLIENT	City of Hamilton		570803,4786739 (+/-4m)	COMPILED BY	RM
JOB NO.	TB111049 DATE 8/16/2011	EQUIPMENT	Mud Rotary	CHECKED BY	MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
0.0	Brown **TOPSOIL**										
0.9	Grey **SILT** with thick (~10cm) CLAY layers; increasing clay with depth							1, 2, 3, 4, 5, 6, 7, 8, 9			
9.1	Grey **CLAY**, hard; high plasticity							10, 11, 12			
12.5	Grey **CLAY**, soft, with red clay, silt and very fine sand							13, 14			

Continued Next Page

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049 DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES					STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)			
							16			Static water level on 16 August 2011 was at 15.54 mbTOC.
16.2	Grey **CLAY**, fining downward sequences very fine SAND to SILT to grey CLAY to red CLAY; repeating with increasing thickness downward						17			
							18			
							19			
							20			
							21			
							22			
							23			
							24			
							25			
							26			
							27			
							28			
							29			
29.3	**CLAY**, hard, mottled red and grey; trace fine sand									

Continued Next Page

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049
DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✠ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
							31			
							32			
							33			
							34			
							35			
							36			
36.6	Grey-brown **SILT**, loose, with thin clay layer						37			
							38			Very low sample return.
39.0	Grey-brown fine **SAND and SILT**, stiff						39			
							40			
							41			
41.2	Grey-brown fine **SAND and SILT**, soft						42			
42.1	Grey-brown fine **SAND and SILT**, stiff									
42.7	Grey-brown fine **SAND and SILT**, soft						43			
							44			

Continued Next Page

amec

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049 DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
45.1	Brown **SILT**, trace fine SAND, stiff									
45.7	Brown **SILT**, trace CLAY, soft						46			
46.6	Brown **SILT**, trace fine SAND, stiff						47			
47.9	Brown **SILT**, trace CLAY, soft						48			
48.0	Brown **SILT**, trace fine SAND, stiff									Water found at 48.46 mbTOC.
48.5	Grey-brown medium coarse **SAND** coarsening down to pea **GRAVEL**						49			
50.1	Dense **TILL** diamicton						50			
50.8	Green **COBBLES**, shaley, rounded						51			
50.9	Grey-green **GRAVEL**, black shale **COBBLES**						52			
52.1	**BOREHOLE TERMINATED**									**Well Details:** Casing: 206 mm I.D. steel riser (+2.6-48.5 m). Screen: 219mm I.D. stainless steel Slot 25 (48.5-49.1m), Slot 45 (49.1-50.1m), TW (Slot 10) (50.1-50.6m), and Slot 20 (50.6-51.5m). Annular Space: silica sand pack #2 (44.2-52.1 m), bentonite gravel (0-2.74 m) and neat cement grout (2.74-44.2 m) above sand pack, filling 311 mm I.D. hole. Locking well cap.

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. *(Place Sticker and/or Print Below)*: A100758

Well Record

Regulation 903 Ontario Water Resources Act

Page ___ of ___

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	CITY OF HAMILTON		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
71 MAIN STREET WEST	HAMILTON	ON	L8P4Y5	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 GOVERNOR'S ROAD	ANCASTER	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570803	4786739		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BROWN	TOPSOIL			0	3
GREY	SILT			3	30
GREY	CLAY		HARD	30	41
GREY	CLAY	SILT LAYERS	SOFT	41	53
GREY	CLAY	FINE SILT SAND LRS		53	96
GRY-RED	CLAY	TRACE SAND		96	120
GREY-BRN	FINE SAND SILT			120	159
GREY-BRN	SAND	GRAVEL	GRADES DOWN	159	167
GREY-GRN	GRAVEL	BLACK SHALE COBBLES		167	171

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used *(Material and Type)*	Volume Placed *(m³/ft³)*
0	9	BENTONITE GRAVEL	
9	145	NEAT CEMENT GROUT	
145	171	SILICA SAND PACK #2,1,1/4X1/8	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify*

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify*

Construction Record - Casing

Inside Diameter *(cm/in)*	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness *(cm/in)*	Depth (m/ft) From	To
8.125	STEEL	.219	+3	159

Construction Record - Screen

Outside Diameter *(cm/in)*	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
8.625	S STEEL	25,45	159	164
		TW,20	164	169

Status of Well

☒ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth	Kind of Water	
159 *(m/ft)* ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	

Hole Diameter

Depth (m/ft) From	To	Diameter *(cm/in)*
0	171	12.25

Results of Well Yield Testing

After test of well yield, water was:
☒ Clear and sand free
☐ Other, *specify*

If pumping discontinued, give reason: STEP TEST ONLY

Pump intake set at *(m/ft)*: 147

Pumping rate *(l/min / GPM)*: 250 IGPM

Duration of pumping: 3 hrs + ___ min

Final water level end of pumping *(m/ft)*: 67

If flowing give rate *(l/min / GPM)*:

Recommended pump depth *(m/ft)*: 100

Recommended pump rate *(l/min / GPM)*: 150 IGPM

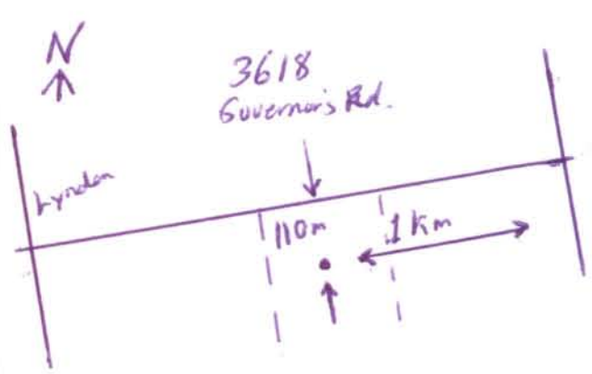
Well production *(l/min / GPM)*: 350

Disinfected? ☒ Yes ☐ No

Draw Down Time *(min)*	Water Level *(m/ft)*	Recovery Time *(min)*	Water Level *(m/ft)*
Static Level	51		
1	67	1	53
2		2	52
3		3	51
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60	67	60	51

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Durl Hopper Ltd.	2644

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont.	N4X1C9	hopper@cyg.net

Bus Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
5192717860	HOPPER, DOUGLAS

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
2323		Y Y Y Y M M D D 8/22/2011

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No	Y Y Y Y M M D D	Y Y Y Y M M D D 8/16/2011

Ministry Use Only

Audit No. z131638

Received

Ministry's Copy

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. *(Place Sticker and/or Print Below)* A100757

Well Record

Regulation 903 Ontario Water Resources Act

Page ___ of ___

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	
	CITY OF HAMILTON		☐ Well Constructed by Well Owner

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
71 MAIN STREET WEST	HAMILTON	ON	L8P4Y5	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 GOVERNOR'S ROAD	ANCASTER	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570810	4786818		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BROWN	TOPSOIL			0	3
GREY	SILT			3	30
GREY	CLAY		HARD	30	41
GREY	CLAY	SILT LAYERS	SOFT	41	53
GREY	CLAY	FINE SILT SAND LRS		53	96
GRY-RED	CLAY	TRACE SAND		96	120
GREY-BRN	FINE SAND SILT			120	159
GREY-BRN	SAND	GRAVEL	GRADES DOWN	159	167
GREY-GRN	GRAVEL	BLACK SHALE COBBLES		167	179

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	9	BENTONITE GRAVEL	
9	145	NEAT CEMENT GROUT	
145	171	SILICA SAND PACK #2,1,1/4X1/8	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify*

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify*

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
2	PVC	SCH40	+2	169

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
10	PVC	10	169	179

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth	Kind of Water	
169 (m/ft) ☐ Gas	☑ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	179	6 1/8

Results of Well Yield Testing

After test of well yield, water was:
☑ Clear and sand free
☐ Other, *specify*

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ___ hrs + ___ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

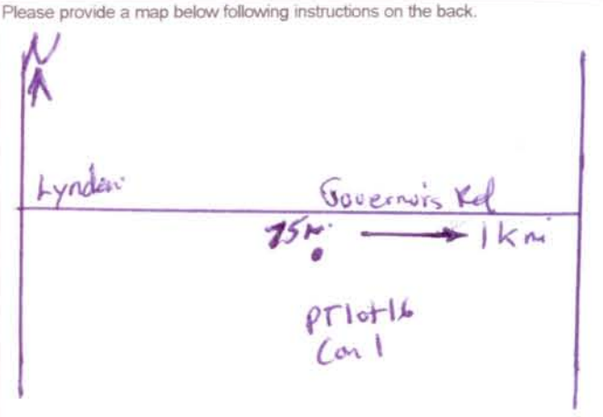
Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level	11		
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Durl Hopper Ltd.	2644

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont.	N4X1C9	hopper@cyg.net

Bus. Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
5192717860	HOPPER, DOUGLAS

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
2323		9/8/2011

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No		7/27/2011

Ministry Use Only

Audit No. z131640

Received

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APPENDIX C

AMEC STATEMENT OF LIMITATIONS

AMEC EARTH & ENVIRONMENTAL, A DIVISION OF AMEC AMERICAS LIMITED
STANDARD TERMS AND CONDITIONS

1) **ENTIRE AGREEMENT.** Upon authorization by the CLIENT and commencement of performance hereunder, these terms constitute the entire agreement between the parties concerning its subject matter. Any changes or additional conditions proposed by CLIENT are hereby rejected, unless expressly stated in the Agreement or incorporated by a change order.
2) **CHANGES.** Upon receipt of notice from CLIENT of a change in the scope of the work hereunder, AMEC will promptly notify the CLIENT if there is an impact on the schedule, price or terms of the Agreement. Thereafter, an estimate of any impact on the Agreement will be prepared and submitted to the CLIENT. The parties agree to promptly negotiate and implement changes to the Agreement. CLIENT acknowledges and agrees that its use of any purchase order or other form to procure services is solely for administrative purposes and in no event shall AMEC be bound to any terms and conditions on such form regardless of reference to or signature. CLIENT shall endeavor to reference this Agreement on any purchase order (or any other form), but CLIENT's failure to do so shall not operate to modify this Agreement.
3) **SITE INFORMATION AND ACCESS.** The CLIENT shall make available to AMEC all relevant information and documents under his control regarding past, present and proposed conditions of the site. The information shall include, but not be limited to, plot plans, topographic surveys, hydrologic data and previous soil and geologic data including borings, field or laboratory tests and written reports. The CLIENT shall immediately transmit to AMEC any new information that becomes available or any change in plans. The CLIENT shall also ensure uninterrupted site access for AMEC throughout performance of this Agreement.
4) **PERMITS AND UTILITIES.** Unless otherwise stated elsewhere, the CLIENT shall apply for and obtain all required permits and licenses and shall make all necessary arrangements for right of entry to provide AMEC access to the site for all equipment and personnel at no charge to AMEC. The CLIENT shall also provide AMEC with the location of all underground utilities and structures in the exploration area. AMEC is not responsible for location or identification of utilities.
5) **PAYMENT AND SUSPENSION.** Unless otherwise stated in the Proposal, invoices will be submitted by AMEC either at the completion of the work or on a monthly basis and will be due and payable on the invoice date. Invoices not paid within thirty (30) days of the invoice date shall be subject to a late fee of one and one-half percent (1.5%) per month computed at 31 days from the date of invoice. In addition, any collection fees, legal fees, court costs, and other related expenses incurred by AMEC in the collection of delinquent invoice amounts shall be paid by CLIENT. **IN THE EVENT CLIENT DISPUTES ALL OR PART OF AN INVOICE, CLIENT MUST ADVISE AMEC IN WRITING WITHIN FIFTEEN (15) DAYS FROM INVOICE DATE**. **UNDISPUTED PORTIONS ARE SUBJECT TO PAYMENT WITHIN THIRTY (30) DAYS.** AMEC may suspend performance of services under this Agreement if: 1) CLIENT fails to make payment in accordance with the terms hereof, 2) CLIENT becomes insolvent, enters bankruptcy, receivership, or other like proceeding (voluntary or involuntary) or makes an assignment for the benefit of creditors, or 3) AMEC reasonably believes that CLIENT will be unable to pay AMEC in accordance with the terms hereof and notifies CLIENT in writing prior to such suspension of services. If any such suspension causes an increase in the time required for AMEC's performance, the performance schedule and/or period for performance shall be extended for a period of time equal to the suspension period. **OWNERSHIP RIGHTS.** Any documents produced by AMEC shall be the sole property of AMEC. At the request and expense of the CLIENT, AMEC shall provide the CLIENT with copies of any or all drawings, specifications and other documents prepared by AMEC.
6) **STANDARD OF CARE.** In the performance of professional services, AMEC will use that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same or similar localities. No warranty, either express or implied, is made or intended by this Agreement or by furnishing oral or written reports of the findings. AMEC is to be liable only for damage proximately caused by the negligence of AMEC. The CLIENT recognizes that subsurface conditions may vary from those encountered at the location where borings, surveys or explorations are made by AMEC and that the data, interpretations and recommendation of AMEC are based solely on the information available to him. AMEC will not be responsible for the interpretation by others of the information developed.
7) **INSURANCE.** AMEC will maintain insurance for this Agreement in the following types: 1) worker's compensation insurance at statutorily required levels, 2) comprehensive general liability (CGL) insurance and 3) automobile liability insurance for bodily injury and property damage.
8) **ENVIRONMENTAL LIABILITY.** Because CLIENT owns and/or operates the site where work is being performed, CLIENT has and shall retain all responsibility and liability associated with the environmental conditions at the site. Unless specifically identified elsewhere, CLIENT'S responsibility and liability includes the handling and disposal of any samples or hazardous materials generated on the site as a result of AMEC's performance hereunder.
9) **CONSEQUENTIAL DAMAGES.** AMEC shall NOT be responsible for any consequential, incidental or indirect damages.
10) **LIMITATION OF LIABILITY.** ***Notwithstanding any other provision of this Agreement, the total liability of AMEC, its officers, directors and employees for liabilities, claims, judgments, demands and causes of action arising under or related to this Agreement, whether based in contract or tort, shall be limited to the total compensation actually paid to AMEC for the services hereunder or $50,000, whichever is less. All claims by CLIENT shall be deemed relinquished unless filed within one (1) year after substantial completion of the services hereunder.***
11) **DISPUTES.** Any dispute arising hereunder shall first be resolved by taking the following steps, where a successive step is taken if the issue is not resolved at the preceding step: 1) by the technical and contractual personnel for each party performing this Agreement, 2) by executive management of each party, 3) by mediation or 4) through the court system of the jurisdiction of the AMEC office that entered into this Agreement. CLIENT hereby waives the right to trial by jury for any disputes arising out of this Agreement. Except as otherwise provided herein, each party shall be responsible for its own legal fees and costs.
12) **AUTHORIZATION TO SIGN.** The person signing this Agreement warrants that he has authority to sign as, or on behalf of, the CLIENT for whom or for whose benefit AMEC's services are rendered. If such a person does not have such authority, he agrees that he is personally liable for all breaches of this Agreement, and that in any such action against him for breach of such warranty, reasonable legal fees and costs shall be included in a judgment rendered.
13) **ASSIGNMENT.** Neither party shall assign its interest in this Agreement without the written consent of the other except that AMEC may assign its interest in the Agreement to related or affiliated companies of AMEC without the consent of CLIENT.
14) **CHOICE OF LAWS.** This Agreement shall be governed by the laws of the province of the AMEC office performing the work.
15) **FORCE MAJEURE.** Should performance of services by AMEC be affected by causes beyond its reasonable control, including but not limited to: acts of God; acts of a legislative, administrative or judicial entity; acts of contractors other than contractors engaged by AMEC; fires; floods; labor disturbances; unusually severe weather and/or an epidemic; then CLIENT will grant AMEC a time extension and the parties will negotiate an equitable adjustment to the price of any affected services, where appropriate.
16) **FIELD REPRESENTATION.** Unless otherwise expressly agreed in writing, AMEC shall not be responsible for the safety or direction of the means and methods at the CLIENT's site of contractors or their employees or agents that are not hired by AMEC, and the presence of AMEC at the CLIENT's site will not relieve the contractor of its responsibilities for performing the work in accordance with applicable regulations, or in accordance with project plans and specifications. If necessary, CLIENT will advise any contractors that AMEC's services are so limited. AMEC will not assume the role of "prime contractor", "principal contractor", "constructor", "controlling employer", or their equivalents unless the scope of such services are expressly agreed in writing.
17) **TERMINATION.** This Agreement may be terminated by either party upon ten (10) days written notice to the other. In the event of a termination, Client shall pay for all reasonable charges for work performed and demobilization by AMEC to date of notice of termination. The limitation of liability and indemnity obligations of this Agreement shall be binding notwithstanding any termination of this Agreement.

Appendix G

Step Test Data

TABLE G-1: STEP TEST PUMPING DATA, LYNDEN WELL FDL-02
LYNDEN WELLS
071-11885

OW		DEPTH (mbgl):	51.2	Measuring Point: 0.68 m above grade
PW:	FDL-02	SWL (m bmp):	15.02	Discharge Rate: see Comments Below
DATE:	15-Oct-12	I.D. (mm):	200	
START:	10:47 AM			

D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
0.0	15.02	0.00				**STEP 1 : 94.8 L/min (25 USgpm)**
0.2	15.26	0.24				
0.3	15.26	0.24				
0.5	15.28	0.26				
0.7	15.28	0.26				
0.8	15.29	0.27				
1.0	15.29	0.27				
1.2	15.29	0.27				
1.3	15.29	0.27				
1.5	15.29	0.27				
1.7	15.30	0.28				
1.8	15.30	0.28				
2.0	15.30	0.28				
2.3	15.30	0.28				
2.5	15.30	0.28				
2.8	15.30	0.28				
3.0	15.30	0.28				
3.3	15.30	0.28				
3.5	15.30	0.28				
3.8	15.30	0.28				
4.0	15.30	0.28				
4.5	15.30	0.28				
5.0	15.30	0.28				
6.0	15.30	0.28				
7.0	15.30	0.28				
8.0	15.31	0.29				
9.0	15.31	0.29				
10.0	15.31	0.29				
15.0	15.32	0.30				
20.0	15.32	0.30				
30.0	15.33	0.31				
40.0	15.34	0.32				
50.0	15.35	0.33				
60.0	15.36	0.34				
60.2	15.18	0.16				**Recovery**
60.3	15.11	0.09				
60.5	15.11	0.09				
60.7	15.08	0.06				
60.8	15.08	0.06				
61.0	15.08	0.06				
61.2	15.07	0.05				
61.3	15.07	0.05				
61.5	15.07	0.05				
61.7	15.07	0.05				
61.8	15.07	0.05				
62.0	15.07	0.05				
62.3	15.07	0.05				
62.5	15.06	0.04				
62.8	15.06	0.04				
63.0	15.06	0.04				
63.3	15.06	0.04				
63.5	15.06	0.04				
63.8	15.05	0.03				
64.0	15.05	0.03				
64.5	15.04	0.02				
65.0	15.04	0.02				
70.0	15.04	0.02				
75.0	15.04	0.02				
90.0	15.03	0.01				

TABLE G-1: STEP TEST PUMPING DATA, LYNDEN WELL FDL-02
LYNDEN WELLS
071-11885

OW		DEPTH (mbgl):	51.2	Measuring Point: 0.68 m above grade
PW:	FDL-02	SWL (m bmp):	15.02	Discharge Rate: see Comments Below
DATE:	15-Oct-12	I.D. (mm):	200	
START:	10:47 AM			

D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
90.2	15.48	0.46				**STEP 2 : 189.5 L/min (50 USgpm)**
90.3	15.51	0.49				
90.5	15.54	0.52				
90.7	15.56	0.54				
90.8	15.56	0.54				
91.0	15.57	0.55				
91.2	15.57	0.55				
91.3	15.57	0.55				
91.5	15.57	0.55				
91.7	15.58	0.56				
91.8	15.58	0.56				
92.0	15.59	0.57				
92.3	15.59	0.57				
92.5	15.59	0.57				
92.8	15.59	0.57				
93.0	15.59	0.57				
93.3	15.59	0.57				
93.5	15.59	0.57				
93.8	15.59	0.57				
94.0	15.59	0.57				
94.5	15.59	0.57				
95.0	15.60	0.58				
96.0	15.61	0.59				
97.0	15.62	0.60				
98.0	15.63	0.61				
99.0	15.63	0.61				
100.0	15.64	0.62				
105.0	15.64	0.62				
110.0	15.65	0.63				
120.0	15.66	0.64				
130.0	15.68	0.66				
140.0	15.69	0.67				
150.0	15.71	0.69				
150.2	15.25	0.23				**Recovery**
150.3	15.25	0.23				
150.5	15.24	0.22				
150.7	15.24	0.22				
150.8	15.23	0.21				
151.0	15.23	0.21				
151.2	15.22	0.20				
151.3	15.20	0.18				
151.5	15.20	0.18				
151.7	15.20	0.18				
151.8	15.20	0.18				
152.0	15.20	0.18				
152.3	15.19	0.17				
152.5	15.19	0.17				
152.8	15.18	0.16				
153.0	15.18	0.16				
153.3	15.18	0.16				
153.5	15.18	0.16				
153.8	15.18	0.16				
154.0	15.18	0.16				
154.5	15.17	0.15				
155.0	15.17	0.15				
160.0	15.15	0.13				
170.0	15.12	0.10				
180.0	15.11	0.09				
195.0	15.10	0.08				
210.0	15.09	0.07				

TABLE G-1: STEP TEST PUMPING DATA, LYNDEN WELL FDL-02
LYNDEN WELLS
071-11885

OW	DEPTH (mbgl):	51.2		Measuring Point: 0.68 m above grade
PW: FDL-02	SWL (m bmp):	15.02		Discharge Rate: see Comments Below
DATE: 15-Oct-12	I.D. (mm):	200		
START: 10:47 AM				

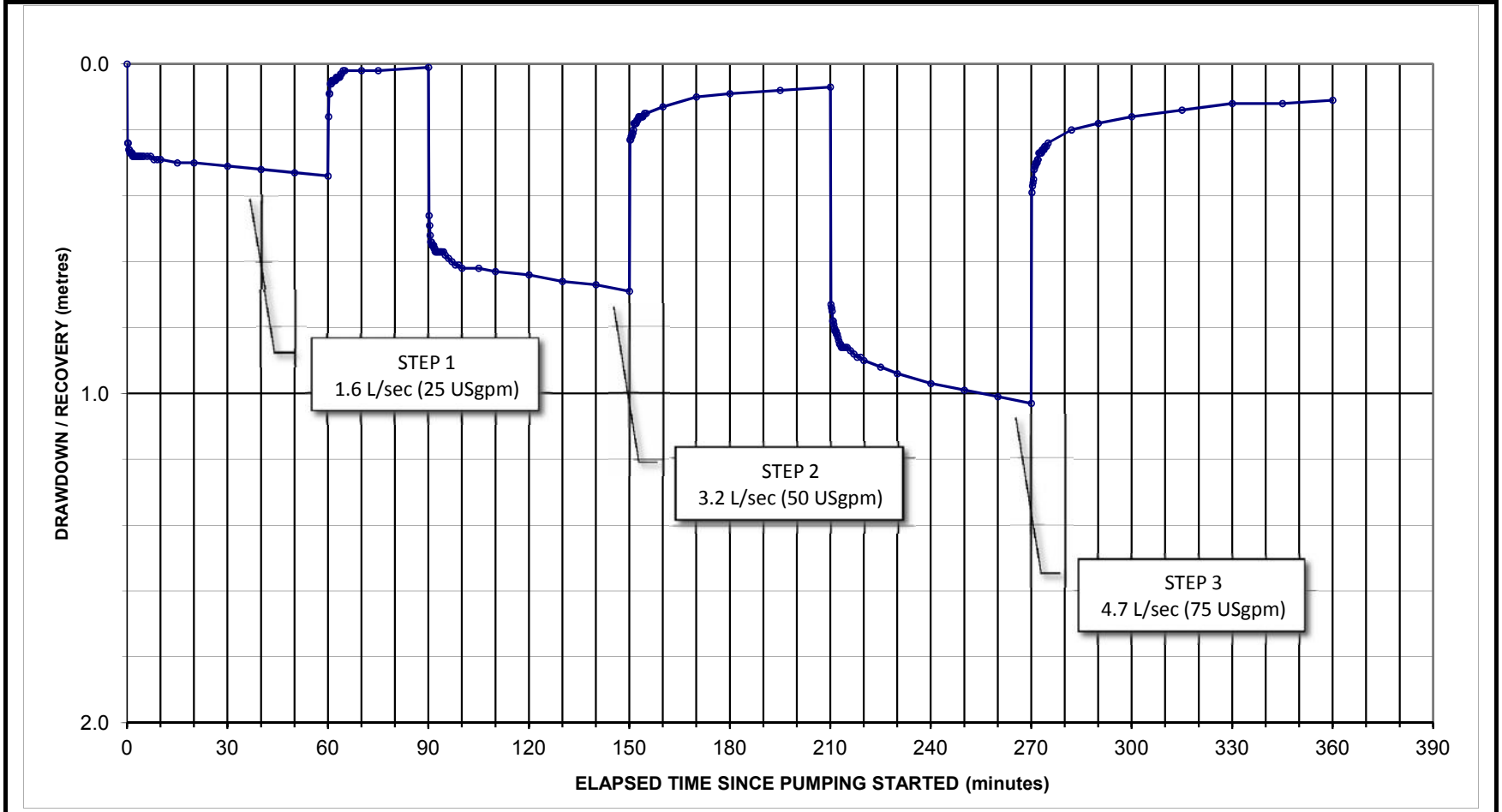
D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
210.2	15.75	0.73				**STEP 3 : 284.3 L/min (75 USgpm)**
210.3	15.76	0.74				
210.5	15.77	0.75				
210.7	15.80	0.78				
210.8	15.80	0.78				
211.0	15.81	0.79				
211.2	15.82	0.80				
211.3	15.83	0.81				
211.5	15.83	0.81				
211.7	15.83	0.81				
211.8	15.84	0.82				
212.0	15.84	0.82				
212.3	15.85	0.83				
212.5	15.86	0.84				
212.8	15.87	0.85				
213.0	15.87	0.85				
213.3	15.88	0.86				
213.5	15.88	0.86				
213.8	15.88	0.86				
214.0	15.88	0.86				
214.5	15.88	0.86				
215.0	15.88	0.86				
216.0	15.89	0.87				
217.0	15.90	0.88				
218.0	15.91	0.89				
219.0	15.91	0.89				
220.0	15.92	0.90				
225.0	15.94	0.92				
230.0	15.96	0.94				
240.0	15.99	0.97				
250.0	16.01	0.99				
260.0	16.03	1.01				
270.0	16.05	1.03				
270.2	15.41	0.39				**Recovery**
270.3	15.39	0.37				
270.5	15.38	0.36				
270.7	15.37	0.35				
270.8	15.34	0.32				
271.0	15.33	0.31				
271.2	15.33	0.31				
271.3	15.32	0.30				
271.5	15.32	0.30				
271.7	15.32	0.30				
271.8	15.31	0.29				
272.0	15.31	0.29				
272.3	15.29	0.27				
272.5	15.29	0.27				
272.8	15.29	0.27				
273.0	15.29	0.27				
273.3	15.28	0.26				
273.5	15.28	0.26				
273.8	15.28	0.26				
274.0	15.27	0.25				
274.5	15.27	0.25				
275.0	15.26	0.24				
282.0	15.22	0.20				
290.0	15.20	0.18				
300.0	15.18	0.16				
315.0	15.16	0.14				
330.0	15.14	0.12				
345.0	15.14	0.12				
360.0	15.13	0.11				

Q: discharge PW: pumped well I.D: inside diameter mbgl: metres below ground level
SWL: static water level OW: observation well mp: measuring point m bmp: metres below measuring point
L/sec: litres per second

FIGURE G-1

RECORD OF STEP TEST DATA - LYNDEN WELL FDL-02

Static Water Level : 14.34 m bgl Well Depth: 51.2 m bgl Pumping Rate: As Shown	Project Name : **LYNDEN WELLS** Project No : 071-11885 Date: 15-Oct-12
mbtoc - metres below top of casing Igpm - Imperial gallons per minute mbgl - metres below ground level L/sec - litres per second	Distance from pumping well = 0 m



C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Step Test\FDL-02 - Step Test Manual Plots.xlsx

FIGURE G-2

OBSERVED DRAWDOWN vs DISCHARGE FDL-01 1985 and FDL-02 2012

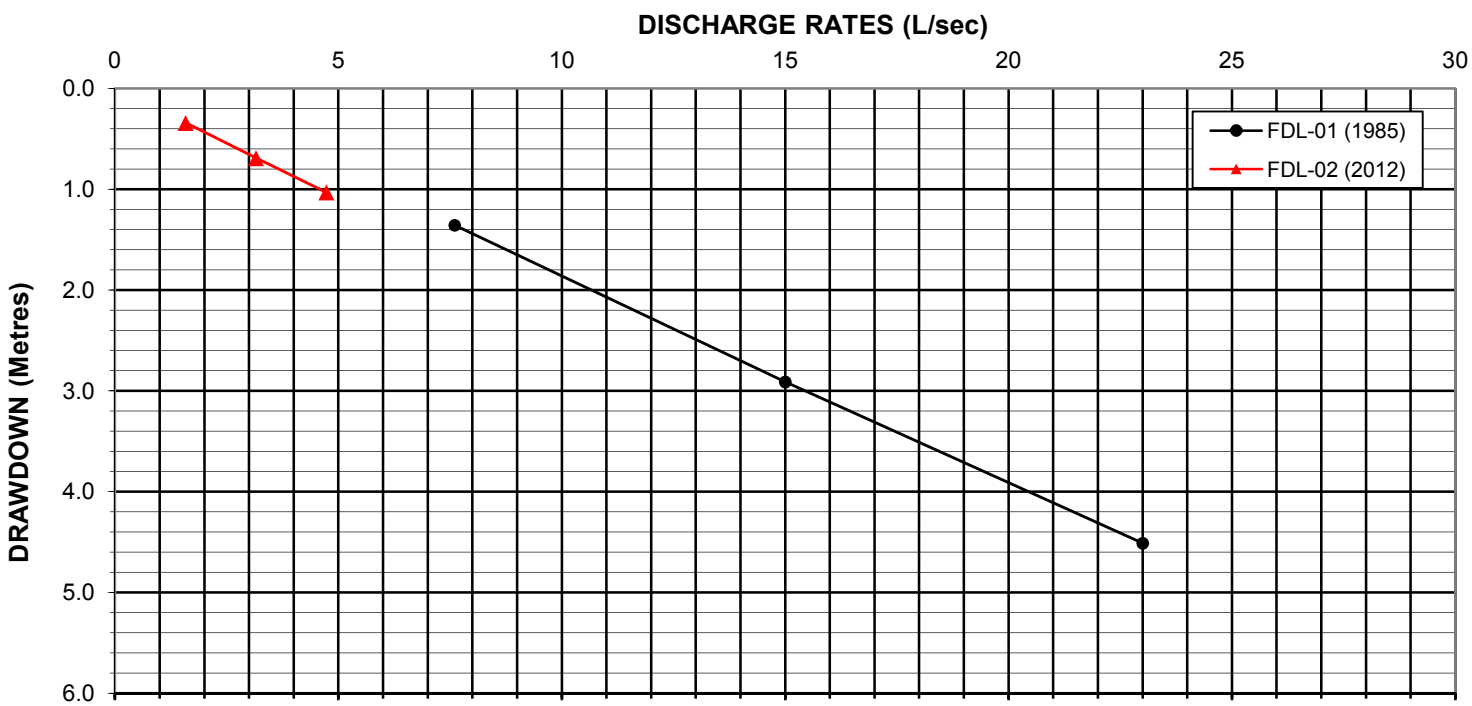
Well Loss Formula: $s = B \times Q + C \times Q^2$

B: Formation Loss C: Well Loss Q L/min - litres per minute

Project Name : **Lynden Wells**

Project No : 071-11885

Date: 15-Oct-12



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Appendix H

Pumping Test Data

TABLE H-1: PUMPING TEST DATA, LYNDEN WELL FDL-02

72 Hour Aquifer Test at FDL-02

Lynden Wells **071-11885**

OW:		DEPTH(m bgl):	51.20	mp (m agl):	0.68
PW:	FDL-02	SWL(m bmp):	15.02	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	200		
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
0.17	15.64	0.62	0.2	16.92	0.47	4.8 L/s (75 Usgpm)
0.33	15.68	0.66	0.3	16.70	0.69	FDL01 off on Sunday October 14
0.5	15.71	0.69	0.5	16.68	0.71	
0.67	15.72	0.70	0.7	16.67	0.72	
0.83	15.73	0.71	0.8	16.66	0.73	
1	15.74	0.72	1.0	16.65	0.74	
1.17	15.75	0.73	1.2	16.65	0.74	
1.33	15.75	0.73	1.3	16.64	0.75	
1.5	15.75	0.73	1.5	16.64	0.75	
1.67	15.76	0.74	1.7	16.63	0.76	
1.83	15.77	0.75	1.8	16.63	0.76	
2	15.77	0.75	2.0	16.62	0.77	
2.25	15.78	0.76	2.3	16.62	0.77	
2.5	15.79	0.77	2.5	16.61	0.78	
2.75	15.79	0.77	2.8	16.61	0.78	
3	15.79	0.77	3.0	16.61	0.78	
3.25	15.8	0.78	3.3	16.60	0.79	
3.5	15.8	0.78	3.5	16.60	0.79	
3.75	15.8	0.78	3.8	16.60	0.79	
4	15.81	0.79	4.0	16.59	0.80	
4.5	15.81	0.79	4.5	16.59	0.80	
5	15.81	0.79	5.0	16.59	0.80	
6	15.82	0.80	6.0	16.58	0.81	
7	15.83	0.81	7.0	16.57	0.82	
8	15.83	0.81	8.0	16.56	0.83	
9	15.85	0.83	9.0	16.55	0.84	
10	15.85	0.83	10.0	16.54	0.85	
15	15.87	0.85	15.0	16.52	0.87	
20	15.9	0.88	20.0	16.50	0.89	
25	15.91	0.89	30.0	16.46	0.93	
30	15.93	0.91	40.0	16.44	0.95	
40	15.95	0.93	50.0	16.42	0.97	
50	15.97	0.95	60.0	16.40	0.99	
60	15.99	0.97	90.0	16.35	1.04	
120	16.07	1.05	120.0	16.30	1.09	
180	16.14	1.12	150.0	16.28	1.11	
240	16.19	1.17	180.0	16.26	1.13	
300	16.24	1.22	252.0	16.18	1.21	
360	16.29	1.27	300.0	16.15	1.24	
420	16.32	1.30	360.0	16.11	1.28	
480	16.35	1.33	720.0	15.96	1.43	
540	16.38	1.36	1500.0	15.73	1.66	
600	16.41	1.39	1940.0	15.64	1.75	
660	16.45	1.43				
720	16.48	1.46				
780	16.51	1.49				

TABLE H-1: PUMPING TEST DATA, LYNDEN WELL FDL-02
72 Hour Aquifer Test at FDL-02
Lynden Wells **071-11885**

OW:		DEPTH(m bgl):	51.20	mp (m agl):	0.68
PW:	FDL-02	SWL(m bmp):	15.02	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	200		
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
840	16.53	1.51				
900	16.56	1.54				
960	16.59	1.57				
1020	16.62	1.60				
1080	16.63	1.61				
1140	16.65	1.63				
1200	16.67	1.65				
1260	16.69	1.67				
1320	16.70	1.68				
1380	16.72	1.70				
1440	16.74	1.72				
1500	16.76	1.74				
1560	16.78	1.76				
1620	16.79	1.77				
1680	16.80	1.78				
1740	16.82	1.80				
1800	16.85	1.83				
1860	16.86	1.84				
1920	16.88	1.86				
1980	16.90	1.88				
2040	16.92	1.90				
2100	16.94	1.92				
2160	16.95	1.93				
2220	16.97	1.95				
2280	16.97	1.95				
2340	16.99	1.97				
2400	17.01	1.99				
2460	17.02	2.00				
2520	17.04	2.02				
2580	17.05	2.03				
2640	17.06	2.04				
2700	17.08	2.06				
2760	17.09	2.07				
2820	17.10	2.08				
2880	17.11	2.09				
2940	17.13	2.11				
3000	17.14	2.12				
3060	17.15	2.13				
3120	17.16	2.14				
3180	17.17	2.15				
3240	17.18	2.16				
3300	17.2	2.18				
3360	17.21	2.19				
3420	17.23	2.21				
3480	17.24	2.22				
3540	17.25	2.23				

TABLE H-1: PUMPING TEST DATA, LYNDEN WELL FDL-02
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:		DEPTH(m bgl):	51.20	mp (m agl):	0.68
PW:	FDL-02	SWL(m bmp):	15.02	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	200		
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
3600	17.26	2.24				
3660	17.27	2.25				
3720	17.29	2.27				
3780	17.3	2.28				
3840	17.31	2.29				
3900	17.32	2.3				
3960	17.33	2.31				
4020	17.34	2.32				
4080	17.35	2.33				
4140	17.36	2.34				
4200	17.37	2.35				
4260	17.38	2.36				
4320	17.39	2.37				Pump shut down.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-2: PUMPING TEST DATA, MONITORING WELL LM-01-11-D
72 Hour Aquifer Test at FDL-02
Lynden Wells **071-11885**

OW:	LM-01-11-D	DEPTH(m bgl):	54.56	mp (m agl):	0.9
PW:	FDL-02	SWL(m bmp):	12.10	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	50	Distance from PW:	79 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
0.17	12.13	0.03	0.17	13.77	0.06	4.7 L/s (75 Usgpm)
0.33	12.15	0.05	0.33	13.75	0.08	FDL01 off on Sunday October 14
0.5	12.17	0.07	0.5	13.73	0.10	
0.67	12.18	0.08	0.67	13.72	0.11	
0.83	12.19	0.09	0.83	13.71	0.12	
1	12.19	0.09	1	13.71	0.12	
1.17	12.2	0.10	1.17	13.70	0.13	
1.33	12.21	0.11	1.33	13.70	0.13	
1.5	12.21	0.11	1.5	13.69	0.14	
1.67	12.22	0.12	1.67	13.69	0.14	
1.83	12.22	0.12	1.83	13.69	0.14	
2	12.22	0.12	2	13.69	0.14	
2.25	12.23	0.13	2.25	13.68	0.15	
2.5	12.23	0.13	2.5	13.675	0.15	
2.75	12.23	0.13	2.75	13.67	0.16	
3	12.23	0.13	3	13.67	0.16	
3.25	12.24	0.14	3.25	13.67	0.16	
3.5	12.24	0.14	3.5	13.67	0.16	
3.75	12.25	0.15	3.75	13.66	0.17	
4	12.25	0.15	4	13.66	0.17	
4.5	12.25	0.15	4.5	13.66	0.17	
5	12.26	0.16	5	13.655	0.18	
6	12.26	0.16	6	13.65	0.18	
7	12.27	0.17	7	13.645	0.19	
8	12.28	0.18	8	13.64	0.19	
9	12.29	0.19	9	13.63	0.20	
10	12.3	0.20	10	13.625	0.21	
15	12.31	0.21	15	13.61	0.22	
20	12.33	0.23	20	13.59	0.24	
30	12.36	0.26	30	13.56	0.27	
40	12.4	0.30	40	13.54	0.29	
50	12.42	0.32	50	13.52	0.31	
60	12.44	0.34	60	13.50	0.33	
120	12.54	0.44	170	13.35	0.48	
180	12.6	0.50	180	13.33	0.50	
240	12.65	0.55	257	13.27	0.56	
300	12.70	0.60	300	13.25	0.58	
360	12.73	0.63	360	13.20	0.63	
420	12.77	0.67	715	13.06	0.77	
480	12.81	0.71	1500	12.82	1.01	
540	12.84	0.74	1940	12.74	1.09	
600	12.87	0.77				
660	12.90	0.80				
720	12.95	0.85				
780	12.98	0.88				
840	13.00	0.90				

TABLE H-2: PUMPING TEST DATA, MONITORING WELL LM-01-11-D
72 Hour Aquifer Test at FDL-02
Lynden Wells **071-11885**

OW:	LM-01-11-D	DEPTH(m bgl):	54.56	mp (m agl):	0.9
PW:	FDL-02	SWL(m bmp):	12.10	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	50	Distance from PW:	79 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
900	13.02	0.92				
960	13.05	0.95				
1020	13.07	0.97				
1080	13.10	1.00				
1140	13.11	1.01				
1200	13.13	1.03				
1260	13.15	1.05				
1320	13.17	1.07				
1380	13.19	1.09				
1440	13.21	1.11				
1500	13.23	1.13				
1560	13.25	1.15				
1620	13.27	1.17				
1680	13.28	1.18				
1740	13.30	1.20				
1800	13.31	1.21				
1860	13.32	1.22				
1920	13.34	1.24				
1980	13.36	1.26				
2040	13.38	1.28				
2100	13.40	1.30				
2160	13.41	1.31				
2220	13.42	1.32				
2280	13.44	1.34				
2340	13.45	1.35				
2400	13.47	1.37				
2460	13.48	1.38				
2520	13.50	1.40				
2580	13.51	1.41				
2640	13.52	1.42				
2700	13.53	1.43				
2760	13.55	1.45				
2820	13.56	1.46				
2880	13.57	1.47				
2940	13.59	1.49				
3000	13.6	1.50				
3060	13.61	1.51				
3120	13.62	1.52				
3180	13.63	1.53				
3240	13.64	1.54				
3300	13.66	1.56				
3360	13.67	1.57				
3420	13.69	1.59				
3480	13.7	1.60				
3540	13.71	1.61				
3600	13.72	1.62				

TABLE H-2: PUMPING TEST DATA, MONITORING WELL LM-01-11-D
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	LM-01-11-D	DEPTH(m bgl):	54.56	mp (m agl):	0.9
PW:	FDL-02	SWL(m bmp):	12.10	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	50	Distance from PW:	79 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
3660	13.74	1.64				
3720	13.76	1.66				
3780	13.76	1.66				
3840	13.77	1.67				
3900	13.79	1.69				
3960	13.8	1.70				
4020	13.79	1.69				
4080	13.8	1.70				
4140	13.81	1.71				
4200	13.82	1.72				
4260	13.83	1.73				Pump shut down at 4320 minutes.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-3: PUMPING TEST DATA, MONITORING WELL LM-01-12-D
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	LM-01-12-D	DEPTH(m bgl):	52.12	mp (m agl):	0.85
PW:	FDL-02	SWL(m bmp):	14.20	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	50	Distance from PW:	92 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
0.17	14.2	0.00	0.17	15.85	0.02	4.7 L/s (75 Usgpm)
0.33	14.22	0.02	0.33	15.83	0.04	FDL01 off on Sunday October 14
0.5	14.24	0.04	0.5	15.82	0.05	
0.67	14.24	0.04	0.67	15.81	0.06	
0.83	14.25	0.05	0.83	15.80	0.07	
1	14.25	0.05	1	15.79	0.08	
1.17	14.26	0.06	1.17	15.78	0.09	
1.33	14.26	0.06	1.33	15.78	0.09	
1.5	14.27	0.07	1.5	15.78	0.09	
1.67	14.28	0.08	1.67	15.77	0.10	
1.83	14.28	0.08	1.83	15.77	0.10	
2	14.29	0.09	2	15.77	0.10	
2.25	14.29	0.09	2.25	15.76	0.11	
2.5	14.3	0.10	2.5	15.76	0.11	
2.75	14.3	0.10	2.75	15.75	0.12	
3	14.3	0.10	3	15.75	0.12	
3.25	14.31	0.11	3.25	15.75	0.12	
3.5	14.31	0.11	3.5	15.74	0.13	
3.75	14.31	0.11	3.75	15.74	0.13	
4	14.32	0.12	4	15.74	0.13	
4.5	14.32	0.12	4.5	15.73	0.14	
5	14.33	0.13	5	15.72	0.15	
6	14.34	0.14	6	15.71	0.16	
7	14.34	0.14	7	15.71	0.16	
8	14.35	0.15	8	15.70	0.17	
9	14.36	0.16	9	15.70	0.17	
10	14.36	0.16	10	15.69	0.18	
15	14.39	0.19	15	15.66	0.21	
20	14.41	0.21	20	15.64	0.23	
30	14.44	0.24	30	15.61	0.26	
40	14.46	0.26	40	15.58	0.29	
50	14.49	0.29	50	15.56	0.31	
60	14.51	0.31	60	15.55	0.32	
120	14.58	0.38	160	15.42	0.45	
180	14.64	0.44	180	15.40	0.47	
240	14.7	0.50	254	15.34	0.53	
300	14.75	0.55	300	15.31	0.56	
360	14.79	0.59	360	15.28	0.59	
420	14.82	0.62	720	15.13	0.74	
480	14.85	0.65	1500	14.89	0.98	
540	14.88	0.68	1940	14.81	1.06	
600	14.92	0.72				
660	14.95	0.75				
720	14.99	0.79				
780	15.02	0.82				
840	15.05	0.85				

TABLE H-3: PUMPING TEST DATA, MONITORING WELL LM-01-12-D
72 Hour Aquifer Test at FDL-02
Lynden Wells **071-11885**

OW:	LM-01-12-D	DEPTH(m bgl):	52.12	mp (m agl):	0.85
PW:	FDL-02	SWL(m bmp):	14.20	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	50	Distance from PW:	92 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
900	15.07	0.87				
960	15.10	0.90				
1020	15.13	0.93				
1080	15.15	0.95				
1140	15.17	0.97				
1200	15.18	0.98				
1260	15.20	1.00				
1320	15.22	1.02				
1380	15.24	1.04				
1440	15.26	1.06				
1500	15.28	1.08				
1560	15.30	1.10				
1620	15.31	1.11				
1680	15.32	1.12				
1740	15.34	1.14				
1800	15.35	1.15				
1860	15.37	1.17				
1920	15.39	1.19				
1980	15.41	1.21				
2040	15.43	1.23				
2100	15.44	1.24				
2160	15.45	1.25				
2220	15.47	1.27				
2280	15.48	1.28				
2340	15.50	1.30				
2400	15.52	1.32				
2460	15.53	1.33				
2520	15.54	1.34				
2580	15.55	1.35				
2640	15.56	1.36				
2700	15.58	1.38				
2760	15.59	1.39				
2820	15.60	1.40				
2880	15.61	1.41				
2940	15.63	1.43				
3000	15.64	1.44				
3060	15.65	1.45				
3120	15.66	1.46				
3180	15.67	1.47				
3240	15.69	1.49				
3300	15.7	1.50				
3360	15.71	1.51				
3420	15.72	1.52				
3480	15.74	1.54				
3540	15.75	1.55				
3600	15.76	1.56				

TABLE H-3: PUMPING TEST DATA, MONITORING WELL LM-01-12-D
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	LM-01-12-D	DEPTH(m bgl):	52.12	mp (m agl):	0.85
PW:	FDL-02	SWL(m bmp):	14.20	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	50	Distance from PW:	92 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
3660	15.77	1.57				
3720	15.79	1.59				
3780	15.8	1.60				
3840	15.81	1.61				
3900	15.82	1.62				
3960	15.83	1.63				
4020	15.84	1.64				
4080	15.85	1.65				
4140	15.86	1.66				
4200	15.87	1.67				
4260	15.87	1.67				
4320	15.87	1.67				Pump turned off.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-4: PUMPING TEST DATA, MONITORING WELL LM-01-03-D
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	LM-01-03-D	DEPTH(m bgl):	56.67	mp (m agl):	0.85
PW:	FDL-02	SWL(m bmp):	12.65	Discharge Rate:	4.8 L/s
DATE:	16-Oct-12	I.D. (mm):	50	Distance from PW:	140 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
0.17	12.65	0.00	0.17	14.31	0.00	4.8 L/s (75 Usgpm)
0.33	12.65	0.00	0.33	14.31	0.00	FDL01 off on Sunday October 14
0.5	12.655	0.00	0.5	14.305	0.01	
0.67	12.66	0.01	0.67	14.3	0.01	
0.83	12.665	0.01	0.83	14.295	0.02	
1	12.67	0.02	1	14.29	0.02	
1.17	12.675	0.03	1.17	14.285	0.03	
1.33	12.68	0.03	1.33	14.28	0.03	
1.5	12.685	0.04	1.5	14.275	0.04	
1.67	12.69	0.04	1.67	14.27	0.04	
1.83	12.695	0.04	1.83	14.265	0.04	
2	12.7	0.05	2	14.265	0.04	
2.25	12.7	0.05	2.25	14.26	0.05	
2.5	12.702	0.05	2.5	14.255	0.05	
2.75	12.705	0.05	2.75	14.25	0.06	
3	12.71	0.06	3	14.245	0.07	
3.25	12.715	0.06	3.25	14.245	0.07	
3.5	12.717	0.07	3.5	14.24	0.07	
3.75	12.72	0.07	3.75	14.235	0.08	
4	12.722	0.07	4	14.235	0.08	
4.5	12.73	0.08	4.5	14.23	0.08	
5	12.735	0.08	5	14.225	0.09	
6	12.74	0.09	6	14.215	0.10	
7	12.75	0.10	7	14.21	0.10	
8	12.76	0.11	8	14.2	0.11	
9	12.76	0.11	9	14.195	0.12	
10	12.765	0.12	10	14.19	0.12	
15	12.79	0.14	15	14.165	0.15	
20	12.81	0.16	20	14.145	0.17	
30	12.845	0.20	25	14.13	0.18	
40	12.87	0.22	30	14.115	0.20	
50	12.895	0.24	40	14.09	0.22	
60	12.915	0.26	50	14.06	0.25	
120	13.00	0.35	60	14.045	0.27	
180	13.07	0.42	170	13.895	0.42	
240	13.12	0.47	180	13.89	0.42	
300	13.16	0.51	259	13.83	0.48	
360	13.20	0.55	300	13.795	0.52	
420	13.24	0.59	360	13.76	0.55	
480	13.27	0.62	720	13.6	0.71	
540	13.29	0.64	1500	13.37	0.94	
600	13.33	0.68	1940	13.29	1.02	
660	13.36	0.71				
720	13.40	0.75				
780	13.44	0.79				
840	13.47	0.82				

TABLE H-4: PUMPING TEST DATA, MONITORING WELL LM-01-03-D
72 Hour Aquifer Test at FDL-02
Lynden Wells **071-11885**

OW:	LM-01-03-D	DEPTH(m bgl):	56.67	mp (m agl):	0.85
PW:	FDL-02	SWL(m bmp):	12.65	Discharge Rate:	4.8 L/s
DATE:	16-Oct-12	I.D. (mm):	50	Distance from PW:	140 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
960	13.52	0.87				
1020	13.54	0.89				
1080	13.57	0.92				
1140	13.59	0.94				
1200	13.60	0.95				
1260	13.62	0.97				
1320	13.64	0.99				
1380	13.66	1.01				
1440	13.68	1.03				
1500	13.70	1.05				
1560	13.72	1.07				
1620	13.74	1.09				
1680	13.76	1.11				
1740	13.77	1.12				
1800	13.78	1.13				
1860	13.80	1.15				
1920	13.82	1.17				
1980	13.84	1.19				
2040	13.85	1.20				
2100	13.87	1.22				
2160	13.88	1.23				
2220	13.89	1.24				
2280	13.91	1.26				
2340	13.92	1.27				
2400	13.94	1.29				
2460	13.96	1.31				
2520	13.97	1.32				
2580	13.98	1.33				
2640	13.99	1.34				
2700	14.00	1.35				
2760	14.01	1.36				
2820	14.02	1.37				
2880	14.04	1.39				
2940	14.06	1.41				
3000	14.07	1.42				
3060	14.08	1.43				
3120	14.1	1.45				
3180	14.12	1.47				
3240	14.12	1.47				
3300	14.14	1.49				
3360	14.16	1.51				
3420	14.17	1.52				
3480	14.17	1.52				
3540	14.18	1.53				
3600	14.2	1.55				
3660	14.21	1.56				

TABLE H-4: PUMPING TEST DATA, MONITORING WELL LM-01-03-D
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	LM-01-03-D	DEPTH(m bgl):	56.67	mp (m agl):	0.85
PW:	FDL-02	SWL(m bmp):	12.65	Discharge Rate:	4.8 L/s
DATE:	16-Oct-12	I.D. (mm):	50	Distance from PW:	140 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
3720	14.22	1.57				
3780	14.23	1.58				
3840	14.24	1.59				
3900	14.25	1.60				
3960	14.26	1.61				
4020	14.27	1.62				
4080	14.28	1.63				
4140	14.29	1.64				
4200	14.3	1.65				
4260	14.31	1.66				
4320	14.31	1.66				Pump shut down.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-5: PUMPING TEST DATA, MONITORING WELL LM-01-08-OB
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	LM-01-08-OB	DEPTH(m bgl):	52.73	mp (m agl):	0.75
PW:	FDL-02	SWL(m bmp):	11.74	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	23	Distance from PW:	550 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
90	11.79	0.05	70	12.9	0.04	4.7 L/s (75 Usgpm)
135	11.83	0.09	205	12.83	0.11	FDL01 off on Sunday October 14
195	11.84	0.10	310	12.78	0.16	
255	11.87	0.13	702	12.67	0.27	
315	11.9	0.16	1490	12.47	0.47	
437	11.96	0.22	1950	12.39	0.55	
555	12.01	0.27				
675	12.04	0.30				
795	12.11	0.37				
915	12.16	0.42				
1035	12.2	0.46				
1155	12.2	0.46				
1275	12.28	0.54				
1395	12.3	0.56				
1515	12.33	0.59				
1635	12.37	0.63				
1755	12.41	0.67				
1875	12.44	0.70				
1995	12.47	0.73				
2115	12.49	0.75				
2235	12.52	0.78				
2355	12.56	0.82				
2475	12.58	0.84				
2595	12.61	0.87				
2715	12.63	0.89				
2835	12.66	0.92				
2955	12.69	0.95				
3025	12.7	0.96				
3195	12.73	0.99				
3315	12.75	1.01				
3435	12.8	1.06				
3555	12.82	1.08				
3675	12.83	1.09				
3795	12.86	1.12				
3915	12.88	1.14				
4035	12.9	1.16				
4155	12.92	1.18				
4275	12.94	1.20				

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-6: PUMPING TEST DATA, PRIVATE WELL - 3606 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	3606	DEPTH(m bgl):	60.96	mp (m agl):	0.97
PW:	FDL-02	SWL(m bmp):	15.08	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	152	Distance from PW:	177 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
1	15.08	0.00	22	16.69	0.00	4.7 L/s (75 Usgpm)
2	15.08	0.00	24	16.67	0.02	FDL01 off on Sunday October 14
3	15.08	0.00	26	16.65	0.03	Data for this well was collected via
4	15.09	0.01	28	16.65	0.04	datalogger. Well use was removed.
5	15.09	0.01	30	16.63	0.06	
6	15.09	0.01	32	16.62	0.07	
7	15.10	0.02	34	16.61	0.08	
8	15.09	0.01	36	16.60	0.09	
9	15.10	0.02	38	16.59	0.10	
10	15.10	0.02	40	16.57	0.11	
11	15.10	0.02	45	16.56	0.13	
12	15.11	0.03	50	16.54	0.14	
13	15.12	0.04	55	16.53	0.15	
14	15.12	0.04	60	16.52	0.17	
15	15.12	0.04	70	16.49	0.19	
16	15.12	0.04	80	16.48	0.21	
17	15.13	0.05	90	16.45	0.23	
18	15.13	0.05	100	16.44	0.25	
19	15.14	0.06	110	16.42	0.27	
20	15.14	0.06	120	16.41	0.27	
22	15.15	0.07	150	16.35	0.33	
24	15.16	0.08	180	16.32	0.36	
26	15.16	0.08	210	16.28	0.40	
28	15.18	0.10	330	16.22	0.47	
30	15.18	0.10	360	16.20	0.48	
32	15.18	0.10	420	16.17	0.52	
34	15.19	0.11	480	16.13	0.55	
36	15.19	0.11	540	16.10	0.58	
38	15.19	0.11	600	16.08	0.61	
40	15.19	0.11	660	16.06	0.62	
45	15.20	0.12	720	16.04	0.65	
50	15.21	0.13	780	16.02	0.67	
55	15.24	0.16	840	16.00	0.69	
60	15.24	0.16	900	15.98	0.71	
70	15.27	0.19	960	15.96	0.72	
80	15.29	0.21	1020	15.95	0.73	
90	15.31	0.23	1080	15.93	0.76	
100	15.32	0.24	1150	15.92	0.77	
110	15.33	0.25	1200	15.89	0.80	
150	15.42	0.34	1260	15.87	0.82	
160	15.42	0.34	1320	15.85	0.84	
180	15.43	0.35	1380	15.83	0.85	
210	15.46	0.38	1430	15.83	0.86	
240	15.48	0.40	1510	15.81	0.88	
270	15.49	0.41	1560	15.79	0.90	
420	15.61	0.53	1620	15.77	0.92	

TABLE H-6: PUMPING TEST DATA, PRIVATE WELL - 3606 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	3606	DEPTH(m bgl):	60.96	mp (m agl):	0.97
PW:	FDL-02	SWL(m bmp):	15.08	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	152	Distance from PW:	177 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
460	15.63	0.55	1730	15.76	0.93	
660	15.71	0.63	1880	15.72	0.97	
690	15.72	0.64	1920	15.72	0.97	
780	15.77	0.69	2100	15.69	0.99	
840	15.80	0.72	2160	15.68	1.00	
900	15.83	0.75	2220	15.67	1.01	
960	15.87	0.79	2280	15.67	1.02	
1020	15.89	0.81	2340	15.66	1.03	
1080	15.91	0.83	2400	15.66	1.03	
1140	15.94	0.86	2460	15.65	1.03	
1200	15.97	0.89	2520	15.65	1.04	
1260	15.97	0.89	2580	15.63	1.06	
1310	15.98	0.90	2640	15.61	1.08	
1380	16.01	0.93	2760	15.62	1.07	
1440	16.03	0.95	2820	15.62	1.07	
1500	16.04	0.96	2880	15.60	1.09	
1560	16.07	0.99	2920	15.59	1.09	
1600	16.07	0.99	2990	15.58	1.11	
1680	16.09	1.01	3240	15.56	1.13	
1710	16.10	1.02	3300	15.55	1.14	
1930	16.19	1.11	3540	15.53	1.15	
1980	16.21	1.13	3600	15.51	1.18	
2040	16.22	1.14	3650	15.50	1.18	74% Recovery upon startup of FDL-01
2100	16.21	1.13				
2160	16.22	1.14				
2220	16.24	1.16				
2280	16.27	1.19				
2340	16.29	1.21				
2400	16.31	1.23				
2440	16.32	1.24				
2540	16.36	1.28				
2580	16.37	1.29				
2640	16.37	1.29				
2700	16.37	1.29				
2750	16.39	1.31				
2820	16.40	1.32				
2880	16.41	1.33				
2940	16.41	1.33				
3000	16.41	1.33				
3060	16.43	1.35				
3180	16.48	1.40				
3310	16.49	1.41				
3360	16.51	1.43				
3420	16.53	1.45				
3510	16.54	1.46				
3540	16.54	1.46				

TABLE H-6: PUMPING TEST DATA, PRIVATE WELL - 3606 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	3606	DEPTH(m bgl):	60.96	mp (m agl):	0.97
PW:	FDL-02	SWL(m bmp):	15.08	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	152	Distance from PW:	177 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
3600	16.56	1.48				
3660	16.57	1.49				
3720	16.57	1.49				
3780	16.57	1.49				
3840	16.58	1.50				
3890	16.60	1.52				
4020	16.63	1.55				
4080	16.64	1.56				
4140	16.66	1.58				
4200	16.67	1.59				
4260	16.68	1.60				
4300	16.69	1.61				

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-7: PUMPING TEST DATA, PRIVATE WELL - 3725 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	3725	DEPTH(m bgl):	54.86	mp (m agl):	0.15
PW:	FDL-02	SWL(m bmp):	14.94	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	152	Distance from PW:	365 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
40	15.07	0.13	25	16.54	0.01	4.7 L/s (75 Usgpm)
45	15.07	0.13	30	16.49	0.06	FDL01 off on Sunday October 14
50	15.07	0.13	35	16.45	0.09	Data for this well was collected via
55	15.09	0.15	40	16.42	0.13	datalogger. Well use was removed.
60	15.09	0.15	50	16.40	0.15	
70	15.12	0.18	60	16.37	0.17	
80	15.14	0.20	70	16.35	0.19	
81	15.13	0.19	80	16.34	0.20	
82	15.14	0.20	90	16.32	0.23	
83	15.14	0.20	300	16.11	0.44	
84	15.14	0.20	330	16.10	0.45	
85	15.14	0.20	360	16.07	0.48	
86	15.15	0.21	420	16.03	0.51	
210	15.31	0.37	480	15.99	0.55	
240	15.33	0.39	540	15.96	0.58	
270	15.34	0.40	570	15.95	0.59	
300	15.36	0.42	630	15.96	0.59	
330	15.40	0.46	720	15.90	0.65	
360	15.41	0.47	780	15.88	0.67	
420	15.45	0.51	960	15.82	0.72	
480	15.50	0.56	1020	15.81	0.74	
540	15.53	0.59	1080	15.79	0.76	
600	15.56	0.62	1140	15.77	0.78	
740	15.61	0.67	1200	15.75	0.80	
780	15.62	0.68	1260	15.73	0.82	
840	15.66	0.72	1320	15.71	0.84	
940	15.71	0.77	1380	15.69	0.85	
1020	15.75	0.81	1560	15.65	0.90	
1080	15.77	0.83	1610	15.64	0.91	
1140	15.79	0.85	1740	15.61	0.94	
1200	15.83	0.89	1860	15.59	0.95	
1230	15.83	0.89	1980	15.57	0.97	
1320	15.85	0.91	2040	15.59	0.96	
1380	15.86	0.92	2100	15.55	1.00	
1450	15.89	0.95	2150	15.54	1.01	
1680	15.94	1.00	2280	15.52	1.02	
1740	15.97	1.03	2340	15.52	1.03	
1800	15.99	1.05	2400	15.52	1.03	
1860	16.03	1.09	2460	15.51	1.03	
1910	16.03	1.09	2520	15.50	1.04	
1980	16.07	1.13	2580	15.48	1.06	
2030	16.07	1.13	2640	15.47	1.08	
2100	16.07	1.13	2700	15.48	1.07	
2160	16.08	1.14	2760	15.47	1.07	
2220	16.10	1.16	2820	15.47	1.07	
2280	16.14	1.20	3180	15.44	1.11	

TABLE H-7: PUMPING TEST DATA, PRIVATE WELL - 3725 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	3725	DEPTH(m bgl):	54.86	mp (m agl):	0.15
PW:	FDL-02	SWL(m bmp):	14.94	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	152	Distance from PW:	365 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
2340	16.14	1.20	3240	15.41	1.13	
2400	16.17	1.23	3270	15.41	1.13	
2460	16.19	1.25	3540	15.38	1.17	
2520	16.21	1.27	3600	15.36	1.18	
2580	16.22	1.28	3650	15.36	1.19	74% Recovery upon startup of FDL-01
2640	16.22	1.28				
2690	16.22	1.28				
2760	16.25	1.31				
2820	16.25	1.31				
2860	16.26	1.32				
2940	16.26	1.32				
3180	16.34	1.40				
3240	16.34	1.40				
3300	16.33	1.39				
3340	16.35	1.41				
3420	16.38	1.44				
3480	16.39	1.45				
3900	16.46	1.52				
3960	16.48	1.54				
4020	16.49	1.55				
4080	16.50	1.56				
4200	16.53	1.59				
4201	16.52	1.58				
4260	16.54	1.60				
4310	16.55	1.61				

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-8: PUMPING TEST DATA, PRIVATE WELL - 3830 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	3830	DEPTH(m bgl):	56.39	mp (m agl):	0.46
PW:	FDL-02	SWL(m bmp):	17.42	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	152	Distance from PW:	743 m
TIME:	8:20 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
18	17.45	0.03	1	18.26	0.00	4.7 L/s (75 Usgpm)
19	17.44	0.02	2	18.26	0.01	FDL-01 off on Sunday October 14
20	17.44	0.02	3	18.26	0.01	Data for this well was collected via
22	17.44	0.02	4	18.26	0.01	datalogger. Well use was removed.
24	17.43	0.01	5	18.26	0.00	
50	17.44	0.02	6	18.26	0.00	
55	17.45	0.03	7	18.26	0.01	
60	17.44	0.02	8	18.26	0.01	
70	17.45	0.03	9	18.26	0.00	
80	17.45	0.03	10	18.26	0.00	
90	17.44	0.02	12	18.26	0.01	
100	17.44	0.02	14	18.26	0.01	
110	17.43	0.01	16	18.26	0.01	
120	17.43	0.01	18	18.26	0.01	
140	17.43	0.01	20	18.26	0.01	
160	17.44	0.02	22	18.26	0.01	
180	17.44	0.02	24	18.26	0.01	
210	17.44	0.02	26	18.25	0.02	
240	17.44	0.02	28	18.26	0.01	
270	17.43	0.01	30	18.26	0.01	
300	17.43	0.01	35	18.25	0.02	
330	17.45	0.03	40	18.24	0.03	
350	17.43	0.01	45	18.25	0.02	
410	17.43	0.01	50	18.25	0.02	
555	17.45	0.03	55	18.25	0.02	
630	17.52	0.10	60	18.25	0.02	
690	17.53	0.11	70	18.25	0.02	
720	17.53	0.11	80	18.25	0.02	
740	17.53	0.11	90	18.24	0.03	
770	17.51	0.09	100	18.24	0.03	
820	17.50	0.08	110	18.23	0.04	
900	17.59	0.17	120	18.24	0.03	
940	17.59	0.17	150	18.21	0.06	
1020	17.63	0.21	180	18.21	0.06	
1080	17.64	0.22	240	18.20	0.07	
1140	17.65	0.23	300	18.20	0.07	
1200	17.68	0.26	360	18.19	0.08	
1260	17.66	0.24	420	18.18	0.09	
1310	17.66	0.24	480	18.16	0.11	
1335	17.68	0.26	540	18.13	0.14	
1400	17.69	0.27	600	18.15	0.12	
1440	17.73	0.31	660	18.13	0.14	
1490	17.71	0.29	720	18.12	0.15	
1560	17.74	0.32	770	18.10	0.17	
1620	17.74	0.32	840	18.10	0.17	
1680	17.74	0.32	900	18.10	0.17	

TABLE H-8: PUMPING TEST DATA, PRIVATE WELL - 3830 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-02
Lynden Wells 071-11885

OW:	3830	DEPTH(m bgl):	56.39	mp (m agl):	0.46
PW:	FDL-02	SWL(m bmp):	17.42	Discharge Rate:	4.7 L/s
DATE:	16-Oct-12	I.D. (mm):	152	Distance from PW:	743 m
TIME:	8:20 a.m.				

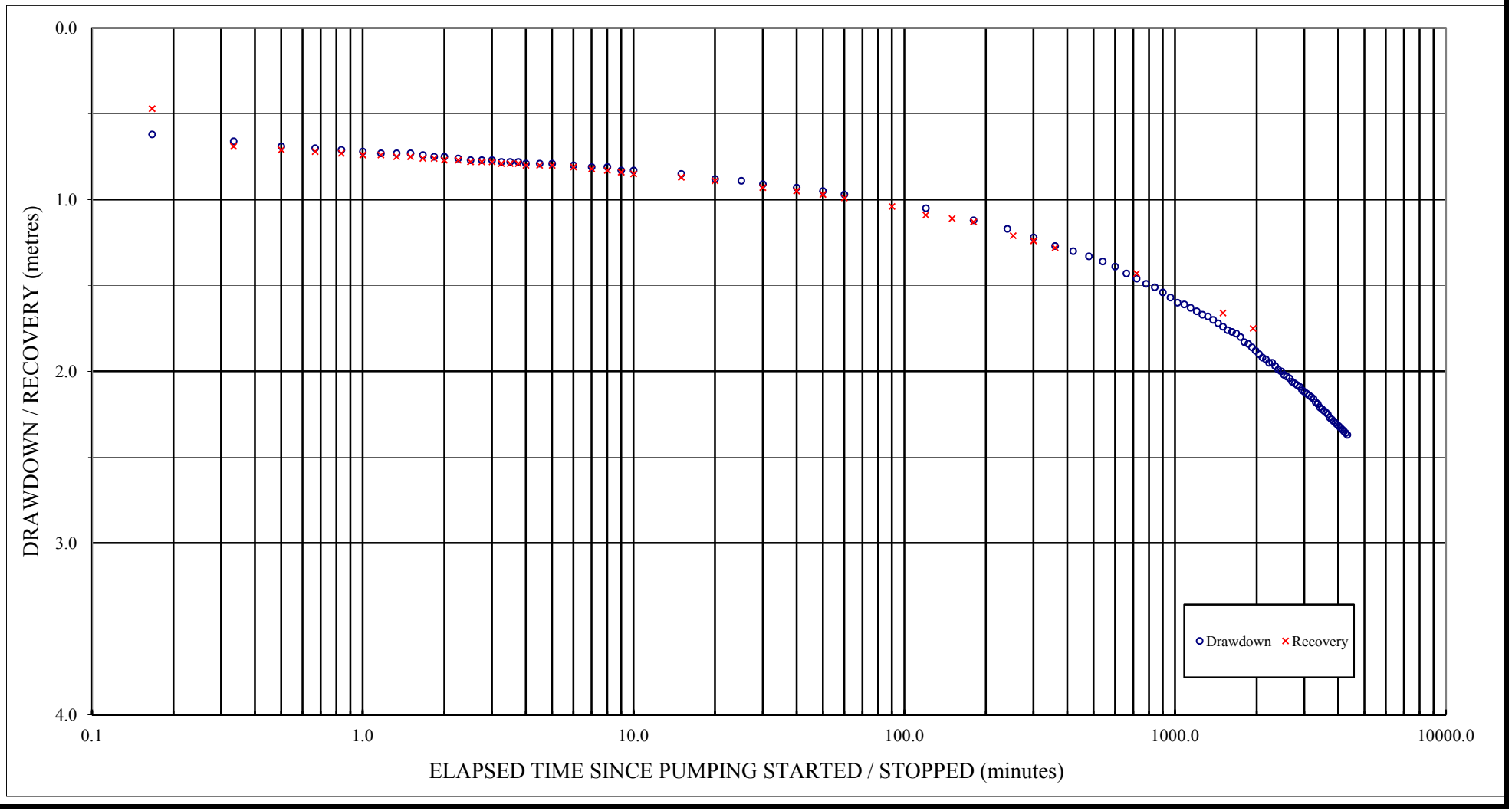
DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
1740	17.76	0.34	970	18.09	0.18	
1800	17.75	0.33	1020	18.10	0.17	
1860	17.77	0.35	1080	18.08	0.19	
1920	17.78	0.36	1140	18.07	0.20	
2000	17.80	0.38	1200	18.05	0.22	
2280	17.92	0.50	1260	18.04	0.23	
2310	17.91	0.49	1320	18.02	0.25	
2400	17.95	0.53	1380	17.99	0.28	
2460	17.95	0.53	1440	18.01	0.26	
2490	17.93	0.51	1500	18.00	0.27	
2580	17.97	0.55	1560	17.97	0.30	
2640	17.96	0.54	1620	17.96	0.31	
2700	17.96	0.54	1680	17.96	0.31	
2760	17.95	0.53	1740	17.94	0.33	
2830	17.98	0.56	1800	17.96	0.31	
3000	18.04	0.62	1860	17.94	0.33	
3060	18.06	0.64	1980	17.98	0.29	
3200	18.05	0.63	2040	17.95	0.32	
3260	18.05	0.63	2160	17.96	0.31	
3300	18.06	0.64	2280	17.96	0.30	
3360	18.07	0.65	2400	17.93	0.34	
3420	18.08	0.66	2460	17.92	0.35	
3460	18.08	0.66	2580	17.89	0.38	
3740	18.19	0.77	2640	17.87	0.40	
3900	18.19	0.77	2700	17.88	0.39	
3960	18.19	0.77	2760	17.87	0.40	
4020	18.19	0.77	2820	17.86	0.41	
4080	18.19	0.77	2940	17.87	0.40	
4140	18.20	0.78	3000	17.84	0.43	
4200	18.21	0.79	3060	17.81	0.46	
4320	18.27	0.85	3180	17.85	0.41	
			3240	17.83	0.43	
			3300	17.82	0.45	
			3360	17.80	0.47	
			3540	17.78	0.49	57% Recovery upon startup of FDL-01

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

FIGURE H-1

PUMPING TEST DATA, LYNDEN WELL FDL-02

Static Water Level : 14.34 m bgl Well Depth: 51.2 m bgl Pumping Rate: 4.7 L/s	Project Name : **Lynden Wells** Project No : 071-11885 Date: 16-Oct-12
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = 0

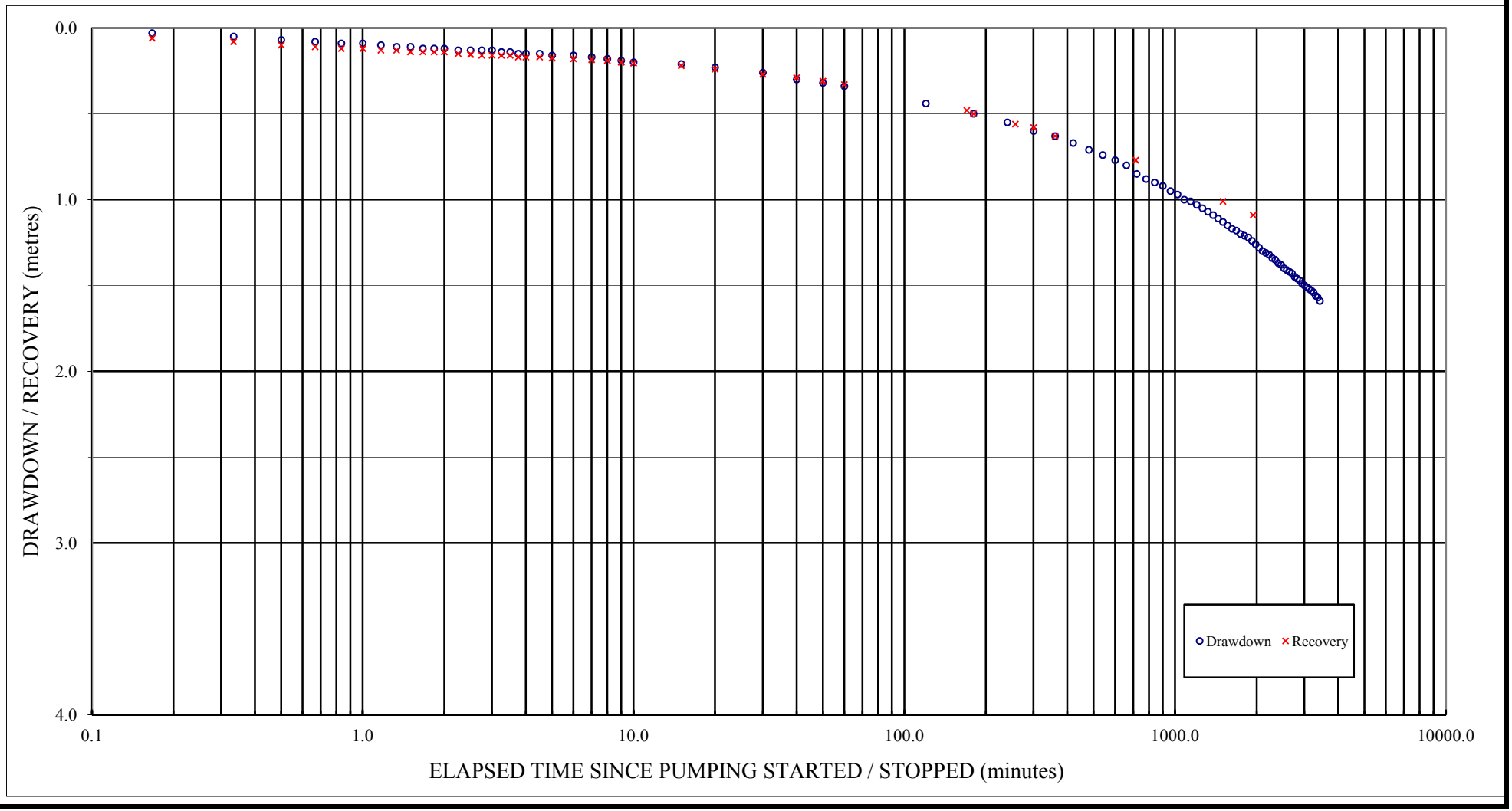


C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\FDL02 - Manual Measurements.xls

FIGURE H-2

PUMPING TEST DATA, MONITORING WELL LM-01-11-D

Static Water Level : 11.2 m bgl Well Depth: 54.5592 m bgl Pumping Rate: 4.7 L/s	Project Name : **Lynden Wells** Project No : 071-11885 Date: 16-Oct-12
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = 79 m

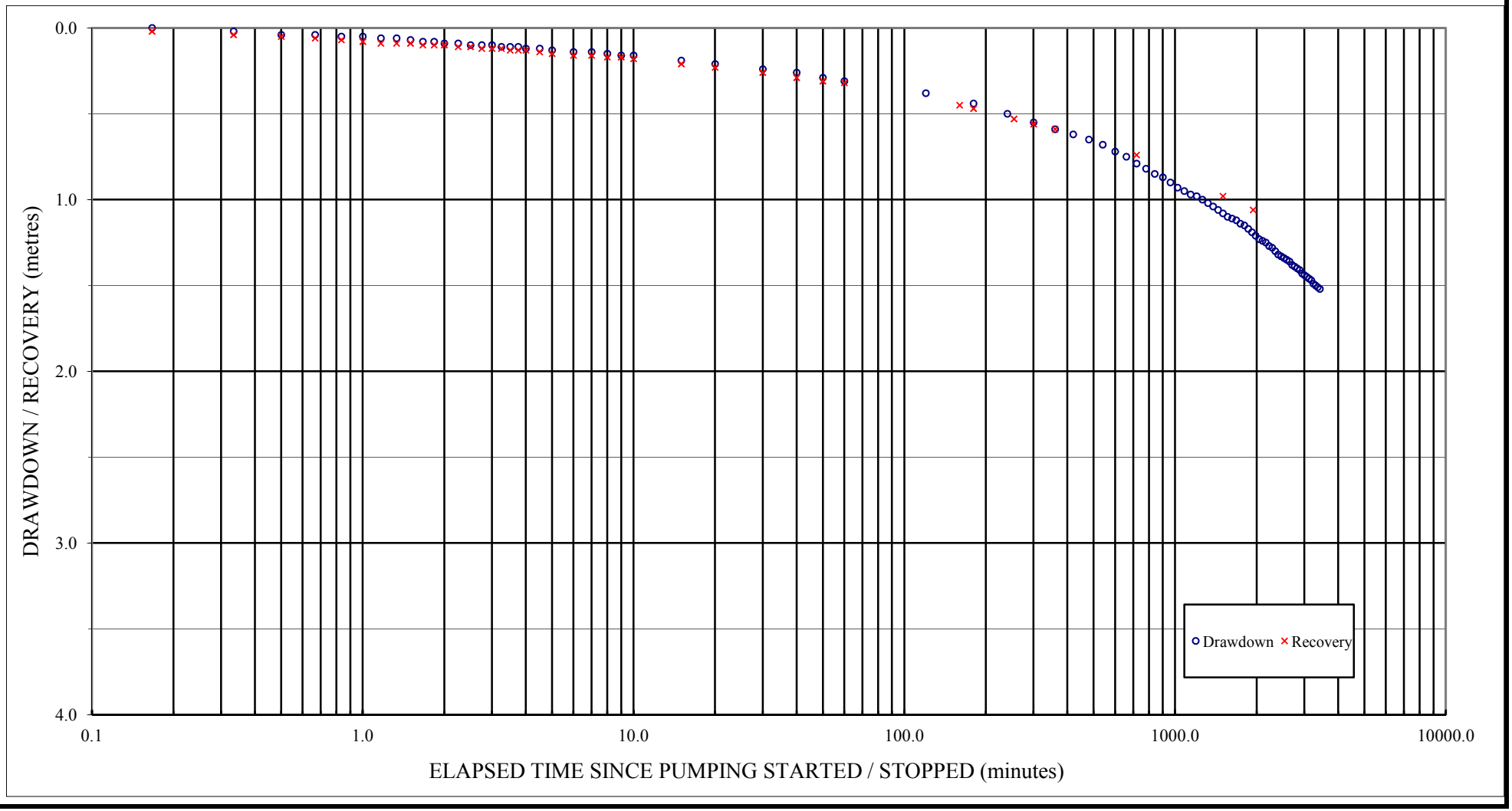


C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\LM-01-11-D - Manual Measurements.xls

FIGURE H-3

PUMPING TEST DATA, MONITORING WELL LM-01-12-D

Static Water Level : 13.35 m bgl Well Depth: 52.12 m bgl Pumping Rate: 4.7 L/s	Project Name : **Lynden Wells** Project No : 071-11885 Date: 16-Oct-12
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = 92 m

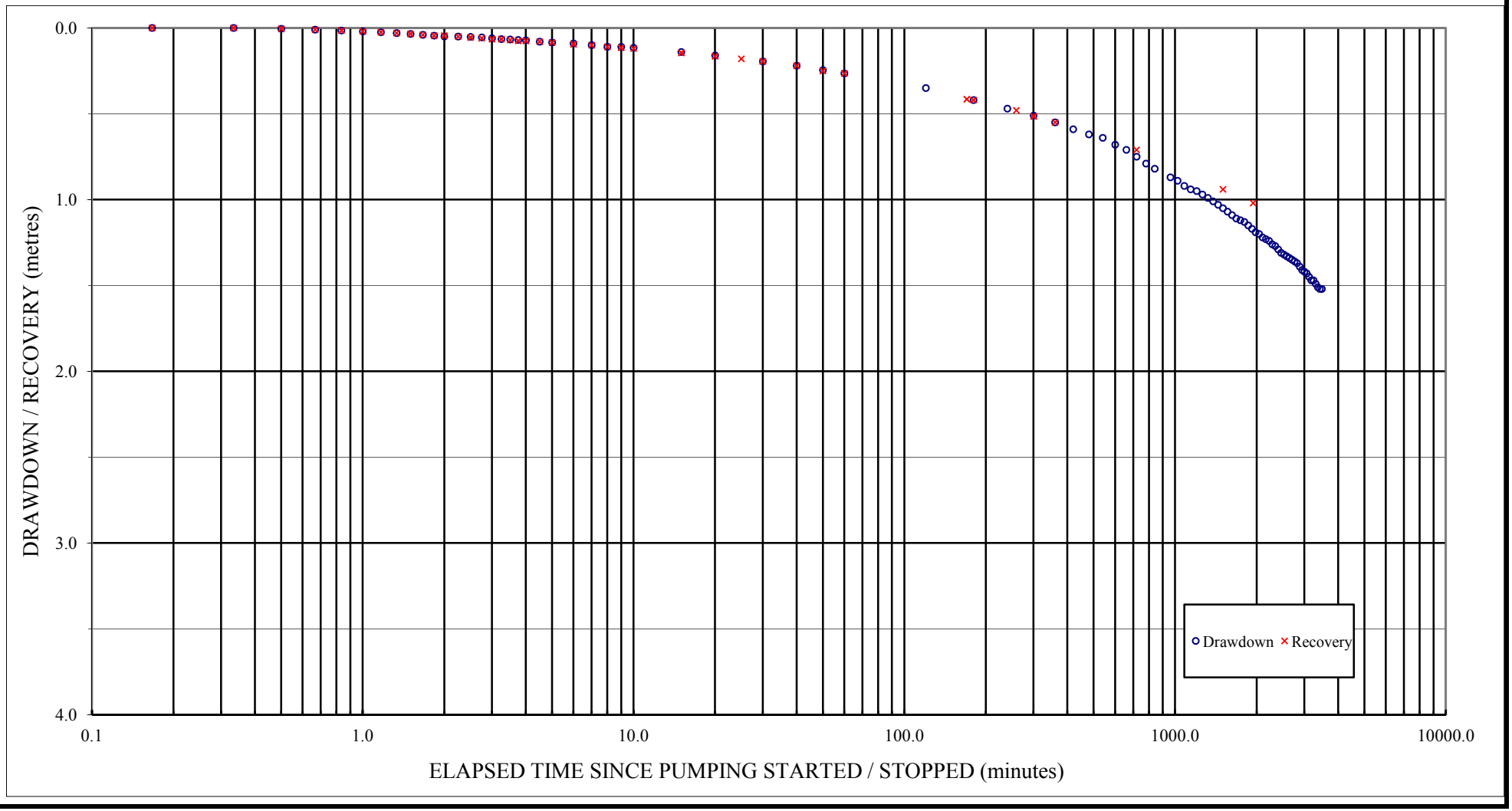


C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\LM-01-12-D - Manual Measurements.xls

FIGURE H-4

PUMPING TEST DATA, MONITORING WELL LM-01-03-D

Static Water Level : 11.8 m bgl Well Depth: 56.67 m bgl Pumping Rate: 4.8 L/s	Project Name : **Lynden Wells** Project No : 071-11885 Date: 16-Oct-12
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = 140 m

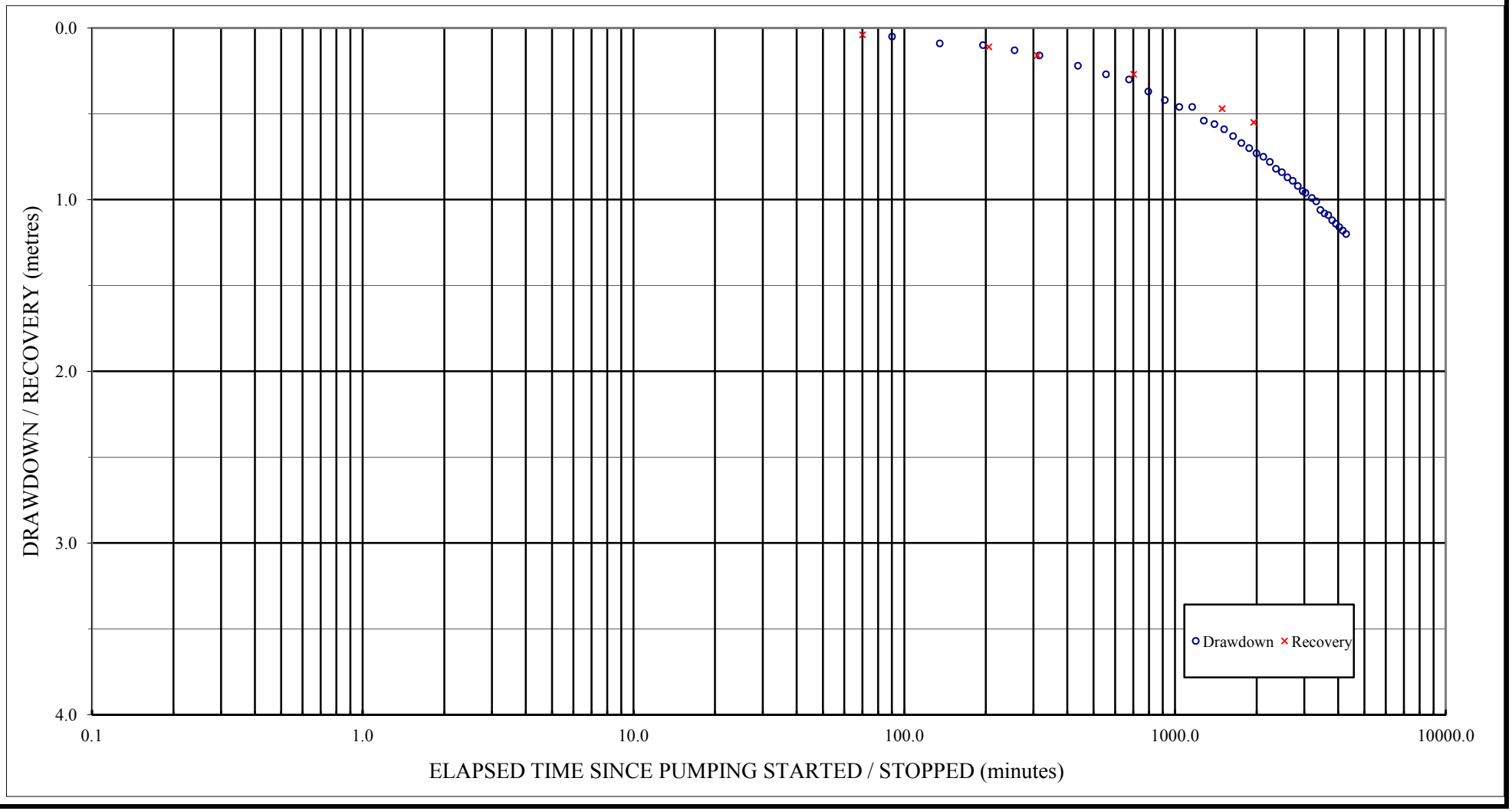


C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\LM-01-03-D - Manual Measurements.xls

FIGURE H-5

PUMPING TEST DATA, MONITORING WELL LM-01-08-OB

Static Water Level : 10.99 m bgl Well Depth: 52.73 m bgl Pumping Rate: 4.7 L/s	Project Name : **Lynden Wells** Project No : 071-11885 Date: 16-Oct-12
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = 550 m

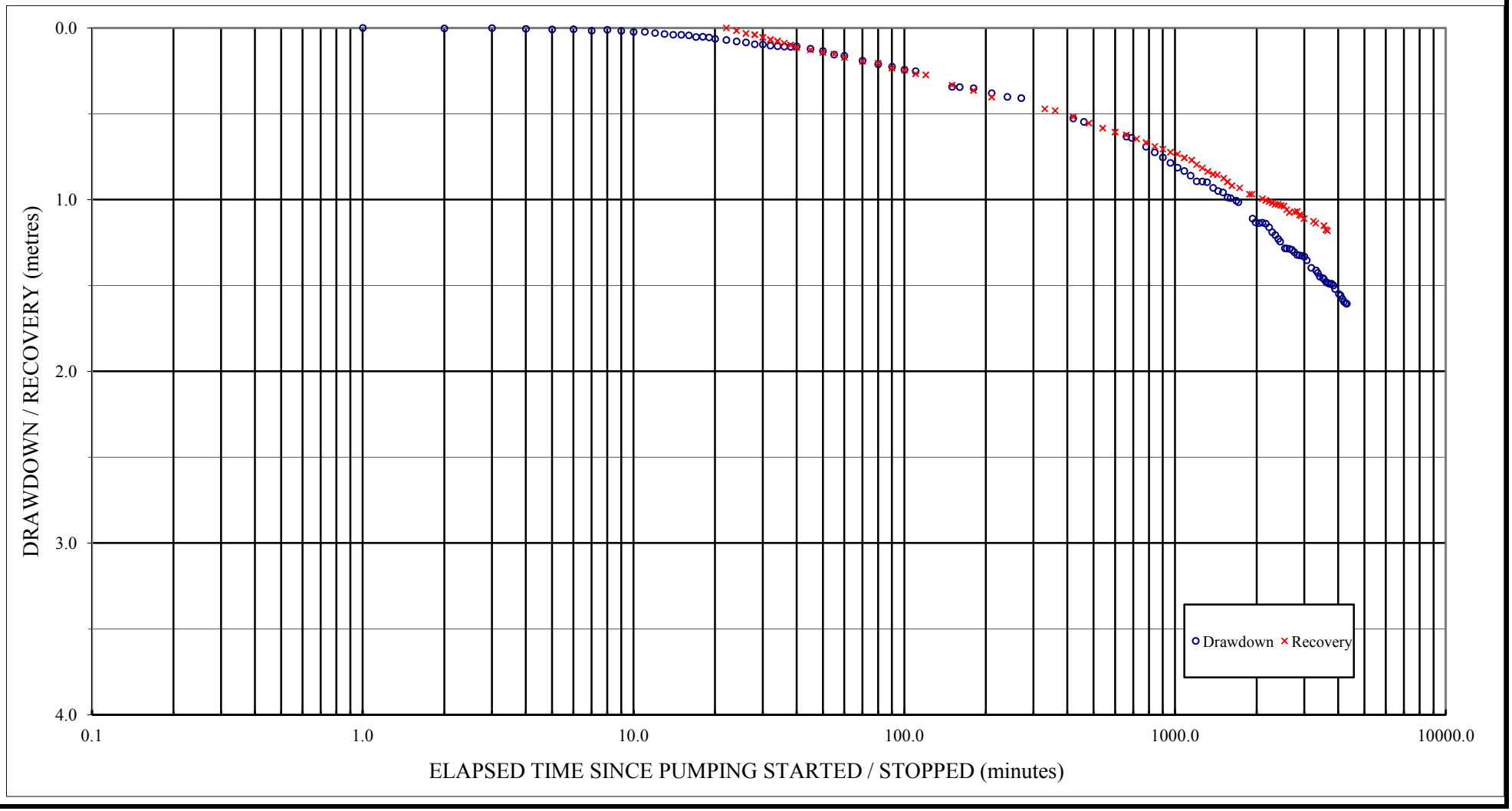


C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\LM-01-08-OB - Manual Measurements.xls

FIGURE H-6

PUMPING TEST DATA, PRIVATE WELL - 3606 GOVERNORS ROAD

Static Water Level : 14.11 m bgl Well Depth: 60.96 m bgl Pumping Rate: 4.7 L/s	Project Name : **Lynden Wells** Project No : 071-11885 Date: 16-Oct-12
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = 177 m

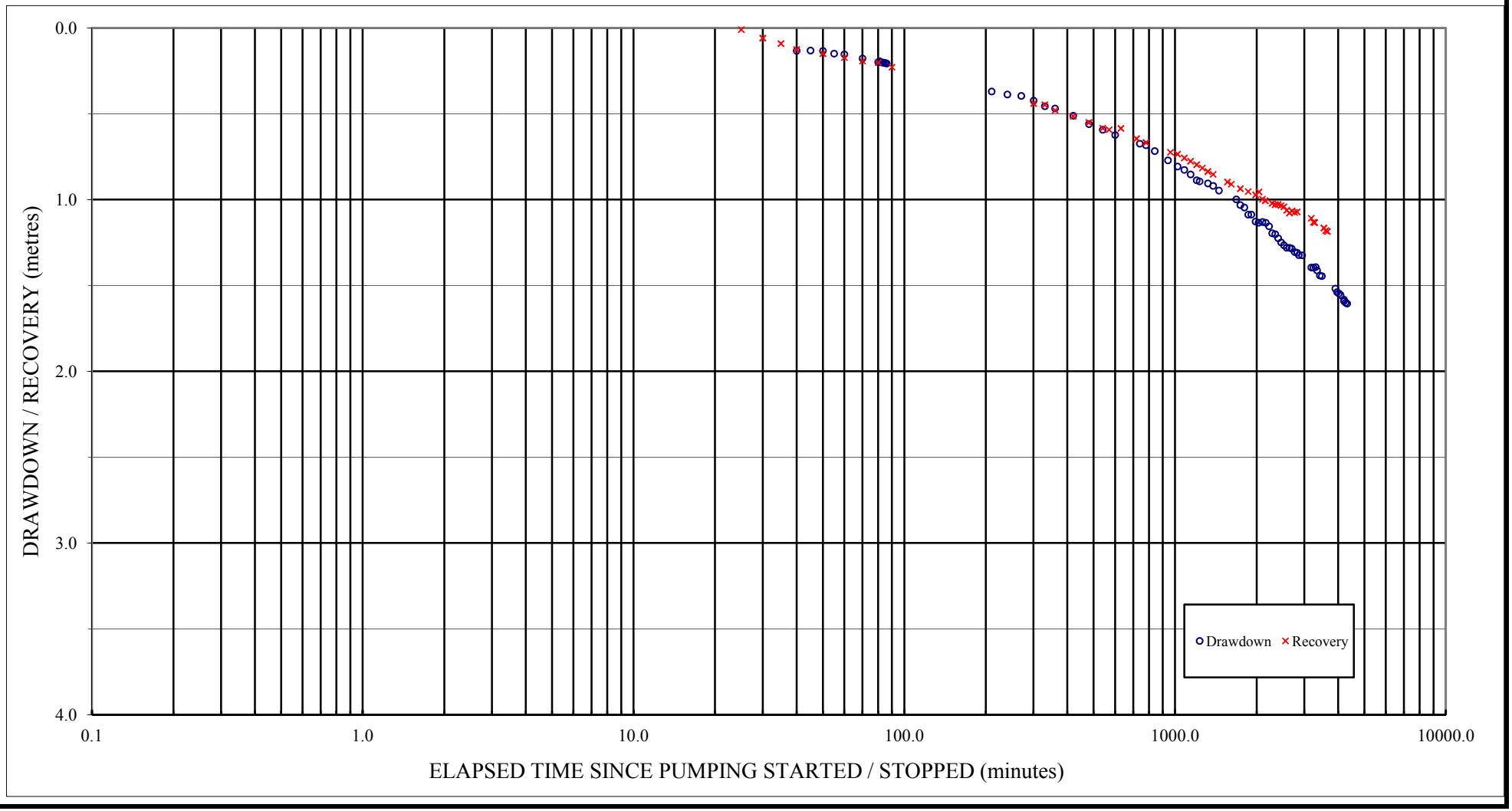


C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\3606 Semilog.xls

FIGURE H-7

PUMPING TEST DATA, PRIVATE WELL - 3725 GOVERNORS ROAD

Static Water Level : 14.79 m bgl Well Depth: 54.864 m bgl Pumping Rate: 4.7 L/s	Project Name : **Lynden Wells** Project No : 071-11885 Date: 16-Oct-12
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = 365 m

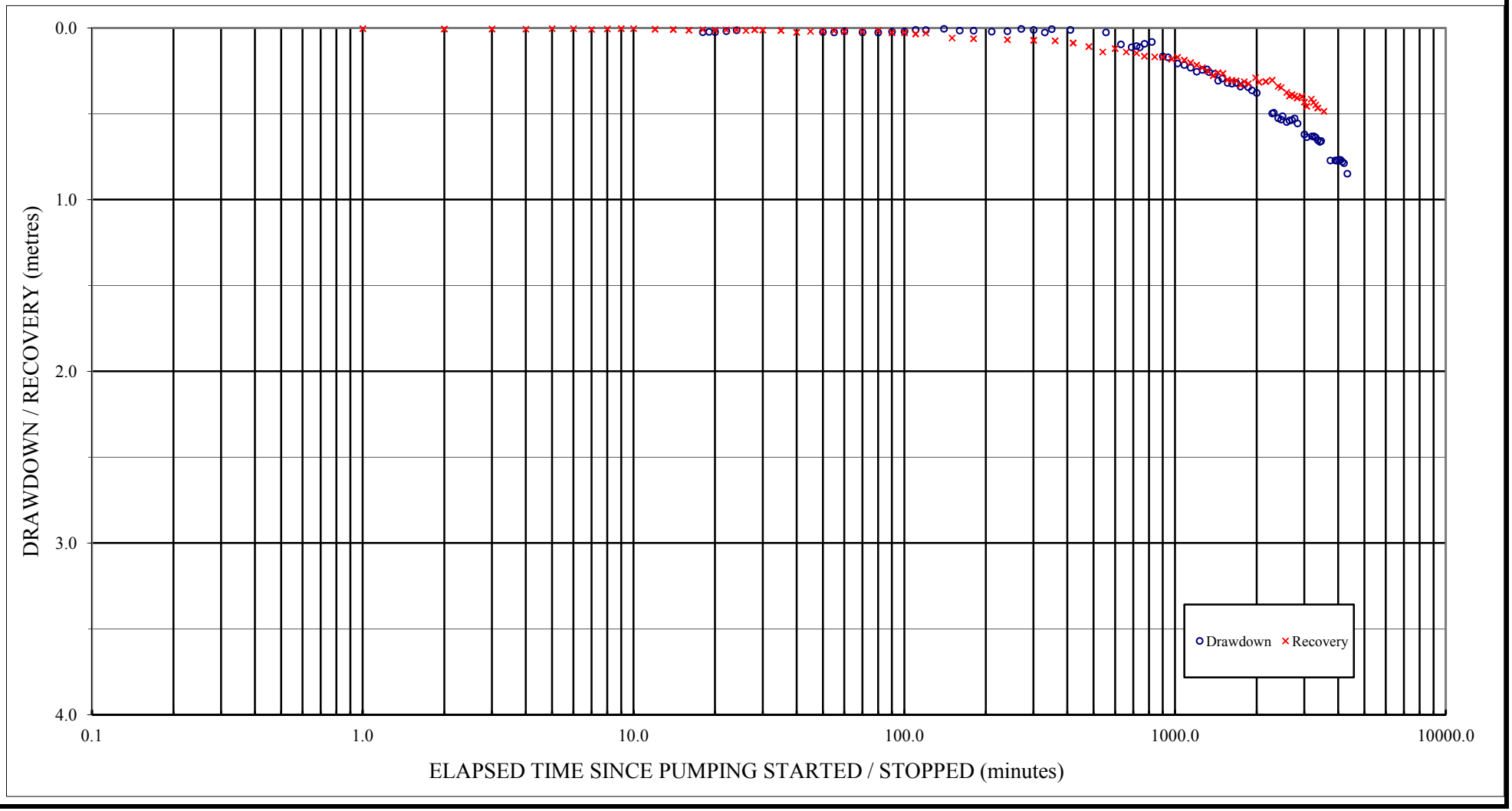


C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\3725 Semilog.xls

FIGURE H-8

PUMPING TEST DATA, PRIVATE WELL - 3830 GOVERNORS ROAD

Static Water Level : 16.96 m bgl Well Depth: 56.39 m bgl Pumping Rate: 4.7 L/s	Project Name : **Lynden Wells** Project No : 071-11885 Date: 16-Oct-12
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = 743 m

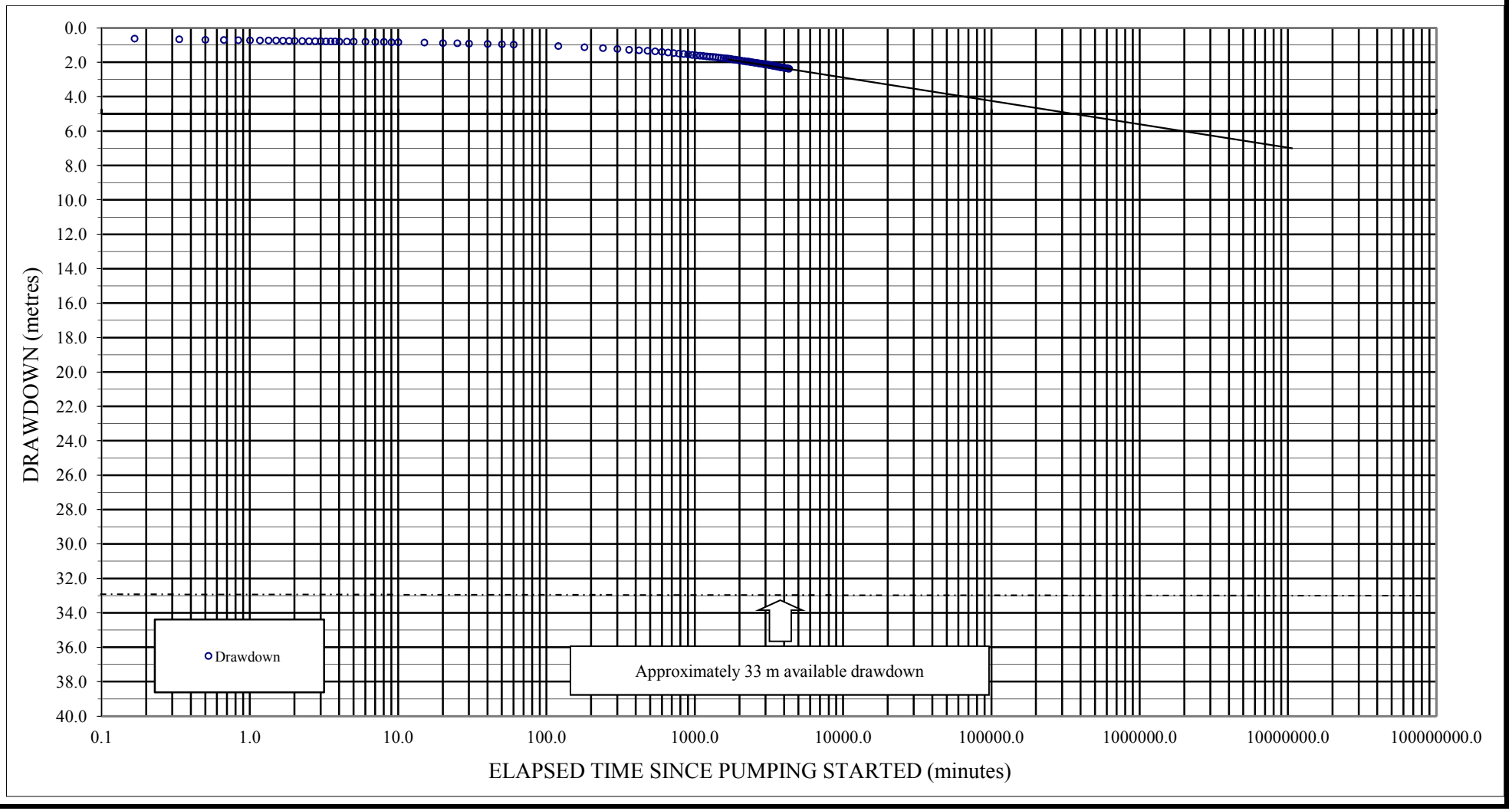


C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\3830 Semilog.xls

FIGURE H-9

20-YEAR PROJECTION FOR FDL-02

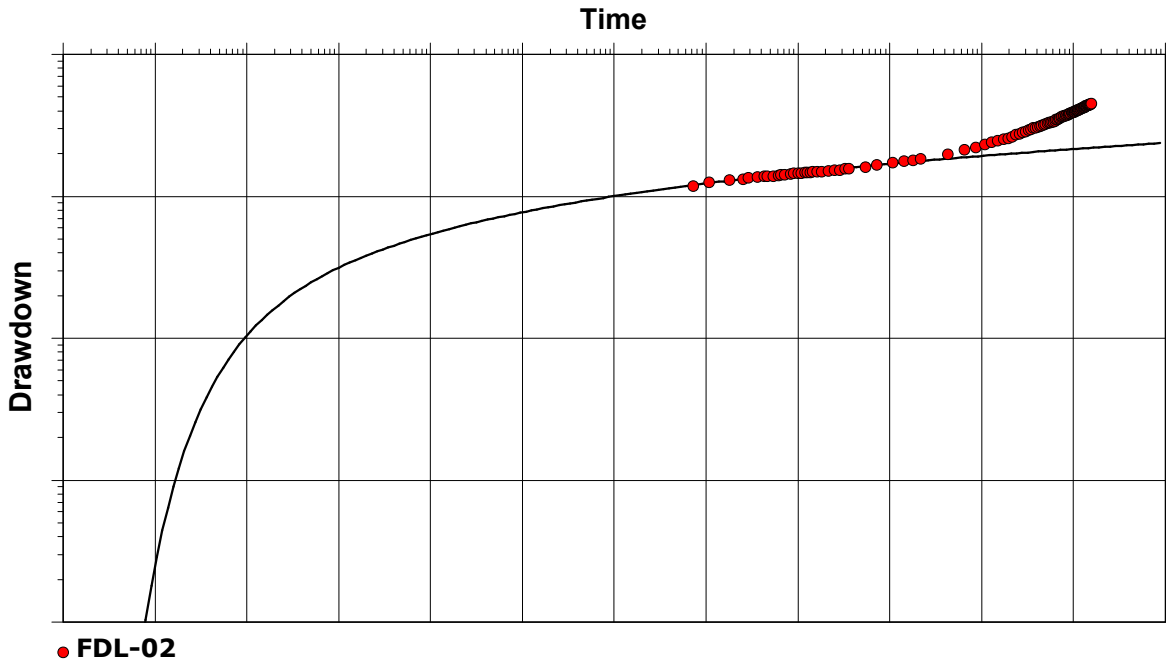
Static Water Level : 14.34 m bgl Well Depth: 51.2 m bgl Pumping Rate: 4.7 L/s	Project Name : **Lynden Wells** Project No : 071-11885 Date: 16-Oct-12
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = n/a



C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\FDL02 - Manual Measurements.xls

Figure H-10 Theis Analysis - FDL-02	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

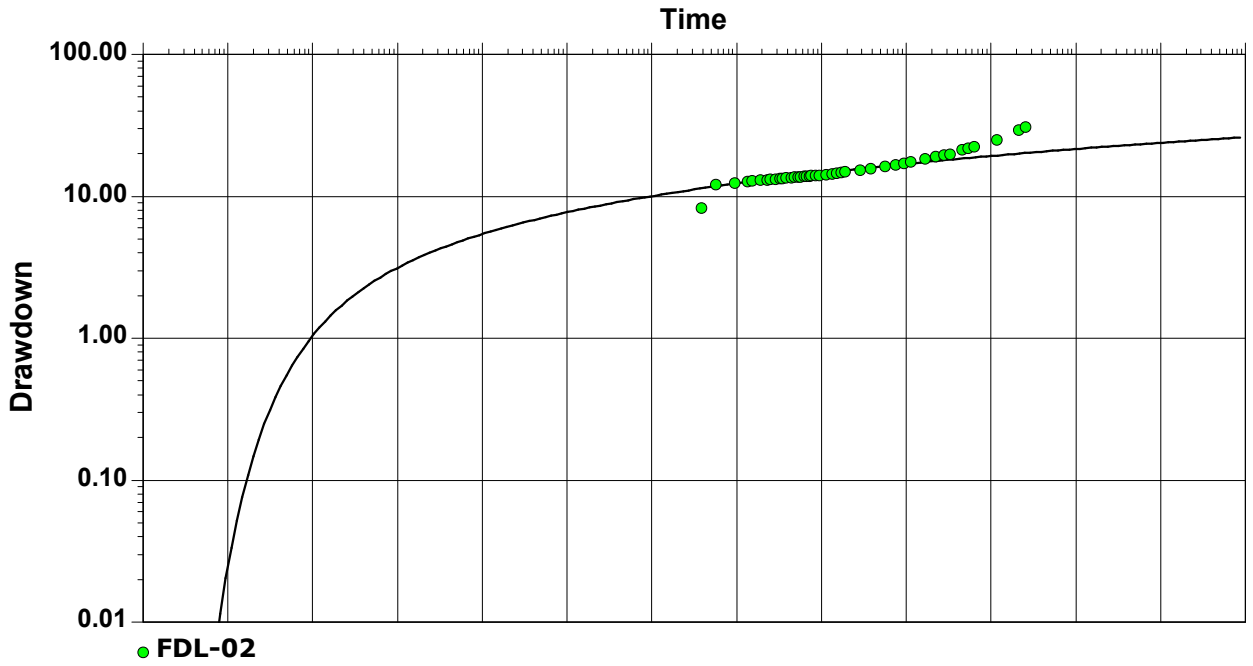


Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
FDL-02	6.25×10^{2}	1.56×10^{2}	1.00×10^{-4}	0.11	

Figure H-11 Agarwal Analysis - FDL-02	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis Recovery	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

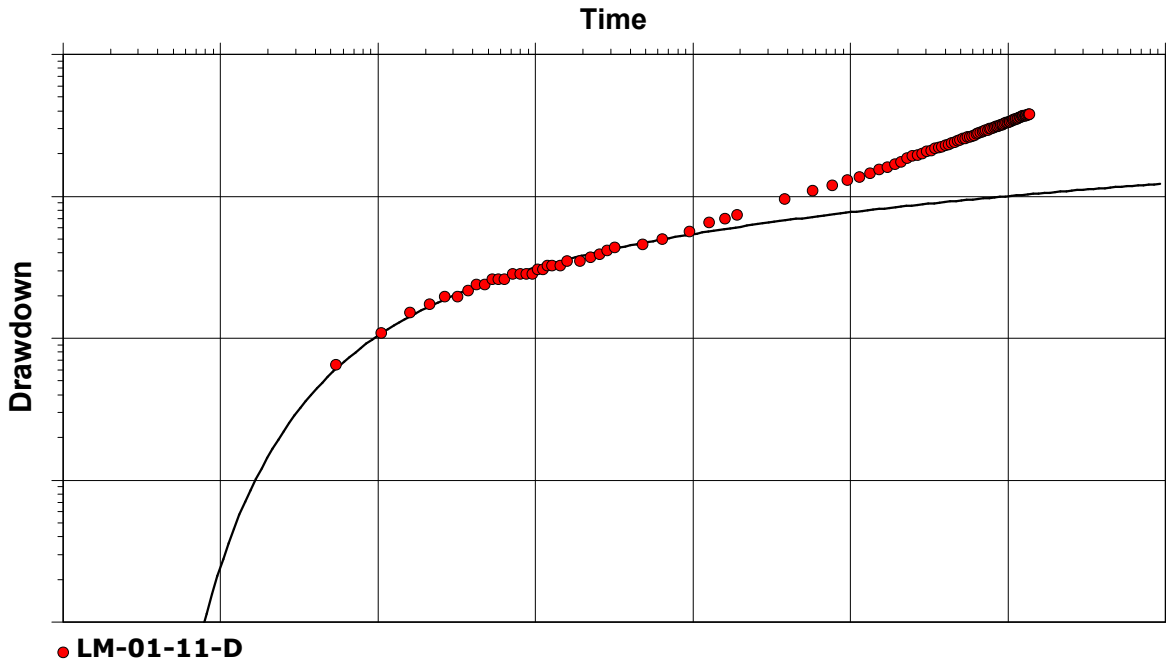


Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
FDL-02	5.80×10^{2}	1.45×10^{2}	1.75×10^{-4}	0.11	

Figure H-12 Theis Analysis - LM-01-11-D	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

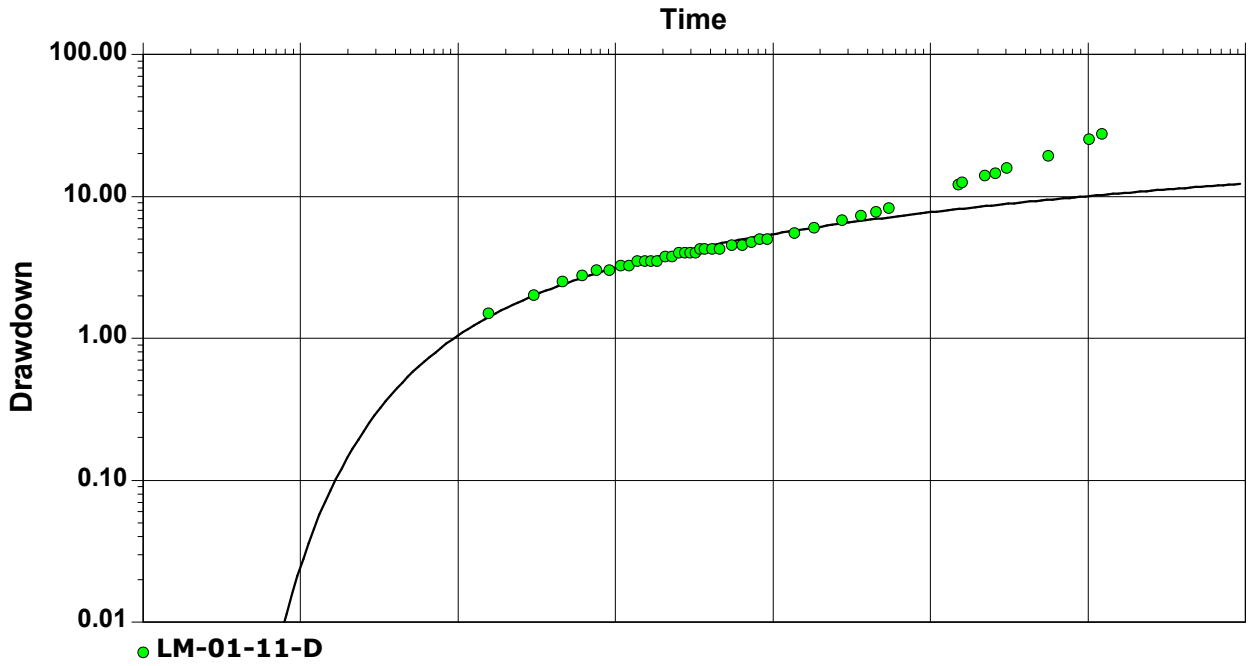


Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
LM-01-11-D	7.20×10^{2}	1.80×10^{2}	2.50×10^{-5}	79.31	

Figure H-13 Agarwal Analysis - LM-01-11-D	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis Recovery	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

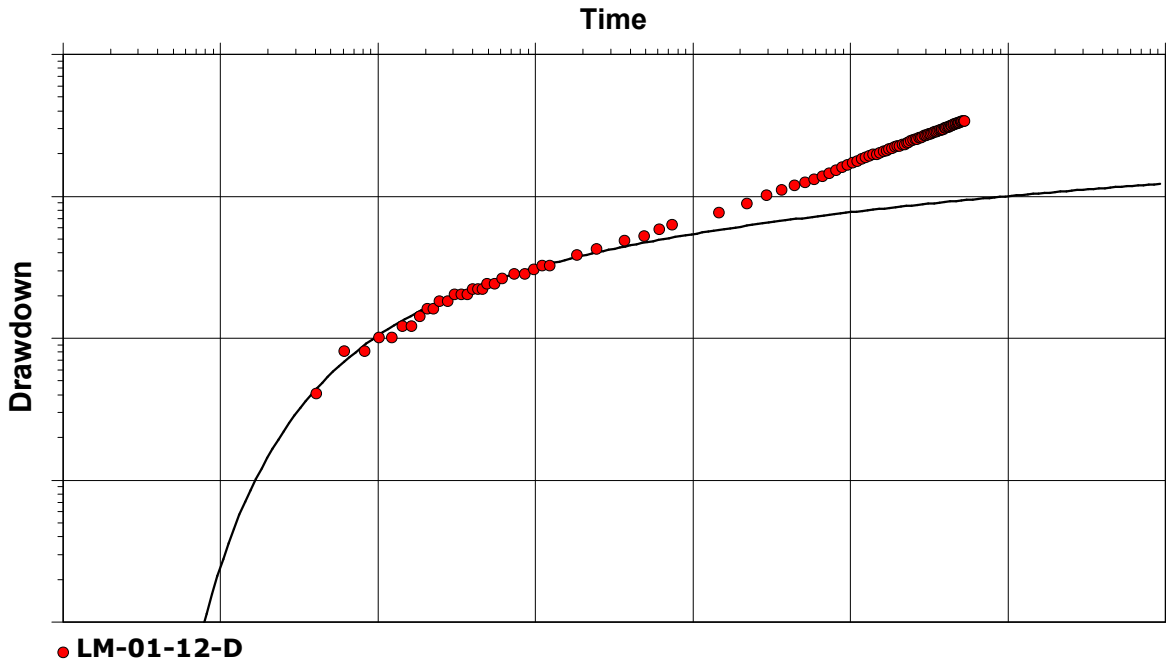


Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
LM-01-11-D	8.30×10^{2}	2.08×10^{2}	1.00×10^{-5}	79.31	

