REPORT

Production Well Capacity and Raw Water Quality Assessment for Stouffville Production Wells

Stouffville Water System Upgrades Class EA, York Region

Submitted to:

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1.0 INTRODUCTION

Golder was retained by The Municipal Infrastructure Group (TMIG) on behalf of York Region to conduct a production well performance and capacity review and raw water quality assessment for the Stouffville Groundwater System in York Region. This assessment is required as part of the Class Environmental Assessment (EA) for Water System Upgrades for the Community of Stouffville, York Region, Ontario.

The scope of work and objectives of this assessment are as follows:

- Review production well performance and capacity based on historical information and well performance evaluations completed to date;
- Assess raw water quality and model water quality trends out to 2041 (EA planning horizon). Assess water quality distribution trends through water quality concentration mapping for parameters of concern for each source aquifer;
  - The objective of the water quality assessment is to identify water quality parameters with increasing trends expected to cause water treatment process issues and/or issues related to meeting regulatory limits (Ontario Drinking Water Standards) within the EA planning horizon;
  - The water quality assessment will consider the newly proposed MAC/AO for Mn, and will assume that MECP adopts these new limits;
  - Based on the conclusions of this assessment, suitable 'water quality thresholds' for each parameter of concern will be established that will enable the Region to monitor for changes in water quality and determine if corrective action (i.e. well replacement) is required within estimated time frames.
- Assess production well lifespan and confirm whether existing production wells are expected to supply adequate yield to meet future demand of the EA planning horizon.
- Assess if well replacement or significant well modification is expected within the EA planning horizon and propose additional exploration studies to be completed, if warranted.

This report provides a background of relevant municipal well information compiled and used in the assessment (Section 2.0), a review of the well performance and capacity of the wells (Section 3.0), an assessment of raw groundwater quality (Section 4.0), and the study key conclusions and recommendations (Section 5.0).

2.0 MUNICIPAL WELL INFORMATION

2.1 Well Construction Details

The Stouffville water supply system consists of five water supply wells at the locations shown on Figure 1. The production well construction details are shown in Table 1.

Table 1: Production Well Construction Details

Well ID	Date	Driller	Ground Surface Elevation (masl)	Casing / Screen Diameter (mm)	Top of Screen (mbgs)	Bottom of Screen (mbgs)	Aquifer
STO PW1	1998	IWS	278.7	600 / 300	94.5	99.1	TAC
STO PW2	1998	IWS	278.4	600 / 300	96.4	100.9	
STO PW3	1976	IWS	287.2	600 x 300	20.5	23.5	Lower ORAC
STO PW5	1960	C.H. Rutledge	308.9	600	7.0	12.5	
STO PW6	1966	Faulkner Well Drilling	305.0	600 x 300	13.7	21.4	

Notes:

IWS = International Water Supply
masl = meters above sea level
mm = millimeters
mbgs = metres below ground surface
TAC = Thorncliffe Aquifer Complex
ORAC = Oak Ridges Aquifer Complex

The municipal production wells include two deep wells PW1 and PW2 screened in the Thorncliffe Aquifer Complex (TAC) and three shallower wells PW3, PW5 and PW6 screened in the lower Oak Ridges Aquifer Complex (ORAC).

There are a total of 23 monitoring wells in Stouffville and 4 monitoring wells in Lemonville operated by York Region at the locations shown in Figure 1. These include 10 wells screened in the deep aquifer (TAC) and 17 wells screened in the shallow aquifer (ORAC).

2.2 Well Pumping Rates

Annual average daily production rates for each municipal production well from 2002 to 2018 are presented on Figure 2. The average daily production rates for each well from 2002 to 2018, 2014 to 2018 (5-year period), and 2018 are presented in Table 2. Table 2 also presents the maximum day well production since 2002 and the permitted rates for the wells.

Table 2: Well Pumping Rates

Well ID	Average Daily Production (m^3/day) 2002-2018	Average Daily Production (m^3/day) 2014-2018	Average Daily Production (m^3/day) 2018	Max. Day Production (m^3/day), since 2002	PTTW Rate (m^3/day)	PTTW Rate (L/s)
STO PW1	599	483	487	2,831, Jul 2016	2,946	34.1
STO PW2	646	553	558	2,817, Jun 2016	2,946	34.1
STO PW3	1169	1079	1128	2,925, Jul 2016	2,946	34.1
STO PW5	1008	729	537	2,878, Jun 2016	3,110	36.0
STO PW6	917	686	577	2,266, Aug 2002	2,290	26.5

The daily production rates for the wells are presented along with groundwater elevation hydrographs for each well on Figures 3 to 7 for the period of 2002 to 2018.

2.3 Theoretical Yield for Well Screens

The theoretical yield for the production wells was estimated using Johnson Screens – Transmitting Capacity Chart for large diameter 304SS free flow or standard construction at 0.03 meter per second average entrance velocity. All wells were assumed to have pipe size screens, based on the descriptions of casing and well screen in the water well records (Appendix A).