Figure H-14 Theis Analysis - LM-01-12-D	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

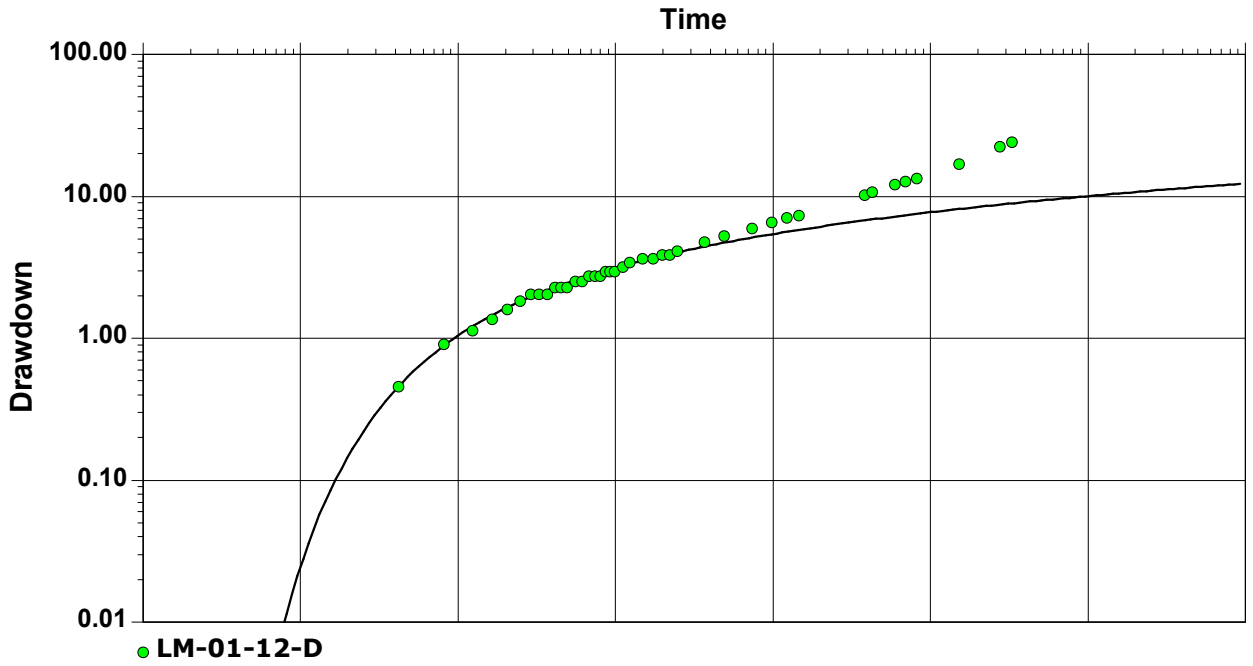


Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
LM-01-12-D	6.70×10^{2}	1.68×10^{2}	4.50×10^{-5}	91.92	

Figure H-15 Agarwal Analysis - LM-01-12-D	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis Recovery	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

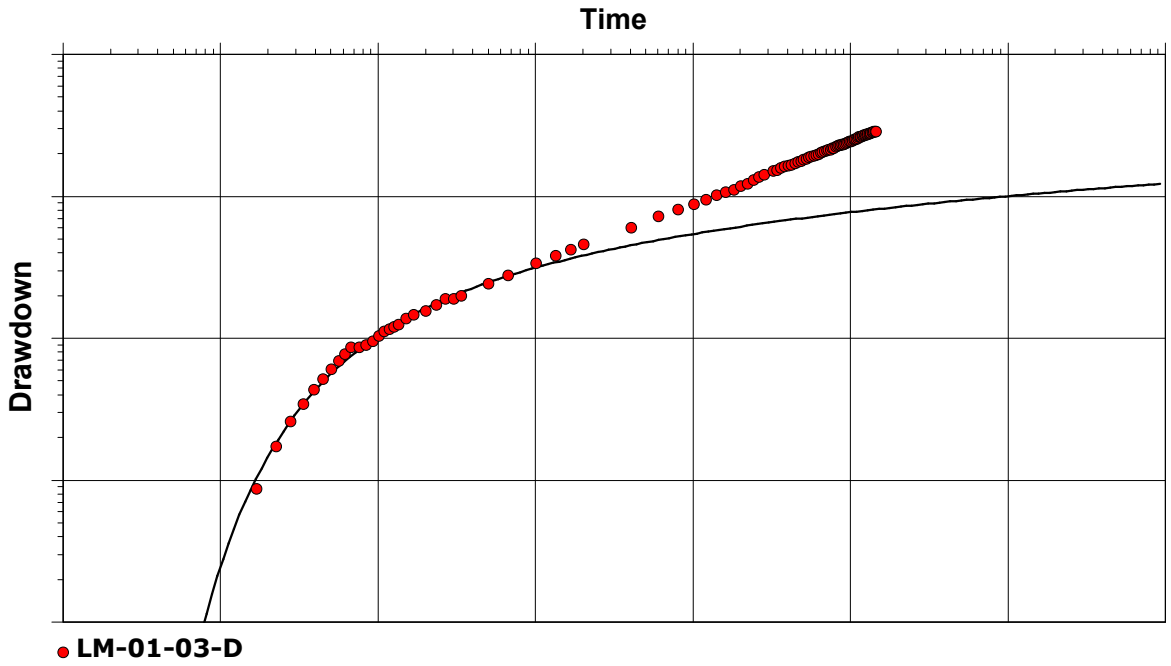


Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
LM-01-12-D	7.50×10^{2}	1.88×10^{2}	2.50×10^{-5}	91.92	

Figure H-16 Theis Analysis - LM-01-03-D	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

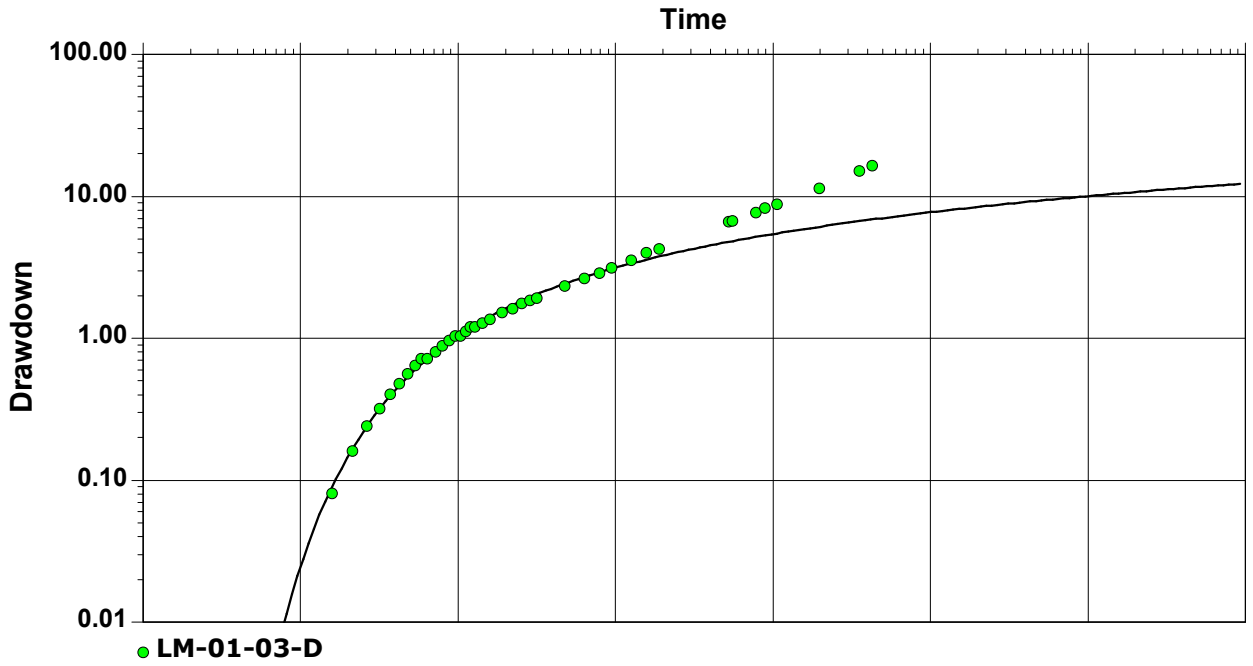


Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
LM-01-03-D	5.70×10^{2}	1.43×10^{2}	6.00×10^{-5}	140.04	

Figure H-17 Agarwal Analysis - LM-01-03-D	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis Recovery	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

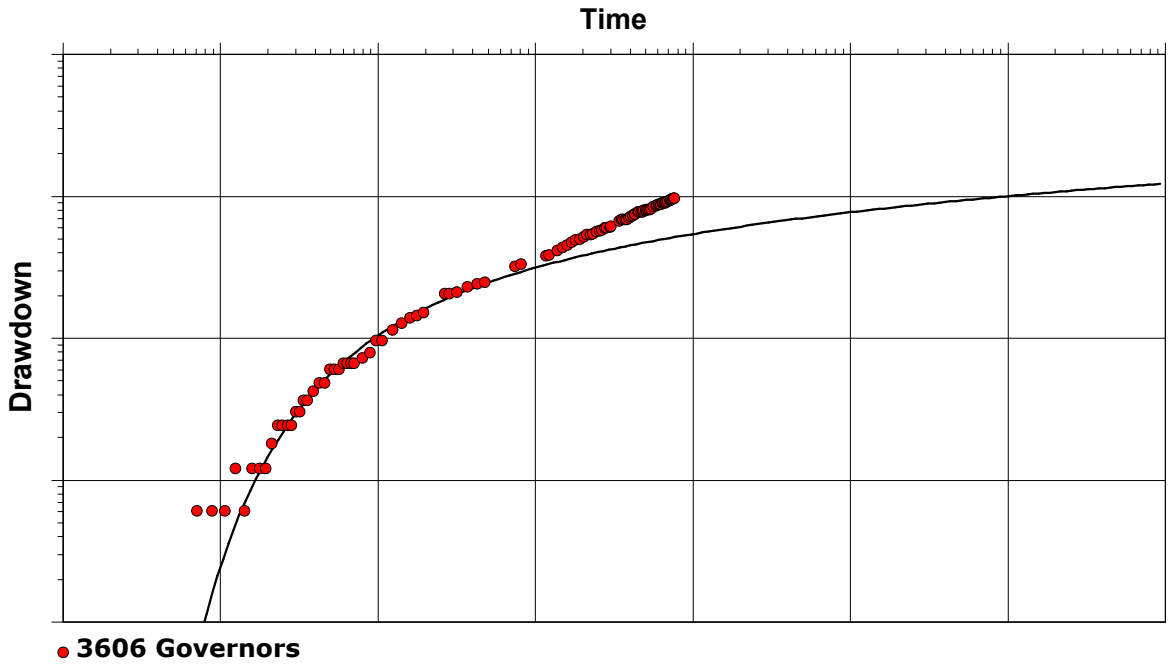


Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
LM-01-03-D	5.30×10^{2}	1.33×10^{2}	5.90×10^{-5}	140.04	

Figure H-18 Theis Analysis - 3606 Governors Road	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

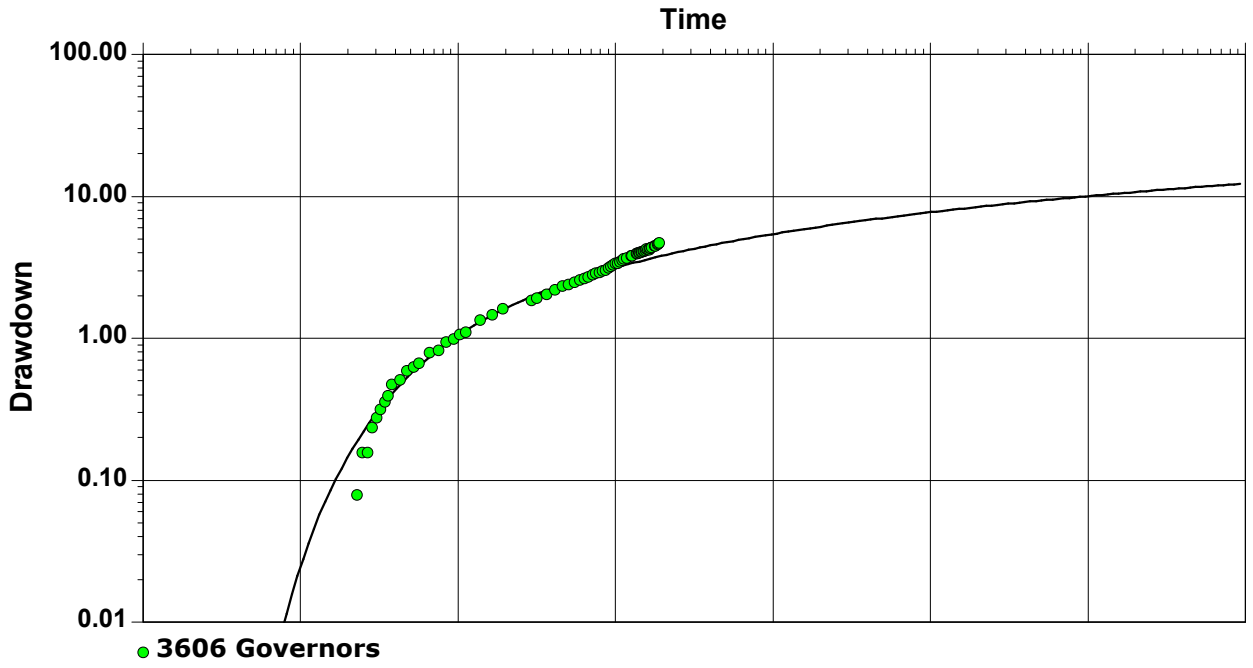


Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
3606 Governors	2.00×10^{2}	5.00×10^{1}	2.50×10^{-4}	177.43	

Figure H-19 Agarwal Analysis 3606 Governors Road	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis Recovery	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

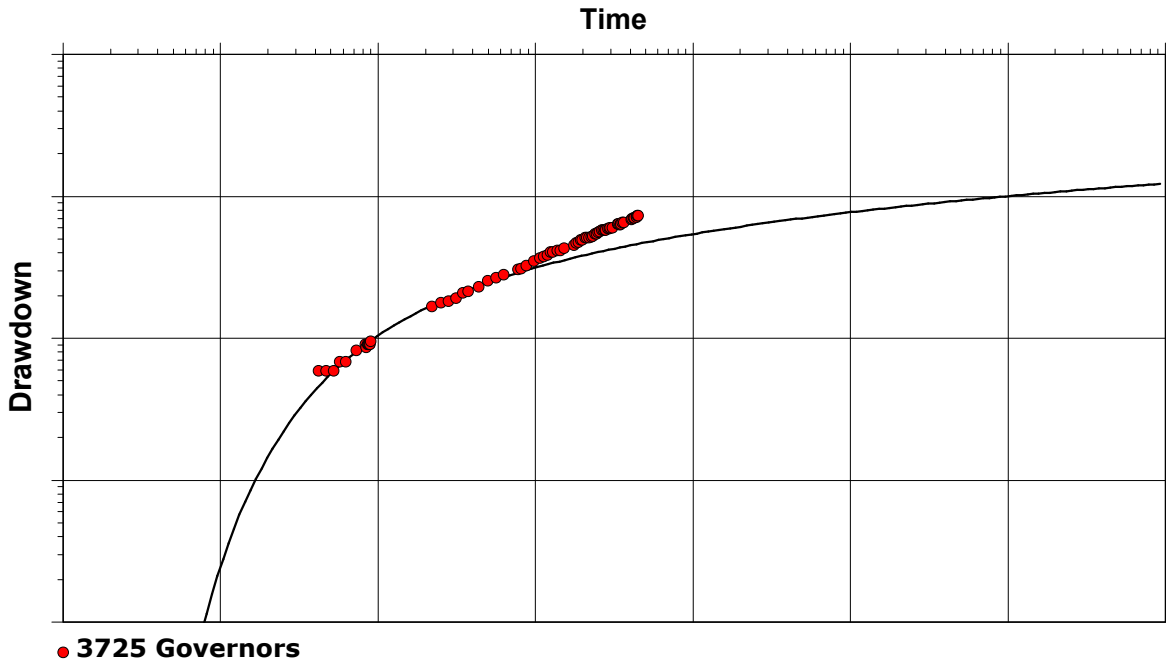


Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
3606 Governors	1.30×10^{2}	3.25×10^{1}	3.00×10^{-4}	177.43	

Figure H-20 Theis Analysis - 3725 Governors Road	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

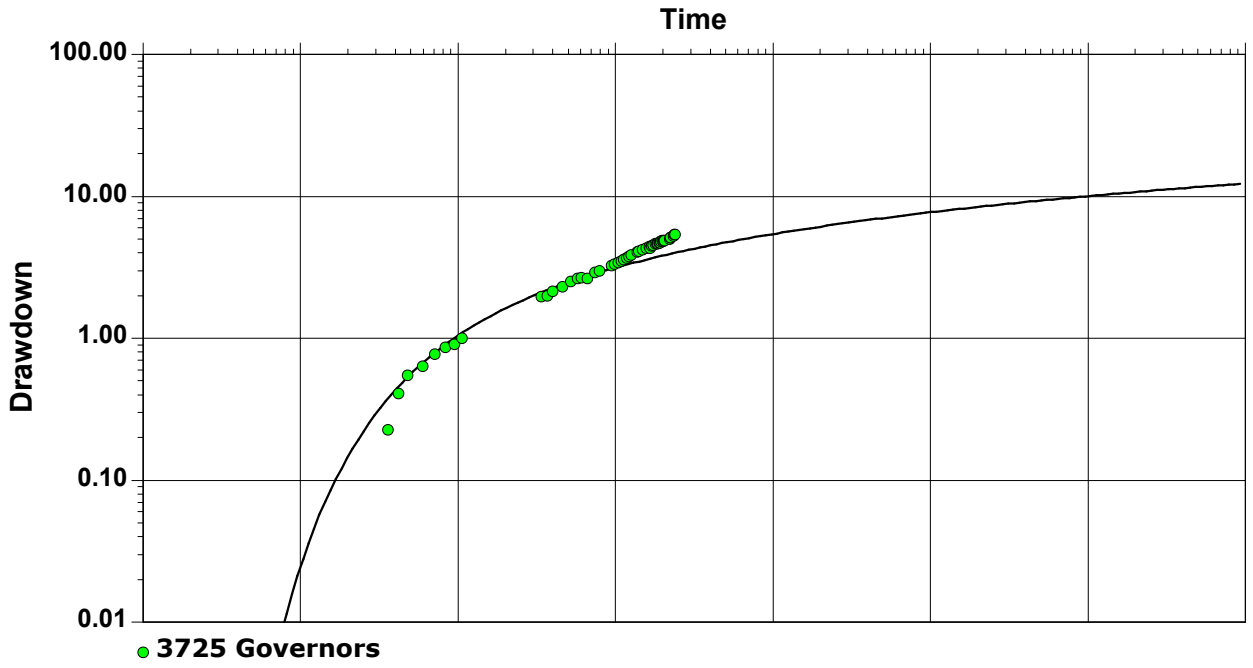


Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
3725 Governors	1.50×10^{2}	3.75×10^{1}	7.50×10^{-5}	365.31	

Figure H-21 Agarwal Analysis 3725 Governors Road	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis Recovery	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

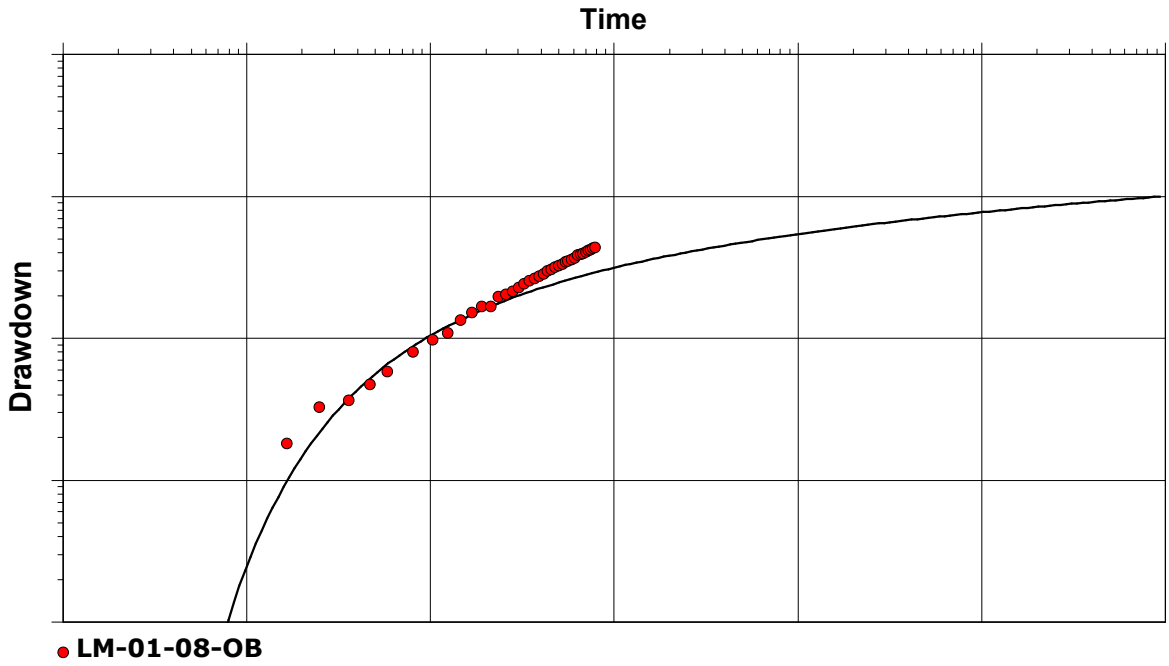


Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
3725 Governors	1.50×10^{2}	3.75×10^{1}	6.50×10^{-5}	365.31	

Figure H-22 Theis Analysis - LM-01-08-OB	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

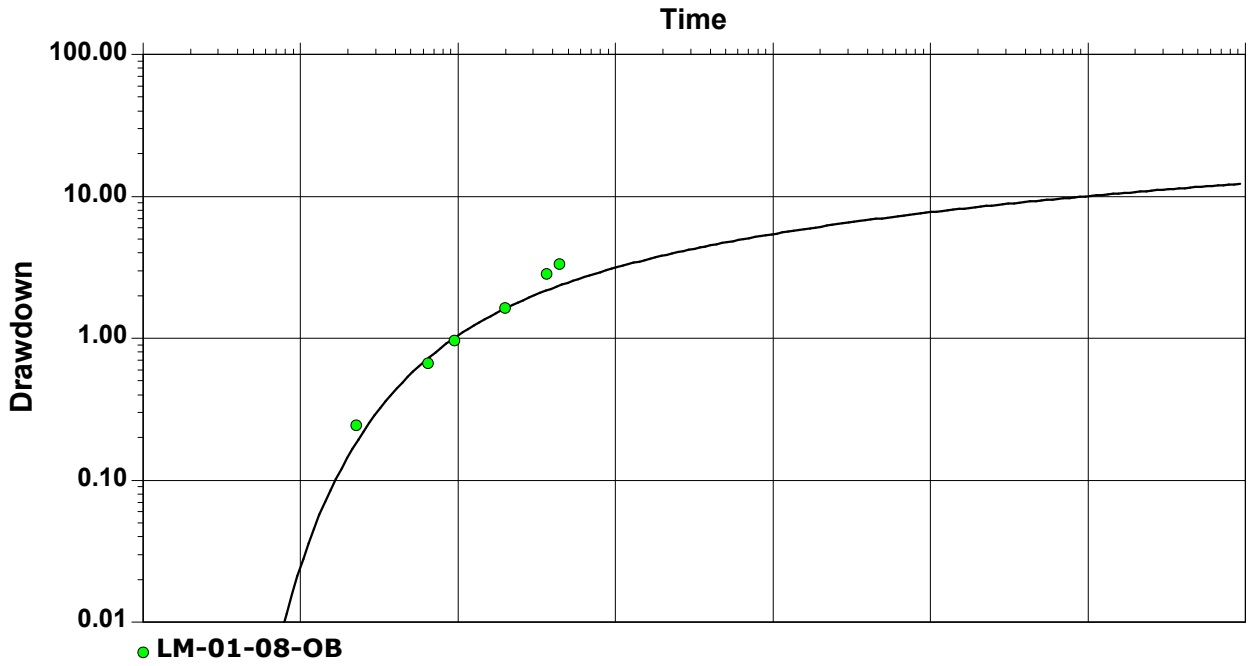


Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
LM-01-08-OB	1.20×10^{2}	3.00×10^{1}	1.50×10^{-4}	549.53	

Figure H-23 Agarwal Analysis - LM-01-08-OB	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis Recovery	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

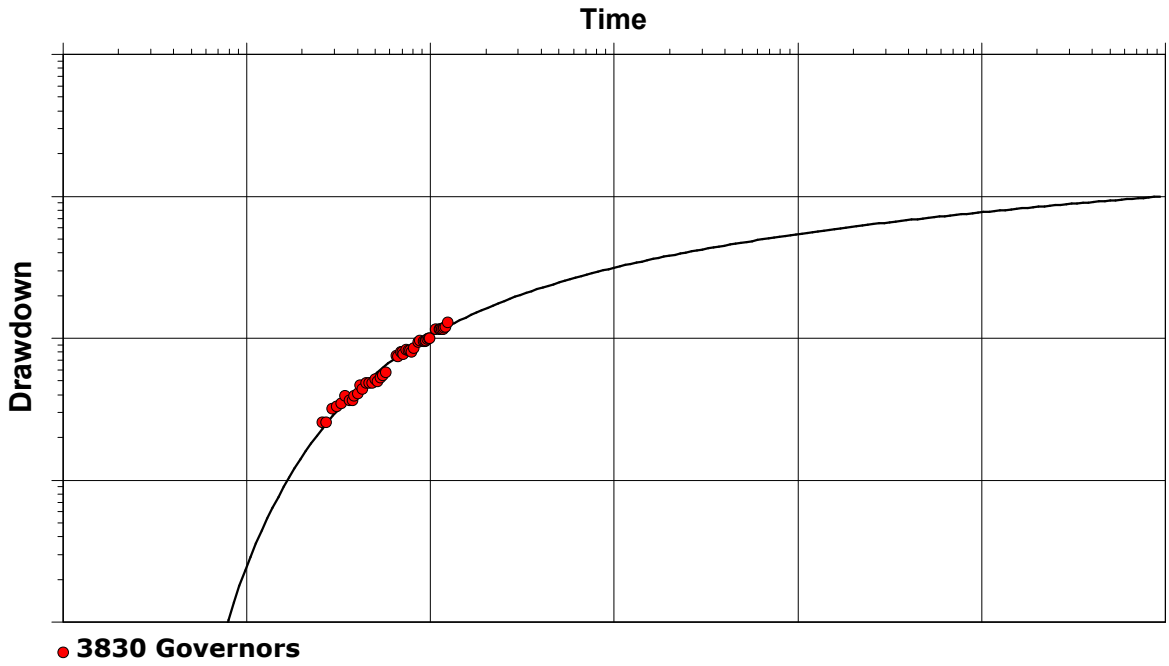


Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
LM-01-08-OB	2.00×10^{2}	5.00×10^{1}	1.40×10^{-4}	549.53	

Figure H-24 Theis Analysis - 3830 Governors Road	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	

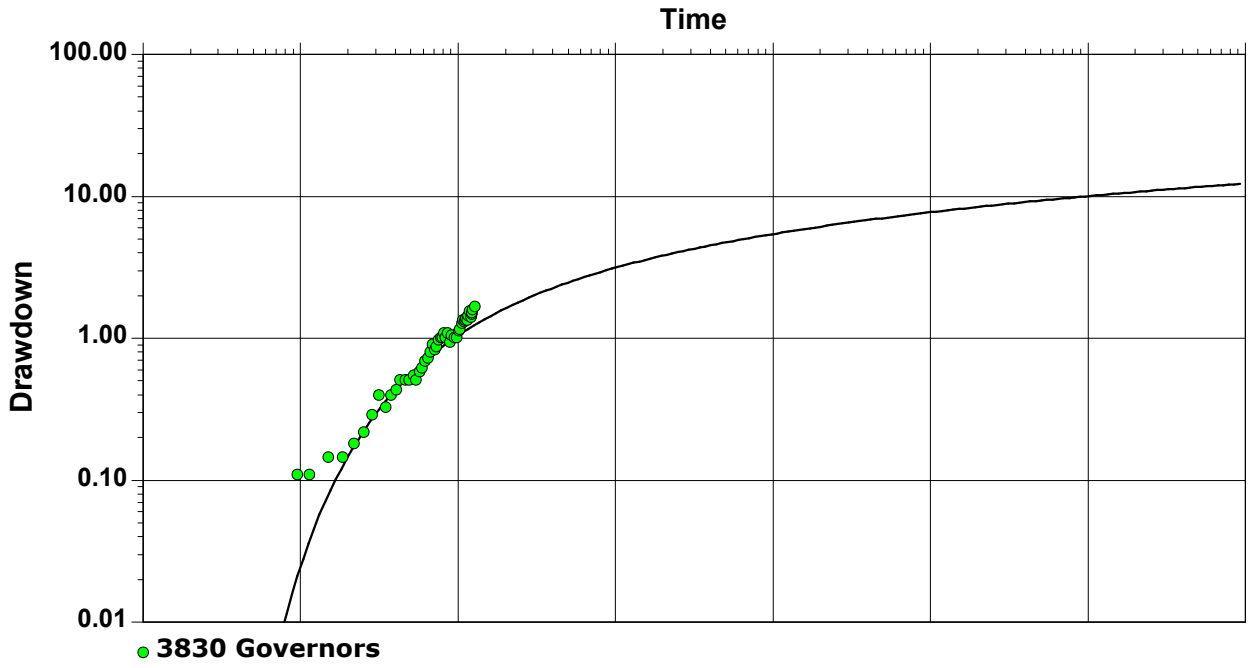


Calculation after Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
3830 Governors	5.00×10^{1}	1.25×10^{1}	2.20×10^{-4}	742.94	

Figure H-25 Agarwal Analysis 3830 Governors Road	Pumping Test Analysis Report
	Project: Lynden Supply Well
	Number: 071-11885-00
	Client: City of Hamilton

Location: Lynden	Pumping Test: Pumping Test - FDL-02	Pumping well: FDL-02
Test conducted by: GENIVAR		Test date: 16/10/2012
Analysis performed by: DB	Theis Recovery	Date: 07/01/2013
Aquifer Thickness: 4.00 m	Discharge: variable, average rate 415 [m³/d]	



Calculation after AGARWAL + Theis

Observation well	Transmissivity [m²/d]	K [m/d]	Storage coefficient	Radial distance to PW [m]	
3830 Governors	1.20×10^{2}	3.00×10^{1}	2.30×10^{-4}	742.94	

Appendix I

Category 2 PTTW for Pumping Test

Ministry of the Environment
West-Central Region
Technical Support Section
Water Resources
12th Floor
119 King St W
Hamilton ON L8P 4Y7
Fax: (905)521-7820
Tel: (905) 521-7640

Ministère de l'Environnement
Direction régionale du Centre-Ouest
Secteur du Soutien Technique
Ressource en eau
12e étage
119 rue King W
Hamilton ON L8P 4Y7
Télécopieur: (905)521-7820
Tél:(905) 521-7640

Ontario

January 19, 2012

City of Hamilton
77 James St N., Suite 400
Hamilton, Ontario
L8R 2K3

Dear Sir/Madam:

RE: Lot 16, Concession 1
Geographic Township of Ancaster
City of Hamilton
Permit Number 8270-8PSS2E

Please find attached a Permit to Take Water which authorizes the withdrawal of water in accordance with the application for this Permit to Take Water, dated December 8, 2011 and signed by Udo Ehrenberg.

This Permit expires on November 30, 2012. Authorized rates and amounts are indicated on Table A.

Ontario Regulation 387/04 (Water Taking) requires all water takers to report daily water taking amounts to the Water Taking Reporting System (WTRS) electronic database: http://www.ene.gov.on.ca/envision/water/pttw.htm . Daily water taking must be reported on a calendar year basis. If no water is taken, then a "no taking" report must be entered. Please consult the Regulation and Section 4 of this Permit for monitoring requirements.

If you have questions about reporting requirements, please call the WTRS Help Desk at 416-235-6322 (toll free: 1-877-344-2011) or by email, WTRSHelpdesk@ontario.ca . It is preferred that you submit your data directly and electronically to the WTRS. Where this is impracticable, please use the Water Taking Submission Form *(included as Appendix C of the Technical Bulletin: Permit To Take Water (PTTW)-Monitoring and Reporting of Water Takings),* which can be downloaded from the above website, and fax your completed forms to 416-235-6549 or mail them to: Water User Reporting Section, 125 Resources Rd. Toronto, ON M9P 3V6.

Please also note Condition 1.4 specifically indicates that this Permit is not transferable to another party. Any queries regarding a change in owner/operator should be made to the Permit to Take Water Evaluator at the above address.

Take notice that in issuing this Permit, terms and conditions pertaining to the taking of water and to the results of the taking have been imposed. The terms and conditions have been designed to allow for the development of water resources, while providing reasonable protection to existing water uses and users.

Yours truly,

B. Koblik

Belinda Koblik
Director, Section 34
Ontario Water Resources Act, R.S.O. 1990
West Central Region

File Storage Number: AP28 ANHA

Ontario

Ministry of the Environment
Ministère de l'Environnement

PERMIT TO TAKE WATER
Pumping Test
NUMBER 8270-8PSS2E

Pursuant to Section 34 of the Ontario Water Resources Act, R.S.O. 1990 this Permit To Take Water is hereby issued to:

City of Hamilton
77 James St N., Suite 400
Hamilton, Ontario L8R 2K3

For the water taking from: One drilled well (FDL-02)
Located at: Lot 16, Concession 1 Ancaster
Hamilton

For the purposes of this Permit, and the terms and conditions specified below, the following definitions apply:

DEFINITIONS

(a) "Director" means any person appointed in writing as a Director pursuant to section 5 of the OWRA for the purposes of section 34, OWRA.

(b) "Provincial Officer" means any person designated in writing by the Minister as a Provincial Officer pursuant to section 5 of the OWRA.

(c) "Ministry" means Ontario Ministry of the Environment.

(d) "District Office" means the Hamilton District Office.

(e) "Permit" means this Permit to Take Water No. 8270-8PSS2E including its Schedules, if any, issued in accordance with Section 34 of the OWRA.

(f) "Permit Holder" means City of Hamilton.

(g) "OWRA " means the *Ontario Water Resources Act,* R.S.O. 1990, c. O. 40, as amended.

You are hereby notified that this Permit is issued subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. Compliance with Permit

1.1 Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, dated December 8, 2011 and signed by Udo Ehrenberg, and all Schedules included in this Permit.

1.2 The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.

1.3 Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.

1.4 This Permit is not transferable to another person.

1.5 This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.

1.6 The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.

2. General Conditions and Interpretation

2.1 Inspections
The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the *Environmental Protection Act* , R.S.O. 1990, the *Pesticides Act* , R.S.O. 1990, or the *Safe Drinking Water Act,* S. O. 2002.

2.2 Other Approvals
The issuance of, and compliance with this Permit, does not:

(a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the *Ontario Water Resources Act* , and the *Environmental Protection Act* , and any regulations made thereunder; or

(b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

(a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or

(b) acceptance by the Ministry of the information's completeness or accuracy.

2.4 Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5 Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6 Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

3. Water Takings Authorized by This Permit

3.1 **Expiry**

This Permit expires on **November 30, 2012**. No water shall be taken under authority of this Permit after the expiry date.

3.2 Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

Table A

	Source Name / Description:	Source: Type:	Taking Specific Purpose:	Taking Major Category:	Max. Taken per Minute (litres):	Max. Num. of Hrs Taken per Day:	Max. Taken per Day (litres):	Max. Num. of Days Taken:	Zone/ Easting/ Northing:
1	FDL-02	Well Drilled	Pumping Test	Miscellaneous	360	24	518,400	6	17 570803 4786739
						Total Taking:	518,400		

3.3 Water taking under the authorization of this Permit shall only occur for one 6 consecutive day period between the date of issuance and November 30, 2012.

4. Monitoring

4.1 Notification to Well Owners
Prior to commencement of the pumping test, the Permit Holder shall identify all wells within the area of the anticipated potential cone of influence, or within 500 metres of the test site, whichever is greater. At least 24 hours prior to beginning the pumping test, the Permit Holder shall provide written notification to the owners of the wells identified within the potential cone of influence. The notification shall include the expected date, time and duration of the pumping test, and a contact telephone number that may be used to report any interferences with water supplies.

4.2 Measuring Water Depths
To establish baseline conditions, well depths and depths to water levels for identified representative wells in the area of the water taking shall be recorded by the Permit Holder. During the pumping test, water levels in the identified wells shall be recorded. The pumping test must be of sufficient duration to accurately predict the long term impacts of the proposed water taking. Water levels in the identified wells shall continue to be monitored beyond the water taking period until at least 85% recovery is achieved.

4.3 Under section 9 of O. Reg. 387/04, and as authorized by subsection 34(6) of the *Ontario Water Resources Act* , the Permit Holder shall, on each day water is taken under the authorization of this Permit, record the date, the volume of water taken on that date and the rate at which it was taken. The daily volume of water taken shall be measured by a flow meter or calculated in accordance with the method described in the application for this Permit, or as otherwise accepted by the Director. The Permit Holder shall keep all records required by this condition current and available at or near the site of the taking and shall produce the records immediately for inspection by a Provincial Officer upon his or her request. The Permit Holder, unless otherwise required by the Director, shall submit, on or before March 31st in every year, the records required by this condition to the ministry's Water Taking Reporting System.

5. Impacts of the Water Taking

5.1 Notification

The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

5.2 Restoration of Water Supply

Where the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of doing so.

6. Director May Amend Permit

The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the *Ontario Water Resources Act* , Section 100 (4).

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.

2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.

3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing, conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, you may by written Notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, as amended, provides that the Notice requiring the hearing shall state:

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these legal requirements, the Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Permit to Take Water number;
6. The date of the Permit to Take Water;
7. The name of the Director;
8. The municipality within which the works are located;

This notice must be served upon:

The Secretary
Environmental Review Tribunal
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5
Fax: (416) 314-4506

AND

The Director, Section 34
Ministry of the Environment
12th Floor
119 King St W
Hamilton ON L8P 4Y7
Fax: (905)521-7820

Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal:

by telephone at (416) 314-4600 ***by fax at (416) 314-4506*** ***by e-mail at www.ert.gov.on.ca***

Dated at Hamilton this 19th day of January, 2012.

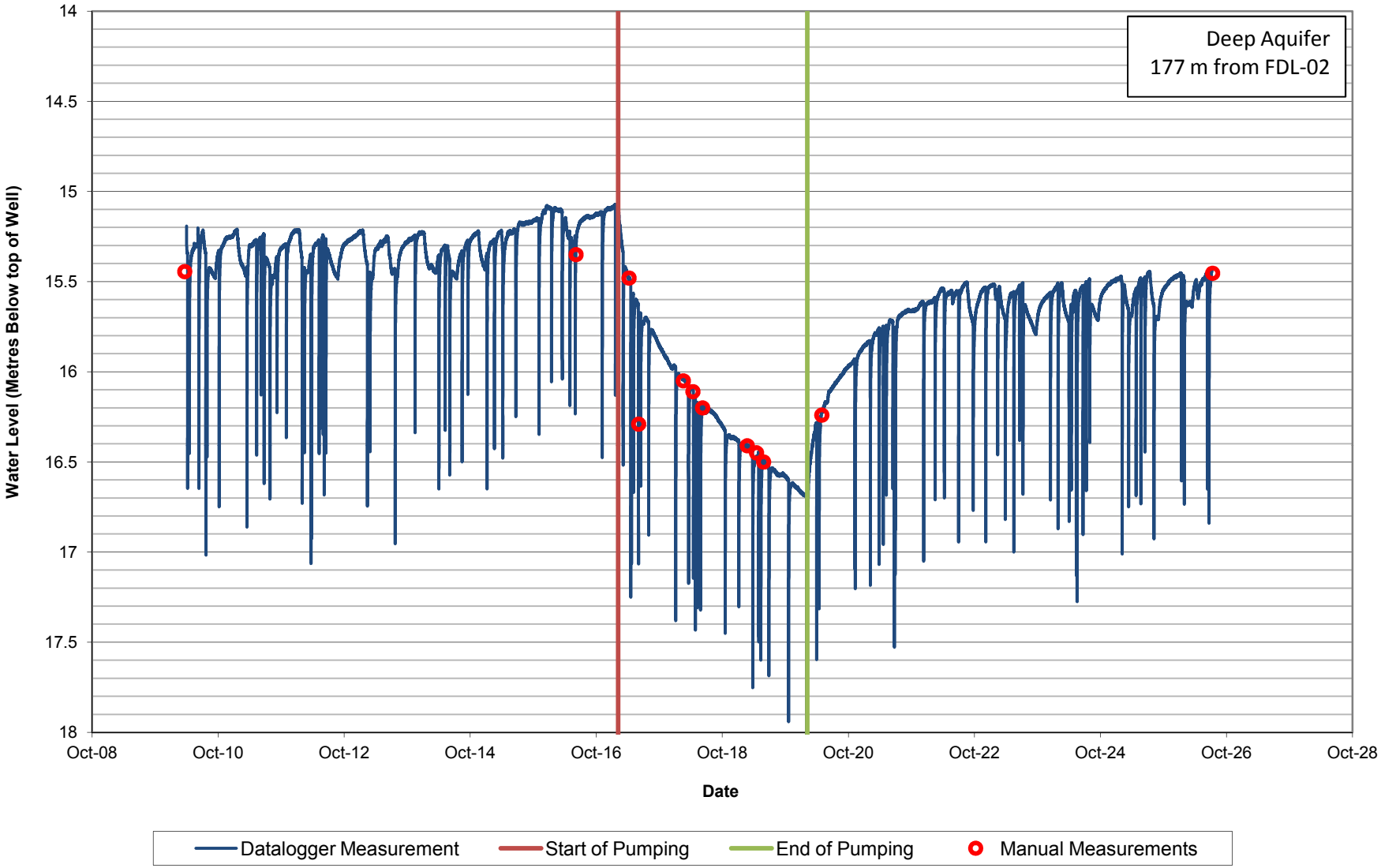
B. Koblik

Belinda Koblik
Director, Section 34
Ontario Water Resources Act , R.S.O. 1990

Appendix J

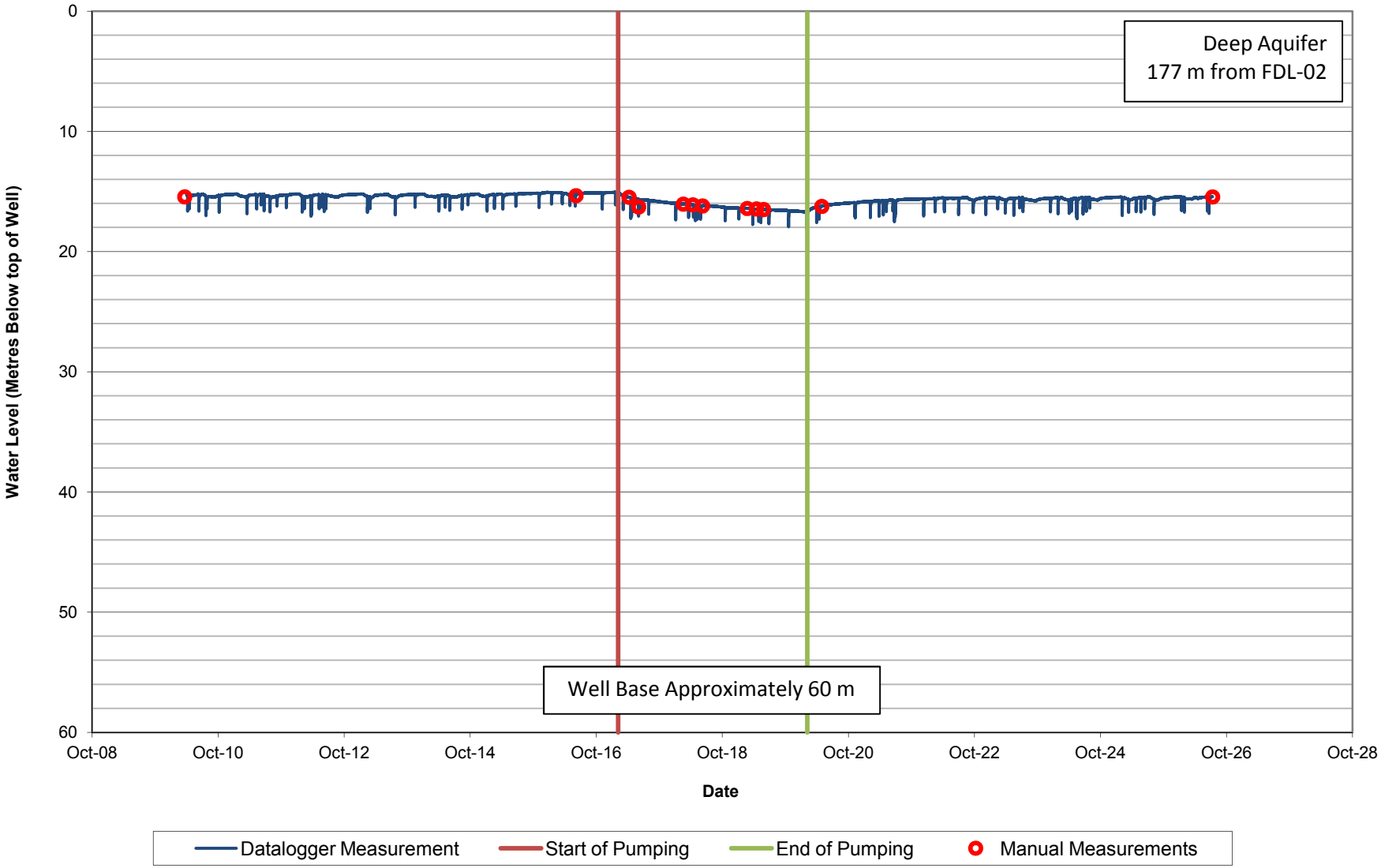
Private Water Well Monitoring Results

Figure J-1 - Groundwater Levels - 3606 Governors Road



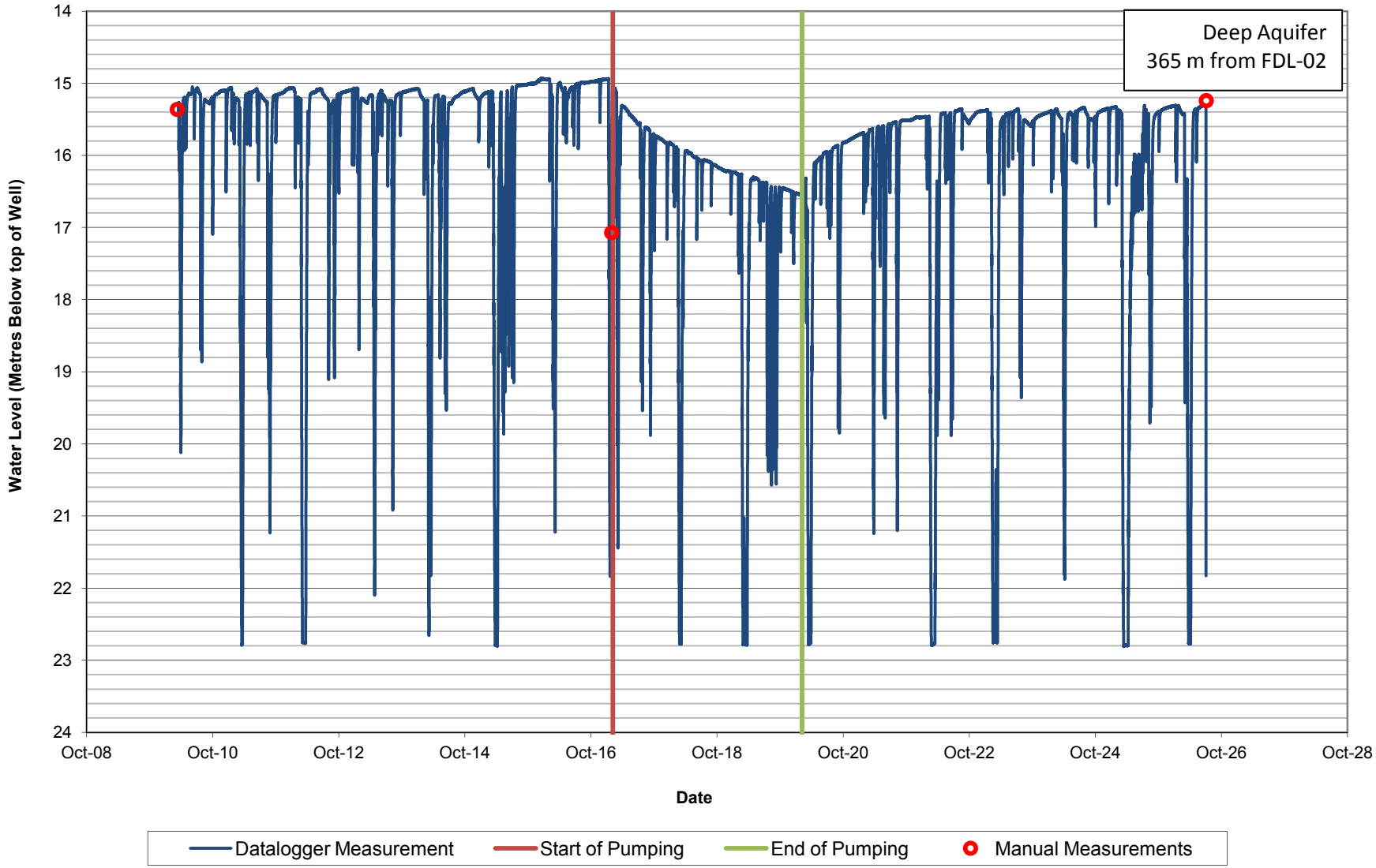
C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\Private Well Loggers\3606.xlsx

Figure J-1a - Groundwater Levels - 3606 Governors Road
Scaled for Depth



C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\Private Well Loggers\3606.xlsx

Figure J-2 - Groundwater Levels - 3725 Governor's Road



C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\Private Well Loggers\3725.xlsx

Figure J-2a - Groundwater Levels - 3725 Governor's Road
Scaled for Depth

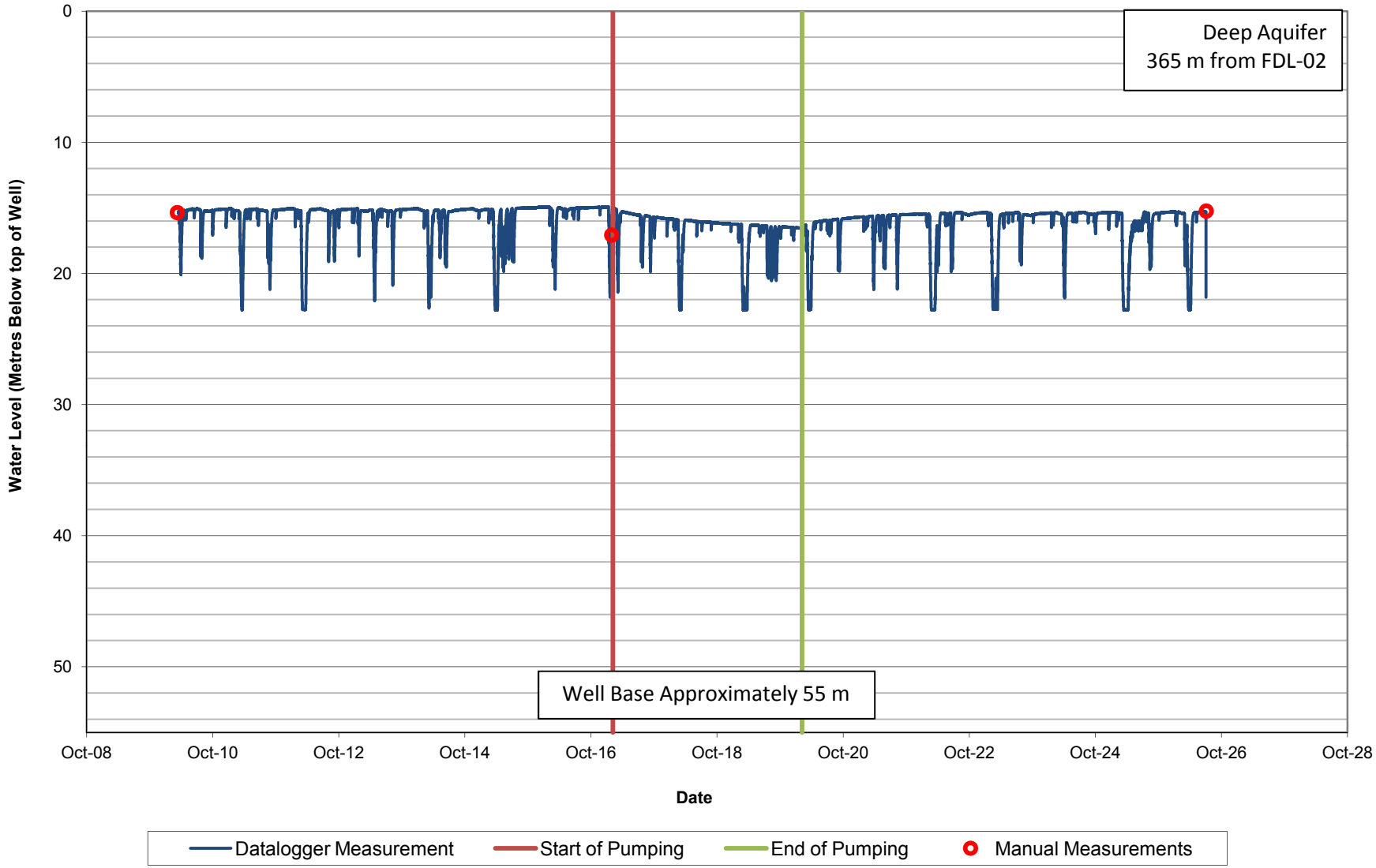


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Figure J-3 - Groundwater Levels - 3830 Governor's Road

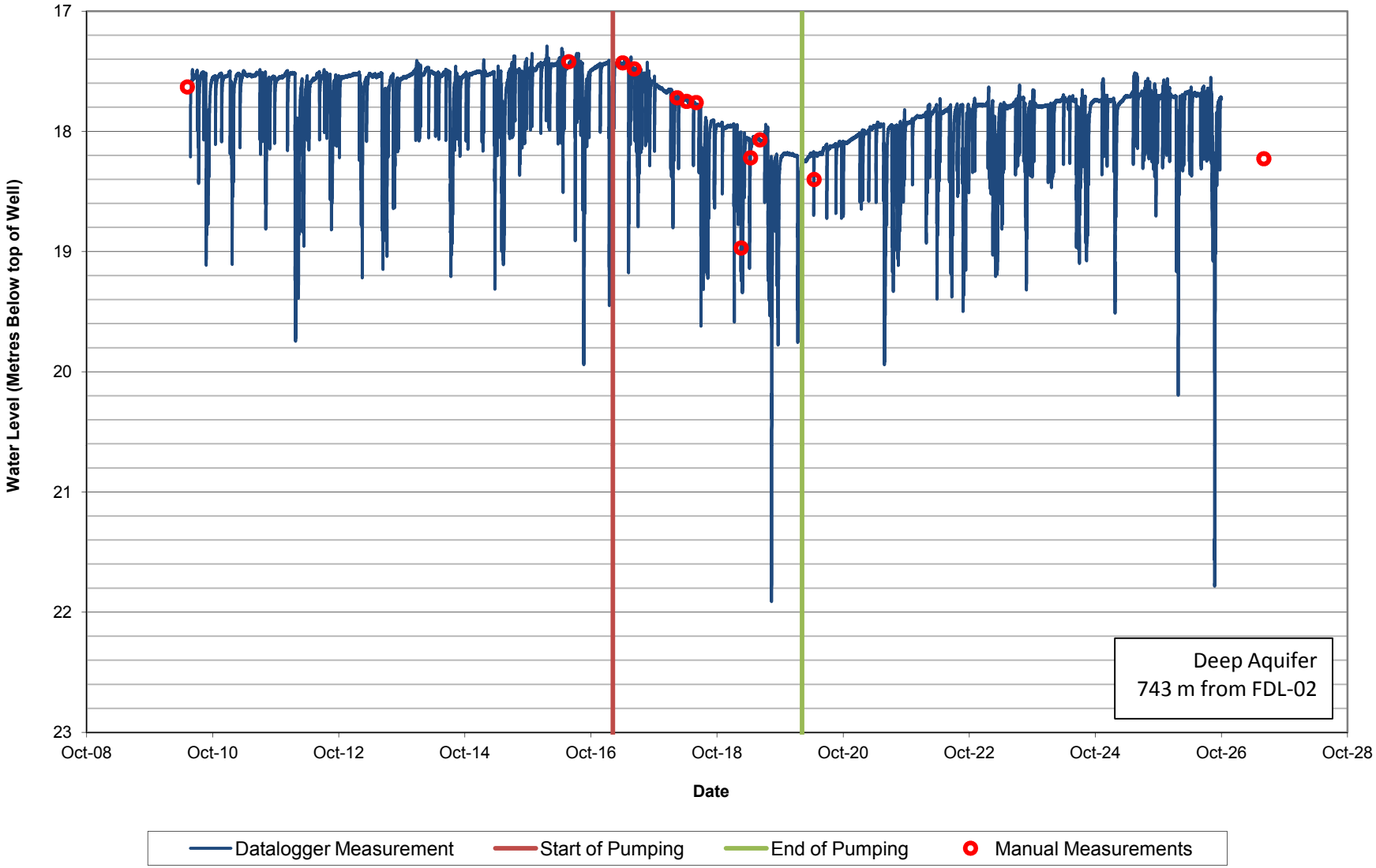

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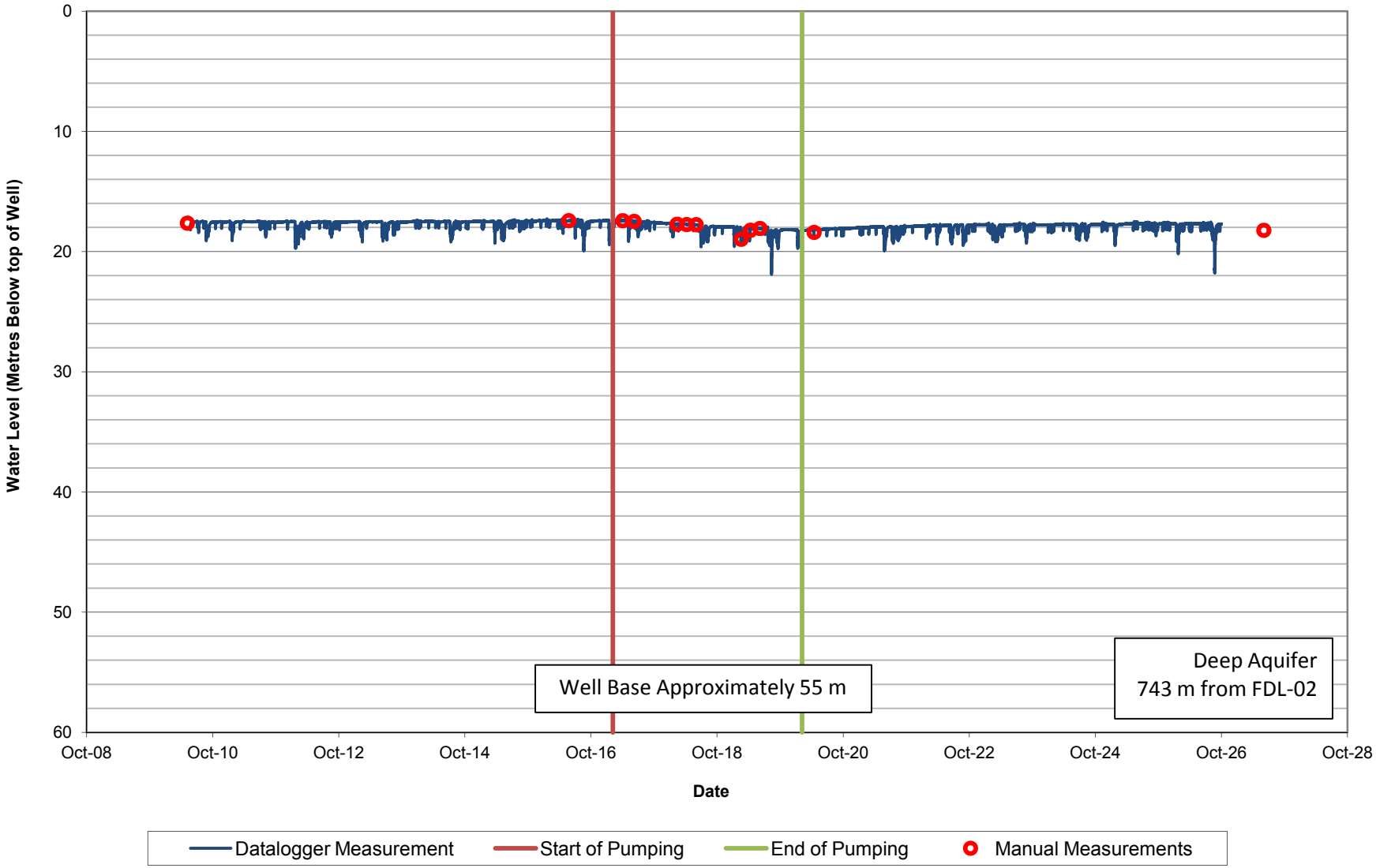
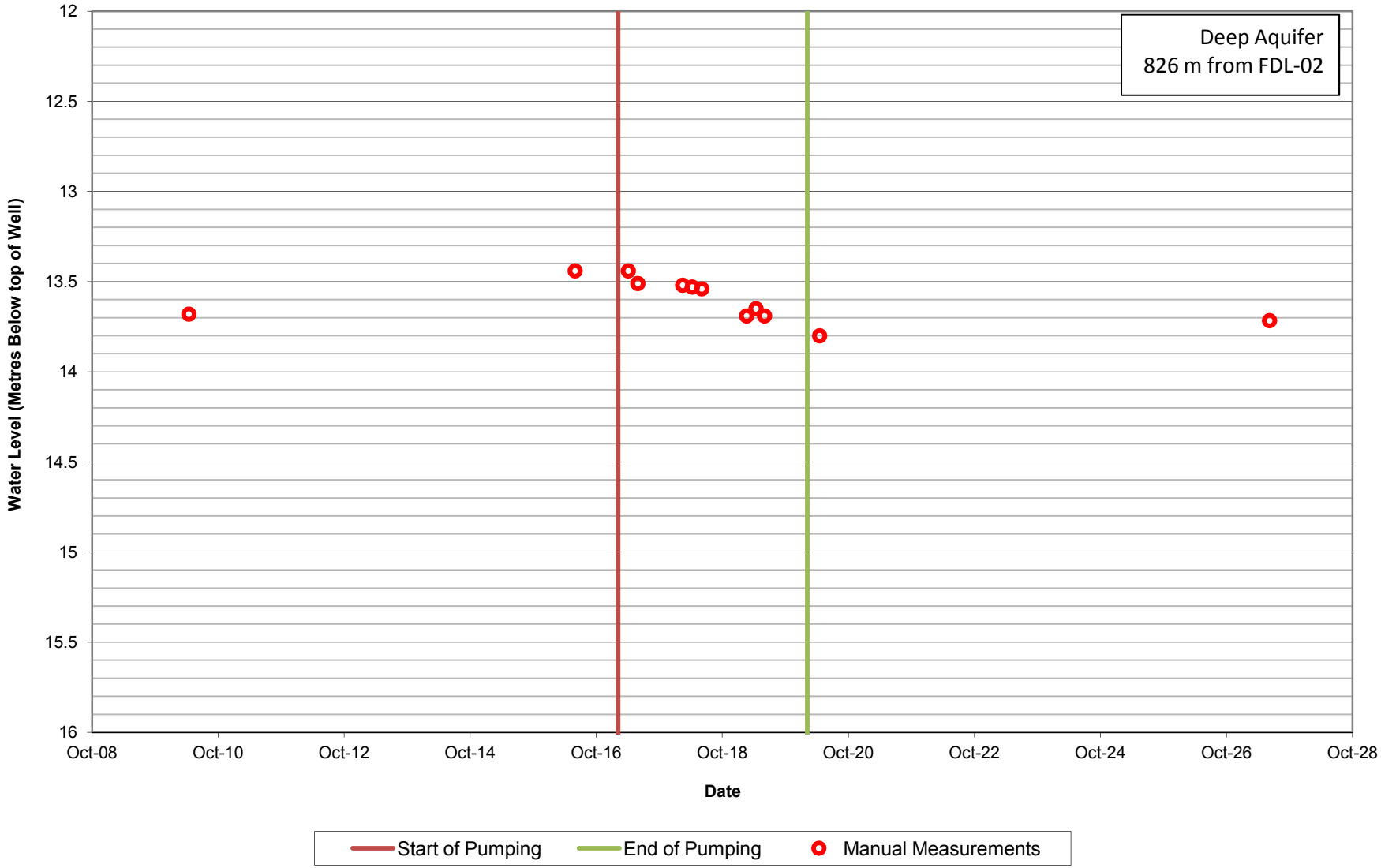
Figure J-3a - Groundwater Levels - 3830 Governor's Road
Scaled for Depth



C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\Private Well Loggers\3830.xlsx

Figure J-4 - Groundwater Levels - 3431 Governor's Road



C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\Private Well Loggers\3431 - No Logger.xlsx

Figure J-4a - Groundwater Levels - 3431 Governor's Road
Scaled for Depth

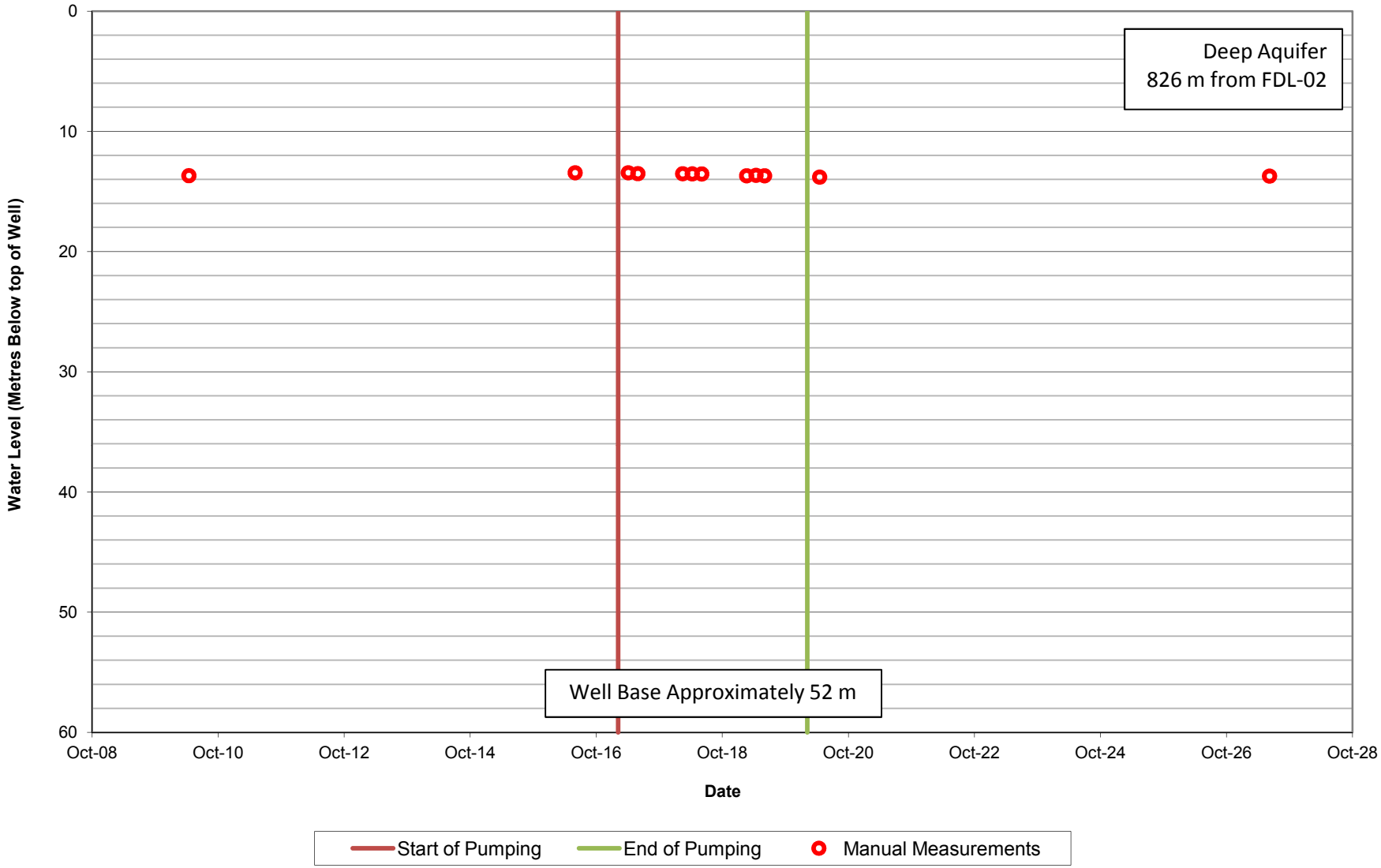


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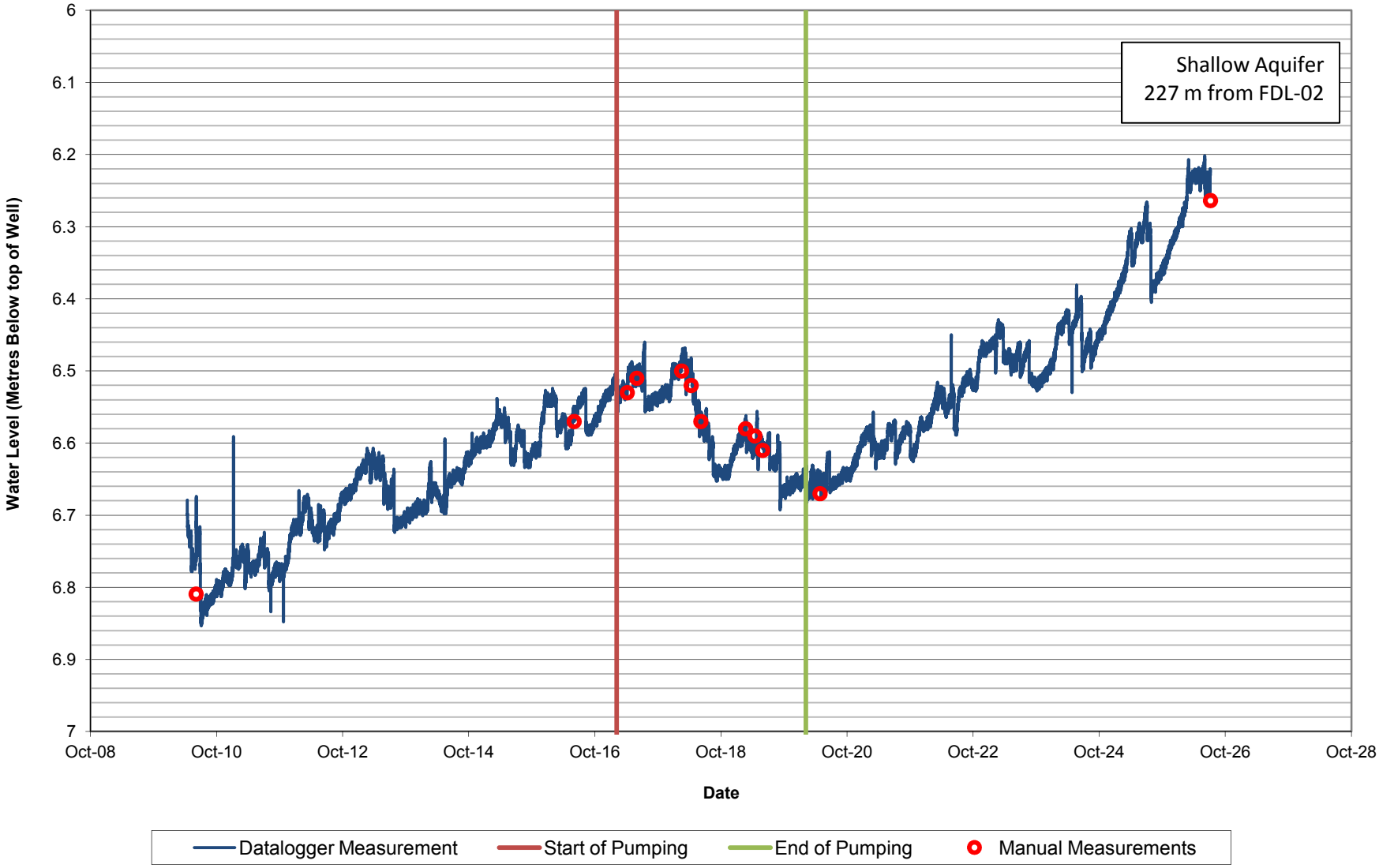
Figure J-5 - Groundwater Levels - 3586 Governor's Road



C:\Work\Projects\Lynden\2011 Work\Pumping Test - Sept 2012\Pumping Test Field Data\Private Well Loggers\3586.xlsx

Figure J-5a - Groundwater Levels - 3586 Governor's Road

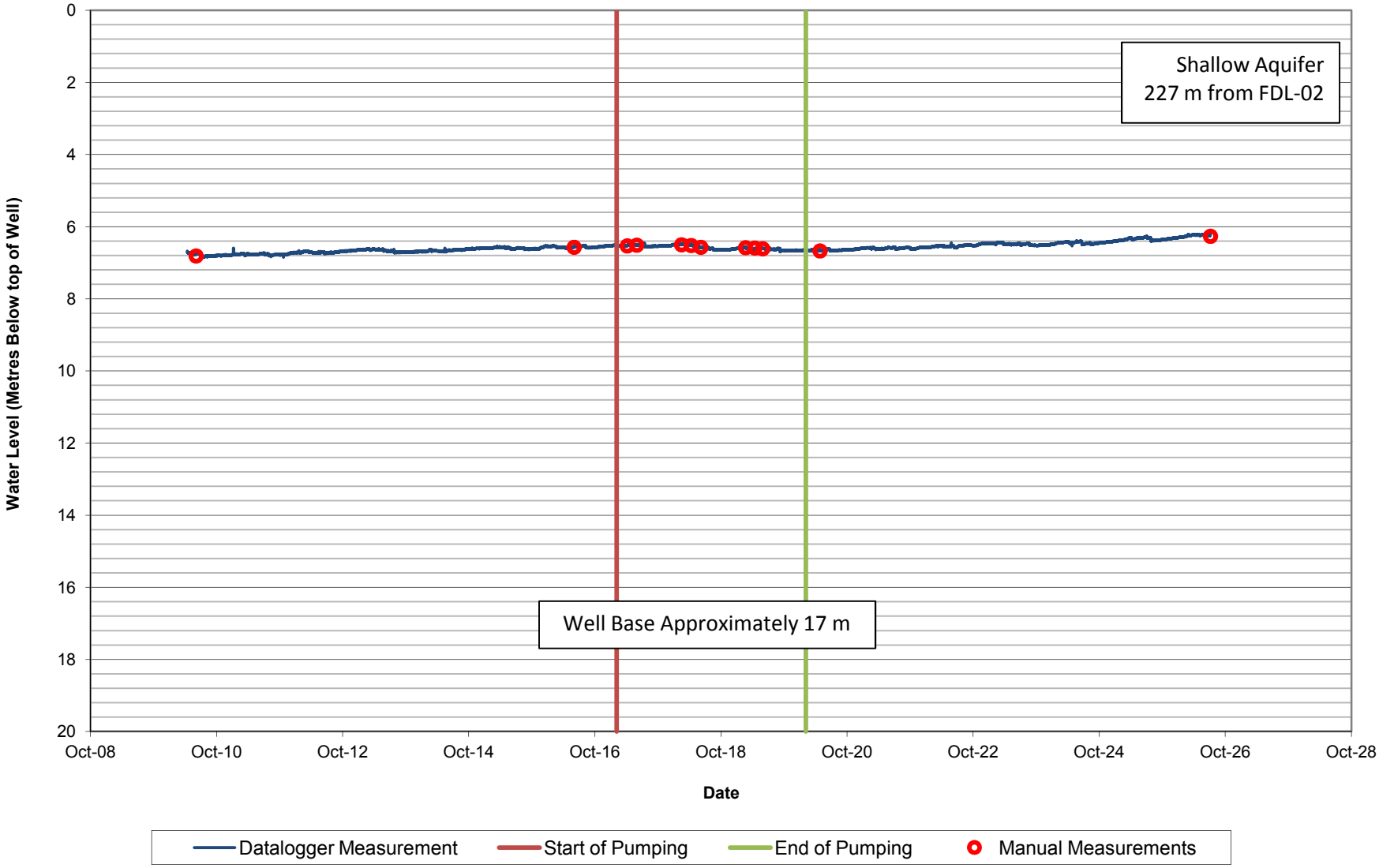


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Figure J-6 - Groundwater Levels - 3826 Governor's Road

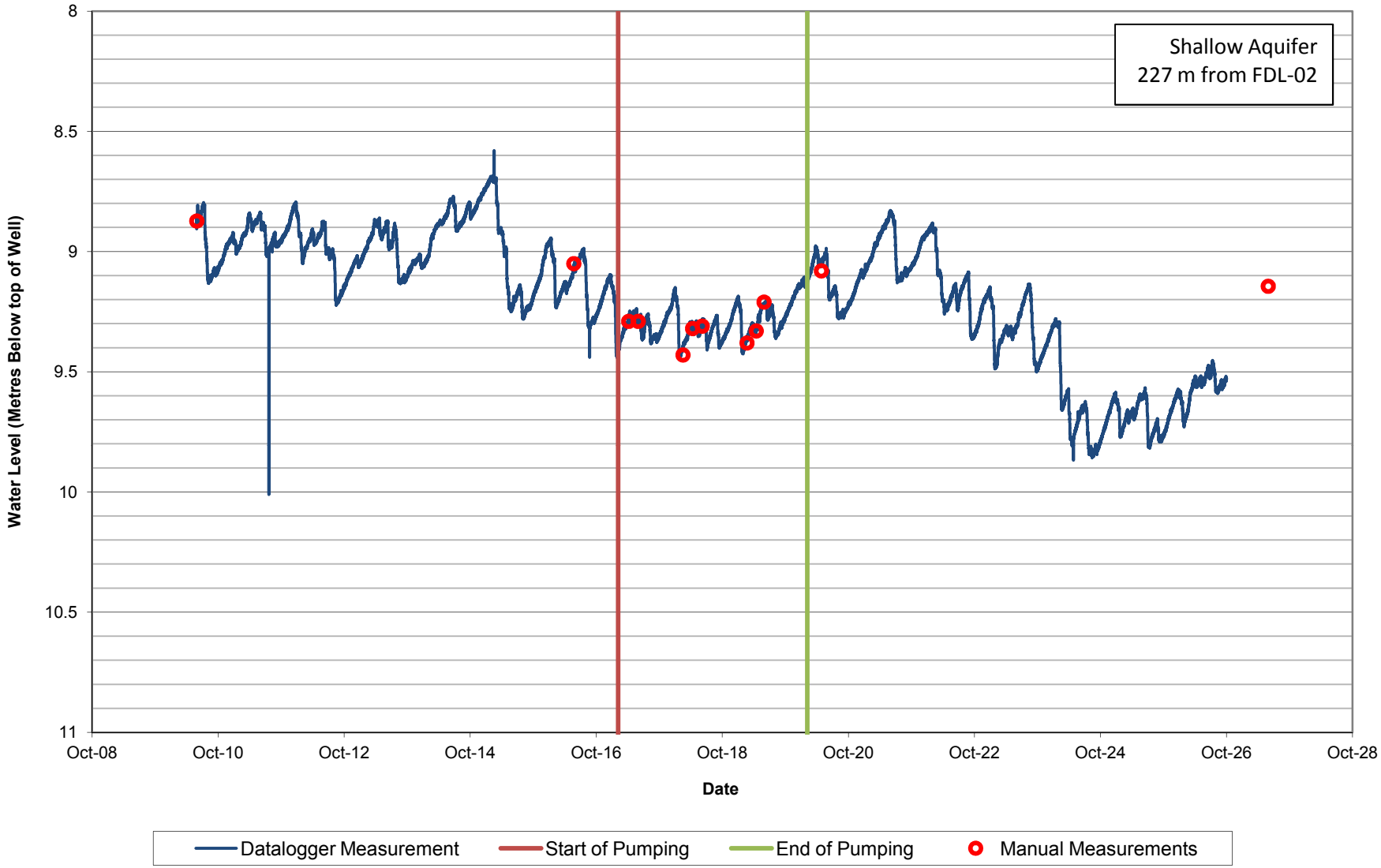

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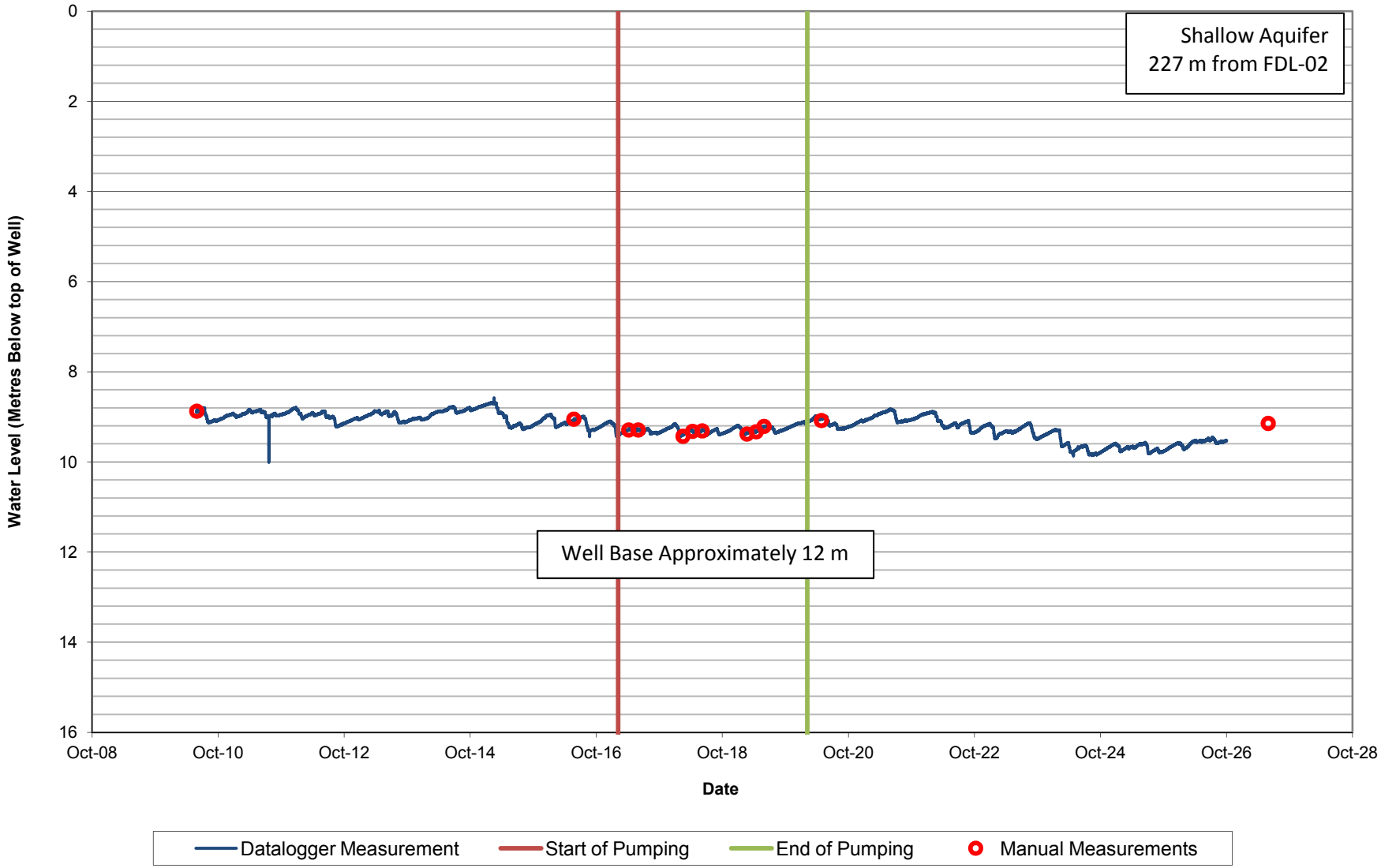
Figure J-6a - Groundwater Levels - 3826 Governor's Road
Scaled for Depth



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Appendix K

Water Quality Results - FDL-02

TABLE K-1:
General Inorganic Water Quality - LYNDEN WELL FDL-02
Community of Lynden

PARAMETER	ODWS Criteria	AO / OG	UNITS	Lynden Well FDL-02			
			Sampling Date Sampling Time	16-Oct-12 1 Hour	17-Oct-12 24 Hour	18-Oct-12 48 Hour	19-Oct-12 72 Hour
Anions							
Chloride	-	250	mg/L	-	-	-	43.4
Flouride	**1.5**	-	mg/L	-	-	-	0.65
Free Cyanide	**0.2**	-	mg/L	-	-	-	ND
Sulphide	-	0.05	mg/L	2.5	2.5	2.5	2.4
Sulphate	-	500	mg/L	-	-	-	6.2
Cations							
Calcium	-	-	mg/L	6.31	6.49	6.69	6.75
Iron	-	0.3	mg/L	0.011	ND	ND	ND
Magnesium	-	-	mg/L	4.31	4.47	4.65	4.69
Manganese	-	0.05	mg/L	0.002	0.001	0.001	0.001
Potassium	-	-	mg/L	0.96	0.96	0.95	0.99
Sodium	-	200	mg/L	54.7	54.4	54.4	55.2
Minor Ions							
Aluminum	-	100	mg/L	-	-	-	ND
Antimony	**0.006**	-	mg/L	ND	ND	ND	ND
Arsenic	**0.025**	-	mg/L	ND	ND	ND	ND
Barium	**1**	-	mg/L	**2.61**	**2.64**	**2.63**	**2.61**
Boron	**5**	-	mg/L	0.522	0.516	0.518	0.532
Cadmium	**0.005**	-	mg/L	ND	ND	ND	ND
Chromium	**0.05**	-	mg/L	ND	ND	ND	ND
Copper	**1**	-	mg/L	ND	ND	ND	ND
Lead	**0.01**	-	mg/L	ND	ND	ND	ND
Mercury	**0.001**	-	mg/L	-	-	-	ND
Selenium	**0.01**	-	mg/L	ND	ND	ND	ND
Uranium	**0.02**	-	mg/L	-	-	-	0.00015
Zinc	**5**	-	mg/L	ND	ND	ND	ND
Nutrients							
Ammonia (as N)	-	-	mg/L	-	-	-	0.1
Nitrate (as N)	**10**	-	mg/L as N	ND	ND	ND	ND
Nitrite (as N)	**1**	-	mg/L as N	ND	ND	ND	ND
Operational							
Alkalinity (as $CaCO_3$)	-	30 - 500	mg/L	-	-	-	94
Colour	-	5	TCU	ND	3	ND	ND
Conductivity (at 25°C)	-	-	umho/cm	-	-	-	351
Hardness	-	80 - 100	mg/L as $CaCO_3$	33.5	34.6	35.9	36.2
pH	-	6.5 - 8.5	pH units	-	-	-	8.42
Total Dissolved Solids	-	500	mg/L	-	-	-	188
Turbidity	-	5	NTU	0.22	0.11	0.07	-
Miscellaneous							
NTA	**0.4**	-	mg/L	-	-	-	ND

Notes:
ND = Not detected
Bold values indicate exceedances of ODWS Criteria
Highlighted values indicate exceedances of aesthetic objectives or operational guidelines.
- (dash) indicates parameter was not tested during the selected sample.
ODWS and AO / OG Criteria: Ontario Regulation 170/03 & Regulation 169/03 made under the Safe Drinking Water Act, 2002 including Microbiological standards.
Released May2, 2003

TABLE K-2:
General Organic Water Quality - LYNDEN WELL FDL-02
Community of Lynden

PARAMETER	ODWS Criteria	AO / OG	UNITS	Lynden Well FDL-02			
			Sampling Date Sampling Time	16-Oct-12 1 Hour	17-Oct-12 24 Hour	18-Oct-12 48 Hour	19-Oct-12 72 Hour
Volatile Organic Compounds							
1,1-Dichloroethylene	**14**	-	ug/L	-	-	-	ND
1,2-Dichlorobenzene	**200**	-	ug/L	-	-	-	ND
1,2-Dichloroethane	**5**	-	ug/L	-	-	-	ND
1,4-Dichlorobenzene	**5**	-	ug/L	-	-	-	ND
Benzene	**5**	-	ug/L	-	-	-	ND
Carbon Tetrachloride	**5**	-	ug/L	-	-	-	ND
Chlorobenzene	**80**	-	ug/L	-	-	-	ND
Methylene Chloride (Dichloromethane)	**50**	-	ug/L	-	-	-	ND
Tetrachloroethylene	**30**	-	ug/L	-	-	-	ND
Toluene	-	**24**	ug/L	-	-	-	ND
Trichloroethylene	**5**	-	ug/L	-	-	-	ND
Vinyl Chloride	**2**	-	ug/L	-	-	-	ND
Xylene (Total)	-	**300**	ug/L	-	-	-	ND
Semivolatile Organics							
NDMA	**0.009**	-	ug/L	-	-	-	ND

Notes:
ND = Not detected
Bold values indicate exceedances of ODWS Criteria
Highlighted values indicate exceedances of aesthetic objectives or operational guidelines.
- (dash) indicates parameter was not tested during the selected sample.
ODWS and AO / OG Criteria: Ontario Regulation 170/03 & Regulation 169/03 made under the Safe Drinking Water Act, 2002 including Microbiological standards.
Released May2, 2003

TABLE K-3:
General Organic Water Quality - LYNDEN WELL FDL-02
Community of Lynden

PARAMETER	ODWS Criteria	AO / OG	UNITS	Lynden Well FDL-02			
			Sampling Date Sampling Time	16-Oct-12 1 Hour	17-Oct-12 24 Hour	18-Oct-12 48 Hour	19-Oct-12 72 Hour
Pesticides and Herbicides							
2,4,5-T	28	-	ug/L	-	-	-	ND
2,4-D	100	-	ug/L	-	-	-	ND
Alachlor	5	-	ug/L	-	-	-	ND
Aldicarb	9	-	ug/L	-	-	-	ND
Aldrin	0.2	-	ug/L	-	-	-	ND
Dieldrin	0.5	-	ug/L	-	-	-	ND
Aldrin + Dieldrin	0.7	-	ug/L	-	-	-	ND
Atrazine	2.5	-	ug/L	-	-	-	ND
Desethyl-atrizine	2.5	-	ug/L	-	-	-	ND
Atrazine + Desethyl-atrazine	5	-	ug/L	-	-	-	ND
Azinphos-methyl (Guthion)	20	-	ug/L	-	-	-	ND
Bendiocarb	40	-	ug/L	-	-	-	ND
Bromoxynil	5	-	ug/L	-	-	-	ND
Carbaryl	90	-	ug/L	-	-	-	ND
Carbofuran	90	-	ug/L	-	-	-	ND
Oxychlordane	4	-	ug/L	-	-	-	ND
g-Chlordane	2	-	ug/L	-	-	-	ND
a-Chlordane	1	-	ug/L	-	-	-	ND
Chlordane (Total)	7	-	ug/L	-	-	-	ND
Chlorpyrifos (Dursban)	90	-	ug/L	-	-	-	ND
Cyanazine (Bladex)	10	-	ug/L	-	-	-	ND
DDT+ Metabolites	30	-	ug/L	-	-	-	ND
Diazinon	20	-	ug/L	-	-	-	ND
Dicamba	120	-	ug/L	-	-	-	ND
Diclofop-methyl	9	-	ug/L	-	-	-	ND
Dimethoate	20	-	ug/L	-	-	-	ND
Dinoseb	10	-	ug/L	-	-	-	ND
Diquat	70	-	ug/L	-	-	-	ND
Diuron	150	-	ug/L	-	-	-	ND
Glyphosate	280	-	ug/L	-	-	-	ND
Heptachlor	1	-	ug/L	-	-	-	ND
Heptachlor epoxide	2	-	ug/L	-	-	-	ND
Heptachlor + Heptachlor epoxide	3	-	ug/L	-	-	-	ND
Lindane	4	-	ug/L	-	-	-	ND
Malathion	190	-	ug/L	-	-	-	ND
Methoxychlor	900	-	ug/L	-	-	-	ND
Metolachlor	50	-	ug/L	-	-	-	ND
Metribuzin (Sencor)	80	-	ug/L	-	-	-	ND
Paraquat	10	-	ug/L	-	-	-	ND
Parathion	50	-	ug/L	-	-	-	ND
Phorate	2	-	ug/L	-	-	-	ND
Picloram	190	-	ug/L	-	-	-	ND
Prometryn	1	-	ug/L	-	-	-	ND
Simazine	10	-	ug/L	-	-	-	ND
Temephos	280	-	ug/L	-	-	-	ND
Terbufos	1	-	ug/L	-	-	-	ND
Triallate	230	-	ug/L	-	-	-	ND
Trifluralin	45	-	ug/L	-	-	-	ND

TABLE K-3:
General Organic Water Quality - LYNDEN WELL FDL-02
Community of Lynden

PARAMETER	ODWS Criteria	AO / OG	UNITS	Lynden Well FDL-02			
			Sampling Date Sampling Time	16-Oct-12 1 Hour	17-Oct-12 24 Hour	18-Oct-12 48 Hour	19-Oct-12 72 Hour
Polycyclic Aromatic Hydrocarbons							
Benzo(a)pyrene	**0.01**	-	ug/L	-	-	-	ND
Phenols							
2,3,4,6-Tetrachlorophenol	**100**	-	ug/L	-	-	-	ND
2,4,6-Trichlorophenol	**5**	-	ug/L	-	-	-	ND
2,4-Dichlorophenol	**900**	-	ug/L	-	-	-	ND
Pentachlorophenol	**60**	-	ug/L	-	-	-	ND
PCBs							
Total PCBs	**3**	-	ug/L	-	-	-	ND

Notes:
ND = Not detected
Bold values indicate exceedances of ODWS Criteria
Highlighted values indicate exceedances of aesthetic objectives or operational guidelines.
- (dash) indicates parameter was not tested during the selected sample.
ODWS and AO / OG Criteria: Ontario Regulation 170/03 & Regulation 169/03 made under the Safe Drinking Water Act, 2002 including Microbiological standards.
Released May2, 2003

Certificate of Analysis

City of Hamilton
Environmental Laboratory
700 Woodward Avenue, Hamilton, ON L8H 6P4
P. (905) 546-2424 F. (905)545-0234

CLIENT INFORMATION

Client Name: INFRASTRUCTURE AND SOURCE WATER PLANNING
Attention: CHRIS SHRIVE

Address: 77 JAMES STREET NORTH
HAMILTON
L8R 2K3

LABORATORY INFORMATION

Sample Date: 2012-10-16
Date Submitted: 2012-10-16

Laboratory Work Order Number: 304779

Samples analysed in this work order were analysed using the following methods:

Bacteria Membrane Filtration DC agar	Bacteria Membrane Filtration-HPC	Metals Hydrides-Hydride AA	Lead Graphite Furnace AA
Metals ICP	Anions IC	Turbidity Turbimeter	Cadmium Graphite Furnace AA
Colour Spectrophotometric	LIMS Calculation	Subcontract	

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The results on this Chemical Analysis Report relate only to the items tested.

Final Report Approval by:

Mira Bogle

Digitally signed by Mira Bogle
Date: 2012.10.29 10:56:08 -04'00'

Mira Bogle, Environmental Compliance Technologist

Rosemary Eszes-Wegner

Digitally signed by Rosemary Eszes
Date: 2012.10.30 14:39:59 -04'00'

Rosemary Eszes-Wegner, Supervisor Quality Assurance

Infrastructure and Source Water Planning

Lynden Well Study - Genivar

Pumping Well 2012-10-16 09:30:00

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)		
Colour (apparent)	<2	CU	2			
Hardness	33.5	mg/L	0.7			
Nitrate as N	<0.01	mg/L	0.01	10.0		MAC
Nitrite as N	<0.01	mg/L	0.01	1.0		MAC
Turbidity	0.22	NTU	0.05			
Escherichia coli	0	CFU/100mL	0	0		MAC
Heterotrophic Plate Count	0	CFU/1mL	0			
Total Coliform	0	CFU/100mL	0	0		MAC
Total Coliform Background	18	CFU/100mL	0			MAC
Antimony	<0.0006	mg/L	0.0006	0.006		MAC
Arsenic	<0.001	mg/L	0.001	0.025		MAC
Barium	2.61	mg/L	0.002	1.0	*	MAC
Beryllium	<0.0001	mg/L	0.0001			
Bismuth	<0.020	mg/L	0.020			
Boron	0.522	mg/L	0.010	5.0		MAC
Cadmium	<0.0001	mg/L	0.0001	0.005		MAC
Calcium	6.31	mg/L	0.10			
Chromium	<0.001	mg/L	0.001	0.05		MAC
Cobalt	<0.0009	mg/L	0.0009			
Copper	<0.002	mg/L	0.002			
Iron	0.011	mg/L	0.010			
Lead	<0.0010	mg/L	0.0010	0.010		MAC
Magnesium	4.31	mg/L	0.10			
Manganese	0.002	mg/L	0.001			
Molybdenum	<0.005	mg/L	0.005			
Nickel	<0.005	mg/L	0.005			
Potassium	0.96	mg/L	0.10			
Selenium	<0.002	mg/L	0.002	0.01		MAC
Silver	<0.005	mg/L	0.005			
Sodium	54.7	mg/L	0.50			
Strontium	0.643	mg/L	0.005			
Thallium	<0.010	mg/L	0.010			
Tin	<0.020	mg/L	0.020			
Titanium	<0.001	mg/L	0.001			
Vanadium	<0.002	mg/L	0.002			
Zinc	<0.005	mg/L	0.005			
Sulphide (Subcontract)	2.50	mg/L	0.020			

Note: Sulphide is expressed as H2S = 2.6 mg/L.

Certificate of Analysis

City of Hamilton
Environmental Laboratory
700 Woodward Avenue, Hamilton, ON L8H 6P4
P. (905) 546-2424 F. (905)545-0234

CLIENT INFORMATION

Client Name: INFRASTRUCTURE AND SOURCE WATER PLANNING
Attention: CHRIS SHRIVE

Address: 77 JAMES STREET NORTH
HAMILTON
L8R 2K3

LABORATORY INFORMATION

Sample Date: 2012-10-17
Date Submitted: 2012-10-17

Laboratory Work Order Number: 304841

Samples analysed in this work order were analysed using the following methods:

Bacteria Membrane Filtration DC agar	Bacteria Membrane Filtration-HPC	Metals Hydrides-Hydride AA	Lead Graphite Furnace AA
Metals ICP	Anions IC	Turbidity Turbimeter	Cadmium Graphite Furnace AA
Colour Spectrophotometric	LIMS Calculation	Subcontract	

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Final Report Approval by:

Digitally signed by Rosemary Eszes
Date: 2012.11.22 18:40:31 -05'00'

Rosemary Eszes-Wegner, Supervisor Quality Assurance

Digitally signed by Pamela Thomas
Date: 2012.11.24 15:35:56 -05'00'

Pamela M. Thomas, Superintendent Environmental Laboratory

Infrastructure and Source Water Planning

Lynden Well Study - Genivar

Lynden Pumping Well 2012-10-17 08:30:00

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)		
Colour (apparent)	3	CU	2			
Hardness	34.6	mg/L	0.7			
Nitrate as N	<0.01	mg/L	0.01	10.0		**MAC**
Nitrite as N	<0.01	mg/L	0.01	1.0		**MAC**
Turbidity	0.11	NTU	0.05			
Escherichia coli	0	CFU/100mL	0	0		**MAC**
Heterotrophic Plate Count	1	CFU/1mL	0			
Total Coliform	0	CFU/100mL	0	0		**MAC**
Total Coliform Background	3	CFU/100mL	0			**MAC**
Antimony	<0.0006	mg/L	0.0006	0.006		**MAC**
Arsenic	<0.001	mg/L	0.001	0.025		**MAC**
Barium	2.64	mg/L	0.002	1.0	*	**MAC**
Beryllium	<0.0001	mg/L	0.0001			
Bismuth	<0.020	mg/L	0.020			
Boron	0.516	mg/L	0.010	5.0		**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005		**MAC**
Calcium	6.49	mg/L	0.10			
Chromium	<0.001	mg/L	0.001	0.05		**MAC**
Cobalt	<0.0009	mg/L	0.0009			
Copper	<0.002	mg/L	0.002			
Iron	<0.010	mg/L	0.010			
Lead	<0.0010	mg/L	0.0010	0.010		**MAC**
Magnesium	4.47	mg/L	0.10			
Manganese	0.001	mg/L	0.001			
Molybdenum	<0.005	mg/L	0.005			
Nickel	<0.005	mg/L	0.005			
Potassium	0.96	mg/L	0.10			
Selenium	<0.002	mg/L	0.002	0.01		**MAC**
Silver	<0.005	mg/L	0.005			
Sodium	54.4	mg/L	0.50			
Strontium	0.666	mg/L	0.005			
Thallium	<0.010	mg/L	0.010			
Tin	<0.020	mg/L	0.020			
Titanium	<0.001	mg/L	0.001			
Vanadium	<0.002	mg/L	0.002			
Zinc	<0.005	mg/L	0.005			
Sulphide (Subcontract)	2.50	mg/L	0.020			

Note: Sulphide is expressed as H2S.

Certificate of Analysis

City of Hamilton
Environmental Laboratory
700 Woodward Avenue, Hamilton, ON L8H 6P4
P. (905) 546-2424 F. (905)545-0234

CLIENT INFORMATION

Client Name: INFRASTRUCTURE AND SOURCE WATER PLANNING
Attention: CHRIS SHRIVE

Address: 77 JAMES STREET NORTH
HAMILTON
L8R 2K3

LABORATORY INFORMATION

Sample Date: 2012-10-18
Date Submitted: 2012-10-18

Laboratory Work Order Number: 304860

Samples analysed in this work order were analysed using the following methods:

Bacteria Membrane Filtration DC agar	Bacteria Membrane Filtration-HPC	Metals Hydrides-Hydride AA	Lead Graphite Furnace AA
Metals ICP	Anions IC	Turbidity Turbimeter	Cadmium Graphite Furnace AA
Colour Spectrophotometric	LIMS Calculation	Subcontract	

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Final Report Approval by:

Digitally signed by Rosemary Eszes
Date: 2012.11.22 18:41:34 -05'00'

Rosemary Eszes-Wegner, Supervisor Quality Assurance

Digitally signed by Pamela Thomas
Date: 2012.11.24 15:36:09 -05'00'

Pamela M. Thomas, Superintendent Environmental Laboratory

Infrastructure and Source Water Planning

Lynden Well Study - Genivar

Lynden Pumping Well 2012-10-18 08:30:00

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)		
Colour (apparent)	<2	CU	2			
Hardness	35.9	mg/L	0.7			
Nitrate as N	<0.01	mg/L	0.01	10.0		**MAC**
Nitrite as N	<0.01	mg/L	0.01	1.0		**MAC**
Turbidity	0.07	NTU	0.05			
Escherichia coli	0	CFU/100mL	0	0		**MAC**
Heterotrophic Plate Count	2	CFU/1mL	0			
Total Coliform	0	CFU/100mL	0	0		**MAC**
Total Coliform Background	0	CFU/100mL	0			**MAC**
Antimony	<0.0006	mg/L	0.0006	0.006		**MAC**
Arsenic	<0.001	mg/L	0.001	0.025		**MAC**
Barium	2.63	mg/L	0.002	1.0	*	**MAC**
Beryllium	<0.0001	mg/L	0.0001			
Bismuth	<0.020	mg/L	0.020			
Boron	0.518	mg/L	0.010	5.0		**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005		**MAC**
Calcium	6.69	mg/L	0.10			
Chromium	<0.001	mg/L	0.001	0.05		**MAC**
Cobalt	<0.0009	mg/L	0.0009			
Copper	<0.002	mg/L	0.002			
Iron	<0.010	mg/L	0.010			
Lead	<0.0010	mg/L	0.0010	0.010		**MAC**
Magnesium	4.65	mg/L	0.10			
Manganese	0.001	mg/L	0.001			
Molybdenum	<0.005	mg/L	0.005			
Nickel	<0.005	mg/L	0.005			
Potassium	0.95	mg/L	0.10			
Selenium	<0.002	mg/L	0.002	0.01		**MAC**
Silver	<0.005	mg/L	0.005			
Sodium	54.4	mg/L	0.50			
Strontium	0.677	mg/L	0.005			
Thallium	<0.010	mg/L	0.010			
Tin	<0.020	mg/L	0.020			
Titanium	<0.001	mg/L	0.001			
Vanadium	<0.002	mg/L	0.002			
Zinc	<0.005	mg/L	0.005			
Sulphide (Subcontract)	2.50	mg/L	0.020			

Note: Sulphide is expressed as H2S.

Certificate of Analysis

City of Hamilton
Environmental Laboratory
700 Woodward Avenue, Hamilton, ON L8H 6P4
P. (905) 546-2424 F. (905)545-0234

CLIENT INFORMATION

Client Name: INFRASTRUCTURE AND SOURCE WATER PLANNING
Attention: CARMEN CHES

Address: 77 JAMES STREET NORTH
HAMILTON

LABORATORY INFORMATION

Sample Date: 2012-10-19
Date Submitted: 2012-10-19

Laboratory Work Order Number: 304871

Samples analysed in this work order were analysed using the following methods:

Alk/pH/Cond/Temp PC Titrate	Bacteria Membrane Filtration DC agar	Bacteria Membrane Filtration-HPC	Volatile Organics-Purge&Trap/GC-MS
TDS Gravimetric	Metals Hydrides-Hydride AA	Mercury Cold Vapour AA	Lead Graphite Furnace AA
Metals ICP	Anions IC	Ammonia Skalar	Cadmium Graphite Furnace AA
Colour Spectrophotometric	LIMS Calculation	Fluoride-PC Titrate	Subcontract
Microcystin ADDA			

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Final Report Approval by:

Digitally signed by Rosemary Eszes
Date: 2012.12.05 15:24:57 -05'00'

Rosemary Eszes-Wegner, Supervisor Quality Assurance

Digitally signed by Pamela Thomas
Date: 2012.12.05 16:42:39 -05'00'

Pamela M. Thomas, Superintendent Environmental Laboratory

Infrastructure and Source Water Planning

Lynden Well Study - Genivar

Lynden Pumping Well 2012-10-19 07:40:00

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)		
Alkalinity	94	mg/L	2			
Ammonia + Ammonium as N	0.08	mg/L	0.01			
Chloride	43.4	mg/L	0.2			
Colour (apparent)	2	CU	2			
Colour (true)	<2	CU	2			
Conductivity	351	umhos/cm	2			
Cyanide - Total (Subcontract)	<0.0050	mg/L	0.0050	0.2		MAC
Fluoride	0.65	mg/L	0.04	1.5		MAC
Hardness	36.2	mg/L	0.7			
Nitrate as N	<0.01	mg/L	0.01	10.0		MAC
Nitrate+Nitrite as N	<0.02	mg/L	0.02	10.0		MAC
Nitrite as N	<0.01	mg/L	0.01	1.0		MAC
pH	8.42	pH	0.01			
Sulphate	6.2	mg/L	0.2			
Total Dissolved Solids	188	mg/L	13			
Escherichia coli	0	CFU/100mL	0	0		MAC
Heterotrophic Plate Count	0	CFU/1mL	0			
Total Coliform	0	CFU/100mL	0	0		MAC
Total Coliform Background	4	CFU/100mL	0			MAC
Aluminum	<0.002	mg/L	0.002			
Antimony	<0.0006	mg/L	0.0006	0.006		MAC
Arsenic	<0.001	mg/L	0.001	0.025		MAC
Barium	2.61	mg/L	0.002	1.0	*	MAC
Beryllium	<0.0001	mg/L	0.0001			
Bismuth	<0.020	mg/L	0.020			
Boron	0.532	mg/L	0.010	5.0		MAC
Cadmium	<0.0001	mg/L	0.0001	0.005		MAC
Calcium	6.75	mg/L	0.10			
Chromium	<0.001	mg/L	0.001	0.05		MAC
Cobalt	<0.0009	mg/L	0.0009			
Copper	<0.002	mg/L	0.002			
Iron	<0.010	mg/L	0.010			
Lead	<0.0010	mg/L	0.0010	0.010		MAC
Magnesium	4.69	mg/L	0.10			
Manganese	0.001	mg/L	0.001			
Mercury	<0.05	ug/L	0.05	1		MAC
Molybdenum	<0.005	mg/L	0.005			
Nickel	<0.005	mg/L	0.005			
Potassium	0.99	mg/L	0.10			
Selenium	<0.002	mg/L	0.002	0.01		MAC
Silver	<0.005	mg/L	0.005			
Sodium	55.2	mg/L	0.50			
Strontium	0.686	mg/L	0.005			
Thallium	<0.010	mg/L	0.010			
Tin	<0.020	mg/L	0.020			
Titanium	<0.001	mg/L	0.001			
Uranium (Subcontract)	0.00015	mg/L	.00010	0.02		MAC
Vanadium	<0.002	mg/L	0.002			
Zinc	<0.005	mg/L	0.005			
1,1-Dichloroethylene	<0.2	ug/L	0.2	14		MAC

Analyte	Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)	
1,2-Dichlorobenzene	<0.2	ug/L	0.2	200	**MAC**
1,2-Dichloroethane	<0.2	ug/L	0.2	5	
1,4-Dichlorobenzene	<0.2	ug/L	0.2	5	**MAC**
Benzene	<0.2	ug/L	0.2	5	**MAC**
Bromodichloromethane	<0.2	ug/L	0.2		
Bromoform	<0.2	ug/L	0.2		
Carbon Tetrachloride	<0.2	ug/L	0.2	5	**MAC**
Chlorobenzene	<0.3	ug/L	0.3	80	**MAC**
Chloroform	<0.2	ug/L	0.2		
Dibromochloromethane	<0.2	ug/L	0.2		
Methylene Chloride	<0.5	ug/L	0.5	50	**MAC**
Ethylbenzene	<0.2	ug/L	0.2		**OG**
m+p-Xylene	<0.2	ug/L	0.2		
o-Xylene	<0.2	ug/L	0.2		
Tetrachloroethylene	<0.2	ug/L	0.2	30	**MAC**
Toluene	<0.2	ug/L	0.2		**OG**
Total Trihalomethanes	<0.4	ug/L	0.4	100	**MAC**
Trichloroethylene	<0.2	ug/L	0.2	5	**MAC**
Vinyl Chloride	<0.2	ug/L	0.2	2	**MAC**
Total Xylenes	<0.3	ug/L	0.3		**OG**
Benzo[a]pyrene (Subcontract)	<0.009	ug/L	0.009	0.01	
Microcystins	<0.15	ug/L	0.15		
2,3,4,6-Tetrachlorophenol (Subcontract)	<0.5	ug/L	0.5	100	
2,4,5,6-tetrachloro-m-xylene (Subcontract)	85	%			
2,4,5-T (Subcontract)	<1	ug/L	1	280	
2,4,6-Tribromophenol (Subcontract)	95	%			
2,4,6-Trichlorophenol (Subcontract)	<0.5	ug/L	0.5	5	
2,4-D (Subcontract)	<1	ug/L	1	100	
2,4'-DDT (Subcontract)	<0.006	ug/L	0.006		
2,4-Dichlorophenol (Subcontract)	<0.5	ug/L	0.5	900	
2-fluorobiphenyl (Subcontract)	74	%			
4,4'-DDD (Subcontract)	<0.006	ug/L	0.006		
4,4'-DDE (Subcontract)	<0.006	ug/L	0.006		
Alachlor (Subcontract)	<0.5	ug/L	0.5	5	
Aldicarb (Subcontract)	<5	ug/L	5	9	
Aldrin (Subcontract)	<0.006	ug/L	0.006		
Aldrin/Dieldrin (Subcontract)	<0.01	ug/L	0.01	0.7	
alpha-Chlordane (Subcontract)	<0.006	ug/L	0.006		
Arochlor 1221 (Subcontract)	<0.05	ug/L	0.05		
Arochlor 1232 (Subcontract)	<0.05	ug/L	0.05		
Arochlor 1242 (Subcontract)	<0.05	ug/L	0.05		
Arochlor 1248 (Subcontract)	<0.05	ug/L	0.05		
Arochlor 1254 (Subcontract)	<0.05	ug/L	0.05		
Arochlor 1260 (Subcontract)	<0.05	ug/L	0.05		
Atrazine (Subcontract)	<0.5	ug/L	0.5		
Atrazine + Desethyl-atrazine (Subcontract)	<1	ug/L	1	5	
Azinphos-methyl (Subcontract)	<2	ug/L	2	20	
Bendiocarb (Subcontract)	<2	ug/L	2	40	
Bromate (Subcontract)	<0.30	ug/L	0.30	10	
Bromoxynil (Subcontract)	<0.5	ug/L	0.5	5	
Carbaryl (Subcontract)	<5	ug/L	5	90	
Carbofuran (Subcontract)	<5	ug/L	5	90	
Chlordane (Subcontract)	<0.01	ug/L	0.01	7	
Chlorpyrifos (Dursban) (Subcontract)	<1	ug/L	1		

Analyte		Result	Units	MDL	ODWS (Amended by O.Reg. 248/06)
Cyanazine (Bladex)	(Subcontract)	<1	ug/L	1	
d-14-p-Terphenyl	(Subcontract)	104	%		
d5-Nitrobenzene	(Subcontract)	73	%		
DDT + Metabolites	(Subcontract)	<0.02	ug/L	0.02	
Decachlorbiphenyl	(Subcontract)	105	%		
Desethyl-atrazine	(Subcontract)	<0.5	ug/L	0.5	
Diazinon	(Subcontract)	<1	ug/L	1	20
Dicamba	(Subcontract)	<1	ug/L	1	120
Diclofop-methyl	(Subcontract)	<0.9	ug/L	0.9	9
Dieldrin	(Subcontract)	<0.006	ug/L	0.006	
Dimethoate	(Subcontract)	<3	ug/L	3	20
Dinoseb	(Subcontract)	<1	ug/L	1	10
Diquat	(Subcontract)	<7	ug/L	7	70
Diuron	(Subcontract)	<10	ug/L	10	150
gamma-Chlordane	(Subcontract)	<0.006	ug/L	0.006	
Glyphosate	(Subcontract)	<10	ug/L	10	280
Heptachlor	(Subcontract)	<0.006	ug/L	0.006	
Heptachlor epoxide	(Subcontract)	<0.006	ug/L	0.006	
Heptachlor+Heptachlor epoxide	(Subcontract)	<0.01	ug/L	0.01	3
Lindane	(Subcontract)	<0.006	ug/L	0.006	4
Malathion	(Subcontract)	<5	ug/L	5	190
Methoxychlor	(Subcontract)	<0.02	ug/L	0.02	900
Metolachlor	(Subcontract)	<0.5	ug/L	0.5	50
Metribuzin (Sencor)	(Subcontract)	<5	ug/L	5	80
NDMA	(Subcontract)	<0.002	ug/L	0.002	0.009
Nitrilotriacetic Acid	(Subcontract)	<0.05	mg/L	0.05	400
Oxychlordane	(Subcontract)	<0.006	ug/L	0.006	
Paraquat	(Subcontract)	<1	ug/L	1	10
Parathion	(Subcontract)	<1	ug/L	1	50
PCBs	(Subcontract)	<0.05	ug/L	0.05	3.0
Pentachlorophenol	(Subcontract)	<0.5	ug/L	0.5	60
Phorate	(Subcontract)	<0.5	ug/L	0.5	2
Picloram	(Subcontract)	<5	ug/L	5	190
Prometryne	(Subcontract)	<0.3	ug/L	0.3	1
Simazine	(Subcontract)	<1	ug/L	1	10
Sulphide	(Subcontract)	2.40	mg/L	0.020	
Temephos	(Subcontract)	<10	ug/L	10	280
Terbufos	(Subcontract)	<0.5	ug/L	0.5	1
Total Toxic Equivalency (MDL)	(Subcontract)	<3.32	ng/L	3.32	
Triallate	(Subcontract)	<1	ug/L	1	230
Trifluralin	(Subcontract)	<1	ug/L	1	45

Note: Sulphide is expressed as H2S.

GENIVAR

TECHNICAL MEMORANDUM

Date: December 20, 2013

To: Carmen Ches

From: Michelle Albert

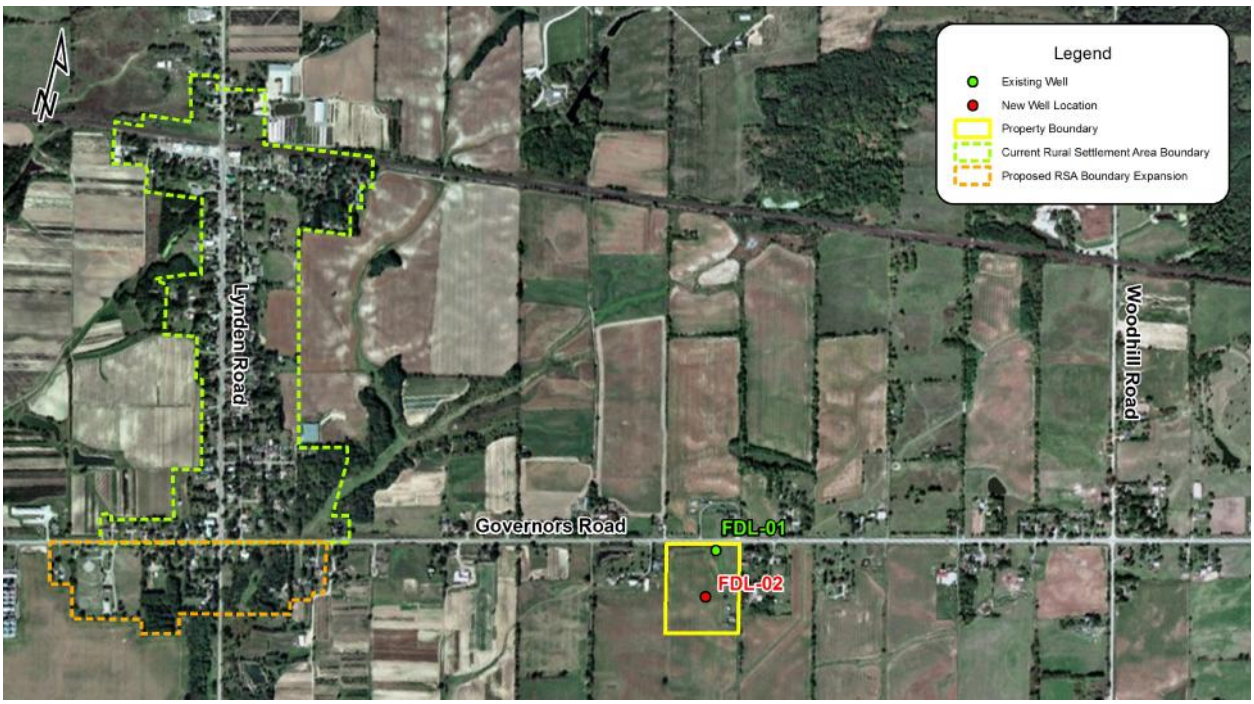
Project No.: 6333

Subject: Lynden Well EA – Alternative Treatment Options

1. Background

The City of Hamilton operates a groundwater sourced municipal drinking water system in the Lynden Rural Settlement Area (RSA), located approximately 20 km west of the City's urban area. The Lynden RSA is currently supplied from a single groundwater well (FDL-01) and single storage/treatment facility located on Governor's Road, approximately 1.5 km east of Lynden Road. The main distribution system is concentrated on Lynden Road, north of Governor's Road. The study area is shown in Figure 1 below.

Figure 1 Lynden Well Location Map



The City has received requests by Lynden residents for additional connections to the municipal system over concerns associated with private well water quality and quantity. In 2001, the groundwater supply experienced a combination of high demand and high turbidity, which prompted the commencement of the water servicing master plan for the Lynden RSA. The master plan investigated several alternatives to ensure adequate quantity and quality of water is supplied to the residents. The preferred option was to upgrade the existing well supply and to secure additional supply. A back-up well was to be established. Accordingly, a Schedule 'C' Class Environmental Assessment (EA) was initiated by the City to address the conditions in the existing Lynden municipal water supply system. The preferred approach was to construct a new well (FDL-02) on the same site as the existing well.

The purpose of this technical memorandum is to provide an overview of the water quantity and quality of the new well (FDL-02) and present alternative treatment options.

2. Existing Well FDL-01

The existing Lynden municipal water supply system consists of a production well (FDL-01) located to the east of the community. In addition to the well, there is a pump house which contains a treatment and control facility. The rated capacity for the municipal well is set out in the Certificate of Approval (C of A) 8235-6UHJBC issued on October 30, 2006 and the Permit to Take Water (PTTW) #2331-826QBK dated December 16, 2009. The details of the existing municipal supply well permits are summarized in Table 2-1.

Table 2-1 – Details of the Lynden Municipal Water Supply Permits

Provincial Instrument	Reference Number	System	Rated Pump Capacity (L/s)	Max Flow Rate (L/min)	Max Daily Volume (m^3/day)
PTTW	2331-826QBK	Well FDL-01	7.6	227	327.312
C of A	8235-6UHJBC	Well FDL-01			

The existing well FDL-01 ground water supply system consists of the following:

- One 200 mm diameter casing 54.56 m deep well
- A 3.75 kW deep well submersible pump rated at 7.6 L/sec at 24.0 m TDH
- A 9.1 x 6.9 m treatment building which includes the following:
    - chemical storage and feed system
    - aeration system
    - standby diesel generator set
    - control system
- A 9.1 x 9.1 m underground reservoir

The underground reservoir is divided into two (2) equal cells. The well water is first introduced into the first cell of the reservoir, where it is aerated for the purpose of removing hydrogen sulfide (H_2S). The second cell is utilized as a contact tank for chlorine disinfection.

Issues and concerns related to water quality as identified from previous records (Lynden Community Information Update – Lynden Municipal Drinking Water System – Elevated Lead Detection) and water quality reports are described below.

Lead

Elevated lead levels within the water system have been detected in recent years, which have led to the Drinking Water Advisory (DWA) that was issued by the City of Hamilton Public Health Services on September 7th, 2011. Based on the investigation carried out by the City's Public Health Services and Public Works Department, it was suggested that the existence of a sediment containing lead at the bottom of the reservoir caused an increase in lead concentration in the drinking water.

A consultant was hired to investigate and report on the actual cause of the lead detections in the drinking water and to determine the source of the lead found in the sediment. The study completed in May 2012 concluded that elevated lead concentration in the Lynden system is not a regular occurrence. The elevated lead incidents have been linked to elevated turbidity present in the treated water. Lead levels above the Ontario Drinking Water Quality Standards (ODWQS) maximum acceptable concentration (MAC) of 0.01 mg/L have occurred only sporadically since 2006. Based on limited water quality data,

elevated lead levels correspond to elevated concentrations of copper, iron and zinc indicating that the source of metals in the treated water may be due to corrosion.

Sulfide

Raw water sulfide concentrations between 1.5 – 1.9 mg/L have been reported for the existing well FDL-01, which exceeded Ontario Drinking Water Quality Aesthetic Objective for sulfide of 0.05 mg/L.

Turbidity

The Ontario Drinking Water Quality Standards (ODWQS) maximum acceptable concentration (MAC) of for turbidity is 1.0 NTU. However, based on a previous sampling program, between 2008 and 2011, the monthly average turbidity is in the range of 1.0 to 2.9 NTU. The maximum turbidity recorded was over 5.1 NTU (XCG report, 2012). The suggested causes for the high turbidity in the well FDL-01 are described below.

The pH of the raw water is above 8, which is not ideal for the removal of H_2S (however, it is not outside the range of 6.5 to 8.5 as recommended by the ODWQS Operational Guideline). At a pH above 8, the aeration process oxidizes sulfides to sulphur crystals that are precipitated at the bottom of the reservoir and/or are carried into the distribution system, which causes higher levels of turbidity in the treated water.

Furthermore, in the second reservoir cell that is used for disinfection, sodium hypochlorite is added which favours calcium carbonate precipitation. The calcium carbonate settles at the bottom of the reservoir and/or is being carried into the distribution system.

The sulphur crystals and the calcium carbonate contained in the finished water affects the final turbidity, which may be the cause of the higher turbidity found in the finished water.

3. New Well FDL-02

Well FDL-02 is located on the south side of Governor's Road approximately 100 m south of the existing production well FDL-01 on land recently acquired by the City. Land use in the vicinity of the well is predominantly agricultural with some scattered residences. Based on the Class EA testing program, Well FDL-02 draws water from a confined overburden aquifer within a buried valley, which trends north to south towards the Dundas Buried Valley. Although steady-state conditions were not achieved during the pumping test, it was noted that FDL-02 should be capable of sustained operation at a discharge rate of 4.7 L/s (75 USgpm).

3.1 Raw Water Quality

Groundwater quality from the new well meets the Ontario Drinking Water Standards, Objectives and Guidelines for the all parameters listed in Schedule 23 and 24 of O. Reg. 170/03 except for barium, sulfides, and hardness. The water quality and Ontario Drinking Water Quality Standards maximum acceptable concentration (MAC), aesthetic objective (AO), and operational guideline (OG) are provided in Table 3-1 below.

Table 3-1 Ontario Drinking Water Quality Standards and the Well FDL-02 Raw Water Quality

Parameter	MAC (mg/L)	AO (mg/L)	OG (mg/L)	FDL-02 (mg/L)
Barium	1	N/A	N/A	2.61 - 2.64
Sulfide	N/A	0.05	N/A	2.4 - 2.5
Hardness (as $CaCO_3$)	N/A	N/A	80-100	33.5 - 36.2
Sodium*	N/A	200	N/A	54.4 - 55.2

*The Ontario Drinking Water Quality Aesthetic Objective (AO) is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets.

4. Treatment Technologies

Based on the raw water data provided in Table 3-1, the treatment technologies will focus on the removal of the following parameters from the raw water:

- Barium
- Sulfides

The treatment alternatives are presented in Section 5. However, a brief description is provided in this section on potential technologies for the removal of Barium and Sulfides.

4.1 Barium Removal

The physical and chemical properties of barium are similar to those of calcium and magnesium, which occur more commonly in groundwater; hence, similar methods apply for its treatment. The best available technologies listed in the current USEPA National Primary Drinking Water Regulations for removing barium in drinking water are as follows: ion exchange, reverse osmosis, lime softening, and electrodialysis.

Based on a Canadian national survey on barium reported by Environmental and Workplace Health, Health Canada (1990), relatively little, if any, soluble or insoluble barium is removed by conventional water treatment processes (i.e. coagulation, flocculation, and direct filtration). Processes effective in removing barium from drinking water include: ion exchange (93 to 98%), lime softening (>90%), and reverse osmosis membrane technology (>90%). Efficiency of removal varies, depending on the concentrations present in the raw water. These technologies are discussed further in Section 5, Treatment Alternatives.

4.2 Sulfide Removal

Hydrogen sulfide (H_2S) in ground water is a common occurrence. Although it is generally not a health risk, the offensive odour and corrosivity of water containing hydrogen sulfide usually make treatment necessary. Depending on the concentration, different treatment methods may be warranted, which include Greensand/potassium permanganate, oxidation/filtration, and air stripping.

Greensand/potassium permanganate can be used to reduce sulfide. However, it requires regeneration of oxidizing media, which increases operational and maintenance complexity. Hence, it is not discussed further.

4.2.1 Oxidation Followed by Filtration

Hydrogen sulfide (H_2S) and bisulfide (HS^-) can be removed by oxidation. Oxidation of hydrogen sulfide or bisulfide ions converts these forms to either elemental sulfur or sulfate depending on the strength of the oxidant added in the system. The most commonly used oxidizing agents are oxygen from the air (aeration), ozone, chlorine, and potassium permanganate. These methods may remove from 1 to 10 mg/L of hydrogen sulfide.

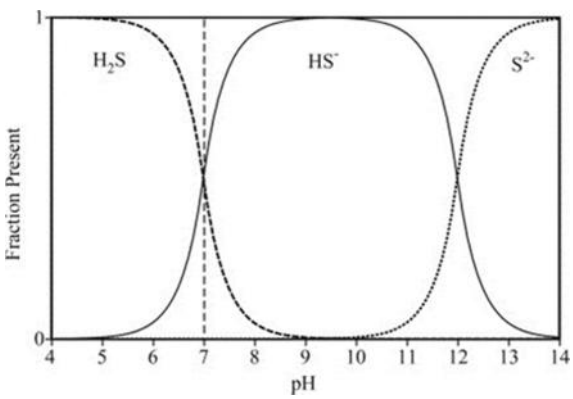
Chlorine may be used as an oxidant since chlorine will be used for disinfection and is already in use at the existing well. To oxidize sulfide to elemental sulfur, 2.2 mg/L of chlorine for 1 mg/L of sulfide is required. Elemental sulfur exists as fine crystals that may contribute to high turbidity readings if it is present at high levels. Oxidation followed by filtration is often used to remove sulfur crystals formed in water. Various media can be used in the filter such as catalytic activated carbon and manganese dioxide, which have large specific surface area and work via adsorption.

The adsorption filtration technology is available in the market. The equipment descriptions and application examples are provided in Appendix A.

4.2.2 Air Stripping

Air stripping is a form of aeration. It is an effective removal mechanism because H_2S exists as a dissolved gas in the raw water and can therefore be stripped from the water. In drinking water systems, total sulfide is primarily composed of H_2S and HS^-. At a pH equal to 7.0 for instance, approximately 50% of the total sulfide is H_2S while 50% is present as HS^-. At a pH equal to 8.0, only 9% of total sulfide is present in the H_2S form while the remaining 91% is HS^-. Figure 2 shows the speciation of hydrogen sulfide as it varies with varying pH values. Of the different sulfide forms, only the H_2S molecule is removed by air stripping. It is important, therefore, to note that at elevated pH values the efficiency of aeration for the removal of hydrogen sulfide is significantly diminished. Air stripping process usually produces a hydrogen sulfide odor near the aerator, and may not always reduce the hydrogen sulfide to non-detectable levels. In such cases, a carbon filter can be used to remove some of the remaining trace amounts of hydrogen sulfide.

Figure 2 Sulfide species distribution as a function of pH



For air stripping, the pH needs to be decreased to between 5 and 6 to achieve optimum conditions for sulfide removal. This can be done using carbon dioxide (CO_2) or acids such as hydrochloric acid (HCl). However, this pH adjustment is not necessary if filtration is followed since the sulfide that is not in H_2S form oxidized to elemental sulfur particles that will be removed by filtration. Where pH needs to be increased such as prior to ion exchange and disinfection, base chemicals such as sodium hydroxide, potassium hydroxide, and calcium hydroxide can be used. The preferred selection for pH adjustment will be discussed during preliminary design. The selection will also consider impact on desired levels for sodium and hardness.

5. Treatment Alternatives

Four main groundwater treatment alternatives have been identified, which include the removal of both barium and sulfide as well as produce potable water. These alternatives are as follows:

- Alternative 1 –Ion Exchange / Oxidation / Filtration / Disinfection
- Alternative 2 – Air Stripping / Ion Exchange / Disinfection
- Alternative 3 – Air Stripping / Reverse Osmosis / Disinfection
- Alternative 4 – Air Stripping / Lime Softening / Disinfection

These alternatives are described in detail in the following subsections. A summary table is provided at the end of this section.

The treatment alternatives are discussed with regards to the following criteria:

- Economic Impact
  - Capital Cost
  - Operations and Maintenance (O&M) Costs
- Environmental Impact
- Technical Impact
  - Effectiveness
  - Ease of Operation
  - Reliability
  - Space Requirements
- Social Impact (Health and Safety – OH&S)

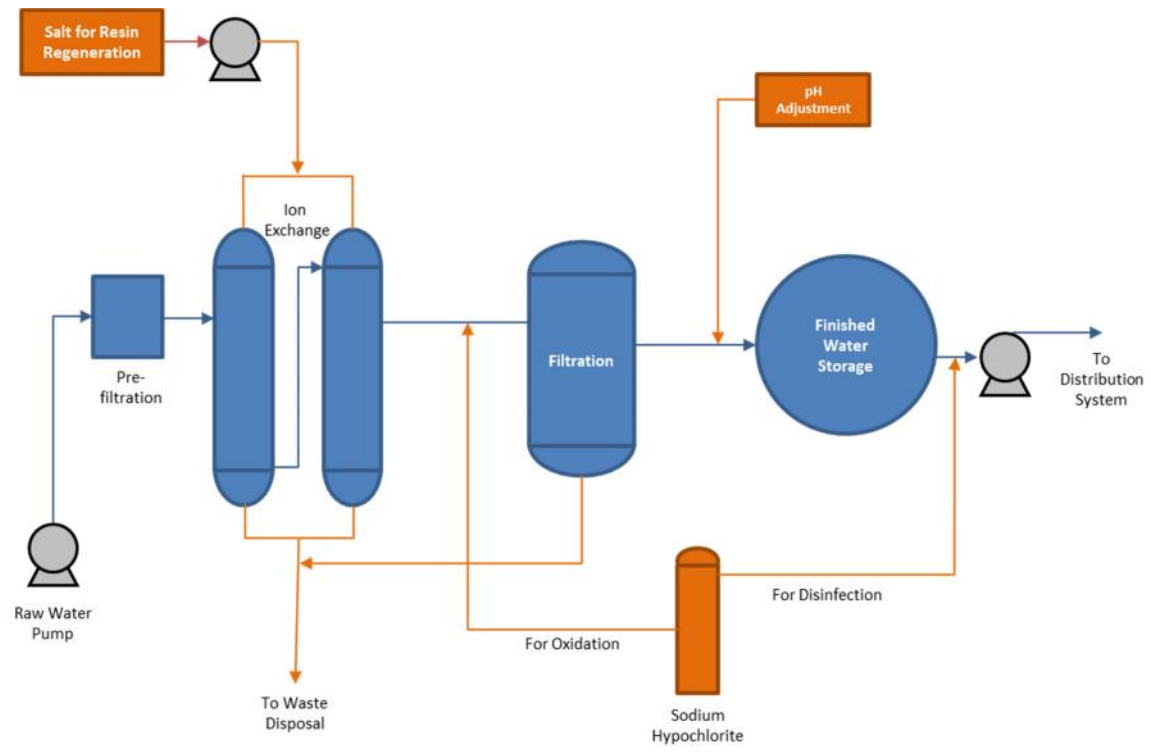
5.1 Alternative 1 – Ion Exchange / Oxidation / Filtration / Disinfection

Alternative 1 consists of the following treatment components:

- Groundwater is pumped to an ion exchange system to remove barium
  - A bag filter prior to ion exchange unite is used for pre-filtration
  - Ion exchange for soluble barium removal uses a charged cation resin to exchange acceptable ions from the resin. A brine addition system is provided for cation resin regeneration.
- It is then processed through an oxidation / filtration process for the removal of H_2S and filtration of sulfur particles
  - Sodium hypochlorite dosage is applied for the oxidation process to remove H_2S and prevent solids buildup to the surface of the media by keeping the surface of the media oxidized
  - The water is then filtered through a media based filtration vessel
- pH adjustment to increase pH to neutral levels.
- Sodium hypochlorite is added for secondary disinfection.

The process schematic is illustrated in Figure 3.

Figure 3 Alternative 1 Process Schematic



The type of ion exchange cation resin can be selected from various options, such as strong acid or weak acid resins; sodium-form, calcium-form, or hydrogen-form. The ion exchange resin should be selected to ensure long regeneration cycles and minimize waste. The type of the ion exchange resin used will have an impact on the sodium concentration, hardness in the finished water, and the strength of waste generated during resin regeneration. Further investigation on the type of resin to be selected will be conducted if this alternative is selected as the preferred option.

At this conceptual design level, based on the barium concentration removal requirement from 2.6 mg/L to 1.0 mg/L, the waste production is estimated to be less than 1%.

In general, high barium removal efficiency can be achieved through ion exchange. High sulfide removal efficiency can be achieved through oxidation/filtration. Filtration may also reduce the risk of exceedance of lead concentration in the finished water that is currently an issue with the existing well. With regards to hardness, this alternative does not lower hardness significantly.

Alternative 1 is summarized below based on the aforementioned criteria:

- Economic Impact
  - Capital Cost
    - Low capital cost for pre-filtration and ion exchange system
    - Medium capital cost for oxidation/filtration system
  - O&M Costs – Low to Medium due to energy usage for pumps and chemical usage for oxidation

- Environmental Impact – Potential negative impacts associated with restocking of salt and chemical supplies for resin regeneration, disinfection and pH adjustment as well as treatment and disposal of waste from the filtration and ion exchange processes.
- Technical Impact
  - Effectiveness - High barium and sulfide removal efficiency, and may potentially reduce high lead concentration risk.
  - Ease of operation – Requires resin regeneration and filter media backwash; however, fairly easy to operate
  - Reliability – Proven performance and technology
  - Space Requirements - Smaller footprint
- Social Impact – OH&S exposure risks due to chemical usage.

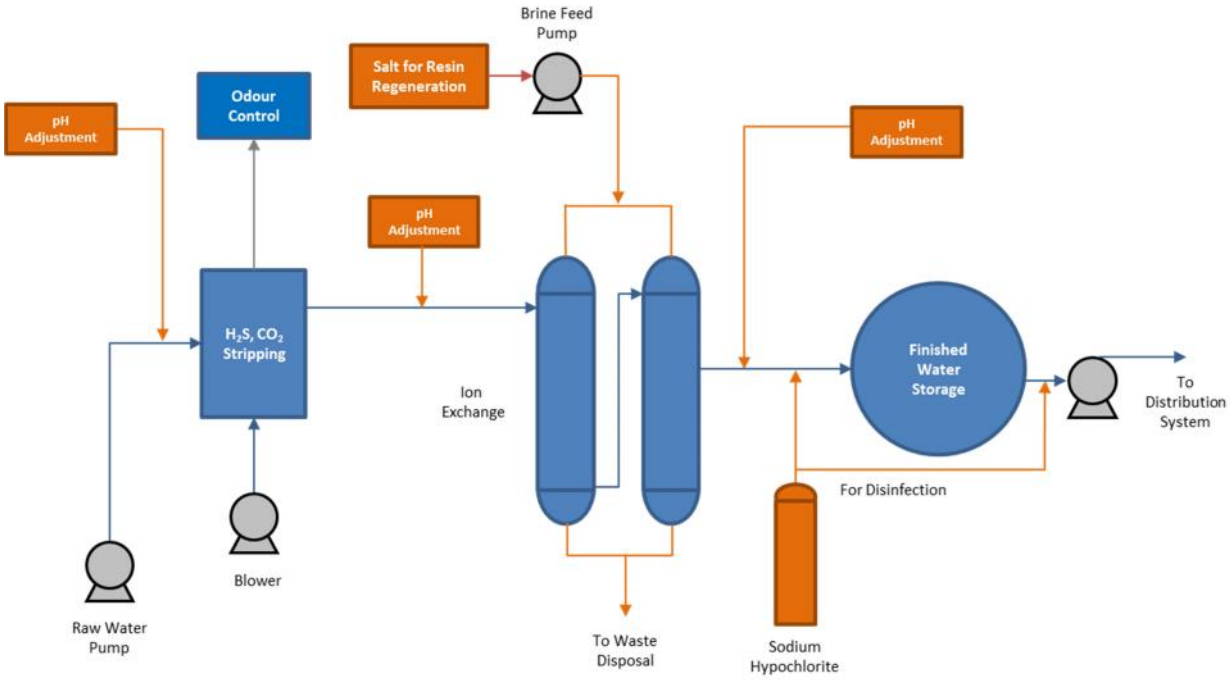
5.2 Alternative 2 – Air Stripping / Ion Exchange / Disinfection

Alternative 2 consists of the following treatment components:

- Groundwater is processed through the aeration system to undergo air stripping for the removal of H_2S
  - Adjust pH to desired level (between 5 and 6) for optimum H_2S stripping
  - Odour control equipment may be required since the air stripping process usually produces a hydrogen sulfide odour near the aerator
- Water is then pumped to an ion exchange system to remove barium
  - Ion exchange for soluble barium removal uses a charged cation resin to exchange acceptable ions from the resin. A brine addition system is provided for cation resin regeneration.
- pH adjustment to increase pH to neutral levels.
- Sodium hypochlorite is added for primary and secondary disinfection.

The process schematic is illustrated in Figure 4.

Figure 4 Alternative 2 Process Schematic



The descriptions of ion exchange technology and selections of the cation resin are the same as presented in Alternative 1.

At this conceptual design level, based on the barium concentration removal requirement from 2.6 mg/L to 1.0 mg/L, the waste production is estimated to be less than 1%.

In general, high barium removal efficiency can be achieved through ion exchange. High sulfide removal efficiency can be achieved through air stripping. With regards to hardness, this alternative does not lower hardness significantly.

Alternative 2 is summarized below based on the aforementioned criteria:

- Economic Impact
  - Capital Cost
    - Low capital cost for ion exchange system
    - Low capital cost for aeration system
  - O&M Costs – Medium due to energy usage for pumps and blowers
- Environmental Impact – Potential negative impacts associated with restocking of salt and chemical supplies for pH adjustment, resin regeneration and disinfection as well as treatment and disposal of waste from the ion exchange process. No waste production during H_2S removal. Odour control equipment may be required to remove stripped sulfides.
- Technical Impact
  - Effectiveness - High barium and sulfide removal efficiency
  - Ease of operation – Requires pH adjustment and resin regeneration; however, fairly easy to operate

        - Reliability – Proven performance and technology
        - Space Requirements - Smaller footprint
    - Social Impact – OH&S exposure risks due to chemical usage

5.3 Alternative 3 – Air Stripping / Reverse Osmosis / Disinfection

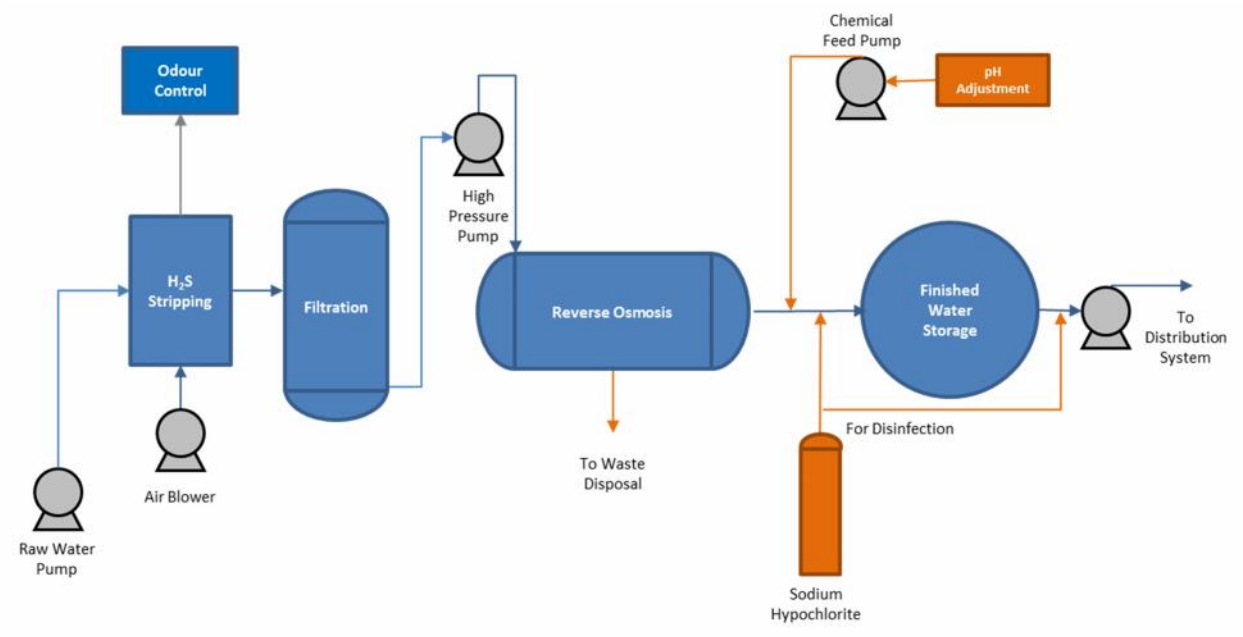
Reverse osmosis (RO) is a common membrane process that is not selective and will therefore remove most minerals including barium and bisulfide. Other common membrane processes include ultrafiltration (UF), electrodialysis (ED), and electrodialysis reversal (EDR). UF membrane porosity is too large for ion rejection, and therefore the UF process will not remove barium and sulfide in water. Electrodialysis (ED) and electrodialysis reversal (EDR) are effective treatment techniques, but due to their high capital and operating costs as well as a lack of installations in Ontario, these membrane processes are not considered further.

Alternative 3 consists of the following treatment components:

- Groundwater is processed through the aeration system to undergo air stripping/aeration for the removal of H_2S
    - Odour control equipment may be required since the air stripping process usually produces a hydrogen sulfide odour near the aerator
- Groundwater is then pumped to a filtration unit which provides preliminary treatment.
- A high pressure pump then transfers the pretreated water to the reverse osmosis columns to remove barium.
- pH adjustment to increase pH to neutral levels.
- The treated water then undergoes a remineralization process
- Sodium hypochlorite is added for primary and secondary disinfection.

The process schematic for this alternative is illustrated in Figure 5.

Figure 5 Alternative 4 Process Schematic



RO for soluble barium uses a semipermeable membrane and the application of pressure to a concentrated solution, which causes water, but not suspended or most dissolved solids (soluble barium), to pass through the membrane. Since RO has no selectivity, most minerals are removed. Remineralization of the finished water is required.

In general, high barium removal efficiency can be achieved. Higher H_2S removal efficiency is expected by a combination of the RO and air stripping processes. Filtration may also reduce the risk of exceedance of lead concentration in the finished water that is currently an issue with the existing well. With regards to hardness, this alternative includes remineralization which can increase hardness to desired levels.

Alternative 3 is summarized below based on the aforementioned criteria:

- Economic Impact
  - Capital Cost - High capital cost of RO units
  - O&M Costs - High due to energy usage for RO units, pumps, and blowers
- Environmental Impact – Low recovery rate causes high amount of process wastewater, potential negative impacts associated with restocking of chemical supplies for disinfection, pH adjustment as well as treatment and disposal of waste from filtration and RO processes. Odour control equipment may be required to remove stripped sulfides.
- Technical Impact
  - Effectiveness - High barium and sulfide removal efficiency, and may potentially reduce high lead concentration risk.
  - Ease of Operation – Requires filter media backwash, antiscalants, remineralization; hence, moderate ease of operation
  - Reliability – Proven performance and technology
  - Space Requirements - Smaller footprint

- Social Impact – OH&S exposure risks due to chemical usage

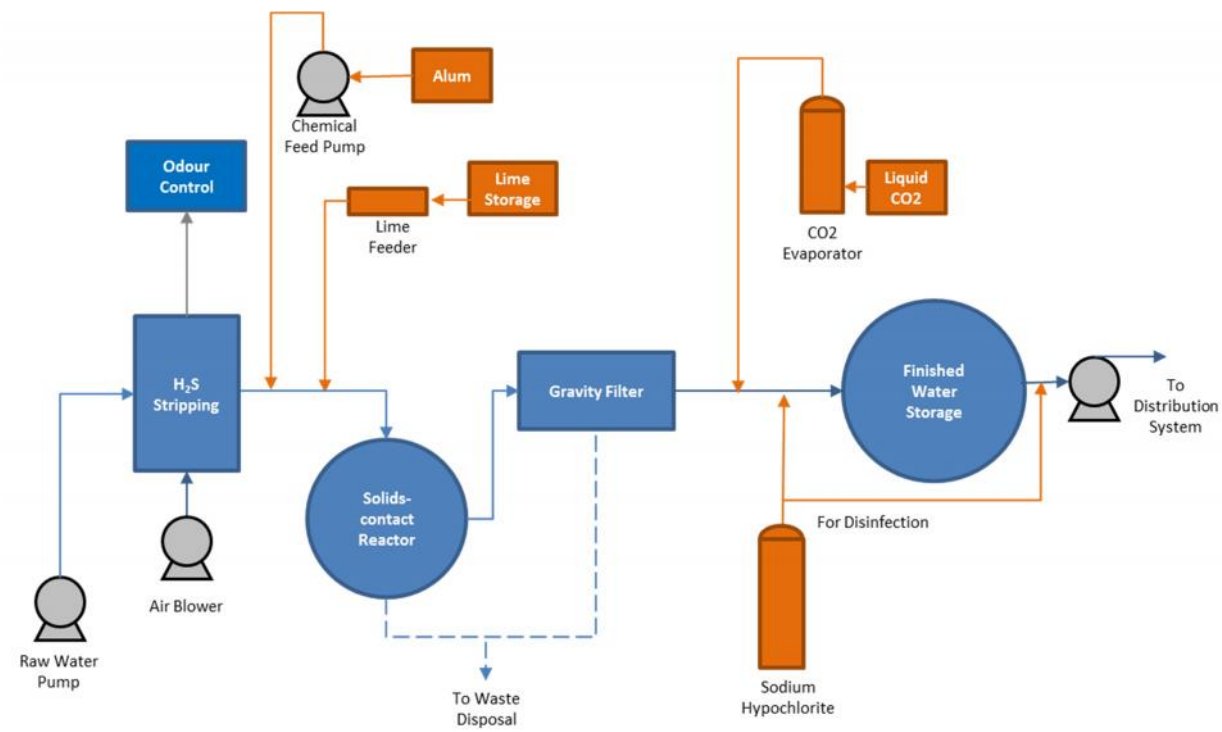
5.4 Alternative 4 – Air Stripping / Lime Softening / Disinfection

Alternative 4 consists of the following treatment components:

- Groundwater is processed through the aeration system to undergo air stripping/aeration for the removal of H_2S
  - Odour control equipment may be required since the air stripping process usually produces a hydrogen sulfide odour near the aerator
- Water then undergoes a typical lime softening process
  - Alum is added to flocculate the fine precipitated particles
  - Lime ($CaCO_3$) is added to remove barium by forming barium carbonate precipitants
  - The reaction takes place in a solids-contact reactor
  - A gravity multi-media filter is then used to remove solids from the water
- CO_2 recarbonation is used to adjust pH to neutral level and stabilize the water.
- Sodium hypochlorite is added for primary and secondary disinfection.

Figure 6 shows the process schematic for this treatment alternative.

Figure 6 Alternative 4 Process Schematic



Lime softening for soluble barium uses lime in sufficient quantity to raise the pH to about 10 to precipitate barium carbonate.

Typically high barium removal efficiency is achieved with this alternative. High sulfide removal efficiency can be achieved through air stripping. Filtration may also reduce the risk of exceedance of lead concentration in the finished water that is currently an issue with the existing well. However, hardness in water could be further reduced.

Alternative 4 is summarized below based on the aforementioned criteria:

- Economic Impact
  - Capital Cost – Medium to high capital cost for construction of lime softening system
  - O&M Costs - Medium due to energy usage for pumps and blowers
- Environmental Impact – potential negative impacts associated with chemical supplies as well as waste solids treatment and disposal.
- Technical Impact
  - Effectiveness - high barium and sulfide removal efficiency, and may potentially reduce high lead concentration risk.
  - Ease of Operation – requires handling of lime, and potential operational issues with buildup in solids contact reactor; hence low ease of operation.
  - Reliability – proven performance and technology
  - Space Requirements - larger footprint
- Social Impact – OH&S exposure risks due to chemical usage

A summary of the treatment alternatives is provided in Table 5-1 below.

Table 5-1 Evaluation Matrix for Alternative Treatment Options

Alternative	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
Process	Ion Exchange / Oxidation / Filtration / Disinfection	Air Stripping / Ion-exchange / Disinfection	Air Stripping / Reverse Osmosis / Disinfection	Air Stripping / Lime Softening / Disinfection
Description	• Ion exchange to remove barium • Hypochlorite addition to oxidize H_2S • Filtration through a media based filter • pH adjustment • Disinfection	• Reduce pH • Air stripping to removal H_2S • Ion exchange to remove barium • pH adjustment • Disinfection	• Air stripping to removal H_2S • Filtration through a media based filter • Reverse osmosis to remove barium • pH adjustment • Remineralization • Disinfection	• Air stripping to removal H_2S • Lime softening to remove barium • remove barium carbonate and sulfur particles • CO_2 recarbonation • Disinfection
Economic Impact	• Estimated capital cost: $2.1 M	• Estimated capital cost: $1.9 M	• Estimated capital cost: $3.0 M	• Estimated capital cost: $2.7 M
	• O&M Costs – Low to medium due to energy usage for pumps and chemical usage for oxidation	• O&M Costs – Medium due to energy usage for pumps and blowers	• O&M Costs - High due to energy usage for high pressure pumps in RO units, and blowers	• O&M Costs - Medium due to energy usage for pumps and blowers
Rating	Most Preferred	Most Preferred	Least Preferred	Less Preferred
Environmental Impact	• Potential negative impacts associated with restocking of salt and chemical supplies for pH adjustment	• Potential negative impacts associated with salt and chemical supplies	• Potential negative impacts associated with chemical supplies	• Potential negative impacts associated with chemical supplies
	• Small volume wastewater production	• Small volume wastewater production from ion exchange • No waste production during H_2S removal	• Low recovery rate causes high amount of process wastewater	• High amount of process waste solids
		• Odour control equipment may be required to remove stripped sulfides	• Odour control equipment may be required to remove stripped sulfides	• Odour control equipment may be required to remove stripped sulfides
Rating	Less Preferred	Less Preferred	Least Preferred	Least Preferred
Technical Impact	• Effectiveness - High barium and sulfide removal efficiency, potential reduce high lead concentration risk.	• Effectiveness - High barium and sulfide removal efficiency	• Effectiveness - High barium and sulfide removal efficiency, potential reduce high lead concentration risk.	
	• Ease of operation – Requires resin regeneration and filter media backwash; however, fairly easy to operate	• Ease of operation – Requires pH adjustment and resin regeneration ; however, fairly easy to operate	• Ease of Operation – requires pH adjustment pre-filtration, antiscalants, remineralization; hence, moderate ease of operation	• Ease of Operation – requires handling of lime, and potential operational issues with buildup in solids contact reactor; hence low ease of operation
	• Reliability – Proven performance and technology			
	• Space Requirements - Smaller footprint	• Space Requirements - Smaller footprint	• Space Requirements - smaller footprint	• Space Requirements - larger footprint
Rating	Most Preferred	Less Preferred	Less Preferred	Least Preferred
Social Impact	• OH&S exposure risks due to chemical usage			
Overall Alternative Rating	Most Preferred	Less Preferred	Least Preferred	Least Preferred

6. Cost Estimate on the Preferred Alternative

Based on a preliminary evaluation, the preferred treatment technology alternative for Lynden FDL Well-02 is Alternative 1, Oxidation / Filtration / Ion Exchange / Disinfection. This treatment process has the benefit of being able to treat the groundwater from both wells, which will optimize operational flexibility if desired by the City.

The estimated preliminary high level capital cost for the preferred alternative is $2.1 million. A breakdown of this preliminary cost estimate is provided in Table 6-1 below.

Table 6-1 Estimated Cost Breakdown for Alternative 1 – Oxidation / Filtration / Ion Exchange / Disinfection

Description	Estimated Cost
Buildings, slab-on-grade, complete with HVAC systems, including construction	$250,000
Site works, General requirements	$250,000
In-ground reservoir including chlorine contact tank	$100,000
Pilot testing	$35,000
Oxidation/Filtration – Ion exchange units including installation	$310,000
Well pump, starter and discharge pipe	$500,000
Sub Total	$1,445,000
Engineering (15%) + Contingency (30%)	$650,000
Total Preliminary Estimated Cost	$2,095,000
Estimated Annual Operating Cost (Media and Salt)	$4,000

7. Waste Stream Disposal

All of the alternatives discussed above require waste disposal. However, Alternatives 1 and 2 are most preferred in terms minimizing of waste disposal. Alternative 3 includes reverse osmosis, which produces a larger amount of wastewater due to low recovery rate. Alternative 4, which includes lime softening, produces not only wastewater, but also waste solids. Waste disposal options for the preferred alternative are discussed below.

Since the target of the ion exchange process is to reduce the barium concentration from 2.6 mg/L to lower than 1.0 mg/L, the regeneration cycle is longer than ion exchange used for softening. As a result, it is estimated that 0.5 m^3 or less of raw water per day will be disposed as brine from the ion exchange process. The calculations for the waste stream are presented in Appendix B. Brine is the liquid residual generated during the ion exchange process. It contains high concentrations of sodium chloride and barium, which can either be disposed of without any additional treatment or minimized prior to disposal. The latter is referred to as brine minimization and includes treatment steps such as brine concentrators and crystallizers by either solar or thermal evaporators in order to reduce the volume of brine discharge and recover more water.

Conventional brine disposal methods are surface water discharge, sewer discharge, deep well injection, evaporation ponds, and land application. (Brandhuber Ph., *et al,* 2008). The associated benefits, constraints, region appropriateness, land requirements, and permitting requirements for these conventional disposal methods are summarized in Appendix C.

The following three waste disposal options are considered for Lynden:

1. Since the well location is far away from city's sanitary sewer system, one option is to store the brine waste on site and truck it to the City's nearest WWTP i.e. Woodward Water Pollution Control Plant (40 kms away) or to the City of Brantford Water Pollution Control Plant (19 kms away). Wastewater from ion exchange is estimated to be 0.5 m^3/day or less.

2. On site treatment with precipitation and settling to remove barium, and dilute the effluent with fresh water to decrease the concentration of chloride to a desirable level. Discharge the diluted water to nearby surface water or constructed filter bed system, and transport the settled solids to landfill. A preliminary search has identified a small creek located about 150 meters southeast of the well. The creek flows down south and joins Dunmark Lake at the City of Hamilton's boundary.

3. Given that the main components in the waste stream are mainly chloride and barium, submit an application for permit to the MOE for the disposal of the waste stream directly to surface water. Based on the Ontario Provincial Water Quality Objectives (PWQOs), there are no guideline objectives or limits for chloride and barium concentrations for discharge to surface water in Ontario. Therefore, prior consultation with MOE should be undertaken to obtain confirmation of acceptance.

Option 2, on-site treatment and disposal, is preferred for the waste stream disposal. The treatment process involves precipitation of barium, and dilution of sodium chloride prior to disposal. Further investigation is required on the acceptable waste stream disposal method.

8. Next Steps

A conference call is requested with Operations staff to discuss the alternatives and the preferred option. Following this conference call, the ESR will be documented to include the identification and evaluation of the alternatives, as well as the selection of the preferred alternative.

Following the confirmation of the preferred option, an on-site pilot test will be coordinated to ensure the removal efficiency for sulfide and barium, as well as address any other concerns currently affecting the existing well. The pilot test will also confirm filter cycles and associated waste amounts.

8.1 Pilot Testing

A detailed pilot study proposal has been conducted by AdEdge Technologies, an equipment supplier for the selected treatment alternative, ion exchange – oxidation / filtration – disinfection. The process equipment and proposal for the pilot testing is presented in Appendix D. The objectives of the pilot study are:

1. Demonstrate barium reduction with the goal of consistently achieving less than 1.0 mg/L of Barium.

2. Demonstrate sulfide reduction with the goal of consistently achieving less than 0.05 mg/L of sulfide.

3. Demonstrate Lead and Copper in treatment effluent is not elevated during the pilot testing.

4. Evaluate the corrosivity of the water source and compare with the treated water effluent utilizing the Langelier Saturation Index and Ryznar Stability Index.

5. The pilot operating conditions shall be equal to the full scale or present more challenging conditions in the pilot with respect to the following design parameters.

- Filtration Loading rate
- Media bed depth

The pilot testing will require the City's support including provision of:

1. Temporary well pump installed,
2. Temporary power supply, and
3. Weather protected environment.

The pilot testing can start on-site as early as January 2014.

9. References

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Appendix A

Intelligent Thinking.....Clean Water

AdEdge AD26 Oxidation / Filtration

For Hydrogen Sulfide Reduction

Effective Removal of Hydrogen Sulfide

Triplex APU26 Skid Mounted System

Designed and built specifically for well head treatment, AD26 systems are engineered as stand alone systems for the removal of hydrogen sulfide.

These systems are ideal for eliminating nuisance parameters and improving overall water quality. Our integrated oxidation and filtration technology utilizes a proprietary, highly active NSF 61 Certified manganese dioxide media packaged in a pre-engineered skid mounted treatment system for simple installation and use. The targeted contaminants are co-precipitated and filtered in the media bed, which is periodically backwashed.

Whether you need to comply with the secondary contaminant standard or simply want to improve the quality of your water, the AD26 system may be the best solution.

ADVANTAGES

Hydrogen sulfides are common in groundwater environments and can produce unpleasant drinking water. The AdEdge AD26 Systems offer the following advantages for achieving compliance with these contaminants:

- *Much higher filtration rates in (6-10 gpm/sq ft) compared to typical manganese greensand (2-3 gpm/sq ft) resulting in significantly smaller systems and footprint*
- *Smaller systems and smaller footprints save you money on building size and real estate*
- *Low capital costs compared to alternatives such as greensand*
- *More reliable and efficient removal of hydrogen sulfides than conventional approaches using other medias*
- *Superior handling properties, stability, and NSF 61 certification - no permanganate or coagulant addition needed*
- *Custom designed with options to effectively treat your water parameters.*
- *Enhanced kinetics that allow short contact times*
- *Long life typically over 10 years before replacement*
- *Performance over wide range of incoming water quality*
- *Ideal complement to granular ferric oxide (GFO) adsorption systems that results in longer media life and lower operating costs*
- *High catalytic / oxidation activity for co-precipitation*

Q: How does the system remove hydrogen sulfides?

A: *Through mechanisms of oxidation and co-precipitation, these contaminants are efficiently removed in the AD26 media beds. Some manganese adsorption is also occurring. Depending on the specific water chemistry, the system can achieve treatment efficiencies for these contaminants to meet the secondary drinking water standards.*

Q: How does it differ from other processes such as Manganese Greensand, Pyrolox, or Water Conditioning?

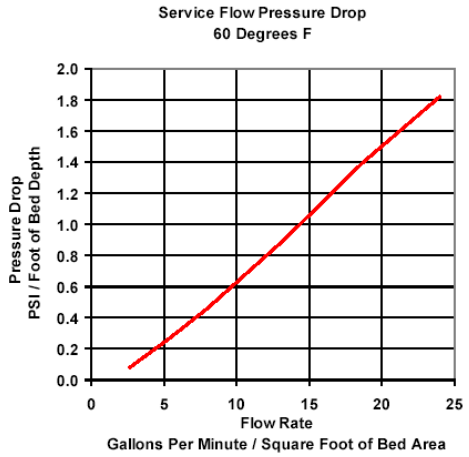
A: *The media is a NSF 61 certified solid phase oxidation mineral. The systems have a small footprint compared to other technologies as design flow rates are typically 8-12 gpm / square foot of bed area. The technology does not require a long contact time, coagulants, or permanganate addition /regeneration like greensand and other oxidation processes. No brine or salt is needed and the process does not generate hazardous waste.*

Q: Is chlorine needed for the system and does the media need replacement?

A: *A low hypochlorite dose is recommended for optimal performance of the AD26 systems. It enhances the removal process, improves longevity, and keeps the surface of the media oxidized to prevent buildup of solids. Media life is typically 10 years before replacement.*

Q: How do I determine the best way to achieve my treatment goals for my particular site?

A: *Begin first by obtaining a complete site specific water profile from a qualified lab. This information can then be submitted to AdEdge technical support to discuss your application, equipment sizing, and costs.*



Operating Conditions	
pH Range	*6.5 – 9.0*
Treatment Goals	*< 0.1 mg/L Hydrogen Sulfide*
Service Flow Rate	*8-12 gpm / Sq Ft*
Backwash Flow Rate	*20 gpm / Sq Ft*
Bed Expansion	*20-30% typical*
Pressure Drop	*2-3 psig @ 9 gpm / sq ft*
Oxidant	*Hypochlorite feed for best results*
Oxidant Contact Time	*15 - 30 seconds*
Typical Oxidant Dosage	*0.5 – 2.0 ppm*
Backwash Frequency	*Site Specific (1-3X per week typical)*
Media Life Expectancy	*Site specific; typically 10+ years*

Q: What experience has AdEdge had with hydrogen sulfide removal?

A: *AdEdge has implemented over 150 full scale AD26 systems for Public Water Systems and multiple industrial and remediation project installations. One of our most notable projects is the Lake Josephine Community in Florida. The water is pumped from the groundwater feed pumps and to the three vessel AD26 system following in-line hypochlorite (chlorine) injection. Hypochlorite solution is fed in-line through a computer controlled metering and feed system capable of real time chlorine residual measurement and control. Hydrogen sulfides are oxidized and filtered/adsorbed with the proprietary AD26 catalytic media based system. Contact AdEdge to discuss your application.*

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Project Profile

Aqua PA – Honesdale, Weidner Well, PA
Manganese and Sulfide Removal

Background

In October 2009, AdEdge Water Technologies, LLC was contacted by Entech Engineering to provide a manganese and sulfide removal system for the Aqua Pennsylvania Honesdale Weidner Well. The existing water system consisted of one well feeding into a centralized distribution system with a maximum capacity of 270 gpm. The raw water has an average manganese level of 0.2 mg/L well above the EPA secondary MCL of 0.05 mg/L and sulfide levels of 17 mg/L. The system was started up in February 2011.

Treatment System

The AdEdge treatment system featured a skid-mounted AD26 oxidation and filtration package unit sized for a maximum design flow rate of 270 gpm. The model APU26-4860CS-3-AVH utilizes AdEdge's NSF 61 certified AD26 manganese dioxide media for the removal of manganese and sulfides. Prior to the treatment system, sodium hypochlorite is injected into the raw water to oxidize the manganese.

The system is equipped with automated control valves and harness, a central control panel with a PLC and a color user interface screen. System features also include differential pressure switches, flow sensors and totalizers and sample ports for a complete functioning packaged unit. Each of the three 48-inch diameter treatment vessels contains 37 cubic feet of AdEdge's AD26 oxidation filtration media. Backwashing of the treatment vessels occurs twice a week during the early morning hours and is automated by the PLC. Backwash water is flushed into a sanitary sewer for safe disposal. Once treated, the water exits the system and goes into a 250,000 gallon storage tower before distribution to the end users.

Performance

The system was started up and commenced in February 2011. Since the system began operation, iron and manganese levels are at non-detectable levels and sulfides are at non-detectable levels.

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Project Profile

Aqua FL – Lake Josephine Community, FL
230 gpm Oxidation/Filtration System
Hydrogen Sulfide Removal

Background

In January 2010, AdEdge Water Technologies, LLC was contacted by Aqua Utilities Florida to provide a hydrogen sulfide removal system for the Lake Josephine Community located in Highlands County, Florida. The existing water system consisted of two wells feeding into a centralized distribution system with a maximum capacity of 230 gpm being consumed by a population of 1,250 persons. The raw water well water contains high levels of hydrogen sulfide which produces objectionable odors in the customers' tap. The treatment goal for the Lake Josephine system is reduce the levels of hydrogen sulfide to the non-detectable odor threshold <0.05 mg/L.

Treatment System

The AdEdge treatment system features a skid-mounted AD26 oxidation and filtration package unit sized for a maximum design flow of 230 gpm. The model APU26-4260CS-3-AVH utilizes AdEdge AD26 media in a three vessel carbon steel configuration in parallel. The system is equipped with automated control valves and harness, central control panel with programmable logic controller (PLC) and a color user interface screen. System features also include differential pressure switches, control panel and local gauges, flow sensors and totalizers, and a central hydraulic panel with sample ports for a complete functioning packaged unit. Each 42-inch diameter treatment vessel contains 30 cubic feet of AdEdge AD26 oxidation/filtration media. AdEdge AD26 is a NSF 61 certified manganese dioxide media.

	Parameters	
pH	7.67	units
Total As	no data	mg/L As
As(III)	no data	mg/L (if known)
Total Sulfides	no data-odor	mg/L (total sulfides)
Hardness	185.0	mg/L (as CaCO3)
Alkalinity	170.0	mg/L (as CaCO3)
Calcium	no data	mg/L Ca
Magnesium	no data	mg/L Mg
Silica	no data	mg/L SiO2
Phosphate	no data	mg/L P04
Suspended Solids	1	mg/L TSS
Iron	0.04	mg/L Fe
Manganese	0.03	mg/L Mn
TOC		mg/L TOC

The AdEdge hydrogen sulfide removal system fully integrates with the existing chlorine chemical feed system to oxidize the sulfide ion to elemental sulfur, which precipitates out of solution and it is then filtered through the media. In addition to the hydrogen sulfide treatment system, AdEdge is providing a backwash recycle system. The backwash recycle system reclaims 100% of the backwash waste water and removes the captured suspended solids as a semi-solid sludge that can be disposed of in a non-hazardous landfill. Backwashing of the treatment system occurs two or three times a week depending on the water usage.

Performance

The system was started up and commenced in November 2011. Since the system began operation, the hydrogen sulfide concentration has been reduced to below the non-detectable odor threshold of <0.05 mg/L.

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Project Profile

Aqua FL – Leisure Lakes Community, FL
100 gpm Oxidation/Filtration System
Hydrogen Sulfide Removal

Background

In January 2010, AdEdge Water Technologies, LLC was contacted by Aqua Utilities Florida to provide a hydrogen sulfide removal system for the Leisure Lakes Community located in Highlands County, Florida. The existing water system consisted of two wells feeding into a centralized distribution system with a maximum capacity of 100 gpm being consumed by a population of 632 persons. The raw water well water contains high levels of hydrogen sulfide which produces objectionable odors in the customers' tap. The treatment goal for the Leisure Lakes Community system is reduce the levels of hydrogen sulfide to the non-detectable odor threshold <0.05 mg/L.

Treatment System

The AdEdge treatment system features a skid-mounted AD26 oxidation and filtration package unit sized for a maximum design flow of 100 gpm. The model APU26-3660CS-2-AVH utilizes AdEdge AD26 media in a two vessel carbon steel configuration in parallel. The system is equipped with automated control valves and harness, central control panel with programmable logic controller (PLC) and a color user interface screen. System features also include differential pressure switches, control panel and local gauges, flow sensors and totalizers, and a central hydraulic panel with sample ports for a complete functioning packaged unit. Each 36-inch diameter treatment vessel contains 22 cubic feet of AdEdge AD26 oxidation/filtration media. AdEdge AD26 is a NSF 61 certified manganese dioxide media.

	Parameters	
pH	7.67	units
Total As	no data	mg/L As
As(III)	no data	mg/L (if known)
Total Sulfides	no data-odor	mg/L (total sulfides)
Hardness	180.0	mg/L (as CaCO3)
Alkalinity	154.0	mg/L (as CaCO3)
Calcium	no data	mg/L Ca
Magnesium	no data	mg/L Mg
Silica	no data	mg/L SiO2
Phosphate	no data	mg/L P04
Suspended Solids	212	mg/L TSS
Iron	0.17	mg/L Fe
Manganese	0.01	mg/L Mn
TOC	no data	mg/L TOC

The AdEdge hydrogen sulfide removal system fully integrates with the existing chlorine chemical feed system to oxidize the sulfide ion to elemental sulfur, which precipitates out of solution and it is then filtered through the media. In addition to the hydrogen sulfide treatment system, AdEdge is providing a backwash recycle system. The backwash recycle system reclaims 100% of the backwash waste water and removes the captured suspended solids as a semi-solid sludge that can be disposed of in a non-hazardous landfill. Backwashing of the treatment system occurs two or three times a week depending on the water usage.

Performance

The system was started up and commenced in April 2012. Since the system began operation, the hydrogen sulfide concentration has been reduced to below the non-detectable odor threshold of <0.05 mg/L.

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Project Profile

Lummi Island, Washington
Arsenic, Iron, Sulfide Treatment System

Background

In mid 2004, AdEdge Technologies Inc. (AdEdge) was selected by Miller Water Association and Anvil Corporation to assist in the design of a full-scale arsenic treatment project for this small community. Arsenic levels are alarmingly high at 0.18 mg/l, 18 times higher than the new Federal standard of 0.010 mg/l. In addition to arsenic, many of the homeowners using the water objected to the sulfide odor resonating from the water. AdEdge worked closely with Anvil Corporation and the Homeowners Association to provide a suitable treatment train that would achieve the treatment objectives in accordance with the Washington Dept. of Health (WDOH) guidelines for an arsenic treatment.

Treatment System

The AdEdge arsenic treatment system consists of two main components: an iron and sulfide removal system and an arsenic adsorption system. Based on the high pH, the site chose to utilize an innovative CO_2 gas membrane injection system for reducing pH of the incoming water (typically 8.6-8.7) to 7.1 prior to treatment for enhancing performance and media life. This pH adjustment system is being used as an alternative to strong acids such as hydrochloric and sulfuric. The first component in the treatment train is the iron/sulfide removal system, which consists of a modular AD26 system using a 12-inch diameter vessel and AD26 media. The AD26 catalytic media oxidizes and filters iron/sulfide from the water supply. The second component is a twin vessel modular arsenic adsorption system in series rated for 10 gallons per minute (gpm). The vessels are configured in a lead / lag arrangement. Groundwater is pumped from the water supply well pump through the AD26 pre-treatment unit, then through the two 14-inch diameter arsenic adsorbers before entering the 2,400-gallon storage tank. The adsorbers each contain Bayoxide E33 adsorption media. Bayoxide E33 is a granular ferric oxide (GFO) media that has been in commercial use since 1999. AdEdge has used GFO media in over 50 small community system applications and in over 1,000 residential applications.

pH **	8.6-8.7	
Total As **	0.180	mg/L As
As(III)	no data	mg/L
Alkalinity	180	mg/L @ CaCO3
Hardness **	100	mg/L @ CaCO3
Silica **	no data	mg/L SiO2
Phosphate **	<0.1	mg/L P04
Sulfate **	85.0	mg/L SO4
Iron **	0.03	mg/L Fe
Manganese **	0.00	mg/L Mn

Performance

The system is installed with automatic controls, backwashing features, pressure gauges, and sample ports for a complete arsenic treatment module. Total gallon throughput and flow rate for each unit is measured continuously with dedicated flow totalizing meters. The AdEdge iron/manganese/sulfide and adsorption systems do not require any chemicals or regeneration, and the process does not generate liquid or solid hazardous waste. The system was installed in October 2004 and has been operating at 1,800 gallons per day with arsenic levels below detection for over 10 months.

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Project Profile

Aqua FL – Sebring Lakes Community, FL
200 gpm Oxidation/Filtration System
Hydrogen Sulfide Removal

Background

In January 2010, AdEdge Water Technologies, LLC was contacted by Aqua Utilities Florida to provide a hydrogen sulfide removal system for the Sebring Lakes Community located in Highlands County, Florida. The existing water system consisted of one well feeding into a centralized distribution system with a maximum capacity of 200 gpm being consumed by a population of 298 persons. The raw water well water contains high levels of hydrogen sulfide which produces objectionable odors in the customers' tap. The treatment goal for the Sebring Lakes Community system is reduce the levels of hydrogen sulfide to the non-detectable odor threshold <0.05 mg/L.

Treatment System

The AdEdge treatment system features a skid-mounted AD26 oxidation and filtration package unit sized for a maximum design flow of 200 gpm. The model APU26-4260CS-3-AVH utilizes AdEdge AD26 media in a three vessel carbon steel configuration in parallel. The system is equipped with automated control valves and harness, central control panel with programmable logic controller (PLC) and a color user interface screen. System features also include differential pressure switches, control panel and local gauges, flow sensors and totalizers, and a central hydraulic panel with sample ports for a complete functioning packaged unit. Each 42-inch diameter treatment vessel contains 30 cubic feet of AdEdge AD26 oxidation/filtration media. AdEdge AD26 is a NSF 61 certified manganese dioxide media.

	Parameters	
pH	7.62	units
Total As	no data	mg/L As
As(III)	no data	mg/L (if known)
Total Sulfides	no data-odor	mg/L (total sulfides)
Hardness	113.0	mg/L (as CaCO3)
Alkalinity	108.0	mg/L (as CaCO3)
Calcium	no data	mg/L Ca
Magnesium	no data	mg/L Mg
Silica	no data	mg/L SiO2
Phosphate	no data	mg/L P04
Suspended Solids	138	mg/L TSS
Iron	0.18	mg/L Fe
Manganese	0.00	mg/L Mn
TOC	no data	mg/L TOC

The AdEdge hydrogen sulfide removal system fully integrates with the existing chlorine chemical feed system to oxidize the sulfide ion to elemental sulfur, which precipitates out of solution and it is then filtered through the media. In addition to the hydrogen sulfide treatment system, AdEdge is providing a backwash recycle system. The backwash recycle system reclaims 100% of the backwash waste water and removes the captured suspended solids as a semi-solid sludge that can be disposed of in a non-hazardous landfill. Backwashing of the treatment system occurs two or three times a week depending on the water usage.

Performance

The system was started up and commenced in November 2011. Since the system began operation, the hydrogen sulfide concentration has been reduced to below the non-detectable odor threshold of <0.05 mg/L.

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Project Profile

Wallenpaupack South Elementary School
Newfoundland, Pennsylvania
Sulfide Removal System

Background

In the Spring of 2009, AdEdge Technologies was contacted by McGoey, Hauser, & Edsall Consulting Engineers to provide a sulfide removal system for Wallenpaupack South Elementary School in Newfoundland, Pennsylvania. Prior to the treatment system, the school experienced sulfide levels of 630 ppb which created a foul taste and smell in the water for the 350 students and faculty at the school. The AdEdge sulfide removal system integrated fully with the existing chlorination system which disinfected the water prior to treatment.

Treatment System

The AdEdge treatment featured a skid-mounted AD26 oxidation and filtration package unit sized for a maximum design flow rate of 45 gpm. The model APU26-2162CO-3-PLC utilizes AdEdge AD26 MnO2 media in a three composite vessel configuration in series. The treatment system utilizes a programmable logic controller (PLC) to perform the automated functions needed for proper operation of the control valves including flow rate, total gallons processed, and backwashing. System features also differential pressure switches, control panel and local gauges, flow sensors & totalizers, and a central hydraulic panel with sample ports for a complete functioning packaged unit. Backwashing of the treatment system occurs every two days. Each 21-inch diameter treatment vessel contains approximately 6 cubic feet of AdEdge AD26 oxidation filtration media.

Priority Parameters		
pH **	8.95 - 9.25	average
Total As **	no data	mg/L As
As(III)	no data	mg/L (if known)
Sulfides**	0.459 - 0.625	mg/L average
Hardness **	11	mg/L @ CaCO3
Alkalinity **	138.0	mg/L @ CaCO3
Silica **	no data	mg/L SiO2
Phosphate **	no data	mg/L P04
Sulfate **	no data	mg/L SO4
Iron **	0.014 - 0.092	mg/L Fe average
Manganese **	0.02	mg/L Mn

Performance

The system was installed and began operation in August 2009. Since the system began running, Dick Smith, Head Custodian of Wallenpaupack South Elementary School, says “we have not had any smell or taste in the water at all.”

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Appendix B

ADIX-Cation Resin - 8% Crosslink Regen Characteristics AdEdge

Hamilton, ON

Note: Water Pressure Unknown
Barium Reduction, No Backwash due to Ba Scale

Daily Usage (gallons / day)	14,400	gpd	Prepared:	11/27/2013
Service Flow Rate	50	gpm		
Number of vessels	2		Alternating System with 2 total Vessel:	
Tank Diameter (inches)	30	in		
Tank Area (sqft)	4.9	sqft		
Resin Volume (cuft / vessel)	15	cuft/vessel		
Resin Depth (inches)	37	in		
salt dose (lbs of salt / cuft of resin)	15	lb/cuft		

Regeneration Design (counter current flow)

	Flow gpm	Time Minutes	Volume Gallons	Bed Volume	Brine Strength
Saturated brine - Up flow	**2.8**		85.0		26%
Dilution Water - Up flow	4.1		123.6		0%
Sub-Total Brine Cycle	6.9	30.0	208.6	1.9	10.6%
Slow rinse - Up flow	4.1	60.0	247.2	2.2	
Backwash (4 gpm / sqft) - Up flow	20.0	0.0	0.0	0.0	
Fast rinse - Down flow	20.0	25.0	500.0	4.4	
Sub-Total Rinse Cycles		85.0	747.2	6.6	
Brine Fill (1 gallon water = 1.13 gallons of brine)	5.0	16.0	76.0		
Vessel Totals		131	956		
Waste Water Generated For System (all vessels)			1912	Gallons	
Waste Generated Annually			34,887	Events per Year x Gallons	

Eduction or Pump Make and Model for Above Calc	1700-6	Fleck
Design Pressure for Eduction	40	psi

Scenario 1

Note:	1 Vessel		
% Bypass Flow Compared to Total Flow	0%		
Bypass Flow	0	gpd	
Treatment Flow	14,400	gpd	
% Bypass Flow Compared to Treatment Flow	0%		
Influent Level	2.6	mg/L as Ba	
Treatment Goal	1	mg/L as Ba	
Resin Capacity (BV)	1,600	BV	
Gallons to Regeneration - per vessel	179,520	gal	**Note: 144,000 gal is 10 days - basis**
Gallons to Regeneration - per system	359,040	gal	
Days to Regeneration, REQUIRED	24.93	days	
Days to Regeneration, SUGGESTED	**20.00**	days	**Note: 10 Days per vessel**
Salt Usage per Regen - per vessel	225	lbs	
Salt Usage per Regen - per system	450	lbs	
Monthly Salt Usage - per vessel	338	lbs	
Monthly Salt Usage - per system	675	lbs	
Yearly Salt Usage, System	8100	lbs	
Yearly Salt Usage, System	4.05	Tons	
Salt Price per Pound	0.12	$/lb	
Yearly Salt Cost	$ 972		

File Name: IX_Upflow Calc_031813.xls

Appendix C

Conventional Brine Disposal Technologies

All of these technologies have been implemented in full scale industrial and municipal applications (Brandhuber Ph., et al, 2008).

Table Conventional Brine Disposal Technologies

Disposal Option	Description	Benefits and Constraints	Region Appropriateness	Land Requirements	Permitting Requirements
Surface Water Discharge	Direct disposal to surface water such as lakes, reservoirs, or rivers	Low capital and O&M costs. Detailed analysis required to obtain permit from authority.	Anywhere surface water body is available.	Small	Required.
Sewer Discharge	Direct disposal to sanitary sewer system.	Cost-effective if existing sewers and wastewater treatment plants nearby.	Anywhere sewer capacity is available.	Small	Industrial waste discharge permit required.
Deep Well Injection	Brine injected into porous subsurface rock formation.	Economy of scale required. Meticulous site evaluation needed. High capital cost	Dependent on local geology.	Land required for injection well field.	Underground injection control permit required.
Evaporation Ponds	Pond that utilizes solar energy to reduce water content in brine solution.	Very reliable, little mechanical equipment required, economical for small volumes.	Dry climates characterized by high evaporation rates; areas where large quantities of land available at low cost.	Large	Monitoring may be required.
Land Application	Full strength or dilute brine sprayed onto land as irrigation water.	Backup disposal method typically needed. Limited types of vegetation can grow with high salinity water.	Anywhere application exists.	Large	Monitoring is typically required.

Appendix D

City of Hamilton, ON
Sulfide and Barium Reduction

Site Profile and Proposal

Contact Information

Customer / Utility:	City of Hamilton, ON	**Date:**	**12/4/2013**
Site or Well Identity / Location:	Lynden Well FDL-02	**AdEdge Rep:**	Ed Broeders - H2flow 909-660-9775 ext 28
Local Engineer / Firm:	Genivar, Inc	**Rep Email:**	ed@h2flow.com
Other Pertinent Notes:		**Site Contact:**	Jianrong Liu - Genivar 905-4745-8727
Operator:	TBD	**Site Email:**	jianrong.liu@genivar.com
Target Date for Installation:	TBD	**Alternate Contact:**	
Treatment Goals or Target Parameters:	Barium < 1 mg/L, Sulfide < 0.1		crm

System Parameters / Site Specific

System Type / Application:	Municipality	(municipal, school, industrial, other)
Population Served:	500	(estimated)
Number of Connections:	TBD	(for municipal applications)
Number of Wells to be treated:	1	(# wells to be treated)
Design Flow (GPM):	50 us gpm - 4.7 L/s	(max design flow)
Ave Flow (GPM):	50 us gpm - 4.7 L/s	(typical)
Adedge Sizing Basis (max GPM):	50 us gpm - 4.7 L/s	(for use by Adedge)
Daily Water Usage:	14400 gpd - 55 cubic meters	(daily demand)
Annual Water Usage:	5,184,000 gallons - 19,700 m3	(estimated annual)
Existing Treatment or disinfection?:	Chlorination	
Equipment available for offloading:	TBD	
Pump Operation / Pressure:	TBD	
Electrical Power Availability:	TBD	
Atm Storage Tank Present / Size:	TBD	
Hydropneumatic Tank Present / Size:	TBD	
Building present/ available space:	TBD	
Any additives ie, phosphates, fluoride:	TBD	
Discharge Options available:	TBD	

Site Specific Notes:

Designed based on information provided to AdEdge

Process Flow:

Well >> APUIX >> Chlorination >> APU26 >> Storage >> Distribution

- APUIX Barium treatment operates with one vessel offline.
- Price based on exchange rate of USD to CAD 1.05
- Non-detect levels not defined
- Backwash with treated water from pressurized source

Site Shipping Address:

City of Hamilton, Ontario

Prepared by:

Chad Miller

chad@adedgetechnologies.com

Water Analysis

Project Specific Parameters	Codes		Parameters		Codes		Parameters	
	All	**pH**	8.42	units	4,5,7	**Sodium**	55.2	mg/L Na
	1,2,7	**Total As**	Non-Detect	mg/L As	4,5,7	**Chlorides**	43.4	mg/L Cl
	Optional	**As(III)**	No Data	mg/L (if known)	4,5,7	**Nitrates**	Non-Detect	mg/L as NO3
	All	**Total Sulfides**	2.50	mg/L (total sulfides)	4,5,7	**Barium**	2.6	mg/L Cl
Codes: All = Applies to all projects	All	**Hardness**	36	mg/L (as CaCO3)	4,5,7	**Bicarbonates**	No Data	mg/L (as CaCO3)
1 = Arsenic project	All	**Alkalinity**	94.0	mg/L (as CaCO3)	4,5,7	**Sulfate**	6.2	mg/L as SO4
2 = Iron / Mn / Sulfide / As project	All	**Calcium**	6.8	mg/L @ Ca	3,4,5,7	**Fluoride**	0.7	mg/L F
3 = Fluoride project	All	**Magnesium**	4.7	mg/L @ Mg	4,5,6.7	**TDS**	188.0	mg/L TDS
4 = Uranium, Radium project	All	**Silica**	No Data	mg/L SiO2	4,5,7	**Gross Alpha**	No Data	pCi/L
5 = Nitrate project	1,2,7	**Phosphate**	No Data	mg/L P04	4,5,7	**Radium**	No Data	pCi/L Ra 226/228
6 = General Filtration	All	**Suspended Solids**	No Data	mg/L TSS	4,5,7	**Uranium**	0.0	mg/L U 238
7 = UF / RO Membrane Filtration	All	**Iron**	0.01	mg/L Fe	All	**Turbidity**	0.1	NTU
8 = Other	All	**Manganese**	0.00	mg/L Mn	All	**Temperature**	No Data	degrees F
	1,2,4,5,7	**TOC**	No Data	mg/L TOC	1,2,4,5,7	**Color**	3.0	PCU

Oxidation Filtration

AdEdge System:	APU26-3072CO-2-315	**Filtration rate (gpm/sf):**	5.1	(per vessel)
No of Vessels:	(2) 30" x 72"	**Ave flow rate:**	50 us gpm - 4.7 L/s	(based on peak flow)
Qty of media (cu ft):	30	**Ave gallons/day :**	14,400	(based on peak flow)
Approximate System footprint (Inches):	90"L x 65"W x 100"H	**Hydraulic Utilization %:**	20.00%	(typical expected)
Media:	AD26	**Est. working capacity:**	240,000	(based on utilization)
Operation:	Parallel	**Bed volumes/day:**	64	(daily over 24 hours)
Backwash Frequency:	Daily @ 98 gpm - 6.2 L/s	**Est. Gallons to Media Replacement:**	53,856,000	(bed volumes to media changeout)
Backwash Rate:	20 gpm/sq ft	**Est. Media Life (months):**	125	(throughput)
Est. BW water per vessel:	700 gallons - 2646 liters	**Est. Media Life (Years):**	10	(est frequency of changeout)
Est. BW water (gallons) per event:	1400 gallons - 5292 liters			

IX - Softening

AdEdge System:	APUIX-3072CO-2-290	**Loading Rate (gpm/cf):**	1.7	**(Per Vessel)**
No of Vessels:	(2) 30" x 72"	**Ave flow rate:**	50 us gpm - 4.7 L/s	(based on peak flow)
Qty of media (cu ft):	30	**Ave gallons/day :**	14400 gpd - 55 cubic meters	(based on peak flow)
Approximate System footprint (Inches):	90"L x 60"W x 100"H	**Hydraulic Utilization %:**	20.00%	(typical expected)
Media:	Cation Resin	**NaCl Setting:**	15 lbs / cu ft	
Operation:	Alternating	**NaCl Usage per vessel (lbs):**	225	(per vessels)
Regen Frequency:	10 day @ 20 gpm	**Monthly Salt Usage (lbs):**	675	
Backwash Rate:	4 gpm/sq ft	**Brine Storage (lbs):**	1,800	(all tanks)
Est. BW water (gallons) per vessel:	956	**Est. Media life (Years):**	2	(est frequency of changeout)
Est. BW water (gallons) per event:	1,912			

System Costs US Dollars

	Capital Costs		Annualized Operating Cost	
Packaged Treatment System (APU26):	Included	**Replacement Media AD26:**	$635	(media, excluding labor)
Packaged Treatment System (APUIX):	Included	**Replacement Media IX:**	$1,200	(media, excluding labor)
Equipment Shop drawings:	Included	**Utilities and Operator Cost:**	Negligible	(kWh $0.10)
Startup and Commissioning:	Included	**Consumable Chemical:**	Existing Chlorination	(estimate for chemical use)
Engineering / Permitting / Installation:	By Others	**Consumable Chemical:**	$972	(Salt $0.12 / lb)
Freight, taxes (if applicable):	NOT Included	**Est. Annual Operating Costs:**	**$2,807**	(combined costs)
Total capital, startup (sans freight):	**$117,000**			

System Costs Canadian Dollars

	Capital Costs		Annualized Operating Cost	
Packaged Treatment System (APU26):	Included	**Replacement Media AD26:**	$667	(media, excluding labor)
Packaged Treatment System (APUIX):	Included	**Replacement Media IX:**	$1,260	(media, excluding labor)
Equipment Shop drawings:	Included	**Utilities and Operator Cost:**	Negligible	(kWh $0.10)
Startup and Commissioning:	Included	**Consumable Chemical:**	Existing Chlorination	(estimate for chemical use)
Engineering / Permitting / Installation:	By Others	**Consumable Chemical:**	$1,021	(Salt $0.12 / lb)
Freight, taxes (if applicable):	NOT Included	**Est. Annual Operating Costs:**	**$2,948**	(combined costs)
Total capital, startup (sans freight):	**$122,850**			

AdEdge Treatment System
Oxidation Filtration for Sulfides
System Scope of Supply and Features

City of Hamilton, ON **12/4/2013**

Adsorption Filtration Vessels/Media

Model APU26-3072CO-2-315
Pre-packaged, skid mounted system
(2) 30 x 72-inch composite vessel
SCH 80 PVC hub and lateral collection system
AD26 Manganese Dioxide, (30) cubic feet total
Garnett underbedding

Process Valves & Piping

(2) 2.0-inch top mount process control valve
Throttling valves for backwash and service flow control
SCH 80 PVC interconnecting pipe, check valves, unions & isolation valves
Flanged skid connections inlet / outlet / auxiliary BW supply / BW discharge
Clear PVC sight window on common service and backwash header
Auxiliary backwash supply: double check valve and electric actuated ball valve
Local and panel mounted sample valves

Instrumentation & Controls

Simple logic control, automated backwash
0-100 psi pressure gauges, local and panel mount
0-15 differential pressure gauge panel mount
In-line flow sensor with panel mount display
Sample valves inlet, outlet for vessel and combined inlet, outlet
InGenius mechanical logic panel enclosure

Field Services & Miscellaneous

System startup & commissioning by AdEdge
AdEdge onsite training with certified operator
System installation & final electrical connections by site
AdEdge shop drawings & design report for submittals
(2) O & M manual hard copy, (1) Electronic Disk

Customer Provided Support

Electrical supply 120VAC to equipment
Sanitary connection for backwash discharge
Concrete slab or base for skid mounted unit
Enclosure / weather protected if outdoors as necessary
Consistent water supply at 30 to 100 PSIG
Plumbing & electrical connections

Terms

Lead time is 8-10 weeks from release to manufacture
15% for submittal preparation, 30% on release to fabricate, 50% delivery, 5% on commissioning
Manufacturer's 1 year warranty
Sales / Use tax not included (if applicable)
Freight not included, FOB Buford, GA
Pricing valid for 45 days

AdEdge Treatment System
Barium Reduction - Ion Exchange
System Scope of Supply and Features

City of Hamilton, ON **12/4/2013**

Ion Exchange Filtration Vessels/Media

Model APUIX-3072CO-2-315
Pre-packaged, skid mounted system
(2) 30 x 72-inch composite vessel
SCH 80 PVC hub and lateral collection system
Cation Resin 8% Crosslink 16x50, (30) cubic feet total
Quartz underbedding

Process Valves & Piping

(2) 2.0-inch top mount process control valve
(2) Flow control orifice plates for backwash flow rates
SCH 80 PVC interconnecting pipe, check valves, unions & isolation valves
Flanged skid connections inlet / outlet / auxiliary treated water / BW discharge
Clear PVC sight window on common service and backwash header
Auxiliary water supply: double check valve
Local and panel mounted sample valves

Instrumentation & Controls

Simple logic control, automated regeneration
Counter current regeneration (up flow)
0-100 psi pressure gauges, local and panel mount
0-15 differential pressure gauge panel mount
In-line flow sensor with panel mount display
In-line Hall Effect flow sensor
Sample valves inlet, outlet for vessel and combined inlet, outlet
InGenius mechanical logic panel enclosure

Brine System

Brine Module with flow restrictor
(2) 24x60-inch HDPE tanks
Non-corrosive plastic, loose fitting cover
Total salt capacity 1800 lbs
(2) brine eductors and float control
Polyethylene tubing to vessels with connectors
Solar Salt - Sodium chloride provided by others
Citric Acid for reduction in Ba Scale- provided by others

Field Services & Miscellaneous

System startup & commissioning by AdEdge
AdEdge onsite training with certified operator
System installation & final electrical connections by site
AdEdge shop drawings & design report for submittals
(2) O & M manual hard copy, (1) Electronic Disk

Customer Provided Support

Electrical supply 120VAC to equipment
Sanitary connection for backwash discharge
Concrete slab or base for skid mounted unit
Enclosure / weather protected if outdoors as necessary
Consistent water supply at 30 to 100 PSIG
Plumbing & electrical connections

Terms

See Terms of Scope Page 1

Customer:	Hamilton Water & Wastewater District, Ontario, Canada
End User:	Hamilton Water & Wastewater
Main Contact:	Jianrong Liu, Genivar Inc.
Date:	December 4, 2013
Pilot Location:	Lynden, Ontario, Lynden Well
Target Contaminants:	Hydrogen Sulphide, Barium Reduction
Start Date:	January 2014
Pilot test Type:	Ion Exchange and Oxidation Filtration
Pilot test duration:	4 days
Attachments:	Sampling and Analysis Testing Matrix

Summary and Treatment Goals:
In coordination with Hamilton Water District and Genivar, AdEdge Water Technologies, LLC. (AdEdge) is employing a small-scale treatment system for a pilot study. The intention of short term pilot program is to demonstrate criteria necessary for a full-scale water treatment plant. These pilot systems are intended to be simple, basic, and economical representations of the full scale systems proposed. If properly designed, operated, monitored, and reported, the pilot system performance results will be sufficient for making full scale treatment decisions. Specific goals for the site include the following:

1. Demonstrate Barium reduction with the goal of consistently attaining less than 1.0 mg/L of Barium.
2. Demonstrate Sulphide reduction with the goal of consistently attaining less than 0.05 mg/L of Sulphide.
3. Demonstrate Lead and Copper in treatment effluent is not elevated during the pilot.
4. Evaluate the corrosivity of the water source and compare with the treated water effluent utilizing the Langelier Saturation Index and Ryznar Stability Index.
5. The pilot operating conditions shall be equal to the full scale or present more challenging conditions in the pilot with respect to the following design parameters.
    a. Filtration Loading Rate
    b. Media Bed Depth

Proposed Pilot Plant

1. **Study Duration** – The pilot study is proposed to operate for 4 days. Steady state conditions are expected to be achieved on the first day of piloting. The daily schedule and run times will determine the actual study period.

2. **Proposed Operating Parameters** - The proposed demonstration parameters are below:

Ion Exchange for Barium

System Design	Full Scale	Pilot
Target design flow (gpm)	50	2.80
Vessel diameter (Inches)	30	10.0
No vessels	2.0	1.0
Square feet (combined vessels)	9.8	0.55
Hydraulic Loading Rate (gpm/ft²)	5.1	5.1
Media Volume (Gallons)	224	11.22
Bed Depth (Inches)	37	33
Backwash Flow (gpm)	20	2.0

Oxidation Filtration for Sulphide

System Design	Full Scale	Pilot
Target design flow (gpm)	50	2.80
Vessel diameter (Inches)	30	10.0
No vessels	2.0	1.0
Square feet (combined vessels)	9.8	0.55
Hydraulic Loading Rate (gpm/ft²)	5.1	5.1
Media Volume (Gallons)	224	11.22
Bed Depth (Inches)	37	33
Backwash Flow (gpm)	98	11

3. **Field Support** – An AdEdge field engineer will provide on-site assistance to set up and start up the pilot unit to verify steady state conditions. Following startup, the field technician will conduct the study for a 4 day period.

4. **Pilot Protocol** – AdEdge will provide guidance and procedures to the client in conducting the pilot test in the pilot protocol document. A spreadsheet for collecting observation data, field samples, water sample collection matrix will be provided. Sampling and analytical testing parameters and frequency can vary widely depending on the water quality and objectives of the pilot. AdEdge will work with the client/host site to determine the most cost-effective test matrix to achieve the desired observations.

5. **Field / Laboratory Data Gathering** – The types of data to be gathered (at least daily) during pilot operation include pressure readings, flow readings, flow totalizer readings, and chemical monitoring parameters. Additionally obtaining performance samples for the offsite lab or field observations. The Sampling Matrix (attached) should be used as the governing document for site specific items, frequency, and location.

6. **Certified Laboratory Analyses** – The site is responsible for providing a representative water analyses prior to pilot field work to (1) pre-qualify the site; (2) predict performance; and (3) define testing parameters. This water analysis shall be analyzed with 12 months of the pilot. Constituents recommended being the same as the baseline data outlined in the pilot test matrix for day one.

   AdEdge has allocated a budget for laboratory analysis per the sampling matrix with a local certified laboratory during the pilot.

7. **Equipment** – See the attached pilot flow schematic for the following approach.
   a. **Ion Exchange** – 1.5 cubic feet of Cation Resin contained in a 10 inch column. A top mount valve assembly, internal standpipe and distribution diffuser. The unit will be equipped with sample ports on inlet and outlet, flow meter and pressure gauges
   b. **Chlorination** – Chemical feed pump and day tank capable of delivering sodium hypochlorite. The chemical pump rate is set to the flow rate of the water source. The site operator must turn off pump when water is not flowing.
   c. **Filtration** – 1.5 cubic feet of AD26 manganese dioxide contained in a 10 inch column. A top mount valve assembly, internal standpipe and distribution diffuser. The unit will be equipped with sample ports on inlet and outlet, flow meter and pressure gauges.
   d. **Auxiliary Backwash Supply** – 100 gallon temporary storage tank for treated water and transfer delivery pump for backwash supply.
   e. **Monitoring Instruments** – Supplied by AdEdge, Flow element displaying instantaneous and total flow, 0-100 psi pressure gauges.
   f. **Valve and Plumbing** – Supplied by AdEdge, 20 feet of flexible hose to the pilot unit from the water supply and 20 feet of flexible hose from the pilot unit to site designated discharge location. Along with valves to isolate and restrict water flow through the pilot.

8. **Pilot Consumables –** The pilot study requires field tests be performed and often requires chemical consumables. AdEdge is responsible for test equipment and chemical consumables specified. Required consumables are listed below.
   a. **Hardness Field Test –** detection limit 0 – 4 mg/L as $CaCO_3$ or 17 to 513 mg/L as $CaCO_3$
   b. **Free Chlorine Field Test –** detection limit 0.02 – 2.00 mg/L
   c. **pH Field Test** – detection limit 5.5 – 9.0 pH units
   d. **Sulfide Field Test** – detection limit 0 to 0.7 mg/L

e. **Chlorine** – liquid chlorine, sodium hypochlorite NSF approved

9. **Representative Water Supply** –The site is responsible for supplying water to the pilot that meets the below conditions. If the site requires deviation from the water supply requirements, notification must be made to AdEdge 10 days prior to the pilot commissioning date.
   - **a.** Water flow for the pilot meets requirements for scaled demonstration of the full scale.
   - **b.** Water supply is representative of barium, sulphide and water characteristics impacting treatment which include; pH, alkalinity, hardness, iron, manganese, vanadium, total organic carbon, temperature, total suspended solids.
   - **c.** Consistent water supply of 30 to 100 psi for the duration of the pilot. Water supply pressure fluctuations are tolerated at a deviation of 10 psi.
   - **d.** Given a temporary well pump is likely to be installed – the pump depth shall be representative of full-scale plans. The well water will need to be pumped for a period of time and wasted to produce representative water characteristic of an operating well.

10. **Electrical Supply –** The site is responsible for supplying power to operate the pilot. The number of electrical connections and is dependent upon the equipment outlined above. Common power requirements are listed below.
    - **a.** Chemical Feed Pump – 1/30 HP motor, 120 VAC, 1 PH, 60 HZ, 1.7 Amps **(Applicable Qty 1)**
    - **b.** Programmable Process Control Valve – 120 VAC, 1 PH, 60 HZ, 500 mA **(Applicable Qty 2)**
    - **c.** Transfer Delivery Pump – 3/4 HP motor, 120 VAC, 1 PH, 60 HZ, 13 Amps **(Applicable Qty 1)**

11. **Weather Protected Environmental –** The site may be responsible for providing a weather protected environment for the equipment depending on the natural environment of the pilot location. The equipment shall be protected from freezing temperatures, incremental weather and preferably not exposed directly to sunlight. If the site and AdEdge deem a weather protected environment is required, the dimensions and footprint of equipment can often be adapted to meet existing space restraints.

12. **Discharge Disposal** – The site is responsible for appropriate disposal of water used in the study. The pilot water can often be routed to a drain, sanitary sewer, or a designated discharge location per local regulations. The discharge location relative to the source water supply shall be provided to AdEdge 10 days prior to the pilot commissioning date with a description of distance and elevation to allow for the necessary component requirements.

13. **Demobilization** – Upon completion of the on-site pilot test, the client may assist in arranging for shipment of the pilot unit back to AdEdge or designated destination.
14. **Pilot Summary** - A summary in coordination with the parties involved will include the following outline:

Pilot Summary Outline:

1. Study objectives.
2. Explanation of treatment approach.
3. Comparison of water supply characteristics anticipated and observed during the pilot.
4. Representative sizing of pilot to full-scale plant.
5. Documented set-up conditions for the pilot.
6. Test conditions including model number and part number for field instruments utilized for observations, independent certified laboratory selection and explanation of targeted flow rates.
7. Pilot results for targeted contaminants, flow rates, filtration rates, bed volumes, empty bed contact times, run length between regeneration or backwash, pressure differential, chemical dosage, backwash characteristics.
8. Conclusions and recommendations for full scale.
9. Figures and exhibits of charts, filtration loading calculations, instrumentation instructions, laboratory reports, field logs, process flow diagram and other pertinent documentation

15. Terms and Conditions – See contract letter for payment schedule and terms.

November 4, 2014

Ms. Carmen Ches
Project Manager
City of Hamilton
400-77 James Street North
Hamilton, Ontario L8R 2K3

Subject: Summary Report and Recommendations – Lynden Barium Assessment

Dear Ms. Ches:

WSP Canada Inc. (WSP), formerly GENIVAR, was retained by the City of Hamilton (the City) under Category 19 (Hydrogeology) of the Hamilton Professional Consultant Services Roster for 2013-2014 to evaluate the source of barium in groundwater the vicinity of the proposed Lynden Municipal Backup Supply Well FDL02 and to identify a new location for a water supply well on the property. The work program was to include drilling of two test wells, soil sampling, step-drawdown testing and water quality sampling.

Background

Water quality samples from proposed replacement well FDL02 indicated that concentrations of barium in the groundwater were greater than the Ontario Drinking Water Quality Standards (ODWQS) health based limit of 1 mg/L with values above 2.6 mg/L. Water quality trends from nearby residential and monitoring wells within approximately 1 km indicate that barium concentrations are generally at or below the ODWQS value of 1 mg/L for most wells that draw water from the deep overburden formations. Barium concentrations in existing production well FDL01 have been slowly increasing over the last decade. Offsite, a monitoring well 2 km to the southeast had barium concentrations greater than 2.1 mg/L, but the rest of the monitoring network in the Lynden area west and north of the site have concentrations well below 0.1 mg/L. This suggests that the barium source may be localized in the vicinity of FDL02. This study is intended to assist in the understanding of the barium distribution in the aquifer formation.

Treatment of Barium can be expensive, so the City has proposed the drilling of additional boreholes on the project site to try to identify a location within the aquifer that will provide the required yield (approximately 4.5 L/s), but with improved quality.

WSP Canada Inc.
1425 Cormorant Road
Hamilton, Ontario
L9G 4V5
www.wspgroup.com

Based on these requirements, a field program was initiated on the City-owned property where FDL01 and FDL02 are located. The field program is discussed in the following sections.

Drilling Program

A site visit was scheduled with the City and G. Hart and Sons Drilling (the Contractor) to finalize the locations of the proposed test wells. The drilling was to target a deep confined sand and gravel aquifer approximately 50 m below ground surface (bgs) and positioned atop the bedrock surface where both existing pumping wells were screened. Site LM-01-14-D was located on a locally high, flat area approximately mid-way between FDL01 and FDL02, and LM-02-14-D was located near the edge of the existing agricultural field approximately 100 feet from the western property boundary (Figure 1). Once the locations were selected, utility locate clearances were obtained both through Ontario One Call and a private locating company.

LM-01-14-D

The Contractor mobilized to site and drilling commenced on July 17, 2014. Drilling was carried out using a dual-drive air rotary drilling method. Drilling encountered silt at ground surface to a depth of approximately 7.0 m bgs, followed by clay to a depth of 39.6 m bgs. A layer of consisting of silty sand to silt was found below this to a depth of 52.0 m bgs, followed by a sand and gravel aquifer to 56.7 m bgs. A strong sulphur odour was noted starting at 50.3 m bgs. The sand and gravel overlies dolostone bedrock, which was drilled to 57.6 m bgs. The MOE well log for LM-01-14-D (drillers reference as TW1) is included in Appendix A. Several soil samples were taken from the aquifer between 50.6 m bgs and 56.7 m bgs for grain size analysis for the purposes of screen selection (Appendix B). Additional soil samples were taken from this interval for chemical analysis for barium, sulphate and barite.

The 159 mm (6 ¼-inch) diameter borehole was advanced to a depth of 57.6 metres below ground surface. A 1 m layer of bentonite was placed in the bottom of the borehole from 57.6 to 56.5 m. LM-01-14-D was constructed with a 254 mm diameter surface casing to a depth of 6.1 m, a 159 mm diameter steel casing extending to 53.3 metres below ground surface, a 152 mm diameter wire wound telescopic stainless steel screen was placed from 53.3 to 56.5 metres below ground surface. Based on the results of the grain size analysis, a screen slot size of 40-slot was chosen. The well screen was placed inside the 159 mm casing, which was then raised to allow the sand and gravel formation to cave in around the well screen. LM-01-14-D was developed using air lifting techniques to achieve a sand free condition. The static groundwater level in the well was measured to be 14.3 m bgs. This suggests that there is over 37 m of available drawdown in this location.

LM-02-14-D

The Contractor moved to the second location on July 24, 2014. Drilling was carried out using a dual-drive air rotary drilling method. Drilling encountered silt to sandy silt at ground surface to a depth of approximately 9.1 m bgs, followed by silty clay and clayey silt to a depth of 40.2 m bgs. A layer of consisting of silty sand to sandy silt was found below this to a depth of 50.3 m bgs, followed by a sand and gravel aquifer to 56.4 m bgs. A strong sulphur odour was noted starting at 50.3 m bgs. The sand and gravel overlies dolostone bedrock, which was drilled to a depth of 57 m bgs. The MOE well log for LM-02-14-D (drillers reference as TW2) is included in Appendix A. Several soil samples were taken from 50.3 m bgs to 56.1 m bgs for grain size analysis for the purposes of screen selection (Appendix B). Additional soil samples were taken from this interval for chemical analysis for barium, sulphate and barite.

The 159 mm (6 ¼-inch) diameter borehole was advanced to 57.0 metres below ground surface. The well was constructed with a 254 mm diameter surface casing to a depth of 6.1 m, a 159 mm diameter steel casing extending to 52.1 metres below ground surface. The screen was chosen based on the results of the grain size analysis. However, given the lengthy development time observed in LM-01-14-D, the slot sizes were chosen to be slightly smaller as a conservative measure. As such, a 152 mm diameter 30-slot wire wound telescopic stainless steel screen was placed from 52.1 to 53.6 m bgs and a 35-slot screen was placed from 53.8 to 55.3 m bgs. The well screen was placed inside the 159 mm casing, which was then raised to allow the sand and gravel formation to cave in around the well screen. LM-02-14-D was developed using air lifting techniques to achieve a sand free condition. The static groundwater level in the well was measured to be 14.3 m bgs. This suggests that there is over 36 m of available drawdown in this location.

Step Testing

LM-01-14-D

On August 26, 2014, a step test was conducted on LM-01-14-D to determine whether the well could produce a similar pumping rate to FDL02 (4.5 L/s) and to provide baseline data with which to assess future well performance. The step test was conducted at three discharge rates (1.5 L/s, 3.0 L/s, and 4.5 L/s). The rates were chosen such that a Permit to Take Water (PTTW) would not be required from MOE. Each step was 60 minutes in length. The test started with the 1.5 L/s step and progressively increased to 4.5 L/s with no delay in between steps. The water level was monitored in the well over the course of the testing using manual measurements and a datalogger. Dataloggers were also deployed in nearby wells.

The results of the step test are summarized below in Table 1. Detailed records of the step test are provided in Appendix C.

Drawdowns were measured to be 0.19 m, 0.28 m and 0.32 m respectively, for a total drawdown of 0.79 m. Recovery was monitored for 60 minutes, but pumping well FDL01 came on about 15 minutes after the end of pumping. LM-01-14-D had achieved approximately 80% recovery at that stage. Since the observed well interference from FDL01 did not affect the analysis of the step test data, a correction of the drawdowns to account for the additional drawdown was not required.

Specific capacity is the pumping rate divided by the drawdown. As shown in Table 1, the specific capacity decreases at an essentially constant rate between steps 1, 2 and 3 (1.6 to 1.4 L/s/m respectively).

Table 1 – Summary of Step Test Data for Lynden LM-01-14-D

Discharge Rate		Cumulative Drawdown	Drawdown per Step	Specific Capacity
(L/s)	(igpm)	(m)	(m)	(L/s/m)
1.5	20	0.19	0.19	8.0
3.0	40	0.47	0.28	6.4
4.5	60	0.79	0.32	5.8

LM-02-14-D

On August 27, 2014, a step test was conducted on LM-02-14-D to determine whether the well could produce a similar pumping rate to FDL02 (4.5 L/s) and to provide baseline data with which to assess future well performance. The step test was conducted at three discharge rates (1.5 L/s, 3.0 L/s, and 4.5 L/s). Each step was 60 minutes in length. The test started with the 1.5 L/s step and progressively increased to 4.5 L/s with no delay in between steps. The water level was monitored in the well over the course of the testing using manual measurements and a datalogger. Dataloggers were also deployed in nearby wells.

During the test, pumping well FDL01 came on approximately 40 minutes into the first step and continued until 30 minutes after the end of the third step, a total of approximately 170 minutes. As such, a correction was applied to the data by subtracting the estimated additional drawdown created by the pumping of FDL01. The additional drawdown was estimated from two complete FDL01 pumping cycles that were captured in the logger data from LM-02-14-D. The correction is represented by a red line in the plot provided in Appendix C.

The corrected results of the step test are summarized below in Table 2. Detailed records of the step test are provided in Appendix C.

Corrected drawdowns per step were measured at 0.33 m, 0.47 m and 0.52 m for a total corrected drawdown of 1.32 m at the end of the test. Recovery was measured for 60 minutes and was estimated at 94.2% based on corrected water levels. Specific capacity is the pumping rate divided by the drawdown. As shown in Table 2, the specific capacity decreases between steps 1, 2 and 3 (0.8 to 0.4 L/s/m respectively).

Table 2 – Summary of Step Test Data for Lynden LM-02-14-D

Discharge Rate		Cumulative Drawdown	Drawdown per Step	Specific Capacity
(L/s)	(igpm)	(m)	(m)	(L/s/m)
1.5	20	0.33	0.33	4.6
3.0	40	0.80	0.47	3.8
4.5	60	1.32	0.52	3.4

Comparison of Results with FDL02 Step Test

The results of observed drawdown and specific capacity estimates for FDL-02, LM-01-14-D, and LM-02-14-D are tabulated in Table 3. Based on the results, LM-01-14-D had the smallest drawdown and the highest specific capacity of all the wells, while LM-02-14-D had the highest drawdown and lowest specific capacity. This could be attributed to the screen selection at LM-02-14-D, which was more conservative than LM-01-14-D. Also, FDL02 is a 203 mm diameter well, compared to 159 mm for LM-01-14-D and LM-02-14-D. Based on these results, it is expected that the aquifer in the locations of LM-01-14-D and LM-02-14-D can produce the required volume with acceptable drawdowns.

Table 3 – Summary of Step Test Data for Lynden LM-02-14-D

Discharge Rate	Cumulative Drawdown			Drawdown per Step			Specific Capacity		
	LM-01-14-D	LM-02-14-D	FDL02	LM-01-14-D	LM-02-14-D	FDL02	LM-01-14-D	LM-02-14-D	FDL02
(L/s)	(m)			(m)			(L/s/m)		
1.5	0.19	0.33	0.34	0.19	0.33	0.34	8.0	4.6	4.6
3.0	0.47	0.80	0.69	0.28	0.47	0.35	6.4	3.8	4.6
4.5[1]	0.79	1.32	1.03	0.32	0.52	0.34	5.8	3.4	4.6

[1] – Flow rates in this step were approximately 409 m^3/day for FDL02 compared to 393 m^3/day for LM-01-14-D and LM-02-14-D.

Sampling Results

Soil Sampling – Barium, Sulphate, Barite

Soil samples were collected during drilling and submitted to AGAT Laboratories in Mississauga to test for the presence of barium, sulphate and barite (barium sulphate) and to assess the distribution within the aquifer and to determine whether or not the levels correlate with high levels in groundwater. Four samples were taken from each test well location at various intervals within the aquifer (Table 4).

Table 4 – Soil Sampling Results

Well	Sample Depth	Barium	Sulphate	Barium Sulphate (Barite)
	(m bgs)	(ug/g)	(ug/g)	%
LM-01-14-D[1]	52.0 – 53.3	923	12	.157
	53.3 – 54.9	376	20	.064
	54.9 – 56.4	385	22	.065
	56.8 – 57.1	IS	45	IS
LM-02-14-D[2]	52.1 – 52.7	322	27	.055
	52.7 – 53.3	367	32	.062
	54.2 – 55.2	537	28	.091
	55.2 – 56.1	331	20	.056

IS – insufficient sample for analysis.
1 – Lab report reference TW1
2 – Lab report reference TW2

The results are summarized as follows:

- Barium concentrations generally fall within a small range, except at one sampling interval in each location. For LM-01-14-D, barium ranged from 376 to 385 ug/g, with a high of 923 ug/g in the 52 – 53.3 m interval. Similarly, barium at LM-02-14-D ranged between 322 and 367 ug/g, with a high of 537 ug/g in the 54.2 – 55.2 m interval.

- Sulphate ranged between 12 – 22 ug/g in LM-01-14-D (except for one reading at 45 ug/g just above bedrock), and 20 – 32 ug/g in LM-02-14-D.

- Barium sulphate was calculated from barium content as a percentage, and as such, was proportional to the barium results.

Based on these results, it appears as though there are barium rich layers at different depths within the aquifer with general “background” levels between 322 and 385 ug/g. Soil sampling laboratory reports are provided in Appendix D (lab referenced wells are TW1 and TW2).

Soil Sampling – Pesticides

An additional soil sample was taken from the top 1.5 m bgs in the vicinity of LM-02-14-D and sent to Maxxam Laboratories to be tested for the presence of pesticides in the shallow subsurface. Results indicate that pesticides could not be detected. Soil sampling lab results are provided in Appendix D.

Water Quality Sampling

Water quality samples were obtained from each test well just prior to the end of the step tests. Samples were taken using standard sampling protocols and submitted to the City of Hamilton’s Environmental Laboratory for analysis. The following results are relevant to the barium assessment:

- Barium concentrations were 1.78 mg/L in LM-01-14-D, which is greater than the ODWQS Health Based Guidelines.
- Barium concentrations were measured to be 0.137 mg/L in LM-02-14-D.
- Colour was elevated in LM-02-14-D at 13 total colour units (TCU), which is above the ODWQS Aesthetic Objectives (AO).
- Iron was measured to be 0.283 mg/L in LM-02-14-D, which is slightly below the ODWQS AO of 0.3 mg/L.

The remainder of the results were within acceptable limits for drinking water. Water quality results were tabulated and compared to levels in FDL02 and local residential wells. The results were found to be within the previously measured ranges. The tables and laboratory reports are provided in Appendix E.

Discussion

Source of Barium

According to the Canadian Council of Ministries of the Environment (CCME) document “Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health”, concentrations of barium in the soil typically range between 15 and 3000 ug/g, with higher barium concentrations associated with limestone and shale deposits. Based on the soil sampling results discussed in the sections above, there is

a general background concentration of barium that ranges between 322 and 385 ug/g. Individual horizons were also identified within the aquifer that had elevated concentrations of barium relative to the background (923 ug/g in LM-01-14-D, 537 ug/g in LM-02-14-D). These values confirm that there is barium in the soil and illustrates the potential variability of concentrations in the aquifer. The higher concentrations observed in the soil and groundwater were higher at LM-01-14-D compared to LM-02-14-D. However, it is likely that a source of barium is located in very close proximity to FDL02.

Assessment of Test Well Sites

Based on the results discussed in the previous sections, the advantages and disadvantages of each well site related to water quality, quantity, proximity to the distribution system, proximity to other wells, and proximity to potential drinking water threats that may be identified as per the Clean Water Act (CWA) directions are listed in Table 5 and discussed in more detail below.

Table 5 – Summary Table for Test Well Locations

Well Site	Advantages	Disadvantages
LM-01-14-D	Sufficient water quantity	High barium levels will require treatment
	Greater than 100 m from existing agricultural practices	High levels of hydrogen sulphide
	Closer to existing distribution system	Closer to private water wells
LM-02-14-D	Sufficient water quantity	Further from existing distribution system
	Low barium concentrations observed to date will not require treatment	High colour values will require further investigation
		Borderline iron levels may require treatment
		High levels of hydrogen sulphide
	Further from private water wells	Less than 100 m from agricultural practices (potential drinking water threats – CWA, 2006)

Water Quantity

From a water quantity perspective, the step testing indicates that both locations will be able to produce the quantities of water (approximately 4.5 L/s) that will be required

without significant drawdowns in the aquifer relative to that currently experienced by FDL01 and FDL02.

Water Quality

From a water quality perspective, the barium concentrations observed to date in LM-01-14-D are greater than the ODWQS health based guideline and would require expensive treatment to remove (millions of dollars). The observed barium concentrations at LM-02-14-D are less than the ODWQS value, hence treatment for barium would not be required. Testing to date identified elevated colour at LM-02-14-D greater than the ODWQS aesthetic objectives. Additional investigations would need to be carried out to determine the source of the colour, and to determine whether the colour values are consistent or will change with additional pumping. Further, the dissolved iron concentrations at LM-02-14-D are just below the ODWQS aesthetic objectives. Aeration of the water to remove hydrogen sulphide may possibly also be effective in lowering the concentrations of iron. Both wells have elevated levels of hydrogen sulphide, which is common in the deep aquifer at this site.

Well Location

The location of the proposed well is important in considering proximity to the existing water infrastructure, existing water well users, and potential drinking water threats. LM-01-14-D is within 100m to the existing infrastructure. Additional watermain would need to be installed for LM-02-14-D, which could cost between $50,000 and $100,000. On the other hand, LM-01-14-D is closer to existing private water wells than LM-02-14-D. However, this is not expected to be significant as additional interference is expected to be negligible.

LM-01-14-D is at least 100 m from potentially significant drinking water threats due to agricultural practices. By contrast, LM-02-14-D is within 100 m of the adjacent agricultural fields. Some of these fields are on City property and could be converted. However, the neighbouring property is within about 30 - 40 m of the well site. Since LM-02-14-D is atop a long, thin hill, a proposed production well could not be moved a sufficient distance from the property boundary. If significant drinking water threats are confirmed, the City would need to negotiate a Risk Management Plan with the owner so that the agricultural practices applied on those lands are carried out in accordance with the Source Protection Plan policies.

Recommendations

From a technical perspective, LM-01-14-D and LM-02-14-D can each provide the required quantities of water to replace FDL02. Concentrations of barium are lower at LM-02-14-D and expensive treatment for barium may not be required. The costs for additional watermain to reach LM-02-14-D and the cost of Source Protection Plan

policy implementation as per the Clean Water Act are less than the projected costs of treatment. Based on this information, it is more technically and economically preferred to construct and test a new well at LM-02-14-D. Therefore, WSP recommends installing a production well at this location to be tested for quality and quantity. Additional testing and possibly treatment may be required in conjunction with the proposed replacement production well to address water quality concerns related to colour and dissolved iron, and to confirm that barium concentrations will remain low in the short-term.

Please do not hesitate to contact the undersigned should you have any questions or concerns.

Derek S Brunner

Derek S. Brunner, M.Sc., P.Geo.
Hydrogeologist / Project Manager, Environment

Enclosures :
Figure 1 – Site Location Map
Appendix A – MOE Well Logs
Appendix B – Grain Size Analyses
Appendix C – Step Test Results
Appendix D – Soil Sampling Results
Appendix E – Water Quality Sampling Results

Figures

CLIENT: Hamilton	CONSULTANT(S): WSP
PROJECT TITLE: LYNDEN BARIUM ASSESSMENT	
DRAWING TITLE: SITE LOCATION MAP	
SCALE: AS SHOWN	DATE: NOVEMBER 2014
PROJECT NO.: 141-17672-00	DRAWING NO.: FIG. 1

Appendix A

MOE WELL LOGS

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. (Place Sticker and/or Print Below): A159041 — Tag#: A159041

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	City of Hamilton		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
77 James St. North, Suite 400	Hamilton	ON	L8R 2K3	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 Governors Rd.	Ancaster	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
Hamilton	Lynden	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570752	4786636		TW#2

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
		* Refer to Attached			
			* Finished Depth 182 ft.		

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	6	Bentonite Chips	
6	20	Bentonite slurry	

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☐ Air percussion ☐ Other, specify Dual Rotary

Well Use

☐ Public ☐ Commercial ☐ Not used ☐ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ Test Hole ☐ Monitoring ☐ Irrigation ☐ Cooling & Air Conditioning ☐ Industrial ☐ Other, specify

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ____ hrs + ____ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level	47		
1		1	
2	Refer to	2	
3	Attached	3	
4	Step Test	4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
6¼"	Steel	0.188	+3	171
5¼"	Steel	0.188	182	185

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
6"	S.S.	30	171	176
6"	S.S.	35	186½	181½

Status of Well

☐ Water Supply ☐ Replacement Well ☐ Test Hole ☐ Recharge Well ☐ Dewatering Well ☐ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☐ Abandoned, other, specify ☐ Other, specify

Water Details

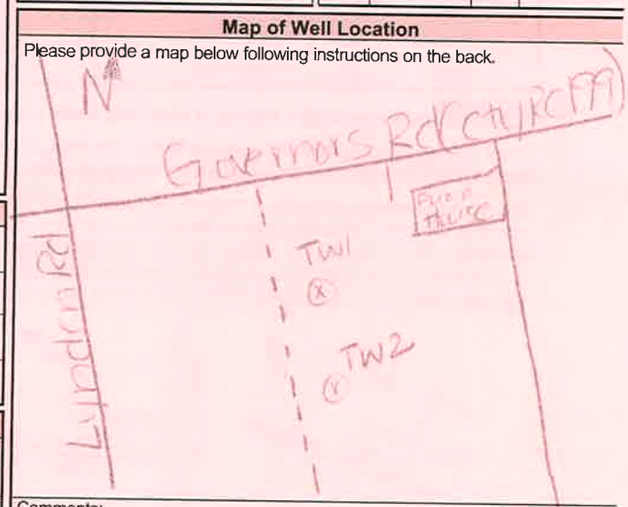
Water found at Depth (m/ft)	Kind of Water	
171-181	☐ Gas	☐ Fresh ☐ Untested ☐ Other, specify
	☐ Gas	☐ Fresh ☐ Untested ☐ Other, specify
	☐ Gas	☐ Fresh ☐ Untested ☐ Other, specify

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	20	10"
20	187	6"

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
G.Hart & Sons Well Drilling Ltd.	2662

Business Address (Street Number/Name)	Municipality
Box 850, 142 County Rd. 8	Fenelon Falls

Province	Postal Code	Business E-mail Address
ON	K0M 1N0	ghart ghart.ca

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
705 887-3331	Watson, Bryan & Rochetta, Mike

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T-2441 & 3435		Y Y Y Y M M D D

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No	Y Y Y Y M M D D	2014 0827

Ministry Use Only

Audit No. Z 195047

Received

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Well Owner's Copy

G. HART & SONS
Well Drilling Ltd.
Box 880, Fenelon Falls, Ont.
K0M 1N0

Tel:(705)-887-3331
Fax:(705)887-4788
E-Mail ghart@ghart.ca

WELL LOG

WELL TAG # : A159041

Lynden - TW2

General Colour	Most Common Material	Other Materials	General Description	Depth From (Feet)	Depth To (Feet)
Brown	Silty Topsoil			0	1
Brown	Silt			1	13
Grey	Sandy Silt			13	30
Grey	Silty Clay			30	60
Grey	Silt & Clay		layered	60	83
Grey	Clay	Silt		83	110
Reddish Grey	Silty Clay			110	132
Reddish Grey	Silty Sand	some gravel		132	136
Reddish Grey	Sandy Silt	clay		136	148
Reddish Grey	Silty Sand	some clay		148	165
Reddish Grey	Sand & Gravel		water bearing	165	173
Reddish Grey	Sand & Gravel	some cobbles	water bearing	173	184
Grey	Gravel	cobbles	not water bearing	184	185
Grey	Dolostone			185	187

G. HART & Sons
Well Drilling Ltd.
Box 860, Fenelon Falls, Ont.
K0M 1N0

Tel:(705)-887-3331
Fax:(705)887-4788
E-Mail ghart@ghart.ca

Step Rate Test

WELL TAG # : A159041

Lynden - TW2

Date: August 27 ,2014

Measuring Point: Top of Casing (3 feet above ground)

PUMPING									RECOVERY	
Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)
0	49.55	0	0	50.82	Flow up	0	52.55	Flow up	0	54.35
0.5	50.14		0.5	51.51		0.5	54.00		0.5	51.32
1	50.19		1	51.62		1	54.17		1	51.20
1.5	50.20		1.5	51.72		1.5	54.22		1.5	51.14
2	50.17		2	51.75		2	54.24		2	51.08
2.5	50.35		2.5	51.78		2.5	54.21		2.5	51.05
3	50.39	20	3	51.81		3	54.30	60	3	51.02
3.5	50.40	20	3.5	52.00	40	3.5	54.30	down	3.5	50.99
4	50.41	20	4	52.03	40	4	53.80		4	50.97
4.5	50.42	20	4.5	52.05	40	4.5	53.69		4.5	50.95
5	50.42	20	5	52.08	40	5	53.67	up	5	50.92
6	50.43	20	6	52.09	40	6	53.87	60	6	50.90
7	50.44	20	7	52.10	40	7	53.89	60	7	50.88
8	50.45	20	8	52.13	40	8	53.94	60	8	50.86
9	50.45	20	9	52.13	40	9	53.95	60	9	50.83
10	50.46	20	10	52.15	40	10	53.96	60	10	50.81
12	50.47	20	12	52.17	40	12	53.97	60	12	50.79
14	50.50	20	14	52.20	40	14	54.00	60	14	50.77
16	50.50	20	16	52.22	40	16	54.02	60	16	50.75
18	50.52	20	18	52.24	40	18	54.04	60	18	50.73
20	50.52	20	20	52.26	40	20	54.05	60	20	50.72
25	50.53	20	25	52.30	40	25	54.10	60	25	50.69
30	50.54	20	30	52.35	40	30	54.15	60	30	50.67
35	50.55	20	35	52.39	40	35	54.19	60	35	50.57
40	50.57	20	40	52.43	40	40	54.22	60	40	50.50
45	50.67	20	45	52.46	40	45	54.26	60	45	50.43
50	50.73	20	50	52.50	40	50	54.31	60	50	50.39
55	50.78	20	55	52.52	40	55	54.31	60	55	50.35
60	50.82	20	60	52.55	40	60	54.35	60	60	50.32

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. (P: A159040

Tag#: A159040

Well Record

Regulation 903 Ontario Water Resources Act

Page _____ of _____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	City of Hamilton		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
77 James St. North, Suite 400	Hamilton	ON	L8R 2K1	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 Governors Rd.	Ancaster	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
Hamilton	Lynden	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570780	4785810		TW#1

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
		* Refer to attached			
17	7	7	7		
		* Finished Depth	186 ft.		