Table 3: Theoretical Yield for Well Screen

Well ID	Screen Length (m)	Screen Diameter (mm)	Screen Slot	Theoretical Yield for Screen (L/s)	PTTW Rate (L/s)
STO PW1	4.6	300	50	36	34.1
STO PW2	4.6	300	50	36	34.1
STO PW3	6.3	300	50/20	37	34.1
STO PW5	5.8	600	50*	46	36.0
STO PW6	7.6	300	35	34	26.5

Note: * Assumed a 50-slot screen as the size was not provided on the well record.

The theoretical yields for the well screens are typically used as a guide in well design and assessment of well performance. The calculated theoretical yields must be used conservatively for design and taking into account well operational monitoring history and assessment of actual well performance testing results.

2.4 Groundwater Levels and Available Drawdown

The groundwater levels monitored at the municipal production wells are shown on Figures 3 to 7.

The height of the groundwater elevation above the pump intake or top of screen (referred to as available drawdown) is shown in Table 4 including the total available drawdown and the available drawdown remaining during pumping at the time of the lowest observed groundwater level.

Table 4: Available Drawdown

				Lowest Observed Pumped Groundwater Level			
Well ID	**Pump Intake / Top of Screen (masl)**	**Average Static Groundwater Elevation (masl)**	**Total Available Drawdown (m)**	**Lowest Groundwater Elevation[1] (masl)**	**Date(s)**	**Pumping Rate[1] (L/s)**	**Remaining Available Drawdown (m)**
STO PW1	203	238	35	221	Jun 2016	31	18
STO PW2	205	236	31	218	Jul 2011, Jun 2016	33	13
STO PW3	269	283	14	270	Jul 2016	34	1
STO PW5	297 / 302	306	4[2]	303	Jun 2016	33	1[2]
STO PW6	287 / 291	304	13[2]	291	May- Sep 2013, Sep 2016, Jul 2019	24	0[2]

Notes:
1) Based on highest daily pumping rates on the date(s) the lowest groundwater elevation was observed.
2) In cases where the pump intake is set below the top of the well screen the top of the well screen was used to calculate the available drawdown.

3.0 WELL PERFORMANCE AND CAPACITY ASSESSMENT

Golder reviewed production well performance documentation for the Stouffville wells provided by York Region including; well performance evaluation memos, well condition inspection reports and maintenance and rehabilitation reports.

Based on the desktop review, the findings are summarized below.

3.1.1 Stouffville PW1

The following provides a summary of well performance testing and rehabilitation completed at the well:

- An initial pumping test and step test were conducted in 1998 shortly after the well was constructed;
- A well inspection video was conducted in 2011 by IWS; and
- The well was step-tested in 2009 by IWS, in 2013 by York Region and again in 2018 by York Region.

The results of the performance testing and specific capacity values are shown in Table 5.

Table 5: PW1 Specific Capacity

Well ID	Test Date	Pumping Rate (L/s)	Duration (hrs)	Drawdown (m)	Specific Capacity (L/s/m)
STO PW1	March 1998	34.1	63	23.3	1.5
	March 1998	33.0	-(1)	8.72	3.8
	March 2018	36.0	1	9.89	-
		33.0	-	8.27(2)	4.0(2)

Note:
(1) Step test duration not specified in reports provided to Golder.
(2) Interpolated value based on 36.0 L/s step test.

Specific capacity values have slightly improved at PW1 without the need for any rehabilitation, when comparing recent and past step tests (York Region, 2018).

The long-term groundwater level trends over the last 5 years have been stable, and when pumping near the permitted limit, pumped groundwater levels are approximately 18 m or more above the pump intake (static levels ~35 m above pump intake).

The production rate at PW1 is not limited by the available drawdown; however, it is not recommended to increase water taking above its currently permitted rate of 34.1 L/s since this is already close to the limit of the theoretical yield for the screen (36 L/s).

From a quantity perspective, PW1 is expected to be capable of providing up to the permitted water taking rate of 34.1 L/s (2,946 m^3/day) for the EA planning horizon (up to 2041).

3.1.2 Stouffville PW2

The following provides a summary of well performance testing and rehabilitation completed at the well:

- Well PW2 was constructed in 1998 by IWS with an initial pumping test conducted; and
- The well was step-tested in 2011 and 2013 by York Region.

The results of the performance testing and specific capacity values are shown in Table 6.

Table 6: PW2 Specific Capacity

Well ID	Test Date	Pumping Rate (L/s)	Duration (hrs)	Drawdown (m)	Specific Capacity (L/s/m)
STO PW2	February 1998	34.1	116	22.7	1.5
	September 2011	24.0	- (1)	9.4	2.6
	June 2013	33.0	<1	12.1	-
		24.0	-	8.8(2)	2.7(2)

Note:
(1) Step test duration not specified in reports provided to Golder.
(2) Interpolated value based on 33.0 L/s step test.

Specific capacity values have slightly improved at PW2 without the need for any rehabilitation, when comparing recent and past step tests (York Region, 2018).

The long-term groundwater level trends over the last 5 years have been stable, and when pumping near the permitted limit, pumped groundwater levels are approximately 13 m or more above the pump intake (static levels ~31 m above pump intake).

The production rate at PW2 is not limited by the available drawdown; however, it is not recommended to increase water taking above its currently permitted rate of 34.1 L/s since this is close to the limit of the theoretical yield for the screen (36 L/s).