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	6	Bentonite chips	
6	20	Bentonite slurry	
186	189	Bentonite chips	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify* Dual Rotary

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify* _____

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
6¼"	Steel	0.188	+3	175
6¼"	Steel	0.188	186	187.5

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
6"	S.S.	40	175	180
6"	S.S.	40	180.5	185.5

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify* _____
☐ Other, *specify* _____

Water Details

Water found at Depth (m/ft)	Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, *specify*
175-180ft	Sulphur

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	20	10"
20	189	6"

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, *specify* _____

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping _____ hrs + _____ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

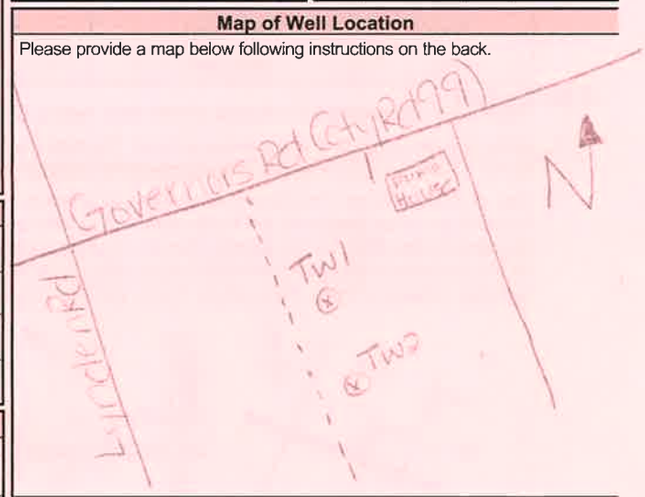
Well production (l/min / GPM): 150 gpm+

Disinfected? ☐ Yes ☐ No

Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	47		
1		1	
2	** Refer to attached Step Test	2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
G.Hart & Sons Well Drilling Ltd.	2662

Business Address (Street Number/Name)	Municipality
Box 850, 142 County Rd. 8	Fenelon Falls

Province	Postal Code	Business E-mail Address
ON	K0M 1N0	ghart ghart.ca

Bus.Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
705 887-3331	Watson, Bryan & Rochetta, Mike

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T-2441 & 3436		

Well owner's information package delivered ☐ Yes ☐ No

Date Package Delivered: Y Y Y Y M M D D

Date Work Completed: 2014 Sept 7

Ministry Use Only

Audit No. Z 195046

Received

Well Owner's Copy

G. HART & Sons
Well Drilling Ltd.
Box 850, Fenelon Falls, Ont.
K0M 1N0

Tel:(705)-887-3331
Fax:(705)887-4788
E-Mail ghart@ghart.ca

WELL LOG

WELL TAG # : A159040

Lynden - TW1

General Colour	Most Common Material	Other Materials	General Description	Depth From (Feet)	Depth To (Feet)
Brown	Silty Topsoil			0	1
Brown	Silt			1	10
Grey	Silt			10	23
Grey	Clay		soft	23	45
Brownish Grey	Silt	some clay		45	60
Grey	Clay			60	79
Reddish Grey	Clay	trace gravel		79	88
Reddish Grey	Clay	silt lenses		88	94
Grey	Clay			94	103
Reddish Grey	Clay	silt lenses, trace gravel		103	114
Grey	Clay	gravel		114	118
Grey	Clay	slity sand		118	130
Reddish Grey	Silty Sand	some clay		130	138
Reddish Grey	Silt	some sand & clay		138	152
Reddish Grey	Silt			152	160
Reddish Grey	Silty Sand			160	166
Reddish Grey	Silty Sand		water bearing	166	170.5
Reddish Grey	Sand & Gravel		water bearing	170.5	186
Grey	Dolostone		boulder	186	186.5
Grey	Gravel			186.5	187.5
Grey	Dolostone			187.5	189

G. HART & SONS
Well Drilling Ltd.
Box 850, Pinedale Falls, Ont.
K0M 1N0

Tel:(705)-887-3331
Fax:(705)887-4788
E-Mail ghart@ghart.ca

Step Rate Test

WELL TAG # : A159040

Lynden - TW1

Date: August 26 ,2014

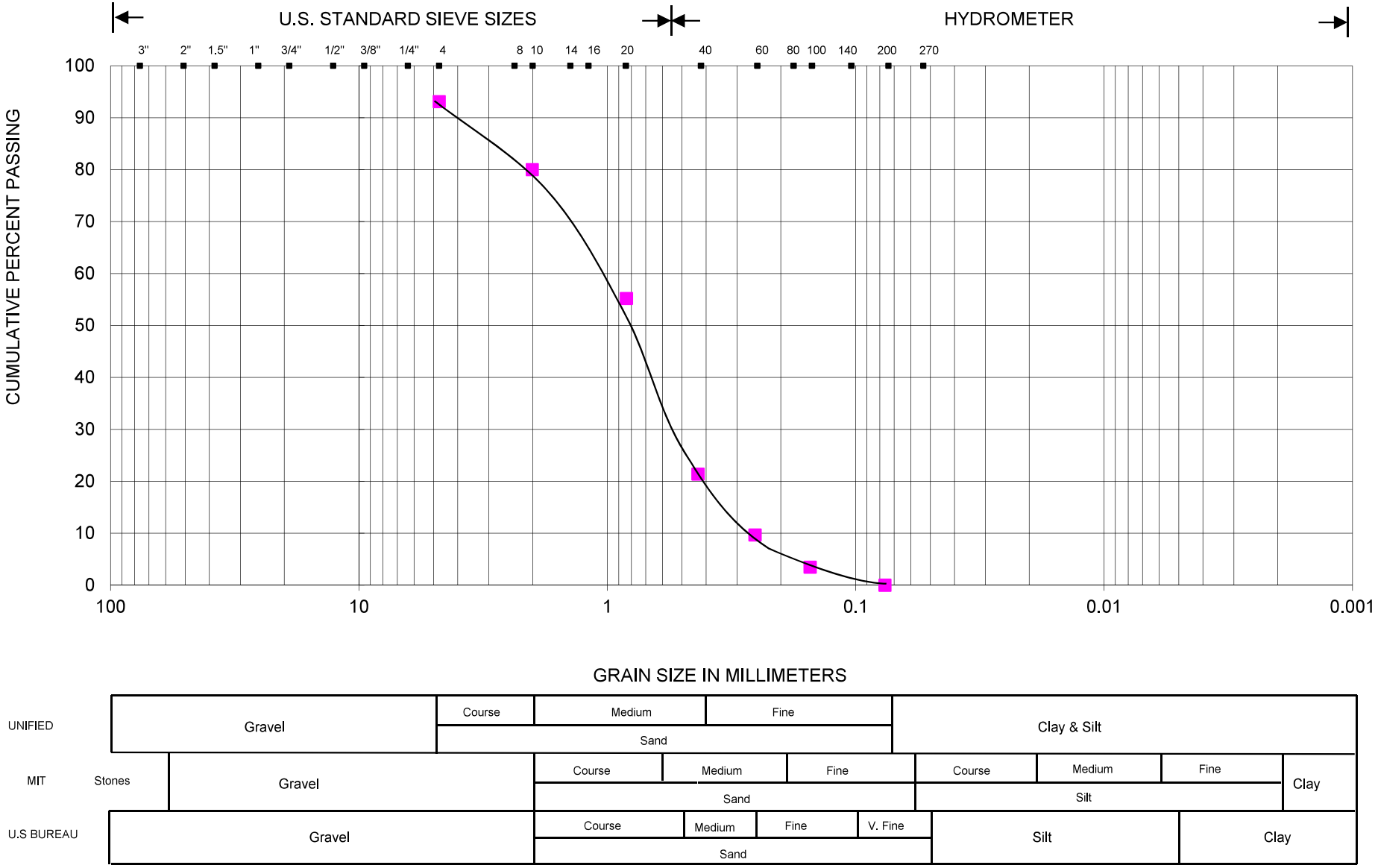
Measuring Point: Top of Casing (3 feet above ground)

PUMPING									RECOVERY	
Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)
0	49.13	0	0	49.74	Flow up	0	50.66	Flow up	0	51.70
0.5	49.41		0.5	50.24		0.5	51.20		0.5	50.03
1	49.55		1	50.33		1	51.31		1	50.03
1.5	49.59		1.5	50.34	40	1.5	51.34		1.5	50.00
2	49.56		2	50.35	40	2	51.35		2	49.95
2.5	49.58	20	2.5	50.36	40	2.5	51.38	down	2.5	49.93
3	49.58	20	3	50.37	40	3	51.29	60	3	49.92
3.5	49.57	20	3.5	50.38	40	3.5	51.33	60	3.5	49.89
4	49.59	20	4	50.39	40	4	51.34	60	4	49.87
4.5	49.61	20	4.5	50.40	40	4.5	51.34	60	4.5	49.85
5	49.61	20	5	50.40	40	5	51.35	60	5	49.84
6	49.62	20	6	50.42	40	6	51.37	60	6	49.81
7	49.62	20	7	50.42	40	7	51.37	60	7	49.79
8	49.62	20	8	50.43	40	8	51.39	60	8	49.76
9	49.64	20	9	50.45	40	9	51.39	60	9	49.75
10	49.65	20	10	----	40	10	51.41	60	10	49.73
12	49.66	20	12	50.47	40	12	51.42	60	12	49.70
14	49.67	20	14	50.49	40	14	51.45	60	14	49.67
16	49.68	20	16	50.50	40	16	51.46	60	16	49.66
18	49.70	20	18	50.52	40	18	51.47	60	18	49.75
20	49.69	20	20	50.52	40	20	51.49	60	20	49.80
25	49.70	20	25	50.54	40	25	51.52	60	25	49.84
30	49.71	20	30	50.56	40	30	51.55	60	30	49.88
35	49.71	20	35	50.59	40	35	51.58	60	35	49.89
40	49.72	20	40	50.61	40	40	51.61	60	40	49.89
45	49.72	20	45	50.62	40	45	51.64	60	45	49.89
50	49.73	20	50	50.64	40	50	51.67	60	50	49.90
55	49.74	20	55	50.65	40	55	51.67	60	55	49.91
60	49.74	20	60	50.66	40	60	51.70	60	60	49.91
									65	49.2

Appendix B

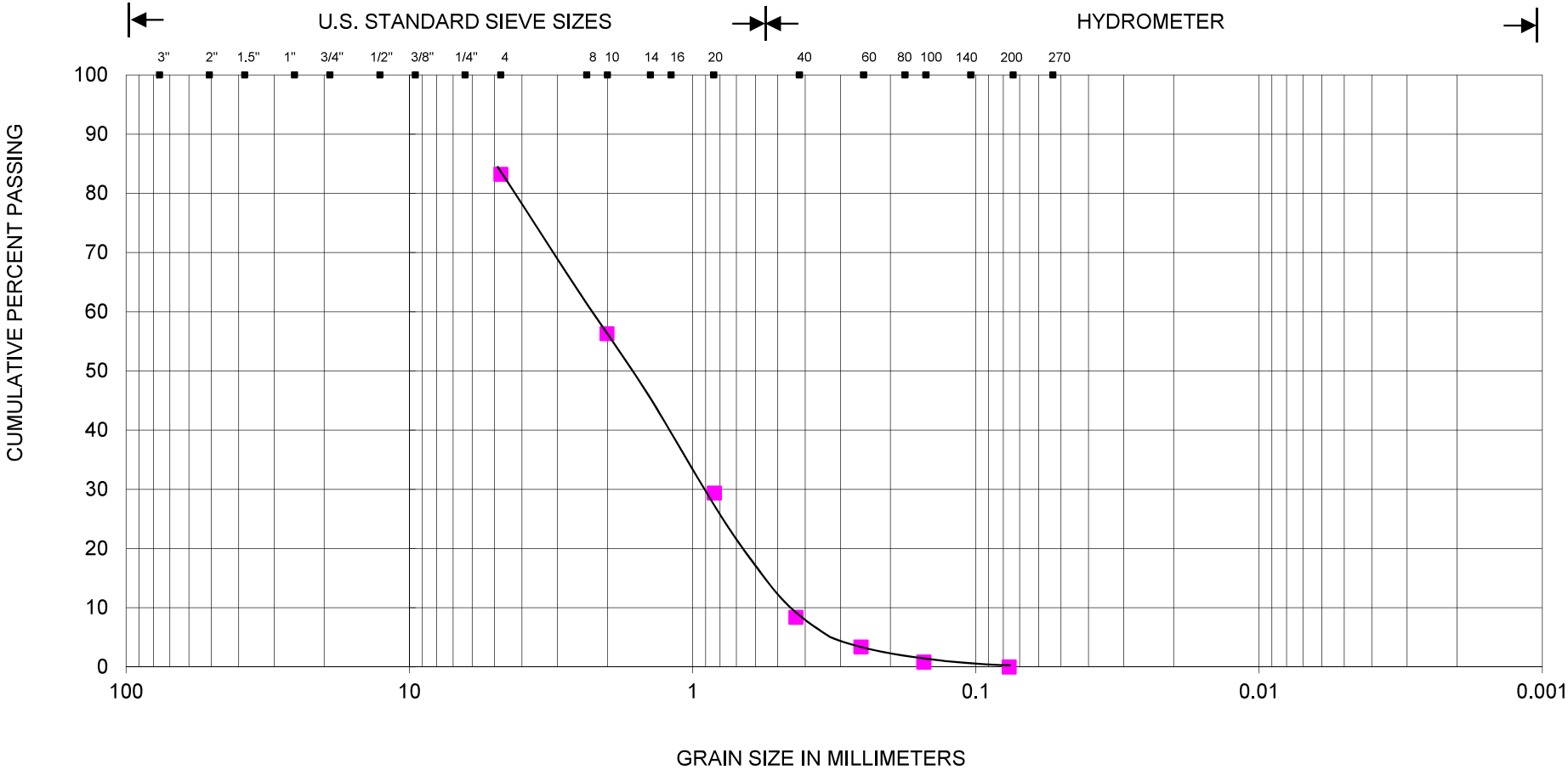
GRAIN SIZE ANALYSES

GRAIN SIZE CURVE



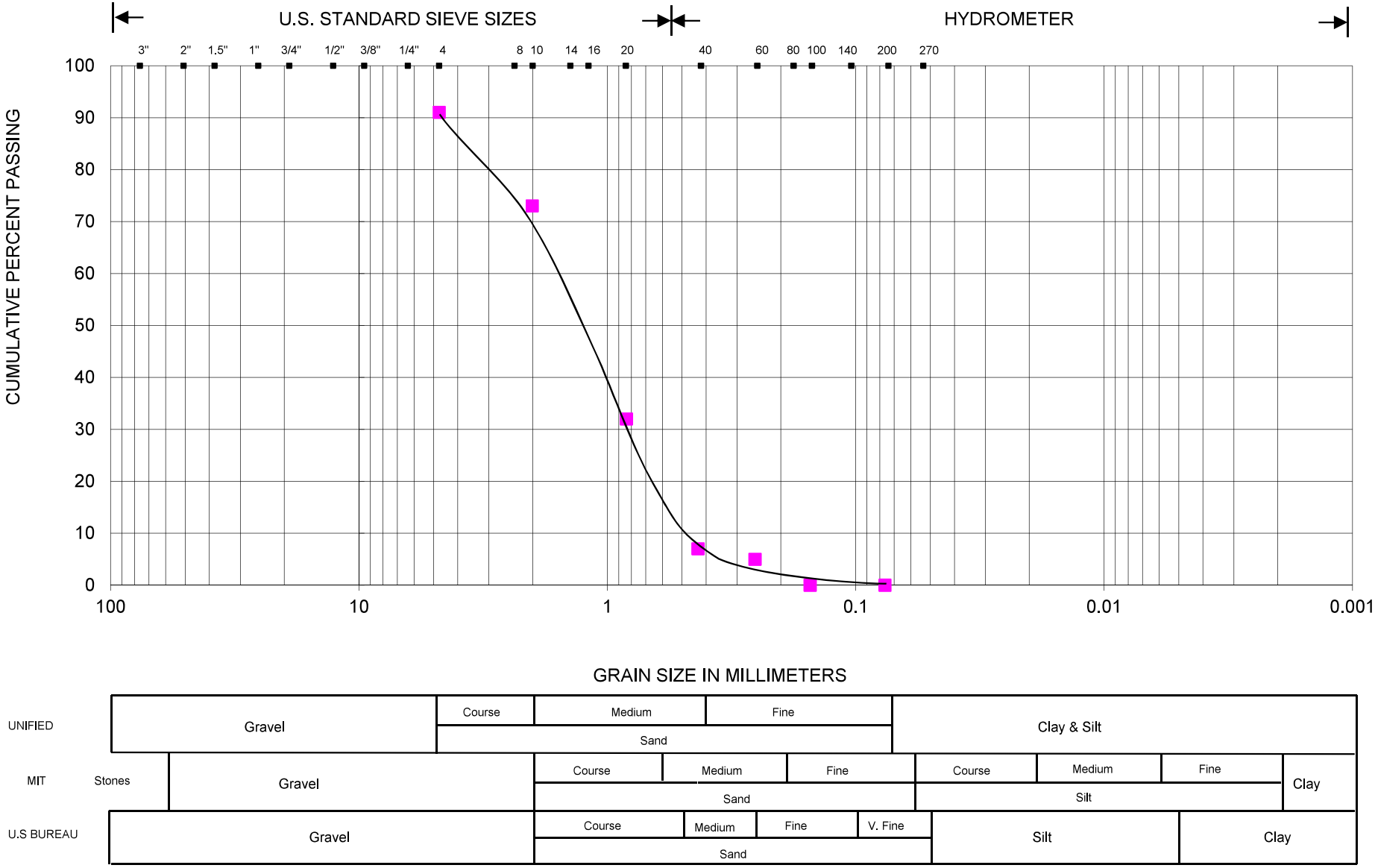
Grain Size Curve Results G. Hart - Lynden LM-01-14-D	Sample No.: 1 Depth: 166-170.5'	Project No.: P1170 Date Sampled: 7/19/2014	Morrison Environmental Limited Groundwater Consultants Morrison Environmental Limited 1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5

GRAIN SIZE CURVE



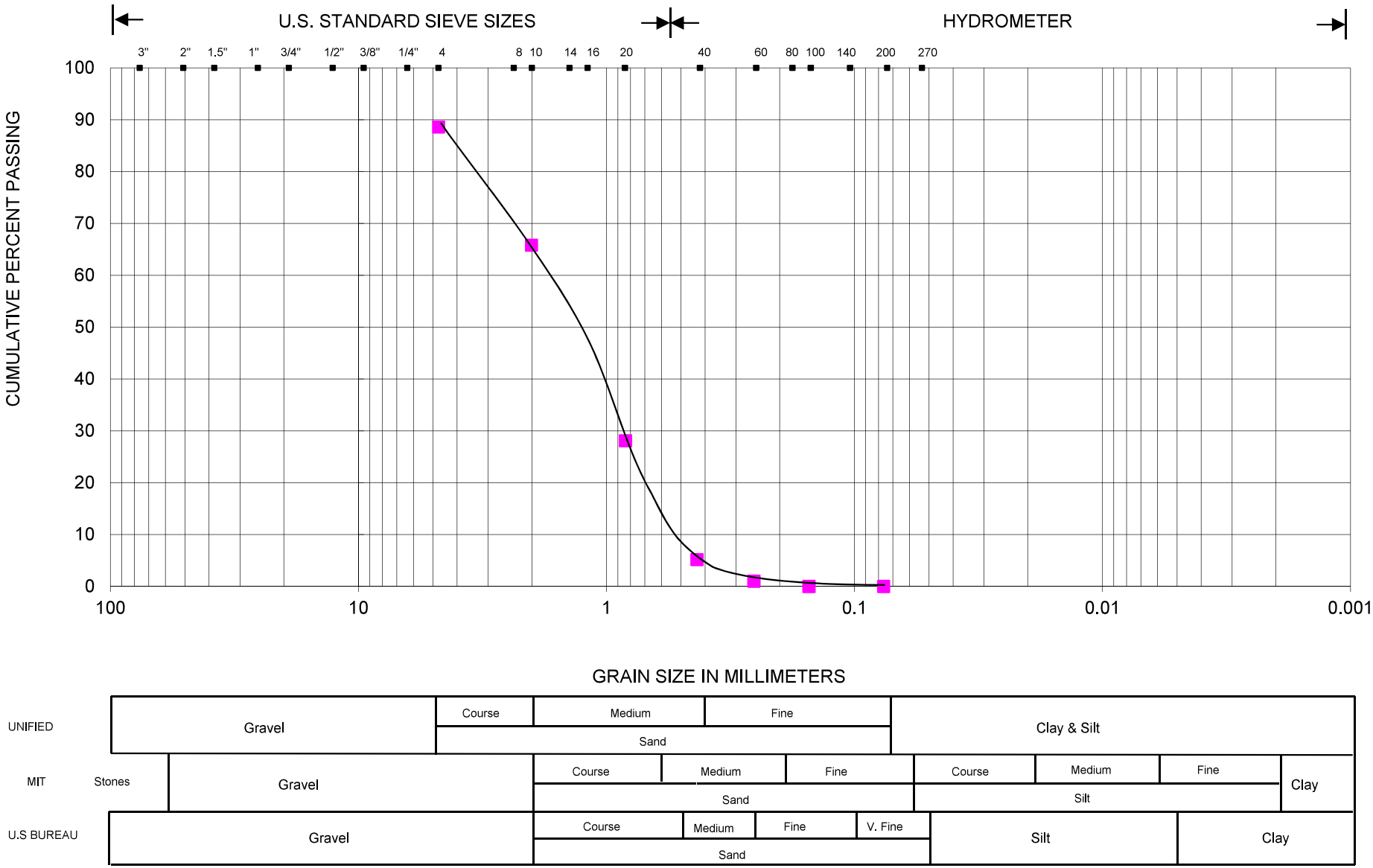
Grain Size Curve Results G. Hart - Lynden LM-01-14-D	Sample No.: 1 Depth: 170.5-175'	Project No.: P1170 Date Sampled: 7/19/2014	Morrison Environmental Limited Groundwater Consultants Morrison Environmental Limited 1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5

GRAIN SIZE CURVE



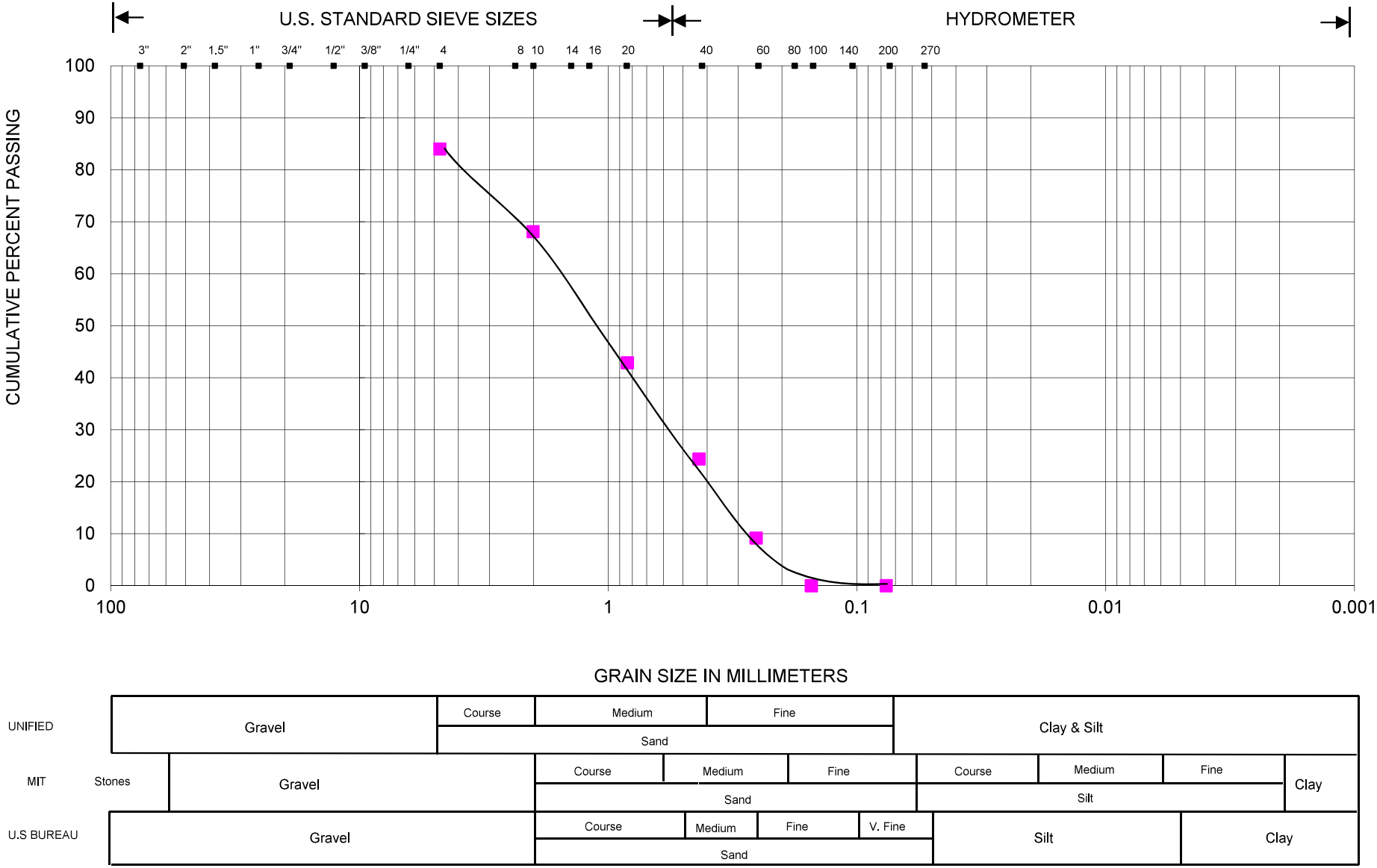
Grain Size Curve Results	Sample No.: 1	Project No.: P1170	Morrison Environmental Limited Groundwater Consultants Morrison Environmental Limited 1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5
G. Hart - Lynden			
LM-01-14-D	Depth: 175-180'	Date Sampled: 7/19/2014	

GRAIN SIZE CURVE



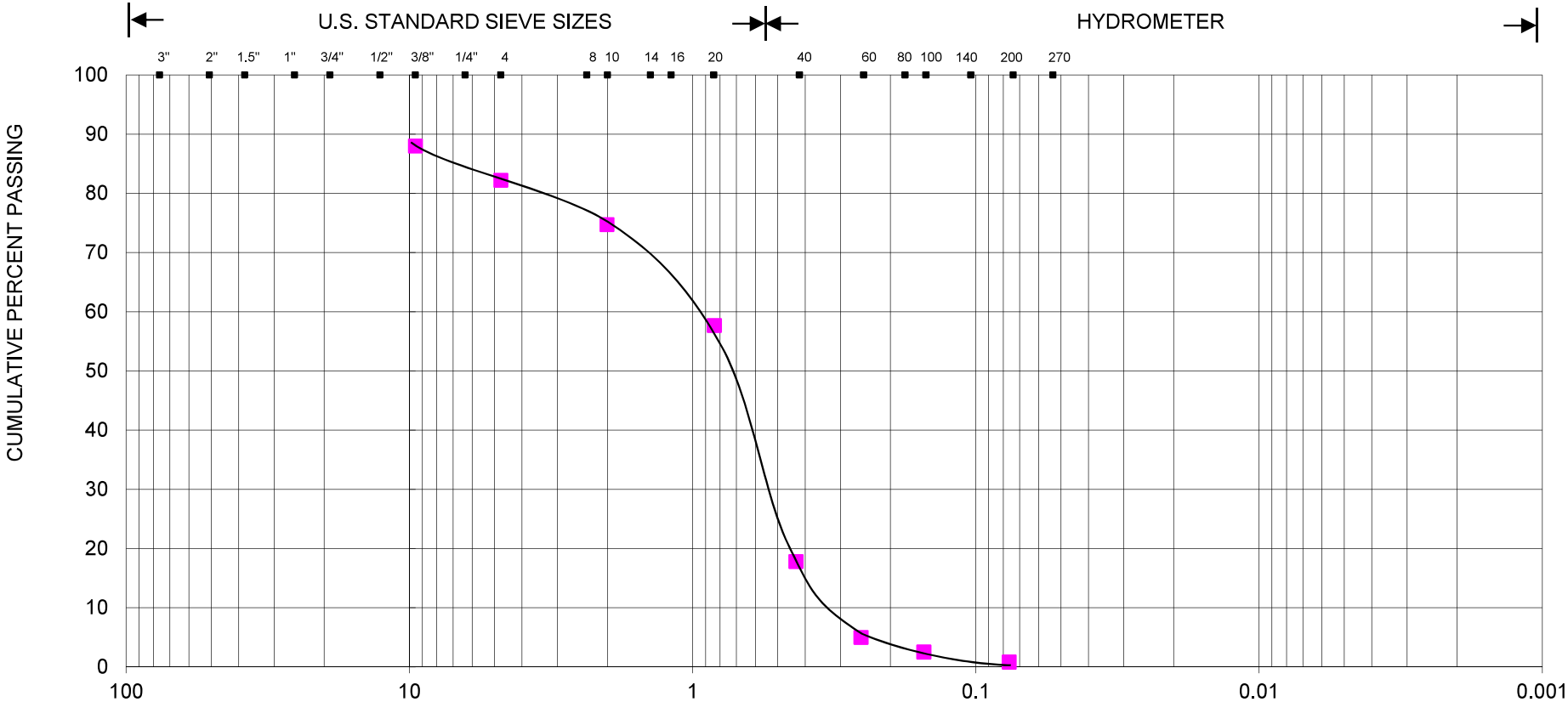
Grain Size Curve Results G. Hart - Lynden LM-01-14-D	Sample No.: 1 Depth: 180-185'	Project No.: P1170 Date Sampled: 7/19/2014	Morrison Environmental Limited Groundwater Consultants Morrison Environmental Limited 1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5

GRAIN SIZE CURVE



Grain Size Curve Results	Sample No.: 1	Project No.: P1170	Morrison Environmental Limited Groundwater Consultants Morrison Environmental Limited 1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5
G. Hart - Lynden			
LM-01-14-D	Depth: 185-186'	Date Sampled: 7/19/2014	

GRAIN SIZE CURVE

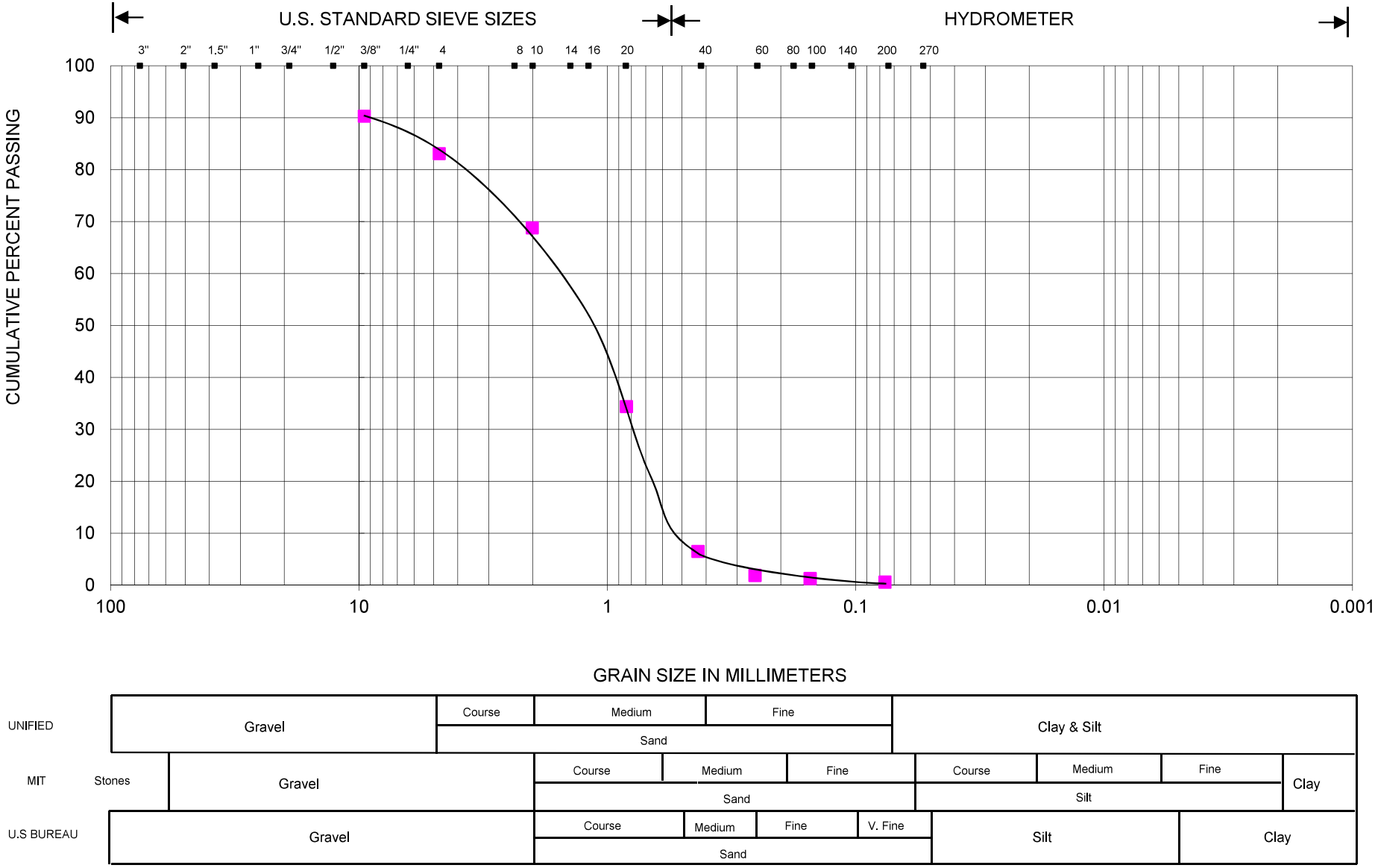


UNIFIED		Gravel	Course	Medium	Fine			Clay & Silt		
			Sand							
MIT	Stones	Gravel	Course	Medium	Fine	Course	Medium	Fine	Clay	
			Sand			Silt				
U.S BUREAU		Gravel	Course	Medium	Fine	V. Fine	Silt	Clay		
			Sand							

Grain Size Curve Results	Sample No.: 1		
G. Hart - Lynden		Project No.: P1170	
DW2			
LM-02-14-D	Depth: 165-168'	Date Sampled: 7/26/2014	

Morrison Environmental Limited
Groundwater Consultants
Morrison Environmental Limited
1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5

GRAIN SIZE CURVE



Grain Size Curve Results	Sample No.: 1		
G. Hart - Lynden		Project No.: P1170	
DW2			
LM-02-14-D	Depth: 168-171'	Date Sampled: 7/26/2014	

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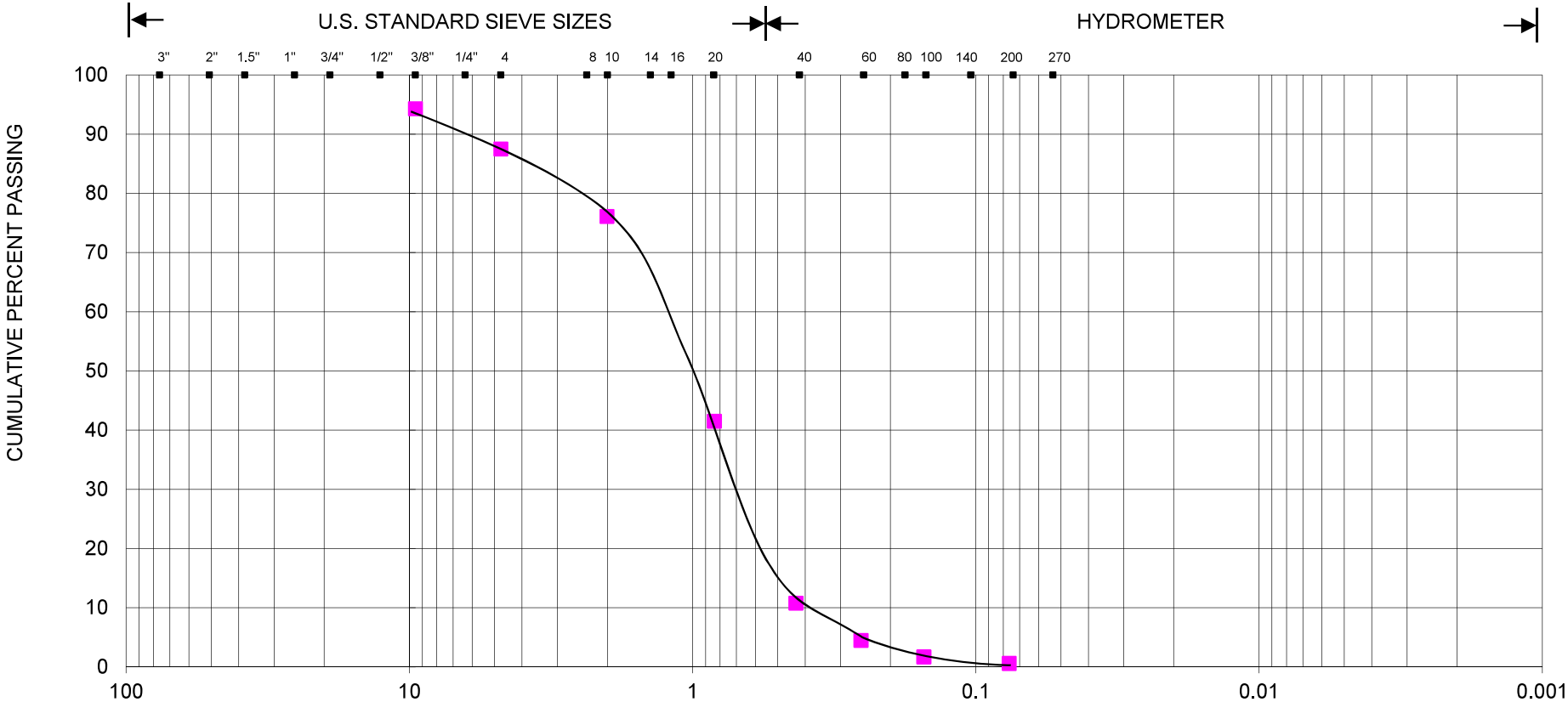
Morrison Environmental Limited
1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5

GRAIN SIZE CURVE



Grain Size Curve Results	Sample No.: 1		
G. Hart - Lynden		Project No.: P1170	
DW2			
LM-02-14-D	Depth: 171-173'	Date Sampled: 7/26/2014	

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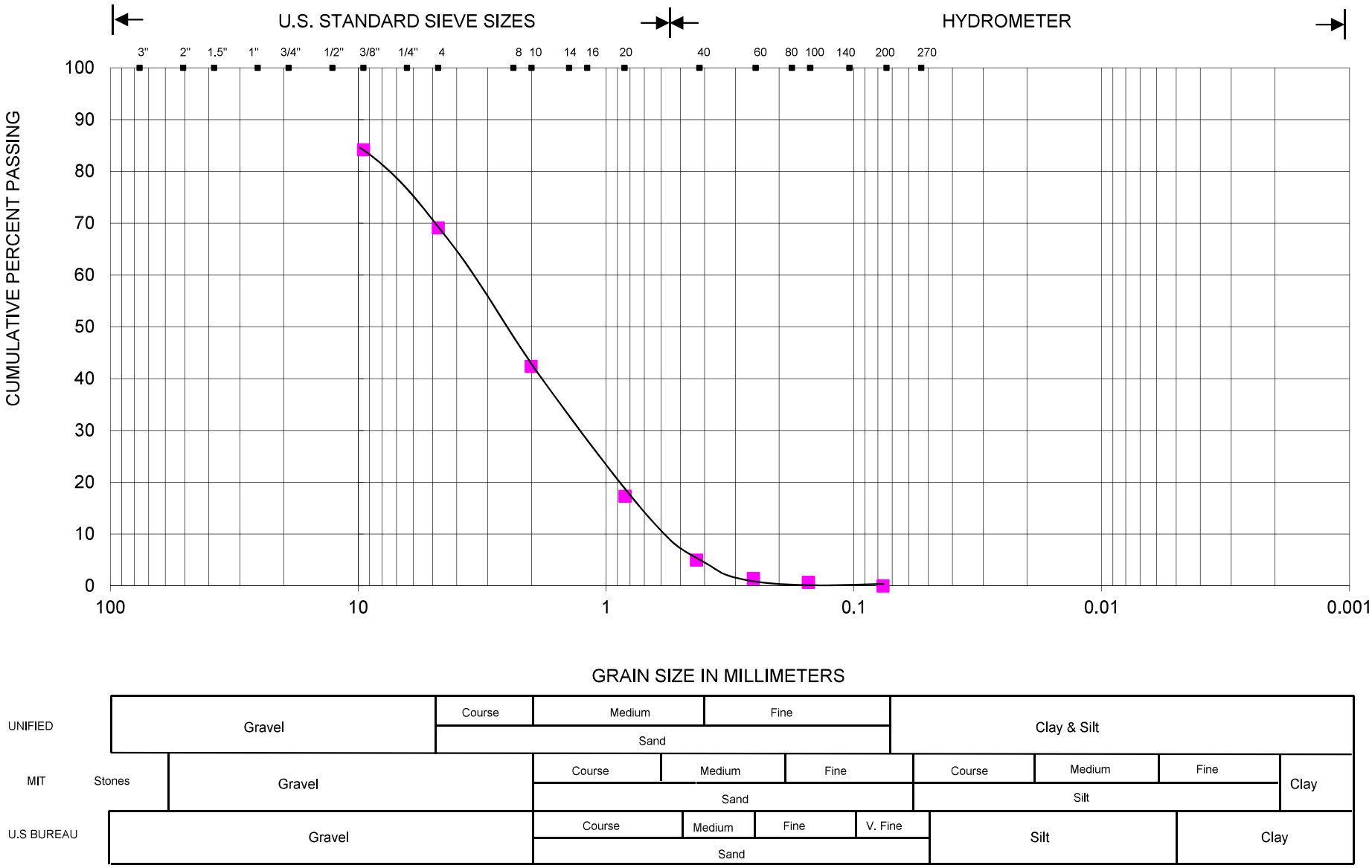
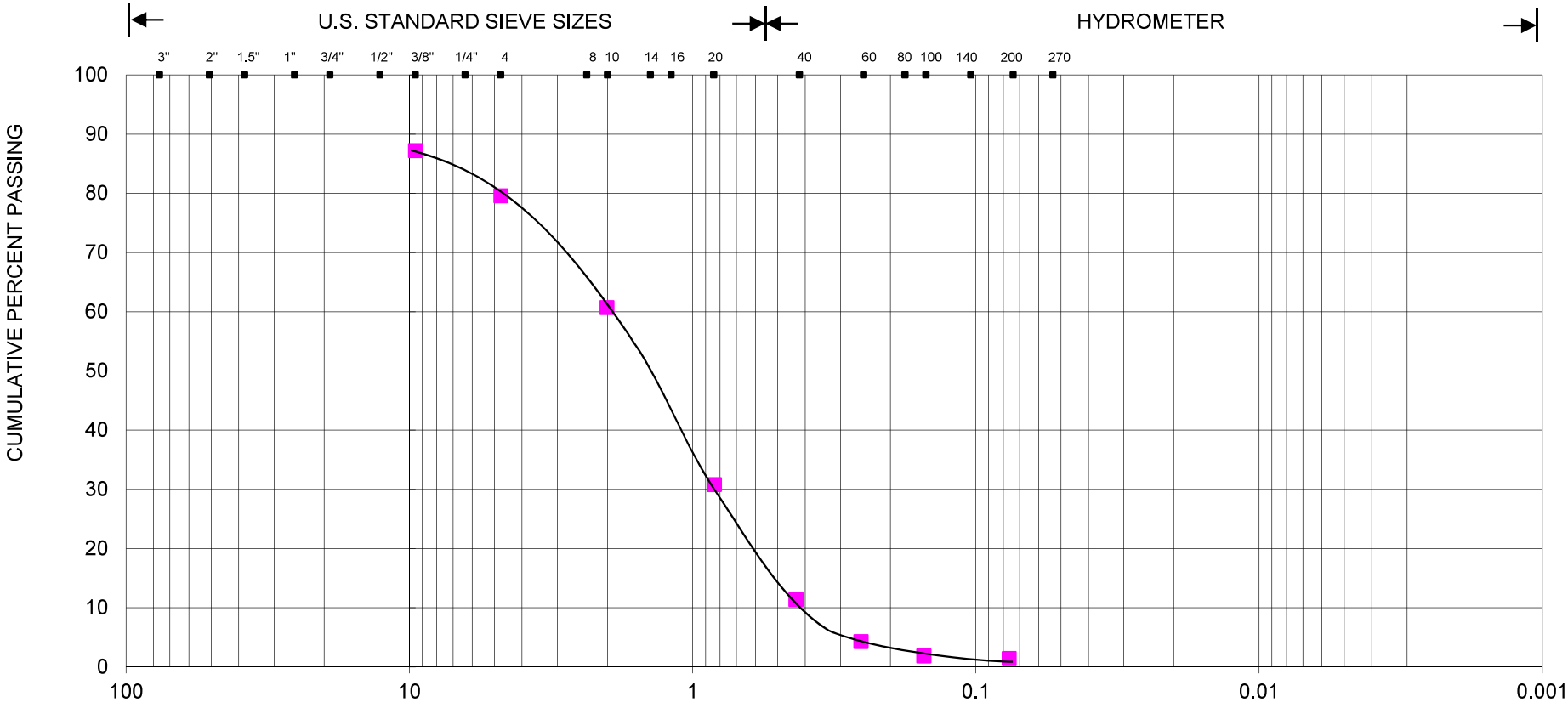
1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5

GRAIN SIZE CURVE



Grain Size Curve Results	Sample No.: 1		
G. Hart - Lynden		Project No.: P1170	Morrison Environmental Limited Groundwater Consultants Morrison Environmental Limited 1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5
DW2			
LM-02-14-D	Depth: 173-175'	Date Sampled: 7/26/2014	

GRAIN SIZE CURVE

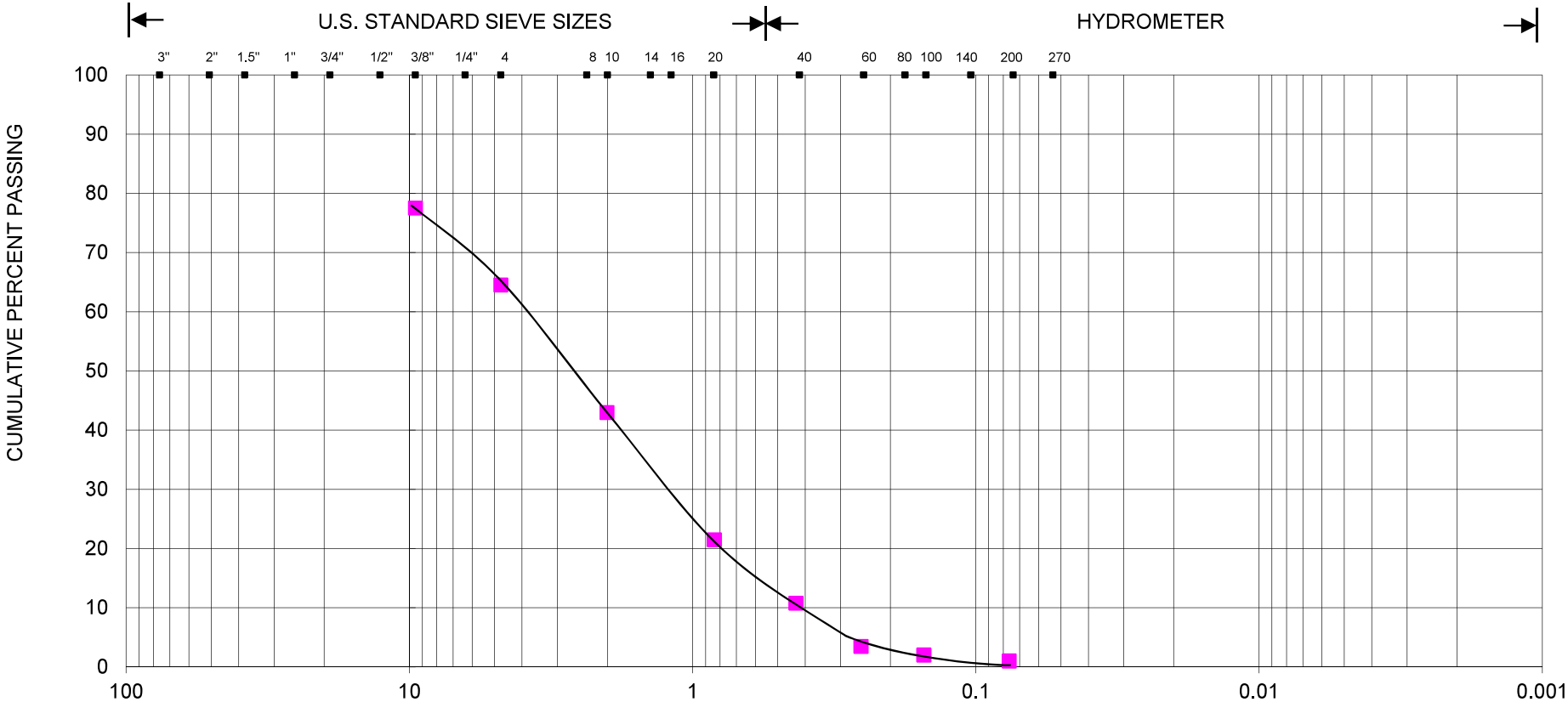


UNIFIED		Gravel	Course	Medium	Fine			Clay & Silt		
			Sand							
MIT	Stones	Gravel	Course	Medium	Fine	Course	Medium	Fine	Clay	
			Sand			Silt				
U.S BUREAU		Gravel	Course	Medium	Fine	V. Fine	Silt	Clay		
			Sand							

Grain Size Curve Results	Sample No.: 1		
G. Hart - Lynden		Project No.: P1170	
DW2			
LM-02-14-D	Depth: 175-178'	Date Sampled: 7/26/2014	

Morrison Environmental Limited
Groundwater Consultants
Morrison Environmental Limited
1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5

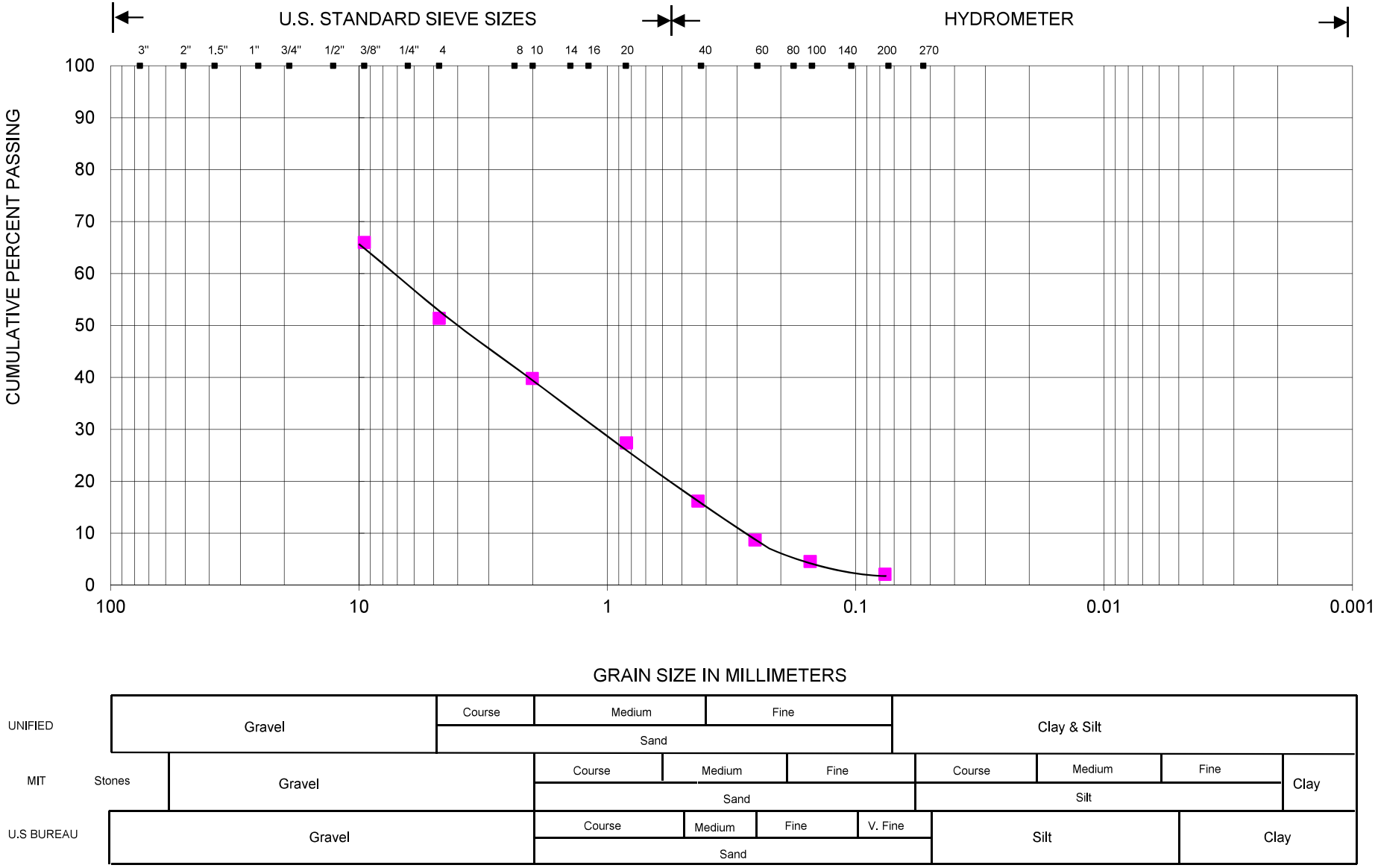
GRAIN SIZE CURVE



Grain Size Curve Results	Sample No.: 1		
G. Hart - Lynden		Project No.: P1170	
DW2			
LM-02-14-D	Depth: 178-181'	Date Sampled: 7/26/2014	

Morrison Environmental Limited
Groundwater Consultants
Morrison Environmental Limited
1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5

GRAIN SIZE CURVE



Grain Size Curve Results	Sample No.: 1		
G. Hart - Lynden		Project No.: P1170	
DW2			
LM-02-14-D	Depth: 181-184'	Date Sampled: 7/26/2014	

Morrison Environmental Limited
Groundwater Consultants
Morrison Environmental Limited
1087 Meyerside Drive, Unit 1, Mississauga, Ontario, L5T1M5

Appendix C

STEP TEST RESULTS

TABLE C-1 STEP TEST PUMPING DATA, LYNDEN TEST WELL LM-01-14-D
Lynden Barium Assessment
Project 141-17672-00

OW		DEPTH (mbgl):	56.7	Measuring Point: 0.84 m above grade
PW:	LM-01-14-D	SWL (m bmp):	14.97	Discharge Rate: see Comments Below
DATE:	26-Aug-14	I.D. (mm):	152	Pump Depth: 32.3 m below top of pipe
START:	12:40 PM			

D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
0.5	15.06	0.09				**STEP 1 : 1.5 L/s (20 Igpm)**
1	15.10	0.13				Fluctuations in flow rate
1.5	15.12	0.15				LM-02-14-D - 15.11 before start of step.
2	15.11	0.14				
2.5	15.11	0.14				
3	15.11	0.14				Flow at 1.5 L/s / 20 igpm
3.5	15.11	0.14				
4	15.12	0.15				
4.5	15.12	0.15				
5	15.12	0.15				
6	15.12	0.15				
7	15.12	0.15				
8	15.12	0.15				
9	15.13	0.16				
10	15.13	0.16				
12	15.14	0.17				
14	15.14	0.17				
16	15.14	0.17				
18	15.15	0.18				
20	15.15	0.18				
25	15.15	0.18				
30	15.15	0.18				
35	15.15	0.18				
40	15.15	0.18				
45	15.15	0.18				
50	15.16	0.19				
55	15.16	0.19				
60	15.16	0.19				

TABLE C-1 STEP TEST PUMPING DATA, LYNDEN TEST WELL LM-01-14-D
Lynden Barium Assessment
Project 141-17672-00

OW		DEPTH (mbgl):	56.7	Measuring Point: 0.84 m above grade
PW:	LM-01-14-D	SWL (m bmp):	14.97	Discharge Rate: see Comments Below
DATE:	26-Aug-14	I.D. (mm):	152	Pump Depth: 32.3 m below top of pipe
START:	12:40 PM			

D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
60.5	15.31	0.34				**STEP 2 : 3.0 L/s (40 Igpm)**
61	15.34	0.37				
61.5	15.34	0.37				
62	15.35	0.38				Flow rate fluctuations - air bubbles
62.5	15.35	0.38				
63	15.35	0.38				
63.5	15.36	0.39				
64	15.36	0.39				
64.5	15.36	0.39				
65	15.36	0.39				
66	15.37	0.40				
67	15.37	0.40				
68	15.37	0.40				
69	15.38	0.41				Flow rate fluctuations - air bubbles
72	15.38	0.41				
74	15.39	0.42				
76	15.39	0.42				
78	15.40	0.43				
80	15.40	0.43				
85	15.40	0.43				
90	15.41	0.44				
95	15.42	0.45				
100	15.43	0.46				
105	15.43	0.46				
110	15.44	0.47				
115	15.44	0.47				
120	15.44	0.47				

TABLE C-1 STEP TEST PUMPING DATA, LYNDEN TEST WELL LM-01-14-D
Lynden Barium Assessment
Project 141-17672-00

OW		DEPTH (mbgl):	56.7	Measuring Point: 0.84 m above grade
PW:	LM-01-14-D	SWL (m bmp):	14.97	Discharge Rate: see Comments Below
DATE:	26-Aug-14	I.D. (mm):	152	Pump Depth: 32.3 m below top of pipe
START:	12:40 PM			

D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
120.5	15.61	0.64				**STEP 3 : 4.5 L/s (60 Igpm)**
121	15.64	0.67				
121.5	15.65	0.68				
122	15.65	0.68				
122.5	15.66	0.69				Flow at 4.7 L/s
123	15.63	0.66				Flow at 4.5 L/s
123.5	15.65	0.68				
124	15.65	0.68				
124.5	15.65	0.68				
125	15.65	0.68				
126	15.66	0.69				
127	15.66	0.69				Flow rate fluctuations
128	15.66	0.69				
129	15.66	0.69				
130	15.67	0.70				
132	15.67	0.70				
134	15.68	0.71				
136	15.69	0.72				
138	15.69	0.72				
140	15.69	0.72				
145	15.70	0.73				
150	15.71	0.74				
155	15.72	0.75				
160	15.73	0.76				
165	15.74	0.77				
170	15.75	0.78				Sample taken. LM-02-14-D level at 15.29 m.
175	15.75	0.78				
180	15.76	0.79				
			180.5	15.25	0.28	Pump off
			181	15.25	0.28	
			181.5	15.24	0.27	
			182	15.22	0.25	
			182.5	15.22	0.25	
			183	15.21	0.24	
			183.5	15.21	0.24	
			184	15.20	0.23	
			184.5	15.19	0.22	
			185	15.19	0.22	
			186	15.18	0.21	
			187	15.18	0.21	
			188	15.17	0.20	
			189	15.16	0.19	
			190	15.16	0.19	
			192	15.15	0.18	
			194	15.14	0.17	
			196	15.14	0.17	
			198	15.16	0.19	FDL01 came on.
			200	15.18	0.21	
			205	15.19	0.22	
			210	15.20	0.23	
			215	15.21	0.24	
			220	15.21	0.24	
			225	15.21	0.24	
			230	15.21	0.24	
			235	15.21	0.24	
			240	15.21	0.24	

Q: discharge PW: pumped well I.D: inside diameter mbgl: metres below ground level
SWL: static water level OW: observation well mp: measuring point m bmp: metres below measuring point
L/sec: litres per second

FIGURE C-1

STEP TEST PUMPING DATA, LYNDEN TEST WELL LM-01-14-D

Static Water Level : 14.13 m bgl Well Depth: 56.7 m bgl Pumping Rate: As Shown	Project Name : **Lynden Barium Assessment** Project No : Project 141-17672-00 Date: 26-Aug-14
mbtoc - metres below top of casing Igpm - Imperial gallons per minute mbgl - metres below ground level L/sec - litres per second	Distance from pumping well = 0 m

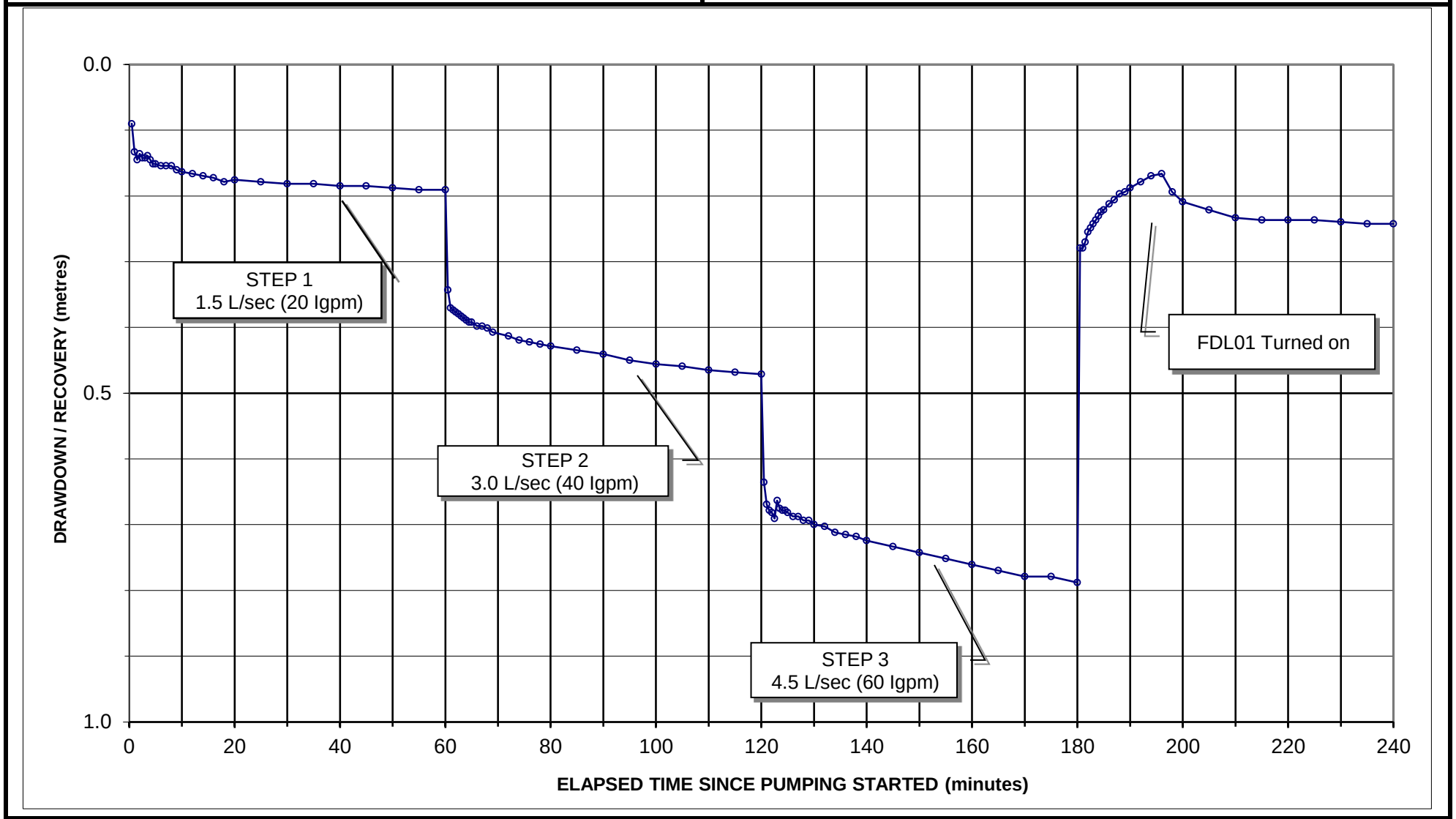


TABLE C-2: STEP TEST PUMPING DATA, LYNDEN TEST WELL LM-02-14-D
Lynden Barium Assessment
Project 141-17672-00

OW	DEPTH (mbgl):	55.5		Measuring Point: 0.89 m above grade
PW: LM-02-14-D	SWL (m bmp):	15.10		Discharge Rate: see Comments Below
DATE: 27-Aug-14	I.D. (mm):	152		Pump Depth: 24.4 m below top of pipe
START: 8:30 AM				

D R A W D O W N			CORRECTION		RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**CORRECTION (metres)**	**DRAWDOWN CORRECTED (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
0.5	15.28	0.18						**STEP 1 : 1.5 L/s (20 Igpm)**
1	15.30	0.20						Fluctuations in flow rate
1.5	15.30	0.20						LM-01-14-D - 14.95 m before start of step.
2	15.29	0.19						Water levels dropping at start of test.
2.5	15.35	0.25						Flow at 1.0 L/s.
3	15.36	0.26						Flow at 1.5 L/s / 20 igpm
3.5	15.36	0.26						Discharge water is black.
4	15.36	0.26						
4.5	15.37	0.27						
5	15.37	0.27						
6	15.37	0.27						
7	15.37	0.27						Flow at 1.5 L/s.
8	15.38	0.28						
9	15.38	0.28						
10	15.38	0.28						
12	15.38	0.28						Discharge water is clear.
14	15.39	0.29						
16	15.39	0.29						
18	15.40	0.30						
20	15.40	0.30						
25	15.40	0.30						
30	15.40	0.30						
35	15.41	0.31						
40	15.41	0.31	0.00	0.31				Air bubbles in discharge.
45	15.44	0.34	0.03	0.32				FDL01 assumed to have come on.
50	15.46	0.36	0.04	0.32				
55	15.48	0.38	0.05	0.33				
60	15.49	0.39	0.06	0.33				

TABLE C-2: STEP TEST PUMPING DATA, LYNDEN TEST WELL LM-02-14-D
Lynden Barium Assessment
Project 141-17672-00

OW	DEPTH (mbgl):	55.5		Measuring Point: 0.89 m above grade
PW: LM-02-14-D	SWL (m bmp):	15.10		Discharge Rate: see Comments Below
DATE: 27-Aug-14	I.D. (mm):	152		Pump Depth: 24.4 m below top of pipe
START: 8:30 AM				

D R A W D O W N			CORRECTION		RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**CORRECTION (metres)**	**DRAWDOWN CORRECTED (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
60.5	15.70	0.60	0.07	0.53				**STEP 2 : 3.0 L/s (40 Igpm)**
61	15.73	0.63	0.07	0.56				
61.5	15.76	0.66	0.07	0.59				
62	15.77	0.67	0.07	0.60				
62.5	15.78	0.68	0.07	0.61				Flow fluctuations.
63	15.79	0.69	0.07	0.62				
63.5	15.85	0.75	0.07	0.68				Flow rate 3.0 L/s.
64	15.86	0.76	0.07	0.69				
64.5	15.86	0.76	0.08	0.68				
65	15.87	0.77	0.08	0.69				Air bubbles in discharge.
66	15.88	0.78	0.08	0.70				
67	15.88	0.78	0.08	0.70				
68	15.89	0.79	0.08	0.71				
69	15.89	0.79	0.08	0.71				
70	15.90	0.80	0.08	0.72				
72	15.90	0.80	0.08	0.72				
74	15.91	0.81	0.08	0.73				
76	15.92	0.82	0.08	0.74				
78	15.92	0.82	0.09	0.73				
80	15.93	0.83	0.09	0.74				
85	15.94	0.84	0.10	0.74				
90	15.96	0.86	0.11	0.75				
95	15.97	0.87	0.11	0.76				
100	15.98	0.88	0.11	0.77				
105	15.99	0.89	0.11	0.78				
110	16.00	0.90	0.11	0.79				LM-01-14-D - 15.28 m. FDL01 still pumping.
115	16.01	0.91	0.12	0.79				
120	16.02	0.92	0.12	0.80				

TABLE C-2: STEP TEST PUMPING DATA, LYNDEN TEST WELL LM-02-14-D
Lynden Barium Assessment
Project 141-17672-00

OW	DEPTH (mbgl):	55.5		Measuring Point: 0.89 m above grade
PW: LM-02-14-D	SWL (m bmp):	15.10		Discharge Rate: see Comments Below
DATE: 27-Aug-14	I.D. (mm):	152		Pump Depth: 24.4 m below top of pipe
START: 8:30 AM				

D R A W D O W N			CORRECTION		RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**CORRECTION (metres)**	**DRAWDOWN CORRECTED (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
120.5	16.46	1.36	0.12	1.24				**STEP 3 : 4.5 L/s (60 Igpm)**
121	16.51	1.41	0.12	1.29				
121.5	16.53	1.43	0.12	1.31				
122	16.53	1.43	0.12	1.31				
122.5	16.52	1.42	0.12	1.30				Flow adjustment.
123	16.55	1.45	0.12	1.33				
123.5	16.55	1.45	0.12	1.33				Flow adjustment.
124	16.40	1.30	0.12	1.18				
124.5	16.36	1.26	0.12	1.14				
125	16.36	1.26	0.12	1.14				Flow adjustment.
126	16.42	1.32	0.12	1.20				
127	16.43	1.33	0.12	1.21				Flow adjustment.
128	16.44	1.34	0.13	1.21				
129	16.44	1.34	0.13	1.21				Flow at 4.5 L/s.
130	16.45	1.35	0.13	1.22				
132	16.45	1.35	0.13	1.22				
134	16.46	1.36	0.13	1.23				
136	16.47	1.37	0.13	1.24				
138	16.47	1.37	0.13	1.24				
140	16.47	1.37	0.13	1.24				
145	16.49	1.39	0.14	1.25				
150	16.50	1.40	0.14	1.26				
155	16.52	1.42	0.14	1.28				
160	16.53	1.43	0.14	1.29				
165	16.54	1.44	0.14	1.30				
170	16.55	1.45	0.15	1.30				Sample taken. LM-01-14-D at 15.435 m.
175	16.55	1.45	0.15	1.30				
180	16.57	1.47	0.15	1.32				

TABLE C-2: STEP TEST PUMPING DATA, LYNDEN TEST WELL LM-02-14-D
Lynden Barium Assessment
Project 141-17672-00

OW	DEPTH (mbgl):	55.5		Measuring Point: 0.89 m above grade
PW: LM-02-14-D	SWL (m bmp):	15.10		Discharge Rate: see Comments Below
DATE: 27-Aug-14	I.D. (mm):	152		Pump Depth: 24.4 m below top of pipe
START: 8:30 AM				

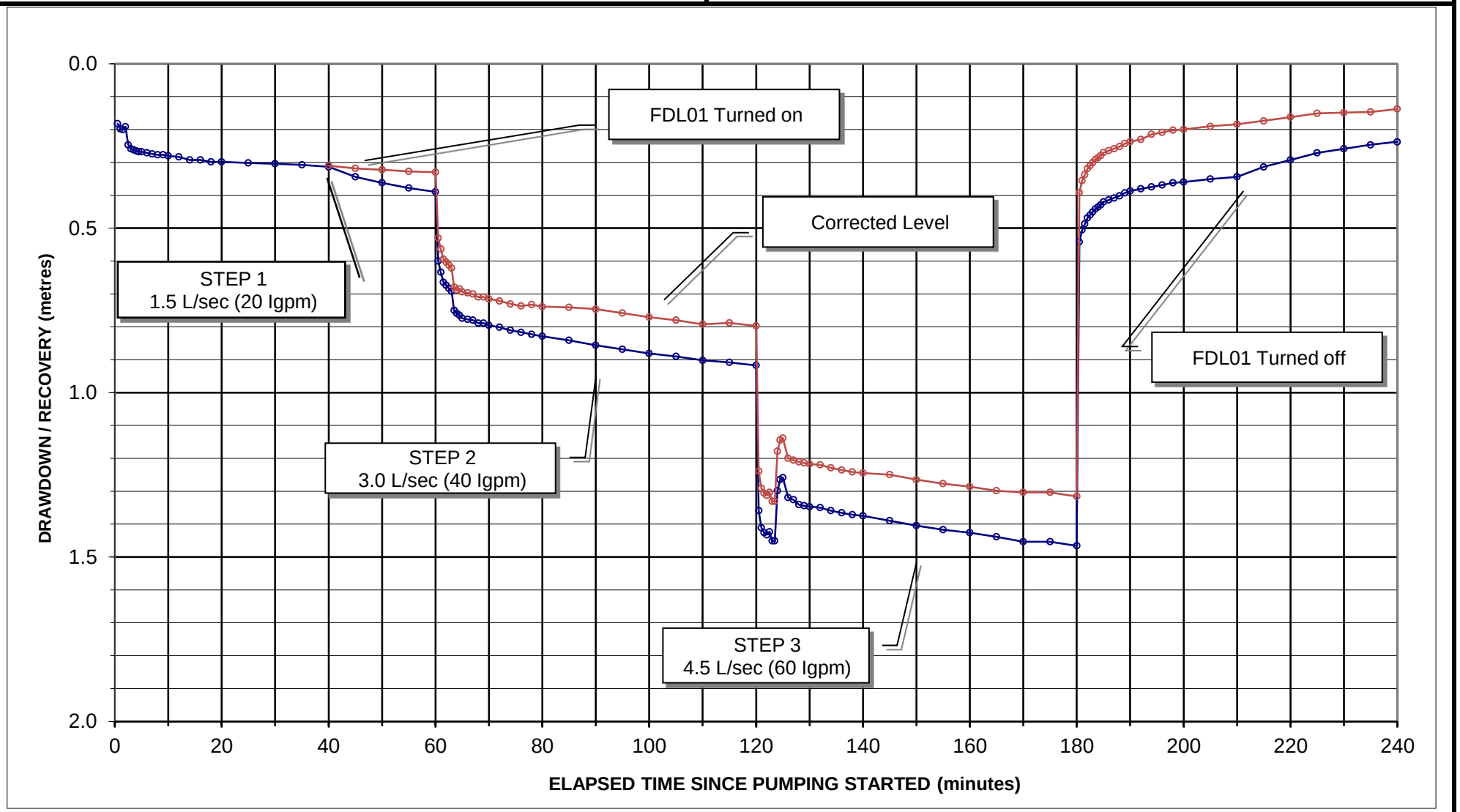
D R A W D O W N			CORRECTION		RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**CORRECTION (metres)**	**DRAWDOWN CORRECTED (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
			0.15	0.39	180.5	15.64	0.54	Pump off
			0.15	0.36	181	15.61	0.51	
			0.15	0.34	181.5	15.59	0.49	
			0.15	0.32	182	15.57	0.47	
			0.15	0.31	182.5	15.56	0.46	
			0.15	0.30	183	15.55	0.45	
			0.15	0.29	183.5	15.54	0.44	
			0.15	0.29	184	15.54	0.44	
			0.15	0.28	184.5	15.53	0.43	
			0.15	0.27	185	15.52	0.42	
			0.15	0.26	186	15.51	0.41	
			0.15	0.26	187	15.51	0.41	
			0.15	0.25	188	15.50	0.40	
			0.15	0.24	189	15.49	0.39	
			0.15	0.24	190	15.49	0.39	
			0.15	0.23	192	15.48	0.38	
			0.16	0.21	194	15.47	0.37	
			0.16	0.21	196	15.47	0.37	
			0.16	0.20	198	15.46	0.36	
			0.16	0.20	200	15.46	0.36	
			0.16	0.19	205	15.45	0.35	
			0.16	0.18	210	15.44	0.34	
			0.14	0.17	215	15.41	0.31	FDL01 off.
			0.13	0.16	220	15.39	0.29	
			0.12	0.15	225	15.37	0.27	
			0.11	0.15	230	15.36	0.26	
			0.10	0.15	235	15.35	0.25	
			0.10	0.14	240	15.34	0.24	

Q: discharge PW: pumped well I.D: inside diameter mbgl: metres below ground level
SWL: static water level OW: observation well mp: measuring point m bmp: metres below measuring point
L/sec: litres per second

FIGURE C-2

STEP TEST PUMPING DATA, LYNDEN TEST WELL LM-02-14-D

Static Water Level : 14.21 m bgl Well Depth: 55.5 m bgl Pumping Rate: As Shown	Project Name : **Lynden Barium Assessment** Project No : Project 141-17672-00 Date: 27-Aug-14
mbtoc - metres below top of casing Igpm - Imperial gallons per minute mbgl - metres below ground level L/sec - litres per second	Distance from pumping well = 0 m



Appendix D

SOIL SAMPLING RESULTS

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: WSP CANADA INC.
SUITE 500, 600 COCHRANE DRIVE
MARKHAM, ON L3R5K3
(905) 475-7270

ATTENTION TO: Derek Brunner

PROJECT: 141-17672

AGAT WORK ORDER: 14T866072

SOIL ANALYSIS REVIEWED BY: Mike Muneswar, BSc (Chem), Senior Inorganic Analyst

DATE REPORTED: Aug 22, 2014

PAGES (INCLUDING COVER): 4

VERSION*: 2

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES
VERSION 2: Revised report sent on September 9, 2014.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Member of: Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA)
Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation.

Results relate only to the items tested and to all the items tested

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 14T866072

PROJECT: 141-17672

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:Derek Brunner

Barium Sulphate (soil)

DATE RECEIVED: 2014-07-21

DATE REPORTED: 2014-08-22

		SAMPLE DESCRIPTION:		TW1 170.5-175	TW1 175-180	TW1 180-185	TW1 186.5-187.5
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		7/18/2014	7/18/2014	7/18/2014	7/18/2014
Parameter	Unit	G / S	RDL	5598579	5598580	5598581	5598582
Barium	µg/g		0.3	923	376	385	I.S.
Barium Sulphate	%		0.005	0.157	0.064	0.065	I.S.

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

5598579-5598581 Barium - Analysis was performed at AGAT's Mining Division.
Values reported for Barium Sulphate were calculated from Barium.

5598582 I.S.- Insuffecient Sample.

Certified By:

Results relate only to the items tested and to all the items tested

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
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FAX (905)712-5122
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Quality Assurance

CLIENT NAME: WSP CANADA INC.

PROJECT: 141-17672

SAMPLING SITE:

AGAT WORK ORDER: 14T866072

ATTENTION TO: Derek Brunner

SAMPLED BY:Derek Brunner

Soil Analysis

RPT Date: Aug 22, 2014			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Barium Sulphate (soil)															
Barium	1		370	370	0.0%	< 0.3	104%	70%	130%	NA	80%	120%	NA	70%	130%

Comments: NA signifies Not Applicable.

Certified By:

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5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: WSP CANADA INC.

AGAT WORK ORDER: 14T866072

PROJECT: 141-17672

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:Derek Brunner

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Barium			ICP/OES
Barium Sulphate			ICP/OES

Results relate only to the items tested and to all the items tested

AGAT Laboratories

5835 Coopers Avenue
Mississauga, ON
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com
P: 905.712.5100 · F: 905.712.5122

Chain of Custody Record

Laboratory Use Only

Arrival Temperature: 23.4, 26.2, 24.3
AGAT WO #:
Lab Temperature: 14T866072
Notes:

Client Information

Company: WSP Canada
Contact: Derek Brunner
Address: 600 Cochrane Drive Suite 500 Markham ON L3R 5K3
Phone: 647-500-6691 Fax: 905-475-5994
Project: 141-17672 PO:
AGAT Quotation #: 49550

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements

☐ Regulation 153/04 (reg. 511 Amend.)
Table ____ Indicate one
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture (check one)
☐ Coarse ☐ Fine

☐ Sewer Use
Region ____ Indicate one
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
☒ 5 to 7 Working Days
Rush TAT (please provide prior notification)
Rush Surcharges Apply
☒ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day
OR
Date Required (Rush surcharges may apply):

*TAT is exclusive of weekends and statutory holidays

Invoice To

Same: Yes ☒ No ☐
Company:
Contact:
Address:

Is this a drinking water sample? (potable water intended for human consumption)
☐ Yes ☒ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition**?
☐ Yes ☒ No

Legend Matrix

GW Ground Water **O** Oil
SW Surface Water **P** Paint
SD Sediment **S** Soil

Report Information – reports to be sent to:

1. Name: Derek Brunner
   Email: derek.brunner@wspgroup.com
2. Name:
   Email:

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N-Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	Barium	Sulphite	Barite (calculation)
TWI 170.5-175	Jul 18/14		S	1																	X	X	X
TWI 175-180	"		S	1																	X	X	X
TWI 180-185	"		S	1																	X	X	X
~~[illegible]~~																							
TWI 186.5-187.5	"		S	1																	X	X	X

Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time
Derek Brunner	July 21/14	Kyle [signature]	2:30 21/07
Derek S Brunner	July 21/14		

Pink Copy - Client
Yellow Copy - AGAT
White Copy - AGAT

Page 1 of 1
Nº: 45485

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: WSP CANADA INC.
SUITE 500, 600 COCHRANE DRIVE
MARKHAM, ON L3R5K3
(905) 475-7270

ATTENTION TO: Derek Brunner

PROJECT: 141-17672

AGAT WORK ORDER: 14T866072

SOIL ANALYSIS REVIEWED BY: Anthony Dapaah, PhD (Chem), Inorganic Lab Manager

DATE REPORTED: Aug 22, 2014

PAGES (INCLUDING COVER): 4

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Member of: Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA)
Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

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AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 14T866072

PROJECT: 141-17672

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:Derek Brunner

Sulphate (Soil)

DATE RECEIVED: 2014-07-21

DATE REPORTED: 2014-08-22

		SAMPLE DESCRIPTION:		TW1 170.5-175	TW1 175-180	TW1 180-185	TW1 186.5-187.5
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		7/18/2014	7/18/2014	7/18/2014	7/18/2014
Parameter	Unit	G / S	RDL	5598579	5598580	5598581	5598582
Sulphate (2:1)	µg/g		2	12	20	22	45

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By:

Results relate only to the items tested and to all the items tested

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: WSP CANADA INC.

PROJECT: 141-17672

SAMPLING SITE:

AGAT WORK ORDER: 14T866072

ATTENTION TO: Derek Brunner

SAMPLED BY:Derek Brunner

Soil Analysis

RPT Date: Aug 22, 2014			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Sulphate (Soil)															
Sulphate (2:1)	1	5598579	12	12	0.0%	< 2	96%	70%	130%	98%	70%	130%	110%	70%	130%

Certified By:

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation.

Results relate only to the items tested and to all the items tested

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: WSP CANADA INC.

AGAT WORK ORDER: 14T866072

PROJECT: 141-17672

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:Derek Brunner

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH

Results relate only to the items tested and to all the items tested

AGAT Laboratories

5835 Coopers Avenue
Mississauga, ON
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com
P: 905.712.5100 · F: 905.712.5122

Chain of Custody Record

Laboratory Use Only

Arrival Temperature: 23.4, 26.2, 24.3
AGAT WO #:
Lab Temperature: 14T866072
Notes:

Client Information

Company: WSP Canada
Contact: Derek Brunner
Address: 600 Cochrane Drive Suite 500 Markham ON L3R 5K3
Phone: 647-500-6691 Fax: 905-475-5994
Project: 141-17672 PO:
AGAT Quotation #: 49550

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements

☐ Regulation 153/04 (reg. 511 Amend.)
Table ____ Indicate one
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture (check one)
☐ Coarse ☐ Fine

☐ Sewer Use
Region ____ Indicate one
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
☒ 5 to 7 Working Days
Rush TAT (please provide prior notification)
Rush Surcharges Apply
☒ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day
OR
Date Required (Rush surcharges may apply):

*TAT is exclusive of weekends and statutory holidays

Invoice To

Same: Yes ☒ No ☐
Company:
Contact:
Address:

Is this a drinking water sample? (potable water intended for human consumption)
☐ Yes ☒ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition**?
☐ Yes ☒ No

Legend Matrix

GW Ground Water **O** Oil
SW Surface Water **P** Paint
SD Sediment **S** Soil

Report Information – reports to be sent to:

1. Name: Derek Brunner
   Email: derek.brunner@wspgroup.com
2. Name:
   Email:

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N-Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	Barium	Sulphite	Barite (calculation)
TWI 170.5-175	Jul 18/14		S	1																	X	X	X
TWI 175-180	"		S	1																	X	X	X
TWI 180-185	"		S	1																	X	X	X
~~[illegible]~~																							
TWI 186.5-187.5	"		S	1																	X	X	X

Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time
Derek Brunner	July 21/14	Kyle [signature]	2:30 21/07
Derek S Brunner	July 21/14		

Pink Copy - Client
Yellow Copy - AGAT
White Copy - AGAT

Page 1 of 1
Nº: 45485

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: WSP CANADA INC.
SUITE 500, 600 COCHRANE DRIVE
MARKHAM, ON L3R5K3
(905) 475-7270

ATTENTION TO: Derek Brunner

PROJECT: 141-17072-00

AGAT WORK ORDER: 14T868505

SOIL ANALYSIS REVIEWED BY: Mike Muneswar, BSc (Chem), Senior Inorganic Analyst

DATE REPORTED: Aug 01, 2014

PAGES (INCLUDING COVER): 4

VERSION*: 2

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES
VERSION 2: Revised report sent on September 9, 2014.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Member of: Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA)
Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation.

Results relate only to the items tested and to all the items tested

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 14T868505

PROJECT: 141-17072-00

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:

Barium Sulphate (soil)

DATE RECEIVED: 2014-07-25

DATE REPORTED: 2014-08-01

		SAMPLE DESCRIPTION:		TW2 171-173	TW2 173-175	TW2 178-181	TW2 181-184
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		7/25/2014	7/25/2014	7/25/2014	7/25/2014
Parameter	Unit	G / S	RDL	5622152	5622159	5622160	5622161
Barium	µg/g		0.3	322	367	537	331
Barium Sulphate	%		0.005	0.055	0.062	0.091	0.056

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
5622152-5622161 Barium - Analysis was performed at AGAT's Mining Division.
Values reported for Barium Sulphate were calculated from Barium.

Certified By:

Results relate only to the items tested and to all the items tested

AGAT Laboratories

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CANADA L4Z 1Y2
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http://www.agatlabs.com

Quality Assurance

CLIENT NAME: WSP CANADA INC.

AGAT WORK ORDER: 14T868505

PROJECT: 141-17072-00

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:

Soil Analysis

RPT Date: Aug 01, 2014			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Barium Sulphate (soil)															
Barium	5628135		331	331	0.0%	< 0.3	104%	70%	130%	NA	80%	120%	NA	70%	130%

Comments: NA signifies Not Applicable.

Certified By:

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CANADA L4Z 1Y2
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Method Summary

CLIENT NAME: WSP CANADA INC.

AGAT WORK ORDER: 14T868505

PROJECT: 141-17072-00

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Barium			ICP/OES
Barium Sulphate			ICP/OES

Results relate only to the items tested and to all the items tested

no ice

AGAT Laboratories

5835 Coopers Avenue
Mississauga, ON
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com
P: 905.712.5100 · F: 905.712.5122

Chain of Custody Record

Laboratory Use Only
Arrival Temperature: 27.3, 27.6, 26.2
AGAT WO #:
Lab Temperature: 14T868505
Notes:

Client Information
Company: WSP CANADA
Contact: DEREK BRUNNER
Address: 600 Cochrane Dr. Suite 500
Markham ON L3R 5K3
Phone: 647-500 6691 Fax: 905 475-5994
Project: 141-17072-00 PO:
AGAT Quotation #: 49550
Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements
☐ Regulation 153/04 (reg. 511 Amend.)
Table ____ Indicate one
☐ Ind/Com
☐ Res/Park
☒ Agriculture
Soil Texture (check one)
☐ Coarse ☐ Fine

☐ Sewer Use
Region ____ Indicate one
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*
Regular TAT
☒ 5 to 7 Working Days
Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day
OR
Date Required (Rush surcharges may apply):
*TAT is exclusive of weekends and statutory holidays

Invoice To Same: Yes ☒ No ☐
Company:
Contact:
Address:

Is this a drinking water sample? (potable water intended for human consumption) ☐ Yes ☒ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a Record of Site Condition? ☐ Yes ☒ No

Legend Matrix
GW Ground Water O Oil
SW Surface Water P Paint
SD Sediment S Soil

Report Information – reports to be sent to:
1. Name: Derek Brunner
Email: derek.brunner@wspgroup.com
2. Name:
Email:

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N- Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	BARIUM	SULPHITE	BARITE (Calculation)
~~TWZ~~																							
TWZ 171-173	25/7/14		S	1																	X	X	X
TWZ 173-175	25/7/14		S	1																	X	X	X
TWZ 178-181	25/7/14		S	1																	X	X	X
TWZ 181-184	25/7/14		S	1																	X	X	X

Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time
Jenny C Cameron	July 25/14	[signature] Mike A	July 25 1:30 pm
Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time

Pink Copy - Client
Yellow Copy - AGAT
White Copy- AGAT

Page 1 of 1
Nº: 45840

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: WSP CANADA INC.
SUITE 500, 600 COCHRANE DRIVE
MARKHAM, ON L3R5K3
(905) 475-7270

ATTENTION TO: Derek Brunner

PROJECT: 141-17072-00

AGAT WORK ORDER: 14T868505

SOIL ANALYSIS REVIEWED BY: Parvathi Malemath, Data Reviewer

DATE REPORTED: Aug 01, 2014

PAGES (INCLUDING COVER): 4

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Member of: Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA)
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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 14T868505

PROJECT: 141-17072-00

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:

Sulphate (soil)

DATE RECEIVED: 2014-07-25

DATE REPORTED: 2014-08-01

		SAMPLE DESCRIPTION:		TW2 171-173	TW2 173-175	TW2 178-181	TW2 181-184
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		7/25/2014	7/25/2014	7/25/2014	7/25/2014
Parameter	Unit	G / S	RDL	5622152	5622159	5622160	5622161
Sulphate (2:1)	µg/g		2	27	32	28	20

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By: Parvathi Malenath

Results relate only to the items tested and to all the items tested

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
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http://www.agatlabs.com

Quality Assurance

CLIENT NAME: WSP CANADA INC.

AGAT WORK ORDER: 14T868505

PROJECT: 141-17072-00

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:

Soil Analysis

RPT Date: Aug 01, 2014			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Sulphate (soil)															
Sulphate (2:1)	5617097		51	52	1.9%	< 2	95%	80%	120%	106%	80%	120%	108%	70%	130%

Certified By: Parvathi Malemath

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: WSP CANADA INC.

AGAT WORK ORDER: 14T868505

PROJECT: 141-17072-00

ATTENTION TO: Derek Brunner

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH

Results relate only to the items tested and to all the items tested

no ice

AGAT Laboratories

5835 Coopers Avenue
Mississauga, ON
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com
P: 905.712.5100 · F: 905.712.5122

Chain of Custody Record

Laboratory Use Only
Arrival Temperature: 27.3, 27.6, 26.2
AGAT WO #:
Lab Temperature: 14T868505
Notes:

Client Information

Company: WSP CANADA
Contact: DEREK BRUNNER
Address: 600 Cochrane Dr. Suite 500
Markham ON L3R 5K3
Phone: 647-500 6691 Fax: 905 475-5994
Project: 141-17072-00 PO:
AGAT Quotation #: 49550

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements

☐ Regulation 153/04 (reg. 511 Amend.)
Table ____ Indicate one
☐ Ind/Com
☐ Res/Park
☒ Agriculture
Soil Texture (check one)
☐ Coarse ☐ Fine

☐ Sewer Use
Region ____ Indicate one
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
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OR
Date Required (Rush surcharges may apply):

*TAT is exclusive of weekends and statutory holidays

Invoice To

Same: Yes ☒ No ☐
Company:
Contact:
Address:

Is this a drinking water sample? (potable water intended for human consumption)
☐ Yes ☒ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition**?
☐ Yes ☒ No

Legend Matrix

GW Ground Water **O** Oil
SW Surface Water **P** Paint
SD Sediment **S** Soil

Report Information – reports to be sent to:

1. Name: Derek Brunner
   Email: derek.brunner@wspgroup.com
2. Name:
   Email:

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N- Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use	BARIUM	SULPHITE	BARITE (Calculation)
~~TWZ~~																							
TWZ 171-173	25/7/14		S	1																	X	X	X
TWZ 173-175	25/7/14		S	1																	X	X	X
TWZ 178-181	25/7/14		S	1																	X	X	X
TWZ 181-184	25/7/14		S	1																	X	X	X

Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time
Jenny C Cameron	July 25/14	[signature] Mike A	July 25 1:30 pm
Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time

Pink Copy - Client
Yellow Copy - AGAT
White Copy- AGAT

Page 1 of 1
Nº: 45840

Maxxam

Success Through Science®

Your Project #: 141-17672-00
Site Location: LYNDEN
Your C.O.C. #: 47700401, 477004-01-01

Attention: Derek Brunner
WSP Canada Inc
600 Cochrane Dr
Suite 500
Markham, ON
L3R 5K3

Report Date: 2014/08/06
Report #: R3112856
Version: 1

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B4D2431
Received: 2014/07/25, 09:10

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Moisture	1	N/A	2014/07/31	CAM SOP-00445	R.Carter,1993
OC Pesticides (Selected) & PCB (1)	1	2014/07/29	2014/07/30	CAM SOP-00307	SW846 8081, 8082
OC Pesticides Summed Parameters	1	N/A	2014/08/01	CAM SOP-00307	EPA 8081/8082 m
GC/MS Analysis of OP Pesticides	1	2014/08/01	2014/08/02	CAM SOP-00301	EPA 8270 m
Phenoxy Acid Herbicides	1	2014/07/29	2014/07/30	CAM SOP-00330	EPA 8270 m
Triazines (2)	1	2014/07/30	2014/07/31	EPA 8270 (modified)	EPA 8270 m

Remarks:

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. Reporting results to two significant figures at the RDL is to permit statistical evaluation and is not intended to be an indication of analytical precision.

The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following the 'Alberta Environment Draft Addenda to the CWS-PHC, Appendix 6, Validation of Alternate Methods'. Documentation is available upon request. Maxxam has made the following improvements to the CWS-PHC reference benchmark method: (i) Headspace for F1; and, (ii) Mechanical extraction for F2-F4. Note: F4G cannot be added to the C6 to C50 hydrocarbons. The extraction date for samples field preserved with methanol for F1 and Volatile Organic Compounds is considered to be the date sampled.

Maxxam Analytics is accredited for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

(1) Chlordane (Total) = Alpha Chlordane + Gamma Chlordane
(2) TRIAZINES: THE SAMPLE RESULTS ARE REPORTED ON DRY WEIGHT BASIS

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

Maxxam Job #: B4D2431
Report Date: 2014/08/06

WSP Canada Inc
Client Project #: 141-17672-00
Site Location: LYNDEN
Sampler Initials: TC

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Asuka Nakamura, Project Manager
Email: ANakamura@maxxam.ca
Phone# (905) 817-5816

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

Total cover pages: 2

Maxxam Job #: B4D2431
Report Date: 2014/08/06

WSP Canada Inc
Client Project #: 141-17672-00
Site Location: LYNDEN
Sampler Initials: TC

RESULTS OF ANALYSES OF SOIL

Maxxam ID		WV8058		
Sampling Date		2014/07/24		
	Units	**0-5'**	**RDL**	**QC Batch**
Inorganics				
Moisture	%	23	1.0	3696348

SEMI-VOLATILE ORGANICS BY GC-MS (SOIL)

Maxxam ID		WV8058	WV8058		
Sampling Date		2014/07/24	2014/07/24		
	Units	**0-5'**	**0-5' Lab-Dup**	**RDL**	**QC Batch**
Pesticides & Herbicides					
Prometon	ug/g	ND	ND	0.050	3693592
Simazine	ug/g	ND	ND	0.25	3693592
Atrazine	ug/g	ND	ND	0.10	3693592
Propazine	ug/g	ND	ND	0.25	3693592
Metribuzin (Sencor)	ug/g	ND	ND	0.10	3693592
Simetryn	ug/g	ND	ND	0.050	3693592
Ametryn	ug/g	ND	ND	0.25	3693592
Prometryne	ug/g	ND	ND	0.25	3693592
Terbutryne	ug/g	ND	ND	0.050	3693592
Cyanazine (Bladex)	ug/g	ND	ND	0.25	3693592
Surrogate Recovery (%)					
2-Fluorobiphenyl	%	74	77		3693592
D14-Terphenyl (FS)	%	85	88		3693592
D5-Nitrobenzene	%	76	79		3693592

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B4D2431
Report Date: 2014/08/06

WSP Canada Inc
Client Project #: 141-17672-00
Site Location: LYNDEN
Sampler Initials: TC

ORGANOPHOSPHORUS PESTICIDES BY GC-MS (SOIL)

Maxxam ID		WV8058	WV8058		
Sampling Date		2014/07/24	2014/07/24		
	Units	**0-5'**	**0-5' Lab-Dup**	**RDL**	**QC Batch**
Pesticides & Herbicides					
Bendiocarb	ug/g	ND	ND	5.0	3696851
Demeton-S	ug/g	ND	ND	5.0	3696851
Dichlorvos	ug/g	ND	ND	5.0	3696851
Dimethoate	ug/g	ND	ND	5.0	3696851
Fenchlorophos (Ronnel)	ug/g	ND	ND	5.0	3696851
Fonofos	ug/g	ND	ND	5.0	3696851
Metolachlor	ug/g	ND	ND	10	3696851
Mevinphos	ug/g	ND	ND	5.0	3696851
Phosmet	ug/g	ND	ND	5.0	3696851
Triallate	ug/g	ND	ND	5.0	3696851
Trifluralin	ug/g	ND	ND	5.0	3696851
Fenthion	ug/g	ND	ND	5.0	3696851
Ethion	ug/g	ND	ND	5.0	3696851
Guthion (Azinphos-methyl)	ug/g	ND	ND	5.0	3696851
Phorate	ug/g	ND	ND	5.0	3696851
Terbufos	ug/g	ND	ND	5.0	3696851
Aldicarb	ug/g	ND	ND	5.0	3696851
Atrazine	ug/g	ND	ND	5.0	3696851
Carbaryl	ug/g	ND	ND	5.0	3696851
Carbofuran	ug/g	ND	ND	5.0	3696851
Cyanazine (Bladex)	ug/g	ND	ND	5.0	3696851
Diazinon	ug/g	ND	ND	5.0	3696851
Parathion Ethyl	ug/g	ND	ND	5.0	3696851
Parathion Methyl	ug/g	ND	ND	5.0	3696851
Prometryne	ug/g	ND	ND	5.0	3696851
Malathion	ug/g	ND	ND	5.0	3696851
Simazine	ug/g	ND	ND	5.0	3696851
Chlorpyrifos (Dursban)	ug/g	ND	ND	5.0	3696851
Surrogate Recovery (%)					
2-Fluorobiphenyl	%	78	68		3696851
D14-Terphenyl (FS)	%	95	93		3696851
D5-Nitrobenzene	%	75	73		3696851

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B4D2431
Report Date: 2014/08/06

WSP Canada Inc
Client Project #: 141-17672-00
Site Location: LYNDEN
Sampler Initials: TC

PHENOXY ACID HERBICIDES BY GC-MS (SOIL)

Maxxam ID		WV8058		
Sampling Date		2014/07/24		
	Units	**0-5'**	**RDL**	**QC Batch**
Pesticides & Herbicides				
2,4,5-T	ug/g	ND	0.1	3693042
2,4,5-TP (Silvex)	ug/g	ND	0.1	3693042
2,4-D	ug/g	ND	0.1	3693042
2,4-D (BEE)	ug/g	ND	0.2	3693042
2,4-DB	ug/g	ND	0.1	3693042
2,4-DP (Dichlorprop)	ug/g	ND	0.1	3693042
Dicamba	ug/g	ND	0.2	3693042
MCPA	ug/g	ND	0.2	3693042
MCPB	ug/g	ND	0.2	3693042
MCPP	ug/g	ND	0.2	3693042
Picloram	ug/g	ND	0.2	3693042
Surrogate Recovery (%)				
2,4-Dichlorophenyl Acetic Acid	%	96		3693042
2,5-Dibromobenzoic Acid	%	93		3693042
4,4-Dibromobiphenyl	%	94		3693042

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Sampler Initials: TC

ORGANOCHLORINATED PESTICIDES BY GC-ECD (SOIL)

Maxxam ID		WV8058		
Sampling Date		2014/07/24		
	Units	**0-5'**	**RDL**	**QC Batch**
Calculated Parameters				
Chlordane (Total)	ug/g	ND	0.0020	3688777
o,p-DDD + p,p-DDD	ug/g	ND	0.0020	3688777
o,p-DDE + p,p-DDE	ug/g	ND	0.0020	3688777
o,p-DDT + p,p-DDT	ug/g	ND	0.0020	3688777
Total Endosulfan	ug/g	ND	0.0020	3688777
Total PCB	ug/g	ND	0.015	3688777
Pesticides & Herbicides				
Aldrin	ug/g	ND	0.0020	3692061
a-Chlordane	ug/g	ND	0.0020	3692061
g-Chlordane	ug/g	ND	0.0020	3692061
o,p-DDD	ug/g	ND	0.0020	3692061
p,p-DDD	ug/g	ND	0.0020	3692061
o,p-DDE	ug/g	ND	0.0020	3692061
p,p-DDE	ug/g	ND	0.0020	3692061
o,p-DDT	ug/g	ND	0.0020	3692061
p,p-DDT	ug/g	ND	0.0020	3692061
Dieldrin	ug/g	ND	0.0020	3692061
Lindane	ug/g	ND	0.0020	3692061
Endosulfan I (alpha)	ug/g	ND	0.0020	3692061
Endosulfan II	ug/g	ND	0.0020	3692061
Endrin	ug/g	ND	0.0020	3692061
Heptachlor	ug/g	ND	0.0020	3692061
Heptachlor epoxide	ug/g	ND	0.0020	3692061
Hexachlorobenzene	ug/g	ND	0.0020	3692061
Hexachlorobutadiene	ug/g	ND	0.0050	3692061
Hexachloroethane	ug/g	ND	0.0050	3692061
Methoxychlor	ug/g	ND	0.0050	3692061
Aroclor 1242	ug/g	ND	0.015	3692061
Aroclor 1248	ug/g	ND	0.015	3692061
Aroclor 1254	ug/g	ND	0.015	3692061
Aroclor 1260	ug/g	ND	0.015	3692061
Surrogate Recovery (%)				
2,4,5,6-Tetrachloro-m-xylene	%	81		3692061
Decachlorobiphenyl	%	114		3692061

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QC Batch = Quality Control Batch

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Test Summary

Maxxam ID WV8058 **Collected** 2014/07/24
Sample ID 0-5' **Shipped**
Matrix Soil **Received** 2014/07/25

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Moisture	BAL	3696348	N/A	2014/07/31	Min Yang
OC Pesticides (Selected) & PCB	GC/ECD	3692061	2014/07/29	2014/07/30	Farahnaz Somwaru
OC Pesticides Summed Parameters	CALC	3688777	N/A	2014/08/01	Automated Statchk
GC/MS Analysis of OP Pesticides	GC/MS	3696851	2014/08/01	2014/08/02	May Yin Mak
Phenoxy Acid Herbicides	GC/MS	3693042	2014/07/29	2014/07/30	May Yin Mak
Triazines	GC/MS	3693592	2014/07/30	2014/07/31	May Yin Mak

Maxxam ID WV8058 Dup **Collected** 2014/07/24
Sample ID 0-5' **Shipped**
Matrix Soil **Received** 2014/07/25

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
GC/MS Analysis of OP Pesticides	GC/MS	3696851	2014/08/01	2014/08/02	May Yin Mak
Triazines	GC/MS	3693592	2014/07/30	2014/07/31	May Yin Mak

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Package 1	4.0°C

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

GENERAL COMMENTS

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Report Date: 2014/08/06

WSP Canada Inc
Client Project #: 141-17672-00
Site Location: LYNDEN
Sampler Initials: TC

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
3692061	2,4,5,6-Tetrachloro-m-xylene	2014/07/30	74	50 - 130	74	50 - 130	75	%		
3692061	Decachlorobiphenyl	2014/07/30	96	50 - 130	99	50 - 130	103	%		
3692061	Aldrin	2014/07/30	75	50 - 130	76	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	a-Chlordane	2014/07/30	87	50 - 130	90	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	g-Chlordane	2014/07/30	88	50 - 130	92	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	o,p-DDD	2014/07/30	103	50 - 130	125	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	p,p-DDD	2014/07/30	95	50 - 130	100	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	o,p-DDE	2014/07/30	83	50 - 130	87	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	p,p-DDE	2014/07/30	95	50 - 130	113	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	o,p-DDT	2014/07/30	90	50 - 130	94	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	p,p-DDT	2014/07/30	90	50 - 130	97	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	Dieldrin	2014/07/30	99	50 - 130	100	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	Lindane	2014/07/30	81	50 - 130	88	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	Endosulfan I (alpha)	2014/07/30	77	50 - 130	78	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	Endosulfan II	2014/07/30	89	50 - 130	88	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	Endrin	2014/07/30	85	50 - 130	84	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	Heptachlor	2014/07/30	82	50 - 130	88	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	Heptachlor epoxide	2014/07/30	85	50 - 130	87	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	Hexachlorobenzene	2014/07/30	81	50 - 130	86	50 - 130	ND, RDL=0.0020	ug/g	NC	40
3692061	Hexachlorobutadiene	2014/07/30	86	50 - 130	94	50 - 130	ND, RDL=0.0050	ug/g	NC	40
3692061	Hexachloroethane	2014/07/30	61	50 - 130	69	50 - 130	ND, RDL=0.0050	ug/g	NC	40
3692061	Methoxychlor	2014/07/30	101	50 - 130	105	50 - 130	ND, RDL=0.0050	ug/g	NC	40
3692061	Aroclor 1242	2014/07/30					ND, RDL=0.015	ug/g	NC	40
3692061	Aroclor 1248	2014/07/30					ND, RDL=0.015	ug/g	NC	40
3692061	Aroclor 1254	2014/07/30					ND, RDL=0.015	ug/g	NC	40
3692061	Aroclor 1260	2014/07/30					ND, RDL=0.015	ug/g	NC	40
3693042	2,4-Dichlorophenyl Acetic Acid	2014/07/30	101	10 - 130	93	10 - 130	85	%		
3693042	2,5-Dibromobenzoic Acid	2014/07/30	104	10 - 130	93	10 - 130	87	%		
3693042	4,4-Dibromobiphenyl	2014/07/30	99	10 - 130	97	10 - 130	96	%		
3693042	2,4,5-T	2014/07/30	112	10 - 130	108	10 - 130	ND, RDL=0.1	ug/g	NC	50
3693042	2,4,5-TP (Silvex)	2014/07/30	111	10 - 130	105	10 - 130	ND, RDL=0.1	ug/g	NC	50
3693042	2,4-D	2014/07/30	110	10 - 130	102	10 - 130	ND, RDL=0.1	ug/g	NC	50
3693042	2,4-D (BEE)	2014/07/30	113	10 - 130	100	10 - 130	ND, RDL=0.2	ug/g		
3693042	2,4-DB	2014/07/30	103	10 - 130	100	10 - 130	ND, RDL=0.1	ug/g	NC	50
3693042	2,4-DP (Dichlorprop)	2014/07/30	103	10 - 130	99	10 - 130	ND, RDL=0.1	ug/g	NC	50
3693042	Dicamba	2014/07/30	104	10 - 130	97	10 - 130	ND, RDL=0.2	ug/g	NC	50
3693042	MCPA	2014/07/30	101	10 - 130	103	10 - 130	ND, RDL=0.2	ug/g	NC	50
3693042	MCPB	2014/07/30	71	10 - 130	106	10 - 130	ND, RDL=0.2	ug/g		
3693042	MCPP	2014/07/30	80	10 - 130	101	10 - 130	ND, RDL=0.2	ug/g	NC	50
3693042	Picloram	2014/07/30	86	10 - 130	79	10 - 130	ND, RDL=0.2	ug/g	NC	50

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Maxxam Job #: B4D2431
Report Date: 2014/08/06

WSP Canada Inc
Client Project #: 141-17672-00
Site Location: LYNDEN
Sampler Initials: TC

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
3693592	2-Fluorobiphenyl	2014/07/31	80	30 - 130	91	30 - 130	89	%		
3693592	D14-Terphenyl (FS)	2014/07/31	88	30 - 130	92	30 - 130	94	%		
3693592	D5-Nitrobenzene	2014/07/31	79	30 - 130	93	30 - 130	89	%		
3693592	Prometon	2014/07/31	74	40 - 130	96	40 - 130	ND, RDL=0.050	ug/g	NC	50
3693592	Simazine	2014/07/31	88	40 - 130	96	40 - 130	ND, RDL=0.25	ug/g	NC	50
3693592	Atrazine	2014/07/31	90	40 - 130	98	40 - 130	ND, RDL=0.10	ug/g	NC	50
3693592	Propazine	2014/07/31	87	40 - 130	94	40 - 130	ND, RDL=0.25	ug/g	NC	50
3693592	Metribuzin (Sencor)	2014/07/31	87	40 - 130	87	40 - 130	ND, RDL=0.10	ug/g	NC	50
3693592	Simetryn	2014/07/31	97	40 - 130	102	40 - 130	ND, RDL=0.050	ug/g	NC	50
3693592	Ametryn	2014/07/31	97	40 - 130	101	40 - 130	ND, RDL=0.25	ug/g	NC	50
3693592	Prometryne	2014/07/31	105	40 - 130	108	40 - 130	ND, RDL=0.25	ug/g	NC	50
3693592	Terbutryne	2014/07/31	87	40 - 130	97	40 - 130	ND, RDL=0.050	ug/g	NC	50
3693592	Cyanazine (Bladex)	2014/07/31	90	40 - 130	92	40 - 130	ND, RDL=0.25	ug/g	NC	50
3696348	Moisture	2014/07/31							1.2	20
3696851	2-Fluorobiphenyl	2014/08/01	82	30 - 130	87	30 - 130	88	%		
3696851	D14-Terphenyl (FS)	2014/08/01	94	30 - 130	93	30 - 130	92	%		
3696851	D5-Nitrobenzene	2014/08/01	75	30 - 130	85	30 - 130	86	%		
3696851	Bendiocarb	2014/08/02	97	30 - 130	89	30 - 130	ND, RDL=5.0	ug/g	NC	40
3696851	Demeton-S	2014/08/02	80	30 - 130	77	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Dichlorvos	2014/08/02	81	30 - 130	82	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Dimethoate	2014/08/02	86	30 - 130	84	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Fenchlorophos (Ronnel)	2014/08/02	98	30 - 130	93	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Fonofos	2014/08/02	92	30 - 130	87	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Metolachlor	2014/08/02	96	30 - 130	91	30 - 130	ND, RDL=10	ug/g	NC	50
3696851	Mevinphos	2014/08/02	103	30 - 130	95	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Phosmet	2014/08/02	91	30 - 130	87	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Triallate	2014/08/02	102	30 - 130	98	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Trifluralin	2014/08/02	84	30 - 130	75	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Fenthion	2014/08/02	99	30 - 130	96	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Ethion	2014/08/02	98	30 - 130	84	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Guthion (Azinphos-methyl)	2014/08/02	96	30 - 130	94	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Phorate	2014/08/02	83	30 - 130	80	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Terbufos	2014/08/02	91	30 - 130	84	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Aldicarb	2014/08/02	80	30 - 130	87	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Atrazine	2014/08/02	90	30 - 130	88	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Carbaryl	2014/08/02	82	30 - 130	87	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Carbofuran	2014/08/02	101	30 - 130	96	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Cyanazine (Bladex)	2014/08/02	87	30 - 130	87	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Diazinon	2014/08/02	103	30 - 130	97	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Parathion Ethyl	2014/08/02	89	30 - 130	85	30 - 130	ND, RDL=5.0	ug/g	NC	50

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QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
3696851	Parathion Methyl	2014/08/02	84	30 - 130	78	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Prometryne	2014/08/02	98	30 - 130	91	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Malathion	2014/08/02	92	30 - 130	86	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Simazine	2014/08/02	89	30 - 130	87	30 - 130	ND, RDL=5.0	ug/g	NC	50
3696851	Chlorpyrifos (Dursban)	2014/08/02	104	30 - 130	99	30 - 130	ND, RDL=5.0	ug/g	NC	50

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.
NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

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Validation Signature Page

Maxxam Job #: B4D2431

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

Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

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

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Appendix E

WATER QUALITY SAMPLING RESULTS

Water Quality Results - Lynden Test Wells LM-01-14-D and LM-02-14-D

	Units	ODWQS Heath Based Guidelines	ODWQS Aesthetic Objective	ODWQS Operational Guideline	FDL-02 (72 hour test)	LM-01-14-D	LM-02-14-D	Property 1	Property 2	Property 3	Property 4	Property 5	Property 6	Property 7	Property 8
Alkalinity	**mg/L**	**-**	**-**	**30-500**	94	**-**	111	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Chloride	**mg/L**	**-**	**250**	**-**	43.4	32.2	19	-	-	-	-	-	-	-	**-**
Colour	**TCU**	**-**	**5**	**-**	ND	4	**13**	22	4	**111**	**64**	**6**	<2	**90**	**25**
Dissolved Organic Carbon	**mg/L**	**-**	**5**	**-**	-	0.7	0.6	-	-	-	-	-	-	-	**-**
Hardness	**mg/L**	**-**	**-**	**80-100**	**36.2**	**39.6**	**60.4**	**62.7**	**23**	**623**	**44.3**	**70.6**	**376**	**<0.7**	**63.4**
Nitrate	**mg/L**	**10**	**-**	**-**	<0.01	<0.05	<0.05	<0.01	<0.01	**17.4**	0.02	<0.01	0.63	0.55	<0.01
Nitrite	**mg/L**	**1**	**-**	**-**	<0.02	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.019	<0.01
Turbidity	**NTU**	**-**	**5**		-	-	2.68	2.15	0.22	13.6	**5.54**	0.5	<0.05	**8.68**	3.56
E.Coli.	**TCU/100ml**	**0**	**-**	**-**	0	0	0	**0**	**40**	**<10**	**<10**	0	0	0	0
HPC	**TCU/100ml**	**-**	**-**	**-**	0	1	2	0	99	32	107	81	240	239	84
Total Coliform	**TCU/100ml**	**0**	**-**	**-**	0	0	0	**0**	**100**	**10**	**50**	0	**4**	0	0
Background	**TCU/ml**	**-**	**-**	**-**	4	2	0	1	n/a	330	n/a	12	83	800	15
Antinomy	**mg/L**	**0.006**	**-**	**-**	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006
Arsenic	**mg/L**	**0.025**	**-**	**-**	<0.001	0.002	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009
Barium	**mg/L**	**1**	**-**	**-**	**2.61**	**1.78**	0.137	0.978	0.641	0.072	0.501	0.982	0.057	<0.002	0.074
Beryllium	**mg/L**	**-**	**-**	**-**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	**mg/L**	**-**	**-**	**-**	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Boron	**mg/L**	**5**	**-**	**-**	0.532	0.502	0.467	0.538	0.553	0.068	0.547	0.555	0.041	0.033	0.401
Cadmium	**mg/L**	**0.005**	**-**	**-**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Calcium	**mg/L**	**-**	**-**	**-**	6.75	7.36	13.1	12.4	4.5	184	8.81	11.3	108	<0.10	12.9
Chromium	**mg/L**	**-**	**-**	**-**	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	**mg/L**	**-**	**-**	**-**	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009
Copper	**mg/L**	**1**	**-**	**-**	<0.002	<0.002	<0.002	0.008	<0.002	0.002	0.064	<0.002	0.008	0.007	0.004
Iron	**mg/L**	**-**	**0.3**	**-**	<0.01	0.086	0.283	0.455	0.069	**0.562**	**2.34**	0.052	0.019	**0.427**	**0.312**
Lead	**mg/L**	**0.01**	**-**	**-**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0013	<0.0010	<0.0010	<0.0010	<0.0010
Magnesium	**mg/L**	**-**	**-**	**-**	4.69	5.15	6.73	7.71	2.85	39.6	5.42	10.3	25.7	<0.10	7.58
Manganese	**mg/L**	**-**	**0.05**	**-**	0.001	0.004	0.014	0.008	0.006	0.029	0.015	0.004	0.003	0.01	0.008
Molybdenum	**mg/L**	**-**	**-**	**-**	<0.005	0.007	0.01	<0.005	0.006	<0.005	<0.005	0.005	<0.005	<0.005	0.007
Nickel	**mg/L**	**-**	**-**	**-**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Potassium	**mg/L**	**-**	**-**	**-**	0.99	1.21	1.23	1.24	0.91	10.6	1.06	1.37	1.28	0.42	1.05
Selenium	**mg/L**	**0.01**	**-**	**-**	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Silver	**mg/L**	**-**	**-**	**-**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium	**mg/L**	**-**	**200 (1)**	**-**	55.2	52.3	44.5	81.7	48.6	70	68.8	80	19.8	71.6	31.3
Strontium	**mg/L**	**-**	**-**	**-**	0.686	0.693	0.747	1.18	0.508	0.507	0.719	0.993	0.26	<0.005	0.0848
Thallium	**mg/L**	**-**	**-**	**-**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin	**mg/L**	**-**	**-**	**-**	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Titanium	**mg/L**	**-**	**-**	**-**	<0.001	<0.001	0.002	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	0.018	<0.001
Vanadium	**mg/L**	**-**	**-**	**-**	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Zinc	**mg/L**	**-**	**5**	**-**	<0.005	<0.005	<0.005	0.017	0.017	0.012	0.01	<0.005	0.006	0.008	<0.005
Hydrogen Sulphide	**mg/L**	**-**	**0.05**	**-**	**2.4**	**2**	**2.2**	**<0.021**	**1.48**	<0.021	**0.201**	<0.021	<0.021	<0.021	<0.021

Notes:

Bolded entries were in exceedance of ODWQS Guidelines

Highlighted, bolded and underlined entries are in exceedance of ODWQS Health Based Guidelines

(1) - The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets

Lab report references LM-01-14-D as TW14-1 and LM-02-14-D as TW14-2.

Certificate of Analysis

City of Hamilton
Environmental Laboratory
700 Woodward Avenue, Hamilton, ON L8H 6P4
P. (905) 546-2424 F. (905)545-0234

CLIENT INFORMATION

Client Name: HAMILTON WATER
Attention: MARCO SILVERIO

Address: 77 JAMES STREET NORTH
HAMILTON
L8R 2K3

LABORATORY INFORMATION

Sample Date: 2014-08-27
Date Submitted: 2014-08-27

Laboratory Work Order Number: 311832

Samples analysed in this work order were analysed using the following methods:

Alk/pH/Cond/Temp PC Titrate	Bacteria Membrane Filtration DC agar	Bacteria Membrane Filtration-HPC	Metals Hydrides-Hydride AA
Lead Graphite Furnace AA	Metals ICP	Anions IC	Turbidity Turbimeter
TOC/DOC Colourimetric	Cadmium Graphite Furnace AA	Colour Spectrophotometric	LIMS Calculation
Subcontract			

NOTES: '<' = less than the Method Detection Limit (MDL), 'NS' = No Sample, 'IS' = Insufficient Sample, '>' = greater than the reported result, " * " indicates result is outside of the applied guideline/objective
Methods used by the City of Hamilton's Environmental Laboratory (CHEL) are based upon or modified from those found in the following sources: Standard Methods for the Examination of Water and Wastewater, 22nd Edition, United States Environmental Protection Agency (EPA), Ministry of the Environment (MOE), Association of Official Analytical Chemists (AOAC) and American Oil Chemists Society (AOCS).
All analytical work performed at the CHEL is done according to accepted quality assurance and quality control procedures. Quality and other related data as well as uncertainty values are available upon request.

The results on this Chemical Analysis Report relate only to the items tested.

Final Report Approval by:

Rosemary Eszes-Wegner, Supervisor Quality Assurance

Pamela M. Thomas, Superintendent Environmental Laboratory

Source Protection Planning

Lynden Well Ground Water Sampling

TW14-1 2014-08-26 15:30:00

Analyte	Result	Units	MDL
Chloride	32.2	mg/L	0.2
Colour (apparent)	4	CU	2
Dissolved Organic Carbon	0.7	mg/L	0.4
Hardness	39.6	mg/L	0.7
Nitrate as N	<0.05	mg/L	0.05
Nitrite as N	<0.05	mg/L	0.05
Escherichia coli	0	CFU/100mL	0
Heterotrophic Plate Count	1	CFU/1mL	0
Total Coliform	0	CFU/100mL	0
Total Coliform Background	2	CFU/100mL	0
Antimony	<0.0006	mg/L	0.0006
Arsenic	0.002	mg/L	0.001
Barium	1.78	mg/L	0.002
Beryllium	<0.0001	mg/L	0.0001
Bismuth	<0.020	mg/L	0.020
Boron	0.502	mg/L	0.010
Cadmium	<0.0001	mg/L	0.0001
Calcium	7.36	mg/L	0.10
Chromium	<0.001	mg/L	0.001
Cobalt	<0.0009	mg/L	0.0009
Copper	<0.002	mg/L	0.002
Iron	0.086	mg/L	0.010
Lead	<0.0010	mg/L	0.0010
Magnesium	5.15	mg/L	0.10
Manganese	0.004	mg/L	0.001
Molybdenum	0.007	mg/L	0.005
Nickel	<0.005	mg/L	0.005
Potassium	1.21	mg/L	0.10
Selenium	<0.002	mg/L	0.002
Silver	<0.005	mg/L	0.005
Sodium	52.3	mg/L	0.50
Strontium	0.693	mg/L	0.005
Thallium	<0.010	mg/L	0.010
Tin	<0.020	mg/L	0.020
Titanium	<0.001	mg/L	0.001
Vanadium	<0.002	mg/L	0.002
Zinc	<0.005	mg/L	0.005
Sulphide (Subcontract)	2.00	mg/L	0.020

TW14-2 2014-08-27 11:20:00

Alkalinity	111	mg/L	2
Chloride	19.0	mg/L	0.2
Colour (apparent)	13	CU	2
Dissolved Organic Carbon	0.6	mg/L	0.4
Hardness	60.4	mg/L	0.7
Nitrate as N	<0.05	mg/L	0.05
Nitrite as N	<0.05	mg/L	0.05
pH	8.41	pH	0.01
Turbidity	2.68	NTU	0.05
Escherichia coli	0	CFU/100mL	0

Analyte	Result	Units	MDL
Heterotrophic Plate Count	2	CFU/1mL	0
Total Coliform	0	CFU/100mL	0
Total Coliform Background	0	CFU/100mL	0
Antimony	<0.0006	mg/L	0.0006
Arsenic	0.007	mg/L	0.001
Barium	0.137	mg/L	0.002
Beryllium	<0.0001	mg/L	0.0001
Bismuth	<0.020	mg/L	0.020
Boron	0.467	mg/L	0.010
Cadmium	<0.0001	mg/L	0.0001
Calcium	13.1	mg/L	0.10
Chromium	0.001	mg/L	0.001
Cobalt	<0.0009	mg/L	0.0009
Copper	<0.002	mg/L	0.002
Iron	0.283	mg/L	0.010
Lead	<0.0010	mg/L	0.0010
Magnesium	6.73	mg/L	0.10
Manganese	0.014	mg/L	0.001
Molybdenum	0.010	mg/L	0.005
Nickel	<0.005	mg/L	0.005
Potassium	1.23	mg/L	0.10
Selenium	<0.002	mg/L	0.002
Silver	<0.005	mg/L	0.005
Sodium	44.5	mg/L	0.50
Strontium	0.747	mg/L	0.005
Thallium	<0.010	mg/L	0.010
Tin	<0.020	mg/L	0.020
Titanium	0.002	mg/L	0.001
Vanadium	<0.002	mg/L	0.002
Zinc	<0.005	mg/L	0.005
Sulphide (Subcontract)	2.20	mg/L	0.020

TESTING PROGRAM FOR LYNDEN SUPPLY WELL FDL-03

LYNDEN WATER SUPPLY CLASS ENVIRONMENTAL ASSESSMENT

City of Hamilton

Project No. 071-11885-01
September 2016
Distribution:
1 c Client
1 c File

WSP Canada Inc.
4 Hughson Street South, Suite 300
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September 26, 2016

Carmen Vega, M.Sc.
Senior Project Manager
Source Protection Planning
Public Works
City of Hamilton
77 James Street North, Suite 400
Hamilton, Ontario
L8R 2K3

Re: Testing Program for Lynden Supply Well FDL-03
Lynden Water Supply Class Environmental Assessment
Project No. 071-11885-01

Dear Ms. Vega:

WSP Canada Inc. (WSP) is pleased to provide this report describing the process and results of the testing of the water supply well designated FDL-03 in the community of Lynden. The test results show that this proposed standby well yields 6.0 L/sec (80 imperial gallons per minute) and that the raw water requires treatment prior to connection to the Lynden system.

This report will serve as supporting documentation for the Category 3 amendment application to the Lynden Permit to Take Water (PTTW).

If you have any questions or comments, please do not hesitate to contact the undersigned.

Yours truly,
WSP Canada Inc.