From a quantity perspective PW2 is expected to be capable of providing up to the permitted water taking rate of 34.1 L/s (2,946 m^3/day) for the EA planning horizon (up to 2041).

3.1.3 Stouffville PW3

The following provides a summary of well performance testing and rehabilitation completed at the well:

- Well PW3 was constructed in 1976 by IWS;
- A well inspection video conducted in 2011 and 2016 by IWS;
- The pump was replaced in 2011 by York Region;
- The well was step-tested in 1975, 2009, and 2011 by IWS. The well was again step-tested in 2016 by York Region and in 2017 by IWS; and

- Well rehabilitation, including casing and screen brushing, chemical (dispersant and disinfection) treatment, Sonar-Jet treatment, and air-lifting, was conducted in 2011 and 2017 by IWS.

The results of the performance testing and specific capacity values are shown in Table 7.

Table 7: PW3 Specific Capacity

Well ID	Test Date	Pumping Rate (L/s)	Duration (hrs)	Drawdown (m)	Specific Capacity (L/s/m)
STO PW3	May 1976	41.7	24	10.1	4.1
	May 1976	33.0	- (1)	5.59	5.9
	March 2009	34.0	- (1)	~9.9	3.4
	March 2011 (post-rehab)	34.1	1	8.10	4.2
	June 2016	32.9	1	9.88	3.3
	Jan 2017 (post-rehab)	33.0	1	8.79	3.8

Note:
(1) Step test duration not specified in reports provided to Golder.

PW3 has a history of iron plugging and deterioration in well performance. Each successive rehabilitation resulted in poorer improvement in performance.

Based on the most recent performance testing (1 hour step test), PW3 can sustain the permitted rate of 34.1 L/s for at least short-durations (with approximately 5 m of available drawdown remaining above the pump intake), following rehabilitation. However, in July 2016 (pre-rehabilitation), a groundwater elevation of 270 masl was observed at PW3 (approximately 1 m above the pump intake) with an average daily production rate of 34 L/s.

Figure 5B shows the groundwater level at PW3 projected to 2041 using a linear regression, based on daily datalogger readings in the production well. This projection shows a water level decline of approximately 1 m every 6 years (a 2 m decline by 2032). This 2 m decline by 2032 could result in the well not being able to achieve its maximum permitted rate of 34.1 L/s. By 2041, the maximum pumping rate may be approximately 28 L/s, assuming the continued deterioration of well performance.

The well therefore is at risk of not meeting its maximum permitted rate of 34.1 L/s, if the well is not frequently rehabilitated and if the observed deterioration of well specific capacity continues.

As recommended by IWS, a well performance test should be conducted every 2-3 years and an intermediate rehabilitation could be conducted between scheduled maintenance (i.e. more frequently than every 5 years) in an attempt to restore the well's performance.

3.1.4 Stouffville PW5

The following provides a summary of well performance testing and rehabilitation completed at the well:

- Well PW5 was constructed in 1960 by C.H. Rutledge;
- The well was step-tested in 2007 by IWS and in 2013 by York Region and GDE; and
- Well rehabilitation, including casing and screen brushing, chemical treatment (acidification and disinfection) and air-lifting, and inspection video was conducted in 2013 by Gerrits Drilling & Engineering (GDE).

The results of the performance testing and specific capacity values are shown in Table 8.

Table 8: PW5 Specific Capacity

Well ID	Test Date	Pumping Rate (L/s)	Duration (hrs)	Drawdown (m)	Specific Capacity (L/s/m)
STO PW5	March 1960	44.2	48	4.0	11.1
	October 2007	26	-(1)	1.30	20.0
	April 2013	25.5	1	1.12	22.8
	August 2013 (post-rehab)	25.5	1	1.11	23.0

Note:
(1) Step test duration not specified in reports provided to Golder.

The specific capacity values at well PW5 continue to improve when comparing recent and past step tests. The well was rehabilitated in 2013 to address buildup of debris in the casing identified from a well inspection video.

At PW5, the theoretical yield for the screen is 46 L/s, which is not a constraint in the well meeting its permitted rate of 36 L/s, however, the well yield is limited due to the shallow depth of the well.

The pump is positioned within the screen at PW5, and it is recommended that the pumped water level not exceed the top of the well screen. The production at PW5 is limited by the available drawdown above the top of the screen (~4 m).

Based on the most recent step testing data (August 2013), approximately 1 m of drawdown was observed after an hour of pumping at the tested rate of 25.5 L/s. In June 2016, a groundwater level of 303 masl was observed (~3 m of drawdown) at an average daily production rate of 33 L/s, leaving only 1 m of available drawdown remaining above the well screen.

Based on the step testing results, the well appears to be capable of supplying 25.5 L/s without dropping the pumping level below the top of the well screen. This capacity of 25.5 L/s for PW5 is assuming that PW6 is pumping at its estimated capacity of 23 L/s (see Section 3.1.5) for a combined total of 48.5 L/s. However, long-term testing at this rate is needed to confirm sustainable rates for both wells PW5 and PW6.

It is recommended that a 72-hour pumping test be conducted at wells PW5 and PW6. The assessment of long-term capacity for well PW5 should take into account the results of the pumping test when available.

3.1.5 Stouffville PW6

The following provides a summary of well performance testing and rehabilitation completed at the well:

- Well PW6 was constructed in 1966 by Faulkner Well Drilling Co. Ltd;
- Step-tested in 2007 by IWS, in 2011, 2012 and 2016 by York Region and again in 2017 by IWS; and
- Well rehabilitation including casing and screen swabbing, Sonar-Jet and surfactant treatment and air-lifting and inspection video conducted in 2012 and 2017 by IWS.

The results of the performance testing and specific capacity values are shown in Table 9.

Table 9: PW6 Specific Capacity

Well ID	Test Date	Pumping Rate (L/s)	Duration (hrs)	Drawdown (m)	Specific Capacity (L/s/m)
STO PW6	1966	22.2	48	15.5	1.4
	May 2007	21.0	-	8.95[(1)]	2.4[(1)]
	October 2011	21.0	-	21.0[(1)]	1.0[(1)]
	March 2012 (post-rehab)	22.7	1	8.98	2.5
		21.0	-	8.25[(1)]	2.6[(1)]
	October 2016	21.0	1	10.16	2.1
	November 2017 (post-rehab)	22.7	1	9.89	2.3

Note:
(1) Interpolated value based on step tests at different rates.

PW6 has a history of bio/mineral deposition, and the well has been rehabilitated on two occasion to improve well performance.

The theoretical yield for the screen at PW6 is 34 L/s, which is not a constraint in the well meeting its permitted rate of 26.5 L/s, however the yield is limited due to the shallow depth of the well. Groundwater level trends have been fairly stable at PW6 and nearby monitoring well MW6, with static levels consistently close to 304 masl (13 m of available drawdown) for the last 5 years.

The pump is positioned within the screen at PW6 and it is recommended that the pumped water level not exceed the top of screen (291 masl). The production at PW6 is limited by the available drawdown (~13 m).

Based on the recent step testing data, approximately 10 m of drawdown was observed after an hour of pumping at the tested rate of 22.7 L/s in November 2017 (post-rehabilitation) and 21.0 L/s in October 2016 (pre-rehabilitation). Groundwater elevations of 291 masl (0 m of remaining drawdown) have been observed at an average daily production rate of approximately 24 L/s.

Based on the step testing results, the well appears to be capable of supplying 23 L/s without dropping the pumping level below the top of the well screen. This capacity of 23 L/s for PW6 is assuming that PW5 is pumping at its estimated capacity of 25.5 L/s (see Section 3.1.4) for a combined total of 48.5 L/s. However, long-term testing at this rate is needed to confirm sustainable rates for both wells PW5 and PW6.

It is recommended that a 72-hour pumping test be conducted at wells PW5 and PW6. The assessment of long-term capacity for well PW6 should take into account the results of the pumping test when available.

4.0 GROUNDWATER QUALITY ASSESSMENT

Raw groundwater quality results for production wells and monitoring wells from 2008 to 2019 were provided by York Region. The results were compared to the Ontario Drinking Water Quality Standards, Objectives and Guidelines (ODWS), Ontario Regulation 169/03 under the Safe Drinking Water Act, 2002.

Parameters of concern were identified based on the 2019 Municipal Drinking Water Licence Renewal (MDWL), Raw Water Assessment (York Region, 2019a), which analyzed water quality data for 2014 to 2018. Parameters, including manganese, iron, sodium and chloride had elevated concentrations or increasing trends at well PW3. Nitrate concentrations show increasing trends at PW5. For the current assessment, the above noted parameters were plotted for all five production wells using the entire dataset (2008 to 2019) and trends were projected out to the EA planning horizon (2041). Manganese, iron, sodium, chloride and nitrate concentrations were also plotted for the monitoring wells (2008 to 2019, where reported). With the exception of nitrate (sampled quarterly), the parameters of concern were sampled once per calendar year. All groundwater quality projections were estimated using a linear regression that took into account the entire dataset. Concentrations below the laboratory method detection limit (MDL) were plotted as their respective MDL. The groundwater quality assessment was based on a limited data set and continued long-term groundwater quality monitoring is recommended to improve reliability of projections and reduce the effect of outlier data.

4.1 Manganese

The current aesthetic objective (AO) for manganese (Mn) in drinking water is 0.05 mg/L due to staining and taste, and there is currently no maximum acceptable concentration (MAC) prescribed under the ODWS. An AO of 0.02 mg/L is proposed for total manganese in drinking water, and a health-based MAC of 0.12 mg/L is also proposed for total manganese in drinking water by Health Canada.

Figure 8 shows the reported concentrations of manganese in raw groundwater sampled from each Stouffville Production Well from 2008 to 2019 and projected to 2041. With the exception of exceedances in 2008, PW3 is the only production well that exceeds the current AO for manganese. Manganese concentrations at PW1 and PW2 were typically found to be between 0.02 and less than 0.05 mg/L, and concentrations at PW5 and PW6 were consistently below 0.02 mg/L. The following are noteworthy based on the trend analysis:

- PW1 and PW2 will continue to exceed the proposed AO and PW1 is projected to exceed the current AO in 2032. PW1 and PW2 are not projected to exceed the proposed MAC by 2041.
- PW3 will continue to exceed the proposed AO and is projected to exceed the proposed MAC by 2040.
- PW5 and PW6 are not projected to exceed the proposed AO before 2041.