Derek S Brunner

Derek Brunner, M.Sc., P.Geo.
Hydrogeologist/Project Manager

DB:nah

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TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 BACKGROUND 1

1.2 LYNDEN'S EXISTING WATER SUPPLY SYSTEM 1

1.3 SCOPE OF WORK 1

2 PHYSICAL SETTING 2

2.1 PHYSIOGRAPHY AND DRAINAGE 2

2.2 REGIONAL GEOLOGY 3

2.2.1 SURFICIAL GEOLOGY 3

2.2.2 BEDROCK GEOLOGY 3

2.3 HYDROSTRATIGRAPHY OF THE LYNDEN AREA 4

2.3.1 UPPER UNCONFINED AQUIFER 4

2.3.2 AQUITARD 5

2.3.3 LOWER CONFINED AQUIFER 5

2.3.4 BEDROCK AQUIFER 5

2.4 LOCAL WATER SUPPLIES 6

3 WELL CONSTRUCTION 7

3.1 PILOT HOLE 7

3.2 PRODUCTION WELL 8

3.3 PLUMBNESS AND ALIGNMENT 8

3.4 WELL DEVELOPMENT 9

3.5 CASING BOND LOG 9

4 AQUIFER TESTING 9

4.1 MONITORING NETWORK 9

4.2 STEP TEST 10

4.2.1 SAND CONTENT TEST 11

4.3 CONSTANT RATE TEST 11
4.3.1 WELL YIELD 12
4.3.2 AQUIFER PARAMETERS 14

5 GROUNDWATER INTERFERENCE 14

5.1 OBSERVED INTERFERENCE 14

5.2 WELL COMPLAINTS 15

5.3 PREDICTED INTERFERENCE 15

6 WATER QUALITY 16

6.1 RESULTS 16

6.2 PARAMETERS OF INTEREST 17
6.2.1 BARIUM 17
6.2.2 LEAD 17

6.3 TRENDS 18

7 GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER (GUDI) 18

8 DRINKING WATER SOURCE PROTECTION 19

9 CONCLUSIONS AND RECOMMENDATIONS 21

9.1 CONCLUSIONS 21

9.2 RECOMMENDATIONS 22

10 REFERENCES 24

TABLES

TABLE 1 – MONITORING NETWORK 9
TABLE 2 – SUMMARY OF STEP TEST DATA FOR FDL-03 10
TABLE 3 – DRAWDOWNS IN WELL FIELD AREA..... 12
TABLE 4 – GUDI CRITERIA AND CLASSIFICATION..... 19
TABLE B-1 – MOECC WATER WELL RECORDS
TABLE D-1 - SUMMARY OF WATER QUALITY RESULTS - PRIVATE WELL SURVEY
TABLE G-1 – STEP TEST PUMPING DATA, LYNDEN WELL FDL-03
TABLE G-2 – SAND CONTENT FROM WELL DEVELOPMENT DATA
TABLE H-1 – PUMPING TEST DATA, LYNDEN WELL FDL-03
TABLE H-2 – PUMPING TEST DATA, MONITORING WELL LM-02-14-D
TABLE H-3 – PUMPING TEST DATA, LYNDEN WELL LM-02-11-D
TABLE H-4 – PUMPING TEST DATA, MONITORING WELL LM-01-14-D
TABLE H-5 – PUMPING TEST DATA, MONITORING WELL LM-01-11-D
TABLE H-6 – PUMPING TEST DATA, MONITORING WELL LM-01-12-D
TABLE H-7 – PUMPING TEST DATA, MONITORING WELL LM-01-03-D
TABLE H-8 – PUMPING TEST DATA, MONITORING WELL LM-01-03-S
TABLE H-9 – PUMPING TEST DATA, PRIVATE WELL – 3606 GOVERNORS ROAD
TABLE H-10 – PUMPING TEST DATA, PRIVATE WELL – 3586 GOVERNORS ROAD
TABLE H-11 – PUMPING TEST DATA, MONITORING WELL LM-01-08-OB
TABLE H-12 – PUMPING TEST DATA, MONITORING WELL LM-01-08-D
TABLE H-13 – PUMPING TEST DATA, PRIVATE WELL – 3826 GOVERNORS ROAD
TABLE H-14 – PUMPING TEST DATA, PRIVATE WELL – 3830 GOVERNORS ROAD
TABLE H-15 – TRANSMISSIVITY AND STORATIVITY SUMMARY
TABLE K-1 – GENERAL INORGANIC WATER QUALITY – LYNDEN WELL FDL-03
TABLE K-2 – GENERAL ORGANIC WATER QUALITY – LYNDEN WELL FDL-03
TABLE K-3 – GENERAL ORGANIC WATER QUALITY – LYNDEN WELL FDL-03

FIGURES

FIGURE 1 – SITE LOCATION PLAN
FIGURE 2 – FDL-03 AND SURROUNDING AREA
FIGURE 3 – SURFICIAL GEOLOGY
FIGURE 4 – BEDROCK TOPOGRAPHY
FIGURE 5 – MOECC WATER WELLS
FIGURE 6 – EAST-WEST CROSS SECTION
FIGURE 7 – NORTH-SOUTH CROSS SECTION
FIGURE 8 – WELL CONSTRUCTION
FIGURE 9 – ZONE OF INFLUENCE
FIGURE 10 – WELLHEAD PROTECTION AREA

FIGURE G-1 – RECORD OF STEP TEST DATA – LYNDEN WELL FDL-03
FIGURE G-2 – OBSERVED DRAWDOWN VS DISCHARGE FDL-01 1985, FDL-02 2012, AND FDL-03 2016
FIGURE H-1 – GROUNDWATER HYDROGRAPH, LYNDEN WELL FDL-03
FIGURE H-2 – GROUNDWATER HYDROGRAPH, LYNDEN WELL LM-02-14-D
FIGURE H-3 – GROUNDWATER HYDROGRAPH, LYNDEN WELL LM-02-11-D
FIGURE H-4 – GROUNDWATER HYDROGRAPH, LYNDEN WELL LM-01-14-D
FIGURE H-5 – GROUNDWATER HYDROGRAPH, MONITORING WELL LM-01-11-D
FIGURE H-6 – GROUNDWATER HYDROGRAPH, MONITORING WELL LM-01-12-D
FIGURE H-7 – GROUNDWATER HYDROGRAPH, MUNICIPAL WELL – FDL-01
FIGURE H-8 – GROUNDWATER HYDROGRAPH, MONITORING WELL LM-01-03-D
FIGURE H-9 – GROUNDWATER HYDROGRAPH, MONITORING WELL LM-01-03-S
FIGURE H-10 – GROUNDWATER HYDROGRAPH, PRIVATE WELL – 3606 GOVERNORS ROAD
FIGURE H-11 – GROUNDWATER HYDROGRAPH, PRIVATE WELL – 3586 GOVERNORS ROAD
FIGURE H-12– GROUNDWATER HYDROGRAPH, MONITORING WELL LM-01-08-OB
FIGURE H-13 – GROUNDWATER HYDROGRAPH, MONITORING WELL LM-01-08-D
FIGURE H-14 – GROUNDWATER HYDROGRAPH, PRIVATE WELL – 3826 GOVERNORS ROAD
FIGURE H-15 – GROUNDWATER HYDROGRAPH, PRIVATE WELL – 3830 GOVERNORS ROAD
FIGURE H-16 – DISTANCE-DRAWDOWN 300 MIN
FIGURE H-17 – DISTANCE DRAWDOWN 72 HRS
FIGURE H-18 – SEMI LOG PLOT – FDL-03
FIGURE H-19 – SEMI-LOG PLOT – LM-02-14-D
FIGURE H-20 – SEMI-LOG PLOT – LM-02-11-D
FIGURE H-21 – SEMI-LOG PLOT – LM-01-14-D
FIGURE H-22 – SEMI-LOG PLOT – LM-01-11-D
FIGURE H-23 – SEMI-LOG PLOT – LM-01-12-D

FIGURE H-24 – SEMI-LOG PLOT – LM-01-03-D
FIGURE H-25 – SEMI-LOG PLOT – 3606 GOVERNORS RD
FIGURE H-26 – SEMI-LOG PLOT – LM-01-08-OB
FIGURE H-27 – SEMI-LOG PLOT – LM-01-08-D
FIGURE H-28 – SEMI-LOG PLOT – 3830 GOVERNORS RD
FIGURE H-29 – 20-YEAR PROJECTION FOR FDL-03

ILLUSTRATIONS

ILLUSTRATION 1 GROUNDWATER HYDROGRAPH – FDL-03 (72H TEST)

APPENDICES

APPENDIX A EXISTING LYNDEN PTTW
APPENDIX B MOE WATER WELL RECORDS
APPENDIX C BOREHOLE LOGS
APPENDIX D PRIVATE WATER WELL SURVEY RESULTS
APPENDIX E PILOT HOLE TESTING RESULTS
APPENDIX F FDL-03 WELL CONSTRUCTION REPORT AND ANALYSES
APPENDIX G STEP TEST DATA
APPENDIX H PUMPING TEST DATA
APPENDIX I CATEGORY 2 PTTW FOR PUMPING TEST
APPENDIX J WATER QUALITY RESULTS – FDL-03
APPENDIX K TRILINEAR DIAGRAM – FDL-03

1 INTRODUCTION

1.1 BACKGROUND

Lynden is a small community (population of approximately 400) located within the City of Hamilton (the City). Lynden obtains its drinking water from a communal well located approximately 1.5 km to the east of the community (Figure 1). In the summer of 2002, the City of Hamilton developed a Comprehensive Water Servicing Master Plan for the Lynden Rural Settlement Area (Totten Sims Hubicki, 2002). The Plan considered the need for additional water supply to the Rural Settlement Area (RSA) and outlined various options of meeting the requirement for the future RSA. One of the alternatives identified was to drill a new municipal supply well to provide this extra water and also to provide redundancy when combined with the existing well (FDL-01). Subsequently, a Schedule 'C' Class Environmental Assessment (EA) was initiated by the City, part of which was to examine alternatives for the location of a new well (the Notice of Completion is still pending).

Based on a number of factors, including proximity to the community, anticipated pumping capacity, potential for Groundwater Under the Direct Influence of Surface Water (GUDI), possible well interference, and potential impacts on surface water bodies and water quality, a number of test holes were drilled to identify a preferred location for further testing.

After several years of test drilling around the community, production well FDL-02 was constructed on the same property as FDL-01 (3618 Governor's Road) and was tested by performing a step-drawdown test and a 72-hour constant rate pumping test (GENIVAR, 2013). However, water quality testing indicated that barium concentrations in the groundwater were greater than the Ontario Drinking Water Quality Standards (ODWQS) and that expensive treatment measures would be required in order to put the well into operation. As such, the City initiated further exploration on the property in 2014 to identify a location with lower levels of barium. Two test wells were drilled, sampled and step-drawdown tests were conducted. The preferred test well, designated LM-02-14-D, was drilled on the edge of an adjacent agricultural field approximately 230 m south of FDL-01 (Figure 2) and had good water quality and quantity. Production well FDL-03 was recommended to be constructed in that location and tested. The exploration program, well construction, testing and analysis were conducted under the direction of WSP Canada Inc. (WSP) (WSP Canada Inc., 2014).

This report documents the construction and testing of FDL-03.

1.2 LYNDEN'S EXISTING WATER SUPPLY SYSTEM

The existing Lynden municipal water supply system consists of a production well located to the east of the community (Figure 1). The well is housed outside its own pump house, which contains treatment and control facilities. The rated capacity for the municipal well is set out in the Permit to Take Water (PTTW) #2331-826QBK dated December 16, 2009 (Appendix A). Projected future maximum daily demands are expected to reach in excess of 4.8 L/s. The new well was designed and constructed to achieve a pumping rate of 6 L/s with this target in mind.

1.3 SCOPE OF WORK

The scope of work for the construction and testing of supply well FDL-03 for Lynden consisted of the following tasks:

- Private water well survey and implementation of monitoring program;

- Drilling, soil sampling and well construction;
- Well development, and sand content test;
- Step drawdown test;
- 72-hour constant rate aquifer test;
- Regulation 170/03 chemical analysis;
- GUDI evaluation; and
- Analysis and reporting.

An update to the previous private water well survey was conducted for residents within 500 m of the proposed well. This included the completion of an updated questionnaire, baseline water quality sampling, and requests to participate in a monitoring program. The monitoring program included installation of dataloggers in residential wells and occasional hand-measurement of water levels.

Drilling and soil sampling were conducted for the new production well. Results from grain size analysis of the aquifer material were reviewed to support the selection of a well screen that would optimize both the transmitting capacity of the screen and the retention of fine-grained sediments.

Upon completion of well construction and development, hydraulic, physical, and chemical tests were carried out in order to assess the capacity of the well, sand content and water quality.

To assess the capacity of the well, a 72-hour constant rate pumping test was carried out. During the constant rate pumping test, the groundwater was sampled at twelve-hour intervals (i.e. after 1, 12, 24, 36, 48, 60 and 72 hours of pumping) and sent for chemical analysis to assess general groundwater quality with respect to the requirements of Regulation 170/03.

Video testing was conducted under static and pumping conditions, plumbness and alignment testing was completed. A cement bond log of the pumping well was also completed.

Finally, an evaluation of groundwater under the direct influence of surface water (GUDI) was carried out for raw water quality based on current regulatory criteria.

The details of this work program are presented in the following sections of this report.

2 PHYSICAL SETTING

2.1 PHYSIOGRAPHY AND DRAINAGE

The Community of Lynden is located within the Norfolk Sand Plain physiographic region, which consists of relatively flat to gently rolling terrain that slopes gently towards Lake Erie to the southwest (Chapman and Putnam, 1984). The sand plain is wedge shaped with a broad base near Lake Erie, tapering to a point near Brantford and Lynden. The sands and silts characteristic of the region were deposited as part of a delta into Glacial Lakes Whittlesey and Warren.

The maximum relief in the Lynden area is approximately 10 m, with drainage towards the south and southwest. A tributary of Fairchild Creek drains the Village of Lynden, which enters the Grand River at Onondaga. A tributary of Big Creek drains the lands east of Lynden, and enters the Grand River east of Middleport (Cowan, 1972). The well site is within the Grand River watershed. The major surficial feature to

the east is the Dundas Valley, a re-entrant in the Niagara Escarpment, which has been traced inland as far as Copetown. Lands to the east near Copetown drain towards the Dundas Valley and Lake Ontario.

2.2 REGIONAL GEOLOGY

2.2.1 SURFICIAL GEOLOGY

The surficial geology in the vicinity of Lynden is dominated by shallow lake and deltaic sediments, consisting mainly of sands and silts deposited during the Lake Warren stage and more recent periods (Cowan, 1972). These deposits are fairly extensive, being found as far east as Waterdown and Ancaster and mantle the top of the Niagara Escarpment (SNC Lavalin and Charlesworth and Associates, 2006). According to Cowan (1972), the area of sand near Lynden and Copetown resulted from sedimentation into glacial Lake Warren, which spread southwards as water levels receded. Near Lynden, the sand deposits are relatively thin and the underlying silt and clay outcrops in most of the valley walls. Surficial geology in the vicinity of Lynden is shown in Figure 3.

The sediments beneath the surficial sands consist of deep-lake deposited silts and clays, which vary from laminated/stratified to varved (Cowan, 1972). Extensive clay layers have been identified in the water well records that extend to great depths. In the Lynden area, the clay layer is up to 50 m in thickness.

Below the clay is a layer of sand and gravel that overlies the bedrock. This sand and gravel unit varies in thickness, extent and composition and appears to be a valley fill deposit associated with the Dundas buried valley and its tributaries, which are located to the south and east of Lynden. In the south, north, and west directions, the aquifer consists mainly of sand, with isolated pockets of gravel. To the east of Lynden, the base of the sand and gravel aquifer was found to consist of a thick gravel layer of greater lateral extent. The deep aquifer is discontinuous towards the north and west of the community.

2.2.2 BEDROCK GEOLOGY

The Lynden area is predominantly underlain by dolostone of the Guelph Formation, which dips gently to the southwest towards the Michigan Basin at 4-5 m/km (Cowan, 1972; Morrison Beatty, 1985). The elevation of the top of bedrock ranges between 190 masl and 170 masl above the Dundas Valley. To the south and east, the Dundas Valley erodes into several underlying bedrock units as described below (from the top down):

- The Eramosa member of the Guelph Formation, is a bituminous dolostone that extends to the southeast of Lynden.
- The Lockport Formation consisting of argillaceous dolostone and shale.
- The Clinton and Cataract groups consisting of sandstone, shale, dolostone and limestone.
- The red shale of the Queenston Formation is the oldest bedrock unit in the area.

The Dundas Buried Valley is described in more detail below.

DUNDAS BURIED VALLEY

The major surficial feature in this area is the Niagara Escarpment, which extends around the western end of Lake Ontario near Hamilton. The Dundas Valley is a major re-entrant into the escarpment that extends westward for some distance before being buried under Quaternary aged sediments. Borings into the Burlington Bar have extended down 137 m without encountering bedrock (Karrow, 1987), which is believed to lie approximately 180 m below the level of Lake Ontario based on gravity data (Greenhouse and Monier-Williams, 1986). This corresponds to an elevation of 105 m below mean sea level. The re-entrant

terminates beneath Copetown, where it is described as being analogous to a buried Niagara gorge by Greenhouse and Monier-Williams (1986). The portion of the buried valley at Copetown and to the east has been studied extensively and has had constraints placed on its lateral and vertical extent (Greenhouse and Monier-Williams, 1986; Sinha, 1990; MacCormack et al., 2005). A test well was installed to a depth of 195 m below ground surface (bgs) without reaching bedrock in Copetown (Stantec Consulting, 2010), suggesting that there may be deeper areas that have not yet been fully characterized.

West of Copetown, the valley extends south of Lynden, where it splits. The main channel is believed to extend west and north and passes south of Scotland and Glen Morris before running beneath the Village of Ayr and may extend as far as Lake Huron (Karrow, 1987). A secondary tributary was traced southwest to the Brantford area, where it is found to connect with the Grand River valley. Karrow (1987) postulated that this extension was likely cut by an earlier Grand River and deepened by glacial action. The valley of the secondary tributary has been interpreted as far north as the Kitchener-Waterloo area and beyond (AquaResource Inc., 2007). A small tributary to the secondary valley connects with the secondary tributary just east of Lynden (Figure 4). The bedrock channel associated with this small tributary was the target location for well FDL-03.

2.3 HYDROSTRATIGRAPHY OF THE LYNDEN AREA

An understanding of the subsurface stratigraphy in the Lynden area, as identified from borehole and water well records, was developed to guide the exploration and assessment program. Existing deep wells from the Water Well Information System (WWIS) database as maintained by the Ministry of the Environment and Climate Change (MOECC) were plotted (Figure 5) and two conceptual cross-sections were prepared (Figures 6 and 7). Based on the descriptions, the sediments can be grouped into four units based on similar genesis and hydrogeological properties, including an upper unconfined aquifer, an aquitard, a lower confined aquifer, and a bedrock aquifer. These hydrogeological units are described in more detail below. Water well records for the project area are summarized in Table B-1 in Appendix B. Additional well logs from other sources are provided in Appendix C.

2.3.1 UPPER UNCONFINED AQUIFER

A discontinuous unconfined aquifer of variable thickness is located at ground surface over much of the area. The aquifer consists of sands and silts with some clay and is associated with saturated portions of the Norfolk Sand Plain. The well records shown in the section suggest thicknesses of up to 20 m near Woodhill Road east of the site. Records suggest that the aquifer is not continuous at ground surface as would be expected from the description in Chapman and Putnam (1984). This can possibly be attributed to the quality of interpretation in the MOECC database, particularly for deeper wells, where sampling at ground surface may not have been as thorough. Previous investigations have suggested the aquifer is thin (up to about 7 m) in the Lynden area and vulnerable to surface contamination, particularly from domestic private sewage systems and agricultural practices.

The surficial sands and silts in the Lynden and surrounding areas provide domestic groundwater supplies for a number of residents. The water levels fluctuate seasonally, leading to potential water shortages in the dry season and a high water table in the wet season. Wells within this aquifer have been noted to have marginal success as a water supply for domestic purposes (Morrison Beatty, 1978). These wells produce between 4.8 and 24 L/min (Morrison Beatty, 1985). Groundwater flow direction within the shallow aquifer is interpreted to be towards the nearest surface water drainage feature, with a component of flow directed downstream.

2.3.2 AQUITARD

Below the upper unconfined aquifer lies a thick layer of clay that is up to 50 m thick in the Lynden area. The unit acts as an aquitard, retarding groundwater flow from the surficial aquifer into underlying units. Near the Lynden well site, the unit appears to be approximately 20 m in thickness.

Previous investigations have reported that the aquitard unit has very low permeability (Morrison Beatty, 1978) although it does contain isolated sand pockets. Like the shallow wells in the area, wells screened within these pockets tend to produce only enough water for domestic supply (Morrison Beatty, 1978; Morrison Beatty, 1985; Morrison Beatty, 1987).

2.3.3 LOWER CONFINED AQUIFER

Beneath the aquitard is a discontinuous sand and gravel aquifer of variable thickness, extent and composition overlying the bedrock. In the vicinity of the Lynden well site, the aquifer appears to exhibit a pattern of fining upwards and may be up to 20 m thick. The coarsest material appears to lie where the bedrock surface is deepest, and consists of sand and gravel at thicknesses of up to 10 m. The aquifer extends to the east and west along the top of the bedrock and thins out. It appears to be discontinuous towards Lynden, with localized areas of medium to fine sand.

Previous investigations suggest that the aquifer tends to be thicker and contains greater amounts of gravel closer to the Dundas buried valley, which is located to the south and east of Lynden and known tributaries to this feature. Aquifer thickness was estimated to be 10-20 m by SNC Lavalin and Charlesworth and Associates (2006). Hydrogeologic cross-sections prepared in previous studies indicate that the highest proportion of continuous gravel is located to the east of Lynden (Morrison Beatty, 1978; Morrison Beatty, 1987; XCG, 2006), with thicker deposits of sand to the south along Lynden Road (Morrison Beatty, 1978). The deep aquifer was also noted to be present to the west and north of Lynden, but available data indicates that it contains higher proportions of silt and is discontinuous (i.e. generally absent) (Morrison Beatty, 1978; Morrison Beatty, 1987).

The gravel unit is believed to outcrop approximately 10 km northeast of Lynden, where it is exposed at ground surface (SNC-Lavalin and Charlesworth and Associates, 2006). Groundwater flow within this unit is interpreted to be in a southerly direction towards the Dundas buried valley (XCG, 2006). This aquifer has considerable storage and likely recharges the underlying bedrock aquifer. At some point in the system, as the elevation of the aquifer gets deeper, it may switch from being a recharge point to a drain.

Wells constructed within this aquifer tend to have higher specific capacities than those in the surficial or bedrock aquifers, with pumping rates generally greater than 45 L/min and occasionally up to 454 L/min, as determined from existing MOECC well records (XCG, 2006). However, private wells are not expected to be representative of the potential for the deeper aquifer, since they are tested at lower rates for domestic demand and may not intersect the entire sequence of the aquifer. The static water level in this aquifer is typically between 9-12 m bgs.

2.3.4 BEDROCK AQUIFER

Bedrock in the area lies beneath the overburden at depths of 50 – 60 m bgs. The bedrock surface dips from approximately 185 masl near Lynden to about 170 masl in the vicinity of the well site, before rising slightly to above 175 masl to the east. This suggests that the bedrock valley that enters the Dundas Valley to the south is shallow and wide (Figure 4). It is not clear if any deeper gorges exist within this area.

The bedrock is a high capacity productive aquifer in several areas north of Lynden, such as Cambridge, Aberfoyle and Guelph (Morrison Beatty, 1978). In areas where it is more crystalline, well yields are lower.

Bedrock wells in the Lynden area generally can produce from 45 – 90 L/min (Morrison Beatty, 1978). Regional groundwater flow within the bedrock is difficult to ascertain based on the limited amount of data, but will typically be controlled by surface drainage patterns.

2.4 LOCAL WATER SUPPLIES

Between November 16 and November 27, 2015, a private well survey was conducted at residences located within 500 m of the proposed Lynden FDL-03 wellsite. The well survey was completed in order to collect background water quality information and interview the residents to ensure that any pertinent information was recorded prior to the completion of the pumping test and the transition to the new well. Five properties agreed to participate in the survey. All of these properties participated in the previous survey prior to the testing of FDL-02 (GENIVAR, 2013).

A WSP field technician interviewed the residents to fill out a questionnaire and inspected the wellhead at each property. General comments on the wellhead condition were recorded on field sheets. Questions posed to the residents were designed to obtain information about known water quality history, general concerns, well depths, whether the resident would allow a water quality sample to be collected and tested, and whether they would allow for a datalogger to be installed into their well and permit manual monitoring of the water levels during hydraulic testing of FDL-03. Four residents agreed to participate in the water level monitoring program. Two of the wells were shallow bored wells that took water from the upper aquifer, whereas the other three were deep wells that were screened in the same deep aquifer as FDL-03.

At all five surveyed residences, water quality samples were collected and submitted to the City of Hamilton's laboratory for analysis. Sampled parameters included:

- colour
- hardness
- nitrates / nitrites
- total phosphorus
- turbidity
- metals
- sulphide
- microbiological parameters (Total Colifom, E.Coli.).

Samples were collected from a fixture located upstream of any water treatment equipment. All analytical results were reviewed and compared to the Ontario Drinking Water Quality Standards (ODWQS). Sodium was also compared to the Ministry of Health Guideline for People on Sodium Restricted Diets. The water quality results are summarized in Appendix D along with applicable water quality standards.

The parameters that exceeded the ODWQS for the five properties are summarized as follows:

- Health based exceedances – 4
  - Total coliforms – 3
  - Nitrate - 1
- Aesthetic exceedances – 8
  - Colour – 3

- Iron – 1
- Turbidity – 2
- Sulphide – 2

→ Operational exceedances – 5

- Hardness – 5

→ Ministry of Health Guideline for Sodium exceedances - 4

In addition, the absence of E.coli could not be confirmed at the residence located at 3826 Governors Road as the plate overgrowth required the minimum detection level to be raised to 10 CFU/100ml. No other collected samples reported non-compliant E.coli results. The identified microbiological exceedances in the water supplies located at 3586 and 3826 Governors Road are typical of shallow groundwater or groundwater that is potentially under the direct influence of surface water. It is possible that some bacteriological contamination could be due to a poorly sealed wellhead/casing, as is suspected in regards to the water supply located at 3725 Governors Road, which is an open well in a barn used to house cattle. This likely also contributed to the Nitrate exceedance reported at 3725 Governors Road. Elevated Nitrates are often associated with proximity to farmland and livestock and wells that may not meet current standards for well construction.

Non-health related exceedances were also noted in the groundwater. Sulphide exceeded the ODWQS aesthetic objectives (AO) of 0.05 mg/L in two wells, iron exceeded the AO of 0.3 mg/L in one well, colour exceeded in three wells, and turbidity in two. While sodium was below the AO of 200 mg/L in all of the wells, it exceeded the value of 20 mg/L for people on sodium restricted diets in four of the five locations.

Hardness values were not within the operational guideline range of 80 – 100 mg/L in all wells. All of the deep drilled wells exhibited naturally soft water (< 80 mg/L) that was lower in calcium and magnesium than expected from wells screened in materials that are apparently derived from limestone / dolostone bedrock. The water in the shallow bored wells was hard (> 100 mg/L), which is common for groundwater in Southern Ontario.

A summary of water quality results from the private well survey is provided in Table D-1 of Appendix D. Laboratory certificates of analysis are also provided in Appendix D.

3 WELL CONSTRUCTION

3.1 PILOT HOLE

The Lynden well FDL-03 was constructed in two phases. The first stage was the drilling of a pilot hole in November, 2015 approximately 10 m east of test well FM-02-14-D. The presence of buried utilities were cleared prior to initiating the drilling.

The stratigraphy encountered during drilling was found to consist of approximately 8.5 metres of fine sandy silt to silt at ground surface (likely corresponding to the Norfolk Sand Plain deposits), overlying clayey silt and silt with some clay to a depth of 39.6 m bgs. Beneath the clay was a layer of sandy silt to silty sand to sand with some silt and clay to a depth of 50.3 m bgs. A gravelly sand to sand and gravel aquifer was identified between 50.3 m and 56.4 m bgs, with bedrock below 54.6 m bgs. The well casing for the pilot hole was seated into bedrock at the end of the drilling.

Soil samples were collected at 3 metre intervals above the aquifer and at 1.5 metre intervals within the deep aquifer. A total of five samples were submitted for laboratory analysis. The grain size analysis plots were used to evaluate the preferred screen size. A screen opening size of 40 slot was selected based on these results.

Two aquitard samples were sent to a certified laboratory and tested using a hydrometer to assess the integrity of the aquitard between the surficial and deep aquifers. The results of this testing inferred that the aquitard is mainly silt and clay to clay and silt with a coefficient of permeability of $1x10^{-9}$ m/s or less.

Geophysical testing by gamma logging was completed in the test hole along the entire length of casing. Gamma logging is useful in identifying clay content in the soil and can help confirm stratigraphy. The assessment shows that the subsurface materials are consistent with the sampling program.

The results of the geophysical assessment, the borehole log and grain size distribution curves of aquifer material samples were reviewed to support the production well design. The borehole stratigraphy, well construction details, the gamma log from the downhole geophysical investigation and the drawdown curve from the pumping test are shown in Figure 8. The grain size plots and hydrometer analysis and geophysical analysis are provided in Appendix E.

3.2 PRODUCTION WELL

Due to winter weather related issues that created problems accessing the site, drilling of the production well did not start until February, 2016. The pilot hole was filled with sand as the 6-inch casing was removed. A layer of bentonite was placed across the base of the upper aquifer to prevent cross-connection of the upper and lower aquifers prior to the start of overdrilling.

A 304 mm diameter surface casing was advanced by means of dual drive, air rotary drilling to a depth of 15.2 m. A 208 mm diameter borehole was then advanced through the base of the 304 mm diameter excavation to a depth of 55.7 metres below ground surface. The well was constructed within the 208 mm diameter borehole by installing a Type 316L stainless steel casing with 8.2 mm wall thickness extending to 52.7 metres below ground surface and a 200 mm outer diameter Type 316L wire wound telescopic stainless steel hi-flow screen (slot 40) extending from 52.7 to 55.7 metres below ground surface. The well screen was installed inside the steel casing and the steel casing was then raised, allowing the aquifer formation to cave in around the well screen. The well screen partially penetrates the aquifer and possesses a theoretical transmitting capacity of 17.4 L/s (230 Igpm). The remaining annular space surrounding the well was sealed with a combination of neat cement grout and bentonite chips. The water well record for FDL-03 is provided in Appendix F.

The static water level in the well after drilling was measured to be approximately 15.0 mbgs, suggesting an available drawdown to a depth of 51 m (1.7 m above the top of well screen) of approximately 36 m. This assumption will conservatively allow for placement of the pump intake and level controls at a depth of 40 mbgs (see next section).

3.3 PLUMBNESS AND ALIGNMENT

A water well should be straight and plumb. A straight well is one where the casing joints are joined with proper alignment. A well that is plumb has its center that does not deviate from an imaginary vertical line that extends down through the middle of the casing. A straight (or aligned) well is more important than a plumb well. A deviation from plumbness of two thirds of the well's inner diameter per 100 feet (35 m) of an anticipated pump setting is allowed and thought to be reasonable (Driscoll, 1986).

Plumbness and alignment tests were conducted on FDL-03 using an acoustic televiewer. The alignment test data (Table F-1, Appendix F) shows the well to be within specifications for depths above 40 m bgs. The well begins to deviate outside of the recommended values below this depth. However, this is not expected to affect the performance of the well, since a submersible pump was installed to a depth of about 30 m bgs for use during the pumping test, and was able to provide sufficient available drawdown for future use. Plumbness and alignment testing plots are provided in Appendix F. Specifications on the acoustic televiewer are also included in Appendix F.

3.4 WELL DEVELOPMENT

Well development is an essential procedure carried out on newly installed water wells in order to maximize the well yield and to achieve sand-free water. Well development repairs the formation materials immediately surrounding the well that may have been altered through the drilling operations and helps to rework the undisturbed portion of the aquifer just beyond the altered material to improve its hydraulic properties.

Prior to initiating the step test and sand test, FDL-03 was developed for a period of about 13 hours. Development of the well consisted of both air-lifting as well as start-stop pumping cycles with a submersible pump.

3.5 CASING BOND LOG

A casing bond log was completed in FDL-03 to ensure a good seal around the casing. The tool is most effective in saturated media. The completed log shows no obvious voids beyond the casing wall. The bond log is included in Appendix F.

4 AQUIFER TESTING

4.1 MONITORING NETWORK

Nine (9) observation wells (not pumped), one (1) municipal well, and four (4) private wells (pumped for residential demand) were selected to be monitored as part of the hydraulic testing of FDL-03. The selected wells and their distance from FDL-03 are summarized in Table 1. Well LM-02-14D being closest to FDL-03 is expected to reflect the potential effects of FDL-03 with minimal influence from other sources.

Table 1 – Monitoring Network

MONITORING LOCATION	WELL TYPE	DISTANCE FROM FDL-03 (m)	HYDROSTRATIGRAPHIC UNIT	MEASUREMENTS
LM-02-14-D	Observation	15	Deep Aquifer	Manual
LM-02-11-D	Observation	105	Deep Aquifer	Manual, Logger
LM-01-14-D	Observation	170	Deep Aquifer	Manual, Logger
LM-01-11-D	Observation	181	Deep Aquifer	Manual, Logger
LM-01-12-D	Observation	193	Deep Aquifer	Manual, Logger
FDL-01	Municipal	226	Deep Aquifer	Logger
LM-01-03-D	Observation	239	Deep Aquifer	Manual, Logger
LM-01-03-S	Observation	239	Shallow Aquifer	Manual, Logger

MONITORING LOCATION	WELL TYPE	DISTANCE FROM FDL-03 (m)	HYDROSTRATIGRAPHIC UNIT	MEASUREMENTS
3606 Governors Road	Private	280	Deep Aquifer	Manual, Logger
3586 Governors Road	Private	337	Shallow Aquifer	Manual, Logger
LM-01-08-OB	Observation	637	Deep Aquifer	Manual, Logger
LM-01-08-D	Observation	637	Bedrock	Manual, Logger
3826 Governors Road	Private	626	Shallow Aquifer	Manual, Logger
3830 Governors Road	Private	704	Deep Aquifer	Manual, Logger

4.2 STEP TEST

On March 18, 2016, a step test was conducted on FDL-03 to assess the ability of the well to sustain the proposed 72-hour test pumping rate and to provide baseline data with which to assess future well performance. The data can also be used to compare with past performance of existing Lynden well FDL-01.

The step test was conducted at four discharge rates (2.5 L/s, 5.0 L/s, 7.5 L/s and 10 L/s). The steps were 60 minutes in length, with 60 minute interruptions between pumping steps to allow the well to recover. This type of testing was chosen to be consistent with previous step testing completed on production wells installed on this site (FDL-01 and FDL-02, now LM-01-11-D) The water levels were monitored manually and with a datalogger. The data is presented graphically in Figure G-1 and tabulated results are shown in Table G-1 of Appendix G. The results of the step test are summarized below in Table 2.

Specific capacity is the pumping rate divided by the drawdown. As shown in Table 2, there is a decrease in the specific capacity of the well during the step test. As discharge rates rise, well losses due to turbulent flow through the well screen appear to cause reduced well efficiency or higher drawdown. The relationship between drawdown and discharge is illustrated in Figure G-2 of Appendix G. This baseline information can be used for comparisons with future step tests to assess the need for periodic maintenance of the well.

Table 2 – Summary of Step Test Data for FDL-03

DISCHARGE RATE		CUMULATIVE DRAWDOWN	DRAWDOWN PER STEP	SPECIFIC CAPACITY
(L/s)	(Igpm)	(m)	(m)	(L/s/m)
2.5	33	0.48	0.48	5.20
5.0	66	1.12	0.64	4.46
7.5	99	1.79	0.67	4.19
10.0	132	2.38	0.59	4.22

The results compare favourably with the data collected for FDL-01 by Morrison Beatty (1985), and FDL-02 (renamed LM-02-11-D) by GENIVAR (2013), following a similar trend (Figure G-2, Appendix G).

Entrance velocities were measured after the step testing on May 24, 2016 at the first three pumping rates (2.5 L/s, 5.0 L/s and 7.5 L/s) and a flow distribution profile was created (Figure G-3, Appendix G). The plot shows that the highest velocities were measured within the top 2 m of the screen. The velocities decreased and were below 0.05 L/s at the bottom of the screen. The velocities increased for higher pumping rates.

The step test data provides sufficient information to proceed with a 72-hour aquifer test at a discharge rate of 6.0 L/s (79.2 Igpm).

4.2.1 SAND CONTENT TEST

Although there is no provincial criterion that provides a quantitative definition of sand-free water, we have adopted the American Water Works Association criterion of 5 mg/L (AWWA Standard A100-06). Sand content testing was carried out on March 17, 2016 to assess the level of sediment entrained in the well water during development. Sediment in water supplies can be destructive to pumps and other related fittings. Thus, a municipal water well must demonstrate a capability of providing essentially sand-free water before it can be incorporated into the water works system.

Sediment content was evaluated with a Rossum Sand Content Sampler and visual observations of the discharge. Suspended sediment concentrations were measured during a series of start-stop pumping cycles. This test method yields the most conservative results as it creates the most turbulence in the well and thus promotes the highest levels of sediment to enter the well.

The well was pumped at the target pumping rate for ten periods of approximately 10 minutes. Both turbidity and sand content were monitored at various times during the pumping cycles. The sand concentrations during the ten cycles were measured to range from less than 0.5 mg/L (but not zero) to 5.3 mg/L, with the highest values measured in the fourth cycle and the lowest (less than 0.5 mg/L) in the last four. Sand content was also measured during the first 20-hours of the pumping test. The sand content did not exceed 0.05 mL during this time, which corresponded to less than 0.4 mg/L at 60 minutes and less than 0.2 mg/L at 120 minutes. The sand content tables for development and pumping are provided in Table G-2 and G-3 of Appendix G. The American Water Works Association recommends that the sand content average no more than 5 mg/L for a pumping cycle of 2 hours in duration (AWWA Standard A100-06). In our opinion, the well provides essentially sand-free water at the target discharge rate.

4.3 CONSTANT RATE TEST

On March 21, 2016, a 72-hour constant rate pumping test was conducted on FDL-03 to evaluate aquifer parameters and assess the long-term performance of the well at a constant discharge rate of 6.0 L/s (79.2 Igpm). Water levels were monitored manually in the pumping well over the course of the test during both the pumping/drawdown and recovery phases and until about 70% recovery was achieved. Water levels were monitored through use of a datalogger prior to and after pumping.

Hydraulic testing of well FDL-02 (Now LM-02-11D) was conducted in 2012 to assess the potential capacity and suitability of this well to supplement the municipal water supply. Production well FDL-01 was shut down for a one week period before, during, and after the hydraulic testing at FDL-02. It was not possible to arrange for an extended shut-down of FDL-01 as part of the hydraulic testing at FDL-03. Pumping at FDL-01 to meet community demands started after approximately 300 minutes into the constant rate pumping test of FDL-03. As such, the observed response after 300 minutes in the constant-rate pumping test reflects the combined pumping of both production wells. Interpretation of the data from after 300 minutes will thus present a conservative (low) estimate of the potential performance and aquifer properties relative to pumping well FDL-03 alone. The relative influence at individual observation wells will reflect the distance from each pumping well.

Drawdown in FDL-03 after 300 minutes was measured at 1.46 m and 72 hours was measured at 2.81 m below the static level of 15.07 m below the top of the well. The drawdowns in each of the wells that responded to pumping are provided in Table 3 for 300 minutes and 72 hrs.

Table 3 – Drawdowns in Well Field Area

LOCATION	WELL TYPE (ZONE)	DISTANCE FROM FDL-03 (m)	OBSERVED DRAWDOWN 300 MIN (m)	FINAL DRAWDOWN 72 HRS (m)
FDL-03	Pumping (Deep Aquifer)	0	1.46	2.81
LM-02-14-D	Observation (Deep Aquifer)	15	0.9	2.22
LM-02-11-D	Observation (Deep Aquifer)	105	0.55	1.97
LM-01-14-D	Observation (Deep Aquifer)	170	0.45	1.94
LM-01-11-D	Observation (Deep Aquifer)	181	0.74	2.31
LM-01-12-D	Observation (Deep Aquifer)	193	0.47	1.91
FDL-01	Municipal (Deep Aquifer)	226	0.29	1.61
LM-01-03-D	Observation (Deep Aquifer)	239	0.43	1.87
3606 Governors Road	Private (Deep Aquifer)	280	0.37	1.81
LM-01-08-OB	Observation (Deep Aquifer)	637	0.18	1.41
3830 Governors Road	Private (Deep Aquifer)	704	-	1.07

The hand-measured drawdown and recovery data for FDL-03 and the monitoring network is provided in Tables H-1 to H-14 and Figures H-1 to H-15 in Appendix H. Note that there is no corresponding data table for FDL-01, as the water levels were not monitored by hand.

A plot of distance vs drawdown for 300 minutes and 72 hours is provided in Figures H-16 and H-17, respectively. In general, the observed drawdown decreased with increasing distance from FDL-03. The potential to vary from this expected trend may be due to local variability of hydraulic conductivity within the aquifer formations, response related to the boundary of the aquifer, and (after 300 minutes) influence from pumping at FDL-01 .

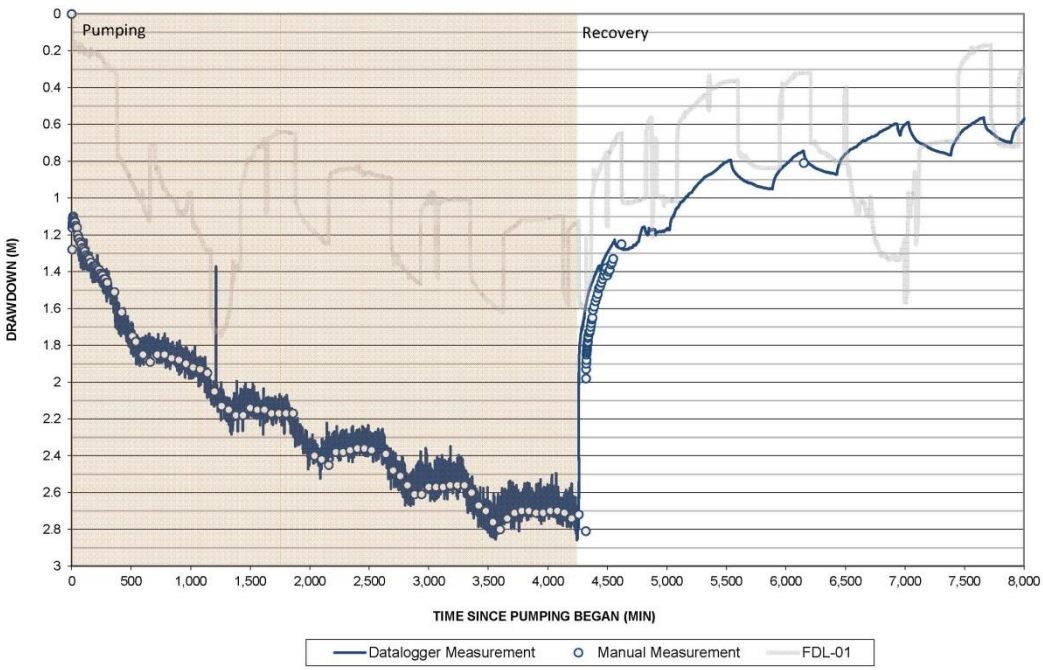
The Category 2 Permit to Take Water for the testing (1780-A3NR4B) is provided in Appendix I.

4.3.1 WELL YIELD

In an ideal confined aquifer, the time-drawdown and time-recovery data from a constant rate test will follow a straight line trend on a semi-log plot. Additionally, the recovery data should mirror the rate of drawdown. In other words, the recovery data for the pumping well should superimpose onto the drawdown data on a semi-logarithmic plot. With the impact of the operation of the municipal pumping well FDL-01, the hydrographs of each well reflect the impact of only FDL-03 for the first 300 minutes of the pumping test, the remainder of the test was during the intermittent pumping of FDL-01.

As shown in Figure H-1 and H-18 in Appendix H and in Illustration 1, the drawdown and recovery data for the FDL-03 generally follow a linear trend for approximately the first 300 minutes, after which drawdown increases, indicating the influence of FDL-01 pumping. After FDL-01 is shut down, there is a slight recovery in FDL-03. This trend of drawdown increase, FDL-01 increased drawdown, and slight recovery continues throughout the test. The hydraulic response compares well with the testing done on FDL-01 by Morrison Beatty in 1985 (24-hour test at 15.8 L/s and 1987 (13.2 day test at 3.2 L/s). The recovery data superimposes on the drawdown data reasonably well at early time, but starts to lag after FDL-01 influences each well. Steady-state conditions have not been reached by the end of the pumping test. Similar trends were observed in the other wells monitored during the pumping test (Figures H-19 to H-28 in Appendix H).

ILLUSTRATION 1: GROUNDWATER HYDROGRAPH - FDL03 (72H TEST)
CITY OF HAMILTON - LYNDEN (FDL 03)



With a pumping rate of 6.0 L/s (79.2 igpm) applied during the 72-hour constant rate test, the drawdown in the pumping well after 20 years was estimated to determine the effects of long-term pumping at the maximum rate. The drawdown after 20 years in FDL-03 is projected to be about 7.3 metres assuming no additional boundaries are encountered (Figure H-29 in Appendix H). This predicted 20-year drawdown is less than the available drawdown of about 25 metres (discussed in Sections 3.2 and 3.3), which indicates that the pumping rate of 6.0 L/s (79.2 Igpm) appears sustainable.

Given that the well will not be pumped constantly at the maximum rate of 6.0 L/s, but rather periodically at lower rates, it is likely that the well will not have any long-term negative impacts to the aquifer. Further, Morrison Beatty (1985) estimated a long-term recharge rate of 13 L/s to this aquifer, suggesting that the rate may be sustainable.

As part of the wellhead protection study completed by SNC Lavalin and Charlesworth and Associates (2006), a steady-state capture zone was generated for FDL-01 at its maximum pumping rate. The capture zone water budget was estimated to have a surplus of 1,164.2 m^3/day, or 13.5 L/s, which corresponds to the estimates provided by Morrison Beatty. Since the increased taking from FDL-03 is proposed to be 1.1 L/s greater than FDL-01, it is expected that the new rate should be sustainable.

4.3.2 AQUIFER PARAMETERS

The pumping test drawdown and recovery data for FDL-03 and wells screened in the well field area were analyzed using the Cooper-Jacob solution. The following assumptions were applied during the analysis:

- Aquifer is assumed to be confined.
- Cooper-Jacob solution was used for drawdown.
- The effects of partial penetration were ignored.
- Drawdowns as a result of well use in private wells were not accounted for in the analysis, to provide a conservative estimate.

The pumping test data was analyzed over three periods:

- During the first 300 minutes of the test.
- From 300 minutes until the end of the test as a result of periodic interference from FDL-01.
- Recovery.

Transmissivity and storativity were calculated for each interval and monitoring locations was summarized in (Table H-15, Appendix H). The analysis for the unaffected drawdown during the first 300 minutes may reflect the presence of negative boundaries. The transmissivity results range between 150 – 950 m^2/day, with higher values being estimated in wells closer to FDL-03.

The calculated transmissivity values after 300 minutes of pumping ranged from 45 – 80 m^2/day, regardless of distance from FDL-03. The change in transmissivity between the unaffected drawdown and the influence of FDL-01 are possibly due to changes in thickness or fining of the aquifer at greater distances.

The transmissivities calculated from recovery data range from 130 to 950 m^2/day and decrease with distance from FDL-03. This range is consistent with the transmissivities estimated from the first 300 minutes and may indicate the presence of a negative boundary condition. The higher transmissivity is considered to reflect a more productive zone in the aquifer close to FDL-03. As the cone of depression expands transmissivities reflect either finer grained segments or a thinning of the aquifer. The regional transmissivities reflect the lower end of the range. The overall drawdown trends are also consistent with the shallow nature of the drawdown cone.

Average storativity values with and without the influence of FDL-01 ranged between 9.2×10^{-5} to 1.0×10^{-4}. These are generally within the range of expected values for confined systems. The storativity value estimated from the data collected at monitoring well LM-02-14-D between 300 minutes and 72 hours was slightly higher than the values measured during the test at 4.2×10^{-2}, and at LM-02-11-D the value was 1.1×10^{-3}. It is not known why these values were different. Analysis plots are provided in H-18 to H-28 of Appendix H.

5 GROUNDWATER INTERFERENCE

5.1 OBSERVED INTERFERENCE

The effects of pumping a well must be evaluated so that potential groundwater interference with local wells can be addressed. Since the pumping requirements for FDL-03 are slightly higher than for FDL-01 (518 m^3/day vs. 327 m^3/day), there may be additional interference with nearby private wells. To quantify the amount of interference from the pumping test, loggers were installed within selected private wells and

monitoring wells as discussed in Sections 2.4 and 4.1. The loggers were installed a week prior to the start of testing to provide baseline water use data, and were removed two weeks after the test was completed. Loggers were installed above the pump intake in all cases. Manual levels were taken after installation, several times a day during testing, and again prior to removal. Plots showing logger trends in private and monitoring wells are included in drawdown and recovery hydrographs of Figures H-1 to H-15 in Appendix H.

Two types of trends were noticed in the logger data recorded during and after the start of the pumping test:

- Instantaneous changes in water level resulting in drawdown and recovery as represented by daily residential use (tens of centimetres to metres).
- Short term drops in water level likely caused by the pumping of FDL-01 (tens of centimetres). These variations were most notable in the deep private wells closest to the site.

During the pumping test, drawdowns as a result of the pumping of FDL-03 were detected in private wells screened in the deep aquifer as listed in Table 3. None of the wells experienced loss of water during the pumping test, and neither of the shallow wells that were monitored exhibited detectable interference.

The use of FDL-01 did appear to have a short-term effect on private wells located within the deep aquifer. In particular, the well at 3606 Governor's Road exhibited clear disturbances of approximately 0.2 metres each time FDL-01 was used. However, once municipal pumping ceased, water levels recovered but reflected a continued impact from the pumping of FDL-03.

Once the pumping test was completed, water levels recovered to within 0.2 to 0.4 metres of their original levels, which corresponds to 75 to 78 percent recovery. The recovery was interrupted by the pumping of FDL-01.

5.2 WELL COMPLAINTS

No complaints were received as a result of the pumping of well FDL-03.

5.3 PREDICTED INTERFERENCE

Monitoring during the pumping test indicated that water levels in nearby wells screened in the same aquifer were influenced by the testing. The trend of the drawdown was measured to be shallow and extensive, with the 1 m drawdown contour extending to a distance of between 600 and 720 m by the end of the test (Figure 9). Since steady-state had not been achieved by the end of the test, it is expected that drawdown will increase with additional pumping. The long-term trend in drawdown is expected to increase in a similar manner, with a shallow but expansive drawdown in the aquifer close to FDL-03. Given the proposed increase in pumping rates for FDL-03 compared to FDL-01, it is expected that nearby private dwellings will experience a slight increase in drawdown in their wells. However, water level changes in the nearest private wells were monitored to be only about 0.2 m as a result of pumping from FDL-01, so additional impacts due to a slight increase in pumping is generally not expected to be significant given the available drawdown in nearby wells of over 30 metres.

LONG TERM INTERFERENCE

Longer term interference was predicted for two scenarios:

- Four (4) months constant pumping at the maximum requested rate (high demand)
- Twelve (12) months constant pumping at the average daily rate (regular demand)

The rationale for examining effects from these two scenarios is that maximum day demand is a stress that is applied to a well during periods of high demand including drought. The assumption that drought conditions will persist for four continuous months and require non-stop pumping of FDL-03 at this maximum rate is considered unlikely to arise. To assess the long-term effects of pumping, average day demand for 365 days without consideration of recharge to the aquifer was considered in the second scenario. Since FDL-01 has operated for many years at average daily demand without stressing the aquifer, the assumption that there is enough recharge to the aquifer on an annual basis seems reasonable to conclude that a 365 day average daily demand scenario should represent long-term effects in the aquifer.

The analysis and results are provided in the following sections.

HIGH DEMAND ZONE OF INFLUENCE

Drawdown in the wells monitored during the test period was estimated at a period of four months using a semi-log plot for each. These values were subsequently plotted on a distance-drawdown curve. Based on this plot, the projected 1-m drawdown zone of influence (ZOI) for four months of pumping at the maximum rate is approximately 1,000 m (Figure 9).

AVERAGE DEMAND ZONE OF INFLUENCE

Similarly, drawdown was estimated at a period of one year using the same semi-log plots. However, since the existing plots were created at the maximum rate, a correction factor is required to estimate drawdown at the lower rate assuming a maximum day factor of 2.5. Based on this calculation, the projected 1-m drawdown ZOI for one year of pumping at the average daily rate of 2.4 L/s is approximately 850 m (Figure 9).

6 WATER QUALITY

6.1 RESULTS

Proposed public groundwater supplies are subject to groundwater quality characterization to demonstrate that these supplies are potable. Water samples were collected from FDL-03 after 1 hour, 12, hours, 24 hours, 36 hours, 48 hours, 60 hours and 72 hours of pumping. These samples were submitted for analytical testing for general inorganic chemistry and for the chemical parameters listed in Schedule 23 and Schedule 24 of O.Reg. 170/03. All samples were preserved as required at the time of collection and stored in coolers for delivery to the City of Hamilton's laboratory. Field parameters were also measured at these same intervals (pH, total dissolved solids, conductivity, temperature, turbidity and oxidation reduction potential).

A summary of the general inorganic chemistry results and the organic chemistry results are provided in Tables J-1 to J-3 of Appendix J. The laboratory certificates of analysis for all chemical and physical parameters tested are also provided in Appendix J. Field parameters are also summarized in Appendix J.

General chemistry parameters include both chemical and physical parameters that relate to the general quality of a water sample such as cations, anions, nutrients, pH, conductivity, turbidity, dissolved organic carbon and metals. Chemical characteristics of drinking water refer to both organic and inorganic chemicals that may be potentially hazardous to human health, aesthetically objectionable or interfere with the operational requirements of the treatment or distribution system. Physical characteristics of groundwater refer to characteristics such as colour, clarity, odour and taste. While these characteristics

directly relate to aesthetics, some may also negatively affect the treatment process or be precursors to potentially harmful chemicals.

All chemical and physical parameters tested meet the Ontario Drinking Water Quality Standards, Objectives and Guidelines, except for sulphide and hardness.

Sulphide levels in the groundwater were measured to be 0.59 to 1.7 mg/L, which is above the aesthetic objective of 0.05 mg/L. It is common in deep wells in the Lynden area, including FDL-01, where treatment systems are in place.

The total hardness in the water ranged between 51.0 and 58.3 mg/L as $CaCO_3$. These levels are below the recommended Operational Guideline of 80 to 100 mg/L as $CaCO_3$, indicating naturally soft water with lower calcium and magnesium values than are expected for sources derived from limestone and dolostone. Water softness can cause corrosion of water pipes.

Sodium levels in the samples, which are in the range of 45.8 to 47.0 mg/L, are below the Aesthetic Objective of 200 mg/L. However, the MOECC requires that the Medical Officer of Health be notified when concentrations of sodium exceed 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium-restricted diets.

Levels for pH were measured to be 8.29 at 72-hours. This is within the Operational Guideline of 6.5 – 8.5 pH units. However, pH has been measured to exceed this level in FDL-01, so this parameter should be monitored to ensure that it remains within this range. pH levels above 8.0 can cause precipitation of lead. Hand measurements of pH were found to exceed the guidelines, measuring between 8.92 and 9.37. The difference between the field measured and laboratory measure value at 72-hour varied by 0.63 pH units.

Hand measurements of Total Dissolved Solids (253 – 291 mg/L) were generally higher than the corresponding laboratory results (170 – 186 mg/L). This is likely again attributable to the greater reliability of laboratory equipment. The hand measured reading of 852 mg/L is expected to be an outlier due to a problem with the equipment.

In summary, groundwater quality is considered to require treatment of hydrogen sulphide in order for it to be palatable.

6.2 PARAMETERS OF INTEREST

6.2.1 BARIUM

The presence of Barium was noted in the groundwater in well FDL-02 at levels in excess of the drinking water standards. Levels of Barium measured during the pumping test at FDL-03 ranged between 0.092 and 0.114 mg/L, which is well below the maximum acceptable concentration of 1.0 mg/L.

6.2.2 LEAD

The existing well FDL-01 has had recent issues with the presence of lead in the distribution system leading to a drinking water advisory to be issued for the community of Lynden. The source of lead has not been identified. Levels of lead in the groundwater measured during the pumping test ranged from below the detection limit of 0.001 mg/L up to 0.0016 mg/L. These values are well below the drinking water limit for lead of 0.01 mg/L. It should be noted that pH levels above 8.0 can cause lead to precipitate from groundwater.

6.3 TRENDS

Review of the water quality data obtained over the 72 hour pumping test identifies a few trends:

- Sulphide concentrations progressively increase (approximately 1 mg/L)
- Sulphate concentrations progressively decrease (approximately 3 mg/L)
- Chloride concentrations progressively increase (approximately 4.1 mg/L)
- Calcium concentrations progressively decrease (approximately 1.6 mg/L)
- Oxidation Reduction Potential (ORP) progressively increases from 40 mV to 135 mV.
- Turbidity progressively decreases (1.5 NTU).

These trends indicate slight changes in water quality during the course of the test. A trilinear diagram is typically used to assist in evaluating these trends (Appendix K).

The observations above are consistent with a scenario where two water types are mixing in different proportion during the course of the test. A mixing trend is typically observed on the trilinear diagram by values reflecting each end of the observation period and a progressive change from each sample interval. Although the magnitude is small, this trend is evident in the trilinear plot in Appendix K.

In this situation, the mixing is considered to reflect an increased contribution of water from the bedrock layer to the sand and gravel aquifer layer during active pumping. Over time, this water quality trend would continue to an end point with water that is more similar to the bedrock water quality.

The water quality experiences an important change in oxygen reduction potential during this test that is reflected by the increase in dissolved sulphide and a reduction in dissolved sulphate concentrations. This suggests that the water being drawn in has higher concentrations of sulphide, consistent with available knowledge of the water quality in the local bedrock aquifer.

7 GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER (GUDI)

Filtration and disinfection requirements for drinking-water systems are dependent upon the type of raw water (e.g. groundwater or surface water) that is supplying the system. These requirements are set out in Ontario Regulation 170/03 (O.Reg. 170/03) for Drinking-Water Systems, made under the Safe Drinking Water Act, 2002 (SDWA).

Where the raw water supply is being drawn from groundwater, the Ministry of the Environment and Climate Change requires an evaluation of whether or not the water supply is ‘groundwater under the direct influence of surface water’ (GUDI). If a drinking-water system is considered to be GUDI, the raw water supply for the system must be considered to be surface water and must receive the appropriate level of treatment.

Table 4 summarizes the O.Reg. 170/03 criteria that define which systems are drinking-water systems that obtain water from a raw water supply that is GUDI, and demonstrates the applicability of the criteria with

respect to FDL-03. The hydrogeologic cross-sections in Figures 6 and 7 provide an illustration in support of the GUDI evaluation, as do the well construction details in Figure 8.

Table 4 – GUDI Criteria and Classification

O.REG. 170/03 CRITERIA FOR DRINKING-WATER SYSTEMS WHOSE RAW WATER SUPPLY IS GUDI	APPLICABILITY OF CRITERIA
1 - Obtains water from a well that is not a drilled well or from a well that does not have a watertight casing that extends to a depth of six metres below ground level.	N/A – The new well is a drilled well, with a watertight casing that extends 52.7 metres below ground surface.
2 - Obtains water from an infiltration gallery.	N/A – The water is not obtained from an infiltration gallery.
3 - Is not capable of supplying water at a rate greater than 0.58 litres per second and that obtains water from a well, any part of which is within 15 metres of surface water.	N/A – The long-term capacity of the new well is 6.0 L/s and the well is not within 15 metres of surface water.
4 - Is capable of supplying water at a rate greater than 0.58 litres per second and that obtains water from an overburden well, any part of which is within 100 metres of surface water.	N/A – The new well is an overburden well with a capacity greater than 0.58 L/s, but it is located more than 100 metres from surface water.
5 - Is capable of supplying water at a rate greater than 0.58 litres per second and that obtains water from a bedrock well, any part of which is within 500 metres of surface water.	N/A –The new well is an overburden well, not a bedrock well.
6 - Exhibits evidence of contamination by surface water.	N/A – Water quality results from FDL-03 do not provide an indication of surface water contamination.
7 - In respect of which, a written report has been prepared by a professional engineer or professional hydrogeologist that concludes that the system's raw water supply is groundwater under the direct influence of surface water and that includes a statement of his or her reasons for reaching that conclusion. O. Reg. 170/03, s. 2 (2).	N/A – a preliminary GUDI assessment by a Professional Engineer and Professional Geoscientist suggests that FDL-01, which is screened in the same aquifer, is not GUDI (Stantec, 2004)

Notes: N/A – Not applicable

Based on the evaluation of the above criteria, the well water from FDL-03 is considered to be "characteristic of groundwater" (not GUDI). Additionally, the aquifer is confined below more than 20 metres of low permeability soil and microbiologic quality at the existing FDL-01 well remains satisfactory, which further supports the evaluation that the well water at FDL-03 is not GUDI.

8 DRINKING WATER SOURCE PROTECTION

Chapter 13 of the Grand River Source Protection Plan (SPP) (Grand River Source Protection Authority, November 2015) contains policies that apply to the delineated vulnerable areas for the Lynden wellfield (Grand River Source Protection Area – Approved Assessment Report, November 2015).

Well Head Protection Area A (WHPA-A), defined as the 100 m radius surrounding the municipal water supply well, is most sensitive and the majority of the SPP policies apply to activities that occur, or may occur, in this area (Figure 10). Activities to be carried out within WHPA-A will typically require a Prescribed Instrument (Environmental Compliance Approval or similar permit/approval issued by a provincial agency) or a Risk Management Plan (RMP) to be negotiated with the Risk Management Official for the City of Hamilton. The activities that require a RMP include:

- The Storage of Agricultural Source Material (ASM) or the Application of ASM to Land;
- The Application of Commercial Fertilizer to Land
- The Application of Pesticide to Land
- The Handling and Storage of Fuel
- The Handling and Storage of Dense Non-Aqueous Phase Liquid (DNAPL)
- The Handling and Storage of an Organic Solvent
- The Use of Land as Livestock Grazing or Pasturing Land, an Outdoor Confinement Area or Farm Animal Yard.

A RMP would also be required for activities that involve the handling and storage of DNAPL within the vulnerable area based on the five-year travel time (WHPA-C).

The construction of the new well (FDL-03) will require an updated delineation of the WHPAs. Once the WHPA delineations have been updated, accepted by the Source Protection Committee, and an update to the Assessment Report has been prepared and accepted by the Ministry of the Environment and Climate Change, the SPP policies will apply to the new vulnerable areas. WHPA-A for FDL-01 will remain unchanged. A new WHPA-A of 100 m radius will be put in place around FDL-03. The policies that currently apply to WHPA-A for FDL-01 will apply to the WHPA-A for FDL-01 and FDL-03. Figure 10 has been prepared to demonstrate the likely extent of the updated WHPA-A areas. Note that a 26 m strip will exist between FDL-01 and FDL-03 and the City of Hamilton may consider requesting to the Source Protection Committee and the MOECC and the that the two WHPA-A be joined to promote consistent policies within this area.

Updated delineation of the WHPAs will need to be carried out using a numerical groundwater flow model (preferably by adding the new well to the existing model). Based on our understanding of the aquifer and the position and proposed capacity of Lynden system (FDL-01 or FDL-03), the shape of the updated WHPA-B to WHPA-D is expected to be similar to the existing WHPA-B to WHPA-D but will extend slightly further to the south and north and be slightly wider in the east-west direction.

The implications of the updated WHPAs for the Lynden Municipal Well System are:

- The area affected by the SPP Policies for WHPA-A for FDL-01 will not change.
- The SPP policies that apply to WHPA-A for FDL-01 will also apply to a 100 m radius around FDL-03 (and, possibly to the 26 m strip between the two WHPA-A to provide similar protection).
- The SPP policies that apply to WHPA-A require a RMP to be in place in order to carry out the following activities (where the activity would be considered to be a significant drinking water threat):
    - The Storage of Agricultural Source Material (ASM) or the Application of ASM to Land;
    - The Application of Commercial Fertilizer to Land
    - The Application of Pesticide to Land
    - The Handling and Storage of Fuel

- The Handling and Storage of DNAPL
- The Handling and Storage of an Organic Solvent
- The Use of Land as Livestock Grazing or Pasturing Land, an Outdoor Confinement Area or Farm Animal Yard.

→ The SPP policies that apply to WHPA-A to C that require a Risk Management Plan for the Handling and Storage of DNAPL will likely apply to a larger area than is currently delineated.

→ SPP policies relating to the operation and maintenance of systems that collects, stores, transmits, treats or disposes of sewage will be implemented.

The WHPA-A for FDL-03 will extend onto adjacent agricultural properties. Review of aerial photographs shows that the 100 m WHPA-A for FDL-03 includes lands that is currently used for crops. A RMP will be need to be negotiated with the property owners in order for them to continue or initiate agricultural operations that involve the activities identified above within the 100 m radius of FDL-01 or FDL-03. The SPP policies will not strictly apply until the Assessment Report has been updated, however, it is prudent to take action and initiate the process to implement the RMP to ensure that the new well is protected from these activities when FDL-03 is brought into service.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

The following conclusions are presented based on the test data collected during this study:

→ FDL-03 is completed in a confined overburden aquifer within a buried valley, which trends north to south towards the Dundas Buried Valley.

→ A number of residences along Governors Road near the well site rely on groundwater as a source of supply.

→ Four private wells sampled during the water well survey had health related exceedances (microbiology – 3, nitrates – 1).

→ One of the drilled wells from the private well survey is located in a barn next to livestock. The well had no cap and a short stickup, making it a potential risk for contamination of the aquifer.

→ Step testing indicates about a 30% decrease in specific capacity as the discharge rate increases. The losses are likely due to turbulent flow.

→ Well FDL-03 produces essentially sand-free water at the design test rate of 6 L/sec.

→ The casing bond log was conducted within the saturated length of the well (below the water level) and shows no evidence of voids beyond the casing.

→ Plumbness and alignment testing shows the well to be within specifications for depths above 40 m. The well is outside of the recommended values below this depth. This is not expected to affect the performance of the well, since a submersible pump was installed to a depth of about 30 m bgs and there appears to be sufficient available drawdown for future use.

- The measured 1 m drawdown zone of influence (ZOI) is between 600 and 720 m distant at the end of the test.
- The projected 1 m drawdown ZOI for four months of pumping at the maximum rate is approximately 1000 m.
- The projected 1 m drawdown ZOI for one year of pumping at the average daily rate is approximately 850 m.
- Recovery in the aquifer was found to lag the drawdown on data plots, possibly due to interference from FDL-01 or nearby boundaries.
- Local transmissivity in the vicinity of the well field may be as high as 950 m^2/day based on the early time data. As the cone of depression expands into finer portions and/or fining of the aquifer, the regional transmissivity is in the range of 105 m^2/day.
- Storativity values were estimated to range between $9.2x10^{-5}$ to $1.0x10^{-4}$
- Although steady-state conditions were not achieved during the pumping test, FDL-03 should be capable of sustained operation at a discharge rate of 6.0 L/s (79.2 Igpm).
- No well complaints were received during the pumping test.
- No adverse effects were detected in shallow wells as a result of the pumping test.
- Groundwater quality sampling from FDL-03 indicates that the well water meets the Ontario Drinking Water Standards, Objectives and Guidelines for all parameters listed in Schedule 23 and 24 of O.Reg. 170/03, except for hydrogen sulphide and hardness. Sulphide levels were measured to range between 0.59 to 1.7 mg/L, which exceeds the aesthetic objective of 0.05 mg/L. The hardness levels in the samples were measured to range from 51.0 and 58.3 mg/L as $CaCO_3$, which is below the Operational Guideline range of 80 to 100 mg/L as $CaCO_3$.
- The groundwater requires treatment for hydrogen sulphide. The water is considered to be soft.
- Sodium levels in the samples, which are in the range of 45.8 to 47.0 mg/L, are below the Aesthetic Objective of 200 mg/L. However, the MOECC requires that the Medical Officer of Health be notified when concentrations of sodium exceed 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium-restricted diets.
- Hand measurements of pH were found to exceed the guidelines, measuring between 8.92 and 9.37. The difference between the field measured and laboratory measure value at 72-hour varied by 0.63 pH units.
- Barium and lead were well below the health related drinking water guidelines.
- Water quality trends are consistent with a scenario where two water types are mixing in different proportion during the course of the test. The mixing is considered to reflect an increased contribution of water from the bedrock layer to the sand and gravel aquifer layer during active pumping.
- FDL-03 is designed to pump at a higher discharge rate than FDL-01. Based on analysis of the pumping test data and water balance calculations, additional interference with nearby private wells is expected to be negligible, with the exception of 3606 Governors Road (approximately 1.8 m drawdown during the duration of the 72hr test).
- The raw water from FDL-03 is characteristic of groundwater and “not GUDI”.
- Source Protection Plan policies will need to be implemented in FDL03 WHPAs.

9.2 RECOMMENDATIONS

The following recommendations are provided based on the conclusions of the testing of FDL-03:

- Lynden well FDL-03 can be operated in place of the existing FDL-01 municipal well.
- Lynden well FDL-03 should be added to the existing systems PTTW and permitted for a maximum taking of 6.0 L/s.
- FDL-03 will require treatment for hydrogen sulphide before being connected to the local supply.
- One of the drilled wells from the private well survey is located in a barn next to livestock. The well had no cap and a short stickup, making it a potential risk for contamination of the aquifer. The City should encourage the well owner to secure the well or offer to provide a proper well lid to protect the aquifer.
- Source Protection Plan policies will need to be implemented developed for the FDL-03 and FDL-01 WHPAs.

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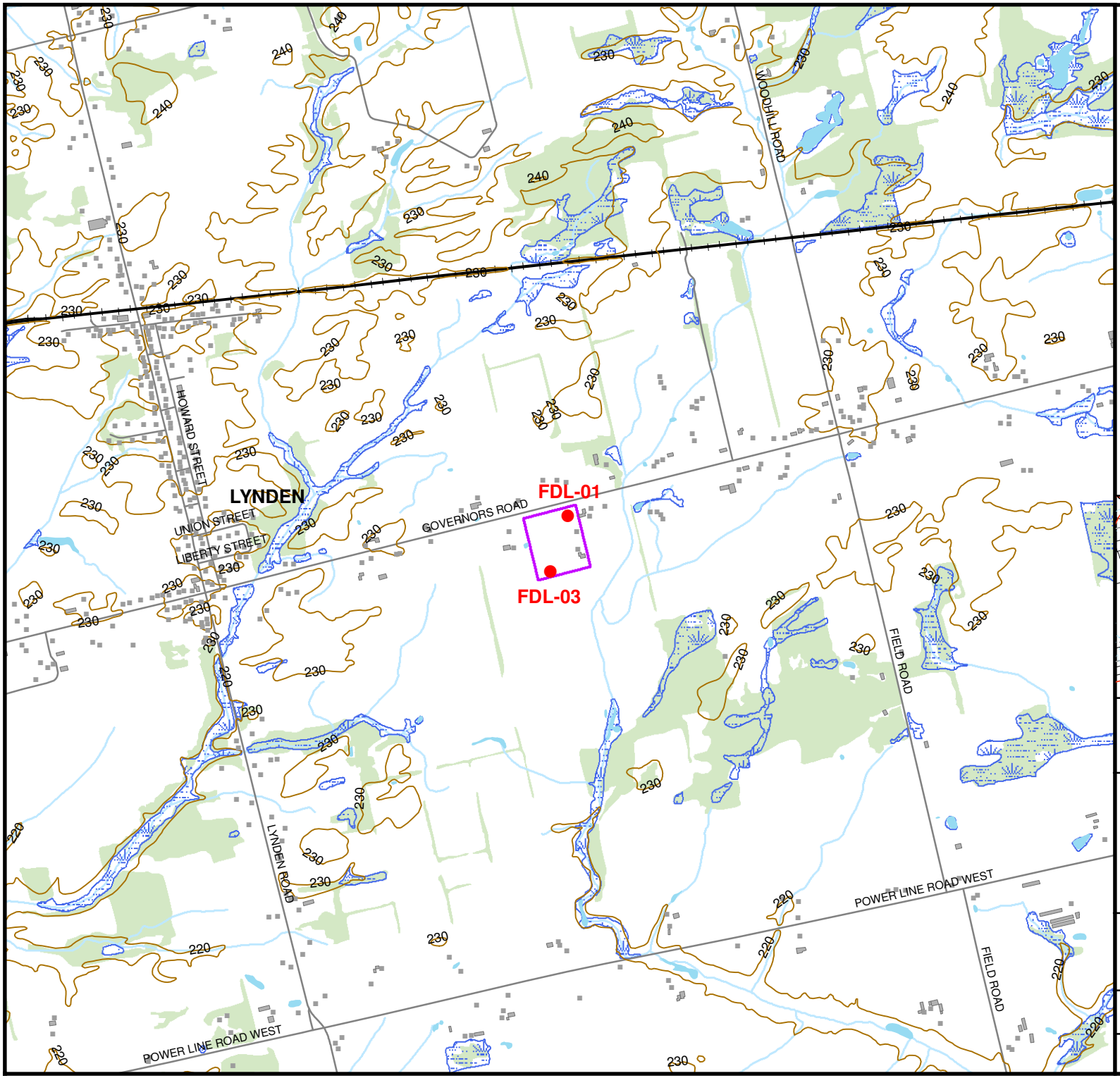
Figures

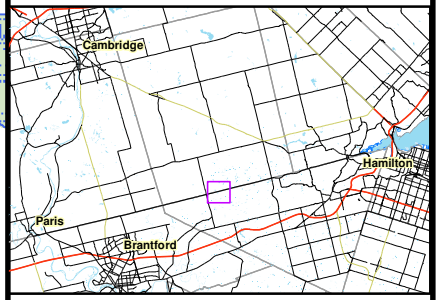


LEGEND

- FDL-01 & FDL-03
- BUILDING SYMBOLS
- 10 m INTERVAL CONTOURS (mASL)
- RAILWAY
- ROADS
- WATERCOURSES
- WATERBODIES
- WETLAND
- WOODED AREA
- SITE LOCATION

Data Source: Ministry of Natural Resources, Ontario Base Mapping, January 2016.

390 195 0 390 Metres



WSP

Project:

LYNDEN WATER SUPPLY CLASS ENVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-03
For: City of Hamilton

Title:

SITE LOCATION PLAN

Project No.:	Date:
071-11885-01	MAY 2016
Scale:	Figure No:
1:20,000	1

LEGEND

- MUNICIPAL WELLS
- MONITORING WELLS
- PRIVATE WELLS
- SITE LOCATION
- WATERCOURSE
- WATERBODIES

60 30 0 60 Meters

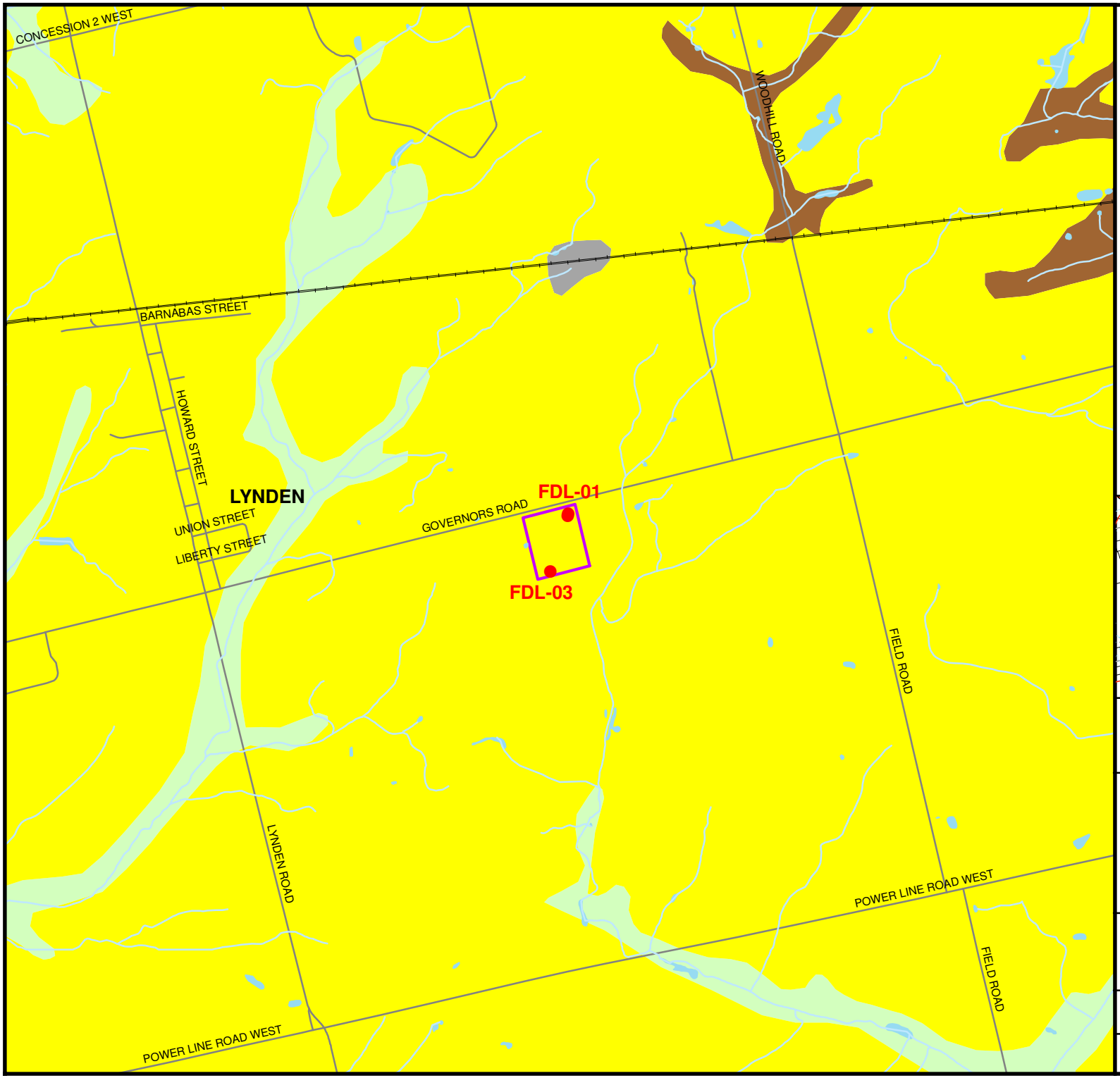
N W E S

Data Source: Ministry of Natural Resources, Ontario Base Mapping, January 2016.

FDL-03 AND SURROUNDING AREA

LYNDEN WATER SUPPLY CLASS ENVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-03
For: City of Hamilton

DATE:	SCALE:
MAY 2016	1:4,000
PROJECT:	FILE NO.:
071-11885-01	071-11885-01 105 F2
WSP	FIGURE 2

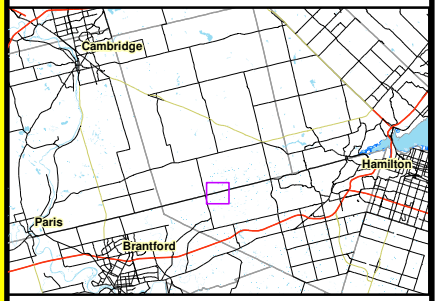


LEGEND

- MUNICIPAL WELLS
- RAILWAY
- ROADS
- WATERCOURSES
- WATERBODIES
- SITE LOCATION
- COARSE-TEXTURED GLACIOLACUSTRINE DEPOSITS
- MASSIVE-WELL LAMINATED
- MODERN ALLUVIAL DEPOSITS
- ORGANIC DEPOSITS

Data Source: Ministry of Natural Resources, Ontario Base Mapping, January 2016. Surficial Geology of Southern Ontario, MRD 128, Ministry of Northern Development and Mines.

390 195 0 390 Metres

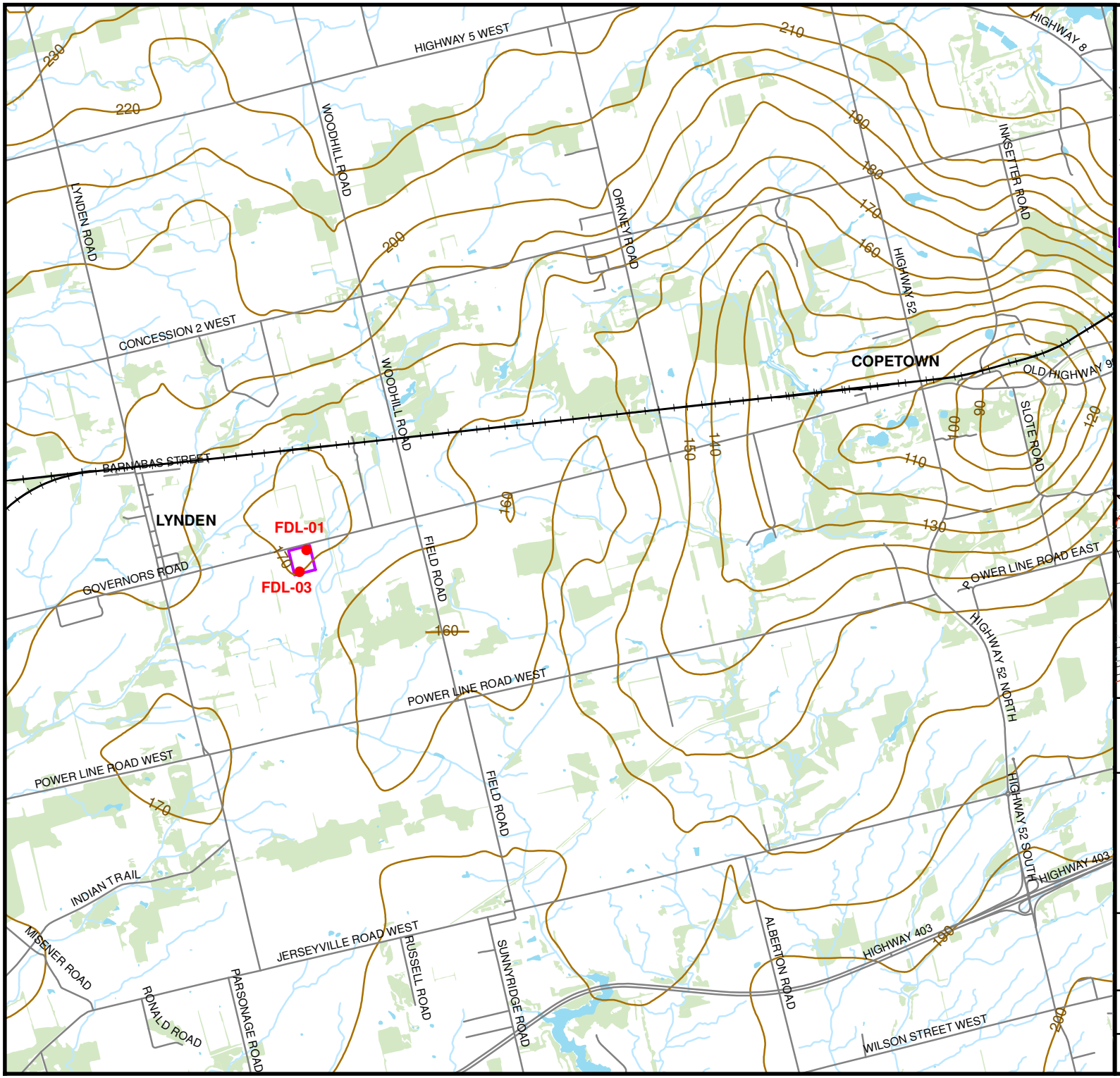


WSP

Project:
LYNDEN WATER SUPPLY CLASS ENVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-03
For: City of Hamilton

Title:
SURFICIAL GEOLOGY

Project No.:	Date:
071-11885-01	MAY 2016
Scale:	Figure No:
1:20,000	3

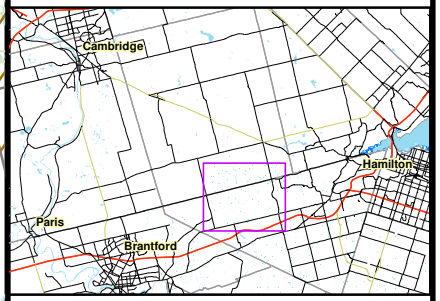


LEGEND

- MUNICIPAL WELLS
- 10 m INTERVAL BEDROCK ELEVATION (mASL)
- RAILWAY
- ROADS
- WATERCOURSES
- WATERBODIES
- WOODED AREA
- SITE LOCATION

Data Source: Ministry of Natural Resources, Ontario Base Mapping, January 2016. Bedrock Topography and Overburden Thickness Mapping, Southern Ontario, MRD 207, Ministry of Northern Development and Mines.

1,000 500 0 1,000 Metres



WSP

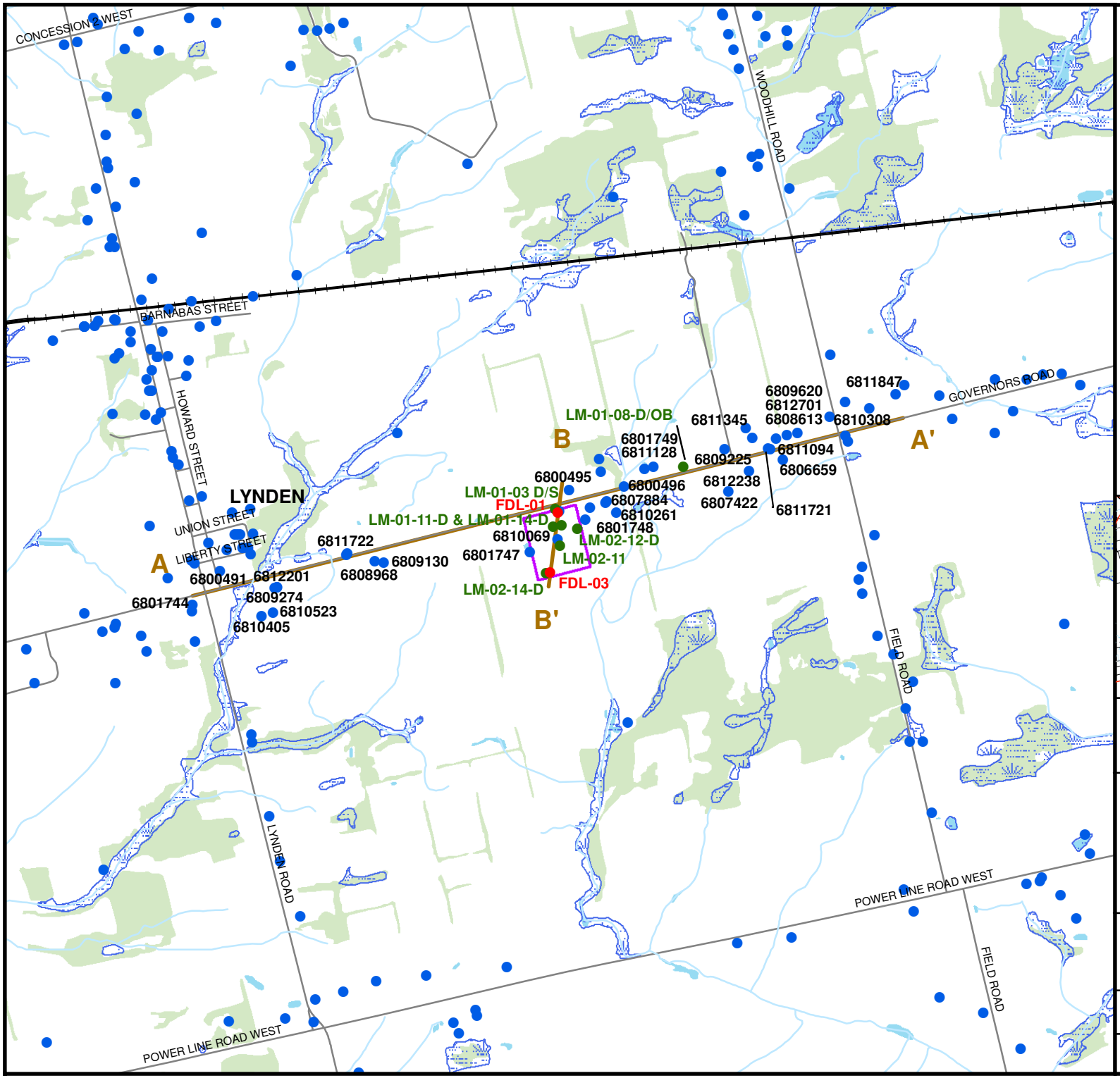
Project:

LYNDEN WATER SUPPLY CLASS ENVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-03
For: City of Hamilton

Title:

BEDROCK TOPOGRAPHY

Project No.:	Date:
071-11885-01	MAY 2016
Scale:	Figure No:
1:50,000	4

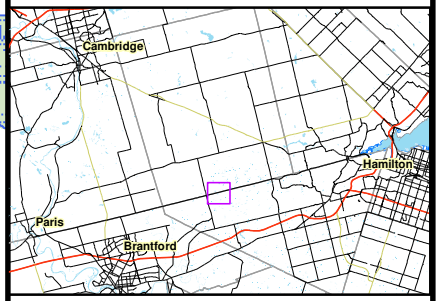


LEGEND

- MUNICIPAL WELLS
- MONITORING WELLS
- WATER WELL LOCATIONS
- A — A' CROSS SECTION LOCATION
- RAILWAY
- ROADS
- WATERCOURSES
- WATERBODIES
- WETLAND
- WOODED AREA
- SITE LOCATION

Data Source: Ministry of Natural Resources, Ontario Base Mapping, January 2016.

400 200 0 400 Metres

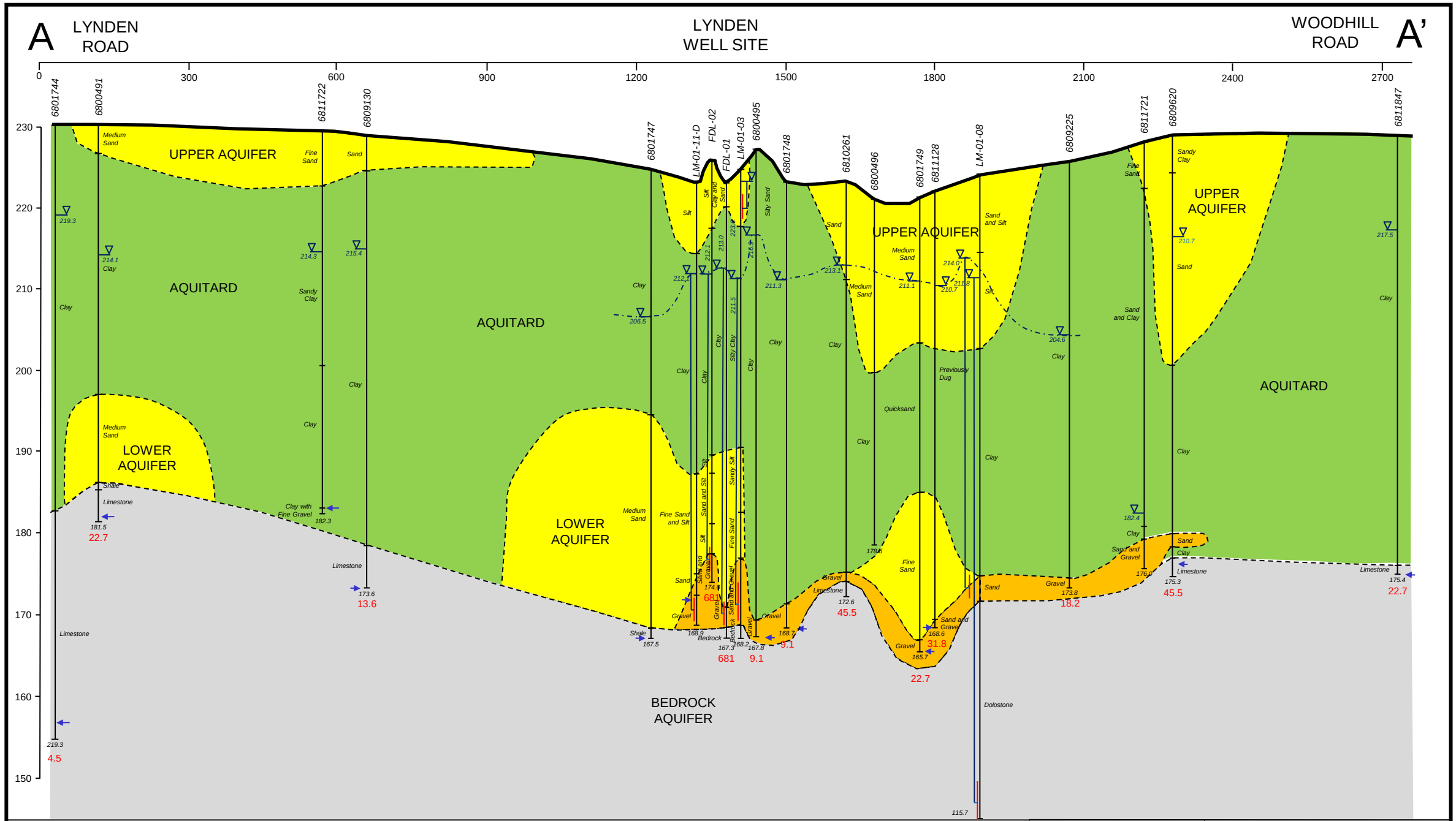


WSP

Project:
LYNDEN WATER SUPPLY CLASS ENVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-03
For: City of Hamilton

Title:
MOECC WATER WELLS

Project No.:	Date:
071-11885-01	SEPTEMBER 2016
Scale:	Figure No:
1:20,000	5



Legend

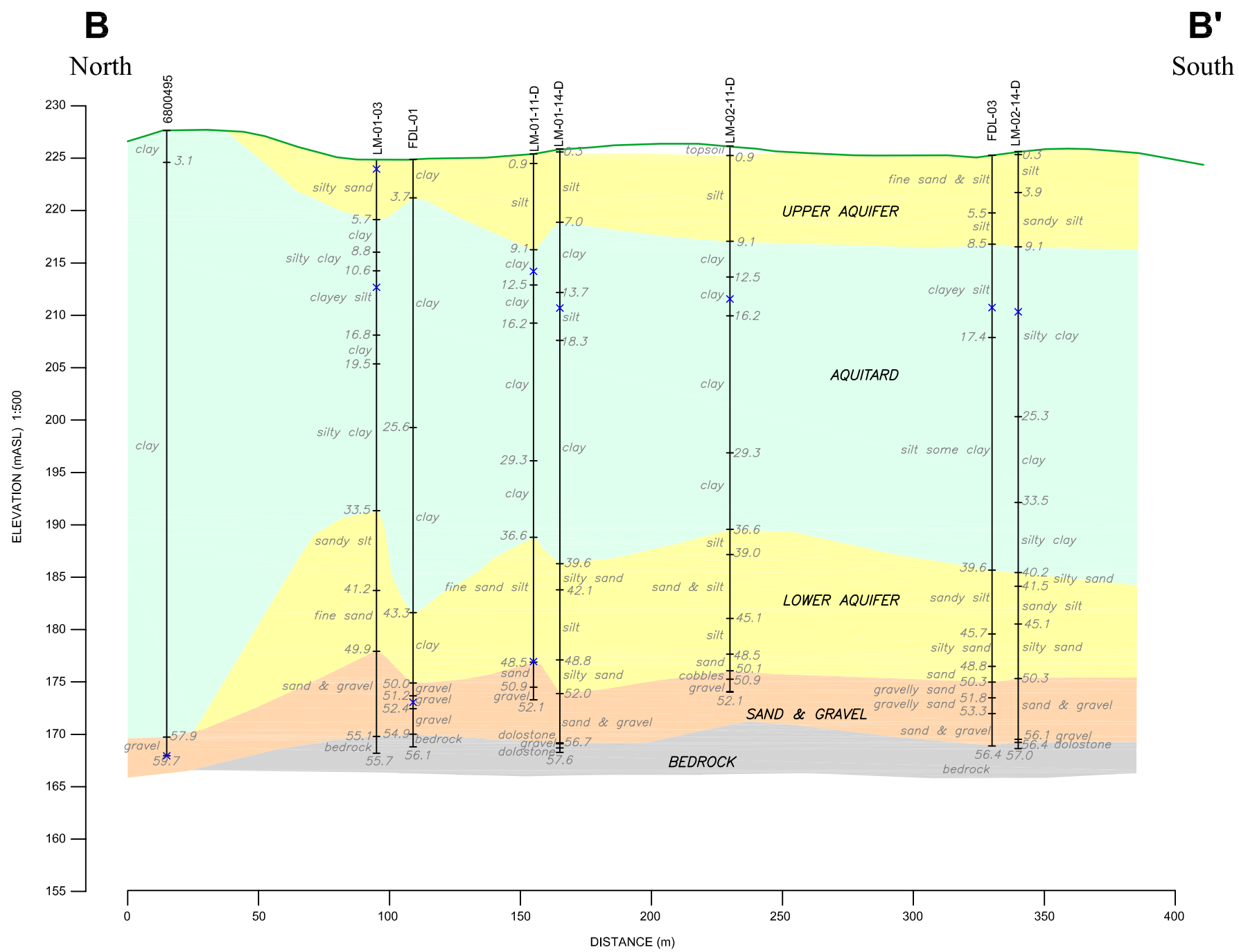
- Aquitard
- Sand and Gravel Aquifer
- Sand Aquifer
- Bedrock Aquifer

LM-01-03 — Location and Designation

206.5 — Surface
Stratigraphic Change
Potentiometric Surface
Static Water Level
Water Found
Screened Interval

167.3 — Bottom of Hole (masl)
681 — Q = Litres / Minute

CLIENT: Hamilton	CONSULTANT(S): WSP
PROJECT TITLE: LYNDEN ENVIRONMENTAL ASSESSMENT	
DRAWING TITLE: EAST-WEST CROSS-SECTION	
SCALE: AS SHOWN	DATE: MAY 2016
PROJECT NO.: 071-11885-01	DRAWING NO.: FIG. 6



LEGEND

6413379

WELL DESIGNATION

GROUND SURFACE

STATIC WATER LEVEL

CHANGE IN STRATIGRAPHY

26.8

END OF BORING (mBGL)

SAND AQUIFER

AQUITARD

SAND & GRAVEL AQUIFER

BEDROCK AQUIFER

NOTE:
THE ACTUAL SOIL STRATIFICATION HAS BEEN VERIFIED FROM DATA OBTAINED AT THE WATER WELL LOCATIONS ONLY. THE INFERRED CONTACTS SHOWN ARE BASED ON GEOLOGICAL EVIDENCE AND THESE MAY VARY FROM THOSE SHOWN BETWEEN BORINGS. WELL DATA IS PROJECTED ONTO THE SECTION WHICH ALSO MAY CREATE SOME IRREGULARITIES IN CONTACT DEPTHS.

NORTH-SOUTH CROSS SECTION

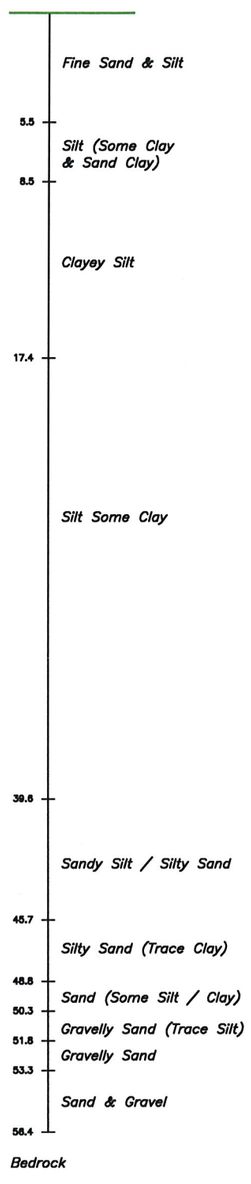
LYNDEN WATER SUPPLY CLASS
ENVIRONMENTAL ASSESSMENT
TESTING PROGRAM FOR
LYNDEN WELL FDL-03
For: City of Hamilton

DATE: MAY 2016	SCALES: AS SHOWN
PROJECT: 071-11885-01 105	FILE NO.: 071-11885-01 105 F7 CR

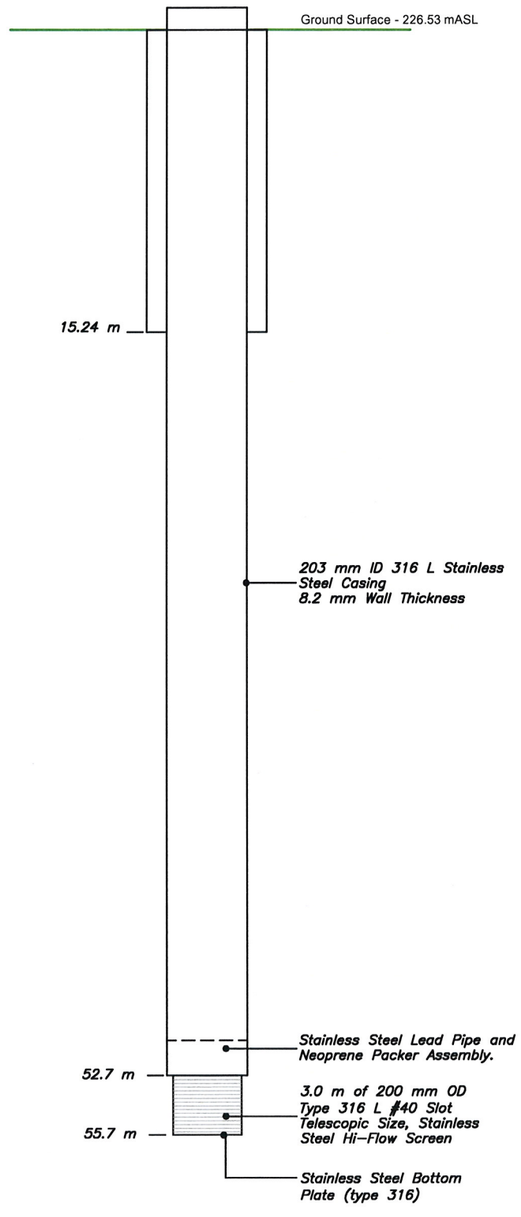
WSP

FIGURE 7

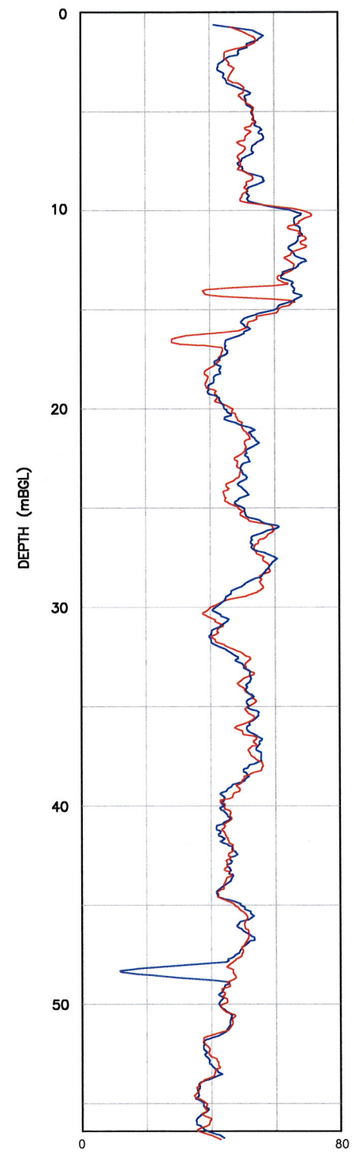
STRATIGRAPHY



WELL CONSTRUCTION DETAILS

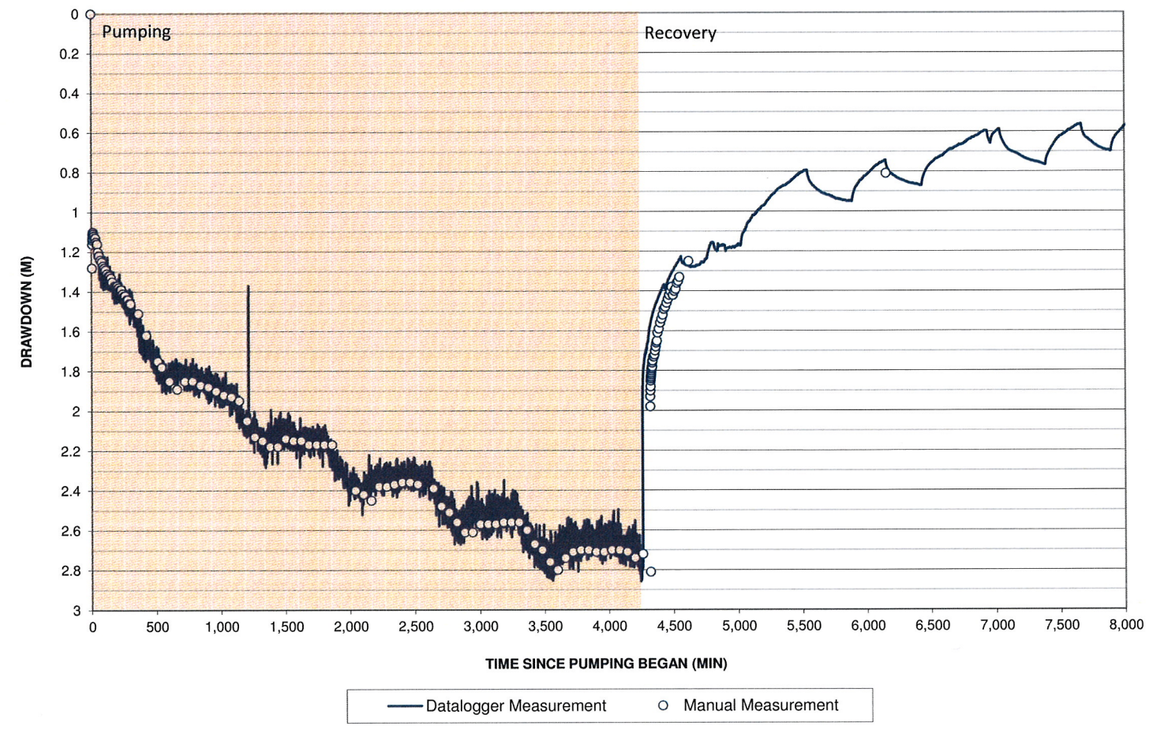


GAMMA



72 HOUR PUMPING TEST HYDROGRAPH
Q = 6 L/sec

FIGURE B-1: GROUNDWATER HYDROGRAPH - FDL03 (72H TEST)
CITY OF HAMILTON - LYNDEN (FDL 03)



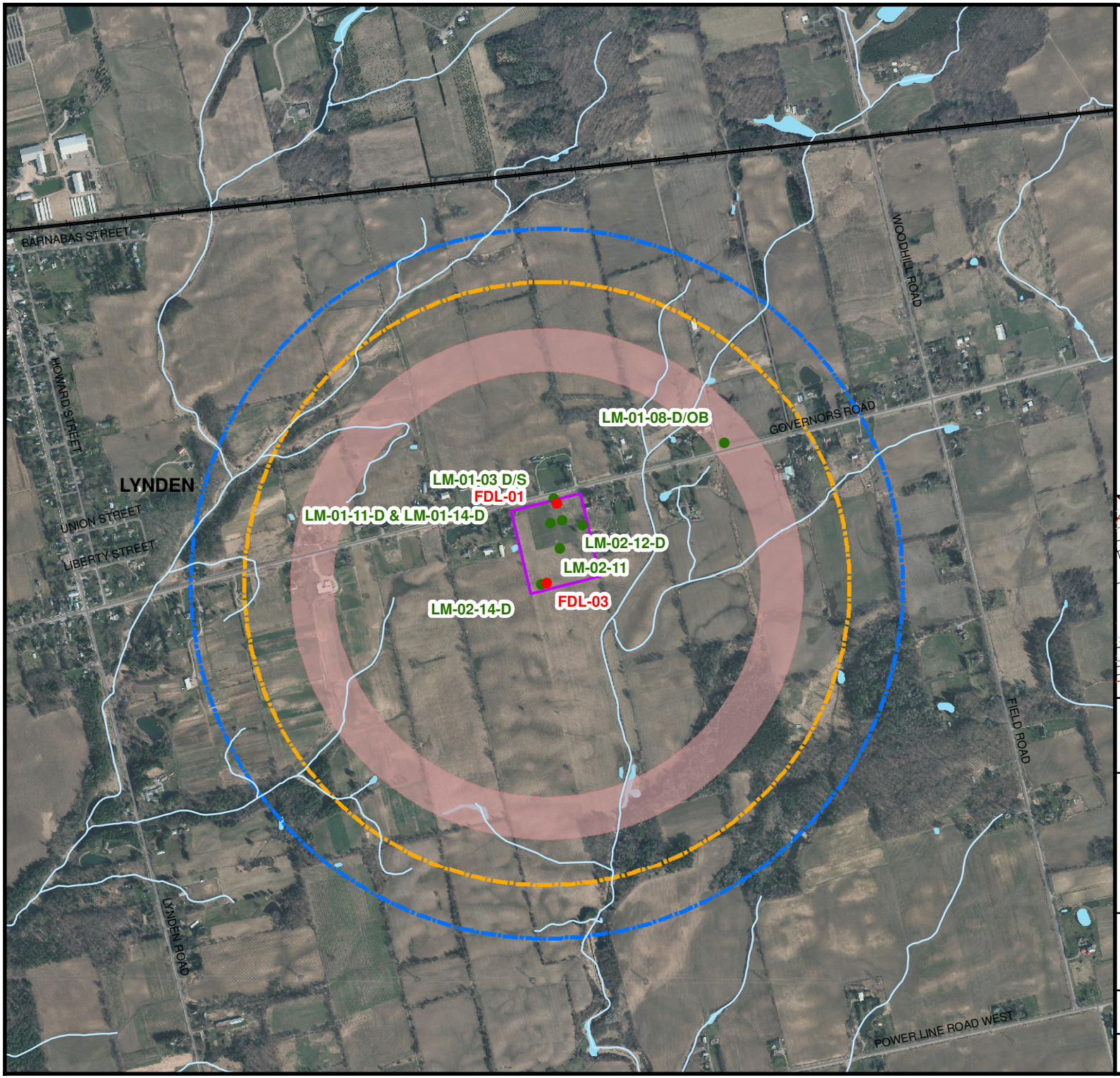
WELL CONSTRUCTION

LYNDEN WATER SUPPLY CLASS
ENVIRONMENTAL ASSESSMENT
TESTING PROGRAM FOR
LYNDEN WELL FDL-03
For: City of Hamilton

DATE: SEPTEMBER 2016	SCALES: AS SHOWN
PROJECT: 071-11885-01	FILE NO.: 071-11885-01 105-0 CR

WSP

Figure
8

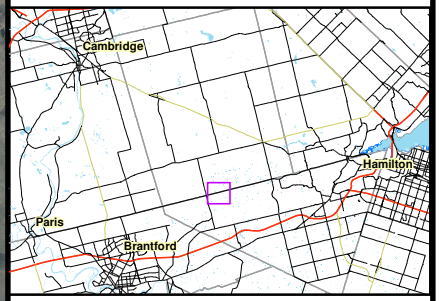


LEGEND

- MUNICIPAL WELLS
- MONITORING WELLS
- RAILWAY
- WATERCOURSES
- WATERBODIES
- SITE LOCATION
- APPROXIMATE ZONE OF INFLUENCE (1 m) 72 HOURS
- APPROXIMATE ZONE OF INFLUENCE (1 m) AVERAGE DAILY RATE 12 MONTHS
- APPROXIMATE ZONE OF INFLUENCE (1 m) MAX DAILY RATE 4 MONTHS

Data Source: Ministry of Natural Resources, Ontario Base Mapping, January 2016.

300 150 0 300 Metres

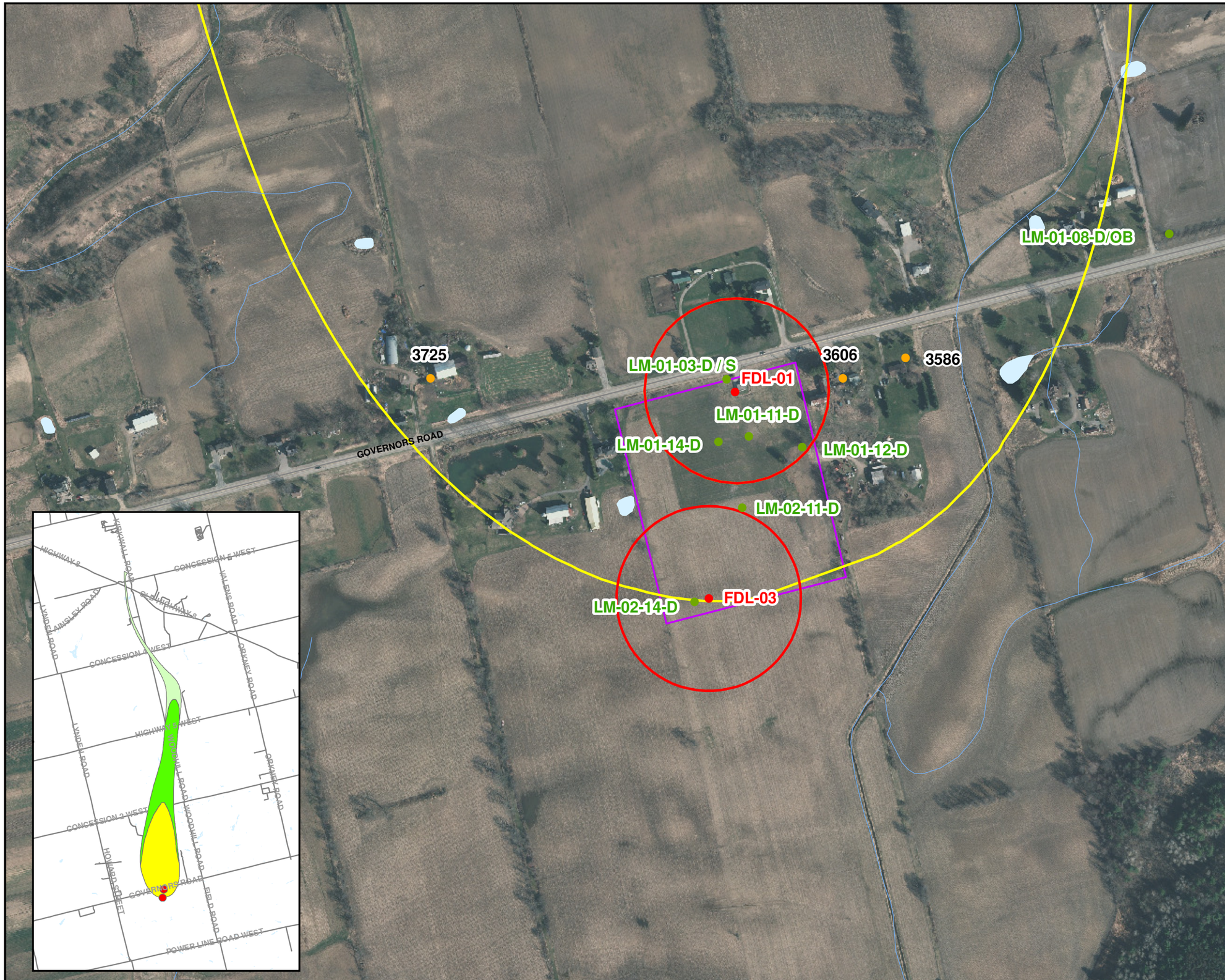


WSP

Project:
LYNDEN WATER SUPPLY CLASS ENVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-03
For: City of Hamilton

Title:
ZONE OF INFLUENCE

Project No.:	Date:
071-11885-01	SEPTEMBER 2016
Scale:	Figure No:
1:15,000	9



LEGEND

- MUNICIPAL WELLS
- MONITORING WELLS
- PRIVATE WELLS
- SITE LOCATION
- WATERCOURSE
- WATERBODIES
- WHPA A
- WHPA B
- WHPA C
- WHPA D

60 30 0 60 Meters

N W E S

Data Source: Ministry of Natural Resources, Ontario Base Mapping, January 2016.

WELLHEAD PROTECTION AREA

LYNDEN WATER SUPPLY CLASS ENVIRONMENTAL ASSESSMENT TESTING PROGRAM FOR LYNDEN WELL FDL-03
For: City of Hamilton

DATE:	SCALE:
SEPTEMBER 2016	1:4,000
PROJECT: 071-11885-01	FILE NO.: 071-11885-01 105 F10
WSP	FIGURE 10

Appendices

Appendix A

EXISTING LYNDEN PTTW

Ontario

Ministry of the Environment
Ministère de l'Environnement

PERMIT TO TAKE WATER
Ground Water
NUMBER 2331-826QBK

Pursuant to Section 34 of the Ontario Water Resources Act, R.S.O. 1990 this Permit To Take Water is hereby issued to:

City of Hamilton
700 Woodward Ave
Hamilton, Ontario L8H 6P4

For the water taking from: Well (FDL01)
Located at: Lot 16, Concession 1, Ancaster
Hamilton

For the purposes of this Permit, and the terms and conditions specified below, the following definitions apply:

DEFINITIONS

(a) "Director" means any person appointed in writing as a Director pursuant to section 5 of the OWRA for the purposes of section 34, OWRA.

(b) "Provincial Officer" means any person designated in writing by the Minister as a Provincial Officer pursuant to section 5 of the OWRA.

(c) "Ministry" means Ontario Ministry of the Environment.

(d) "District Office" means the Hamilton District Office.

(e) "Permit" means this Permit to Take Water No. 2331-826QBK including its Schedules, if any, issued in accordance with Section 34 of the OWRA.

(f) "Permit Holder" means City of Hamilton.

(g) "OWRA " means the *Ontario Water Resources Act,* R.S.O. 1990, c. O. 40, as amended.

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You are hereby notified that this Permit is issued subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. Compliance with Permit

1.1 Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, dated December 16, 2009 and signed by Rosa Gonzalez, and all Schedules included in this Permit.

1.2 The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.

1.3 Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.

1.4 This Permit is not transferable to another person.

1.5 This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.

1.6 The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.

1.7 The Permit Holder shall report any changes of address to the Director within thirty days of any such change. The Permit Holder shall report any change of ownership of the property for which this Permit is issued within thirty days of any such change. A change in ownership in the property shall cause this Permit to be cancelled.

2. General Conditions and Interpretation

2.1 Inspections
The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the *Environmental Protection Act* , R.S.O. 1990, the *Pesticides Act* , R.S.O. 1990, or the *Safe Drinking Water Act,* S. O. 2002.

2.2 Other Approvals
The issuance of, and compliance with this Permit, does not:

(a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the *Ontario Water Resources Act* , and

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the *Environmental Protection Act* , and any regulations made thereunder; or

(b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

(a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or

(b) acceptance by the Ministry of the information's completeness or accuracy.