4.2 Iron

The current AO for iron (Fe) is 0.3 mg/L due to staining and taste, and there is currently no maximum acceptable concentration (MAC) prescribed under the ODWS.

Figure 9 shows the reported concentrations of iron in raw groundwater sampled from each Stouffville Production Well from 2008 to 2019 and projected to 2041

PW3 consistently exceeds the current AO for iron, and all other production wells have exceeded the AO on one or more occasions. Iron concentrations at PW1 and PW2 fluctuate above and below the current AO. With the exception of 2017 data, all reported iron concentrations for PW5 and PW6 were at or below 0.1 mg/L. Although, Figure 9 indicates PW5 is projected to exceed the AO for iron by 2035, this trendline is influenced by the 2017 data. Subsequent iron concentrations were lower and comparable to typical levels measured since 2008, which have been below the AO.

4.3 Sodium

The current AO for sodium (Na) is 200 mg/L, and there is currently no maximum acceptable concentration (MAC) prescribed under the ODWS. However, the local Medical Officer of Health should be notified when the sodium concentrations exceed 20 mg/L, so that this information may be passed on to local physicians.

As shown on Figure 10, the reported concentrations of sodium in raw groundwater from 2008 to 2019 have not exceeded the AO for sodium at any of the Stouffville Production Wells. By 2041, none of the production wells are projected to exceed the current AO for sodium.

4.4 Chloride

The current AO for chloride (Cl) is 250 mg/L at which it produces a detectable salty taste, and there is currently no maximum acceptable concentration (MAC) prescribed under the ODWS.

As shown on Figure 11, the reported concentrations of chloride in raw groundwater from 2008 to 2019 have not exceeded the AO for chloride at any of the Stouffville production wells. Only PW3 is projected to exceed the current AO for chloride in 2035.

4.5 Nitrate

The current health-based MAC for nitrate is 10 mg/L.

As shown on Figure 12, the reported concentrations of nitrate in raw groundwater from 2008 to 2019 have not exceeded the MAC for nitrate at any of the Stouffville Production Wells. By 2041, none of the production wells are projected to exceed the current MAC for nitrate. Between 2017 and 2019, several results at PW3 were below an elevated MDL of 2.5 or 5 mg/L. In 2017 and 2018, two results at PW5 were below an elevated MDL of 5 mg/L. For the purposes of projecting concentrations, anomalous non-detect data points that were above historical reportable concentrations were removed from Figure 12.

4.6 Monitoring Well Groundwater Quality

Figure B-1 to B-10, in Appendix B, shows the reported concentrations of manganese, iron, sodium, chloride and nitrate in raw groundwater sampled from ORAC and TAC monitoring wells in 2008 to 2019 (where reported).

- MW1, MW2 (no data), MW8D, and MW15 are proximal to **PW1 and PW2**, screened within the **TAC**:
  - Concentrations of manganese were generally above the proposed AO and below the current AO. It should be noted that MW15 (ID “MW15-NP”) had a reported manganese concentration near the proposed MAC in 2015 (0.11 mg/L);

  - Concentrations of iron at all three monitoring wells were generally near or above the current AO, with the highest concentration observed at MW8D in 2009 (1.99 mg/L);
  - Concentrations of sodium and chloride at all three monitoring wells were below the current AO;
  - Concentrations of nitrate at all three monitoring wells were below the current MAC;
  - The concentration trends for parameters of concern at these monitoring wells are generally consistent with trends observed at PW1 and PW2. The groundwater quality at these monitoring wells appears representative of the source aquifer. Specifically, the TAC has naturally occurring manganese and iron.
- MW3, MW7, MW9, and MW22 are proximal to **PW3**, screened within the **ORAC**:
  - At MW3 concentrations of manganese were consistently above the current AO. Concentrations of manganese at MW7 and MW9 were near or above the proposed AO. MW22 exceeded the proposed MAC for manganese on multiple occasions (maximum reported concentration of 0.72 mg/L);
  - Concentrations of iron at all four monitoring wells were generally above the current AO, with the highest concentration observed at MW9 in 2008 (2.32 mg/L);
  - The concentration trends for parameters of concern at these monitoring wells (except MW22) are generally consistent with trends observed at PW3. The groundwater quality at MW3, MW7 and MW9 appears representative of the source aquifer (elevated manganese and iron).
  - MW22 shows anomalously high sodium and chloride concentrations;
    - Concentrations of sodium at MW22 ranged from 597 to 950 mg/L (current AO of 200 mg/L);
    - Concentrations of chloride at MW22 ranged from 914 to 1930 mg/L (current AO of 250 mg/L);
  - MW3, MW7 and MW9 had reported sodium and chloride concentrations below the current AO;
  - Concentrations of nitrate at all four monitoring wells were below the current MAC.
- MW4, MW5, MW6, and MW11S are proximal to **PW5 and PW6**, screened within the **ORAC**:
  - Concentrations of manganese at all four monitoring wells were generally below the proposed AO;
  - Concentrations of iron at all four monitoring wells were generally below the current AO, except for 2017 values (MW4 and MW5);
  - Concentrations of sodium and chloride at all four monitoring wells were below the current AO;
  - Concentrations of nitrate at MW4 were above the current MAC in 2008 and 2010 (10.9 and 10.4 mg/L, respectively), and the other three monitoring wells were below the current MAC;
  - The concentration trends for parameters of concern at these monitoring wells are generally consistent with trends observed at PW5 and PW6. The groundwater quality at these monitoring wells appears representative of the source aquifer, with the exception of nitrate concentrations at MW4.
- Stouffville monitoring wells further away from the municipal production wells:

- Other than MW22, the highest reported concentrations of manganese occurred at MW21 (TAC, maximum concentration of 0.17 mg/L in 2017) and MW28S (ORAC, 0.19 mg/L in 2017), versus the proposed MAC of 0.12 mg/L. Manganese exceedances above the proposed AO were reported at ORAC wells MW13 and MW36S, and TAC wells MW18, MW23 and MW36D.
- The highest reported concentrations of iron occurred at MW21 (TAC, 3.46 mg/L reported in 2014), and MW36S (ORAC, 5.54 mg/L in 2013), versus the current AO of 0.3 mg/L. Iron exceedances were also reported at MW16 (ORAC) and TAC wells MW11D, MW18, MW23 and MW36D.
- Other than MW22, the highest reported concentrations of sodium and chloride occurred at MW11D (TAC, 716 mg/L for sodium and 1700 mg/L for chloride, reported in 2011 which was the last reported date). The current AO for sodium and chloride are 200 and 250 mg/L, respectively. Sodium exceedances were also reported at MW28S (ORAC), and chloride exceedances were reported at ORAC wells MW28S, MW36S and MW39S.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The following table provides a summary of the results of the assessment of well capacity and groundwater quality at the five Stouffville municipal wells.

Table 10: Stouffville Well Capacity and Groundwater Quality Summary

Well ID	PTTW Rate (L/s)	Well Capacity Constraints	Groundwater Quality Constraints
STO PW1	34.1	■ Capable of producing the permitted rate of 34.1 L/s for the EA planning horizon (2041)	■ Exceeds proposed AO for Mn ■ Projected to exceed current AO for Mn in 2032 ■ Previously exceeded the AO for Fe, with increasing trend
STO PW2	34.1	■ Capable of producing the permitted rate of 34.1 L/s for the EA planning horizon	■ Exceeds proposed AO for Mn ■ Previously exceeded the AO for Fe, with increasing trend
STO PW3	34.1	■ Currently capable of producing 34.1 L/s ■ At risk of not being able to sustain 34.1 L/s due to declining well yield and need for frequent rehab over EA horizon	■ Exceeds current and proposed AO for Mn, and current AO for Fe ■ Projected to exceed proposed MAC for Mn by 2040 ■ Projected to exceed the AO for Cl in 2035
STO PW5	36.0	■ Constrained by shallow well depth ■ Appears capable of producing 25.5 L/s for the EA horizon ■ Long-term testing is needed to confirm capacity	■ Fe concentrations above AO noted in 2017; however, subsequent concentrations were lower, comparable to typical levels measured since 2008
STO PW6	26.5	■ Constrained by shallow well depth	■ Fe concentrations above AO noted in 2017; however, subsequent concentrations were lower,

Well ID	PTTW Rate (L/s)	Well Capacity Constraints	Groundwater Quality Constraints
		■ Appears capable of producing 23 L/s for EA horizon with frequent rehabilitation ■ Long-term testing is needed to confirm capacity	comparable to typical levels measured since 2008

A 72-hour pumping test is recommended at wells PW5 and PW6 to better define the long-term well capacity of these supply wells.

The program of well performance testing and rehabilitation should continue to monitor and correct potential well yield declines particularly at wells PW3, PW5 and PW6.

Given the well capacity constraints identified above (PW3, PW5 and PW6) and the water quality constraints, a groundwater exploration program is recommended to investigate additional sources of supply in order to maintain the currently permitted total capacity of the Stouffville well system through the EA planning horizon to 2041.

The groundwater quality assessment was based on a limited data set and continued long-term groundwater quality monitoring is recommended to improve reliability of projections and reduce the effect of outlier data.

Signature Page

Golder Associates Ltd.

John Easton, M.Sc., P.Geo
Senior Hydrogeologist, Associate

John Piersol, M.Sc., P.Geo
Senior Hydrogeologist, Associate

AS/JS/JP/ng/ly

https://golderassociates.sharepoint.com/sites/13234g/5000 hydrogeology/report/rev1/1668667-5000-rev1-2april2020-stouffville hydrogeological report.docx

REFERENCES

Gerrits Drilling & Engineering Ltd, 2013. Stouffville Well 5 – 2013 Well Rehabilitation and Testing, submitted September 16, 2013.

International Water Supply Ltd (IWS), 2011. Stouffville Well No. 3 – Well and Pump Maintenance, submitted April 11, 2011.

International Water Supply Ltd (IWS), 2012. Rehabilitation of Stouffville Well No. 6, submitted May 30, 2012.

International Water Supply Ltd (IWS), 2017. Stouffville Well No. 3 – Well and Pump Maintenance, submitted June 20, 2017.

International Water Supply Ltd (IWS), 2018. Stouffville Well No. 6 – Well and Pump Maintenance, submitted May 4, 2018.

York Region, 2013a. Stouffville PW5 Step Test Conducted on April 18, 2013. Internal memorandum submitted April 26, 2013.

York Region, 2013b. Stouffville PW2 Step Test Conducted on June 25, 2013. Internal memorandum submitted July 11, 2013.

York Region, 2016a. Stouffville PW 3 Well Performance Test (June 7, 2016). Internal memorandum submitted July 11, 2016.

York Region, 2016b. Stouffville PW6 Step Test Conducted on October 19, 2016. Internal memorandum submitted October 28, 2016.

York Region, 2017. Stouffville – Local Groundwater Flow Model – Presentation Report, dated March 20, 2017.

York Region, 2018. Stouffville PW1 Step Test Conducted on March 2, 2018. Internal memorandum submitted April 10, 2018.

York Region, 2019a. 2019 Municipal Drinking Water Licence Renewal – Raw Water Assessment, submitted July 2019.

York Region, 2019b. Stouffville Production Well Raw Water Quality Data, 2008 - 2018, received July 31, 2019.

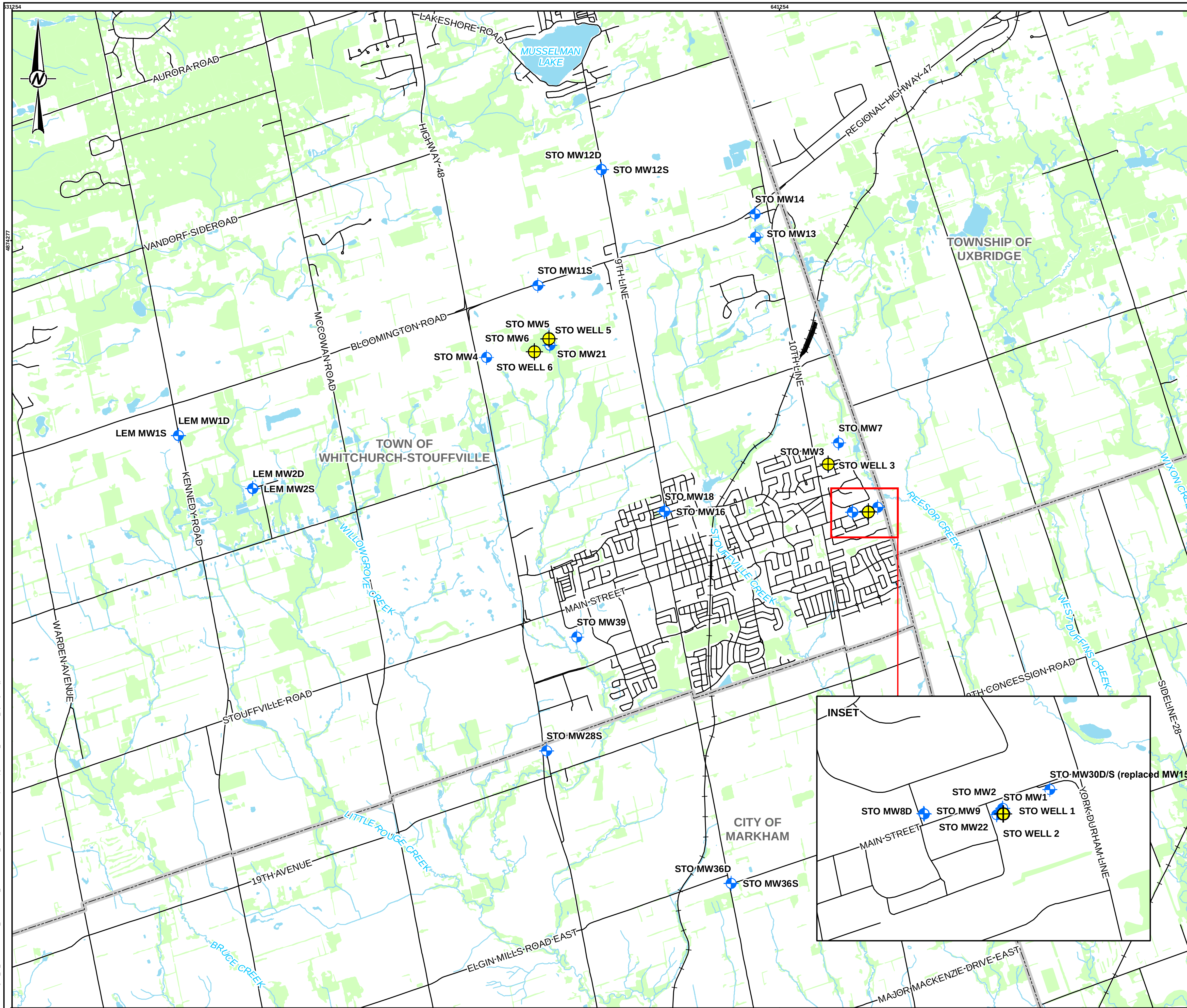
York Region, 2019c. Stouffville Monitoring Well Raw Water Quality Data, 2008 - 2018, received July 31, 2019.

York Region, 2019d. Stouffville Hydrographs and Production Volumes, 2019, received August 15, 2019.