2.4 Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5 Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6 Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

3. Water Takings Authorized by This Permit

3.1 Expiry

This Permit expires on **May 31, 2019**. No water shall be taken under authority of this Permit after the expiry date.

3.2 Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

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Table A

	Source Name / Description:	Source Type:	Taking Specific Purpose:	Taking Major Category:	Max. Taken per Minute (litres):	Max. Num. of Hrs Taken per Day:	Max. Taken per Day (litres):	Max. Num. of Days Taken per Year:	Zone/ Easting/ Northing:
1	Well (FDL01)	Well Drilled	Municipal	Water Supply	227	24	327,312	365	17 570797 4786865
						Total Taking:	327,312		

4. Monitoring

4.1 Under section 9 of O. Reg. 387/04, and as authorized by subsection 34(6) of the *Ontario Water Resources Act* , the Permit Holder shall, on each day water is taken under the authorization of this Permit, record the date, the volume of water taken on that date and the rate at which it was taken. The daily volume of water taken shall be measured by a flow meter or calculated in accordance with the method described in the application for this Permit, or as otherwise accepted by the Director. The Permit Holder shall keep all records required by this condition current and available at or near the site of the taking and shall produce the records immediately for inspection by a Provincial Officer upon his or her request. The Permit Holder, unless otherwise required by the Director, shall submit, on or before March 31st in every year, the records required by this condition to the ministry's Water Taking Reporting System.

5. Impacts of the Water Taking

5.1 Notification

The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

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5.2 For Groundwater Takings

If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so.

If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected.

6. Director May Amend Permit

The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the *Ontario Water Resources Act* , Section 100 (4).

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.

2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.

3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing, conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

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In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, you may by written Notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, as amended, provides that the Notice requiring the hearing shall state:

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these legal requirements, the Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Permit to Take Water number;
6. The date of the Permit to Take Water;
7. The name of the Director;
8. The municipality within which the works are located;

This notice must be served upon:

The Secretary
Environmental Review Tribunal
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5

AND

The Director, Section 34
Ministry of the Environment
12th Floor
119 King St W
Hamilton ON L8P 4Y7
Fax: (905)521-7820

Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal:

by telephone at (416) 314-4600 ***by fax at (416) 314-4506*** ***by e-mail at www.ert.gov.on.ca***

This Permit cancels and replaces Permit Number 88-P-2000, issued on 2001/04/19 12:00:00 AM.

Dated at Hamilton this 23 rd day of March, 2010.

Carl Slater

Carl Slater
Director, Section 34
Ontario Water Resources Act , R.S.O. 1990

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Schedule A

This Schedule "A" forms part of Permit To Take Water 2331-826QBK, dated March 23, 2010.

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Appendix B

MOECC WATER WELL RECORDS

Table B-1 - MOECC Water Well Records

Well ID	Color	Material	Material 2	Material 3	Depth (m)	Original Depth	Unit	Final Status	Use 1	Use 2	Static WL			Water Found (m)		Casing	Surface Elevation (masl)	Layer Elevation (masl)
											(ft)	(m)	(masl)	(m)	(masl)			
6800491		MEDIUM SAND	SILT		3.66	12	ft	Water Supply	Domestic		52	15.85	214.08	48.158	181.77	STEEL	229.93	226.27
		CLAY	MEDIUM SAND		33.53	110	ft										229.93	196.40
		MEDIUM SAND	SILT	CLAY	43.89	144	ft										229.93	186.03
	GREY	SHALE			44.50	146	ft									OPEN HOLE	229.93	185.42
	GREY	LIMESTONE			48.46	159	ft										229.93	181.46
6800495	BROWN	CLAY			3.05	10	ft	Water Supply	Livestock	Domestic	35	10.67	216.87	59.74	167.80	STEEL	227.54	224.49
	BLUE	CLAY			57.91	190	ft										227.54	169.63
		GRAVEL			59.74	196	ft										227.54	167.80
6800496		TOPSOIL			1.52	5	ft	Abandoned Supply								STEEL	221.32	219.79
		MEDIUM SAND			21.34	70	ft										221.32	199.98
		CLAY			42.67	140	ft										221.32	178.64
6801744	BROWN	CLAY			1.8288	6	ft	Water Supply	Domestic		35	10.67	219.30	73.15	156.82	STEEL	229.97	228.14
	BLUE	CLAY			48.768	160	ft										229.97	181.20
		LIMESTONE			75.2856	247	ft									OPEN HOLE	229.97	154.68
6801747		TOPSOIL			1.22	4	ft	Water Supply	Livestock	Domestic	60	18.29	206.49	57.30	167.47	STEEL	224.77	223.56
	BLUE	CLAY			30.48	100	ft										224.77	194.29
		MEDIUM SAND			56.39	185	ft										224.77	168.39
		SHALE			57.30	188	ft									OPEN HOLE	224.77	167.47
6801748	BROWN	CLAY			2.44	8	ft	Water Supply	Livestock	Domestic	40	12.19	211.34	54.86	168.66	STEEL	223.53	221.09
	BLUE	CLAY			51.82	170	ft										223.53	171.71
		GRAVEL			54.86	180	ft										223.53	168.66
		GRAVEL			54.86	180	ft									OPEN HOLE	223.53	168.66
6801749		TOPSOIL	MEDIUM SAND		1.52	5	ft	Water Supply	Livestock	Domestic	35	10.67	211.13	56.08	165.72	STEEL	221.80	220.28
	BROWN	MEDIUM SAND			18.29	60	ft										221.80	203.51
		QUICKSAND			36.58	120	ft										221.80	185.23
		FINE SAND			54.86	180	ft										221.80	166.94
		GRAVEL			56.08	184	ft										221.80	165.72
6806659	BROWN	CLAY			1.83	6	ft	Water Supply	Livestock	Domestic	7	2.13	224.89	2.13	224.89	CONCRETE	227.02	225.19
	GREY	SILT	MEDIUM SAND		6.40	21	ft										227.02	220.62
6807422	BROWN	TOPSOIL			0.61	2	ft	Water Supply	Domestic		6			6.71	218.53	CONCRETE	225.24	224.63
	RED	CLAY			1.83	6	ft										225.24	223.41
	GREY	SILT	MEDIUM SAND		10.67	35	ft							9.14	216.10		225.24	214.57
	GREY	CLAY			12.19	40	ft									OPEN HOLE	225.24	213.04
6807884	BROWN	TOPSOIL			0.91	3	ft	Water Supply	Domestic		10	3.05	221.31	3.05	221.31	CONCRETE	224.36	223.45
	BROWN	CLAY	MEDIUM SAND		3.05	10	ft										224.36	221.31
		CLAY	SILT	MEDIUM SAND	5.18	17	ft										224.36	219.18
	BLUE	CLAY	SILT		10.67	35	ft										224.36	213.69
	GREY	MEDIUM SAND	SILT		14.94	49	ft							9.75	214.61		224.36	209.43
	BLUE	CLAY			15.24	50	ft										224.36	209.12
6808613	BROWN	CLAY	SAND		2.13	7	ft	Water Supply	Domestic		7	2.13	227.11	2.13	227.11	CONCRETE	229.25	227.11
	GREY	SILT	SAND		4.57	15	ft										229.25	224.68
	GREY	SILT			8.84	29	ft							7.62	221.63		229.25	220.41
	BLUE	CLAY			10.06	33	ft										229.25	219.19
6808968	YELLOW	SAND			0.61	2	ft	Water Supply	Domestic					3.05	225.22	CONCRETE	228.27	227.66
	BROWN	CLAY	SANDY		3.05	10	ft							4.57	223.70		228.27	225.22
	GREY	SILT			4.57	15	ft										228.27	223.70
	BLUE	CLAY			6.10	20	ft							10.67	217.60		228.27	222.17
	GREY	SILT	SAND	LAYERED	12.19	40	ft										228.27	216.08

Table B-1 - MOECC Water Well Records

Well ID	Color	Material	Material 2	Material 3	Depth (m)	Original Depth	Unit	Final Status	Use 1	Use 2	Static WL			Water Found (m)		Casing	Surface Elevation (masl)	Layer Elevation (masl)
											(ft)	(m)	(masl)	(m)	(masl)			
6809130	BROWN	SAND			4.27	14	ft	Water Supply	Livestock	Domestic	44	13.41	215.36	54.86	173.91	STEEL	228.77	224.50
	GREY	CLAY			30.48	100	ft										228.77	198.29
	GREY	CLAY	SILT		50.60	166	ft										228.77	178.18
	GREY	LIMESTONE			55.17	181	ft									OPEN HOLE	228.77	173.60
6809225		TOPSOIL			1.83	6	ft	Water Supply	Domestic		70	21.34	204.59	52.12	173.81	STEEL	225.93	224.10
	BROWN	CLAY			8.23	27	ft										225.93	217.70
	BLUE	CLAY			51.82	170	ft										225.93	174.11
	GREY	GRAVEL			52.12	171	ft										225.93	173.81
6809274	BROWN	SAND	CLAY		2.44	8	ft	Water Supply	Domestic					5.49	224.16	CONCRETE	229.65	227.21
	GREY	SAND	SILT		10.67	35	ft										229.65	218.98
	GREY	SILT	CLAY		12.19	40	ft										229.65	217.46
6809620	BROWN	CLAY	SANDY	LOOSE	4.27	14	ft	Water Supply	Domestic		40	12.19	216.71	52.73	176.18	STEEL	228.91	224.64
	BROWN	SAND	LOOSE		27.43	90	ft										228.91	201.47
	BROWN	CLAY	SANDY	LOOSE	34.75	114	ft										228.91	194.16
	GREY	CLAY	LOOSE		48.77	160	ft										228.91	180.14
	BROWN	SAND	LOOSE		50.29	165	ft										228.91	178.61
	BROWN	CLAY	SANDY		51.82	170	ft										228.91	177.09
	GREY	LIMESTONE	HARD		53.64	176	ft									OPEN HOLE	228.91	175.26
6810069		TOPSOIL			1.83	6	ft	Water Supply	Livestock		40	12.19		52.73		STEEL	227.24	225.41
	BROWN	CLAY			6.71	22	ft										227.24	220.53
	BLUE	CLAY			30.48	100	ft										227.24	196.76
	BROWN	QUICKSAND			49.99	164	ft										227.24	177.25
	GREY	GRAVEL			52.73	173	ft										227.24	174.51
6810261	BROWN	SAND	LOOSE		3.05	10	ft	Water Supply	Domestic		35	10.67	213.14	50.60	173.21	STEEL	223.81	220.76
	GREY	SAND	LOOSE		12.19	40	ft										223.81	211.61
	GREY	CLAY	LOOSE		17.68	58	ft										223.81	206.13
	GREY	CLAY	SANDY	LOOSE	22.86	75	ft										223.81	200.95
	GREY	CLAY	LOOSE		48.16	158	ft										223.81	175.65
	BROWN	GRAVEL			49.38	162	ft										223.81	174.43
	GREY	LIMESTONE	HARD		51.21	168	ft									OPEN HOLE	223.81	172.60
6810308	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		15	4.57	225.86	4.57	225.86	CONCRETE	230.43	230.12
	BROWN	CLAY	SANDY		4.57	15	ft							7.62	222.81		230.43	225.86
	GREY	SILT			6.10	20	ft							10.67	219.76		230.43	224.33
		UNKNOWN			12.19	40	ft										230.43	218.24
6810405	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		15	4.57	224.50	4.57	224.50	CONCRETE	229.08	228.77
	BROWN	CLAY	SANDY		4.57	15	ft							7.62	221.46		229.08	224.50
	GREY	SILT			11.89	39	ft							10.67	218.41		229.08	217.19
	BLUE	CLAY	SILT	LAYERED	15.24	50	ft							13.72	215.36		229.08	213.84
6810523	BROWN	SAND			6.10	20	ft	Water Supply	Domestic		12	3.66	227.59	3.66	227.59	CONCRETE	231.25	225.15
	BLUE	CLAY			9.14	30	ft									GALVANIZED	231.25	222.11
6811094	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		4	1.22	225.65	1.22	225.65	CONCRETE	226.87	226.57
	BROWN	SAND			1.22	4	ft										226.87	225.65
	BROWN	SAND	WATER-BEARING		4.57	15	ft										226.87	222.30
	GREY	SAND	SILT	LAYERED	9.14	30	ft										226.87	217.73
6811128		PREV. DRILLED			53.0352	174	ft	Water Supply	Domestic		38	11.58	210.69	53.645	168.63	STEEL	222.27	169.24
	GREY	SAND	GRAVEL		53.6448	176	ft										222.27	168.63
6811345	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		10	3.05	222.29	3.05	222.29	CONCRETE	225.34	225.03
	BROWN	CLAY	SANDY		3.05	10	ft										225.34	222.29
	GREY	SILT	SAND	LAYERED	6.10	20	ft										225.34	219.24
	BLUE	CLAY			9.14	30	ft										225.34	216.19

Table B-1 - MOECC Water Well Records

Well ID	Color	Material	Material 2	Material 3	Depth (m)	Original Depth	Unit	Final Status	Use 1	Use 2	Static WL			Water Found (m)		Casing	Surface Elevation (masl)	Layer Elevation (masl)
											(ft)	(m)	(masl)	(m)	(masl)			
6811721	BROWN	FINE SAND			4.88	16	ft	Observation Wells	Municipal		150	45.72	182.44			STEEL	228.16	223.28
	GREY	SAND			7.62	25	ft										228.16	220.54
	GREY	SAND	CLAY		39.62	130	ft										228.16	188.53
	BROWN	SAND	CLAY		45.11	148	ft										228.16	183.05
	BROWN	SAND	CLAY	GRAVEL	47.24	155	ft										228.16	180.91
	BROWN	CLAY	SILTY	FINE GRAVEL	48.46	159	ft										228.16	179.69
	BROWN	GRAVEL	SAND	CLAY	51.21	168	ft										228.16	176.95
	BROWN	SAND	GRAVEL	CLAY	52.12	171	ft										228.16	176.04
6811722	BROWN	FINE SAND			6.40	21	ft	Observation Wells	Municipal		49	14.94	214.28	46.33	182.89	STEEL	229.22	222.82
	GREY	CLAY	SANDY		28.96	95	ft										229.22	200.26
	BROWN	CLAY			46.33	152	ft										229.22	182.89
	BROWN	CLAY	FINE GRAVEL		46.94	154	ft										229.22	182.28
6811847		TOPSOIL			1.83	6	ft	Water Supply	Livestock		38	11.58	217.50	53.645	175.43	STEEL	229.08	227.25
	BROWN	CLAY	SANDY		5.49	18	ft										229.08	223.59
	BLUE	CLAY	SANDY		19.51	64	ft										229.08	209.57
	BLUE	CLAY			53.04	174	ft										229.08	176.04
	GREY	LIMESTONE			53.64	176	ft										229.08	175.43
6812201		PREVIOUSLY DUG			12.19	40	ft	Water Supply	Domestic					13.72	216.37	CONCRETE	230.09	217.90
	GREY	SAND	SILT		18.29	60	ft										230.09	211.80
6812238	BROWN	TOPSOIL			0.30	1	ft	Water Supply	Domestic		5	1.52	224.40	1.52	224.40		225.93	225.62
	BROWN	SAND			2.74	9	ft							2.74	223.18		225.93	223.18
	GREY	SAND	SILT		10.67	35	ft							7.62	218.31		225.93	215.26
	BLUE	CLAY			11.58	38	ft							9.75	216.17		225.93	214.34
6812701		UNKNOWN TYPE			6.71	22	ft	Water Supply	Domestic		20	6.10	222.82	6.71	222.21	CONCRETE	228.92	222.21
	GREY	SILT	CLAY	LAYERED	10.67	35	ft										228.92	218.25

Appendix C

BOREHOLE LOGS

morrison beatty limited
consulting engineers and hydrogeologists
4500 dixie road, unit 12a, mississauga, ontario L4W 1V7 (416-624-9308)

TEST WELL
FDL-01

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT
Region of Hamilton-Wentworth	Ancaster	Conc. I	16

OWNER (SURNAME FIRST)	ADDRESS	DATE COMPLETED
Region of Hamilton-Wentworth	71 Main St.W. Hamilton,Ont.	DAY 21 MO Dec YR 84

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
Brown	clay	sand stones	layered	0	12
Grey	clay		dense (soft)	12	84
Grey	clay	stones	hard	84	140
Grey	clay	sand	layered	142	164
Grey-Black	Gravel	some clay streaks	layered	164	168
Grey-Black	Gravel	more clay streaks	layered	168	172
Grey-Black	gravel	sand,particles clay	layered,loose	172	180
Grey	rock		dense	180	184

K packer+22' leader on top

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
170-179	☒ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL
	☐ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL
	☐ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL
	☐ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL
	☐ FRESH ☐ SULPHUR ☐ SALTY ☐ MINERAL

CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
8	☒ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE	.279	+1	166
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE			
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER	LENGTH
5'-60 5'-40 5'-25	7 7/8 INCHES	13 FEET
MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN	
Sta.St. wire wd.	166 FEET	

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

PUMPING TEST

PUMPING TEST METHOD	PUMPING RATE	DURATION OF PUMPING
☒ PUMP ☐ BAILER	250 GPM	24 HOURS 0 MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING ☒ PUMPING ☐ RECOVERY			
		15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
34'-11/2" FEET	Drawdown 57 FEET	12-1/2" FEET	12'3/4" FEET	13' FEET	13'-5/8" FEET

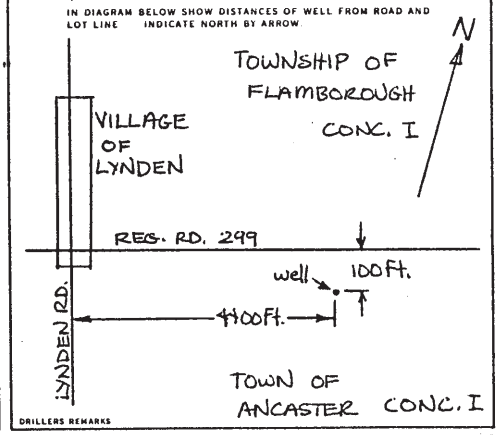
IF FLOWING, GIVE RATE	PUMP INTAKE SET AT	WATER AT END OF TEST
GPM	140 FEET	☒ CLEAR ☐ CLOUDY

RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING	RECOMMENDED PUMPING RATE
☐ SHALLOW ☒ DEEP	140 FEET	150 GPM

FINAL STATUS OF WELL	☒ WATER SUPPLY ☐ OBSERVATION WELL ☐ TEST HOLE ☐ RECHARGE WELL ☐ ABANDONED, INSUFFICIENT SUPPLY ☐ ABANDONED, POOR QUALITY ☐ UNFINISHED
WATER USE	☐ DOMESTIC ☐ STOCK ☐ IRRIGATION ☐ INDUSTRIAL ☐ OTHER ☐ COMMERCIAL ☒ MUNICIPAL ☐ PUBLIC SUPPLY ☐ COOLING OR AIR CONDITIONING ☐ NOT USED
METHOD OF DRILLING	☐ CABLE TOOL ☒ ROTARY (CONVENTIONAL) ☐ ROTARY (REVERSE) ☐ ROTARY (AIR) ☐ AIR PERCUSSION ☐ BORING ☐ DIAMOND ☐ JETTING ☐ DRIVING

6450 LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS

CONTRACTOR

NAME OF WELL CONTRACTOR	LICENCE NUMBER
Northern Well Drilling Limited	3903
ADDRESS: P.O. Box 358 Unionville,Ontario.	
NAME OF DRILLER OR BORER: Jerry W. Renwick	LICENCE NUMBER: 4508
SIGNATURE OF CONTRACTOR	SUBMISSION DATE: DAY ___ MO. ___ YR. ___

OFFICE USE ONLY

FORM NO. 0506—4—77 FORM 7

LM-01-03-V LINDEN

BOREHOLE LOG

Logged By:	Reviewed By:	Sheet Number:	Borehole Number:
H.Sangam	H. Jackson	1 of 3	LM-01-03

Drilling Company:	Drilling Equipment:	Drilling Method:	Start Date:	End Date:
Lantech Drilling Services	CM-75		01 Apr 03	05 Apr 03

Final Hole Depth (m):	Final Well Depth (m):	Hole Diameter (m):	Well Diameter (m):	Pipe Stickup (m):
56.67	56.67	0.1	0.051	0.85

Ground Elevation (m):	TOC Elevation (m):	Depth to Water BTOC (m):	Depth to Water BGS (m):	Groundwater Elevation (m):
224.89	Not Surveyed	13.35	12.50	211.54 (05 Apr 03)

Sample Type Legend:

- SS Split Spoon Sample
- PS Pistar Sample
- GR Grab Sample
- RX Core Sample
- AU Auger Sample
- VA Vane Test Interval
- SP Standard Penetration Test
- SH Shelby Tube Sample

Borehole Location Description/Notes:

Northing: 4766878
Easting: 570786 Zone 17T

Sample Type, No., and Interval	Blow Counts (N/15 cm)	N-Value	Sample Recovery	Elevation (m) / Depth (m)	Depth Scale (m)	Material	Stratigraphic Description	Well Materials	Well Construction Details
SS-1		92		224.79 / 0.10			TOPSOIL		Concrete Seal
					1–5		SILTY SAND -brown -becoming wet and saturated with depth -some gravel		
SS-2		20							
				219.17 / 5.72	6		CLAY -brown-greyish -plastic		
RX-3		n.a.			7				
RX-4		n.a.			8				
				216.05 / 8.84	9		SILTY CLAY -brown -soft -layered		
RX-5		n.a.			10				
				214.27 / 10.62	11		CLAYEY SILT -light brown to brwon-greyish -interlayered clay, plastic		
RX-6		n.a.			12				
RX-7		n.a.			13				
RX-8		n.a.			14				
					15				
RX-9		n.a.			16				
				208.13 / 16.76	17		CLAY -grey, soft -plastic		
RX-10		n.a.			18				
RX-11		n.a.			19				
				205.38 / 19.51			SILTY CLAY		

SNC·LAVALIN
Engineers & Constructors

Project Name: Hamilton Grounwater Study
Project Location: Lynden

LM-01-03-D LYNDEN

BOREHOLE LOG

Logged By:	Reviewed By:	Sheet Number:	Borehole Number:
H.Sangam	H. Jackson	2 of 3	LM-01-03

Sample Type Legend:

- SS Split Spoon Sample
- PS Piontar Sample
- GR Grab Sample
- RX Core Sample
- AU Auger Sample
- VA Vane Test Interval
- SP Standard Penetration Test
- SH Shelby Tube Sample

Borehole Location Description/Notes:

Northing: 4788878
Easting: 570786 Zone 17T

Sample Type, No., and Interval	Blow Counts (N/15 cm)	N-Value	Sample Recovery	Elevation (m) Depth (m)	Depth Scale (m)	Material	Stratigraphic Description	Well Materials	Well Construction Details
RX-1		n.a.			21		-brwon-greyish -layered -stiff, becoming soft at about 32 mbgs		
RX-1		n.a.			22				
					23				
RX-1		n.a.			24				
RX-1		n.a.			25				Bentonite Grout
					26				
RX-1		n.a.			27				
RX-1		n.a.			28				
					29				
RX-1		n.a.			30				
					31				
RX-1		n.a.			32				
RX-2		n.a.			33				
				191.38 33.53	34		SANDY SILT -brown-greyish, damp -fine sand -some gravel		
RX-2		n.a.			35				
RX-2		n.a.			36				
					37				
RX-2		n.a.			38				
RX-2		n.a.			39				
					40				
RX-2		n.a.			41				
				163.74 41.15	42		FINE SAND -brown -some silt and clay		
RX-2		n.a.							

SNC·LAVALIN
Engineers & Constructors

Project Name: Hamilton Groundwater Study
Project Location: Lynden

LM-01-03-D LYNDEN

BOREHOLE LOG

Logged By:	Reviewed By:	Sheet Number:	Borehole Number:
H.Sangam	H. Jackson	3 of 3	LM-01-03

Sample Type Legend:

- SS Split Spoon Sample
- PS Piezjer Sample
- GR Grab Sample
- RX Core Sample
- AU Auger Sample
- VA Vane Test Interval
- SP Standard Penetration Test
- SH Shelby Tube Sample

Borehole Location Description/Notes:

Northing: 4786878
Easting: 570768 Zone 17T

Sample Type, No., and Interval	Blow Counts (N/15 cm)	N-Value	Sample Recovery	Elevation (m) Depth (m)	Depth Scale (m)	Material	Stratigraphic Description	Well Materials	Well Construction Details
RX-2		n.a.			43				
RX-2		n.a.			44				
RX-2		n.a.			45				
RX-2		n.a.			46				
				177.95-46.94	47		SAND and GRAVEL		
RX-3		n.a.			48		-brown-greyish, damp		
RX-3		n.a.			49		-fine sand becoming coarser with depth -subrounded gravel		Bentonite Plug
RX-3		n.a.			50				Sand Pack
RX-3		n.a.			51				
RX-3		n.a.			52				
RX-3		n.a.			53				Slotted screen
RX-3		n.a.			54				
				169.82-55.07	55		BEDROCK - DOLOMITE		
RX-3		n.a.			56		-dark grey -massive, smooth core -ocasional dissolution cavities -secondary very low permeability		
				168.22-56.67			End of Borehole		

SNC•LAVALIN

Project Name: Hamilton Grounwater Study
Project Location: Lynden

LYNDEN

BOREHOLE LOG

Logged By:	Reviewed By:	Sheet Number:	Borehole Number:
H.Sangam	H. Jackson	1 of 1	LM-02-03

Drilling Company:	Drilling Equipment:	Drilling Method:	Start Date:	End Date:
Lantech Drilling Services	CM-75		04 Apr 03	04 Apr 03

Final Hole Depth (m):	Final Well Depth (m):	Hole Diameter (m):	Well Diameter (m):	Pipe Stickup (m):
6.07	6.07	0.1	0.051	0.70

Ground Elevation (m):	TOC Elevation (m):	Depth to Water BTOC (m):	Depth to Water BGS (m):	Groundwater Elevation (m):
224.73	Not Surveyed	1.10	0.40	223.63 (05 Apr 03)

Sample Type Legend:

- SS Split Spoon Sample
- PS Pionjer Sample
- GR Grab Sample
- RX Core Sample
- AU Auger Sample
- VA Vane Test Interval
- SP Standard Penetration Test
- SH Shelby Tube Sample

Borehole Location Description/Notes:

Northing: 4766878
Easting: 570791 Zone 17T

Sample Type, No., and Interval	Blow Counts (N/15 cm)	N-Value	Sample Recovery	Elevation (m) Depth (m)	Depth Scale (m)	Material	Stratigraphic Description	Well Materials	Well Construction Details
				224.63 / 0.10			TOPSOIL		Concrete Seal
							SILTY SAND -brown -becoming wet and saturated with depth -some gravel		Bentonite Grout
					1				
					2				Bentonite Plug
									Sand Pack
					3				
					4				Slotted screen
					5				
				219.01 / 5.72			CLAY -brown-greyish -plastic		
				218.66 / 6.07	6		End of Borehole		

SNC·LAVALIN
Engineers & Constructors

Project Name: Hamilton Groundwater Study
Project Location: Lynden

RECORD OF BOREHOLE No FDL-02

PROJECT	Proposed Municipal Well, Lynden, ON	LOCATION	3618 Governors Road, Lynden, Ontario	ORIGINATED BY	MB
CLIENT	City of Hamilton		570803,4786739 (+/-4m)	COMPILED BY	RM
JOB NO.	TB111049 DATE 8/16/2011	EQUIPMENT	Mud Rotary	CHECKED BY	MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
0.0	Brown **TOPSOIL**										
0.9	Grey **SILT** with thick (~10cm) CLAY layers; increasing clay with depth							1, 2, 3, 4, 5, 6, 7, 8, 9			
9.1	Grey **CLAY**, hard; high plasticity							10, 11, 12			
12.5	Grey **CLAY**, soft, with red clay, silt and very fine sand							13, 14			

Continued Next Page

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049 DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES					STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH (m)			
							16			Static water level on 16 August 2011 was at 15.54 mbTOC.
16.2	Grey **CLAY**, fining downward sequences very fine SAND to SILT to grey CLAY to red CLAY; repeating with increasing thickness downward						17			
							18			
							19			
							20			
							21			
							22			
							23			
							24			
							25			
							26			
							27			
							28			
							29			
29.3	**CLAY**, hard, mottled red and grey; trace fine sand									

Continued Next Page

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049
DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✠ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
							31			
							32			
							33			
							34			
							35			
							36			
36.6	Grey-brown **SILT**, loose, with thin clay layer						37			
							38			Very low sample return.
39.0	Grey-brown fine **SAND and SILT**, stiff						39			
							40			
							41			
41.2	Grey-brown fine **SAND and SILT**, soft						42			
42.1	Grey-brown fine **SAND and SILT**, stiff									
42.7	Grey-brown fine **SAND and SILT**, soft						43			
							44			

Continued Next Page

amec

RECORD OF BOREHOLE No FDL-02

PROJECT Proposed Municipal Well, Lynden, ON
LOCATION 3618 Governors Road, Lynden, Ontario
ORIGINATED BY MB
CLIENT City of Hamilton
570803,4786739 (+/-4m)
COMPILED BY RM
JOB NO. TB111049 DATE 8/16/2011
EQUIPMENT
CHECKED BY MGS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH (m)	STANDARD PENETRATION TEST □ DYNAMIC PENETRATION TEST ■ (20 40 60 80 100) SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL ▲ FIELD VANE ✤ LAB VANE (200 400 600)	△ Total Combustible Organic Vapour (% LEL) (20 40 60 80) ● Total Organic Vapour (ppm) (100 200 300 400)	OBSERVATIONS & REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
45.1	Brown **SILT**, trace fine SAND, stiff									
45.7	Brown **SILT**, trace CLAY, soft						46			
46.6	Brown **SILT**, trace fine SAND, stiff						47			
47.9	Brown **SILT**, trace CLAY, soft						48			
48.0	Brown **SILT**, trace fine SAND, stiff									Water found at 48.46 mbTOC.
48.5	Grey-brown medium coarse **SAND** coarsening down to pea **GRAVEL**						49			
50.1	Dense **TILL** diamicton						50			
50.8	Green **COBBLES**, shaley, rounded						51			
50.9	Grey-green **GRAVEL**, black shale **COBBLES**						52			
52.1	**BOREHOLE TERMINATED**									**Well Details:** Casing: 206 mm I.D. steel riser (+2.6-48.5 m). Screen: 219mm I.D. stainless steel Slot 25 (48.5-49.1m), Slot 45 (49.1-50.1m), TW (Slot 10) (50.1-50.6m), and Slot 20 (50.6-51.5m). Annular Space: silica sand pack #2 (44.2-52.1 m), bentonite gravel (0-2.74 m) and neat cement grout (2.74-44.2 m) above sand pack, filling 311 mm I.D. hole. Locking well cap.

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. *(Place Sticker and/or Print Below)*: A100758

Well Record

Regulation 903 Ontario Water Resources Act

Page ___ of ___

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	CITY OF HAMILTON		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
71 MAIN STREET WEST	HAMILTON	ON	L8P4Y5	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 GOVERNOR'S ROAD	ANCASTER	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570803	4786739		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BROWN	TOPSOIL			0	3
GREY	SILT			3	30
GREY	CLAY		HARD	30	41
GREY	CLAY	SILT LAYERS	SOFT	41	53
GREY	CLAY	FINE SILT SAND LRS		53	96
GRY-RED	CLAY	TRACE SAND		96	120
GREY-BRN	FINE SAND SILT			120	159
GREY-BRN	SAND	GRAVEL	GRADES DOWN	159	167
GREY-GRN	GRAVEL	BLACK SHALE COBBLES		167	171

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used *(Material and Type)*	Volume Placed *(m³/ft³)*
0	9	BENTONITE GRAVEL	
9	145	NEAT CEMENT GROUT	
145	171	SILICA SAND PACK #2,1,1/4X1/8	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify*

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify*

Construction Record - Casing

Inside Diameter *(cm/in)*	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness *(cm/in)*	Depth (m/ft) From	To
8.125	STEEL	.219	+3	159

Construction Record - Screen

Outside Diameter *(cm/in)*	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
8.625	S STEEL	25,45	159	164
		TW,20	164	169

Status of Well

☒ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Water Details

Water found at Depth	Kind of Water	
159 *(m/ft)* ☐ Gas	☒ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	
(m/ft) ☐ Gas	☐ Fresh ☐ Untested ☐ Other, *specify*	

Hole Diameter

Depth (m/ft) From	To	Diameter *(cm/in)*
0	171	12.25

Results of Well Yield Testing

After test of well yield, water was:
☒ Clear and sand free
☐ Other, *specify*

If pumping discontinued, give reason: STEP TEST ONLY

Pump intake set at *(m/ft)*: 147

Pumping rate *(l/min / GPM)*: 250 IGPM

Duration of pumping: 3 hrs + ___ min

Final water level end of pumping *(m/ft)*: 67

If flowing give rate *(l/min / GPM)*:

Recommended pump depth *(m/ft)*: 100

Recommended pump rate *(l/min / GPM)*: 150 IGPM

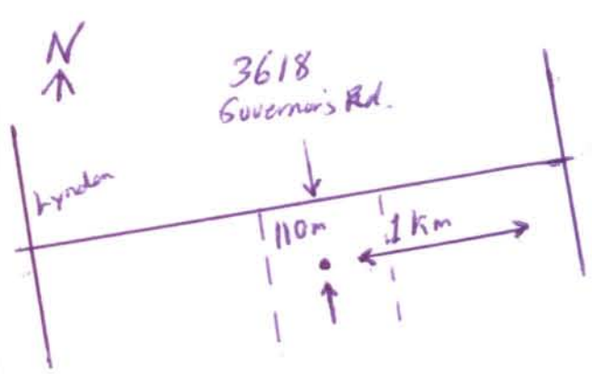
Well production *(l/min / GPM)*: 350

Disinfected? ☒ Yes ☐ No

Draw Down Time *(min)*	Water Level *(m/ft)*	Recovery Time *(min)*	Water Level *(m/ft)*
Static Level	51		
1	67	1	53
2		2	52
3		3	51
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60	67	60	51

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Durl Hopper Ltd.	2644

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont.	N4X1C9	hopper@cyg.net

Bus Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
5192717860	HOPPER, DOUGLAS

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
2323		Y Y Y Y M M D D 8/22/2011

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No	Y Y Y Y M M D D	Y Y Y Y M M D D 8/16/2011

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Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. (Place Sticker and/or Print Below): A100758

Well Record

Regulation 903 Ontario Water Resources Act

Page 1 of 1

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	
	CITY OF HAMILTON		☐ Well Constructed by Well Owner

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
71 MAIN STREET WEST	HAMILTON	ON	L8P4Y5	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 GOVERNOR'S ROAD	ANCASTER	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570803	4786739		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BROWN	TOPSOIL			0	3
GREY	SILT			3	30
GREY	CLAY		HARD	30	41
GREY	CLAY	SILT LAYERS	SOFT	41	53
GREY	CLAY	FINE SILT SAND LRS		53	96
GRY-RED	CLAY	TRACE SAND		96	120
GREY-BRN	FINE SAND SILT			120	159
GREY-BRN	SAND	GRAVEL	GRADES DOWN	159	167
GREY-GRN	GRAVEL	BLACK SHALE COBBLES		167	171

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
0	9	BENTONITE GRAVEL	
9	145	NEAT CEMENT GROUT	
145	171	SILICA SAND PACK #2,1,1/4X1/8	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, specify

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, specify

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
8.125	STEEL	.219	+3	159

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
8.625	S STEEL	25,45	159	164
		TW,20	164	169

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, specify
☐ Other, specify

Water Details

Water found at Depth (m/ft)	Kind of Water	
159	☐ Gas	☐ Other, specify
	☐ Gas	☐ Other, specify
	☐ Gas	☐ Other, specify

Kind of Water: ☐ Fresh ☐ Untested

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	171	12.25

Results of Well Yield Testing

After test of well yield, water was: ☒ Clear and sand free ☐ Other, specify

If pumping discontinued, give reason: STEP TEST ONLY

Pump intake set at (m/ft): 147

Pumping rate (l/min / GPM): 250 IGPM

Duration of pumping: 3 hrs + min

Final water level end of pumping (m/ft): 67

If flowing give rate (l/min / GPM):

Recommended pump depth (m/ft): 100

Recommended pump rate (l/min / GPM): 150 IGPM

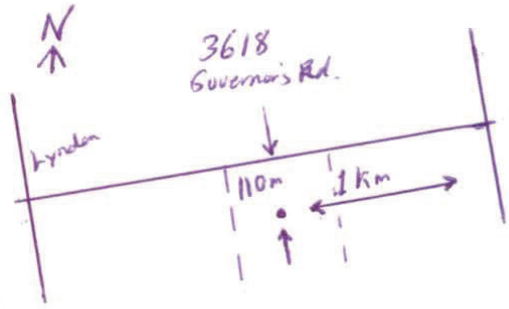
Well production (l/min / GPM): 350

Disinfected? ☒ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level	51		
1	67	1	53
2		2	52
3		3	51
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60	67	60	51

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Durl Hopper Ltd.	2644

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont.	N4X1C9	hopper@cyg.net

Bus Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
5192717860	HOPPER, DOUGLAS

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
2323		8/22/2011

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No		8/16/2011

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Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. (Place Sticker and/or Print Below): A159041 — Tag#: A159041

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	City of Hamilton		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
77 James St. North, Suite 400	Hamilton	ON	L8R 2K3	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 Governors Rd.	Ancaster	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
Hamilton	Lynden	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570752	4786636		TW#2

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
		* Refer to Attached			
			* Finished Depth 182 ft.		

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	6	Bentonite Chips	
6	20	Bentonite slurry	

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☐ Air percussion ☐ Other, specify Dual Rotary

Well Use

☐ Public ☐ Commercial ☐ Not used ☐ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ Test Hole ☐ Monitoring ☐ Irrigation ☐ Cooling & Air Conditioning ☐ Industrial ☐ Other, specify

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ____ hrs + ____ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level	47		
1		1	
2	Refer to	2	
3	Attached	3	
4	Step Test	4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
6¼"	Steel	0.188	+3	171
5¼"	Steel	0.188	182	185

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
6"	S.S.	30	171	176
6"	S.S.	35	186½	181½

Status of Well

☐ Water Supply ☐ Replacement Well ☐ Test Hole ☐ Recharge Well ☐ Dewatering Well ☐ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☐ Abandoned, other, specify ☐ Other, specify

Water Details

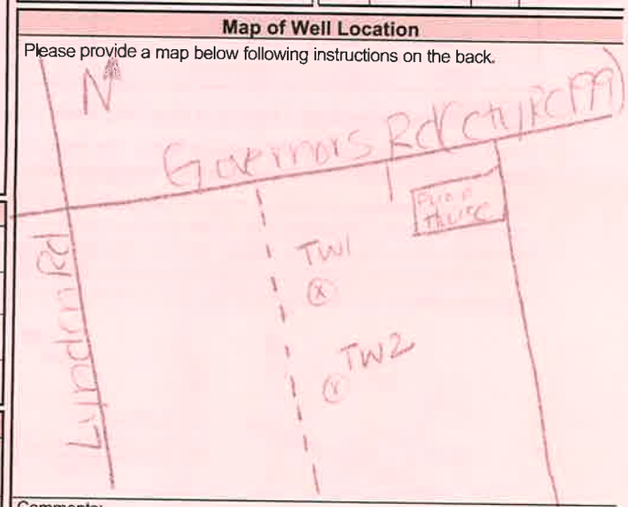
Water found at Depth (m/ft)	Kind of Water	
171-181	☐ Gas	☐ Fresh ☐ Untested ☐ Other, specify
	☐ Gas	☐ Fresh ☐ Untested ☐ Other, specify
	☐ Gas	☐ Fresh ☐ Untested ☐ Other, specify

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	20	10"
20	187	6"

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
G.Hart & Sons Well Drilling Ltd.	2662

Business Address (Street Number/Name)	Municipality
Box 850, 142 County Rd. 8	Fenelon Falls

Province	Postal Code	Business E-mail Address
ON	K0M 1N0	ghart ghart.ca

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
705 887-3331	Watson, Bryan & Rochetta, Mike

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T-2441 & 3435		Y Y Y Y M M D D

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No	Y Y Y Y M M D D	2014 0827

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Well Owner's Copy

G. HART & SONS
Well Drilling Ltd.
Box 880, Fenelon Falls, Ont.
K0M 1N0

Tel:(705)-887-3331
Fax:(705)887-4788
E-Mail ghart@ghart.ca

WELL LOG

WELL TAG # : A159041

Lynden - TW2

General Colour	Most Common Material	Other Materials	General Description	Depth From (Feet)	Depth To (Feet)
Brown	Silty Topsoil			0	1
Brown	Silt			1	13
Grey	Sandy Silt			13	30
Grey	Silty Clay			30	60
Grey	Silt & Clay		layered	60	83
Grey	Clay	Silt		83	110
Reddish Grey	Silty Clay			110	132
Reddish Grey	Silty Sand	some gravel		132	136
Reddish Grey	Sandy Silt	clay		136	148
Reddish Grey	Silty Sand	some clay		148	165
Reddish Grey	Sand & Gravel		water bearing	165	173
Reddish Grey	Sand & Gravel	some cobbles	water bearing	173	184
Grey	Gravel	cobbles	not water bearing	184	185
Grey	Dolostone			185	187

G. HART & Sons
Well Drilling Ltd.
Box 860, Fenelon Falls, Ont.
K0M 1N0

Tel:(705)-887-3331
Fax:(705)887-4788
E-Mail ghart@ghart.ca

Step Rate Test

WELL TAG # : A159041

Lynden - TW2

Date: August 27 ,2014

Measuring Point: Top of Casing (3 feet above ground)

PUMPING									RECOVERY	
Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)
0	49.55	0	0	50.82	Flow up	0	52.55	Flow up	0	54.35
0.5	50.14		0.5	51.51		0.5	54.00		0.5	51.32
1	50.19		1	51.62		1	54.17		1	51.20
1.5	50.20		1.5	51.72		1.5	54.22		1.5	51.14
2	50.17		2	51.75		2	54.24		2	51.08
2.5	50.35		2.5	51.78		2.5	54.21		2.5	51.05
3	50.39	20	3	51.81		3	54.30	60	3	51.02
3.5	50.40	20	3.5	52.00	40	3.5	54.30	down	3.5	50.99
4	50.41	20	4	52.03	40	4	53.80		4	50.97
4.5	50.42	20	4.5	52.05	40	4.5	53.69		4.5	50.95
5	50.42	20	5	52.08	40	5	53.67	up	5	50.92
6	50.43	20	6	52.09	40	6	53.87	60	6	50.90
7	50.44	20	7	52.10	40	7	53.89	60	7	50.88
8	50.45	20	8	52.13	40	8	53.94	60	8	50.86
9	50.45	20	9	52.13	40	9	53.95	60	9	50.83
10	50.46	20	10	52.15	40	10	53.96	60	10	50.81
12	50.47	20	12	52.17	40	12	53.97	60	12	50.79
14	50.50	20	14	52.20	40	14	54.00	60	14	50.77
16	50.50	20	16	52.22	40	16	54.02	60	16	50.75
18	50.52	20	18	52.24	40	18	54.04	60	18	50.73
20	50.52	20	20	52.26	40	20	54.05	60	20	50.72
25	50.53	20	25	52.30	40	25	54.10	60	25	50.69
30	50.54	20	30	52.35	40	30	54.15	60	30	50.67
35	50.55	20	35	52.39	40	35	54.19	60	35	50.57
40	50.57	20	40	52.43	40	40	54.22	60	40	50.50
45	50.67	20	45	52.46	40	45	54.26	60	45	50.43
50	50.73	20	50	52.50	40	50	54.31	60	50	50.39
55	50.78	20	55	52.52	40	55	54.31	60	55	50.35
60	50.82	20	60	52.55	40	60	54.35	60	60	50.32

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. (P: A159040

Tag#: A159040

Well Record

Regulation 903 Ontario Water Resources Act

Page _____ of _____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	City of Hamilton		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
77 James St. North, Suite 400	Hamilton	ON	L8R 2K1	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
3618 Governors Rd.	Ancaster	16	1

County/District/Municipality	City/Town/Village	Province	Postal Code
Hamilton	Lynden	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570780	4785810		TW#1

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
		* Refer to attached			
17	7	7	7		
		* Finished Depth	186 ft.		

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	6	Bentonite chips	
6	20	Bentonite slurry	
186	189	Bentonite chips	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify* Dual Rotary

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify* _____

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
6¼"	Steel	0.188	+3	175
6¼"	Steel	0.188	186	187.5

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
6"	S.S.	40	175	180
6"	S.S.	40	180.5	185.5

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify* _____
☐ Other, *specify* _____

Water Details

Water found at Depth (m/ft)	Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, *specify*
175-180ft	Sulphur

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	20	10"
20	189	6"

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, *specify* _____

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping _____ hrs + _____ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

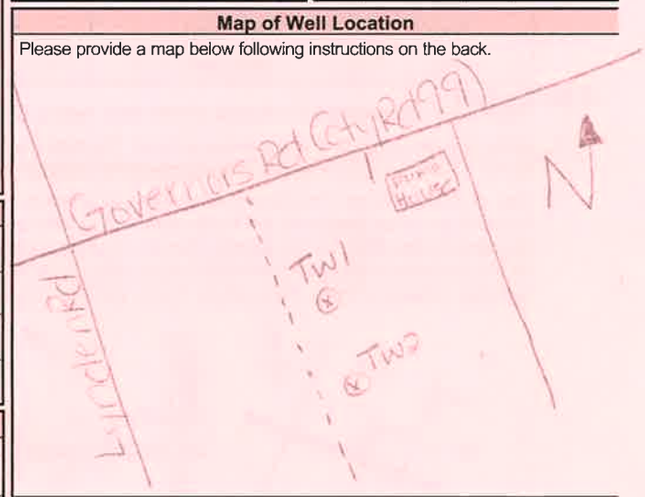
Well production (l/min / GPM): 150 gpm+

Disinfected? ☐ Yes ☐ No

Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level	47		
1		1	
2	** Refer to attached Step Test	2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
G.Hart & Sons Well Drilling Ltd.	2662

Business Address (Street Number/Name)	Municipality
Box 850, 142 County Rd. 8	Fenelon Falls

Province	Postal Code	Business E-mail Address
ON	K0M 1N0	ghart ghart.ca

Bus.Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
705 887-3331	Watson, Bryan & Rochetta, Mike

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T-2441 & 3436		

Well owner's information package delivered ☐ Yes ☐ No

Date Package Delivered: Y Y Y Y M M D D

Date Work Completed: 2014 Sept 7

Ministry Use Only

Audit No. Z 195046

Received

Well Owner's Copy

G. HART & Sons
Well Drilling Ltd.
Box 850, Fenelon Falls, Ont.
K0M 1N0

Tel:(705)-887-3331
Fax:(705)887-4788
E-Mail ghart@ghart.ca

WELL LOG

WELL TAG # : A159040

Lynden - TW1

General Colour	Most Common Material	Other Materials	General Description	Depth From (Feet)	Depth To (Feet)
Brown	Silty Topsoil			0	1
Brown	Silt			1	10
Grey	Silt			10	23
Grey	Clay		soft	23	45
Brownish Grey	Silt	some clay		45	60
Grey	Clay			60	79
Reddish Grey	Clay	trace gravel		79	88
Reddish Grey	Clay	silt lenses		88	94
Grey	Clay			94	103
Reddish Grey	Clay	silt lenses, trace gravel		103	114
Grey	Clay	gravel		114	118
Grey	Clay	slity sand		118	130
Reddish Grey	Silty Sand	some clay		130	138
Reddish Grey	Silt	some sand & clay		138	152
Reddish Grey	Silt			152	160
Reddish Grey	Silty Sand			160	166
Reddish Grey	Silty Sand		water bearing	166	170.5
Reddish Grey	Sand & Gravel		water bearing	170.5	186
Grey	Dolostone		boulder	186	186.5
Grey	Gravel			186.5	187.5
Grey	Dolostone			187.5	189

G. HART & SONS
Well Drilling Ltd.
Box 850, Pinedale Falls, Ont.
K0M 1N0

Tel:(705)-887-3331
Fax:(705)887-4788
E-Mail ghart@ghart.ca

Step Rate Test

WELL TAG # : A159040

Lynden - TW1

Date: August 26 ,2014

Measuring Point: Top of Casing (3 feet above ground)

PUMPING									RECOVERY	
Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)	Flow Rate (Imp. gpm)	Time (Min)	Water Level (Feet)
0	49.13	0	0	49.74	Flow up	0	50.66	Flow up	0	51.70
0.5	49.41		0.5	50.24		0.5	51.20		0.5	50.03
1	49.55		1	50.33		1	51.31		1	50.03
1.5	49.59		1.5	50.34	40	1.5	51.34		1.5	50.00
2	49.56		2	50.35	40	2	51.35		2	49.95
2.5	49.58	20	2.5	50.36	40	2.5	51.38	down	2.5	49.93
3	49.58	20	3	50.37	40	3	51.29	60	3	49.92
3.5	49.57	20	3.5	50.38	40	3.5	51.33	60	3.5	49.89
4	49.59	20	4	50.39	40	4	51.34	60	4	49.87
4.5	49.61	20	4.5	50.40	40	4.5	51.34	60	4.5	49.85
5	49.61	20	5	50.40	40	5	51.35	60	5	49.84
6	49.62	20	6	50.42	40	6	51.37	60	6	49.81
7	49.62	20	7	50.42	40	7	51.37	60	7	49.79
8	49.62	20	8	50.43	40	8	51.39	60	8	49.76
9	49.64	20	9	50.45	40	9	51.39	60	9	49.75
10	49.65	20	10	----	40	10	51.41	60	10	49.73
12	49.66	20	12	50.47	40	12	51.42	60	12	49.70
14	49.67	20	14	50.49	40	14	51.45	60	14	49.67
16	49.68	20	16	50.50	40	16	51.46	60	16	49.66
18	49.70	20	18	50.52	40	18	51.47	60	18	49.75
20	49.69	20	20	50.52	40	20	51.49	60	20	49.80
25	49.70	20	25	50.54	40	25	51.52	60	25	49.84
30	49.71	20	30	50.56	40	30	51.55	60	30	49.88
35	49.71	20	35	50.59	40	35	51.58	60	35	49.89
40	49.72	20	40	50.61	40	40	51.61	60	40	49.89
45	49.72	20	45	50.62	40	45	51.64	60	45	49.89
50	49.73	20	50	50.64	40	50	51.67	60	50	49.90
55	49.74	20	55	50.65	40	55	51.67	60	55	49.91
60	49.74	20	60	50.66	40	60	51.70	60	60	49.91
									65	49.2

Monitoring Well: MW-OGS-08 S/D

Project:	Copetown Test Hole	**Drillrig:**	CME 75	**Casing Diameter:**	102 mm (overburden), 100 mm (bedrock)	**Ground surface elevation:**	n/a
Client:	City of Hamilton	**Bit Type:**	Diamond	**Inclination:**	90 °	**Top of casing elevation:**	n/a
Location:	Copetown, Ontario	**Flush:**	Potable water - Brethren Water Service	**Azimuth:**	n/a	**Easting:**	571266
Number:	1609-00519	**Feed:**	Potable water - Brethren Water Service	**Date Started:**	Sep-15-2008	**Northing:**	4787035
Field investigator:	R.Dong	**Core Diameter:**	PQ-85 mm(overburden), HQ-63.5 mm (bedrock)	**Date Completed:**	Oct-14-2008	**Stick up:**	n/a
Contractor:	ProCore Drilling Ltd.						

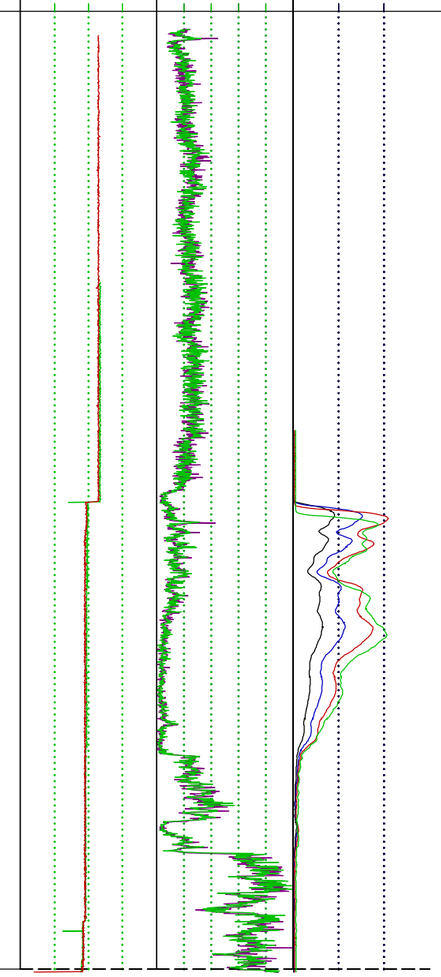
SUBSURFACE PROFILE

Depth (m)	Lithologic Description	Elevation (m AMSL) Depth (m BGS)
0	Ground Surface	0.00
0	TOPSOIL organic, brown, very moist	0.00
4	SAND trace fines, organics, rootlets, brown and grey mottled, rusty colour, very moist	0.91
8	fine grained, brown, homogeneous, very moist	1.22
10	some silt, fine grained, browny grey, homogeneous, wet	3.53
14	SILT little sand, browny grey, wet	4.82
16	SANDY SILT lenses of grey silty clay, browny grey, wet	5.94
20	CLAYEY SILT trace fine sand, lenses of clayey silt, little sand, browny grey, wet	6.35
22	SILT trace sand, trace grey clay pockets, browny grey, homogeneous, wet	7.87
26	SILT AND SAND fine grained, browny grey, very stiff, wet	9.40
30	some clay, reddy brown	16.89
32	CLAY/SAND/SILT light to dark grey, grey mottled, moist	20.06
34	SAND AND SILT grey, fine grained, moist	20.40
36	SAND/SILT AND CLAY fine grained, reddy brown, browny grey, grey, soft, stiff	21.59
38	SAND fine grained, reddy brown/browny grey, varved, moist	50.54
40	SAND AND SILT trace fine to coarse gravel, little medium to coarse sand	52.37
42	ERAMOSA FORMATION (REFORMATORY QUARRY MEMBER) dolostone, light to dark grey	53.39
44	ERAMOSA FORMATION (VINEMOUNT MEMBER) dolostone, light to dark grey, petroleum odour	57.20
48	GOAT ISLAND FORMATION (ANCASTER MEMBER) dolostone, light to medium dark grey, trace soft white clasts, fine bedding plans	66.75
50	GASPORT FORMATION dolostone, light grey to grey, sinewy bedding planes, trace chert clasts	80.14
52	ROCHESTER FORMATION shale and limestone, grey to black	83.57
54	IRONDEQUOIT FORMATION limestone, light grey, porous	91.11
56	ROCKWAY FORMATION dolostone, light grey	92.38
58	MERRITTON FORMATION	94.18
60	CABOT HEAD FORMATION shale and limestone, green and red	95.79
66	End of Borehole	108.80

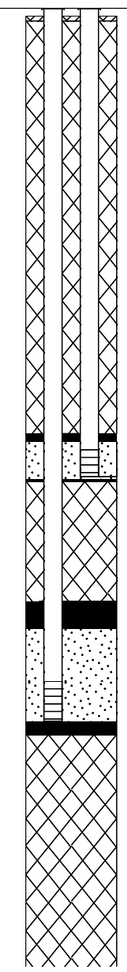
CORE RECOVERY DATA

Run Number	TCR	SCR	RQD	Fractures per 1.52 m	Surface Description	Rock Strength
37	69%	53%	50%	1	irregular/rough	
38	85%	46%	28%	8	irregular/rough	
39	100%	91%	90%	5	irregular/rough	
40	100%	89%	89%	4	irregular/rough	
41	87%	87%	85%	1	irregular/rough	
42	98%	98%	90%	1	irregular/rough	
43	100%	98%	98%	2		
44	100%	100%	100%	1		
45	100%	99%	NA	0	irregular/rough	
46	100%	96%	93%	2		
47	100%	NA	NA	0		
48	100%	98%	99%	1		
49	100%	98%	98%	1	irregular/rough	
50	100%	99%	99%	1	irregular/rough	
51	100%	99%	99%	1		
52	100%	98%	99%	0		
53	100%	96%	96%	4		
54	100%	94%	94%	4	irregular/rough	
55	100%	94%	89%	5	irregular/rough	
56	100%	94%	94%	2		
57	100%	92%	93%	0		
58	100%	100%	100%	0		
59	100%	95%	95%	2		
60	100%	100%	100%	0		
61	100%	98%	98%	0		
62	100%	97%	98%	0	irregular/rough	
63	100%	96%	97%	1		
64	100%	97%	91%	5		
65	100%	100%	100%	0		
66	100%	100%	100%	0		
67	100%	NA	NA	0		
68	100%	23%	NA	1		
69	100%	100%	100%	1		
70	100%	100%	100%	0		
71	100%	29.69%	100%	0		
72	NA	NA	NA	2		
73	100%	NA	NA	5		

GEOPHYSICS



WELL DETAILS



NOTES:

TCR - Total Core Recovery

SCR - Solid Core Recovery

RQD - Rock Quality Designation

mAMSL - metres above mean sea level

mBGS - metres below ground surface

Electrode spread

- No.8
- No.16
- No.32
- No.64

Stantec

Ontario — Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. *(Place Sticker and/or Print Below)* A115331

Well Record

Regulation 903 Ontario Water Resources Act

Page _____ of _____

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
	CITY OF HAMILTON		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. *(inc. area code)*
77 JAMES STREET NORTH	HAMILTON	ON	L8R2K3	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
1618 GOVERNORS ROAD	ANCASTER	16	

County/District/Municipality	City/Town/Village	Province	Postal Code
HAMILTON - WENTWORTH	LYNDEN	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	570958	4786204		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
			NO PREVIOUS RECORD FOUND		
			EXISTING DRILLED WELL	0	171
			WELL WAS CLEANED AND NEW 2"		
			PVC MONITOR WAS INSTALLED		

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used *(Material and Type)*	Volume Placed (m^3/ft^3)
0	150	BENTONITE CHIPS	
150	171	SILICA SAND	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ Rotary (Conventional) ☐ Jetting
☐ Rotary (Reverse) ☐ Driving
☐ Boring ☐ Digging
☐ Air percussion
☐ Other, *specify* _____

Well Use

☐ Public ☐ Commercial ☐ Not used
☐ Domestic ☐ Municipal ☐ Dewatering
☐ Livestock ☐ Test Hole ☐ Monitoring
☐ Irrigation ☐ Cooling & Air Conditioning
☐ Industrial
☐ Other, *specify* _____

Construction Record - Casing

Inside Diameter *(cm/in)*	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness *(cm/in)*	Depth (m/ft) From	Depth (m/ft) To
2	PVC SCH 40		+2	151

Construction Record - Screen

Outside Diameter *(cm/in)*	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To
2	PVC SCH 40	10	151	171

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☐ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify* _____
☐ Other, *specify* _____

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, *specify* _____

If pumping discontinued, give reason: NOT TESTED

Pump intake set at *(m/ft)*

Pumping rate *(l/min / GPM)*

Duration of pumping _____ hrs + _____ min

Final water level end of pumping *(m/ft)*

If flowing give rate *(l/min / GPM)*

Recommended pump depth *(m/ft)*

Recommended pump rate *(l/min / GPM)*

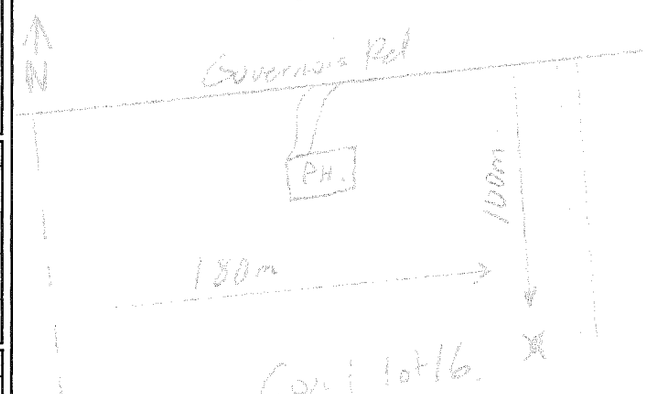
Well production *(l/min / GPM)*

Disinfected? ☐ Yes ☐ No

Draw Down Time *(min)*	Draw Down Water Level *(m/ft)*	Recovery Time *(min)*	Recovery Water Level *(m/ft)*
Static Level	45		
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Water Details

Water found at Depth *(m/ft)*	Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, *specify* _____
Water found at Depth *(m/ft)*	Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, *specify* _____
Water found at Depth *(m/ft)*	Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, *specify* _____

Hole Diameter

Depth (m/ft) From	Depth (m/ft) To	Diameter *(cm/in)*

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Dun Hopper Ltd.	2844

Business Address (Street Number/Name)	Municipality
RR#7	St. Marys

Province	Postal Code	Business E-mail Address
Ont.	N4X1C8	hopper@cyg.net

Bus.Telephone No. *(inc. area code)*	Name of Well Technician (Last Name, First Name)
519-271-7240	HOPPER, SIMON

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
3051		2014-04-16

Well owner's information package delivered	Date Package Delivered	Date Work Completed
☐ Yes ☐ No		2014-04-16

Ministry Use Only

Audit No. Z140523

Received

Appendix D

PRIVATE WATER WELL SURVEY RESULTS

Table D-1: Summary of Water Quality Results - Private Well Survey

Parameter	Units	Health Based Guideline	Aesthetic Based Guideline	Operational Based Guideline	PWQO	3606 Governors 16-Nov-15	3725 Governors 16-Nov-15	3826 Governors 16-Nov-15	3586 Governors 16-Nov-15	3830 Governors 27-Nov-15
Colour	CU		5			30	2	36	4	10
Total Hardness (as CaCO3)	mg/L			80-100		41.1	20.6	581	365	60.7
Nitrate as N	mg/L	10				<0.01	<0.01	22.1	0.26	<0.01
Nitrite as N	mg/L	1				<0.01	<0.01	<0.01	<0.01	<0.01
Total Phosphorus	mg/L					<0.01	<0.01	<0.01	<0.01	<0.01
Turbidity	NTU		5			5.07	0.22	5.08	0.17	1.89
Escherichia coli	CFU/100ml	0				0	0	<10	0	0
Total Coliforms	CFU/100ml	0				0	4	30	49	0
Aluminum	mg/L			0.1	0.075	0.004	<0.002	0.127	0.003	0.004
Antimony	mg/L	0.006			0.02	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006
Arsenic	mg/L	0.025			0.005	<0.001	<0.001	<0.001	<0.001	0.009
Barium	mg/L	1				0.469	0.567	0.066	0.06	0.071
Beryllium	mg/L				1.1	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	mg/L					<0.02	<0.02	<0.02	<0.02	<0.02
Boron	mg/L	5			0.2	0.508	0.537	0.064	0.037	0.38
Cadmium	mg/L	0.005			0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Calcium	mg/L					8.37	4.14	173	106	12.6
Chromium	mg/L	0.05			0.0089	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L				0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009
Copper	mg/L	1			0.005	<0.002	<0.002	0.003	0.009	0.004
Iron	mg/L		0.3		0.3	0.659	0.055	0.195	0.016	0.24
Lead	mg/L	0.01			0.005	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	mg/L					<0.1	<0.1	<0.1	<0.1	<0.1
Magnesium	mg/L					4.9	2.5	36.2	24.3	7.1
Manganese	mg/L		0.05			0.01	0.006	0.006	<0.001	0.007
Molybdenum	mg/L				0.04	<0.005	<0.005	<0.005	<0.005	0.007
Nickel	mg/L				0.025	<0.005	<0.005	<0.005	<0.005	<0.005
Potassium	mg/L					1.01	0.86	5.26	1.39	1.0
Selenium	mg/L	0.01			0.1	<0.002	<0.002	<0.002	<0.002	<0.002
Silver	mg/L				0.0001	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium	mg/L		200 (MOH 20)			69.8	49.6	69.8	19.5	33.4
Strontium	mg/L					0.681	0.462	0.469	0.268	0.8
Sulphur	mg/L					0.893	3.31	41.8	22.8	5.7
Thallium	mg/L				0.0003	<0.01	<0.01	<0.01	<0.01	<0.01
Tin	mg/L					<0.02	<0.02	<0.02	<0.02	<0.02
Titanium	mg/L					<0.001	<0.001	0.003	<0.001	<0.001
Tungsten	mg/L				0.03	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L				0.006	<0.002	<0.002	<0.002	<0.002	<0.002
Zinc	mg/L		5		0.02	<0.005	<0.005	0.036	0.006	<0.005
Zirconium	mg/L				0.004	<0.003	<0.003	<0.003	<0.003	<0.003
Sulphide	mg/L					0.65	1	<0.02	<0.02	<0.02

###	- Aesthetic/operational exceedance
###	- Above Ministry of Heatlth (MOH) guideline for people on sodium restricted diets
###	- Health based exceedance
###	- PWQO exceedance
NDOGT	- No Data; Overgrown with Target, refers to over-crowding microbial growth (health based exceedance)

Appendix E

PILOT HOLE TESTING RESULTS

Terraprobe

WASH SIEVE ANALYSIS TEST REPORT

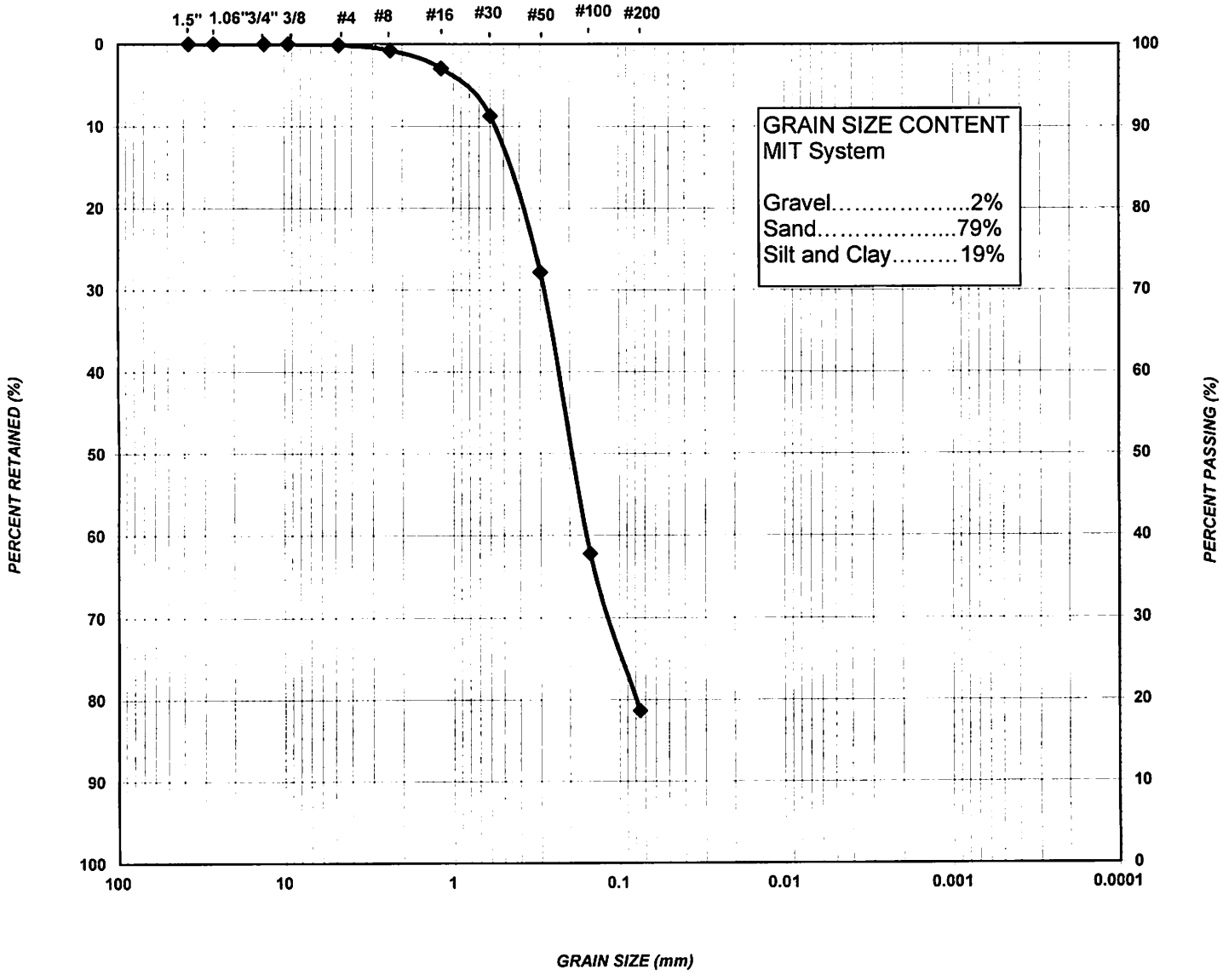
PROJECT: **Lynden Well Laboratory Testing**
LOCATION: **N/A**
CLIENT: **Gerritts Engineering Limited**

FILE NO.: **32-15-2164**
LAB NO.: **2179a**
SAMPLE DATE: **Dec-09-15**
SAMPLED BY: **Client**

TEST HOLE NUMBER: **1** SAMPLE DEPTH: **160 to 165'**
SAMPLE NUMBER: **1**
SAMPLE LOCATION: **Lynden Well**
SAMPLE DESCRIPTION: **Sand, trace gravel, some silt**

GRAIN SIZE DISTRIBUTION

U.S. STANDARD SIEVE SIZES



MIT SYSTEM	GRAVEL	COARSE	MEDIUM	FINE	SILT	CLAY
		SAND				

UNIFIED SYSTEM	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY
	GRAVEL		SAND			

Terraprobe

WASH SIEVE ANALYSIS TEST REPORT

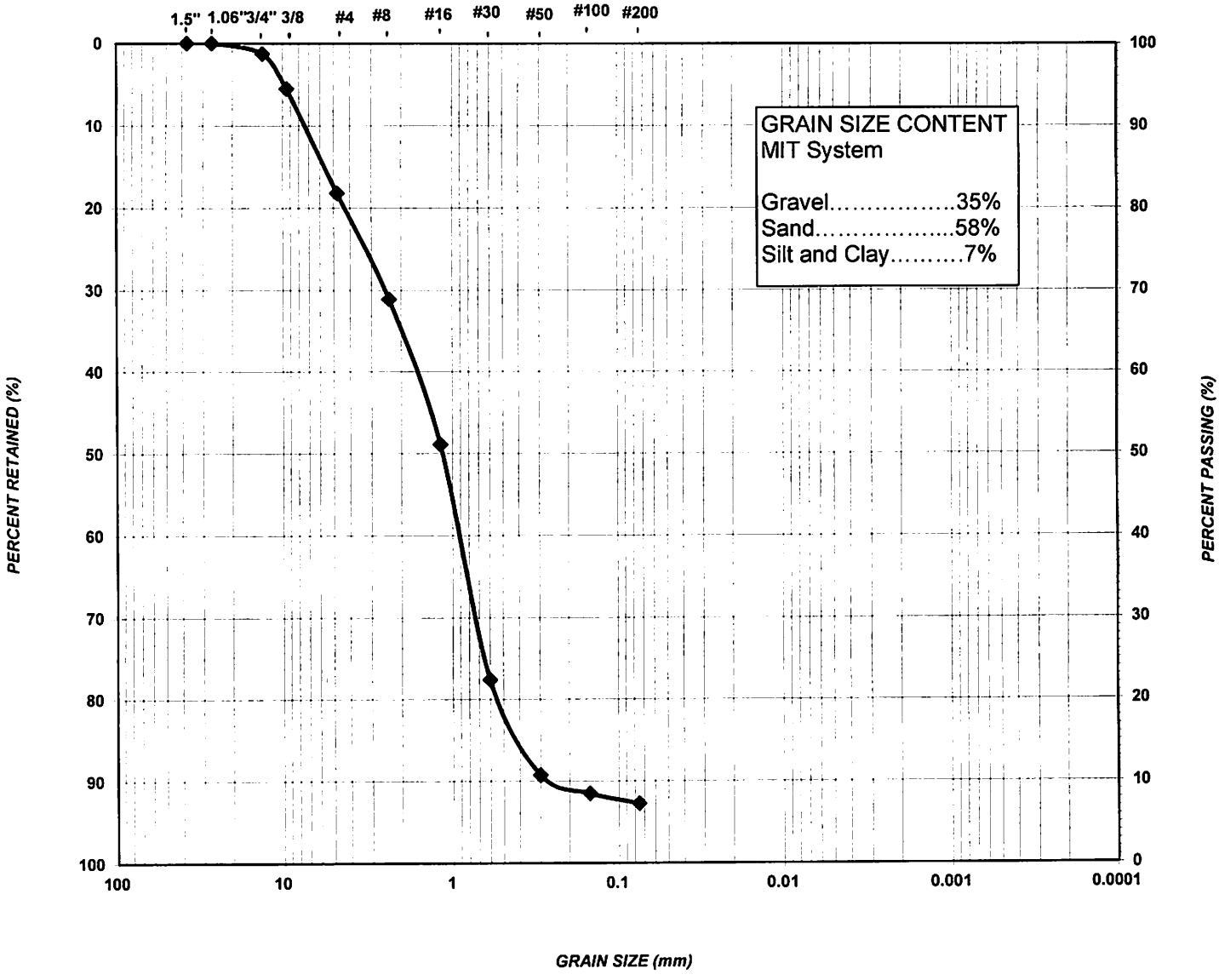
PROJECT: **Lynden Well Laboratory Testing**
LOCATION: **N/A**
CLIENT: **Gerritts Engineering Limited**

FILE NO.: **32-15-2164**
LAB NO.: **2179b**
SAMPLE DATE: **Dec-09-15**
SAMPLED BY: **Client**

TEST HOLE NUMBER: **1** SAMPLE DEPTH: **165 to 170'**
SAMPLE NUMBER: **1**
SAMPLE LOCATION: **Lynden Well**
SAMPLE DESCRIPTION: **Gravelly sand, trace silt**

GRAIN SIZE DISTRIBUTION

U.S. STANDARD SIEVE SIZES



MIT SYSTEM	GRAVEL	COARSE	MEDIUM	FINE	SILT	CLAY
		SAND				

UNIFIED SYSTEM	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY
	GRAVEL		SAND			

Terraprobe

WASH SIEVE ANALYSIS TEST REPORT

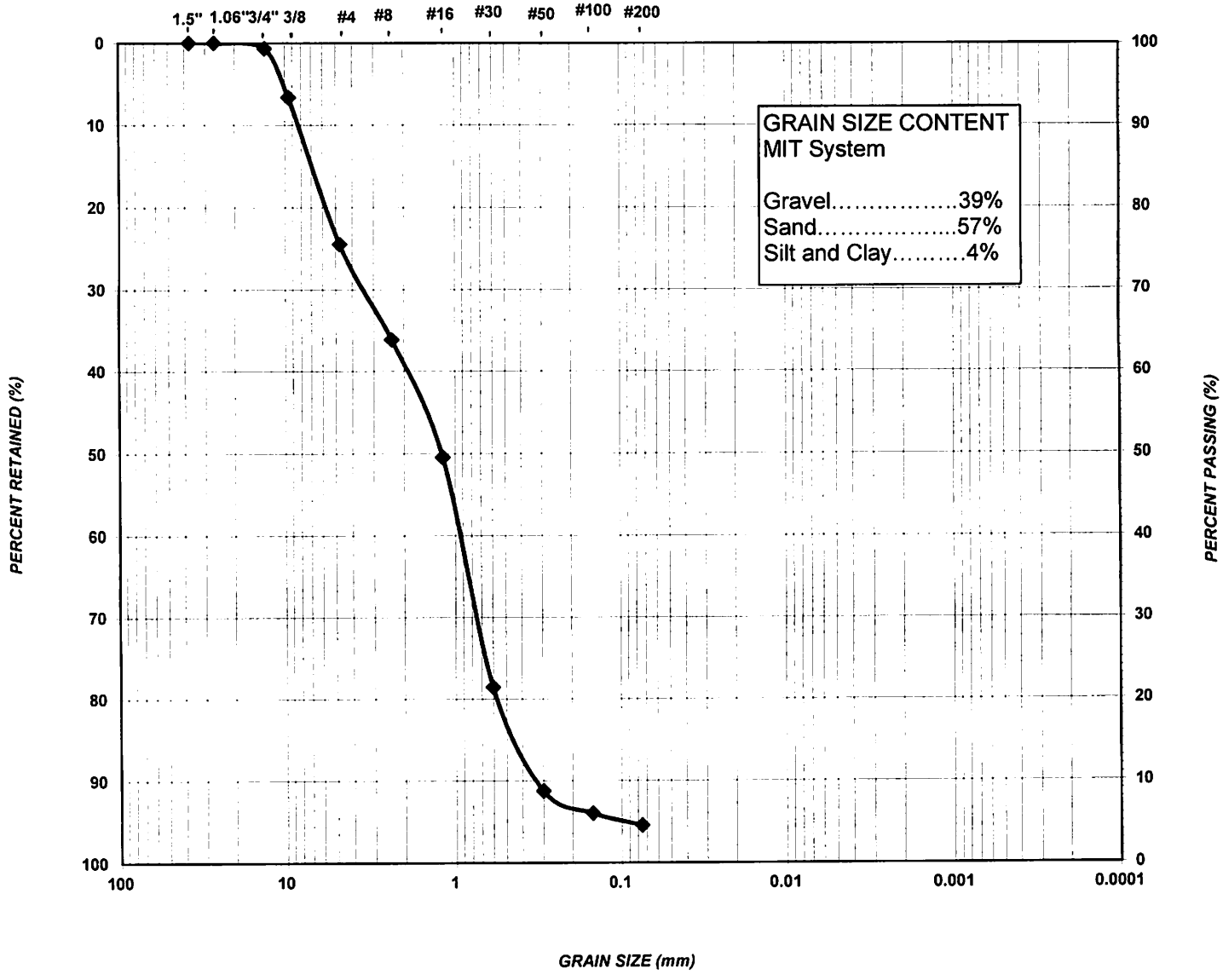
PROJECT: **Lynden Well Laboratory Testing**
LOCATION: **N/A**
CLIENT: **Gerritts Engineering Limited**

FILE NO.: **32-15-2164**
LAB NO.: **2179c**
SAMPLE DATE: **Dec-09-15**
SAMPLED BY: **Client**

TEST HOLE NUMBER: **1** SAMPLE DEPTH: **170 to 175'**
SAMPLE NUMBER: **1**
SAMPLE LOCATION: **Lynden Well**
SAMPLE DESCRIPTION: **Sand and gravel, trace silt**

GRAIN SIZE DISTRIBUTION

U.S. STANDARD SIEVE SIZES



MIT SYSTEM	GRAVEL	COARSE	MEDIUM	FINE	SILT	CLAY
		SAND				

UNIFIED SYSTEM	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY
	GRAVEL		SAND			

Terraprobe

WASH SIEVE ANALYSIS TEST REPORT

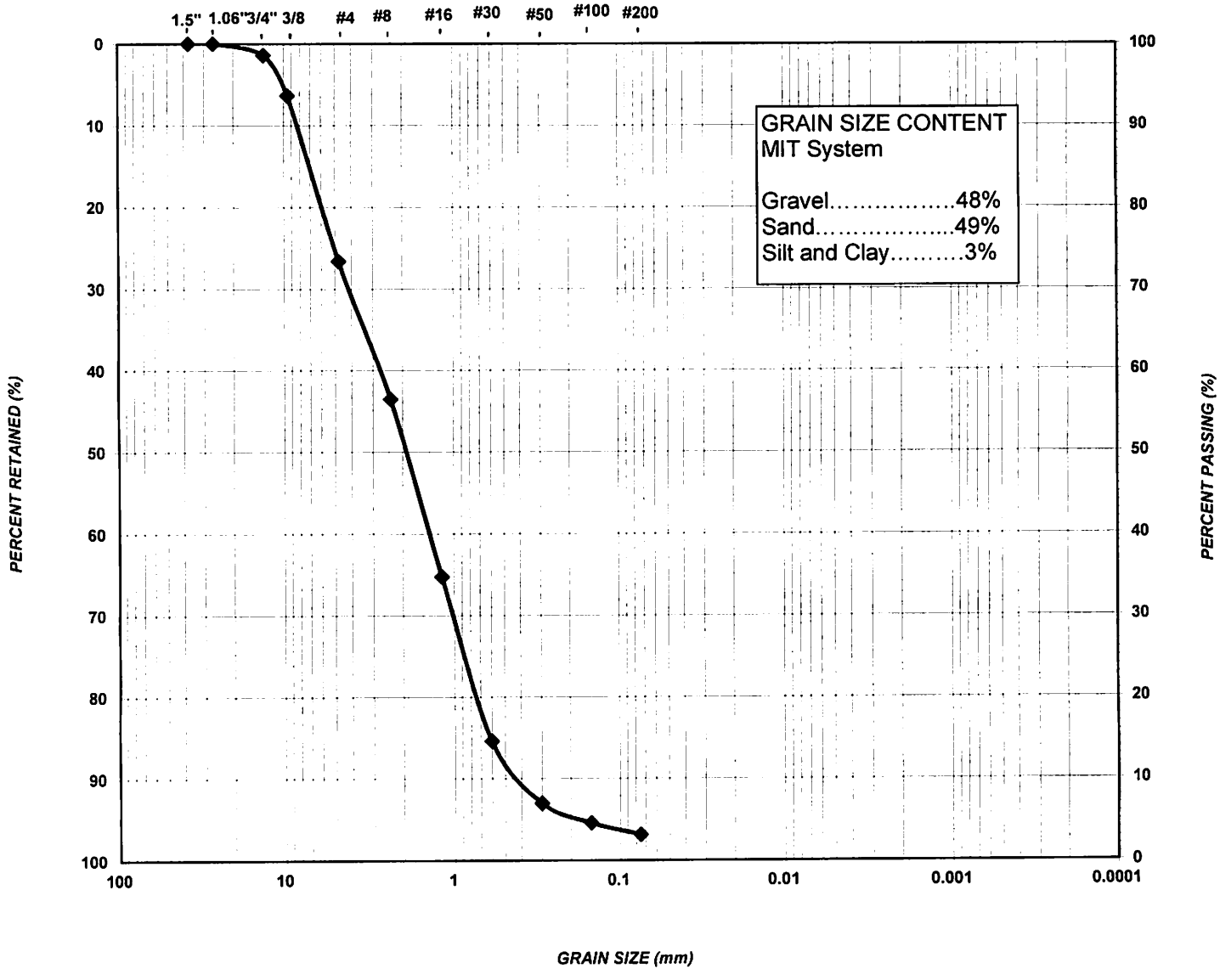
PROJECT: **Lynden Well Laboratory Testing**
LOCATION: **N/A**
CLIENT: **Gerritts Engineering Limited**

FILE NO.: **32-15-2164**
LAB NO.: **2179d**
SAMPLE DATE: **Dec-09-15**
SAMPLED BY: **Client**

TEST HOLE NUMBER: **1** SAMPLE DEPTH: **175 to 180'**
SAMPLE NUMBER: **1**
SAMPLE LOCATION: **Lynden Well**
SAMPLE DESCRIPTION: **Sand and gravel, trace silt**

GRAIN SIZE DISTRIBUTION

U.S. STANDARD SIEVE SIZES



MIT SYSTEM	GRAVEL	COARSE	MEDIUM	FINE	SILT	CLAY
		SAND				

UNIFIED SYSTEM	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY
	GRAVEL		SAND			

Terraprobe

WASH SIEVE ANALYSIS TEST REPORT

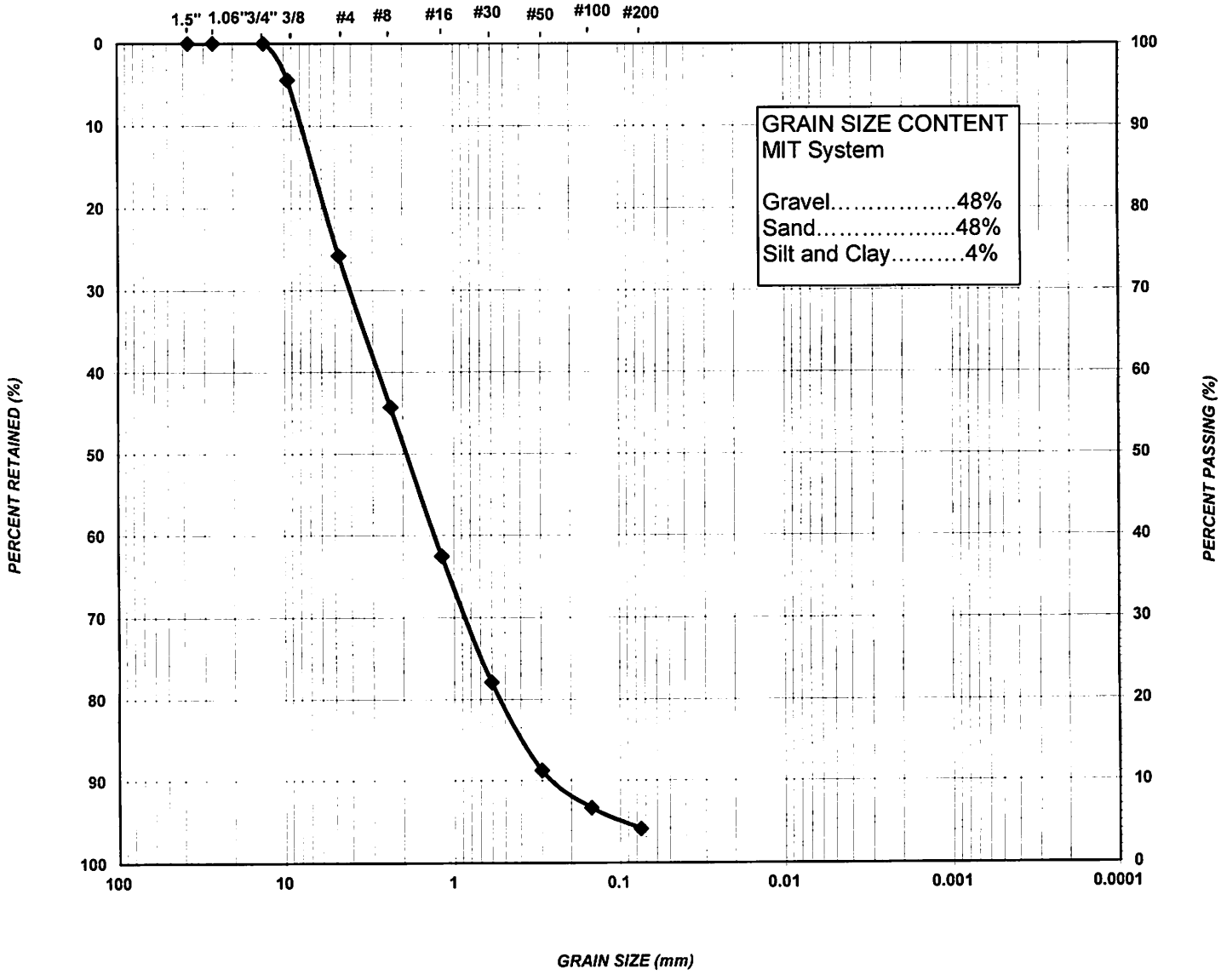
PROJECT: **Lynden Well Laboratory Testing**
LOCATION: **N/A**
CLIENT: **Gerritts Engineering Limited**

FILE NO.: **32-15-2164**
LAB NO.: **2179e**
SAMPLE DATE: **Dec-09-15**
SAMPLED BY: **Client**

TEST HOLE NUMBER: **1** SAMPLE DEPTH: **180 to 185'**
SAMPLE NUMBER: **1**
SAMPLE LOCATION: **Lynden Well**
SAMPLE DESCRIPTION: **Sand and gravel, trace silt**

GRAIN SIZE DISTRIBUTION

U.S. STANDARD SIEVE SIZES



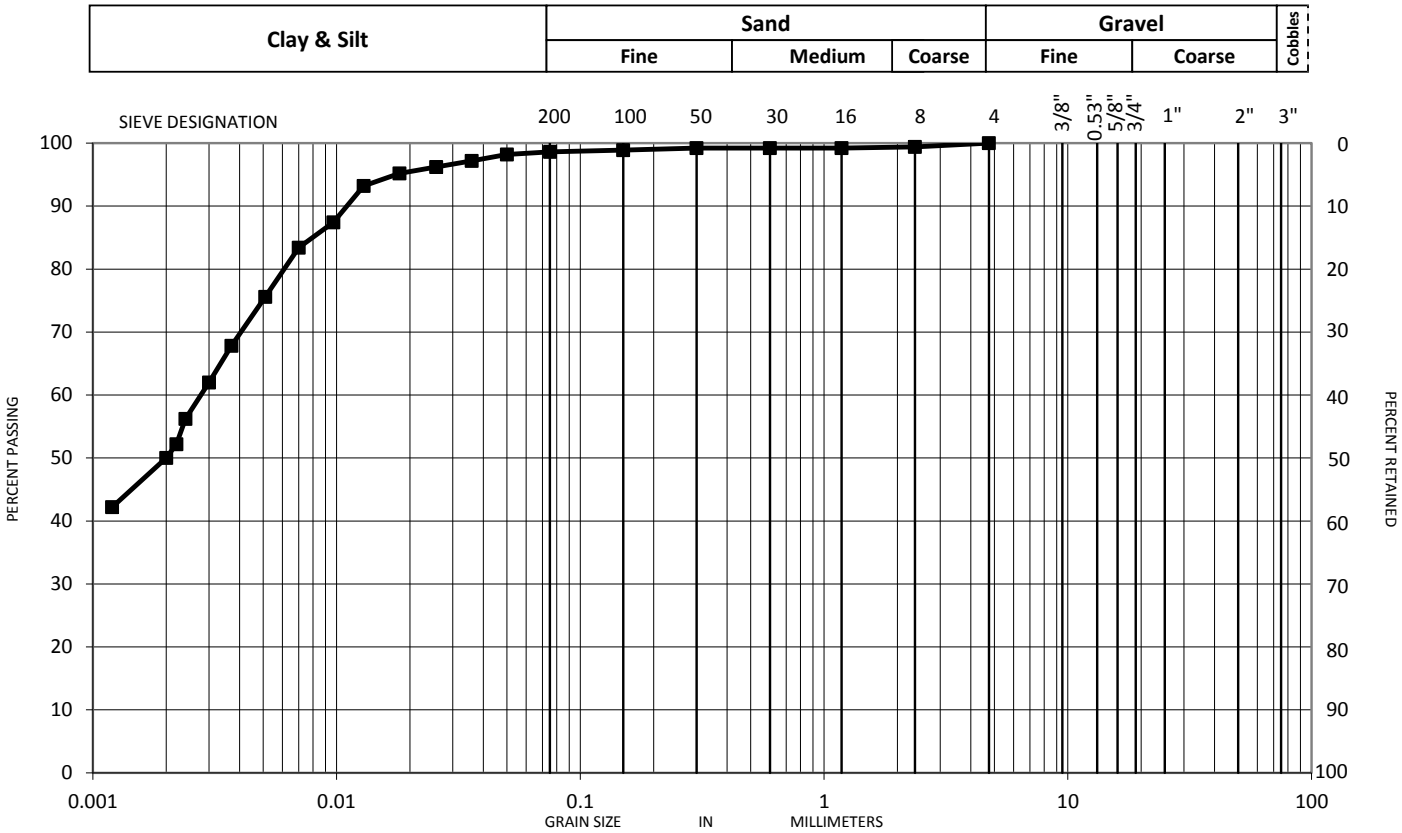
MIT SYSTEM	GRAVEL	COARSE	MEDIUM	FINE	SILT	CLAY
		SAND				

UNIFIED SYSTEM	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY
	GRAVEL		SAND			

GRAIN SIZE DISTRIBUTION CHART

CLIENT:	WSP Canada Inc.	**DATE:**	January 12, 2016
		ENCLOSURE N°:	1
PROJECT:	Lynden Municipal Wells	**PROJECT N°:**	071-11885-01
LAB N° / TYPE:	1 / 1 / Native	**DATE SAMPLED:**	November 25, 2015
SAMPLED BY:	S.K	**DATE RECEIVED:**	January 7, 2016
SAMPLED FROM:	Well at 29.5 - 33.5 m	**DATE TESTED:**	January 12, 2016
DESCRIPTION:	Clay and Silt with trace Sand.	**GRAVEL (%)**	0%
COMMENTS:	The material, as representative by the sample obtained, is a **Clay and Silt with trace Sand** and mostly resembles C.H. Soil Type with a Percolation Time of over 50 min/cm and a Coefficient of Permability <1 x 10^{-7} cm/sec.		

UNIFIED SOIL CLASSIFICATION SYSTEM *(ASTM D 2487)*

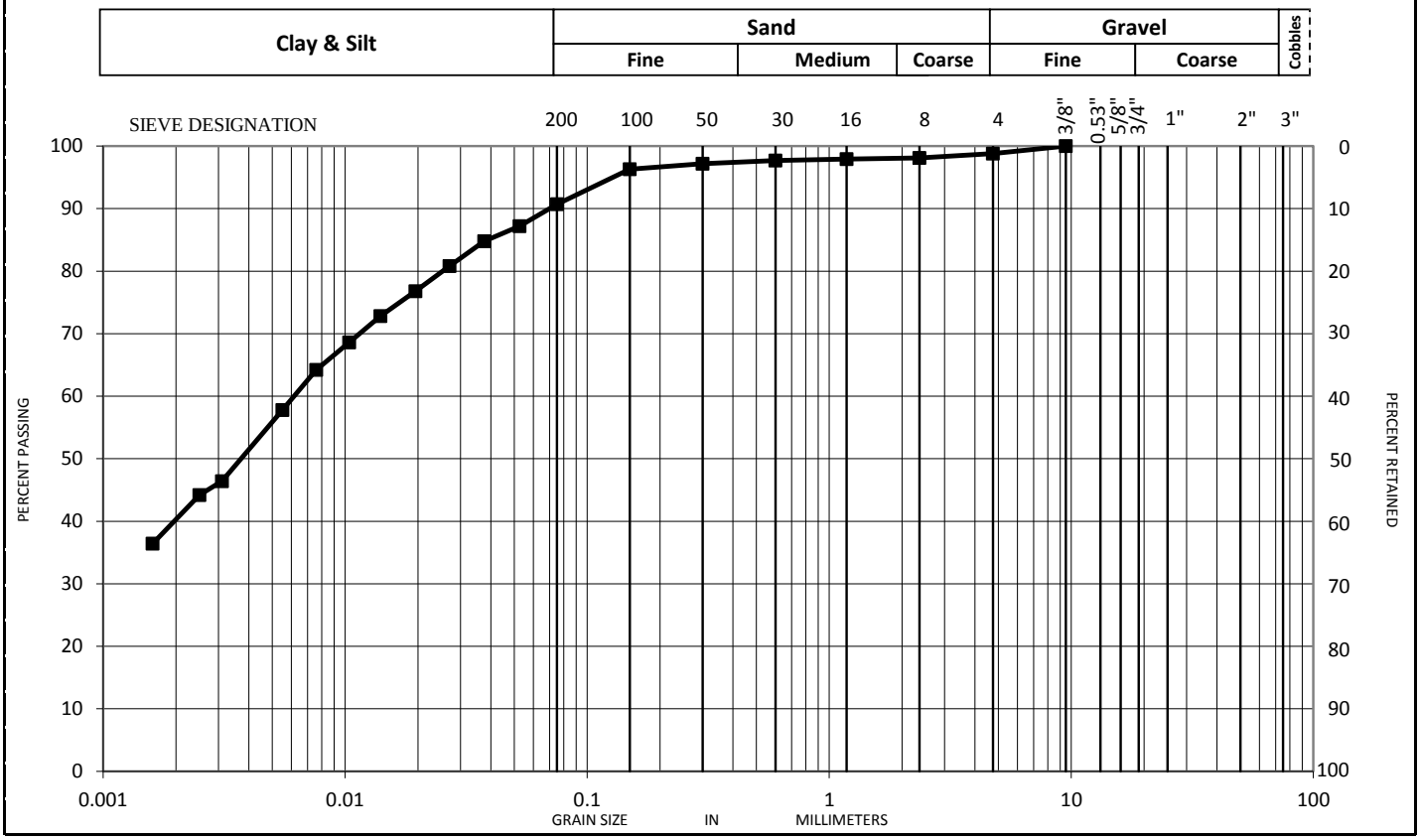


GRAIN SIZE DISTRIBUTION CHART

CLIENT:	WSP Canada Inc.	**DATE:**	January 13, 2016
		ENCLOSURE N°:	2
PROJECT:	Lynden Municipal Wells	**PROJECT N°:**	071-11885-01
LAB N° / TYPE:	2 / 1 / Native	**DATE SAMPLED:**	November 25, 2015
SAMPLED BY:	S.K	**DATE RECEIVED:**	January 7, 2016
SAMPLED FROM:	Well at 8.5 - 11.5 m	**DATE TESTED:**	January 13, 2016
DESCRIPTION:	Silt and Clay with trace Sand and Gravel	**GRAVEL(%):**	1%
COMMENTS:	The material, as represented by the sample obtained, is a **Silt and Clay with trace Sand and Gravel** and mostly resembles the C. H. soil type with a Percolation Time of over 50 mins/cm and a Coefficient of Permabilty of 1 x 10^{-7}cm/sec		

TP = Test Pit

UNIFIED SOIL CLASSIFICATION SYSTEM *(ASTM D 2487)*

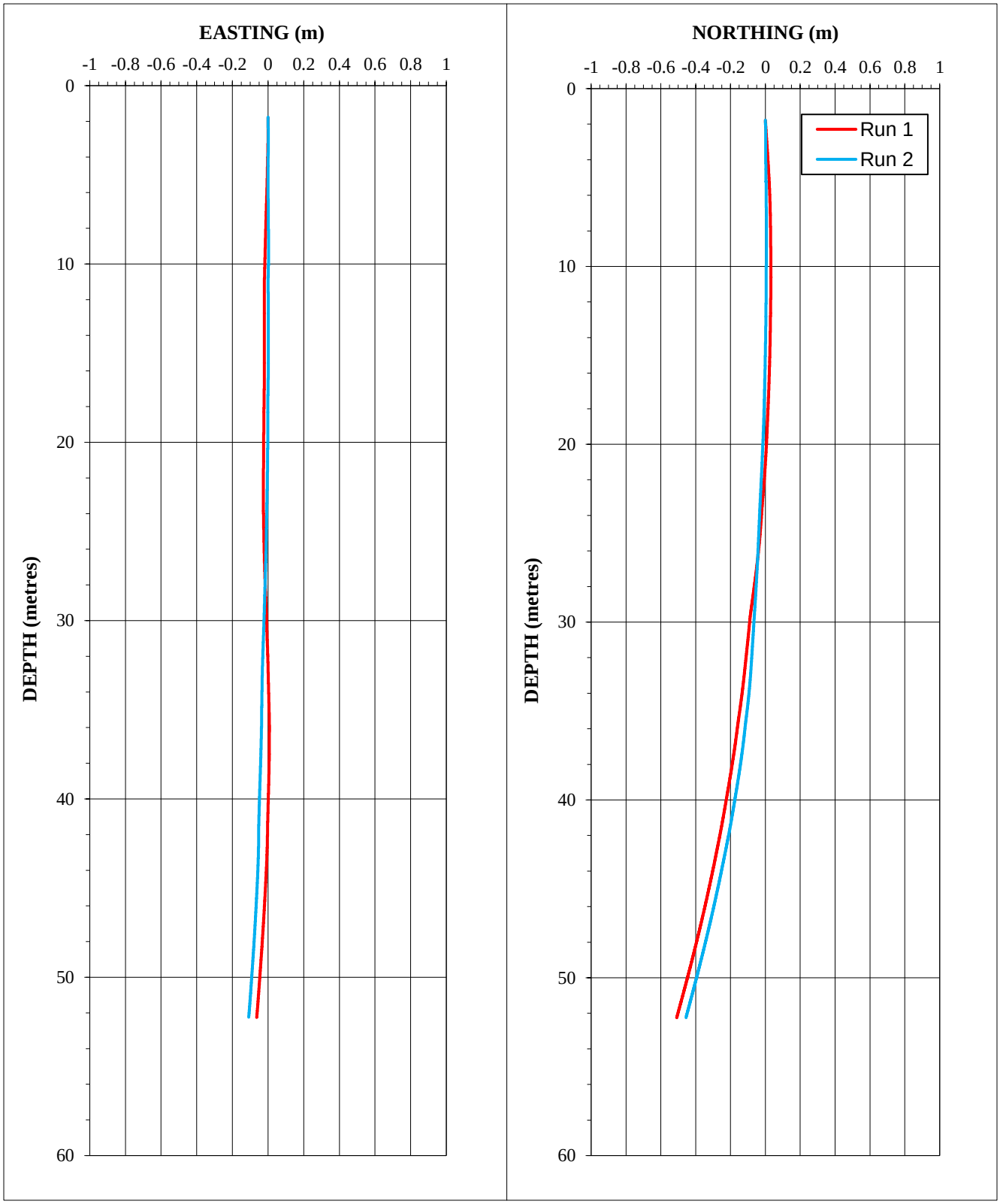


Appendix F

FDL-03 WELL CONSTRUCTION REPORT AND ANALYSES

TABLE F-1 - PLUMBNESS DATA FOR LYNDEN WELL FDL-03

DEPTH	DRIFT EAST	DRIFT NORTH	TOTAL DRIFT	ALLOWABLE DRIFT
m	m	m	m	m
5	-0.004	0.020	0.02	0.02
10	-0.018	0.032	0.04	0.04
15	-0.020	0.025	0.03	0.07
20	-0.025	-0.015	0.03	0.09
25	-0.024	-0.038	0.04	0.11
30	-0.023	-0.090	0.09	0.13
35	-0.035	-0.147	0.15	0.16
40	-0.048	-0.225	0.23	0.18
45	-0.062	-0.324	0.33	0.20
50	-0.092	-0.447	0.46	0.22
52.24	-0.108	-0.509	0.52	0.23



Notes:

Reference Point: Top of casing
Date Logged: May 26, 2016

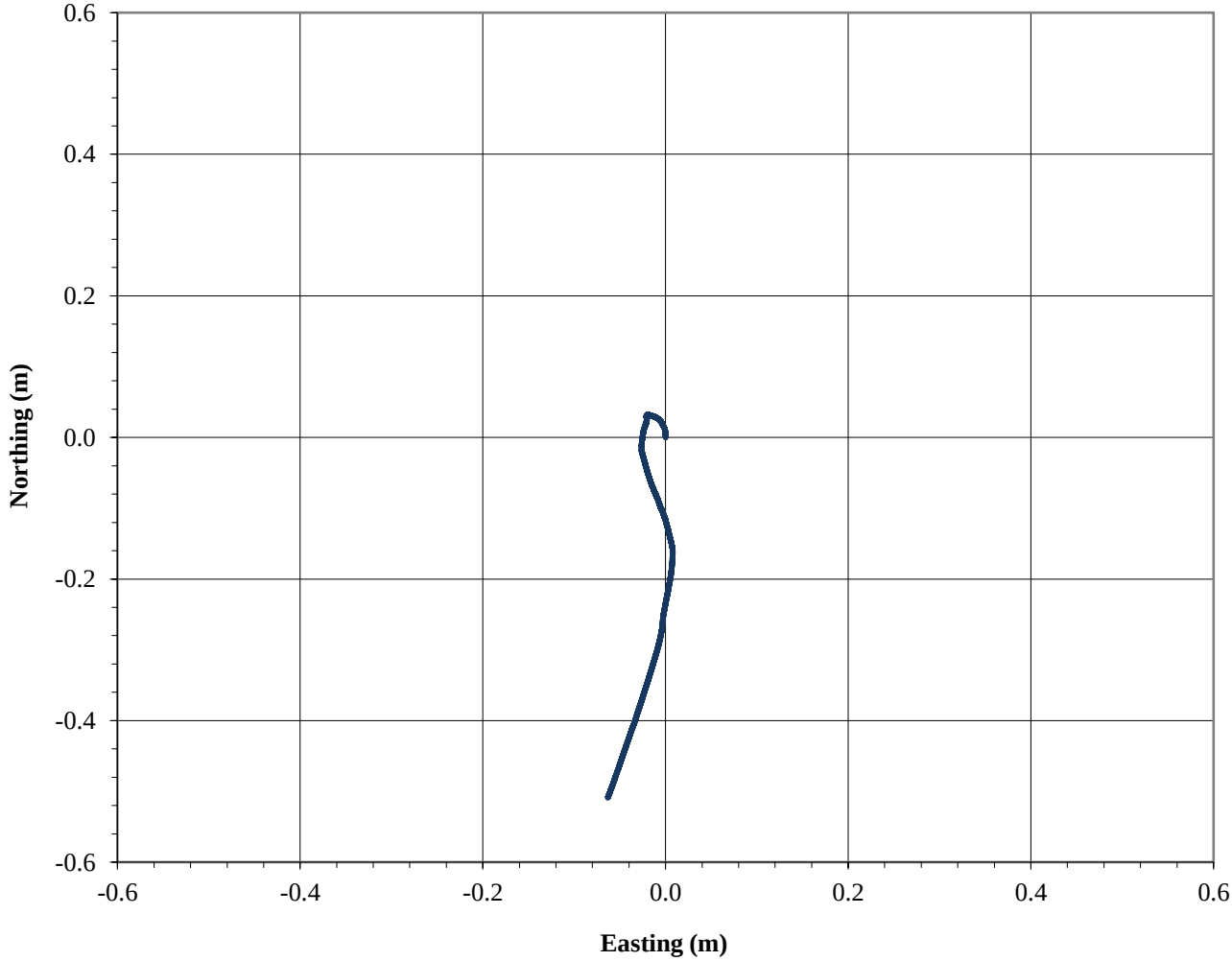
Region of Hamilton-Wentworth

FDL03

Alignment Log

Lotowater Technical Services Inc.

Reference: 156-044 5/30/2016



Notes:
Reference Point: Top of casing
Date Logged: May 26, 2016

Region of Hamilton-Wentworth

FDL03

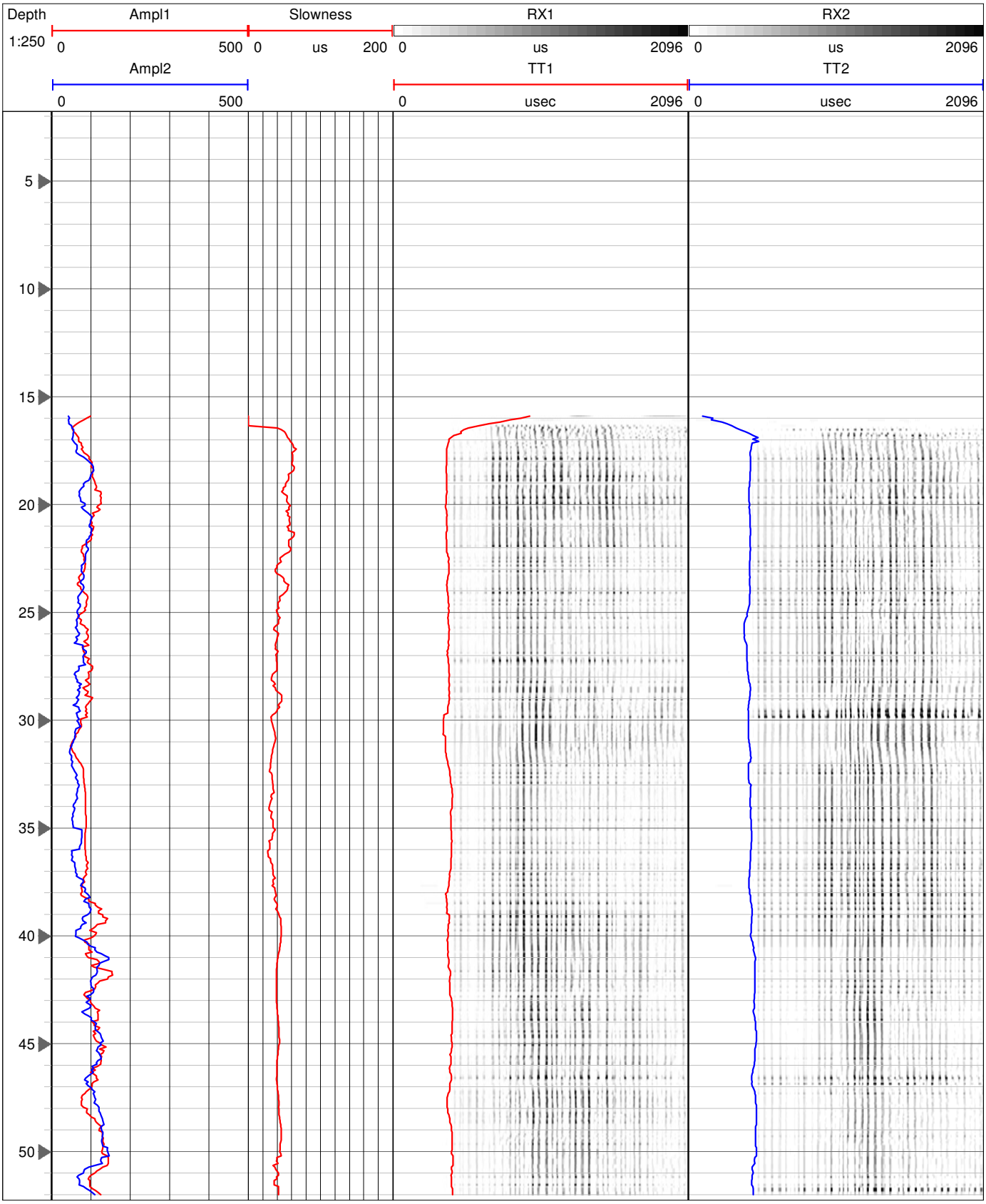
Alignment Log

Lotowater Technical Services Inc.

Reference: 156-044 5/30/2016

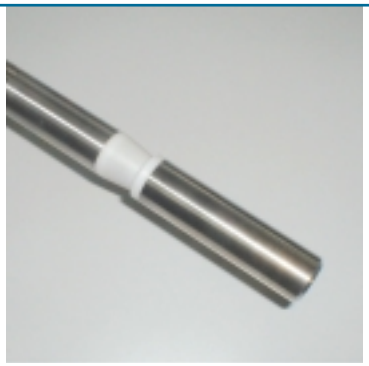
Lotowater TECHNICAL SERVICES INC.

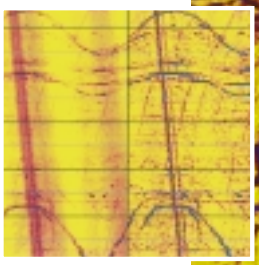
Client:	City Of Hamilton	Measuring Point:	TOC
Well Name:	FDL03	Measuring Point Elev:	226.93m ASL
Location:	Lynden	Logged By:	J.Dion
Project No:	156-044	Logging Date:	May 26, 2016

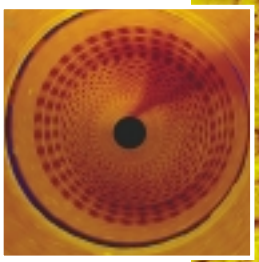


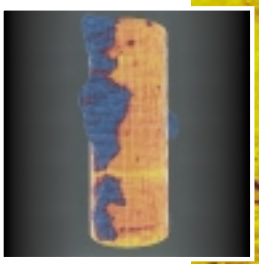
ABI 40

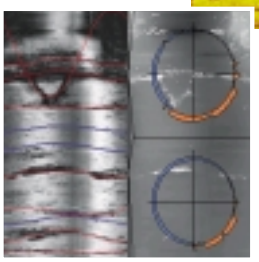
slimhole acoustic televiewer



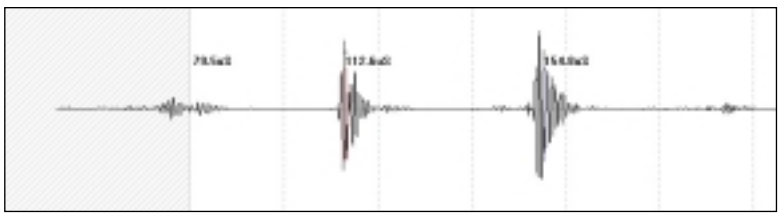


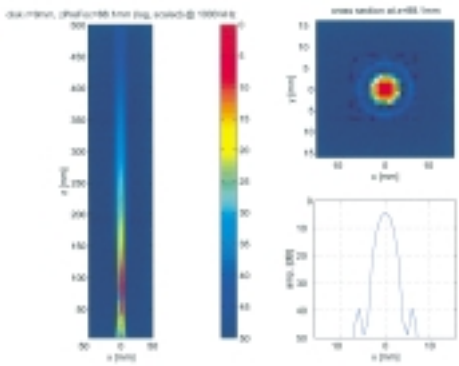


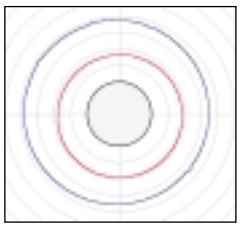




The ABI40 is the latest generation of the FAC40. Based on 8 years of experience and market leadership with BHTV technology, the new system consists of industry standard focused acoustic head with completely new deviation subsystem and redesigned electronics. The new electronic architecture uses a A/D converter 14 Bit directly coupled to a super FAST 75Mops DSP processor. The DSP is performing complex data processing operations in real time on each individual ultrasonic wave train enabling higher dynamic range of signal detection and easy field operation in a wide variety of logging applications.







Advanced Logic Technology

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L-8506 Redange-sur-Attert.
Grand-Duché de Luxembourg

T:(352)23 649 289 • F:(352)23 649 364
e-mail: sales@alt.lu www.alt.lu

ABI 40

slimhole acoustic televiewer

- Direct linear 14 Bit,10mhz A/D conversion (automatic gain settings)
- Dynamic range of amplitude measurement is 84dB
- Caliper resolution is better than 0.1mm
- New orientation sensor (3 accelerometers and 3 axis magnetometer)
- New orientation sensor (3 accelerometers and 3 axis magnetometer) which does not require field calibration
- Increased telemetry bandwidth (data transmission rate up to 500 Kbits depending on wireline), 166 kbps typical on 3000m four-conductor.
- Full wave form recording and real time display for quality control
- Multiecho mode to realize acoustic measurements through plastic pipes (require the plastic pipe to be centralized inside the borehole.
- Pipe-inspection mode to detect inner corrosion, outer corrosion, and wall thickness
- Automatic measurement window definition to gain optimum performance and variable borehole conditions

Tool design philosophy :

Acoustic borehole scanner tools generates an image of the borehole wall by transmitting ultrasound pulses from a rotating sensor and recording the amplitude and travel time of the signals reflected at the interface between mud and formation (borehole wall). Compared to the FAC40, which measures one echo (one amplitude and one travel time), the ABI is a multi-echo system. This is achieved by digital recording of the reflected acoustic wave train. On line analysis of the acoustic data is made by a DSP (digital Signal Processor). Sophisticated algorithms allow the system to detect the reflection from the acoustic window and to separate/classify all subsequent echoes. Minimum input of the operator is needed to enable:

- Automatic optimisation of measurement window under all borehole conditions
- Automatic adaptation to variable borehole conditions
- Improvement of dynamic range of signal detection
- Very high travel time resolution
- Implementation of different operating modes.

E.g. when run inside plastic casing, the tool can record both the echo of the casing and of the borehole wall. Tool upgrades and implementations of customised operating modes can be simply made by downloading new firmware into the tool from the surface computer.

Technical specifications

Diameter:	40mm
Length:	1.6 m
Weight:	6kgs
Max temp:	70°C
Max pressure:	200 bar
Borehole diameter:	2" to 21" depending on mud conditions
Logging speed:	variable function of resolution and wireline. i.e 2.0 m/min at 144x3mm

Cable:

Cable type:	mono, four-conductor, seven-conductor
digital data transmission:	up to 500 Kbits per second depending on wireline.
compatibility:	ALTlogger - ALTboxOX - Mount Sopris MgxII (limited to 41 Kbps)

sensor:

acoustic sensor:	fixed transducer and rotating focusing mirror
focusing:	3" or 6"
frequency:	1.2 MHz
acoustic beam width:	1.5 mm (-3db) focal distance
rotation speed:	up to 10 revolutions per second - automatic
samples per revolution:	72, 144, 288 user defined
caliper resolution:	0.08mm
orientation:	3 axis magnetometer, 3 accelerometers
Inclination accuracy:	+/- 0.5 degree
Azimuth accuracy:	+/- 1.0 degree

The specifications are not contractual and are subject to modification without notice.

Applications:

The purpose of the acoustic borehole imaging tool is to provide detailed, oriented caliper and structural information on the basis of high resolution, ultrasonic travel time and amplitude images. The travel time is used to determine exceptionally accurate borehole diameter data, which makes the tool ideal for borehole deformation description (stress field analysis) and casing inspection. Travel time is also used for quality control of the amplitude measurement. The amplitude of the reflection from the borehole wall is representative of the acoustic (elastic) properties of the surrounding rock. Therefore, the tool is ideal for fracture detection and geotechnical rock classification. Cement bond quality can be checked if the reflection signal from behind casing is analyzed.

Most common applications are:

- fracture detection and evaluation
- detection of thin beds
- determination of bedding dip
- lithological characterization
- breakout analysis
- monitoring of earth stress field
- casing inspection
- high resolution caliper measurements

Advanced Logic Technology

* released in 2002

Appendix G

STEP TEST DATA

FIGURE G-1

RECORD OF STEP TEST DATA - LYNDEN WELL FDL-03

Static Water Level : 14.22 m bgl Well Depth: 51.2 m bgl Pumping Rate: As Shown	Project Name : **LYNDEN WELLS** Project No : 071-11885 Date: 18-Mar-16
mbtoc - metres below top of casing lgpm - Imperial gallons per minute mbgl - metres below ground level L/sec - litres per second	Distance from pumping well = 0 m

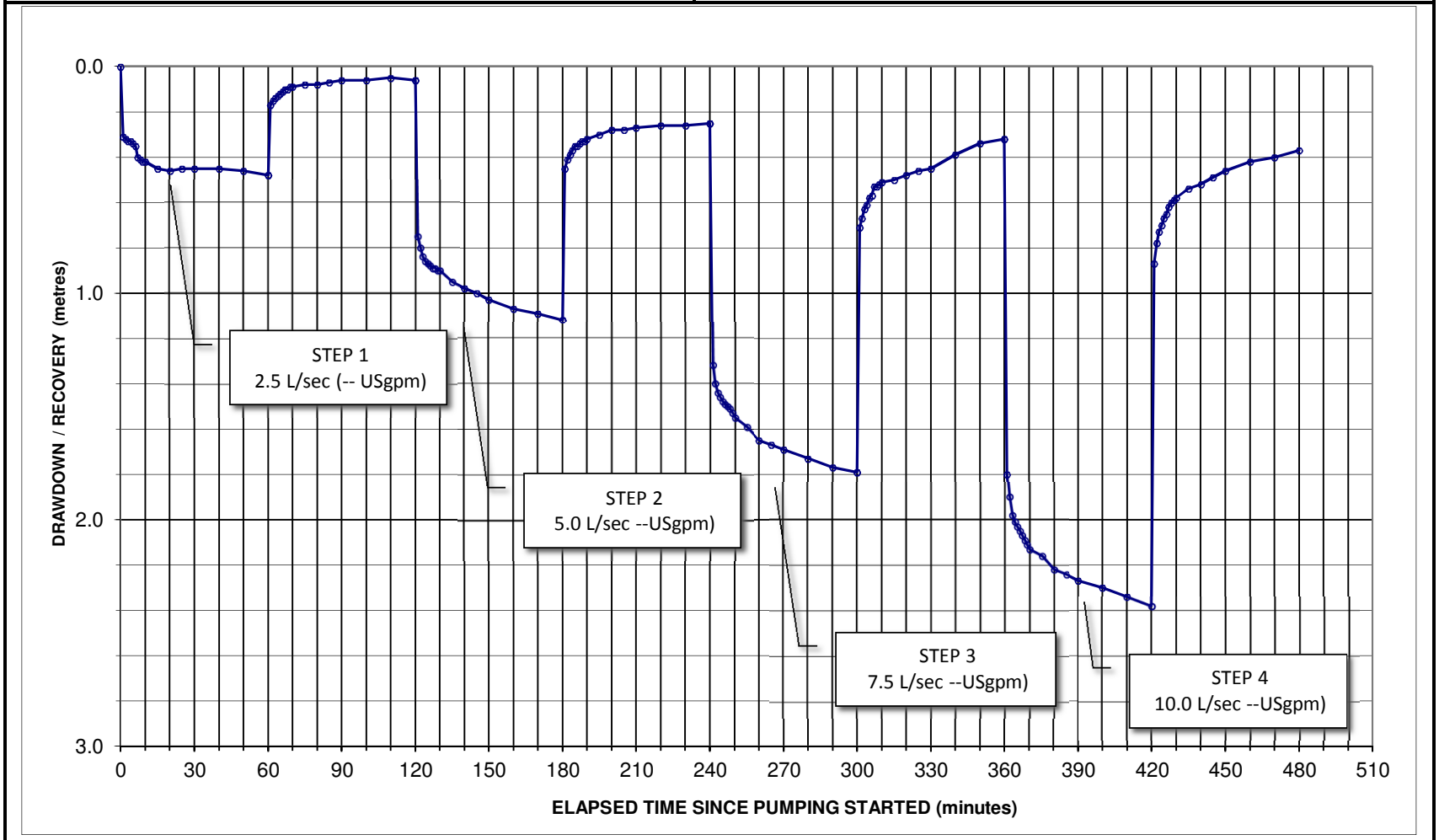
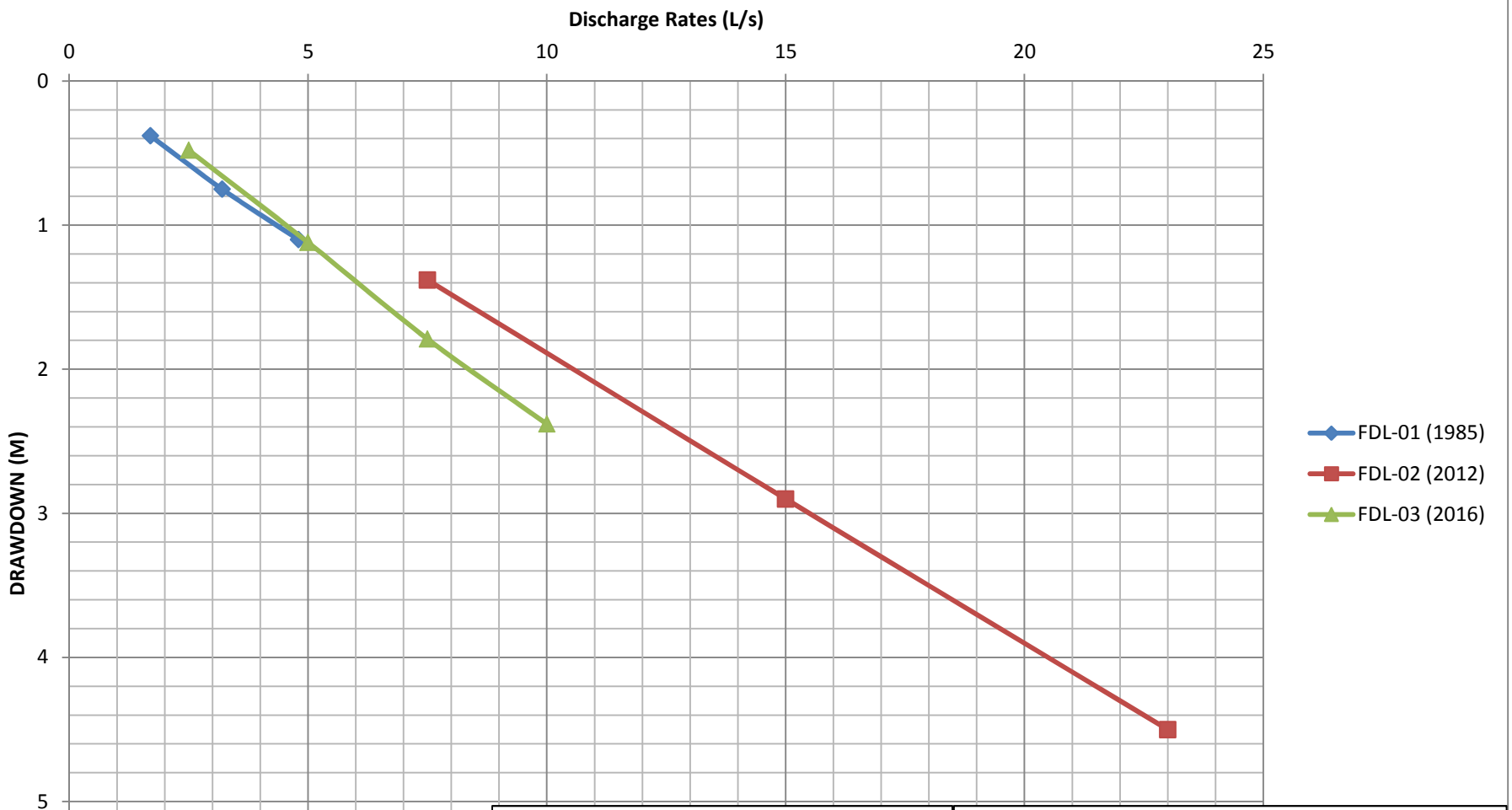


FIGURE G-2
Observed Drawdown Vs. Discharge (FDL-01, FDL-02, FDL-03 Comparison)



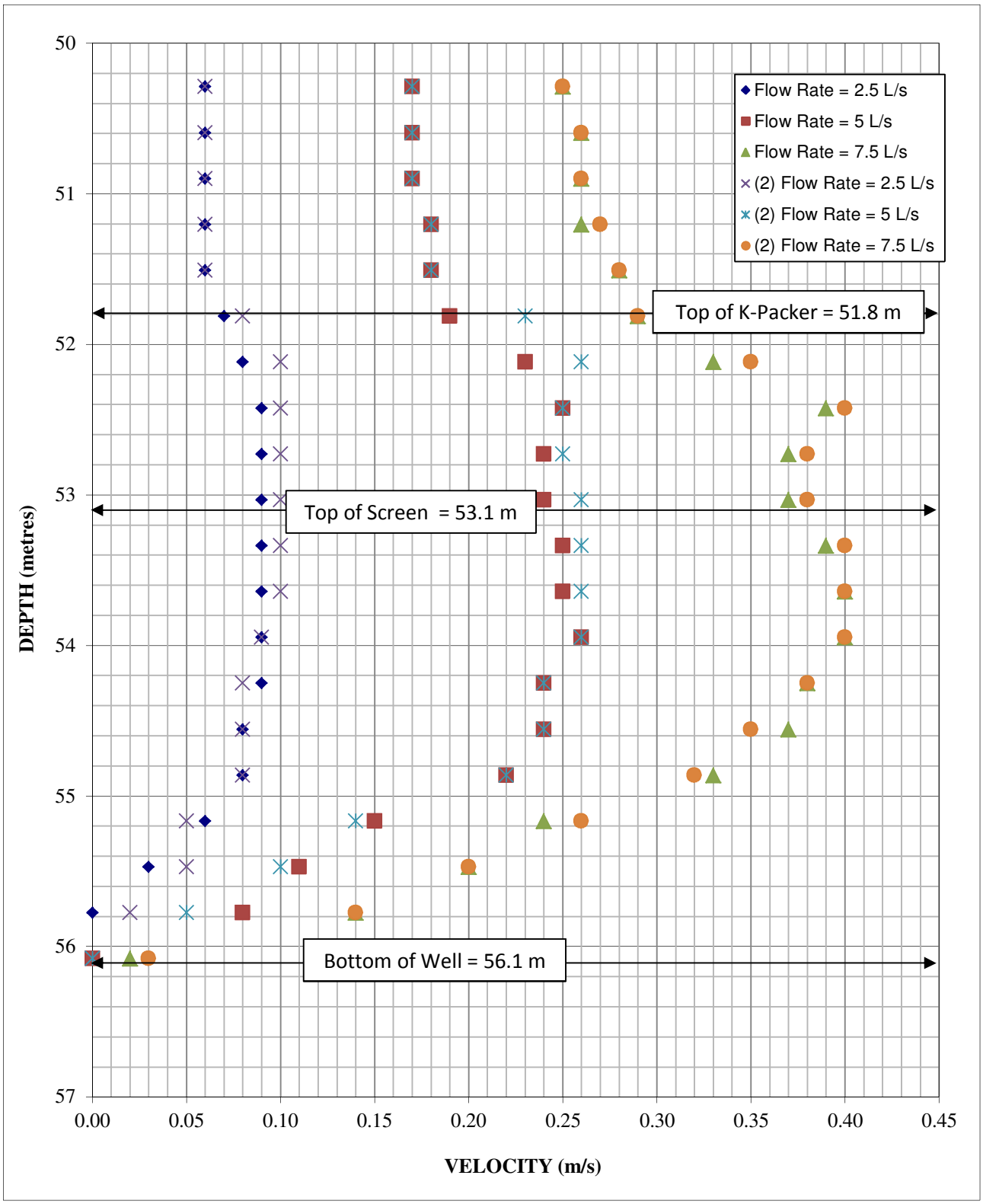
Well Loss Formula: s = B X Q + C x Q2

B: Formation Loss
C: Well Loss

Project Name: Lynden FDL-03

Project No: 071-11885
Date: 24-Mar-16

WSP



Notes:
Measurement point: Top of casing = 0.4 m above ground surface
Well construction details provided by WSP
Test Date: May 24, 2016

Region of Hamilton-Wentworth

Lynden Well FDL03

Flow Distribution Profile

Lotowater Technical Services Inc. **Figure G-3**

Reference: 156-044 5/24/2016

TABLE G-1: STEP TEST PUMPING DATA, LYNDEN WELL FDL-03
LYNDEN WELLS
071-11885

OW	DEPTH (mbgl):	51.2		Measuring Point: 0.53 m above grade
PW: FDL-03	SWL (m bmp):	14.90		Discharge Rate: see Comments Below
DATE: 18-Mar-16	I.D. (mm):	200		
START: 9:32 AM				

D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
0.0	14.90	0.00	0.0			**STEP 1 : 2.5 L/sec**
1.0	15.21	0.31	1.0			
2.0	15.22	0.32	2.0			
3.0	15.23	0.33	3.0			
4.0	15.23	0.33	4.0			
5.0	15.24	0.34	5.0			
6.0	15.25	0.35	6.0			
7.0	15.30	0.40	7.0			Flow adjustment back up to 2.5 L/s
8.0	15.31	0.41	8.0			
9.0	15.32	0.42	9.0			
10.0	15.32	0.42	10.0			
15.0	15.35	0.45	15.0			
20.0	15.36	0.46	20.0			
25.0	15.35	0.45	25.0			
30.0	15.35	0.45	30.0			
40.0	15.35	0.45	40.0			
50.0	15.36	0.46	50.0			
60.0	15.38	0.48	60.0			Sand volume 0.08 mL, turbidity 0.31
60.0			60.0	15.38	0.48	Recovery
61.0			61.0	15.07	0.17	
62.0			62.0	15.05	0.15	
63.0			63.0	15.04	0.14	
64.0			64.0	15.03	0.13	
65.0			65.0	15.02	0.12	
66.0			66.0	15.01	0.11	
67.0			67.0	15.00	0.10	
68.0			68.0	15.00	0.10	
69.0			69.0	14.99	0.09	
70.0			70.0	14.99	0.09	
75.0			75.0	14.98	0.08	
80.0			80.0	14.98	0.08	
85.0			85.0	14.97	0.07	
90.0			90.0	14.96	0.06	
100.0			100.0	14.96	0.06	
110.0			110.0	14.95	0.05	
120.0			120.0	14.96	0.06	

TABLE G-1: STEP TEST PUMPING DATA, LYNDEN WELL FDL-03
LYNDEN WELLS
071-11885

OW	DEPTH (mbgl):	51.2		Measuring Point: 0.53 m above grade
PW: FDL-03	SWL (m bmp):	14.90		Discharge Rate: see Comments Below
DATE: 18-Mar-16	I.D. (mm):	200		
START: 9:32 AM				

D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
120.0	14.96	0.06	120.0			**STEP 2 : 5.0 L/sec**
121.0	15.65	0.75	121.0			
122.0	15.70	0.80	122.0			
123.0	15.74	0.84	123.0			
124.0	15.76	0.86	124.0			
125.0	15.77	0.87	125.0			
126.0	15.78	0.88	126.0			
127.0	15.79	0.89	127.0			
128.0	15.79	0.89	128.0			
129.0	15.80	0.90	129.0			
130.0	15.80	0.90	130.0			
135.0	15.85	0.95	135.0			
140.0	15.88	0.98	140.0			
145.0	15.90	1.00	145.0			
150.0	15.93	1.03	150.0			
160.0	15.97	1.07	160.0			
170.0	15.99	1.09	170.0			
180.0	16.02	1.12	180.0			Sand volume 0.1 mL, turbidity 0.4
180.0			180.0	16.02	1.12	Recovery
181.0			181.0	15.35	0.45	
182.0			182.0	15.31	0.41	
183.0			183.0	15.29	0.39	
184.0			184.0	15.27	0.37	
185.0			185.0	15.25	0.35	
186.0			186.0	15.25	0.35	
187.0			187.0	15.24	0.34	
188.0			188.0	15.23	0.33	
189.0			189.0	15.23	0.33	
190.0			190.0	15.22	0.32	
195.0			195.0	15.20	0.30	
200.0			200.0	15.18	0.28	
205.0			205.0	15.18	0.28	
210.0			210.0	15.17	0.27	
220.0			220.0	15.16	0.26	
230.0			230.0	15.16	0.26	
240.0			240.0	15.15	0.25	

TABLE G-1: STEP TEST PUMPING DATA, LYNDEN WELL FDL-03
LYNDEN WELLS
071-11885

OW	DEPTH (mbgl):	51.2		Measuring Point: 0.53 m above grade
PW: FDL-03	SWL (m bmp):	14.90		Discharge Rate: see Comments Below
DATE: 18-Mar-16	I.D. (mm):	200		
START: 9:32 AM				

D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
240.0	15.15	0.25	240.0			**STEP 3 : 7.5 L/sec**
241.0	16.22	1.32	241.0			
242.0	16.30	1.40	242.0			
243.0	16.34	1.44	243.0			
244.0	16.36	1.46	244.0			
245.0	16.38	1.48	245.0			
246.0	16.39	1.49	246.0			
247.0	16.40	1.50	247.0			
248.0	16.41	1.51	248.0			
249.0	16.43	1.53	249.0			
250.0	16.45	1.55	250.0			
255.0	16.49	1.59	255.0			
260.0	16.55	1.65	260.0			Flow adjust back up to 7.5 L/s
265.0	16.57	1.67	265.0			
270.0	16.59	1.69	270.0			
280.0	16.63	1.73	280.0			
290.0	16.67	1.77	290.0			
300.0	16.69	1.79	300.0			Sand volume 0.07 mL, turbidity 0.43
300.0			300.0	16.69	1.79	Recovery
301.0			301.0	15.61	0.71	
302.0			302.0	15.57	0.67	
303.0			303.0	15.53	0.63	
304.0			304.0	15.51	0.61	
305.0			305.0	15.48	0.58	
306.0			306.0	15.47	0.57	
307.0			307.0	15.43	0.53	
308.0			308.0	15.43	0.53	
309.0			309.0	15.42	0.52	
310.0			310.0	15.41	0.51	
315.0			315.0	15.40	0.50	
320.0			320.0	15.38	0.48	
325.0			325.0	15.36	0.46	
330.0			330.0	15.35	0.45	
340.0			340.0	15.29	0.39	
350.0			350.0	15.24	0.34	
360.0			360.0	15.22	0.32	

TABLE G-1: STEP TEST PUMPING DATA, LYNDEN WELL FDL-03
LYNDEN WELLS
071-11885

OW	DEPTH (mbgl):	51.2		Measuring Point: 0.53 m above grade
PW: FDL-03	SWL (m bmp):	14.90		Discharge Rate: see Comments Below
DATE: 18-Mar-16	I.D. (mm):	200		
START: 9:32 AM				

D R A W D O W N			RECOVERY			C O M M E N T S
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
360.0	15.22	0.32	360.0			**STEP 4 : 10.0 L/sec**
361.0	16.70	1.80	361.0			
362.0	16.80	1.90	362.0			
363.0	16.88	1.98	363.0			
364.0	16.91	2.01	364.0			
365.0	16.93	2.03	365.0			
366.0	16.95	2.05	366.0			
367.0	16.97	2.07	367.0			
368.0	16.99	2.09	368.0			
369.0	17.01	2.11	369.0			
370.0	17.03	2.13	370.0			
375.0	17.06	2.16	375.0			
380.0	17.12	2.22	380.0			
385.0	17.14	2.24	385.0			
390.0	17.17	2.27	390.0			
400.0	17.20	2.30	400.0			
410.0	17.24	2.34	410.0			
420.0	17.28	2.38	420.0			sand volume 0.04 mL, turbidity 0.38
420.0			420.0	17.28	2.38	Recovery
421.0			421.0	15.77	0.87	
422.0			422.0	15.68	0.78	
423.0			423.0	15.63	0.73	
424.0			424.0	15.60	0.70	
425.0			425.0	15.57	0.67	
426.0			426.0	15.55	0.65	
427.0			427.0	15.52	0.62	
428.0			428.0	15.50	0.60	
429.0			429.0	15.49	0.59	
430.0			430.0	15.48	0.58	
435.0			435.0	15.44	0.54	
440.0			440.0	15.42	0.52	
445.0			445.0	15.39	0.49	
450.0			450.0	15.36	0.46	
460.0			460.0	15.32	0.42	
470.0			470.0	15.30	0.40	
480.0			480.0	15.27	0.37	

Q: discharge PW: pumped well I.D: inside diameter mbgl: metres below ground level
SWL: static water level OW: observation well mp: measuring point m bmp: metres below measuring point
L/sec: litres per second

Table G-2 - Sand Content from Well Development Data

Project Name: Lynden FDL03

Project Number: 071-11885-01

Cycle # - Run #	Date	Run Time (min)	Recovery (min)	Turbidity (ntu)	Sand Volume (mL)	Sand Concentration (mg/L)	Comments
1	17-Mar-16	10	10	2.41	0.05	**2.6**	4 large grains of sand in first minute
2	17-Mar-16	10	10	4.97	0.09	**4.8**	Continuous Accumulation
3	17-Mar-16	10	10	6.28	0.08	**4.2**	Continuous Accumulation
4	17-Mar-16	10	10	3.54	0.1	**5.3**	Continuous Accumulation
5	17-Mar-16	10	10	1.04	0.05	**2.6**	Continuous Accumulation
6	17-Mar-16	10	10	0.74	0.02	**1.1**	Intermittent Accumulation
7	17-Mar-16	10	10	0.52	0.01	**0.5**	Intermittent Accumulation
8	17-Mar-16	10	10	0.81	0.01	**0.5**	Less than 0.01 but not zero. Accumulation in first minute.
9	17-Mar-16	10	10	0.86	0.01	**0.5**	Less than 0.01 but not zero. Less sand than Run 8. Continuous Accumulation
10	17-Mar-16	10	10	0.71	0.01	**0.5**	Less than 0.01 but not zero. Same as Run 9. Continuous Accumulation

Appendix H

PUMPING TEST DATA

FIGURE H-1: GROUNDWATER HYDROGRAPH - FDL-03 (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

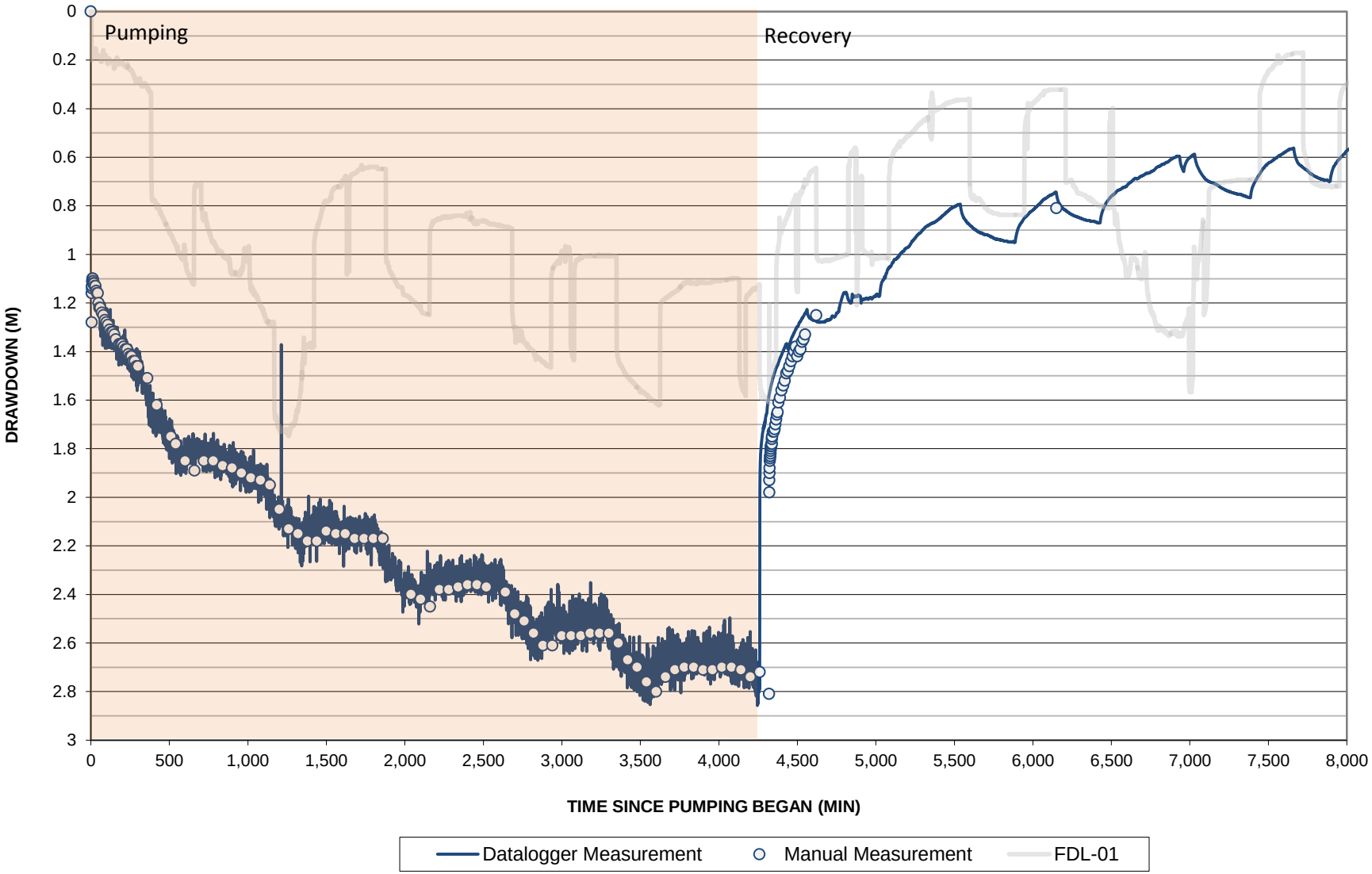


FIGURE H-2: GROUNDWATER HYDROGRAPH - LM-02-14-D (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

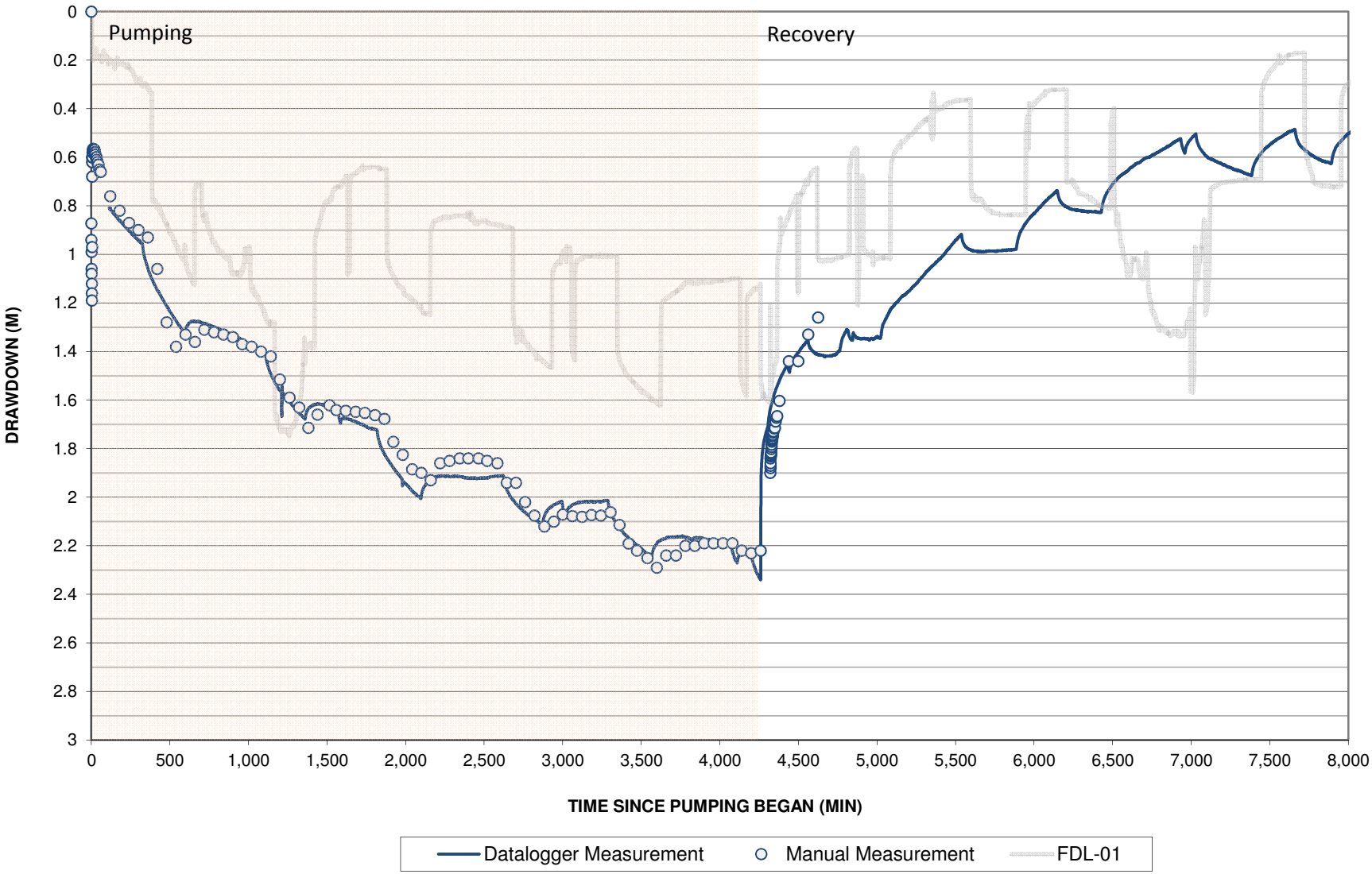


FIGURE H-3: GROUNDWATER HYDROGRAPH - LM-02-11-D (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

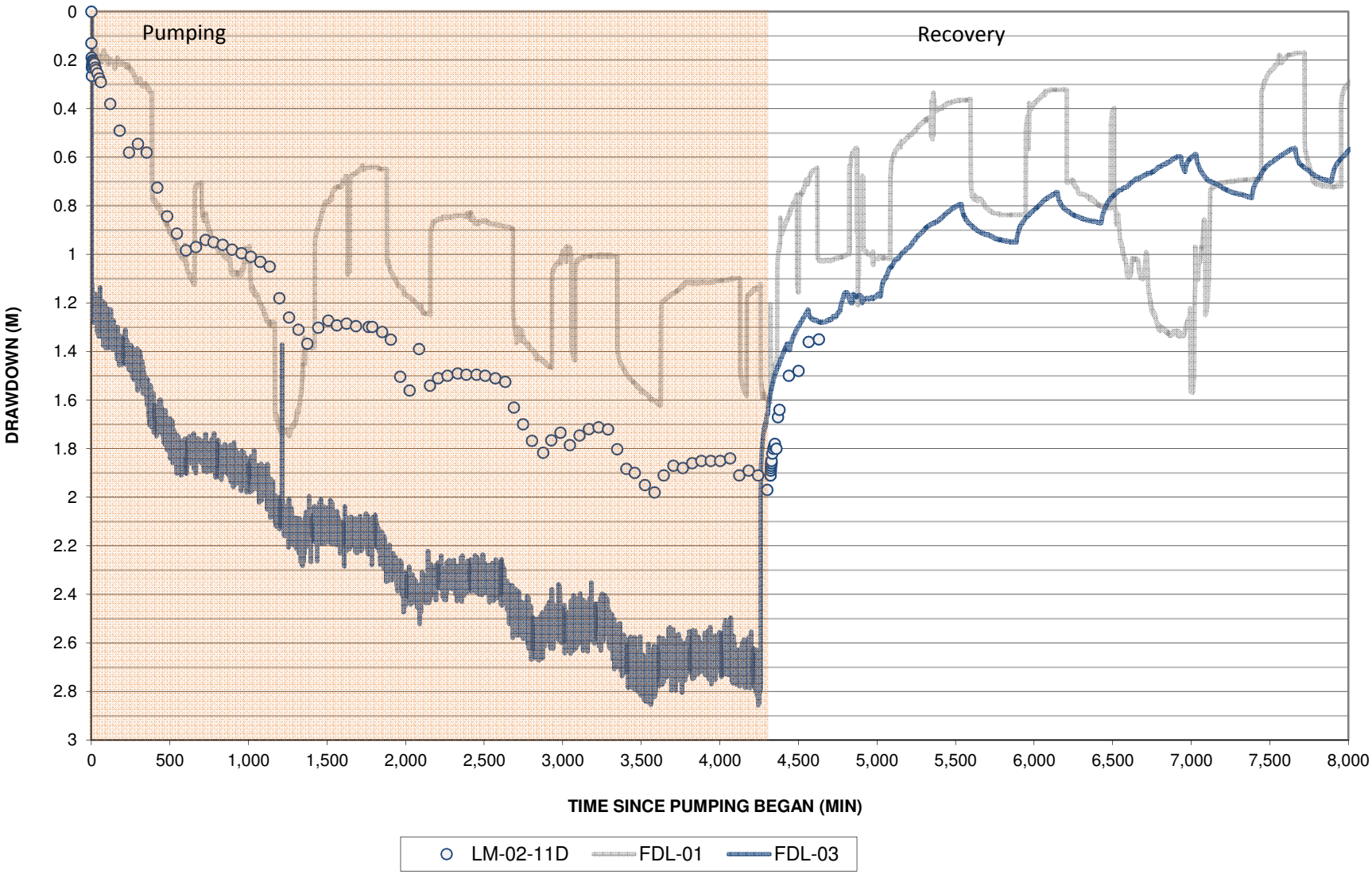


FIGURE H-4: GROUNDWATER HYDROGRAPH - LM-01-14-D (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

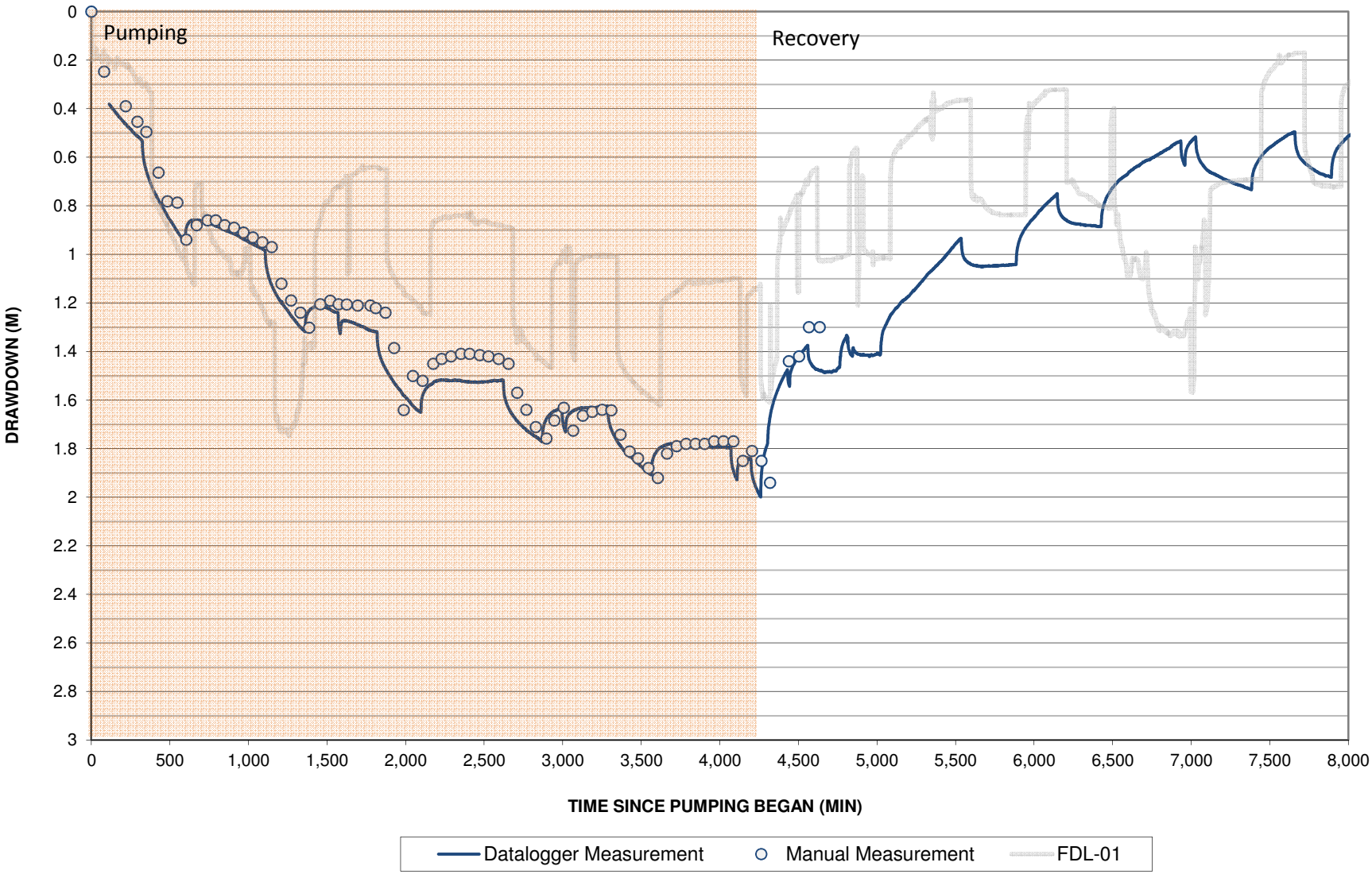


FIGURE H-5: GROUNDWATER HYDROGRAPH - LM-01-11-D (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

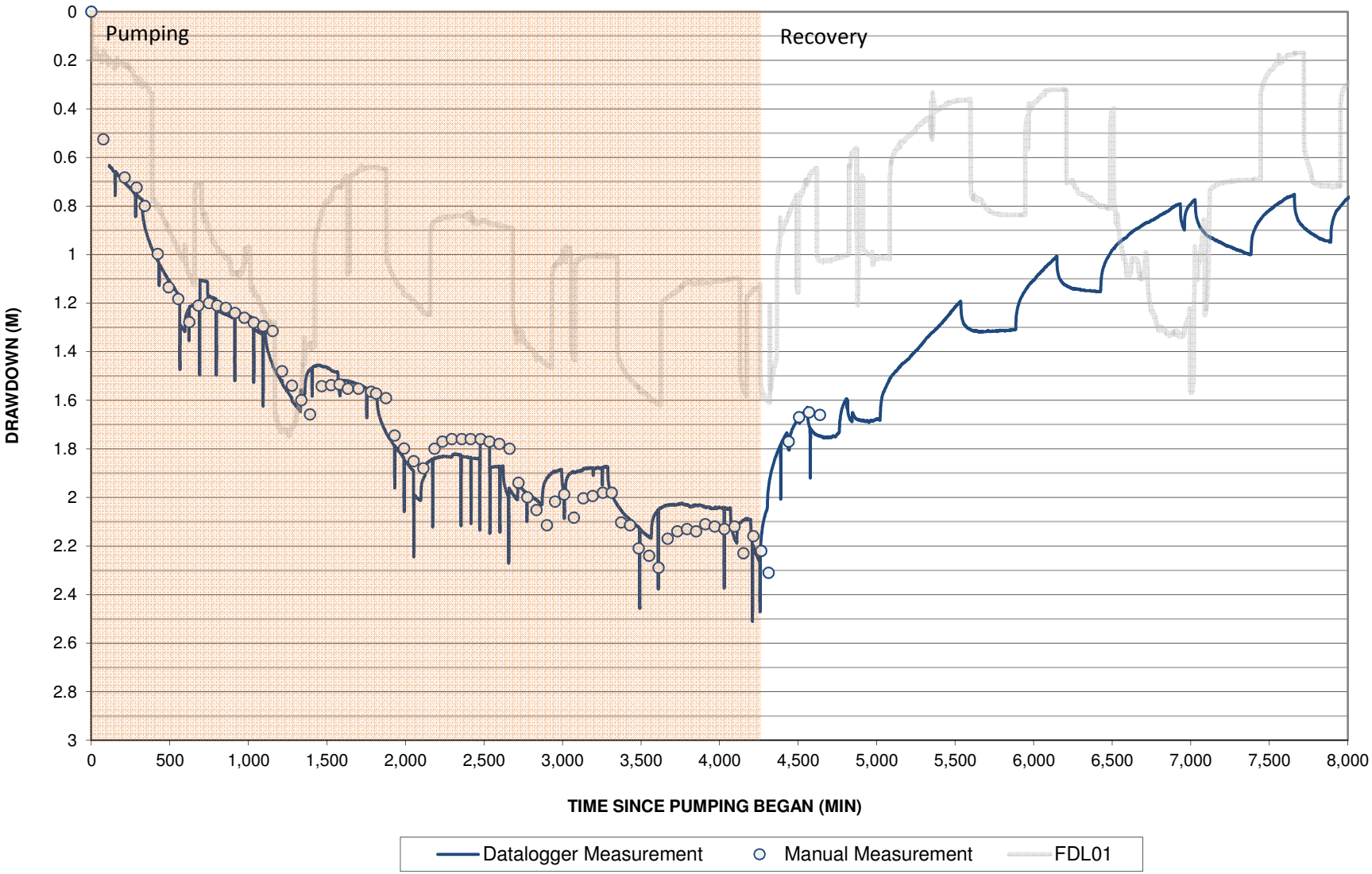


FIGURE H-6: GROUNDWATER HYDROGRAPH - LM-01-12-D (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

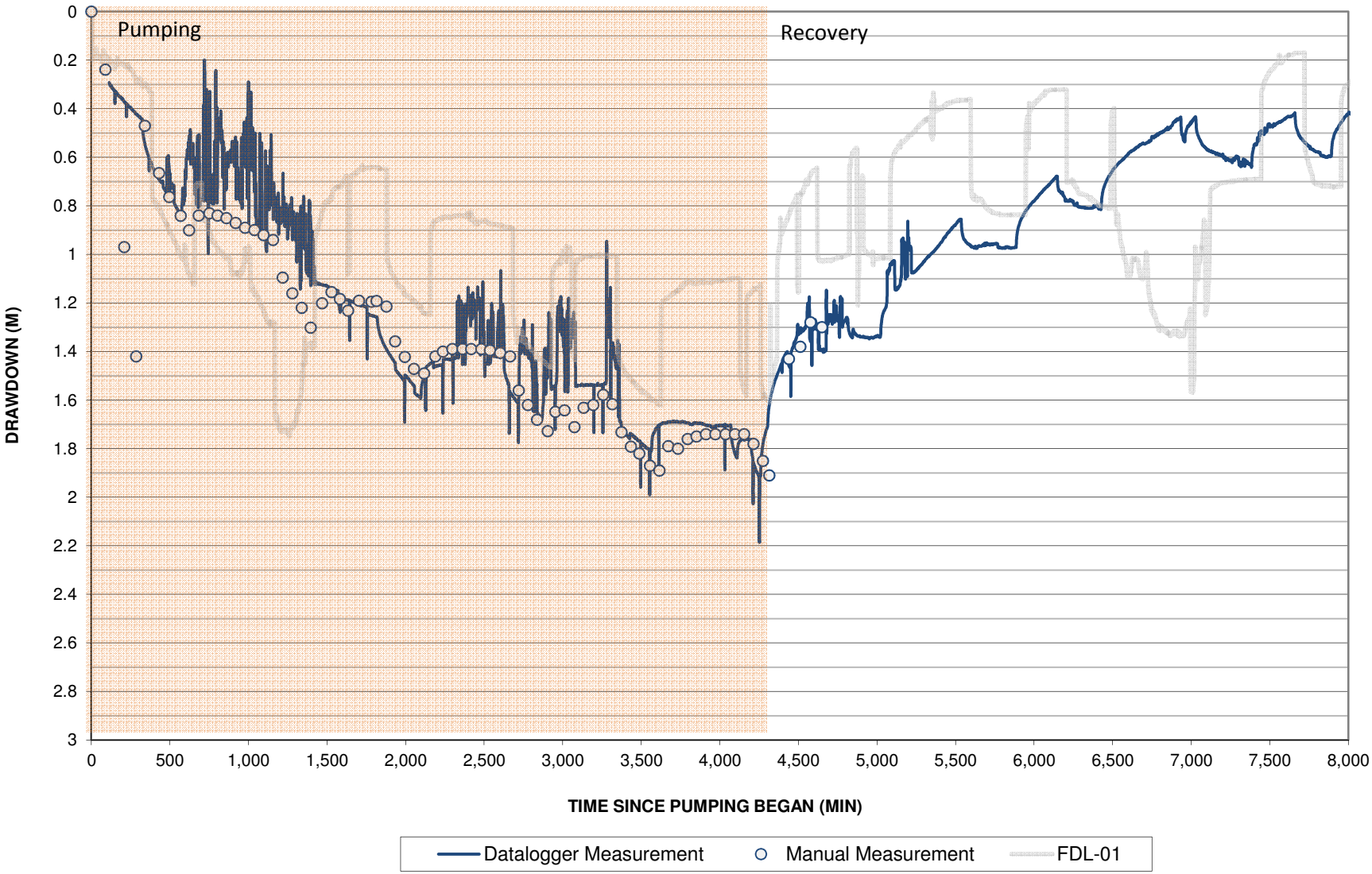


FIGURE H-7: GROUNDWATER HYDROGRAPH FDL-01 (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

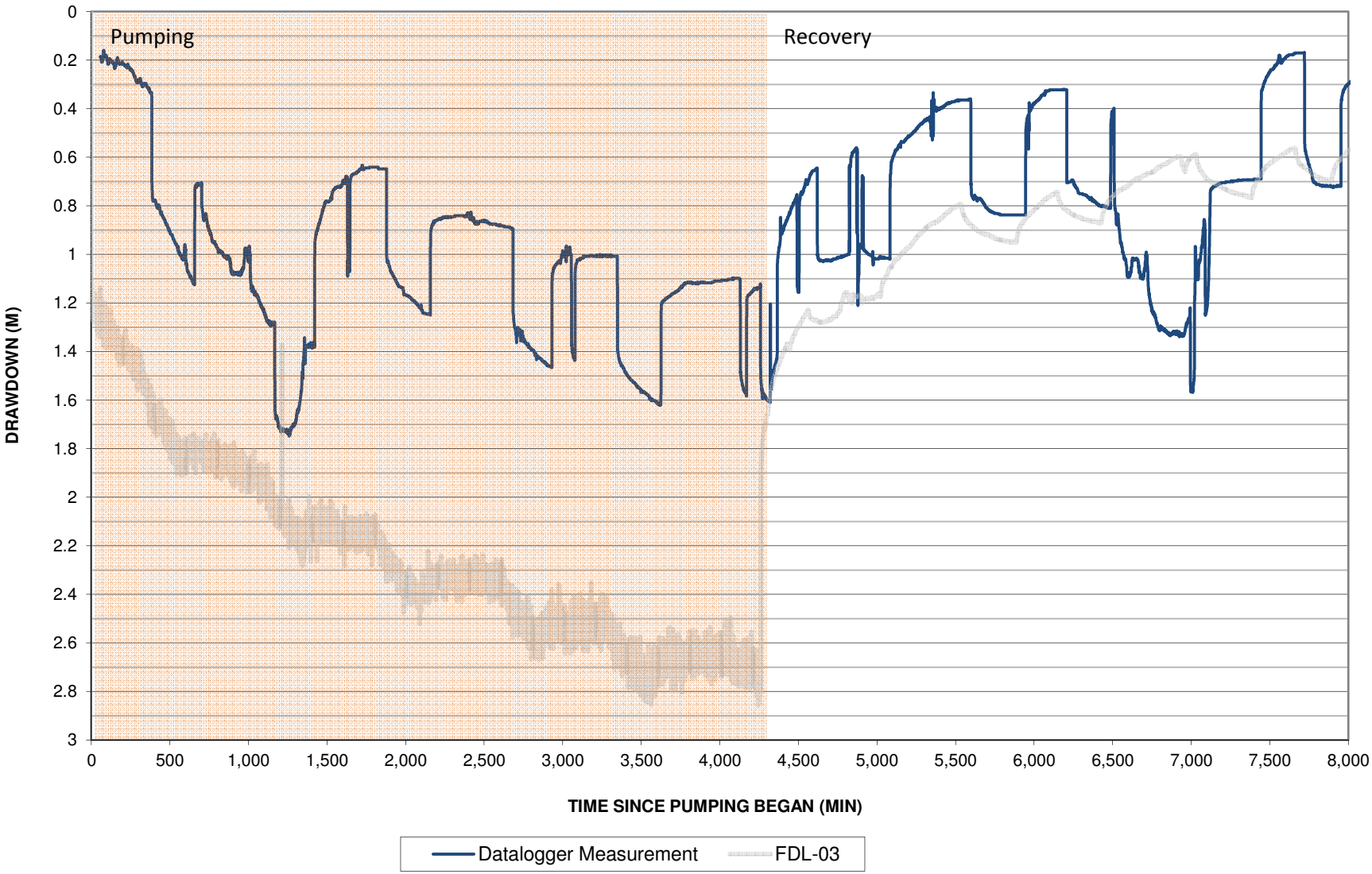


FIGURE H-8: GROUNDWATER HYDROGRAPH - LM-01-03-D (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

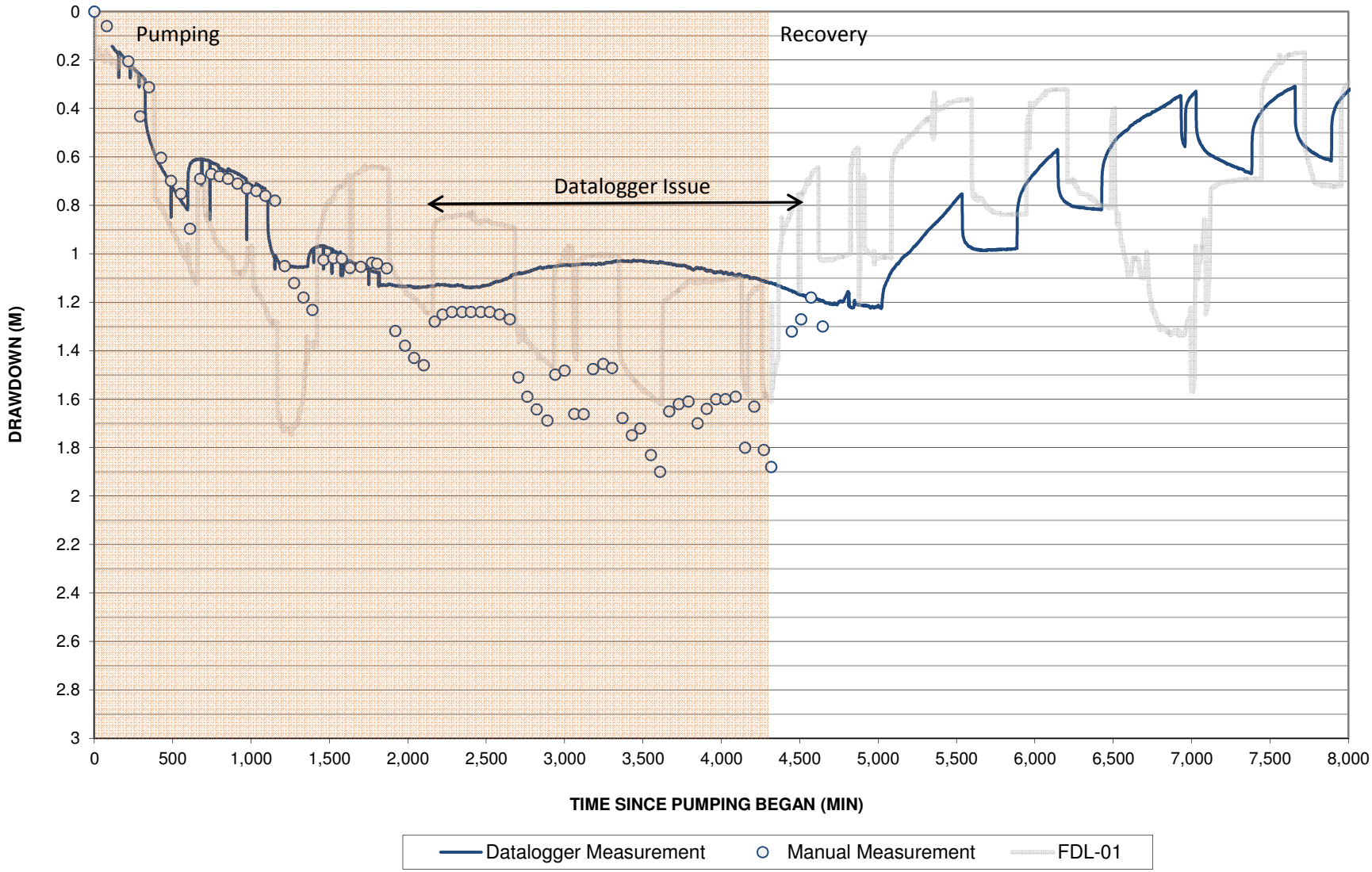


FIGURE H-9: GROUNDWATER HYDROGRAPH - LM-01-03-S (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

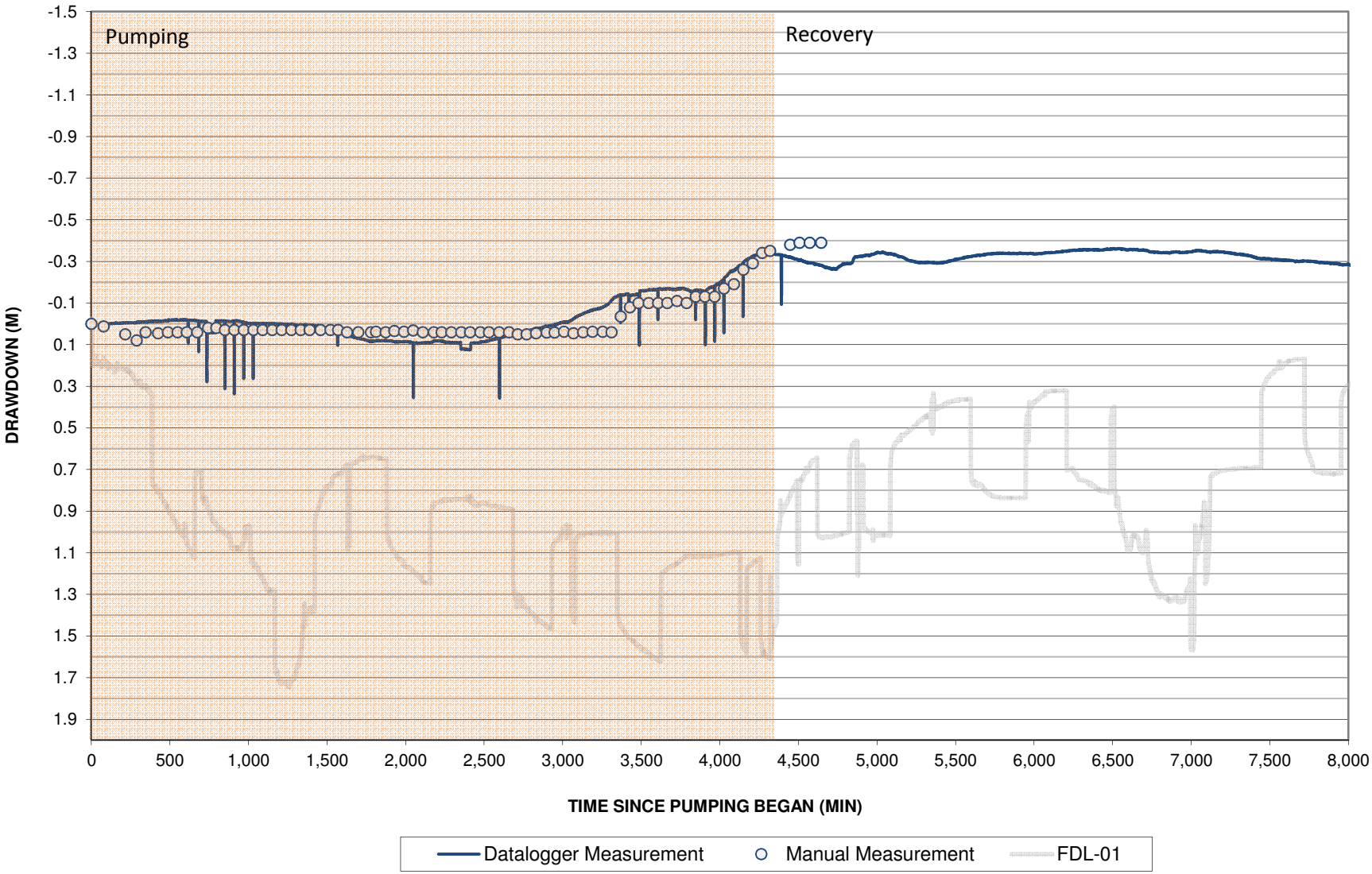


FIGURE H-10: GROUNDWATER HYDROGRAPH - 3606 GOVERNORS (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

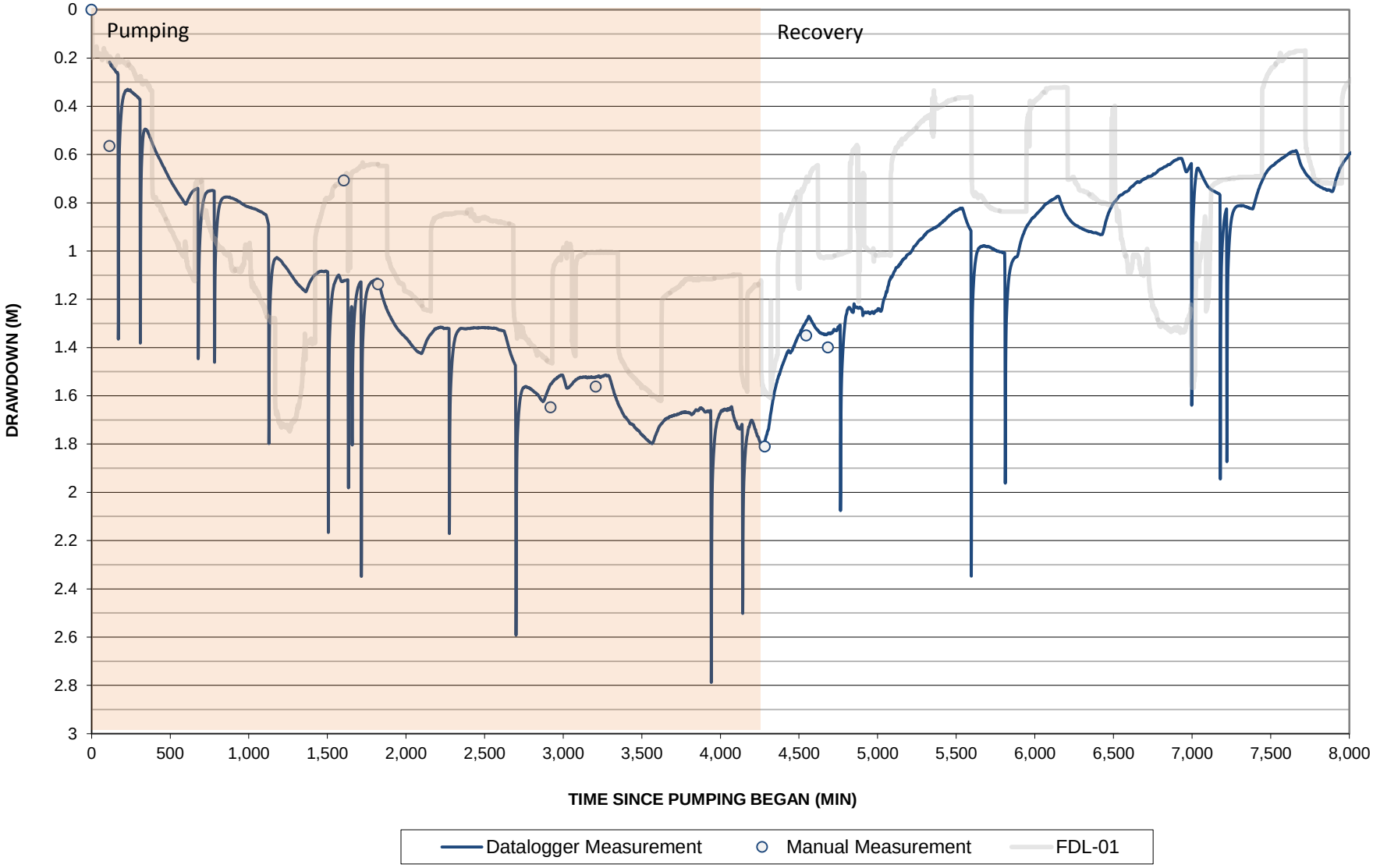


FIGURE H-11: GROUNDWATER HYDROGRAPH - 3586 GOVERNORS (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-02)

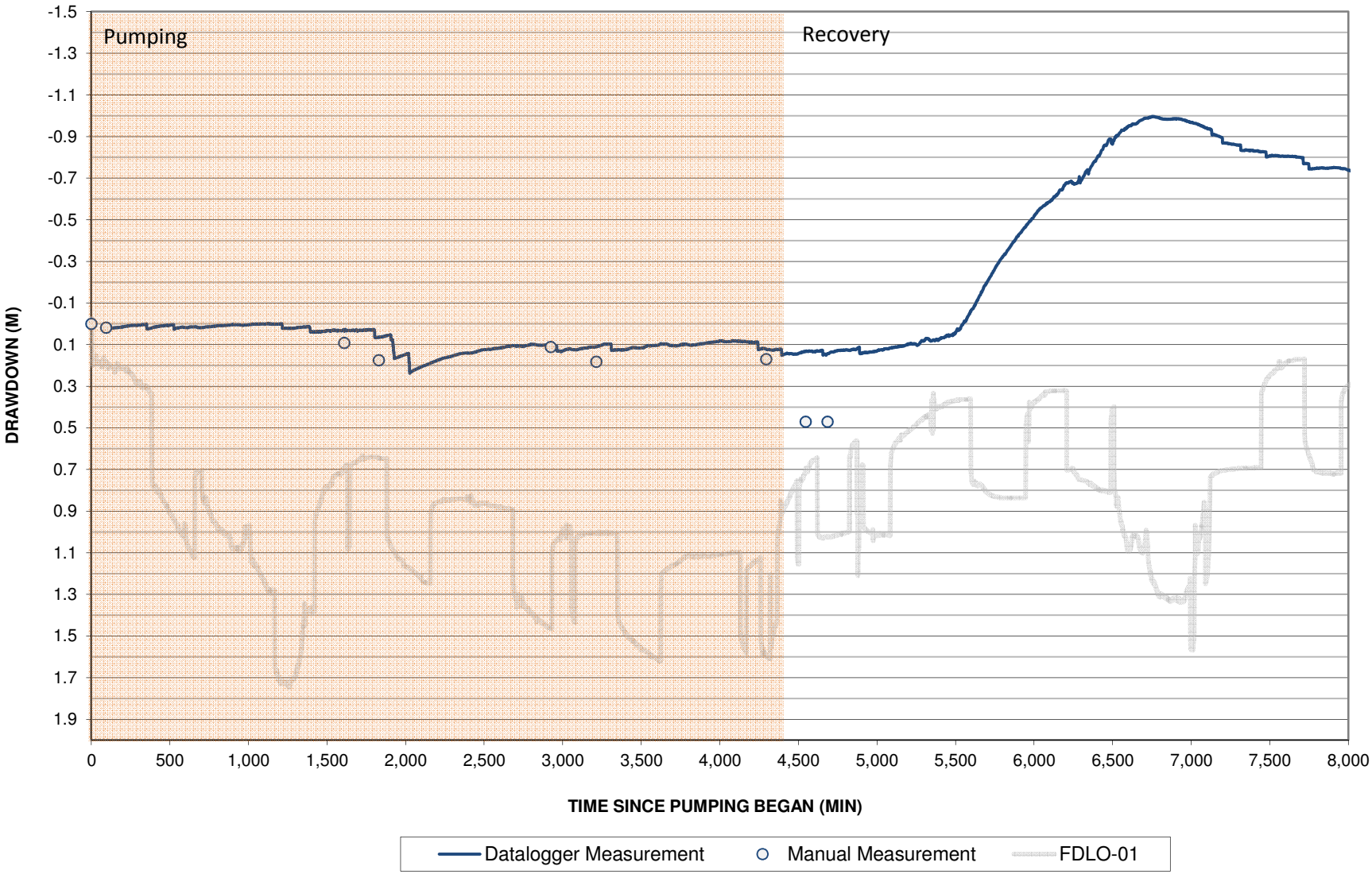


FIGURE H-12: GROUNDWATER HYDROGRAPH - LM-01-08-OB (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

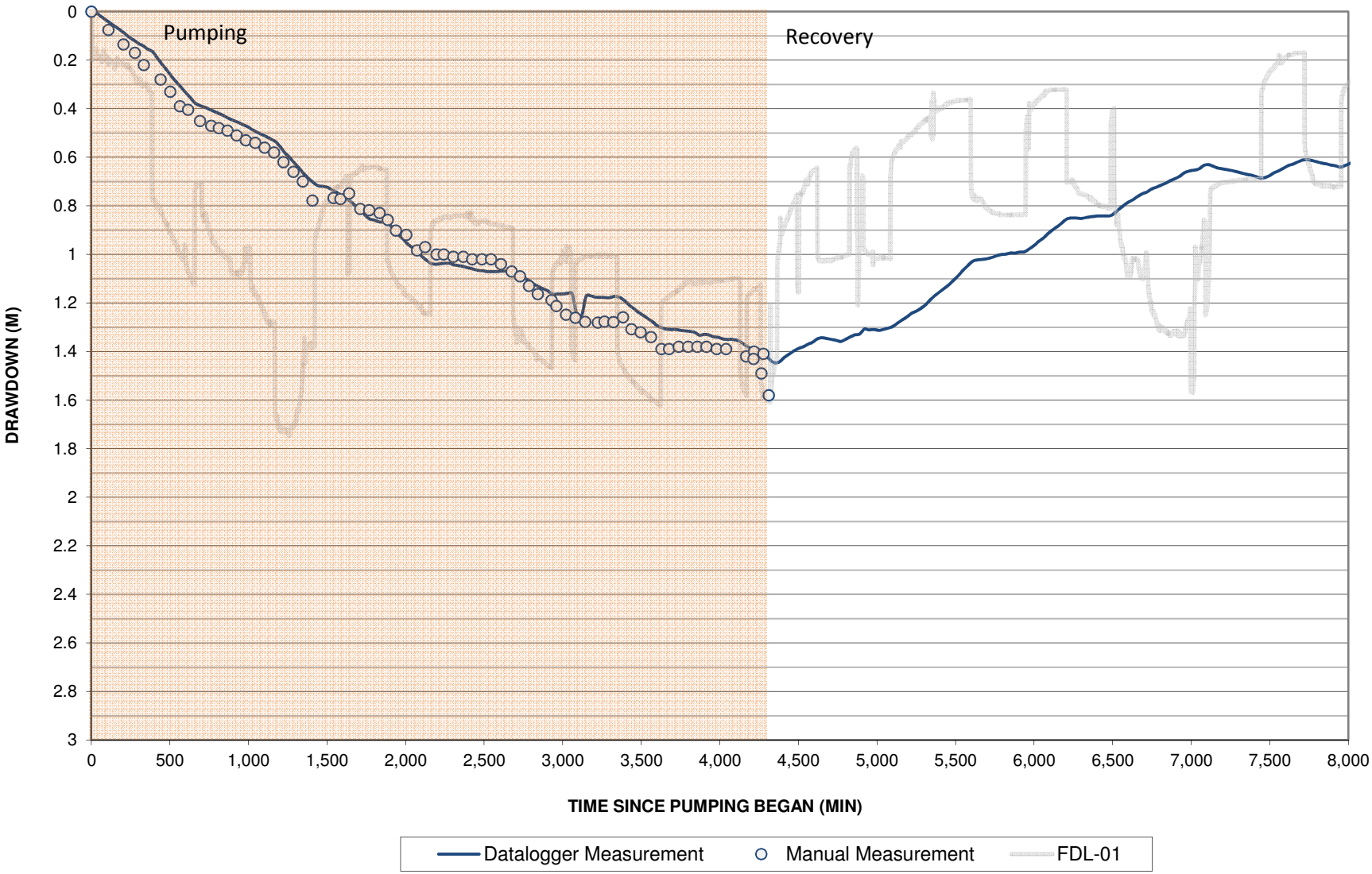


FIGURE H-13: GROUNDWATER HYDROGRAPH - LM-01-08-D (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

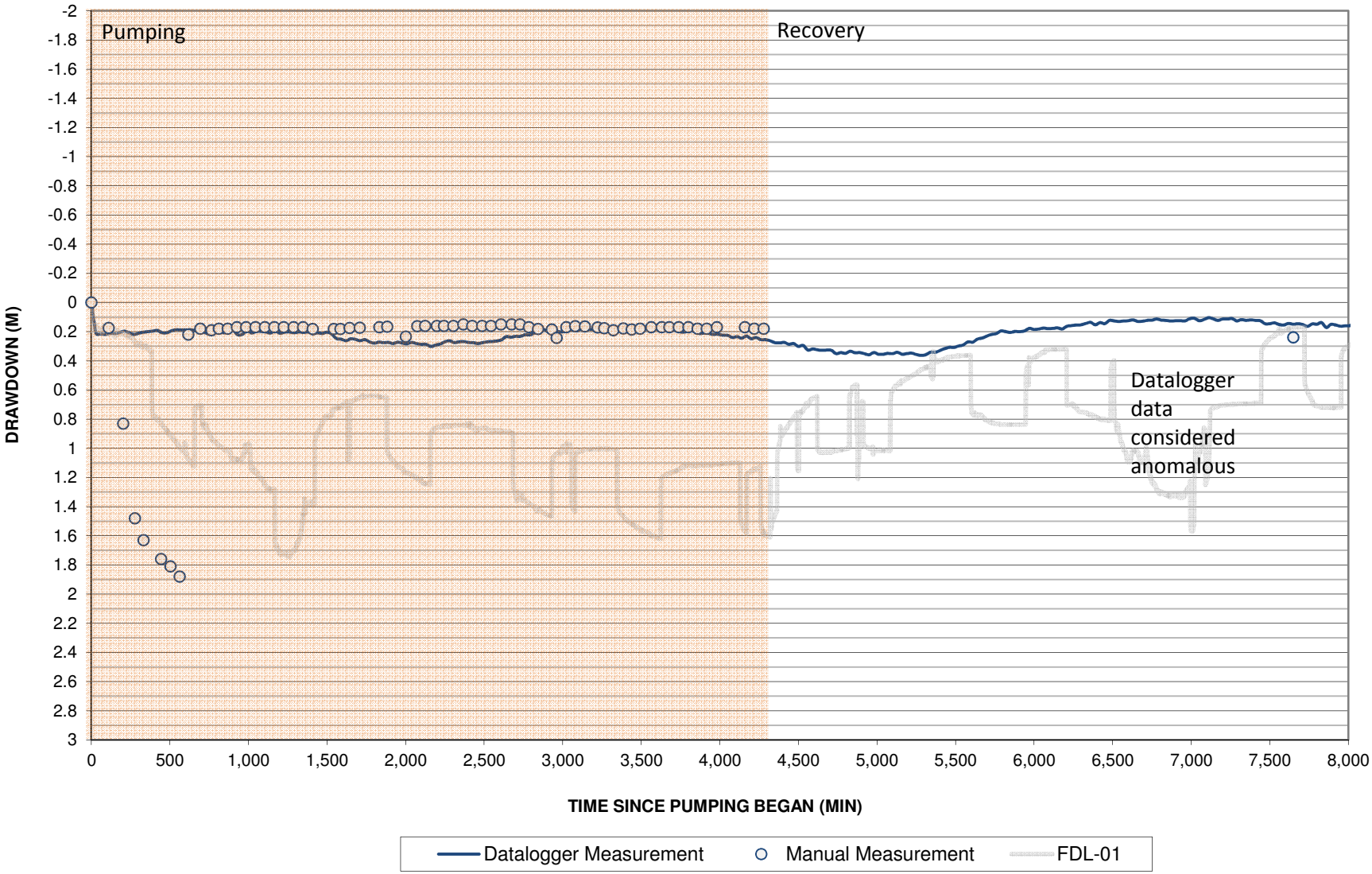


FIGURE H-14: GROUNDWATER HYDROGRAPH - 3826 GOVERNORS (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

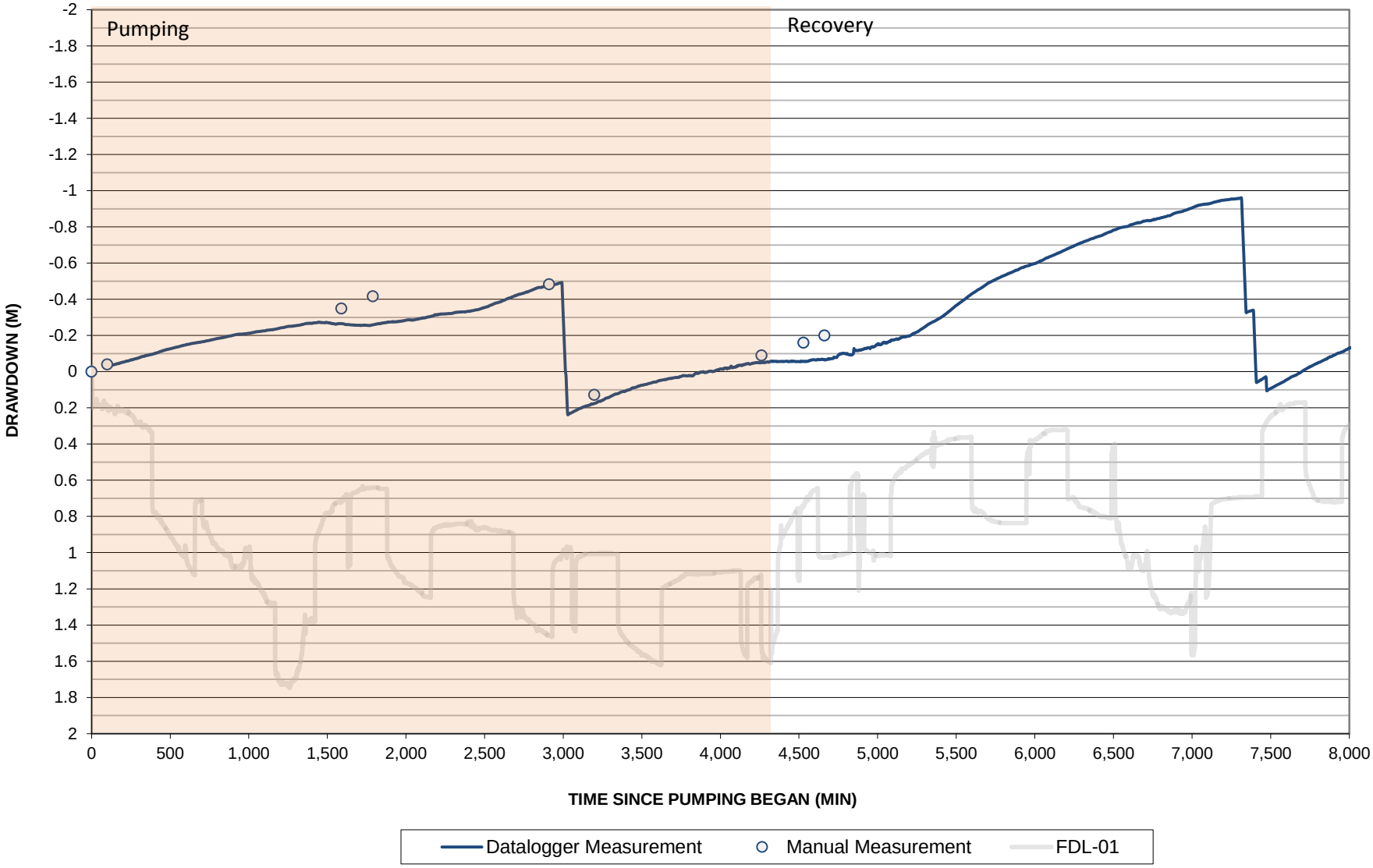


FIGURE H-15: GROUNDWATER HYDROGRAPH - 3830 GOVERNORS (72H TEST)

CITY OF HAMILTON - LYNDEN (FDL-03)

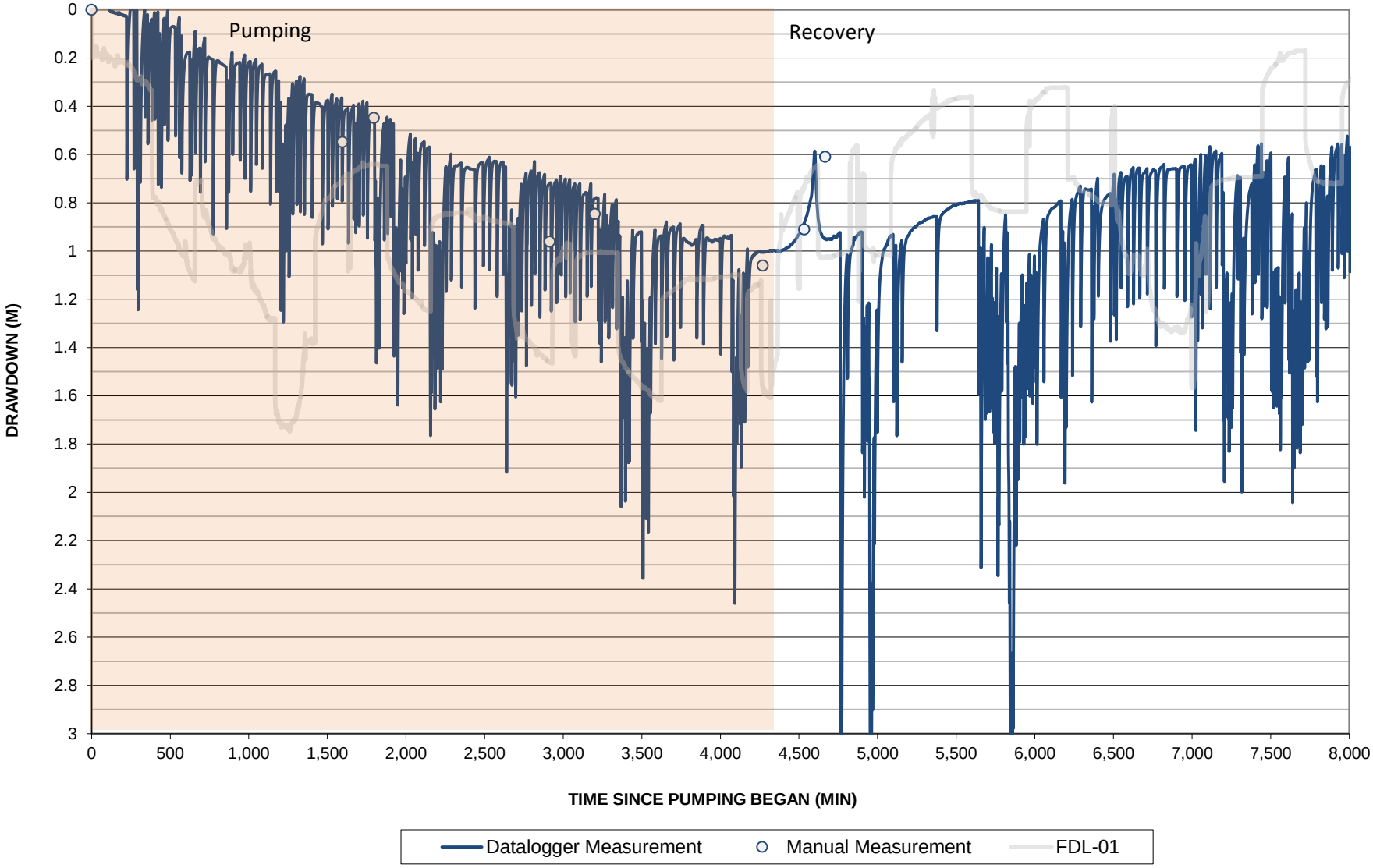


Figure H-16 - Distance Drawdown - 300 Min

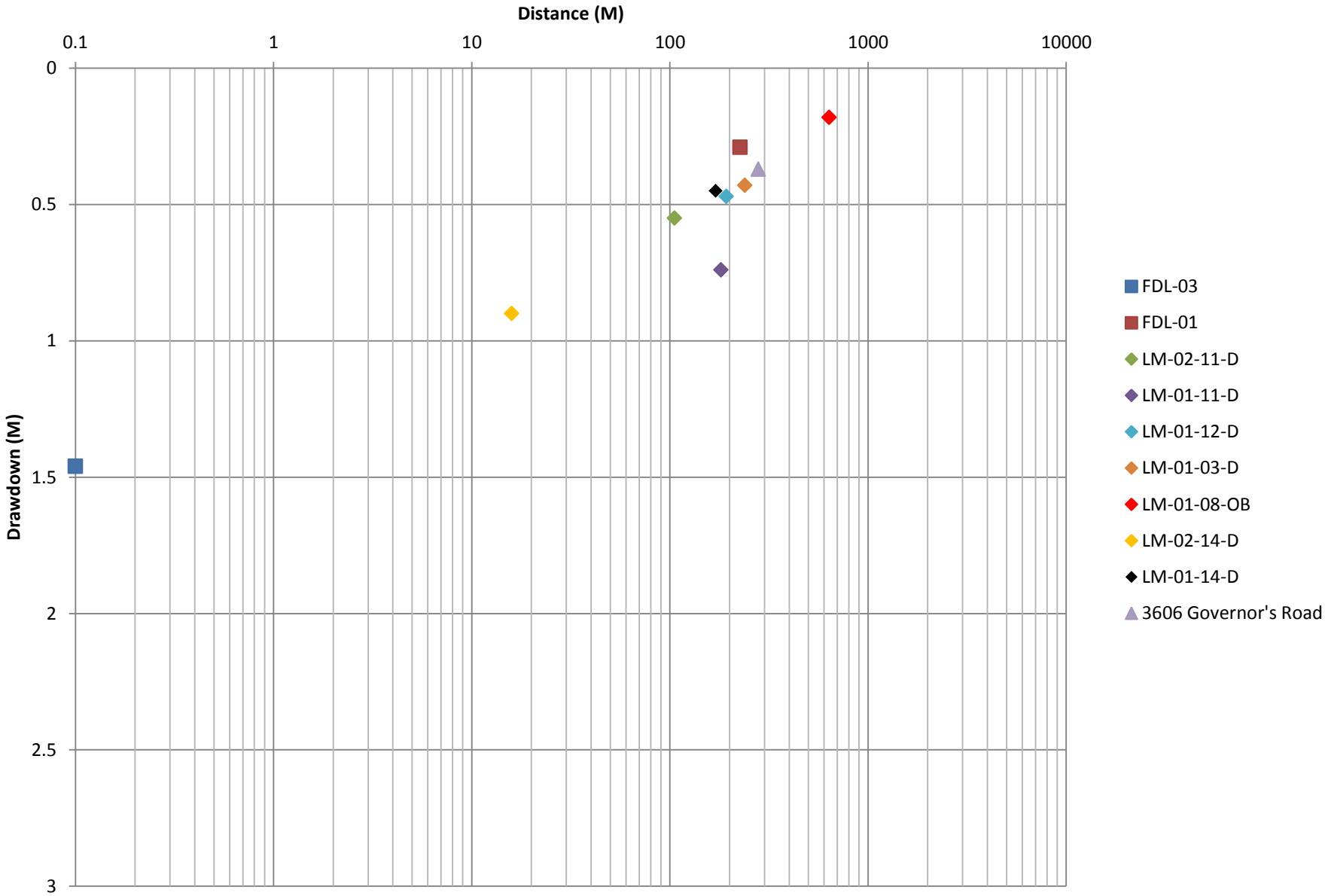


Figure H-17 - Distance Drawdown - End Of Test

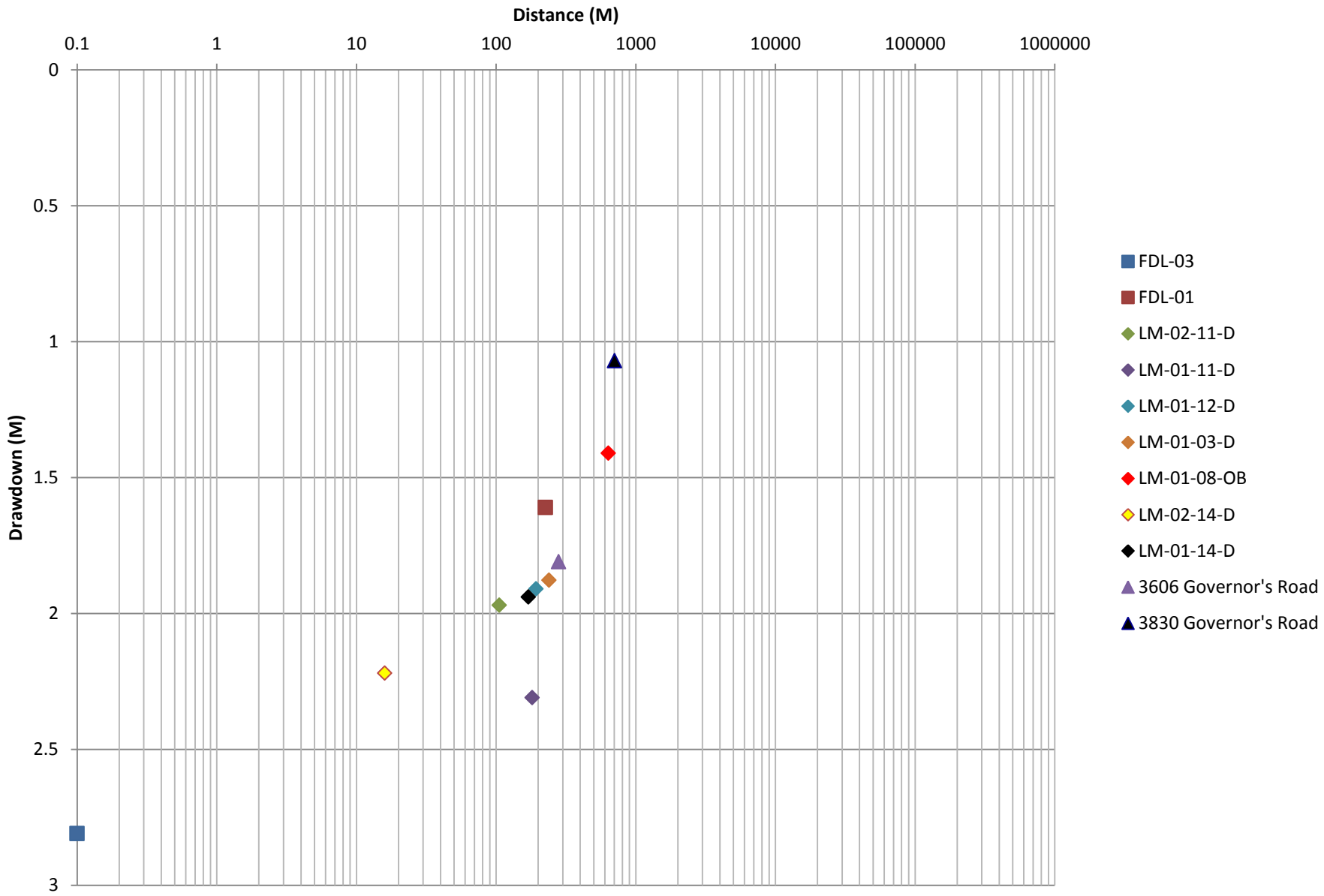


FIGURE H-18

SEMI-LOG PLOT- PUMPING WELL FDL-03

Static Water Level : 15.07 m bmp Well Depth: 51.2 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 0 metres

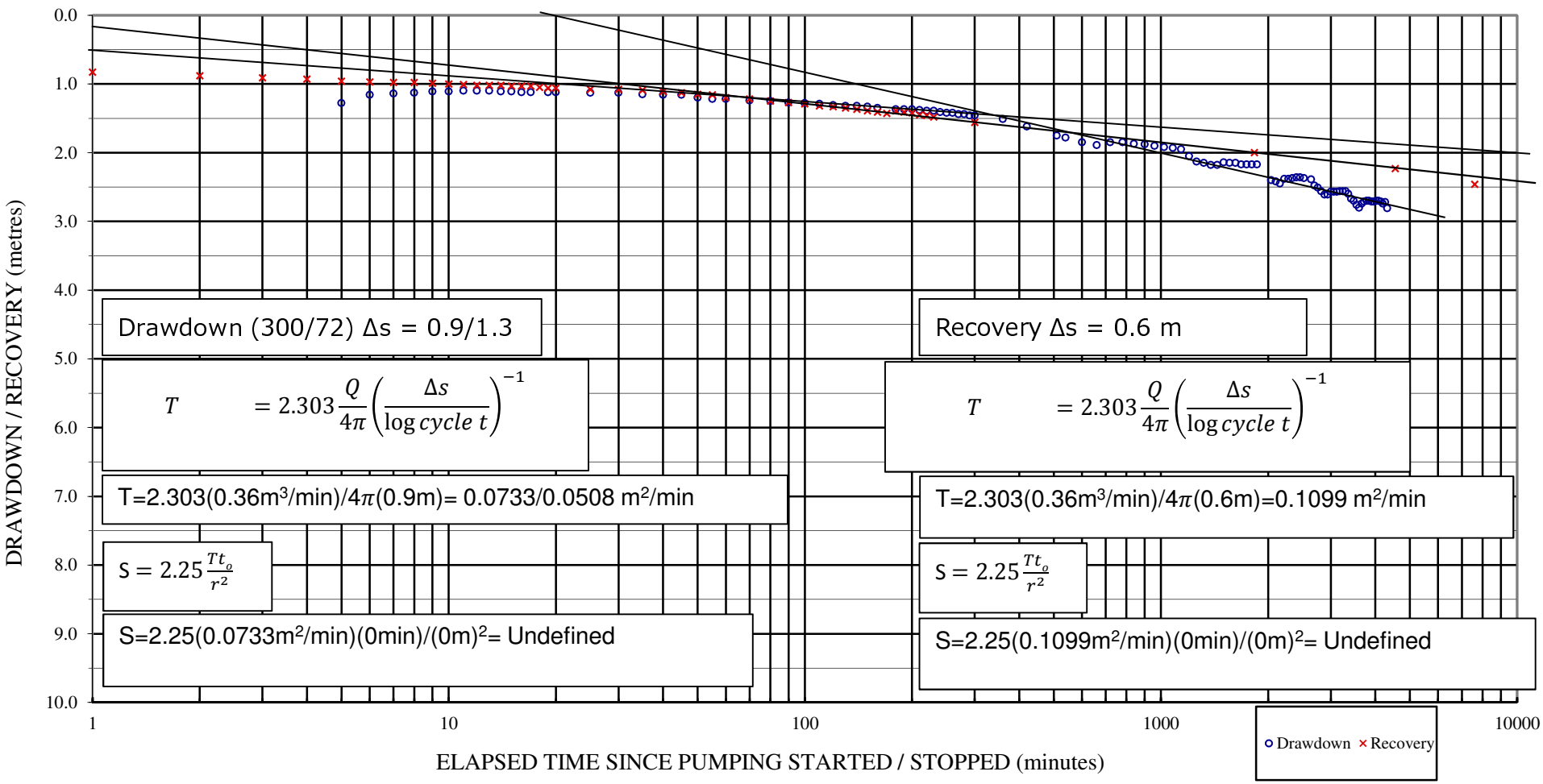


FIGURE H-19

SEMI-LOG PLOT- OBSERVATION WELL LM-02-14-D

Static Water Level : 15.34 m bmp Well Depth: 57.00 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 15 metres

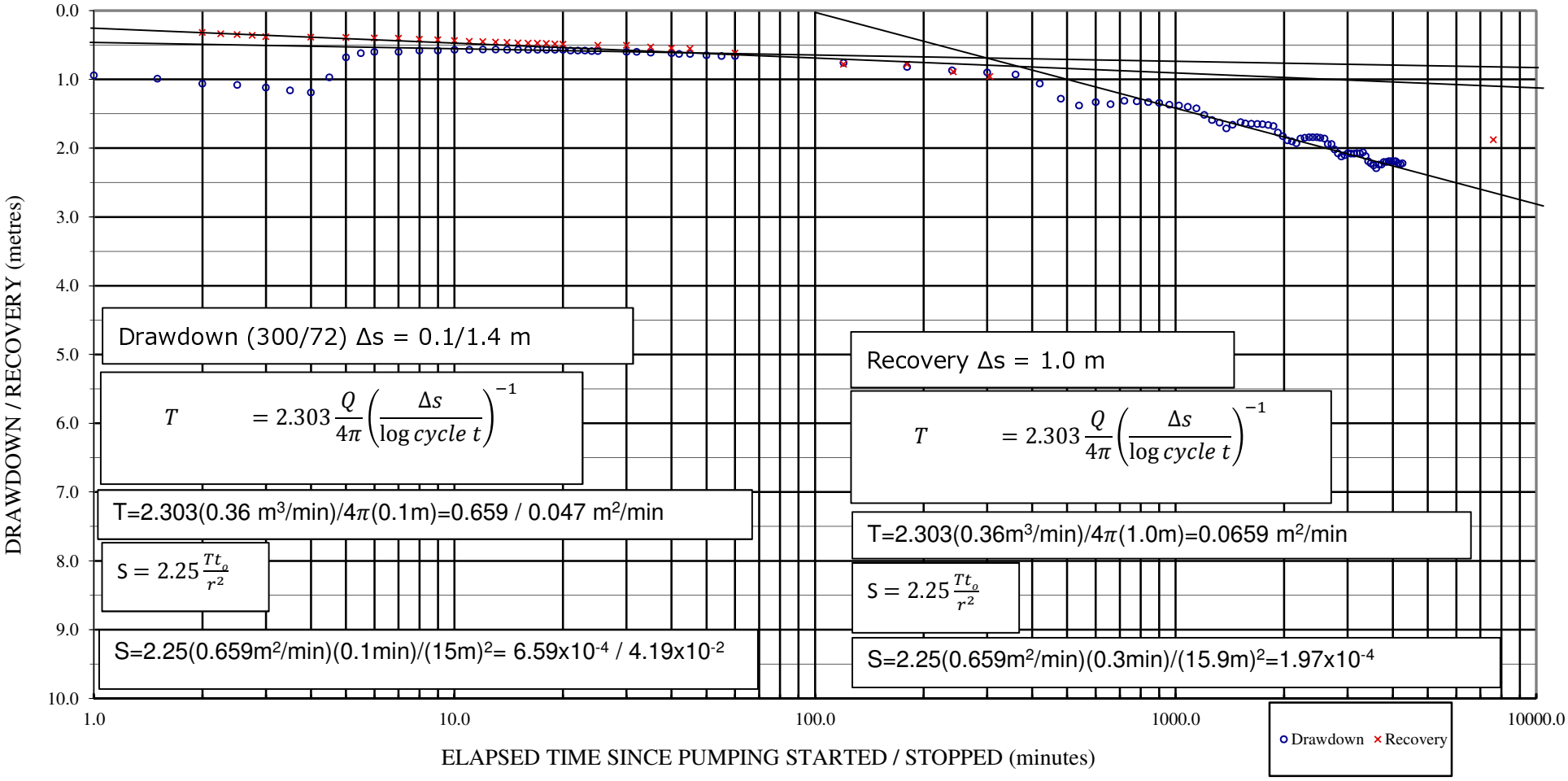


FIGURE H-20

SEMI-LOG PLOT- OBSERVATION WELL LM-02-11-D

Static Water Level : 15.27 m bmp Well Depth: 51.20 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 105 metres

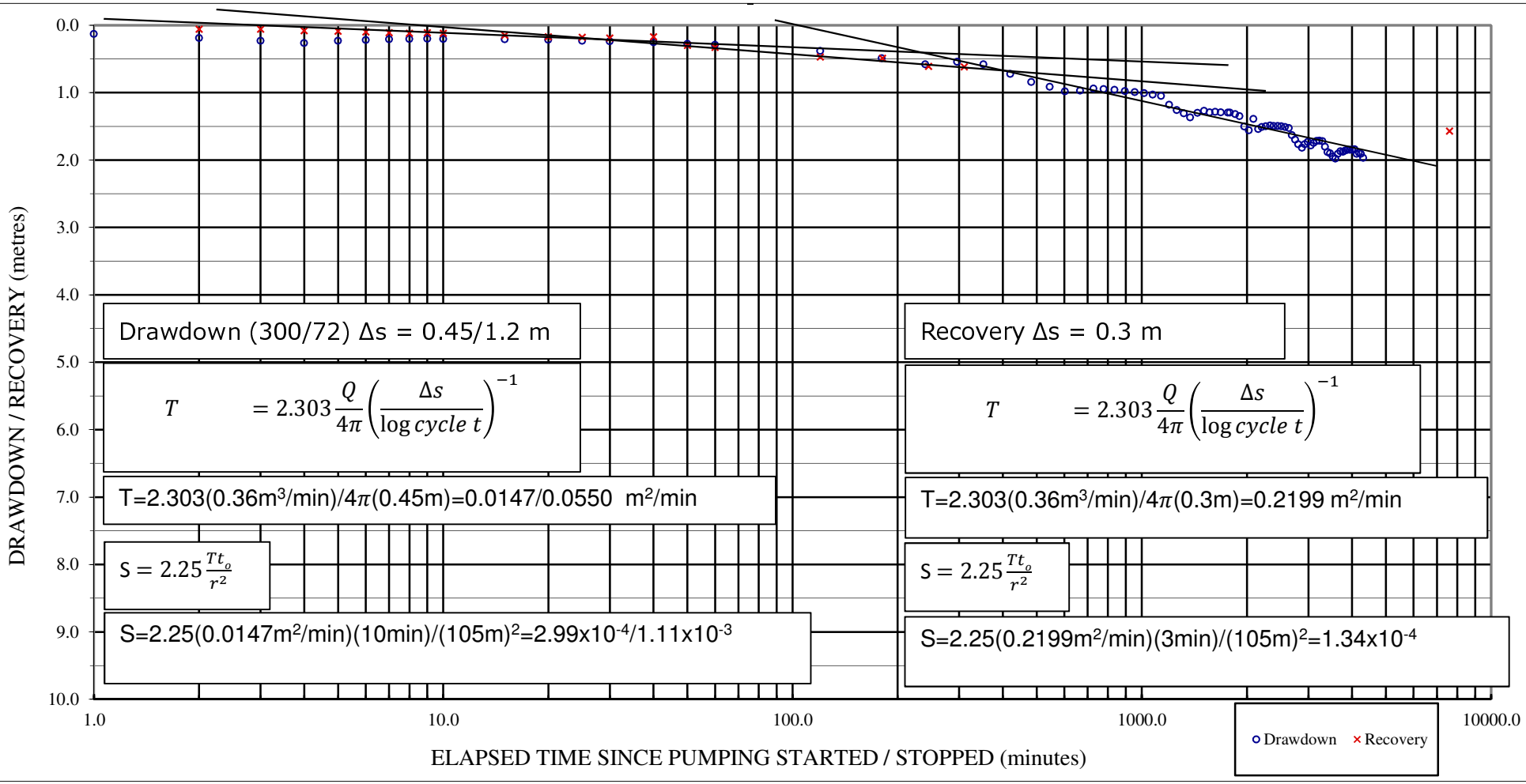


FIGURE H-21

SEMI-LOG PLOT- OBSERVATION WELL LM-01-14-D

Static Water Level : 15.22 m bmp Well Depth: 57.61 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 170 metres

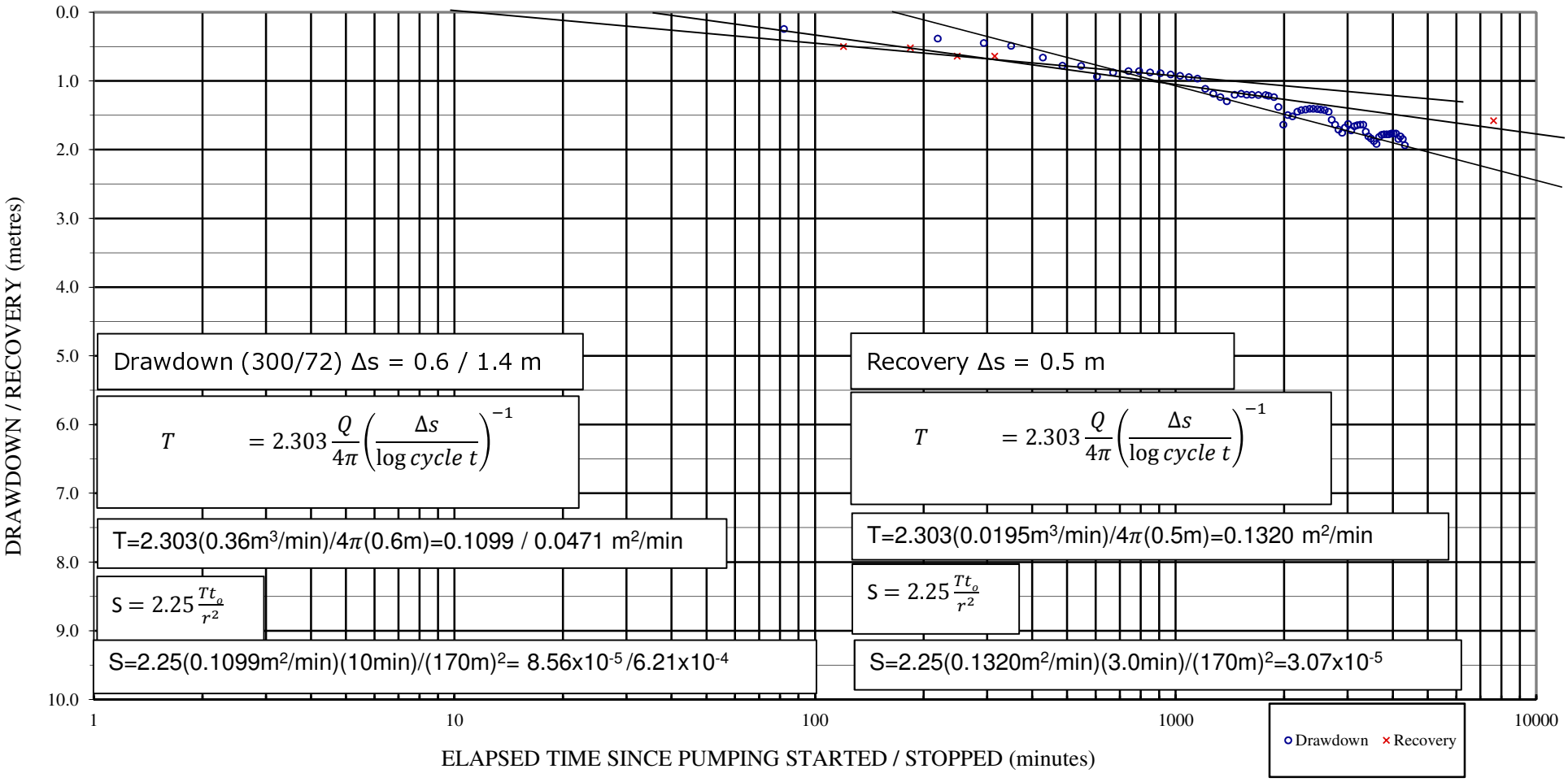


FIGURE H-22

SEMI-LOG PLOT- OBSERVATION WELL LM-01-11-D

Static Water Level : 12.13 m bmp Well Depth: 54.56 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 181 metres

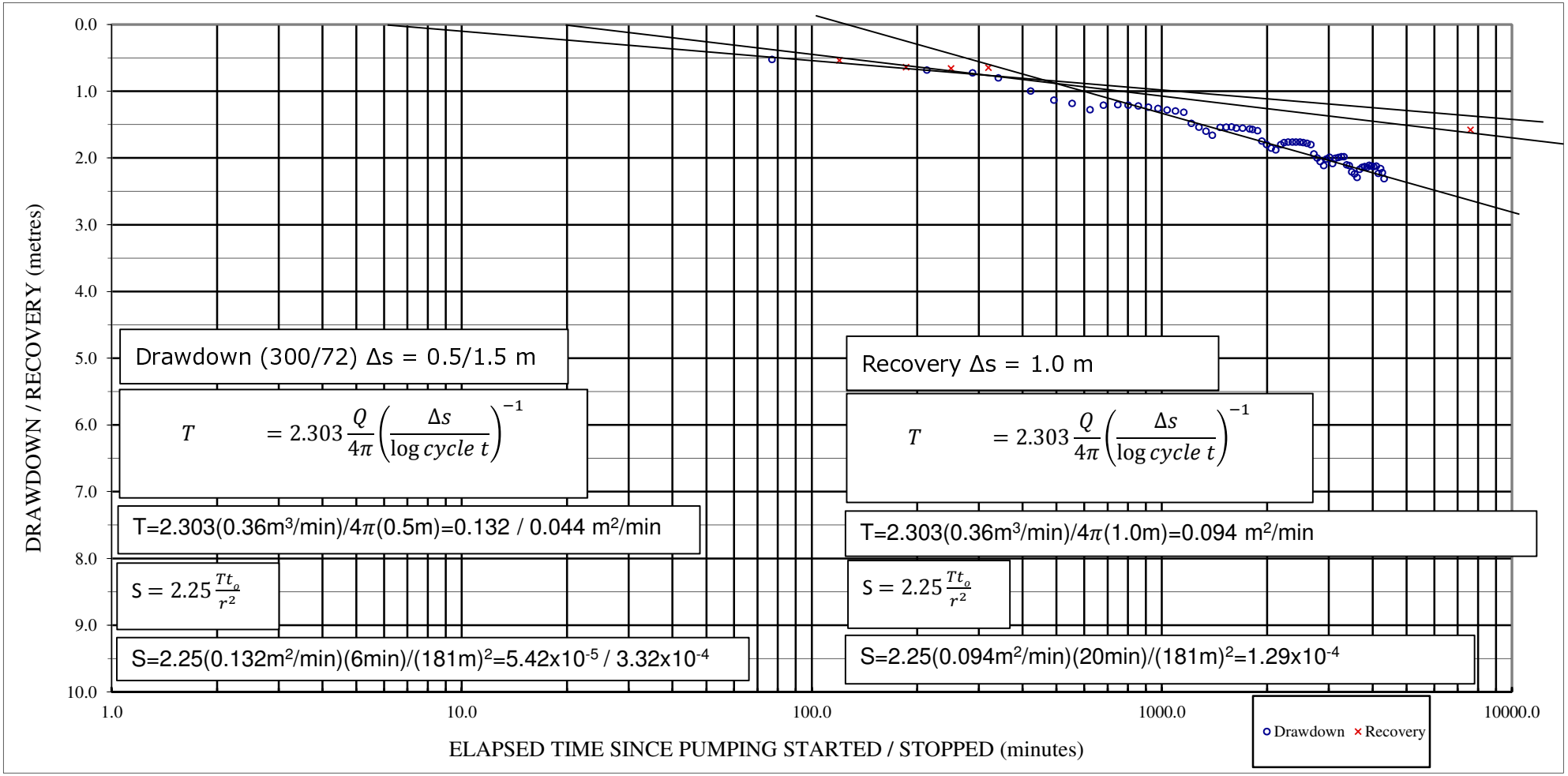


FIGURE H-23

SEMI-LOG PLOT- OBSERVATION WELL LM-01-12-D

Static Water Level : 14.48 m bmp Well Depth: 52.12 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 193 metres

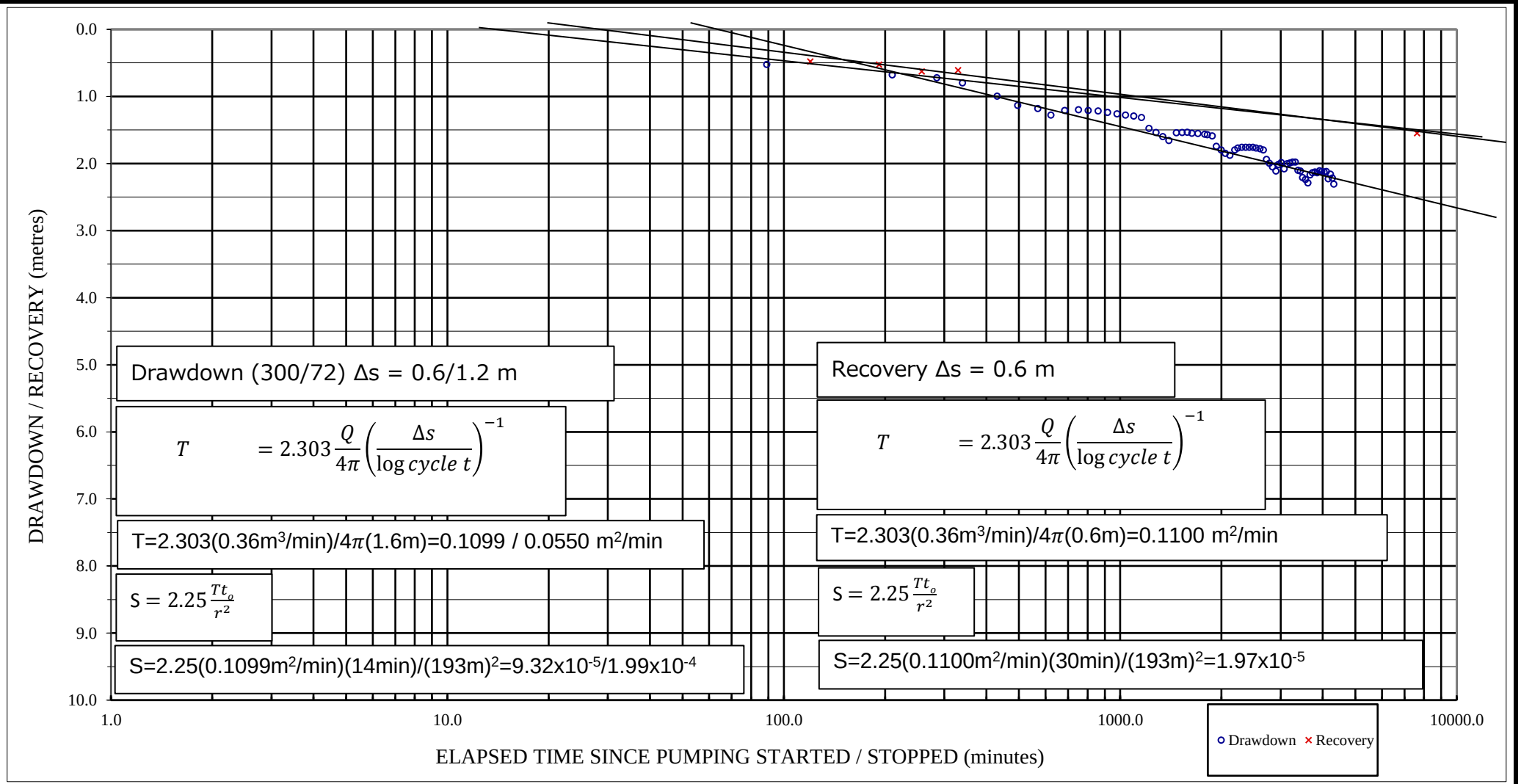


FIGURE H-24

SEMI-LOG PLOT- OBSERVATION WELL LM-01-03D

Static Water Level : 13.09 m bmp Well Depth: 56.67 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 239 metres

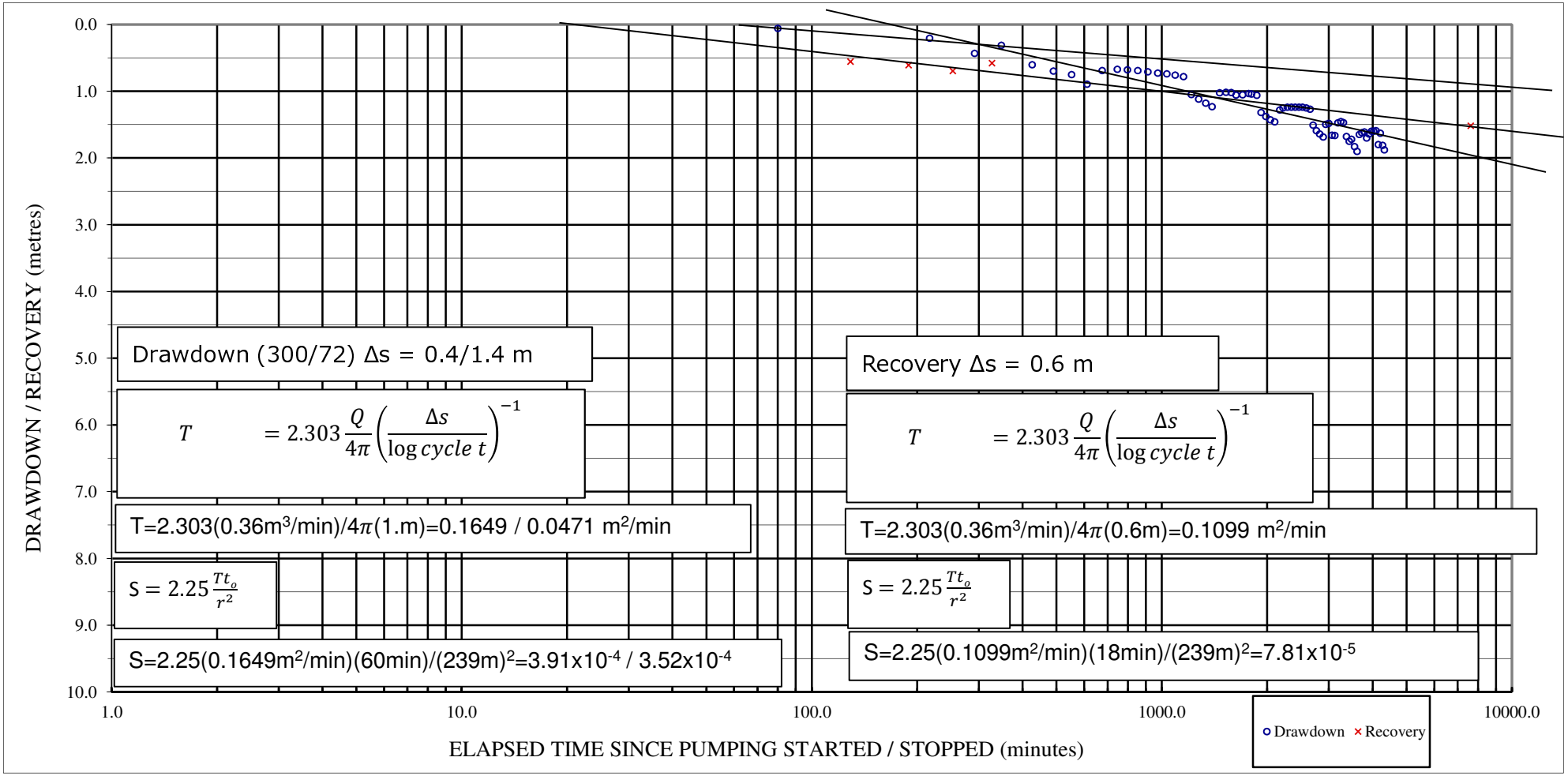


FIGURE H-25

SEMI-LOG PLOT- Private Well 3606 Govenors Road

Static Water Level : 15.43 m bmp Well Depth: 60.96 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 280 metres

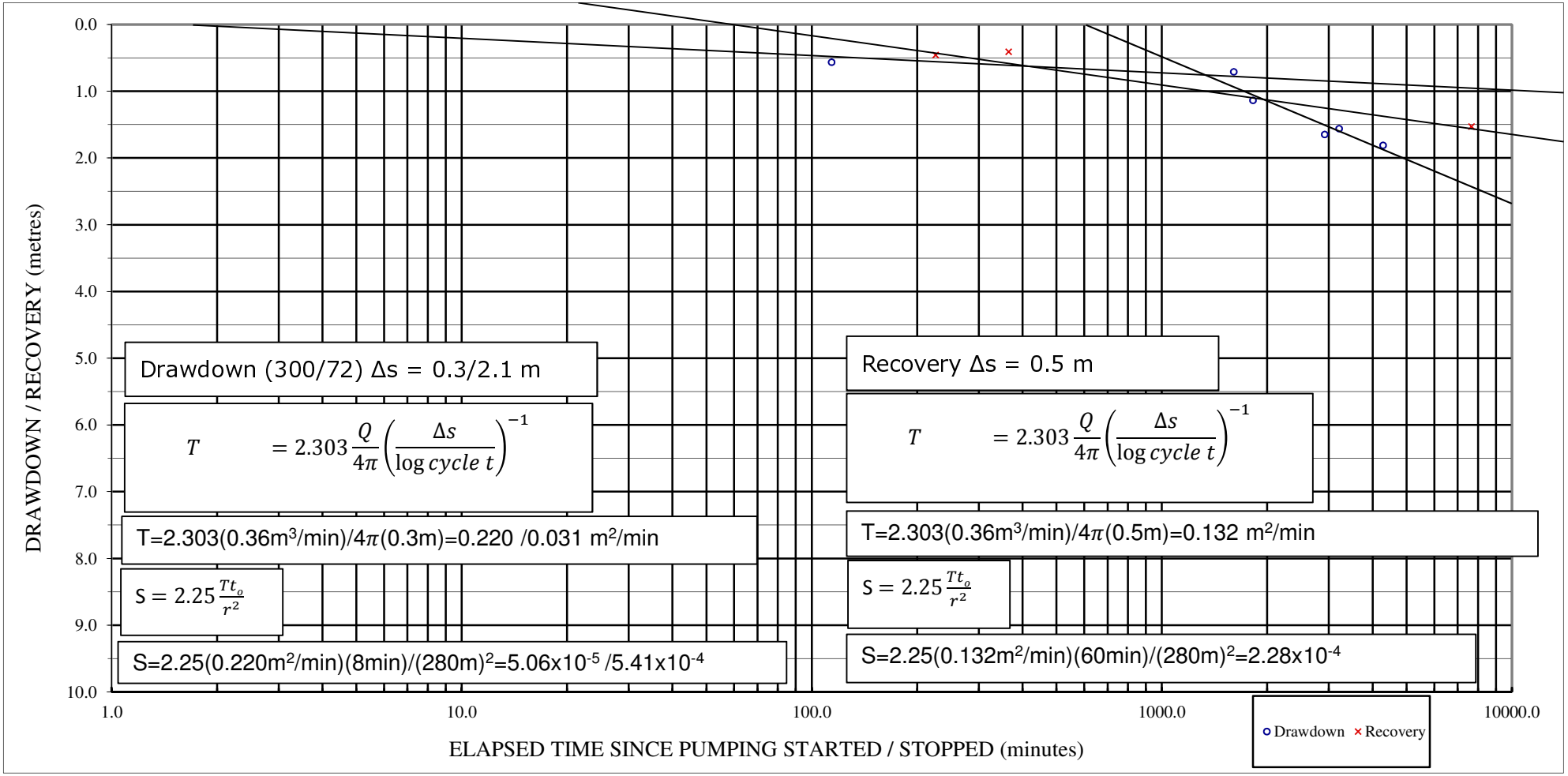


FIGURE H-26

SEMI-LOG PLOT- OBSERVATION WELL LM-01-08-OB

Static Water Level : 11.86 m bmp Well Depth: 52.73 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 637 metres

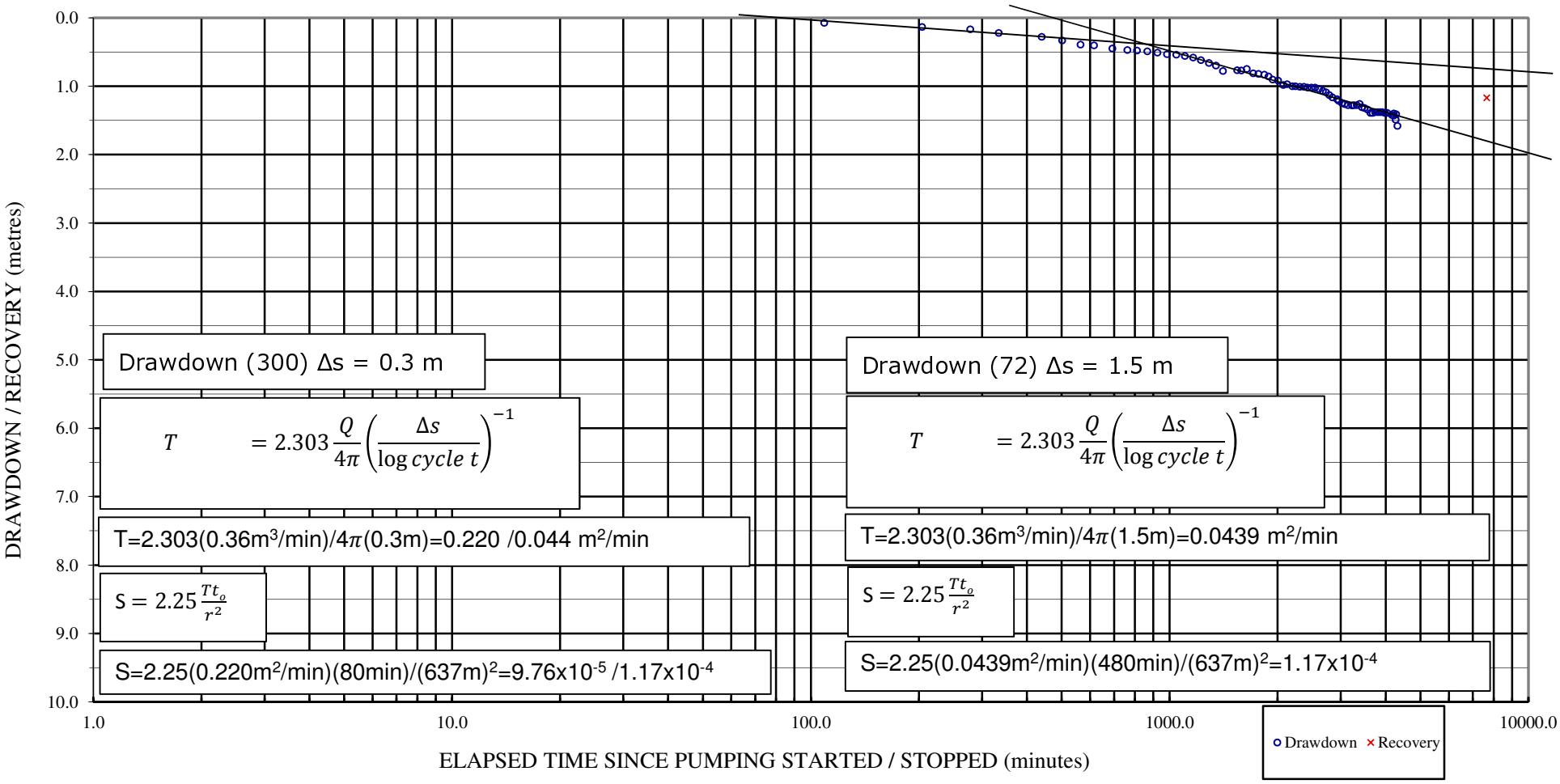


FIGURE H-27

SEMI-LOG PLOT- OBSERVATION WELL LM-01-08D

Static Water Level : 10.82 m bmp Well Depth: 52.73 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 637 metres

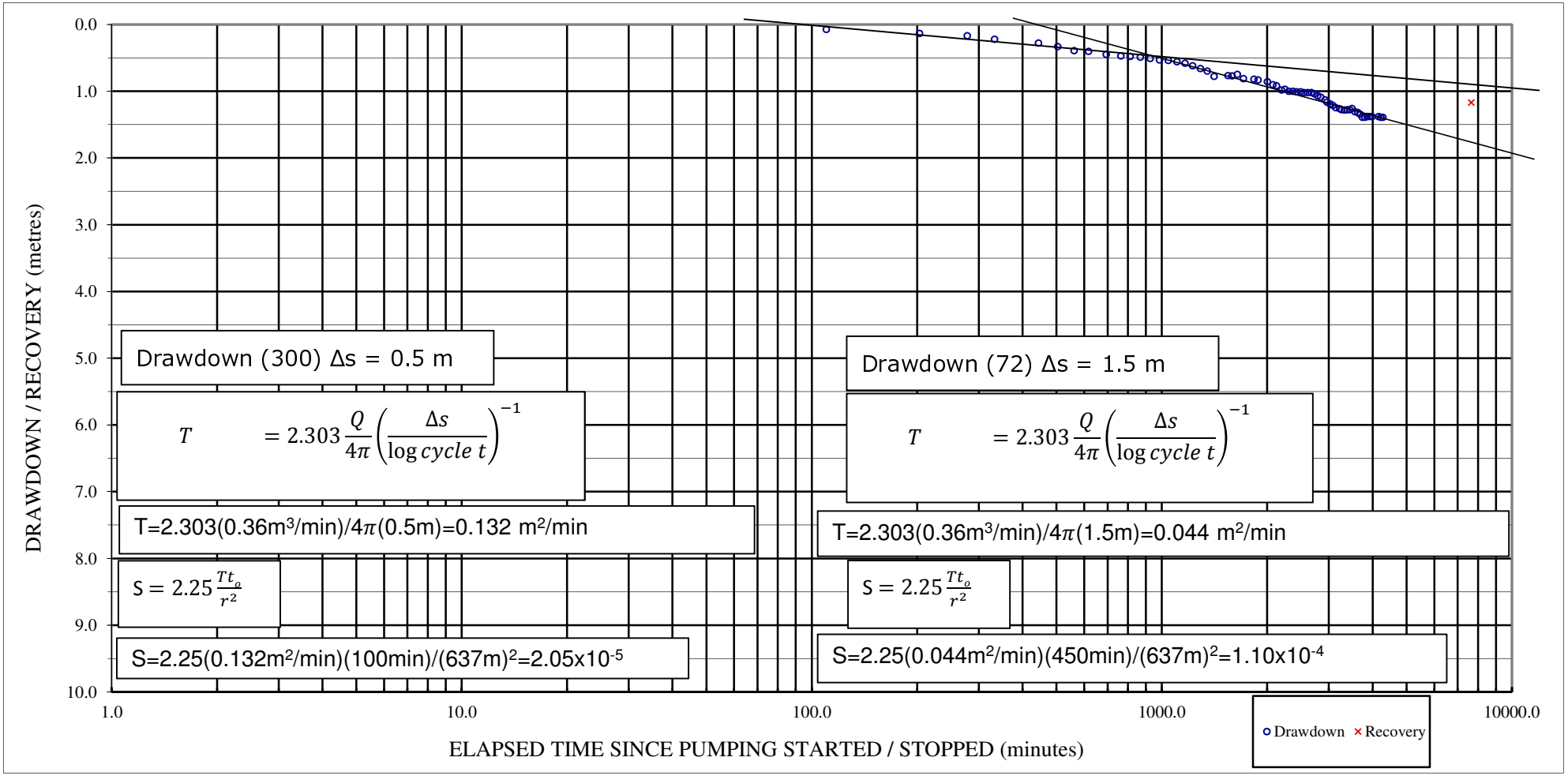


FIGURE H-28

SEMI-LOG PLOT- Private Well 3830 Govenors Road

Static Water Level : 17.49 m bmp Well Depth: 56.39 m bmp Pumping Rate: 360 L/min	Project Name : **72 Hour Aquifer Test at FDL-03** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point L/min - litres per minute	Distance from pumping well = 704 metres

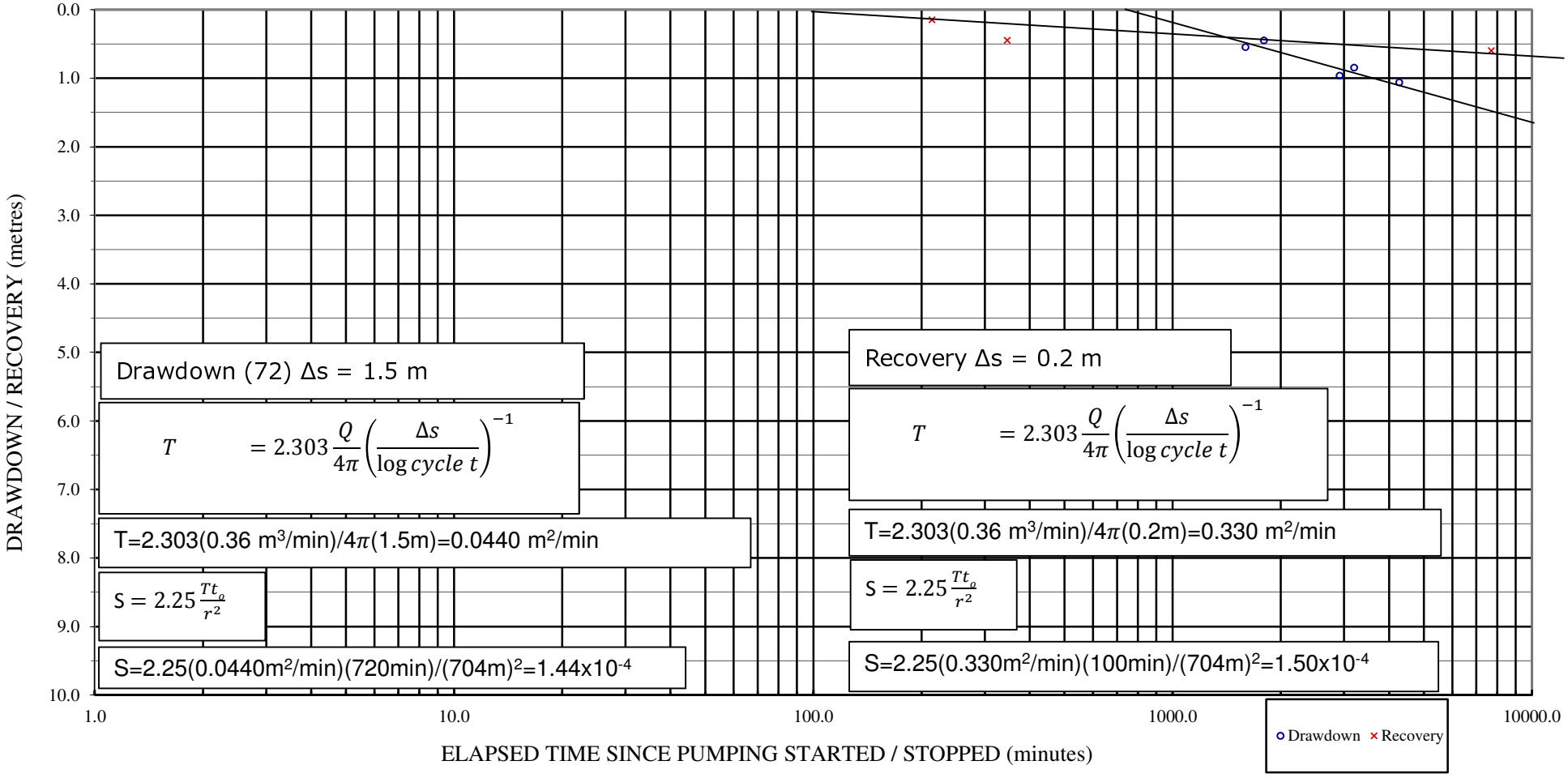


FIGURE H-29

20-YEAR PROJECTION FOR FDL-03

Static Water Level : 15.07 m bgl Well Depth: 51.20 m bgl Pumping Rate: 6.0 L/s	Project Name : **Lynden Wells** Project No : 071-11885-01 Date: 21/3/2016
mbmp - metres below measuring point mbgl - metres below ground level Igpm - Imperial gallons per minute L/sec - litres per second	Distance from pumping well = n/a

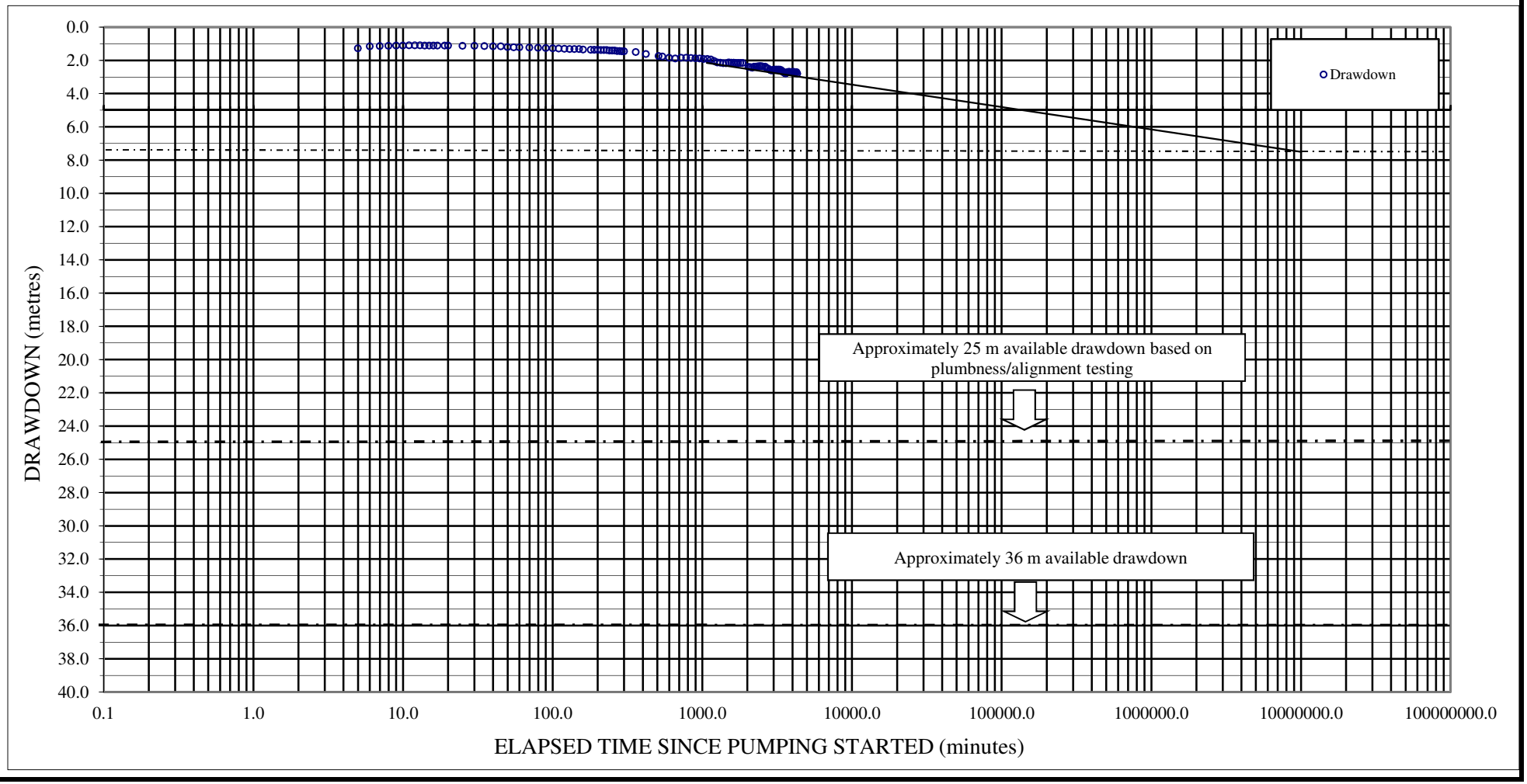


TABLE H-1: PUMPING TEST DATA, LYNDEN WELL FDL-03
72 Hour Aquifer Test at FDL-03
Lynden Wells **071-11885-01**

OW:		DEPTH(m bgl):	51.20	mp (m agl):	0.68
PW:	FDL-03	SWL(m bmp):	15.07	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	200	Distance:	0 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
5	16.35	1.28	1	17.05	0.83	6.0 L/s (95 Usgpm)
6	16.23	1.16	2	17.00	0.88	Starting Totalizer = 24884.2
7	16.21	1.14	3	16.97	0.91	
8	16.20	1.13	4	16.95	0.93	Pump rate adjustment
9	16.18	1.11	5	16.92	0.96	
10	16.18	1.11	6	16.91	0.97	
11	16.17	1.10	7	16.90	0.98	
12	16.17	1.10	8	16.90	0.98	6 L/s
13	16.17	1.10	9	16.89	0.99	
14	16.18	1.11	10	16.88	1.00	
15	16.18	1.11	11	16.87	1.01	
16	16.19	1.12	12	16.86	1.02	
17	16.19	1.12	13	16.86	1.02	
19	16.19	1.12	14	16.86	1.02	
20	16.19	1.12	15	16.85	1.03	
25	16.20	1.13	16	16.85	1.03	
30	16.20	1.13	17	16.85	1.03	
35	16.22	1.15	18	16.83	1.05	
40	16.23	1.16	19	16.82	1.06	
45	16.23	1.16	20	16.82	1.06	
50	16.27	1.20	25	16.80	1.08	Flow adjustment
55	16.29	1.22	30	16.80	1.08	
60	16.29	1.22	35	16.79	1.09	Water Quality Sample 1hr
70	16.31	1.24	40	16.77	1.11	
80	16.32	1.25	45	16.75	1.13	
90	16.34	1.27	50	16.73	1.15	
100	16.35	1.28	55	16.72	1.16	
110	16.36	1.29	60	16.68	1.20	
120	16.38	1.31	70	16.66	1.22	
130	16.39	1.32	80	16.63	1.25	
140	16.39	1.32	90	16.61	1.27	
150	16.40	1.33	100	16.59	1.29	
160	16.42	1.35	110	16.56	1.32	
180	16.44	1.37	120	16.55	1.33	
190	16.44	1.37	130	16.53	1.35	
200	16.44	1.37	140	16.51	1.37	
210	16.45	1.38	150	16.49	1.39	
220	16.46	1.39	160	16.47	1.41	
230	16.46	1.39	170	16.45	1.43	
240	16.48	1.41	180	16.49	1.39	
250	16.49	1.42	190	16.47	1.41	
260	16.49	1.42	200	16.46	1.42	
270	16.51	1.44	210	16.43	1.45	
280	16.51	1.44	220	16.42	1.46	
290	16.53	1.46	230	16.40	1.48	
300	16.53	1.46	300	16.32	1.56	

TABLE H-1: PUMPING TEST DATA, LYNDEN WELL FDL-03
72 Hour Aquifer Test at FDL-03
Lynden Wells **071-11885-01**

OW:		DEPTH(m bgl):	51.20	mp (m agl):	0.68
PW:	FDL-03	SWL(m bmp):	15.07	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	200	Distance:	0 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
360	16.58	1.51	1830	15.88	2.00	
420	16.69	1.62	4550	15.65	2.23	FDL01 on
510	16.82	1.75	7605	15.42	2.46	FDL01 on
540	16.85	1.78				
600	16.92	1.85				
660	16.96	1.89				
720	16.92	1.85				
780	16.92	1.85				
840	16.94	1.87				
900	16.95	1.88				
960	16.97	1.90				
1020	16.99	1.92				
1080	17.00	1.93				
1140	17.02	1.95				
1200	17.12	2.05				
1260	17.20	2.13				
1320	17.22	2.15				
1380	17.25	2.18				
1440	17.25	2.18				Water Quality Sample 24 hr
1500	17.21	2.14				
1560	17.22	2.15				
1620	17.22	2.15				
1680	17.24	2.17				
1740	17.24	2.17				
1800	17.24	2.17				
1860	17.24	2.17				
2040	17.47	2.40				
2100	17.49	2.42				
2160	17.52	2.45				
2220	17.45	2.38				
2280	17.45	2.38				
2340	17.44	2.37				
2400	17.43	2.36				
2460	17.43	2.36				
2520	17.44	2.37				
2640	17.46	2.39				
2700	17.55	2.48				
2760	17.58	2.51				
2820	17.63	2.56				
2880	17.68	2.61				Water Quality Sample 48 hr
2940	17.68	2.61				
3000	17.64	2.57				
3060	17.64	2.57				

TABLE H-1: PUMPING TEST DATA, LYNDEN WELL FDL-03
72 Hour Aquifer Test at FDL-03
Lynden Wells

071-11885-01

OW:		DEPTH(m bgl):	51.20	mp (m agl):	0.68
PW:	FDL-03	SWL(m bmp):	15.07	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	200	Distance:	0 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
3120	17.64	2.57				
3180	17.63	2.56				
3240	17.63	2.56				
3300	17.63	2.56				
3360	17.67	2.6				
3420	17.74	2.67				
3480	17.77	2.7				
3540	17.83	2.76				
3600	17.87	2.8				Water Quality Sample 60 hr
3660	17.81	2.74				
3720	17.78	2.71				
3780	17.77	2.7				
3840	17.77	2.7				
3900	17.78	2.71				
3960	17.78	2.71				
4020	17.77	2.7				
4080	17.77	2.7				
4140	17.78	2.71				
4200	17.81	2.74				
4260	17.79	2.72				ODWS Water Quality Sample
4320	17.88	2.81				Pump shut down.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-2: PUMPING TEST DATA, LYNDEN WELL LM-02-14-D

72 Hour Aquifer Test at FDL-03

Lynden Wells

071-11885-01

OW:	LM-02-14-D	DEPTH(m bgl):	57.00	mp (m agl):	0.89
PW:	FDL-03	SWL(m bmp):	15.34	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	150	Distance:	15 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
0.50	16.21	0.87	2	17.24	0.32	6.0 L/s (95 Usgpm)
1.00	16.28	0.94	2.25	17.22	0.34	
1.5	16.33	0.99	3	17.21	0.35	
2.00	16.40	1.06	2.75	17.20	0.36	
2.50	16.42	1.08	3	17.18	0.38	
3	16.46	1.12	4	17.17	0.39	
3.50	16.50	1.16	5	17.17	0.39	
4.00	16.53	1.19	6	17.16	0.40	Pump adjustment
4.5	16.31	0.97	7	17.16	0.40	
5.00	16.02	0.68	8	17.14	0.42	
5.50	15.96	0.62	9	17.13	0.43	
6	15.94	0.60	10	17.12	0.44	
7	15.94	0.60	11	17.11	0.45	
8	15.92	0.58	12	17.11	0.45	
9	15.92	0.58	13	17.10	0.46	
10	15.91	0.57	14	17.10	0.46	
11	15.91	0.57	15	17.09	0.47	
12	15.91	0.57	16	17.09	0.47	
13	15.91	0.57	17	17.09	0.47	
14	15.91	0.57	18	17.08	0.48	
15	15.91	0.57	19	17.07	0.49	
16	15.91	0.57	20	17.07	0.49	
17	15.91	0.57	25	17.06	0.50	
18	15.91	0.57	30	17.05	0.51	
19	15.91	0.57	35	17.03	0.53	
20	15.91	0.57	40	17.01	0.55	
21	15.92	0.58	45	17.01	0.55	
22	15.92	0.58	60	16.94	0.62	
23	15.92	0.58	120	16.78	0.78	
24	15.93	0.59	180	16.78	0.78	
25	15.93	0.59	242	16.67	0.89	
30	15.94	0.60	305	16.60	0.96	
32	15.94	0.60	7605	15.68	1.88	
35	15.95	0.61				
40	15.96	0.62				
42	15.97	0.63				
45	15.97	0.63				
50	15.99	0.65				
55	16.00	0.66				
60	16.00	0.66				
120	16.10	0.76				
180	16.16	0.82				
240	16.21	0.87				
300	16.24	0.90				
360	16.27	0.93				
420	16.40	1.06				

TABLE H-2: PUMPING TEST DATA, LYNDEN WELL LM-02-14-D

72 Hour Aquifer Test at FDL-03

Lynden Wells **071-11885-01**

OW:	LM-02-14-D	DEPTH(m bgl):	57.00	mp (m agl):	0.89
PW:	FDL-03	SWL(m bmp):	15.34	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	150	Distance:	15 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
480	16.62	1.28				
540	16.72	1.38				
600	16.67	1.33				
660	16.70	1.36				
720	16.65	1.31				
780	16.66	1.32				
840	16.67	1.33				
900	16.68	1.34				
960	16.71	1.37				
1021	16.72	1.38				
1080	16.74	1.40				
1141	16.76	1.42				
1200	16.86	1.52				
1262	16.93	1.59				
1323	16.97	1.63				
1381	17.05	1.71				
1439	17.00	1.66				
1515	16.96	1.62				
1560	16.98	1.64				
1620	16.98	1.64				
1683	16.99	1.65				
1740	16.99	1.65				
1805	17.00	1.66				
1866	17.02	1.68				
1922	17.11	1.77				
1982	17.17	1.83				
2042	17.23	1.89				
2100	17.24	1.90				
2160	17.27	1.93				
2220	17.20	1.86				
2280	17.19	1.85				
2344	17.18	1.84				
2400	17.18	1.84				
2465	17.18	1.84				
2520	17.19	1.85				
2584	17.20	1.86				
2644	17.28	1.94				
2703	17.28	1.94				
2760	17.36	2.02				
2820	17.42	2.08				
2883	17.46	2.12				
2943	17.44	2.10				
3001	17.41	2.07				
3061	17.42	2.08				
3123	17.42	2.08				
3183	17.41	2.07				

TABLE H-2: PUMPING TEST DATA, LYNDEN WELL LM-02-14-D

72 Hour Aquifer Test at FDL-03

Lynden Wells

071-11885-01

OW:	LM-02-14-D	DEPTH(m bgl):	57.00	mp (m agl):	0.89
PW:	FDL-03	SWL(m bmp):	15.34	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	150	Distance:	15 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
3243	17.42	2.08				
3305	17.40	2.06				
3361	17.45	2.11				
3420	17.53	2.19				
3473	17.56	2.22				
3540	17.59	2.25				
3600	17.63	2.29				
3660	17.58	2.24				
3720	17.58	2.24				
3780	17.54	2.20				
3840	17.54	2.20				
3900	17.53	2.19				
3960	17.53	2.19				
4020	17.53	2.19				
4080	17.53	2.19				
4140	17.56	2.22				
4200	17.57	2.23				
4260	17.56	2.22				Pump shut down.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-3: PUMPING TEST DATA, LYNDEN WELL LM-02-11-D
72 Hour Aquifer Test at FDL-03
Lynden Wells **071-11885-01**

OW:	LM-02-11-D	DEPTH(m bgl):	52.10	mp (m agl):	0.68
PW:	FDL-03	SWL(m bmp):	15.27	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	200	Distance:	105 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
1	15.40	0.13	2	17.18	0.06	6.0 L/s (95 Usgpm)
2	15.46	0.19	3	17.18	0.06	
3	15.50	0.23	4	17.16	0.08	
4	15.54	0.27	5	17.15	0.09	
5	15.50	0.23	6	17.14	0.10	
6	15.49	0.22	7	17.13	0.11	
7	15.48	0.21	8	17.12	0.12	
8	15.48	0.21	9	17.13	0.11	
9	15.47	0.20	10	17.12	0.12	
10	15.48	0.21	15	17.09	0.15	
15	15.48	0.21	20	17.07	0.17	
20	15.49	0.22	25	17.06	0.18	
25	15.50	0.23	30	17.05	0.19	
30	15.51	0.24	40	17.07	0.17	
40	15.53	0.26	50	16.94	0.30	
50	15.55	0.28	60	16.91	0.33	
60	15.56	0.29	120	16.77	0.47	
120	15.65	0.38	181	16.75	0.49	
180	15.76	0.49	245	16.63	0.61	
240	15.85	0.58	310	16.62	0.62	
296	15.82	0.55	7610	15.67	1.57	
352	15.85	0.58				
420	16.00	0.73				
483	16.11	0.84				
545	16.18	0.91				
602	16.25	0.98				
666	16.24	0.97				
728	16.21	0.94				
778	16.22	0.95				
836	16.23	0.96				
895	16.25	0.98				
955	16.27	1.00				
1016	16.28	1.01				
1075	16.30	1.03				
1136	16.32	1.05				
1197	16.45	1.18				
1259	16.53	1.26				
1319	16.58	1.31				
1375	16.64	1.37				
1445	16.57	1.30				
1508	16.54	1.27				
1563	16.56	1.29				
1624	16.56	1.29				
1684	16.57	1.30				
1765	16.57	1.30				
1788	16.57	1.30				

TABLE H-3: PUMPING TEST DATA, LYNDEN WELL LM-02-11-D
72 Hour Aquifer Test at FDL-03
Lynden Wells

071-11885-01

OW:	LM-02-11-D	DEPTH(m bgl):	52.10	mp (m agl):	0.68
PW:	FDL-03	SWL(m bmp):	15.27	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	200	Distance:	105 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
1851	16.59	1.32				
1906	16.62	1.35				
1966	16.77	1.50				
2026	16.83	1.56				
2086	16.66	1.39				
2156	16.81	1.54				
2207	16.78	1.51				
2267	16.77	1.50				
2331	16.76	1.49				
2387	16.77	1.50				
2451	16.77	1.50				
2507	16.77	1.50				
2571	16.78	1.51				
2635	16.80	1.53				
2690	16.90	1.63				
2748	16.97	1.70				
2804	17.04	1.77				
2876	17.09	1.82				
2927	17.04	1.77				
2986	17.00	1.73				
3046	17.06	1.79				
3107	17.02	1.75				
3167	16.99	1.72				
3228	16.98	1.71				
3289	16.99	1.72				
3347	17.07	1.80				
3405	17.15	1.88				
3458	17.17	1.90				
3524	17.22	1.95				
3585	17.25	1.98				
3643	17.18	1.91				
3704	17.14	1.87				
3765	17.15	1.88				
3825	17.13	1.86				
3883	17.12	1.85				
3943	17.12	1.85				
4003	17.12	1.85				
4065	17.11	1.84				
4124	17.18	1.91				
4183	17.16	1.89				
4244	17.18	1.91				
4302	17.24	1.97				Pump shut down.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-4: PUMPING TEST DATA, LYNDEN WELL LM-01-14-D

72 Hour Aquifer Test at FDL-03

Lynden Wells **071-11885-01**

OW:	LM-01-14-D	DEPTH(m bgl):	57.61	mp (m agl):	0.84
PW:	FDL-03	SWL(m bmp):	15.22	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	200	Distance:	170 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
82	15.47	0.24	120	16.66	0.50	6.0 L/s (95 Usgpm)
219	15.61	0.39	184	16.64	0.52	
294	15.67	0.45	248	16.52	0.64	
350	15.72	0.49	315	16.52	0.64	
428	15.88	0.66	7615	15.58	1.58	
485	16.00	0.78				
547	16.01	0.78				
605	16.16	0.93				
671	16.10	0.88				
740	16.08	0.86				
792	16.08	0.86				
849	16.10	0.88				
908	16.11	0.89				
968	16.13	0.91				
1028	16.15	0.93				
1088	16.17	0.95				
1149	16.19	0.97				
1209	16.34	1.12				
1271	16.41	1.19				
1331	16.46	1.24				
1387	16.52	1.30				
1457	16.43	1.20				
1520	16.41	1.19				
1574	16.43	1.20				
1626	16.43	1.20				
1696	16.43	1.21				
1777	16.43	1.21				
1810	16.44	1.22				
1872	16.46	1.24				
1927	16.61	1.38				
1988	16.86	1.64				
2047	16.72	1.50				
2108	16.74	1.52				
2177	16.67	1.45				
2229	16.65	1.43				
2289	16.64	1.42				
2353	16.63	1.41				
2408	16.63	1.41				
2473	16.64	1.41				
2528	16.64	1.42				
2592	16.65	1.43				
2656	16.67	1.45				
2711	16.79	1.57				
2769	16.86	1.64				
2829	16.93	1.71				
2896	16.98	1.75				

TABLE H-4: PUMPING TEST DATA, LYNDEN WELL LM-01-14-D

72 Hour Aquifer Test at FDL-03

Lynden Wells

071-11885-01

OW:	LM-01-14-D	DEPTH(m bgl):	57.61	mp (m agl):	0.84
PW:	FDL-03	SWL(m bmp):	15.22	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	200	Distance:	170 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
2947	16.90	1.68				
3006	16.85	1.63				
3066	16.95	1.72				
3128	16.88	1.66				
3188	16.87	1.64				
3252	16.86	1.64				
3310	16.86	1.64				
3367	16.96	1.74				
3426	17.03	1.81				
3480	17.06	1.84				
3546	17.10	1.88				
3606	17.14	1.92				
3664	17.04	1.82				
3725	17.01	1.79				
3786	17.00	1.78				
3845	17.00	1.78				
3904	17.00	1.78				
3964	16.99	1.77				
4024	16.99	1.77				
4086	16.99	1.77				
4146	17.07	1.85				
4204	17.03	1.81				
4265	17.07	1.85				
4320	17.16	1.94				Pump shut down.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-5: PUMPING TEST DATA, MONITORING WELL LM-01-11-D

72 Hour Aquifer Test at FDL-03

Lynden Wells **071-11885-01**

OW:	LM-01-11-D	DEPTH(m bgl):	54.56	mp (m agl):	0.9
PW:	FDL-03	SWL(m bmp):	12.13	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	50	Distance from PW:	181 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
77	12.66	0.52	120	13.90	0.54	6.0 L/s (95 Usgpm)
213	12.81	0.68	186	13.80	0.64	
288	12.85	0.72	250	13.78	0.66	
341	12.93	0.80	320	13.79	0.65	
422	13.13	1.00	7620	12.86	1.58	
492	13.27	1.14				
554	13.31	1.18				
624	13.41	1.28				
681	13.34	1.21				
749	13.33	1.20				
802	13.34	1.21				
857	13.35	1.22				
915	13.37	1.24				
975	13.39	1.26				
1035	13.41	1.28				
1094	13.43	1.30				
1155	13.45	1.32				
1215	13.61	1.48				
1277	13.67	1.54				
1337	13.73	1.60				
1393	13.79	1.66				
1467	13.67	1.54				
1526	13.67	1.54				
1580	13.67	1.54				
1633	13.68	1.55				
1702	13.68	1.55				
1782	13.70	1.57				
1814	13.70	1.57				
1877	13.72	1.59				
1931	13.88	1.75				
1992	13.93	1.80				
2052	13.98	1.85				
2115	14.01	1.88				
2185	13.93	1.80				
2235	13.90	1.77				
2296	13.89	1.76				
2359	13.89	1.76				
2415	13.89	1.76				
2479	13.89	1.76				
2535	13.90	1.77				
2599	13.91	1.78				
2663	13.93	1.80				
2719	14.07	1.94				
2776	14.13	2.00				
2835	14.18	2.05				
2901	14.25	2.12				

TABLE H-5: PUMPING TEST DATA, MONITORING WELL LM-01-11-D

72 Hour Aquifer Test at FDL-03

Lynden Wells

071-11885-01

OW:	LM-01-11-D	DEPTH(m bgl):	54.56	mp (m agl):	0.9
PW:	FDL-03	SWL(m bmp):	12.13	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	50	Distance from PW:	181 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
2953	14.15	2.02				
3011	14.12	1.99				
3072	14.21	2.08				
3132	14.13	2.00				
3192	14.12	1.99				
3257	14.11	1.98				
3314	14.11	1.98				
3374	14.23	2.10				
3431	14.25	2.12				
3485	14.34	2.21				
3552	14.37	2.24				
3611	14.42	2.29				
3670	14.30	2.17				
3731	14.27	2.14				
3793	14.26	2.13				
3851	14.27	2.14				
3910	14.24	2.11				
3970	14.25	2.12				
4031	14.26	2.13				
4096	14.25	2.12				
4153	14.36	2.23				
4215	14.29	2.16				
4265	14.35	2.22				
4312	14.44	2.31				Pump shut down at 4320 minutes.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-6: PUMPING TEST DATA, MONITORING WELL LM-01-12-D

72 Hour Aquifer Test at FDL-03

Lynden Wells **071-11885-01**

OW:	LM-01-12-D	DEPTH(m bgl):	52.12	mp (m agl):	0.85
PW:	FDL-03	SWL(m bmp):	14.48	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	50	Distance from PW:	193 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
89	14.72	0.24	120	15.91	0.48	6.0 L/s (95 Usgpm)
210	15.45	0.97	192	15.86	0.53	
285	15.90	1.42	257	15.76	0.63	
340	14.95	0.47	330	15.78	0.61	
431	15.15	0.66	7635	14.84	1.55	
496	15.24	0.76				
569	15.32	0.84				
622	15.38	0.90				
684	15.32	0.84				
752	15.31	0.83				
804	15.32	0.84				
860	15.33	0.85				
918	15.35	0.87				
978	15.37	0.89				
1038	15.38	0.90				
1097	15.40	0.92				
1157	15.42	0.94				
1218	15.58	1.10				
1279	15.64	1.16				
1339	15.70	1.22				
1396	15.78	1.30				
1469	15.68	1.20				
1528	15.64	1.16				
1582	15.66	1.18				
1634	15.71	1.23				
1704	15.67	1.19				
1783	15.68	1.20				
1816	15.67	1.19				
1879	15.70	1.22				
1933	15.84	1.36				
1995	15.90	1.42				
2054	15.95	1.47				
2118	15.97	1.49				
2189	15.90	1.42				
2238	15.88	1.40				
2298	15.87	1.39				
2362	15.87	1.39				
2418	15.87	1.39				
2482	15.87	1.39				
2537	15.88	1.40				
2602	15.89	1.41				
2665	15.90	1.42				
2721	16.04	1.56				
2778	16.10	1.62				
2837	16.16	1.68				
2904	16.21	1.73				

TABLE H-6: PUMPING TEST DATA, MONITORING WELL LM-01-12-D

72 Hour Aquifer Test at FDL-03

Lynden Wells

071-11885-01

OW:	LM-01-12-D	DEPTH(m bgl):	52.12	mp (m agl):	0.85
PW:	FDL-03	SWL(m bmp):	14.48	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	50	Distance from PW:	193 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
2954	16.13	1.65				
3012	16.12	1.64				
3074	16.19	1.71				
3133	16.11	1.63				
3194	16.10	1.62				
3258	16.06	1.58				
3316	16.10	1.62				
3375	16.21	1.73				
3434	16.27	1.79				
3487	16.30	1.82				
3555	16.35	1.87				
3615	16.37	1.89				
3672	16.27	1.79				
3733	16.28	1.80				
3795	16.24	1.76				
3852	16.23	1.75				
3912	16.22	1.74				
3972	16.22	1.74				
4037	16.22	1.74				
4097	16.22	1.74				
4155	16.22	1.74				
4215	16.26	1.78				
4275	16.33	1.85				
4315	16.39	1.91				Pump turned off.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-7: PUMPING TEST DATA, MONITORING WELL LM-01-03-D
72 Hour Aquifer Test at FDL-03
Lynden Wells **071-11885-01**

OW:	LM-01-03-D	DEPTH(m bgl):	56.67	mp (m agl):	0.85
PW:	FDL-03	SWL(m bmp):	13.09	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	50	Distance from PW:	239 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
80	13.15	0.06	129	14.41	0.56	6.0 L/s (95 Usgpm)
217	13.30	0.20	189	14.36	0.61	
292	13.52	0.43	253	14.27	0.70	
348	13.40	0.31	327	14.39	0.58	
426	13.69	0.60	7630	13.45	1.52	
490	13.79	0.70				
552	13.84	0.75				
611	13.99	0.89				
675	13.78	0.69				
746	13.76	0.67				
798	13.77	0.68				
854	13.78	0.69				
913	13.80	0.71				
973	13.82	0.73				
1033	13.83	0.74				
1092	13.85	0.76				
1153	13.87	0.78				
1214	14.14	1.05				
1275	14.21	1.12				
1335	14.27	1.18				
1391	14.32	1.23				
1462	14.12	1.02				
1525	14.11	1.02				
1579	14.11	1.02				
1630	14.15	1.06				
1700	14.14	1.05				
1771	14.13	1.04				
1804	14.13	1.04				
1866	14.15	1.06				
1920	14.41	1.32				
1982	14.47	1.38				
2041	14.52	1.43				
2102	14.55	1.46				
2172	14.37	1.28				
2221	14.34	1.25				
2282	14.33	1.24				
2346	14.33	1.24				
2403	14.33	1.24				
2466	14.33	1.24				
2522	14.33	1.24				
2586	14.34	1.25				
2650	14.36	1.27				
2705	14.60	1.51				
2762	14.68	1.59				
2823	14.73	1.64				
2890	14.78	1.69				

TABLE H-7: PUMPING TEST DATA, MONITORING WELL LM-01-03-D
72 Hour Aquifer Test at FDL-03
Lynden Wells

071-11885-01

OW:	LM-01-03-D	DEPTH(m bgl):	56.67	mp (m agl):	0.85
PW:	FDL-03	SWL(m bmp):	13.09	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	50	Distance from PW:	239 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
2941	14.59	1.50				
3000	14.57	1.48				
3061	14.75	1.66				
3121	14.75	1.66				
3182	14.57	1.47				
3246	14.55	1.45				
3303	14.56	1.47				
3370	14.77	1.68				
3429	14.84	1.75				
3483	14.81	1.72				
3550	14.92	1.83				
3609	14.99	1.90				
3668	14.74	1.65				
3729	14.71	1.62				
3790	14.70	1.61				
3849	14.79	1.70				
3907	14.73	1.64				
3967	14.69	1.60				
4027	14.69	1.60				
4092	14.68	1.59				
4151	14.89	1.80				
4210	14.72	1.63				
4271	14.90	1.81				
4318	14.97	1.88				Pump shut down at 4320.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-8: PUMPING TEST DATA, MONITORING WELL LM-01-03-S

72 Hour Aquifer Test at FDL-03

Lynden Wells **071-11885-01**

OW:	LM-01-03-S	DEPTH(m bgl):	6.07	mp (m agl):	0.7
PW:	FDL-03	SWL(m bmp):	1.58	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	50	Distance:	239 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
78	1.59	0.01	128	1.20	0.03	
215	1.63	0.05	188	1.19	0.04	
289	1.66	0.08	252	1.19	0.04	
345	1.62	0.04	325	1.19	0.04	
424	1.63	0.04	7625	1.45	-0.22	
487	1.62	0.04				
550	1.62	0.04				
608	1.62	0.04				
674	1.62	0.04				
743	1.60	0.02				
796	1.60	0.02				
851	1.61	0.03				
911	1.61	0.03				
970	1.61	0.03				
1031	1.61	0.03				
1090	1.61	0.03				
1151	1.61	0.03				
1211	1.61	0.03				
1273	1.61	0.03				
1333	1.61	0.03				
1389	1.61	0.03				
1459	1.61	0.03				
1523	1.61	0.03				
1571	1.61	0.03				
1628	1.62	0.04				
1698	1.62	0.04				
1779	1.62	0.04				
1812	1.62	0.04				
1874	1.62	0.04				
1928	1.62	0.03				
1990	1.62	0.04				
2049	1.61	0.03				
2110	1.62	0.04				
2180	1.62	0.04				
2230	1.62	0.04				
2291	1.62	0.04				
2355	1.62	0.04				
2411	1.62	0.04				
2475	1.62	0.04				
2531	1.62	0.04				
2595	1.62	0.04				
2658	1.62	0.04				
2714	1.63	0.05				
2771	1.63	0.05				
2831	1.63	0.04				
2898	1.62	0.04				

TABLE H-8: PUMPING TEST DATA, MONITORING WELL LM-01-03-S

72 Hour Aquifer Test at FDL-03

Lynden Wells

071-11885-01

OW:	LM-01-03-S	DEPTH(m bgl):	6.07	mp (m agl):	0.7
PW:	FDL-03	SWL(m bmp):	1.58	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	50	Distance:	239 m
TIME:	10:30:00				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
2949	1.62	0.04				
3008	1.62	0.04				
3069	1.63	0.04				
3129	1.62	0.04				
3190	1.62	0.04				
3254	1.62	0.04				
3311	1.62	0.04				
3369	1.55	-0.04				Rainfall / freezing rain event begins
3428	1.50	-0.08				
3482	1.48	-0.10				
3548	1.48	-0.10				
3608	1.48	-0.10				
3666	1.48	-0.10				
3727	1.47	-0.11				
3789	1.48	-0.10				
3847	1.45	-0.13				
3906	1.45	-0.13				
3966	1.45	-0.13				
4026	1.41	-0.17				
4090	1.39	-0.19				
4150	1.32	-0.26				
4209	1.29	-0.29				
4269	1.24	-0.34				
4319	1.23	-0.35				FDL-03 off at 4320 min

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-9: PUMPING TEST DATA, PRIVATE WELL - 3606 GOVERNORS ROAD

72 Hour Aquifer Test at FDL-03

Lynden Wells

071-11885-01

OW:	3606	DEPTH(m bgl):	60.96	mp (m agl):	0.97
PW:	FDL-03	SWL(m bmp):	15.43	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	152	Distance from PW:	280 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
114	16.00	0.56	219	16.78	0.46	6.0 L/s (95 Usgpm)
1605	16.14	0.71	355	16.83	0.41	Owner mentioned that his water turned
1822	16.57	1.14	7680	15.71	1.53	black and the sulphur odour increased for 1
2920	17.08	1.65				day after the 1 inch pipe was installed on
3207	16.99	1.56				Mar. 15. He also said this was expected but
4282	17.24	1.81				wanted us to know. Also, one nut is missing
						from the well cap, replace this on next visit.

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-10: PUMPING TEST DATA, PRIVATE WELL - 3586 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-03
Lynden Wells

071-11885-01

OW:	3586	DEPTH(m bgl):	16.86	mp (m agl):	0.97
PW:	FDL-03	SWL(m bmp):	2.14	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	914	Distance from PW:	337 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
95	2.16	0.02	226	1.67	0.30	6.0 L/s (95 Usgpm)
1610	2.23	0.09	365	1.67	0.30	
1829	2.32	0.18	7665	1.94	0.03	
2925	2.25	0.11				
3214	2.32	0.18				
4295	1.97	-0.17				Pump off at 4320 Min

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-11: PUMPING TEST DATA, MONITORING WELL LM-01-08-OB
72 Hour Aquifer Test at FDL-03
Lynden Wells **071-11885-01**

OW:	LM-01-08-OB	DEPTH(m bgl):	52.73	mp (m agl):	0.75
PW:	FDL-03	SWL(m bmp):	11.86	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	23	Distance from PW:	637 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
109	11.94	0.08	7650	12.27	1.00	6.0 L/s (95 Usgpm)
204	12.00	0.14				
278	12.03	0.17				
334	12.08	0.22				
440	12.14	0.28				
502	12.19	0.33				
564	12.25	0.39				
615	12.26	0.40				
692	12.31	0.45				
763	12.33	0.47				
811	12.34	0.48				
866	12.35	0.49				
924	12.37	0.51				
983	12.39	0.53				
1043	12.40	0.54				
1103	12.42	0.56				
1163	12.44	0.58				
1223	12.48	0.62				
1286	12.52	0.66				
1346	12.56	0.70				
1408	12.64	0.78				
1542	12.63	0.77				
1585	12.63	0.77				
1641	12.61	0.75				
1711	12.67	0.81				
1768	12.68	0.82				
1835	12.69	0.83				
1886	12.72	0.86				
1938	12.76	0.90				
2004	12.78	0.92				
2073	12.84	0.98				
2124	12.83	0.97				
2198	12.86	1.00				
2243	12.86	1.00				
2304	12.87	1.01				
2368	12.87	1.01				
2424	12.88	1.02				
2486	12.88	1.02				
2543	12.88	1.02				
2607	12.90	1.04				

TABLE H-11: PUMPING TEST DATA, MONITORING WELL LM-01-08-OB
72 Hour Aquifer Test at FDL-03
Lynden Wells

071-11885-01

OW:	LM-01-08-OB	DEPTH(m bgl):	52.73	mp (m agl):	0.75
PW:	FDL-03	SWL(m bmp):	11.86	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	23	Distance from PW:	637 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
2675	12.93	1.07				
2728	12.95	1.09				
2785	12.99	1.13				
2842	13.02	1.16				
2929	13.05	1.19				
2960	13.07	1.21				
3021	13.11	1.25				
3081	13.12	1.26				
3142	13.14	1.28				
3224	13.14	1.28				
3265	13.14	1.28				
3322	13.14	1.28				
3384	13.12	1.26				
3438	13.17	1.31				
3495	13.18	1.32				
3562	13.20	1.34				
3629	13.25	1.39				
3677	13.25	1.39				
3738	13.24	1.38				
3799	13.24	1.38				
3857	13.24	1.38				
3915	13.24	1.38				
3980	13.25	1.39				
4040	13.25	1.39				
4168	13.28	1.42				
4218	13.26	1.40				
4278	13.27	1.41				Pump Off At 4320 min

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-12: PUMPING TEST DATA, MONITORING WELL LM-01-08-D
72 Hour Aquifer Test at FDL-03
Lynden Wells **071-11885-01**

OW:	LM-01-08-D	DEPTH(m bgl):	80.77	mp (m agl):	0.75
PW:	FDL03	SWL(m bmp):	10.99	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	23	Distance:	637m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
110	11.00	0.00	7645	11.06	-0.06	6.0 L/s (95 Usgpm)
203	11.65	0.66				Elapsed Time 203 - 617 considered
278	12.30	1.31				anomalous
333	12.45	1.46				
444	12.58	1.59				
504	12.63	1.64				
562	12.70	1.71				
617	11.04	0.05				
694	11.00	0.01				
764	11.01	0.02				
812	11.00	0.01				
868	11.00	0.01				
926	10.99	0.00				
984	10.99	0.00				
1044	10.99	0.00				
1104	10.99	0.00				
1164	10.99	0.00				
1225	10.99	0.00				
1288	10.99	0.00				
1347	10.99	0.00				
1409	11.00	0.01				
1544	11.00	0.01				
1586	11.00	0.01				
1643	11.00	0.00				
1709	10.99	0.00				
1833	10.99	0.00				
1884	10.99	0.00				
2002	11.05	0.06				
2075	10.98	-0.01				
2125	10.98	-0.01				
2199	10.98	-0.01				
2244	10.98	-0.01				
2304	10.98	-0.01				
2368	10.97	-0.02				
2424	10.98	-0.01				
2487	10.98	-0.01				
2543	10.98	-0.01				
2607	10.97	-0.02				
2675	10.97	-0.02				
2728	10.97	-0.02				
2785	10.99	0.00				
2843	11.00	0.01				
2931	11.01	0.02				
2961	11.06	0.07				
3023	10.99	0.00				
3079	10.98	-0.01				
3141	10.99	-0.01				

TABLE H-12: PUMPING TEST DATA, MONITORING WELL LM-01-08-D
72 Hour Aquifer Test at FDL-03
Lynden Wells

071-11885-01

OW: LM-01-08-D DEPTH(m bgl): 80.77 mp (m agl): 0.75
PW: FDL03 SWL(m bmp): 10.99 Discharge Rate: 6.0 L/s
DATE: 21/3/2016 I.D. (mm): 23 Distance: 637m
TIME: 10:30 a.m.

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
3222	10.99	0.00				
3264	11.00	0.01				
3323	11.01	0.02				
3385	11.00	0.01				
3439	11.01	0.02				
3493	11.00	0.01				
3564	10.99	0.00				
3630	10.99	0.00				
3679	10.99	0.00				
3739	10.99	0.00				
3800	10.99	0.00				
3859	11.00	0.01				
3917	11.00	0.01				
3981	10.99	0.00				
4160	10.99	0.00				
4220	11.00	0.01				
4280	11.00	0.01				FDL-03 Off at 4320 Min

Q: discharge PW: pumped well I.D: inside diameter mbgl: metres below ground level
SWL: static water level OW: observation well mp: measuring point m bmp: metres below measuring point
L/sec: litres per second

TABLE H-13: PUMPING TEST DATA, PRIVATE WELL - 3826 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-03
Lynden Wells

071-11885-01

OW:	3826	DEPTH(m bgl):	18.28	mp (m agl):	0.46
PW:	FDL-03	SWL(m bmp):	5.27	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	914	Distance from PW:	626 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	DRAWDOWN (metres)	ELAPSED TIME (minutes)	WATER LEVEL (m bmp)	RECOVERY (metres)	
100	5.23	-0.03	209	5.11	0.07	6.0 L/s (95 Usgpm)
1590	4.92	-0.34	342	5.07	0.11	
1790	4.85	-0.41	7695	5.75	-0.57	
2911	4.79	-0.48				
3198	5.40	0.13				
4262	5.18	-0.09				

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

TABLE H-14: PUMPING TEST DATA, PRIVATE WELL - 3830 GOVERNORS ROAD
72 Hour Aquifer Test at FDL-03
Lynden Wells

071-11885-01

OW:	3830	DEPTH(m bgl):	56.39	mp (m agl):	0.46
PW:	FDL-03	SWL(m bmp):	17.49	Discharge Rate:	6.0 L/s
DATE:	21/3/2016	I.D. (mm):	152	Distance from PW:	704 m
TIME:	10:30 a.m.				

DRAWDOWN			RECOVERY			COMMENTS
ELAPSED TIME (minutes)	**WATER LEVEL (m bmp)**	**DRAWDOWN (metres)**	**ELAPSED TIME (minutes)**	**WATER LEVEL (m bmp)**	**RECOVERY (metres)**	
105	17.49	0.00	214	18.40	0.15	6.0 L/s (95 Usgpm)
1595	18.04	0.55	346	18.10	0.45	
1795	17.94	0.45	7710	17.95	0.60	
2914	18.45	0.97				
3201	18.34	0.85				
4270	18.55	1.07				Pump off at 4320 Min

Q: discharge
PW: pumped well
I.D: inside diameter
mbgl: metres below ground level
SWL: static water level
OW: observation well
mp: measuring point
m bmp: metres below measuring point
L/sec: litres per second

Table H-15
Pumping Test Analysis - Summary Table
Lynden FDL-03 Pump Test

Well ID	Test Method	Drawdown						Recovery	
		Transmissivity (m^2/day)			Storativity				
		0-300 Minutes	300-4320 Minutes	Average	0-300 Minutes	300-4320 Minutes	Average	Transmissivity (m2/day)	Storativity
FDL-03	Cooper & Jacob I	105.56	73.08	89.32	NA	NA	NA	158.34	NA
LM-02-11-D	Cooper & Jacob I	211.12	79.17	145.15	2.99E-04	1.12E-03	7.11E-04	316.69	1.35E-04
LM-01-14-D	Cooper & Jacob I	158.34	67.86	113.10	8.56E-05	6.21E-04	3.53E-04	190.01	3.08E-05
LM-02-14-D	Cooper & Jacob I	950.06	67.86	508.96	6.60E-04	4.19E-02	2.13E-02	95.01	1.98E-04
LM-01-11-D	Cooper & Jacob I	190.01	63.34	126.67	5.42E-05	3.32E-04	1.93E-04	135.72	1.29E-04
LM-01-12-D	Cooper & Jacob I	158.34	79.17	118.76	9.30E-05	1.99E-04	1.46E-04	158.34	1.99E-04
LM-01-03-D	Cooper & Jacob I	237.51	67.86	152.69	3.90E-04	3.53E-04	3.71E-04	158.34	7.80E-05
LM-01-08-OB	Cooper & Jacob I	316.69	63.34	190.01	9.76E-05	1.17E-04	1.07E-04	NA	NA
LM-01-08-D	Cooper & Jacob I	190.01	63.34	126.67	7.32E-05	1.10E-04	9.15E-05	NA	NA
3606 Governors	Cooper & Jacob I	316.69	45.24	180.96	5.05E-05	5.41E-04	2.96E-04	190.01	2.27E-04
3830 Governors	Cooper & Jacob I	NA	63.34	63.34	NA	1.44E-04	1.44E-04	475.03	1.50E-04

Appendix I

CATEGORY 2 PTTW FOR PUMPING TEST

Ministry of the Environment and Climate Change
West-Central Region
Technical Support Section
Water Resources
12th Floor
119 King St W
Hamilton ON L8P 4Y7
Fax: (905) 521-7820
Tel: (905) 521-7640

Ministère de l'Environnement et de l'Action en matière de changement climatique
Direction régionale du Centre-Ouest
Secteur du Soutien Technique
Ressource en eau
12e étage
119 rue King W
Hamilton ON L8P 4Y7
Télécopieur: (905) 521-7820
Tél:(905) 521-7640

October 26, 2015

City of Hamilton
Suite 400 - 77 James St. N.
Hamilton, Ontario
L8R 2K3

Attention: Carmen Ches

Dear Sir/Madam:

RE: Lot 16, Concession 1
Geographic Township of Ancaster
City of Hamilton
Permit to Take Water Number 1780-A3NR4B

Please find attached a Permit to Take Water which authorizes the withdrawal of water in accordance with the application for this Permit to Take Water, dated August 13, 2015 and signed by Carmen Ches.

This Permit expires on June 30, 2016. Authorized rates and amounts are indicated on Table A. This Permit cancels and replaces Permit Number 4737-A29QFG, issued on September 14, 2015.

Ontario Regulation 387/04 (Water Taking and Transfer) requires all water takers to report daily water taking amounts to the Water Taking Reporting System (WTRS) electronic database (https://www.lrcsde.lrc.gov.on.ca/wtrs/). Daily water taking must be reported on a calendar year basis. If no water is taken, then a "no taking" report must be entered. Please consult the Regulation and Section 4 of this Permit for monitoring requirements.

If you have questions about reporting requirements, please call the WTRS Help Desk at 416-235-6322 (toll free: 1-877-344-2011) or by email, WTRSHelpdesk@ontario.ca. It is preferred that you submit your data directly and electronically to the WTRS. Where this is impracticable, please contact the WTRS Help Desk to arrange for written submission of your data.

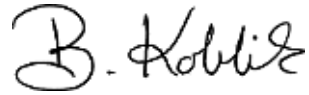
Condition 1.4 specifically indicates that this Permit is not transferable to another party. Any queries regarding a change in owner/operator should be made to the Permit to Take Water Evaluator at the above address.

Take notice that in issuing this Permit, terms and conditions pertaining to the taking of water and to the results of the taking have been imposed. The terms and conditions have been designed to allow for the development of water resources, while providing reasonable protection to existing water uses and users.

The Environmental Review Tribunal (ERT) has recently changed its phone and fax phone numbers, and as such you will need to use the following should you wish to contact the ERT:

New Public Inquiry Telephone Number:	**New Fax Number:**
Tel. (416) 212-6349	**Fax: (416) 326-5370**
Toll Free 1(866) 448-2248	**Toll Free: 1(844) 213-3474**

Yours truly,



Belinda Koblik
Director, Section 34.1
Ontario Water Resources Act, R.S.O. 1990
West Central Region

File Storage Number: AP28 AN HA

Ontario

Ministry of the Environment and Climate Change
Ministère de l'Environnement et de l'Action en matière de changement climatique

AMENDED PERMIT TO TAKE WATER
Pumping Test
NUMBER 1780-A3NR4B

Pursuant to Section 34.1 of the Ontario Water Resources Act, R.S.O. 1990 this Permit To Take Water is hereby issued to:

City of Hamilton
Suite 400 - 77 James St. N.
Hamilton, Ontario L8R 2K3

For the water taking from: Well (FDL-03)

Located at: Lot 16, Concession 1 Ancaster, Geographic Township of Ancaster
Hamilton

For the purposes of this Permit, and the terms and conditions specified below, the following definitions apply:

DEFINITIONS

(a) "Director" means any person appointed in writing as a Director pursuant to section 5 of the OWRA for the purposes of section 34.1, OWRA.

(b) "Provincial Officer" means any person designated in writing by the Minister as a Provincial Officer pursuant to section 5 of the OWRA.

(c) "Ministry" means Ontario Ministry of the Environment and Climate Change.

(d) "District Office" means the Hamilton District Office.

(e) "Permit" means this Permit to Take Water No. 1780-A3NR4B including its Schedules, if any, issued in accordance with Section 34.1 of the OWRA.

(f) "Permit Holder" means City of Hamilton.

(g) "OWRA " means the *Ontario Water Resources Act*, R.S.O. 1990, c. O. 40, as amended.

You are hereby notified that this Permit is issued subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. Compliance with Permit

1.1 Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, dated August 13, 2015 and signed by Carmen Ches, and all Schedules included in this Permit.

1.2 The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.

1.3 Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.

1.4 This Permit is not transferable to another person.

1.5 This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.

1.6 The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.

2. General Conditions and Interpretation

2.1 Inspections
The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the *Environmental Protection Act*, R.S.O. 1990, the *Pesticides Act*, R.S.O. 1990, or the *Safe Drinking Water Act*, S. O. 2002.

2.2 Other Approvals
The issuance of, and compliance with this Permit, does not:

(a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the *Ontario Water Resources Act*, and the *Environmental Protection Act*, and any regulations made thereunder; or

(b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3 Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

(a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or

(b) acceptance by the Ministry of the information's completeness or accuracy.

2.4 Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5 Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6 Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

3. Water Takings Authorized by This Permit

3.1 **Expiry**

This Permit expires on **June 30, 2016**. No water shall be taken under authority of this Permit after the expiry date.

3.2 Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

Table A

	Source Name / Description:	Source: Type:	Taking Specific Purpose:	Taking Major Category:	Max. Taken per Minute (litres):	Max. Num. of Hrs Taken per Day:	Max. Taken per Day (litres):	Max. Num. of Days Taken:	Zone/ Easting/ Northing:
1	FDL-03	Well Dug	Pumping Test	Miscellaneous	600	24	864,000	7	17 570761 4786637
						Total Taking:	864,000		

3.3 Water taking under the authorization of this Permit shall occur for no more than 7 days between the date of issuance and June 30, 2016.

3.4 Prior to taking of water under this Permit, the Permit Holder shall ensure that any and all applicable permits or authorizations are obtained from Federal and Provincial Agencies having legislative mandates in water resources management.

4. Monitoring

4.1 Notification to Well Owners
Prior to commencement of the pumping test, the Permit Holder shall identify all wells within the area of the anticipated potential cone of influence, or within 500 metres of the test site, whichever is greater. At least 24 hours prior to beginning the pumping test, the Permit Holder shall provide written notification to the owners of the wells identified within the potential cone of influence. The notification shall include the expected date, time and duration of the pumping test, and a contact telephone number that may be used to report any interferences with water supplies.

4.2 Measuring Water Depths
To establish baseline conditions, well depths and depths to water levels for identified representative wells in the area of the water taking shall be recorded by the Permit Holder. During the pumping test, water levels in the identified wells shall be recorded. The pumping test must be of sufficient duration to accurately predict the long term impacts of the proposed water taking. Water levels in the identified wells shall continue to be monitored beyond the water taking period until at least 85% recovery is achieved.

4.3 Under section 9 of O. Reg. 387/04, and as authorized by subsection 34(6) of the *Ontario Water Resources Act* , the Permit Holder shall, on each day water is taken under the authorization of this Permit, record the date, the volume of water taken on that date and the rate at which it was taken. The daily volume of water taken shall be measured by a flow meter or calculated in accordance with the method described in the application for this Permit, or as otherwise accepted by the Director. The Permit Holder shall keep all records required by this condition current and available at or near the site of the taking and shall produce the records immediately for inspection by a Provincial Officer upon his or her request. The Permit Holder, unless

otherwise required by the Director, shall submit, on or before March 31st in every year, the records required by this condition to the ministry's Water Taking Reporting System.

5. Impacts of the Water Taking

5.1 Notification

The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

5.2 Restoration of Water Supply

Where the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of doing so.

6. Director May Amend Permit

The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the *Ontario Water Resources Act* , Section 100 (4).

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.

2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.

3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing, conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

The Environmental Review Tribunal (ERT) has recently changed its phone and fax phone numbers, and as such you will need to use the following should you wish to contact the

ERT:

<u>New Public Inquiry Telephone Number</u>:
Tel. (416) 212-6349
Toll Free 1(866) 448-2248

<u>New Fax Number</u>:
Fax: (416) 326-5370
Toll Free: 1(844) 213-3474

In accordance with Section 100 of the Ontario Water Resources Act, R.S.O. 1990, you may by written Notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 101 of the Ontario Water Resources Act, R.S.O. 1990, as amended, provides that the Notice requiring the hearing shall state:

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these legal requirements, the Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Permit to Take Water number;
6. The date of the Permit to Take Water;
7. The name of the Director;
8. The municipality within which the works are located;

This notice must be served upon:

The Secretary
Environmental Review Tribunal
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5
Fax: (416) 314-4506
Email: ERTTribunalsecretary@ontario.ca

AND

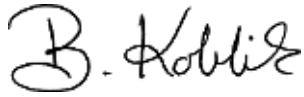
The Director, Section 34.1, Ministry of the Environment and Climate Change
12th Floor
119 King St W
Hamilton ON L8P 4Y7
Fax: (905) 521-7820

Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal:

by telephone at (416) 314-4600 ***by fax at (416) 314-4506*** ***by e-mail at www.ert.gov.on.ca***

This Permit cancels and replaces Permit Number 4737-A29QFG, issued on 2015/09/14.

Dated at Hamilton this 26th day of October, 2015.



Belinda Koblik
Director, Section 34.1
Ontario Water Resources Act , R.S.O. 1990

Appendix J

WATER QUALITY RESULTS – FDL-03

TABLE J-1:
General Inorganic Water Quality - LYNDEN WELL FDL-03
Community of Lynden

PARAMETER	UNITS	ODWS Criteria			Lynden Well FDL-03						
		Health Based Guideline	Aesthetic Based	Operational Based	21-Mar-16 1 Hour	21-Mar-16 12 Hour	22-Mar-16 24 Hour	22-Mar-16 36 Hour	23-Mar-16 48 Hour	23-Mar-16 60 Hour	24-Mar-16 72 Hour
Anions											
Chloride	mg/L	-	250	-	24.4	25.9	27.3	29.2	28.9	31	29.5
Flouride	mg/L	**1.5**	-	-	0.67	0.69	0.68	0.69	0.69	0.69	0.69
Sulphate	mg/L	-	500	-	16.7	15.5	15	14.6	14.5	14.3	13.7
Sulphide	mg/L	-	0.05	-	0.89	1.4	0.59	1.4	1.5	1.5	1.7
Hydrogen Sulphide	mg/L	-	-	-	0.943	1.48	0.625	1.48	1.59	1.59	1.8
Cations											
Calcium	mg/L	-	-	-	12.8	12.1	12.1	11.3	11.2	11.1	11.2
Iron	mg/L	-	0.3	-	0.022	0.016	0.016	0.013	0.01	0.01	0.012
Magnesium	mg/L	-	-	-	6.39	6.01	6.09	5.67	5.59	5.52	5.6
Manganese	mg/L	-	0.05	-	0.01	0.009	0.009	0.008	0.008	0.008	0.008
Potassium	mg/L	-	-	-	1.1	1.03	1.02	1.05	0.96	0.99	-
Sodium	mg/L	-	200 (20)	-	46.8	46.2	46.6	46.6	45.8	46.4	47
Minor Ions											
Aluminum	mg/L	-	-	0.1	0.009	0.005	0.005	0.004	0.004	0.004	0.003
Antimony	mg/L	**0.006**	-	-	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006	< 0.0006
Arsenic	mg/L	**0.025**	-	-	0.006	0.003	0.002	0.002	0.002	0.002	0.002
Barium	mg/L	**1**	-	-	0.114	0.096	0.097	0.092	0.092	0.093	0.096
Beryllium	mg/L	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-
Bismuth	mg/L	-	-	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-
Boron	mg/L	**5**	-	-	0.474	0.461	0.465	0.443	0.428	0.43	0.439
Cadmium	mg/L	**0.005**	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	**0.05**	-	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	-	-	-	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	< 0.0009	-
Copper	mg/L	**1**	-	-	0.036	0.031	0.016	0.026	0.034	0.04	0.004
Lead	mg/L	**0.01**	-	-	0.0011	0.001	< 0.001	0.0013	0.0011	0.0016	< 0.001
Mercury	mg/L	**0.001**	-	-	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Molybdenum	mg/L	-	-	-	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-
Nickel	mg/L	-	-	-	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-
Selenium	mg/L	**0.01**	-	-	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Silver	mg/L	-	-	-	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-
Strontium	mg/L	-	-	-	0.719	0.681	0.685	0.65	0.634	0.633	-
Thallium	mg/L	-	-	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-
Tin	mg/L	-	-	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	-
Titanium	mg/L	-	-	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	**0.02**	-	-	0.00011	0.000047	0.000042	0.000037	0.000029	0.000029	0.000031
Vanadium	mg/L	-	-	-	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	-
Zinc	mg/L	**5**	-	-	0.022	0.129	0.009	0.190	0.033	0.112	< 0.005
Nutrients											
Nitrate (as N)	mg/L as N	**10**	-		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrite (as N)	mg/L as N	**1**	-		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate + Nitrite (as N)	mg/L as N	**10**	-	-	-	-	-	-	-	-	< 0.02
Operational											
Alkalinity (as $CaCO_3$)	mg/L	-	-	30 - 500	100	98	96	98	97	96	95
Carbonate	mg/L	-	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Colour	TCU	-	5	-	4	-	2	-	< 2	-	< 2
Hardness	mg/L as $CaCO_3$	-	-	80 - 100	58.3	-	55.3	-	51	-	51
pH	pH units	-	6.5 - 8.5		-	-	-	-	-	-	8.24
Total Dissolved Solids	mg/L	-	500	-	182	-	186	-	170	-	176
Turbidity	NTU	-	5	-	0.57	-	0.41	-	0.14	-	0.13
Field Measured Parameters											
pH	pH units	-	-	6.5 - 8.5	9.37	8.98	9.08	9.07	9.21	9.05	8.92
Total Dissolved Solids	mg/L	-	500	-	265	253	852	253	291	259	257
Conductivity (at 25°C)	umho/cm				361	355	354	357	408	359	360
Temperature	degrees Celcius	-	15	-	7.7	8.1	8.3	8.6	8.6	6.7	8.6
Oxidation Reduction Potential	mV	-	-	-	40	92	93	105	107	115	135
Turbidity	NTU	-	5	-	2.89	2.53	2.78	3.03	3.05	3.27	1.34

Notes:
ND = Not detected
- (dash) indicates parameter was not tested during the selected sample.
ODWS and AO / OG Criteria: Ontario Regulation 170/03 & Regulation 169/03 made under the Safe Drinking Water Act, 2002 including Microbiological standards.
Released May 2, 2003

###	- Aesthetic/operational exceedance
###	- Above Ministry of HeatIth (MOH) guideline for people on sodium restricted diets
###	- Health based exceedance

TABLE J-2:
General Organic Water Quality - LYNDEN WELL FDL-03
Community of Lynden

PARAMETER	UNITS	ODWS Criteria			Lynden Well FDL-03
		Health Based Guideline	Aesthetic Based	Operational Based	24-Mar-16 72 Hour
Volatile Organic Compounds					
1,1-Dichloroethylene	ug/L	**14**	-	-	< 0.33
1,2-Dichlorobenzene	ug/L	**200**	**3**	-	< 0.41
1,2-Dichloroethane	ug/L	**5**	-	-	< 0.35
1,4-Dichlorobenzene	ug/L	**5**	**1**	-	< 0.36
Benzene	ug/L	**5**	-	-	< 0.32
Bromodichloromethane	ug/L	-	-	-	< 0.26
Bromoform	ug/L	-	-	-	< 0.34
Carbon Tetrachloride	ug/L	**5**	-	-	< 0.16
Chlorobenzene (Monochlorobenzene)	ug/L	**80**	**30**	-	< 0.3
Chloroform	ug/L	-	-	-	< 0.29
Dibrochloromethane	ug/L	-	-	-	< 0.37
Dichloromethane (Methylene Chloride)	ug/L	**50**	-	-	< 0.35
Ethylbenzene	ug/L	-	**2.4**	-	< 0.33
Tetrachloroethylene	ug/L	**30**	-	-	< 0.35
Toluene	ug/L	-	**24**	-	< 0.36
Trichloroethylene	ug/L	**5**	-	-	< 0.44
Vinyl Chloride	ug/L	**2**	-	-	< 0.17
Xylene (m+p)	ug/L	-	-	-	< 0.43
Xylene (o)	ug/L	-	-	-	< 0.17
Xylene (Total)	ug/L	-	**300**	-	< 0.43
Semivolatile Organics					
NDMA	ug/L	**0.009**	-	-	< 0.0008
Anions					
Free Cyanide	mg/L	**0.2**	-	-	< 0.003
Microbiology					
Background	CFU/100 ml	**200**	-	-	2
Heterotrophic Plate Count	CFU/ml	**500**	-	-	27
Total Coliforms	CFU/100 ml	**0**	-	-	0
E. Coli	CFU/100 ml	**0**	-	-	0
Nutrients					
Ammonia and Ammonium (as N)	mg/L	-	-	-	0.12
Total Kjeldahl Nitrogen (as N)	mg/L	-	-	-	0.11
Total Organic Nitrogen	mg/L	-	-	0.15	< 0
Dissolved Organic Carbon	mg/L	-	5	-	0.7
Fixed Gases					
Methane	L/m³	**3**	-	-	0.38
Radiological					
Gross Alpha	Bq/L	**0.5**	-	-	< 0.1
Gross Beta	Bq/L	**1**	-	-	< 0.1
Tritium	Bq/L	**7000**	-	-	< 15
Miscellaneous					
Total Trihalomethanes	ug/L	**100**	-	-	< 0.37
Bromate	ug/L	**10**	-	-	< 3
Microcystins	ug/L	**1.5**	-	-	< 0.15
NTA	mg/L	**0.4**	-	-	< 0.03

Notes:
- (dash) indicates parameter was not tested during the selected sample.
ODWS and AO / OG Criteria: Ontario Regulation 170/03 & Regulation 169/03 made under the Safe Drinking Water Act, 2002 including Microbiological standards.
Released May 2, 2003
Gross Alpha and Gross Beta criteria are based on the Canadian Drinking Water Quality Standards.

###	- Aesthetic/operational exceedance
###	- Above Ministry of Heatlth (MOH) guideline for people on sodium restricted diets
###	- Health based exceedance

TABLE J-3:
General Organic Water Quality - LYNDEN WELL FDL-03
Community of Lynden

PARAMETER	UNITS	ODWS Criteria			Lynden Well FDL-03
		Health Based Guideline	Aesthetic Based	Operational Based	24-Mar-16 72 Hour
Pesticides and Herbicides					
2,4,5-T	ug/L	**28**	**20**	-	< 0.22
2,4-D	ug/L	**100**	-	-	< 0.19
2,4'-DDT	ug/L	**-**	-	-	< 0.01
4,4'-DDD	ug/L	**-**	-	-	< 0.01
4,4'-DDE	ug/L	**-**	-	-	< 0.01
4,4'-DDT	ug/L	**-**	-	-	< 0.01
Alachlor	ug/L	**5**	-	-	< 0.02
Aldicarb	ug/L	**9**	-	-	< 0.01
Aldrin	ug/L	**0.2**	-	-	< 0.01
Dieldrin	ug/L	**0.5**	-	-	< 0.01
Aldrin + Dieldrin	ug/L	**0.7**	-	-	< 0.01
Atrazine	ug/L	**2.5**	-	-	< 0.01
Desethyl-atrizine	ug/L	**2.5**	-	-	< 0.01
Atrazine + Desethyl-atrazine	ug/L	**5**	-	-	< 0.01
Azinphos-methyl (Guthion)	ug/L	**20**	-	-	< 0.05
Bendiocarb	ug/L	**40**	-	-	< 0.01
Bromoxynil	ug/L	**5**	-	-	< 0.33
Carbaryl	ug/L	**90**	-	-	< 0.05
Carbofuran	ug/L	**90**	-	-	< 0.01
Oxychlordane	ug/L	**4**	-	-	< 0.01
g-Chlordane	ug/L	**2**	-	-	< 0.01
a-Chlordane	ug/L	**1**	-	-	< 0.01
Chlordane (Total)	ug/L	**7**	-	-	< 0.01
Chlorpyrifos (Dursban)	ug/L	**90**	-	-	< 0.02
Cyanazine (Bladex)	ug/L	**10**	-	-	< 0.03
DDT+ Metabolites	ug/L	**30**	-	-	< 0.01
Diazinon	ug/L	**20**	-	-	< 0.02
Dicamba	ug/L	**120**	-	-	< 0.2
Diclofop-methyl	ug/L	**9**	-	-	< 0.4
Dimethoate	ug/L	**20**	-	-	< 0.03
Dinoseb	ug/L	**10**	-	-	< 0.36
Diquat	ug/L	**70**	-	-	< 1
Diuron	ug/L	**150**	-	-	< 0.03
Glyphosate	ug/L	**280**	-	-	< 1
Heptachlor	ug/L	**1**	-	-	< 0.01
Heptachlor epoxide	ug/L	**2**	-	-	< 0.01
Heptachlor + Heptachlor epoxide	ug/L	**3**	-	-	< 0.01
Lindane	ug/L	**4**	-	-	< 0.01
Malathion	ug/L	**190**	-	-	< 0.02
Methoxychlor	ug/L	**900**	-	-	< 0.01
Metolachlor	ug/L	**50**	-	-	< 0.01
Metribuzin (Sencor)	ug/L	**80**	-	-	< 0.02
Paraquat	ug/L	**10**	-	-	< 1
Parathion	ug/L	**50**	-	-	< 0.02
Phorate	ug/L	**2**	-	-	< 0.01
Picloram	ug/L	**190**	-	-	< 1
Prometryn	ug/L	**1**	-	-	< 0.03
Simazine	ug/L	**10**	-	-	< 0.01
Temephos	ug/L	**280**	-	-	< 0.01
Terbufos	ug/L	**1**	-	-	< 0.01
Total Toxic Equivalency (MDL)	-	**-**	-	-	0
Triallate	ug/L	**230**	-	-	< 0.01
Trifluralin	ug/L	**45**	-	-	< 0.02
Polycyclic Aromatic Hydrocarbons					
Benzo(a)pyrene	ug/L	**0.01**	-	-	< 0.004
Phenols					
2,3,4,6-Tetrachlorophenol	ug/L	**100**	**1**	-	< 0.2
2,4,6-Trichlorophenol	ug/L	**5**	**2**	-	< 0.25
2,4-Dichlorophenol	ug/L	**900**	**0.3**	-	< 0.15
Pentachlorophenol	ug/L	**60**	**30**	-	< 0.15
PCBs					
Total PCBs	ug/L	**3**	-	-	< 0.04

Notes:
- (dash) indicates parameter was not tested during the selected sample.
ODWS and AO / OG Criteria: Ontario Regulation 170/03 & Regulation 169/03 made under the Safe Drinking Water Act, 2002 including Microbiological standards.
Released May 2, 2003

###	- Aesthetic/operational exceedance
###	- Above Ministry of Heatlh (MOH) guideline for people on sodium restricted diets
###	- Health based exceedance

Certificate of Analysis

City of Hamilton
Environmental Laboratory
700 Woodward Avenue, Hamilton, ON L8H 6P4
P. (905) 546-2424 F. (905)545-0234

CLIENT INFORMATION

Client Name: HAMILTON WATER
Attention: CARMEN VEGA

Address: 77 JAMES STREET NORTH
HAMILTON
L8R 2K3

LABORATORY INFORMATION

Sample Date: 2016-03-23
Date Submitted: 2016-03-24

Laboratory Work Order Number: 317381

Samples analysed in this work order were analysed using the following methods:

Alk/pH/Cond/Temp PC Titrate	TDS Gravimetric	Metals Hydrides-Hydride AA	Mercury Cold Vapour AA
Lead Graphite Furnace AA	Metals ICP	Anions IC	Turbidity Turbimeter
Cadmium Graphite Furnace AA	Colour Spectrophotometric	LIMS Calculation	Fluoride-PC Titrate
Subcontract			

NOTES: '<' = less than the Method Detection Limit (MDL), 'NS' = No Sample, 'IS' = Insufficient Sample, '>' = greater than the reported result, " * " indicates result is outside of the applied guideline/objective
Methods used by the City of Hamilton's Environmental Laboratory (CHEL) are based upon or modified from those found in the following sources: Standard Methods for the Examination of Water and Wastewater, 22nd Edition, United States Environmental Protection Agency (EPA), Ministry of the Environment (MOE), Association of Official Analytical Chemists (AOAC) and American Oil Chemists Society (AOCS).
All analytical work performed at the CHEL is done according to accepted quality assurance and quality control procedures. Quality and other related data as well as uncertainty values are available upon request.

The results on this Chemical Analysis Report relate only to the items tested.

Final Report Approval by:

Rosemary Eszes-Wegner, Supervisor Quality Assurance

Pamela M. Thomas, Superintendent Environmental Laboratory

Source Protection Planning

Lynden FDL03 72 Hour Pump Test

FDL03 - 1 HOUR 2016-03-21 11:30:00

Analyte	Result	Units	MDL
Alkalinity	100	mg/L	2
Carbonate	<2	mg/L	2
Chloride	24.4	mg/L	0.2
Colour (apparent)	4	CU	2
Fluoride	0.67	mg/L	0.04
Hardness	58.3	mg/L	0.7
Nitrate as N	<0.01	mg/L	0.01
Nitrite as N	<0.01	mg/L	0.01
Sulphate	16.7	mg/L	0.2
Total Dissolved Solids	182	mg/L	13
Turbidity	0.57	NTU	0.05
Aluminum	0.009	mg/L	0.002
Antimony	<0.0006	mg/L	0.0006
Arsenic	0.006	mg/L	0.001
Barium	0.114	mg/L	0.002
Beryllium	<0.0001	mg/L	0.0001
Bismuth	<0.020	mg/L	0.020
Boron	0.474	mg/L	0.010
Cadmium	<0.0001	mg/L	0.0001
Calcium	12.8	mg/L	0.10
Chromium	<0.001	mg/L	0.001
Cobalt	<0.0009	mg/L	0.0009
Copper	0.036	mg/L	0.002
Iron	0.022	mg/L	0.010
Lead	0.0011	mg/L	0.0010
Magnesium	6.39	mg/L	0.10
Manganese	0.010	mg/L	0.001
Mercury	<0.05	ug/L	0.05
Molybdenum	<0.005	mg/L	0.005
Nickel	<0.005	mg/L	0.005
Potassium	1.10	mg/L	0.10
Selenium	<0.002	mg/L	0.002
Silver	<0.005	mg/L	0.005
Sodium	46.8	mg/L	0.50
Strontium	0.719	mg/L	0.005
Thallium	<0.010	mg/L	0.010
Tin	<0.020	mg/L	0.020
Titanium	<0.001	mg/L	0.001
Uranium (Subcontract)	0.000110	mg/L	0.000002
Vanadium	<0.002	mg/L	0.002
Zinc	0.022	mg/L	0.005
Sulphide (Subcontract)	0.890	mg/L	0.020

Note: Hydrogen sulphide result is calculated to be 0.943 mg/L.

FDL03 - 12 HOUR 2016-03-21 22:30:00

Alkalinity	98	mg/L	2
Carbonate	<2	mg/L	2
Chloride	25.9	mg/L	0.2
Fluoride	0.69	mg/L	0.04
Nitrate as N	<0.01	mg/L	0.01
Nitrite as N	<0.01	mg/L	0.01

Analyte	Result	Units	MDL
Sulphate	15.5	mg/L	0.2
Aluminum	0.005	mg/L	0.002
Antimony	<0.0006	mg/L	0.0006
Arsenic	0.003	mg/L	0.001
Barium	0.096	mg/L	0.002
Beryllium	<0.0001	mg/L	0.0001
Bismuth	<0.020	mg/L	0.020
Boron	0.461	mg/L	0.010
Cadmium	<0.0001	mg/L	0.0001
Calcium	12.1	mg/L	0.10
Chromium	<0.001	mg/L	0.001
Cobalt	<0.0009	mg/L	0.0009
Copper	0.031	mg/L	0.002
Iron	0.016	mg/L	0.010
Lead	0.0010	mg/L	0.0010
Magnesium	6.01	mg/L	0.10
Manganese	0.009	mg/L	0.001
Mercury	<0.05	ug/L	0.05
Molybdenum	<0.005	mg/L	0.005
Nickel	<0.005	mg/L	0.005
Potassium	1.03	mg/L	0.10
Selenium	<0.002	mg/L	0.002
Silver	<0.005	mg/L	0.005
Sodium	46.2	mg/L	0.50
Strontium	0.681	mg/L	0.005
Thallium	<0.010	mg/L	0.010
Tin	<0.020	mg/L	0.020
Titanium	<0.001	mg/L	0.001
Uranium (Subcontract)	0.000047	mg/L	0.000002
Vanadium	<0.002	mg/L	0.002
Zinc	0.129	mg/L	0.005
Sulphide (Subcontract)	1.40	mg/L	0.020

Note: Hydrogen sulphide result is calculated to be 1.48 mg/L.

FDL03 - 24 HOUR 2016-03-22 10:30:00

Alkalinity	96	mg/L	2
Carbonate	<2	mg/L	2
Chloride	27.3	mg/L	0.2
Colour (apparent)	2	CU	2
Fluoride	0.68	mg/L	0.04
Hardness	55.3	mg/L	0.7
Nitrate as N	<0.01	mg/L	0.01
Nitrite as N	<0.01	mg/L	0.01
Sulphate	15.0	mg/L	0.2
Total Dissolved Solids	186	mg/L	13
Turbidity	0.41	NTU	0.05
Aluminum	0.005	mg/L	0.002
Antimony	<0.0006	mg/L	0.0006
Arsenic	0.002	mg/L	0.001
Barium	0.097	mg/L	0.002
Beryllium	<0.0001	mg/L	0.0001
Bismuth	<0.020	mg/L	0.020
Boron	0.465	mg/L	0.010
Cadmium	<0.0001	mg/L	0.0001
Calcium	12.1	mg/L	0.10

Analyte	Result	Units	MDL
Chromium	<0.001	mg/L	0.001
Cobalt	<0.0009	mg/L	0.0009
Copper	0.016	mg/L	0.002
Iron	0.016	mg/L	0.010
Lead	<0.0010	mg/L	0.0010
Magnesium	6.09	mg/L	0.10
Manganese	0.009	mg/L	0.001
Mercury	<0.05	ug/L	0.05
Molybdenum	<0.005	mg/L	0.005
Nickel	<0.005	mg/L	0.005
Potassium	1.02	mg/L	0.10
Selenium	<0.002	mg/L	0.002
Silver	<0.005	mg/L	0.005
Sodium	46.6	mg/L	0.50
Strontium	0.685	mg/L	0.005
Thallium	<0.010	mg/L	0.010
Tin	<0.020	mg/L	0.020
Titanium	<0.001	mg/L	0.001
Uranium (Subcontract)	0.000042	mg/L	0.000002
Vanadium	<0.002	mg/L	0.002
Zinc	0.009	mg/L	0.005
Sulphide (Subcontract)	0.590	mg/L	0.020

Note: Hydrogen sulphide result is calculated to be 0.625 mg/L.

FDL03 - 36 HOUR 2016-03-22 22:30:00

Alkalinity	98	mg/L	2
Carbonate	<2	mg/L	2
Chloride	29.2	mg/L	0.2
Fluoride	0.69	mg/L	0.04
Nitrate as N	<0.01	mg/L	0.01
Nitrite as N	<0.01	mg/L	0.01
Sulphate	14.6	mg/L	0.2
Aluminum	0.004	mg/L	0.002
Antimony	<0.0006	mg/L	0.0006
Arsenic	0.002	mg/L	0.001
Barium	0.092	mg/L	0.002
Beryllium	<0.0001	mg/L	0.0001
Bismuth	<0.020	mg/L	0.020
Boron	0.443	mg/L	0.010
Cadmium	<0.0001	mg/L	0.0001
Calcium	11.3	mg/L	0.10
Chromium	<0.001	mg/L	0.001
Cobalt	<0.0009	mg/L	0.0009
Copper	0.026	mg/L	0.002
Iron	0.013	mg/L	0.010
Lead	0.0013	mg/L	0.0010
Magnesium	5.67	mg/L	0.10
Manganese	0.008	mg/L	0.001
Mercury	<0.05	ug/L	0.05
Molybdenum	<0.005	mg/L	0.005
Nickel	<0.005	mg/L	0.005
Potassium	1.05	mg/L	0.10
Selenium	<0.002	mg/L	0.002
Silver	<0.005	mg/L	0.005
Sodium	46.6	mg/L	0.50

Analyte	Result	Units	MDL
Strontium	0.650	mg/L	0.005
Thallium	<0.010	mg/L	0.010
Tin	<0.020	mg/L	0.020
Titanium	<0.001	mg/L	0.001
Uranium (Subcontract)	0.000037	mg/L	0.000002
Vanadium	<0.002	mg/L	0.002
Zinc	0.190	mg/L	0.005
Sulphide (Subcontract)	1.40	mg/L	0.020

Note: Hydrogen sulphide result is calculated to be 1.48 mg/L.

FDL03 - 48 HOUR 2016-03-23 10:30:00

Alkalinity	97	mg/L	2
Carbonate	<2	mg/L	2
Chloride	28.9	mg/L	0.2
Colour (apparent)	<2	CU	2
Fluoride	0.69	mg/L	0.04
Hardness	51.0	mg/L	0.7
Nitrate as N	<0.01	mg/L	0.01
Nitrite as N	<0.01	mg/L	0.01
Sulphate	14.5	mg/L	0.2
Total Dissolved Solids	170	mg/L	13
Turbidity	0.14	NTU	0.05
Aluminum	0.004	mg/L	0.002
Antimony	<0.0006	mg/L	0.0006
Arsenic	0.002	mg/L	0.001
Barium	0.092	mg/L	0.002
Beryllium	<0.0001	mg/L	0.0001
Bismuth	<0.020	mg/L	0.020
Boron	0.428	mg/L	0.010
Cadmium	<0.0001	mg/L	0.0001
Calcium	11.2	mg/L	0.10
Chromium	<0.001	mg/L	0.001
Cobalt	<0.0009	mg/L	0.0009
Copper	0.034	mg/L	0.002
Iron	0.010	mg/L	0.010
Lead	0.0011	mg/L	0.0010
Magnesium	5.59	mg/L	0.10
Manganese	0.008	mg/L	0.001
Mercury	<0.05	ug/L	0.05
Molybdenum	<0.005	mg/L	0.005
Nickel	<0.005	mg/L	0.005
Potassium	0.96	mg/L	0.10
Selenium	<0.002	mg/L	0.002
Silver	<0.005	mg/L	0.005
Sodium	45.8	mg/L	0.50
Strontium	0.634	mg/L	0.005
Thallium	<0.010	mg/L	0.010
Tin	<0.020	mg/L	0.020
Titanium	<0.001	mg/L	0.001
Uranium (Subcontract)	0.000029	mg/L	0.000002
Vanadium	<0.002	mg/L	0.002
Zinc	0.033	mg/L	0.005
Sulphide (Subcontract)	1.50	mg/L	0.020

Note: Hydrogen sulphide result is calculated to be 1.59 mg/L.

FDL03 - 60 HOUR 2016-03-23 22:30:00

Analyte	Result	Units	MDL
Alkalinity	96	mg/L	2
Carbonate	<2	mg/L	2
Chloride	31.0	mg/L	0.2
Fluoride	0.69	mg/L	0.04
Nitrate as N	<0.01	mg/L	0.01
Nitrite as N	<0.01	mg/L	0.01
Sulphate	14.3	mg/L	0.2
Aluminum	0.004	mg/L	0.002
Antimony	<0.0006	mg/L	0.0006
Arsenic	0.002	mg/L	0.001
Barium	0.093	mg/L	0.002
Beryllium	<0.0001	mg/L	0.0001
Bismuth	<0.020	mg/L	0.020
Boron	0.430	mg/L	0.010
Cadmium	<0.0001	mg/L	0.0001
Calcium	11.1	mg/L	0.10
Chromium	<0.001	mg/L	0.001
Cobalt	<0.0009	mg/L	0.0009
Copper	0.040	mg/L	0.002
Iron	0.010	mg/L	0.010
Lead	0.0016	mg/L	0.0010
Magnesium	5.52	mg/L	0.10
Manganese	0.008	mg/L	0.001
Mercury	<0.05	ug/L	0.05
Molybdenum	<0.005	mg/L	0.005
Nickel	<0.005	mg/L	0.005
Potassium	0.99	mg/L	0.10
Selenium	<0.002	mg/L	0.002
Silver	<0.005	mg/L	0.005
Sodium	46.4	mg/L	0.50
Strontium	0.633	mg/L	0.005
Thallium	<0.010	mg/L	0.010
Tin	<0.020	mg/L	0.020
Titanium	<0.001	mg/L	0.001
Uranium (Subcontract)	0.000029	mg/L	0.000002
Vanadium	<0.002	mg/L	0.002
Zinc	0.112	mg/L	0.005
Sulphide (Subcontract)	1.50	mg/L	0.020

Note: Hydrogen sulphide result is calculated to be 1.59 mg/L.

Certificate of Analysis

City of Hamilton
Environmental Laboratory
700 Woodward Avenue, Hamilton, ON L8H 6P4
P. (905) 546-2424 F. (905)545-0234

CLIENT INFORMATION

Client Name: HAMILTON WATER
Attention: CARMEN VEGA

Address: 77 JAMES STREET NORTH
HAMILTON
L8R 2K3

LABORATORY INFORMATION

Sample Date: 2016-03-24
Date Submitted: 2016-03-24

Laboratory Work Order Number: 317409

Samples analysed in this work order were analysed using the following methods:

Alk/pH/Cond/Temp PC Titrate	Bacteria Membrane Filtration DC agar	Bacteria Membrane Filtration-HPC	TDS Gravimetric
Metals Hydrides-Hydride AA	Mercury Cold Vapour AA	Lead Graphite Furnace AA	Metals ICP
Anions IC	Ammonia Skalar	Cyanide Skalar	Turbidity Turbimeter
TOC/DOC Colourimetric	Cadmium Graphite Furnace AA	Colour Spectrophotometric	LIMS Calculation
Fluoride-PC Titrate	Subcontract	Microcystin ADDA	

NOTES: '<' = less than the Method Detection Limit (MDL), 'NS' = No Sample, 'IS' = Insufficient Sample, '>' = greater than the reported result, " * " indicates result is outside of the applied guideline/objective
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All analytical work performed at the CHEL is done according to accepted quality assurance and quality control procedures. Quality and other related data as well as uncertainty values are available upon request.

The results on this Chemical Analysis Report relate only to the items tested.

Final Report Approval by:

Rosemary Eszes-Wegner, Supervisor Quality Assurance

Pamela M. Thomas, Superintendent Environmental Laboratory

ODWS (Amended by O.Reg. 248/06)

Source Protection Planning

Lynden FDL03 72 Hour Pump Test

FDL03 - 72 HOUR 2016-03-24 10:30:00

Analyte	Result	Units	MDL		
Alkalinity	95	mg/L	2		
Ammonia + Ammonium as N	0.12	mg/L	0.01		
Chloride	29.5	mg/L	0.2		
Colour (apparent)	<2	CU	2		
Dissolved Organic Carbon	0.7	mg/L	0.4		
Fluoride	0.69	mg/L	0.04	1.5	**MAC**
Hardness	51.0	mg/L	0.7		
Nitrate as N	<0.01	mg/L	0.01	10.0	**MAC**
Nitrate+Nitrite as N	<0.02	mg/L	0.02	10.0	**MAC**
Nitrite as N	<0.01	mg/L	0.01	1.0	**MAC**
pH	8.24	pH	0.01		
Sulphate	13.7	mg/L	0.2		
Total Dissolved Solids	176	mg/L	13		
Total Kjeldahl Nitrogen as N (Subcontract)	0.11	as N mg/L	0.05		
Turbidity	0.13	NTU	0.05		
Escherichia coli	0	CFU/100mL	0	0	**MAC**
Heterotrophic Plate Count	27	CFU/1mL	0		
Total Coliform	0	CFU/100mL	0	0	**MAC**
Total Coliform Background	2	CFU/100mL	0		
Aluminum	0.003	mg/L	0.002		
Antimony	<0.0006	mg/L	0.0006	0.006	**MAC**
Arsenic	0.002	mg/L	0.001	0.025	**MAC**
Barium	0.096	mg/L	0.002	1.0	**MAC**
Boron	0.439	mg/L	0.010	5.0	**MAC**
Cadmium	<0.0001	mg/L	0.0001	0.005	**MAC**
Calcium	11.2	mg/L	0.10		
Chromium	<0.001	mg/L	0.001	0.05	**MAC**
Copper	0.004	mg/L	0.002		
Iron	0.012	mg/L	0.010		
Lead	<0.0010	mg/L	0.0010	0.010	**MAC**
Magnesium	5.60	mg/L	0.10		
Manganese	0.008	mg/L	0.001		
Mercury	<0.05	ug/L	0.05	1	**MAC**
Selenium	<0.002	mg/L	0.002	0.01	**MAC**
Sodium	47.0	mg/L	0.50	20	*
Titanium	<0.001	mg/L	0.001		
Uranium (Subcontract)	0.000031	mg/L	0.002	0.02	**MAC**
Zinc	<0.005	mg/L	0.005		
1,1-Dichloroethylene (Subcontract)	< 0.33	µg/L	0.33	14	**MAC**
1,2-Dichlorobenzene (Subcontract)	< 0.41	µg/L	0.41	200	**MAC**
1,2-Dichloroethane (Subcontract)	< 0.35	µg/L	0.35	5	**MAC**
1,4-Dichlorobenzene (Subcontract)	< 0.36	µg/L	0.36	5	**MAC**
Benzene (Subcontract)	< 0.32	µg/L	0.32	5	**MAC**
Bromodichloromethane (Subcontract)	< 0.26	µg/L	0.26		
Bromoform (Subcontract)	< 0.34	µg/L	0.34		
Carbon Tetrachloride (Subcontract)	< 0.16	µg/L	0.16	5	**MAC**
Chlorobenzene (Subcontract)	< 0.3	µg/L	0.3	80	**MAC**
Chloroform (Subcontract)	< 0.29	µg/L	0.29		
Dibromochloromethane (Subcontract)	< 0.37	µg/L	0.37		
Dichloromethane (Subcontract)	< 0.35	µg/L	0.35	50	**MAC**
Ethylbenzene (Subcontract)	< 0.33	ug/L	0.33		
m+p-Xylene (Subcontract)	< 0.43	µg/L	0.43		

ODWS (Amended by O.Reg. 248/06)

Analyte		Result	Units	MDL		
o-Xylene	(Subcontract)	< 0.17	µg/L	0.17		
Tetrachloroethylene	(Subcontract)	< 0.35	µg/L	0.35	30	**MAC**
Toluene	(Subcontract)	< 0.36	ug/L	0.36		
Total Trihalomethanes	(Subcontract)	< 0.37	µg/L	0.37	100	**MAC**
Trichloroethylene	(Subcontract)	< 0.44	µg/L	0.44	5	**MAC**
Vinyl Chloride	(Subcontract)	< 0.17	µg/L	0.17	2	**MAC**
Xylene	(Subcontract)	< 0.43	µg/L	0.43		
Benzo[a]pyrene	(Subcontract)	<0.004	µg/L	0.004	0.01	
	Microcystins	<0.15	ug/L	0.15		
2,3,4,6-Tetrachlorophenol	(Subcontract)	< 0.20	µg/L	0.2	100	
2,4,5-T	(Subcontract)	< 0.22	µg/L	0.22	280	
2,4,6-Trichlorophenol	(Subcontract)	< 0.25	µg/L	0.25	5	
2,4-D	(Subcontract)	< 0.19	µg/L	0.19	100	
2,4'-DDT	(Subcontract)	<0.01	µg/L	0.01		
2,4-Dichlorophenol	(Subcontract)	< 0.15	µg/L	0.15	900	
4,4'-DDD	(Subcontract)	<0.01	µg/L	0.01		
4,4'-DDE	(Subcontract)	<0.01	µg/L	0.01		
4,4'-DDT	(Subcontract)	<0.01	µg/L	0.01		
Alachlor	(Subcontract)	<0.02	µg/L	0.02	5	
Aldicarb	(Subcontract)	<0.01	µg/L	0.01	9	
Aldrin	(Subcontract)	<0.01	µg/L	0.01		
Aldrin+Dieldrin	(Subcontract)	<0.01	µg/L	0.01	0.7	
alpha-Chlordane	(Subcontract)	<0.01	µg/L	0.01		
Atrazine	(Subcontract)	<0.01	µg/L	0.01		
Atrazine + Desethyl-atrazine	(Subcontract)	<0.01	µg/L	0.01	5	
Azinphos-methyl	(Subcontract)	<0.05	µg/L	0.05	20	
Bendiocarb	(Subcontract)	<0.01	µg/L	0.01	40	
Bromate	(Subcontract)	< 0.003	mg/L	0.003	10	
Bromoxynil	(Subcontract)	< 0.33	µg/L	0.33	5	
Carbaryl	(Subcontract)	<0.05	µg/L	0.05	90	
Carbofuran	(Subcontract)	<0.01	µg/L	0.01	90	
Chlordane (Total)	(Subcontract)	<0.01	µg/L	0.01	7	
Chlorpyrifos (Dursban)	(Subcontract)	<0.02	µg/L	0.02		
Cyanazine (Bladex)	(Subcontract)	<0.03	µg/L	0.03		
	Cyanide - Free	<0.003	mg/L	0.003		
DDT + Metabolites	(Subcontract)	<0.01	µg/L	0.01		
Desethyl-atrazine	(Subcontract)	<0.01	µg/L	0.01		
Diazinon	(Subcontract)	<0.02	µg/L	0.02	20	
Dicamba	(Subcontract)	< 0.20	µg/L	0.20	120	
Diclofop-methyl	(Subcontract)	< 0.40	µg/L	0.40	9	
Dieldrin	(Subcontract)	<0.01	µg/L	0.01		
Dimethoate	(Subcontract)	<0.03	µg/L	0.03	20	
Dinoseb	(Subcontract)	< 0.36	µg/L	0.36	10	
Diquat	(Subcontract)	<1	ug/L	1	70	
Diuron	(Subcontract)	<0.03	µg/L	0.03	150	
gamma-Chlordane	(Subcontract)	<0.01	µg/L	0.01		
Glyphosate	(Subcontract)	<1	ug/L	1	280	
Gross Alpha	(Subcontract)	<0.10				
Gross Beta	(Subcontract)	<0.10		<0.10		
Heptachlor	(Subcontract)	<0.01	µg/L	0.01		
Heptachlor epoxide	(Subcontract)	<0.01	µg/L	0.01		
Heptachlor+Heptachlor epoxide	(Subcontract)	<0.01	µg/L	0.01	3	
Lindane	(Subcontract)	<0.01	µg/L	0.01	4	
Malathion	(Subcontract)	<0.02	µg/L	0.02	190	
Methane	(Subcontract)	0.38	L/m3	0.02		
Methoxychlor	(Subcontract)	<0.01	µg/L	0.01	900	
Metolachlor	(Subcontract)	<0.01	µg/L	0.01	50	

ODWS (Amended by O.Reg. 248/06)

Analyte		Result	Units	MDL	
Metribuzin (Sencor)	(Subcontract)	<0.02	µg/L	0.02	80
NDMA	(Subcontract)	<0.0008	µg/L	0.0008	0.009
Nitrilotriacetic Acid	(Subcontract)	< 0.03	mg/L	0.03	400
Organic Nitrogen		<0	mg/L	0	
Oxychlordane	(Subcontract)	<0.01	µg/L	0.01	
Paraquat	(Subcontract)	<1	ug/L	1	10
Parathion	(Subcontract)	<0.02	µg/L	0.02	50
PCBsTotal	(Subcontract)	<0.04	µg/L	0.04	3.0
Pentachlorophenol	(Subcontract)	< 0.15	µg/L	0.15	60
Phorate	(Subcontract)	<0.01	µg/L	0.01	2
Picloram	(Subcontract)	< 1	µg/L	1	190
Prometryne	(Subcontract)	<0.03	µg/L	0.03	1
Simazine	(Subcontract)	<0.01	µg/L	0.01	10
Sulphide	(Subcontract)	1.70	mg/L	0.020	
Temephos	(Subcontract)	<0.01	µg/L	0.01	280
Terbufos	(Subcontract)	<0.01	µg/L	0.01	1
Total Toxic Equivalency (MDL)	(Subcontract)	0			
Triallate	(Subcontract)	<0.01	µg/L	0.01	230
Trifluralin	(Subcontract)	<0.02	µg/L	0.02	45
Tritium	(Subcontract)	<15			

Note: Hydrogen sulphide result is calculated to be 1.80 mg/L.

Report Comment: The ODWS does not specify a MAC for sodium, however, as per section 18 of the SDWA, sodium results above 20 mg/L on a regulatory sample are prescribed as adverse results with a duty to report as specified in the applicable regulation.

Certificate of Analysis

City of Hamilton
Environmental Laboratory
700 Woodward Avenue, Hamilton, ON L8H 6P4
P. (905) 546-2424 F. (905)545-0234

CLIENT INFORMATION

Client Name: HAMILTON WATER
Attention: CARMEN VEGA

Address: 77 JAMES STREET NORTH
HAMILTON
L8R 2K3

LABORATORY INFORMATION

Sample Date: 2016-03-24
Date Submitted: 2016-03-24

Laboratory Work Order Number: 317409

Revised Report to update the organic nitrogen value

Samples analysed in this work order were analysed using the following methods:

Alk/pH/Cond/Temp PC Titrate	Bacteria Membrane Filtration DC agar	Bacteria Membrane Filtration-HPC	TDS Gravimetric
Metals Hydrides-Hydride AA	Mercury Cold Vapour AA	Lead Graphite Furnace AA	Metals ICP
Anions IC	Ammonia Skalar	Cyanide Skalar	Turbidity Turbimeter
TOC/DOC Colourimetric	Cadmium Graphite Furnace AA	Colour Spectrophotometric	LIMS Calculation
Fluoride-PC Titrate	Subcontract	Microcystin ADDA	

NOTES: '<' = less than the Method Detection Limit (MDL), 'NS' = No Sample, 'IS' = Insufficient Sample, '>' = greater than the reported result, " * " indicates result is outside of the applied guideline/objective
Methods used by the City of Hamilton's Environmental Laboratory (CHEL) are based upon or modified from those found in the following sources: Standard Methods for the Examination of Water and Wastewater, 22nd Edition, United States Environmental Protection Agency (EPA), Ministry of the Environment (MOE), Association of Official Analytical Chemists (AOAC) and American Oil Chemists Society (AOCS).
All analytical work performed at the CHEL is done according to accepted quality assurance and quality control procedures. Quality and other related data as well as uncertainty values are available upon request.

The results on this Chemical Analysis Report relate only to the items tested.

Final Report Approval by:

Rosemary Eszes-Wegner, Supervisor Quality Assurance

Pamela M. Thomas, Superintendent Environmental Laboratory

Source Protection Planning

Lynden FDL03 72 Hour Pump Test

FDL03 - 72 HOUR 2016-03-24 10:30:00

Analyte	Result	Units	MDL
Alkalinity	95	mg/L	2
Ammonia + Ammonium as N	0.12	mg/L	0.01
Chloride	29.5	mg/L	0.2
Colour (apparent)	<2	CU	2
Cyanide - Free	<0.003	mg/L	0.003
Dissolved Organic Carbon	0.7	mg/L	0.4
Fluoride	0.69	mg/L	0.04
Hardness	51.0	mg/L	0.7
Microcystins	<0.15	ug/L	0.15
Nitrate as N	<0.01	mg/L	0.01
Nitrate+Nitrite as N	<0.02	mg/L	0.02
Nitrite as N	<0.01	mg/L	0.01
Organic Nitrogen	<0.05	mg/L	0.05
pH	8.24	pH	0.01
Sulphate	13.7	mg/L	0.2
Total Dissolved Solids	176	mg/L	13
Total Kjeldahl Nitrogen as N (Subcontract)	0.11	as N mg/L	0.05
Turbidity	0.13	NTU	0.05
Escherichia coli	0	CFU/100mL	0
Heterotrophic Plate Count	27	CFU/1mL	0
Total Coliform	0	CFU/100mL	0
Total Coliform Background	2	CFU/100mL	0
Aluminum	0.003	mg/L	0.002
Antimony	<0.0006	mg/L	0.0006
Arsenic	0.002	mg/L	0.001
Barium	0.096	mg/L	0.002
Boron	0.439	mg/L	0.010
Cadmium	<0.0001	mg/L	0.0001
Calcium	11.2	mg/L	0.10
Chromium	<0.001	mg/L	0.001
Copper	0.004	mg/L	0.002
Iron	0.012	mg/L	0.010
Lead	<0.0010	mg/L	0.0010
Magnesium	5.60	mg/L	0.10
Manganese	0.008	mg/L	0.001
Mercury	<0.05	ug/L	0.05
Selenium	<0.002	mg/L	0.002
Sodium	47.0	mg/L	0.50
Titanium	<0.001	mg/L	0.001
Uranium (Subcontract)	0.000031	mg/L	0.002
Zinc	<0.005	mg/L	0.005
1,1-Dichloroethylene (Subcontract)	< 0.33	µg/L	0.33
1,2-Dichlorobenzene (Subcontract)	< 0.41	µg/L	0.41
1,2-Dichloroethane (Subcontract)	< 0.35	µg/L	0.35
1,4-Dichlorobenzene (Subcontract)	< 0.36	µg/L	0.36
Benzene (Subcontract)	< 0.32	µg/L	0.32
Bromodichloromethane (Subcontract)	< 0.26	µg/L	0.26
Bromoform (Subcontract)	< 0.34	µg/L	0.34
Carbon Tetrachloride (Subcontract)	< 0.16	µg/L	0.16
Chlorobenzene (Subcontract)	< 0.3	µg/L	0.3
Chloroform (Subcontract)	< 0.29	µg/L	0.29
Dibromochloromethane (Subcontract)	< 0.37	µg/L	0.37

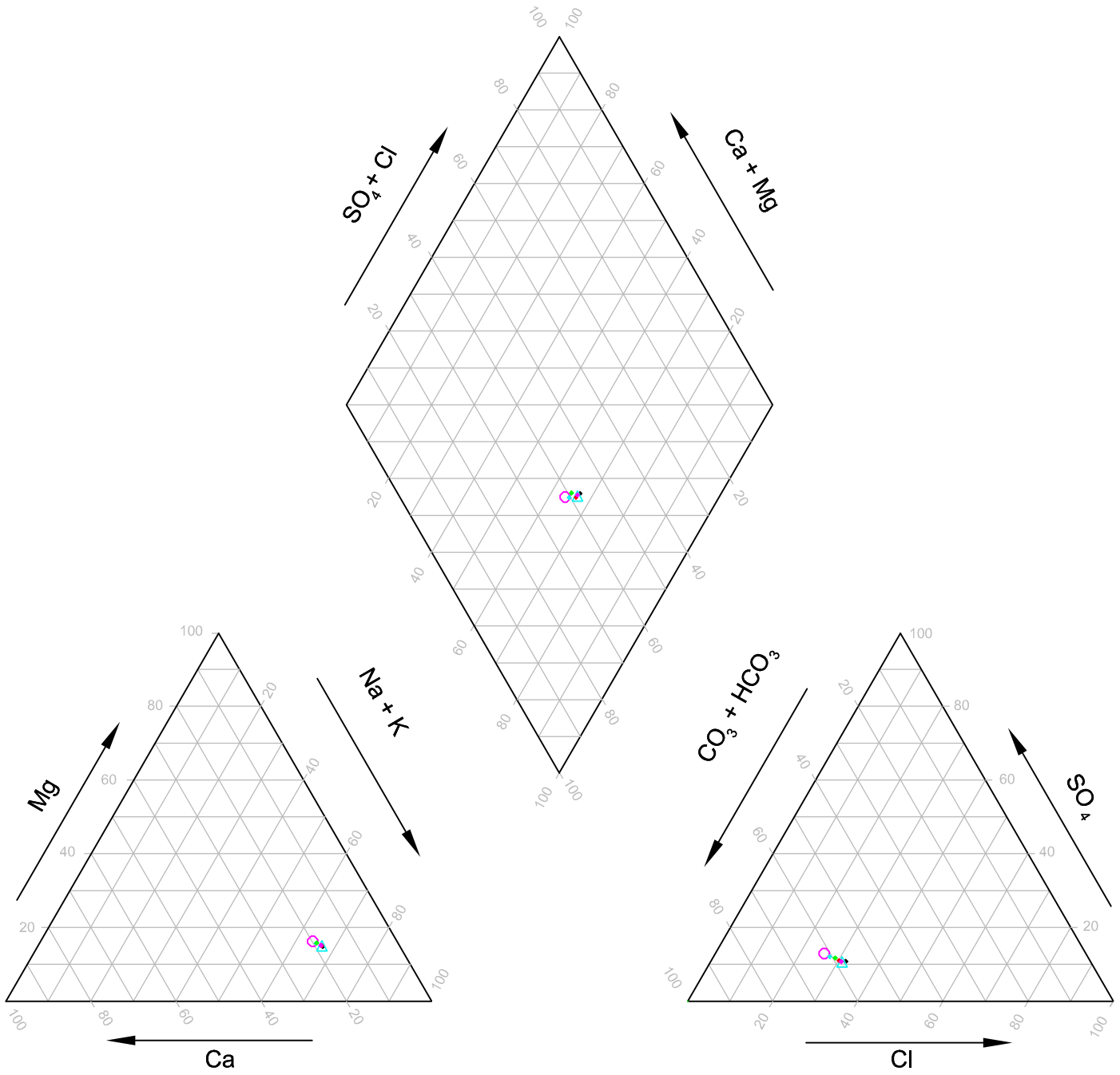
Analyte		Result	Units	MDL
Dichloromethane	(Subcontract)	< 0.35	µg/L	0.35
Ethylbenzene	(Subcontract)	< 0.33	ug/L	0.33
m+p-Xylene	(Subcontract)	< 0.43	µg/L	0.43
o-Xylene	(Subcontract)	< 0.17	µg/L	0.17
Tetrachloroethylene	(Subcontract)	< 0.35	µg/L	0.35
Toluene	(Subcontract)	< 0.36	ug/L	0.36
Total Trihalomethanes	(Subcontract)	< 0.37	µg/L	0.37
Trichloroethylene	(Subcontract)	< 0.44	µg/L	0.44
Vinyl Chloride	(Subcontract)	< 0.17	µg/L	0.17
Xylene	(Subcontract)	< 0.43	µg/L	0.43
Benzo[a]pyrene	(Subcontract)	<0.004	µg/L	0.004
2,3,4,6-Tetrachlorophenol	(Subcontract)	< 0.20	µg/L	0.2
2,4,5-T	(Subcontract)	< 0.22	µg/L	0.22
2,4,6-Trichlorophenol	(Subcontract)	< 0.25	µg/L	0.25
2,4-D	(Subcontract)	< 0.19	µg/L	0.19
2,4'-DDT	(Subcontract)	<0.01	µg/L	0.01
2,4-Dichlorophenol	(Subcontract)	< 0.15	µg/L	0.15
4,4'-DDD	(Subcontract)	<0.01	µg/L	0.01
4,4'-DDE	(Subcontract)	<0.01	µg/L	0.01
4,4'-DDT	(Subcontract)	<0.01	µg/L	0.01
Alachlor	(Subcontract)	<0.02	µg/L	0.02
Aldicarb	(Subcontract)	<0.01	µg/L	0.01
Aldrin	(Subcontract)	<0.01	µg/L	0.01
Aldrin+Dieldrin	(Subcontract)	<0.01	µg/L	0.01
alpha-Chlordane	(Subcontract)	<0.01	µg/L	0.01
Atrazine	(Subcontract)	<0.01	µg/L	0.01
Atrazine + Desethyl-atrazine	(Subcontract)	<0.01	µg/L	0.01
Azinphos-methyl	(Subcontract)	<0.05	µg/L	0.05
Bendiocarb	(Subcontract)	<0.01	µg/L	0.01
Bromate	(Subcontract)	< 0.003	mg/L	0.003
Bromoxynil	(Subcontract)	< 0.33	µg/L	0.33
Carbaryl	(Subcontract)	<0.05	µg/L	0.05
Carbofuran	(Subcontract)	<0.01	µg/L	0.01
Chlordane (Total)	(Subcontract)	<0.01	µg/L	0.01
Chlorpyrifos (Dursban)	(Subcontract)	<0.02	µg/L	0.02
Cyanazine (Bladex)	(Subcontract)	<0.03	µg/L	0.03
DDT + Metabolites	(Subcontract)	<0.01	µg/L	0.01
Desethyl-atrazine	(Subcontract)	<0.01	µg/L	0.01
Diazinon	(Subcontract)	<0.02	µg/L	0.02
Dicamba	(Subcontract)	< 0.20	µg/L	0.20
Diclofop-methyl	(Subcontract)	< 0.40	µg/L	0.40
Dieldrin	(Subcontract)	<0.01	µg/L	0.01
Dimethoate	(Subcontract)	<0.03	µg/L	0.03
Dinoseb	(Subcontract)	< 0.36	µg/L	0.36
Diquat	(Subcontract)	<1	ug/L	1
Diuron	(Subcontract)	<0.03	µg/L	0.03
gamma-Chlordane	(Subcontract)	<0.01	µg/L	0.01
Glyphosate	(Subcontract)	<1	ug/L	1
Gross Alpha	(Subcontract)	<0.10		
Gross Beta	(Subcontract)	<0.10		<0.10
Heptachlor	(Subcontract)	<0.01	µg/L	0.01
Heptachlor epoxide	(Subcontract)	<0.01	µg/L	0.01
Heptachlor+Heptachlor epoxide	(Subcontract)	<0.01	µg/L	0.01
Lindane	(Subcontract)	<0.01	µg/L	0.01
Malathion	(Subcontract)	<0.02	µg/L	0.02
Methane	(Subcontract)	0.38	L/m3	0.02
Methoxychlor	(Subcontract)	<0.01	µg/L	0.01

Analyte		Result	Units	MDL
Metolachlor	(Subcontract)	<0.01	µg/L	0.01
Metribuzin (Sencor)	(Subcontract)	<0.02	µg/L	0.02
NDMA	(Subcontract)	<0.0008	µg/L	0.0008
Nitrilotriacetic Acid	(Subcontract)	< 0.03	mg/L	0.03
Oxychlordane	(Subcontract)	<0.01	µg/L	0.01
Paraquat	(Subcontract)	<1	ug/L	1
Parathion	(Subcontract)	<0.02	µg/L	0.02
PCBsTotal	(Subcontract)	<0.04	µg/L	0.04
Pentachlorophenol	(Subcontract)	< 0.15	µg/L	0.15
Phorate	(Subcontract)	<0.01	µg/L	0.01
Picloram	(Subcontract)	< 1	µg/L	1
Prometryne	(Subcontract)	<0.03	µg/L	0.03
Simazine	(Subcontract)	<0.01	µg/L	0.01
Sulphide	(Subcontract)	1.70	mg/L	0.020
Temephos	(Subcontract)	<0.01	µg/L	0.01
Terbufos	(Subcontract)	<0.01	µg/L	0.01
Total Toxic Equivalency (MDL)	(Subcontract)	0	ppq	0
Triallate	(Subcontract)	<0.01	µg/L	0.01
Trifluralin	(Subcontract)	<0.02	µg/L	0.02
Tritium	(Subcontract)	<15		

Note: Hydrogen sulphide result is calculated to be 1.80 mg/L.

Appendix K

TRILINEAR DIAGRAM – FDL-03



LEGEND

- 1 HOUR
- 12 HOUR
- 24 HOUR
- 36 HOUR
- 48 HOUR
- 60 HOUR
- 72 HOUR

TRILINEAR DIAGRAM

LYNDEN WATER SUPPLY CLASS
ENVIRONMENTAL ASSESSMENT
TESTING PROGRAM FOR
LYNDEN WELL FDL-03
For: City of Hamilton

DATE: MAY 2016	SCALE: AS SHOWN
PROJECT:071-11885-01 105	REF. NO.: 071-11885-01 105 FK-TD

WSP

FIGURE
K