York Region, 2019e. Stouffville Production Well Raw Water Quality Data, 2019, received August 15, 2019.

York Region, 2019f. Stouffville Monitoring Well Raw Water Quality Data, 2019, received August 15, 2019.

FIGURES



LEGEND

- Monitoring Well
- Production Well
- ROAD
- RAILWAY
- WATERCOURSE
- WATERBODY
- WOODED AREA
- MUNICIPAL BOUNDARY

0 1 2 3

1:50,000 KILOMETRES

REFERENCE(S)

1. MONITORING WELL LOCATION - YORK REGION, 2017
2. BASE DATA - MNRF LIO, OBTAINED 2017
3. PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2017

CLIENT

THE MUNICIPAL INFRASTRUCTURE GROUP

PROJECT

PRODUCTION WELL CAPACITY AND RAW WATER QUALITY ASSESSMENT
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA, YORK REGION

TITLE

LOCATION PLAN

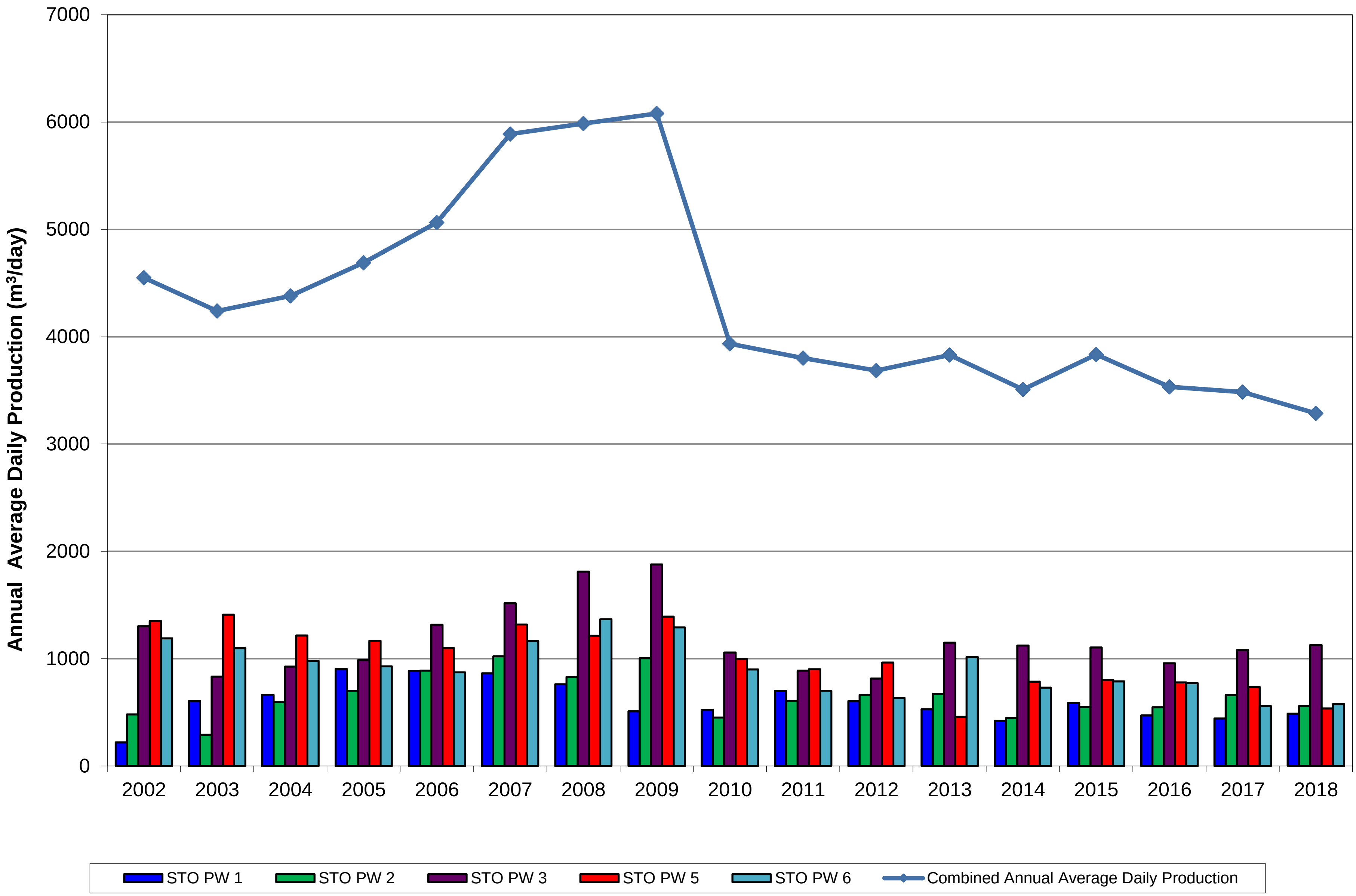
CONSULTANT

GOLDER

YYYY-MM-DD	2019-11-01
DESIGNED	JT
PREPARED	PR
REVIEWED	AS
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1668667			1

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



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CONSULTANT GOLDER	YYYY-MM-DD	2019-11-01	TITLE **ANNUAL AVERAGE DAILY PRODUCTION 2002 - 2018**		
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	DESIGN	AS			
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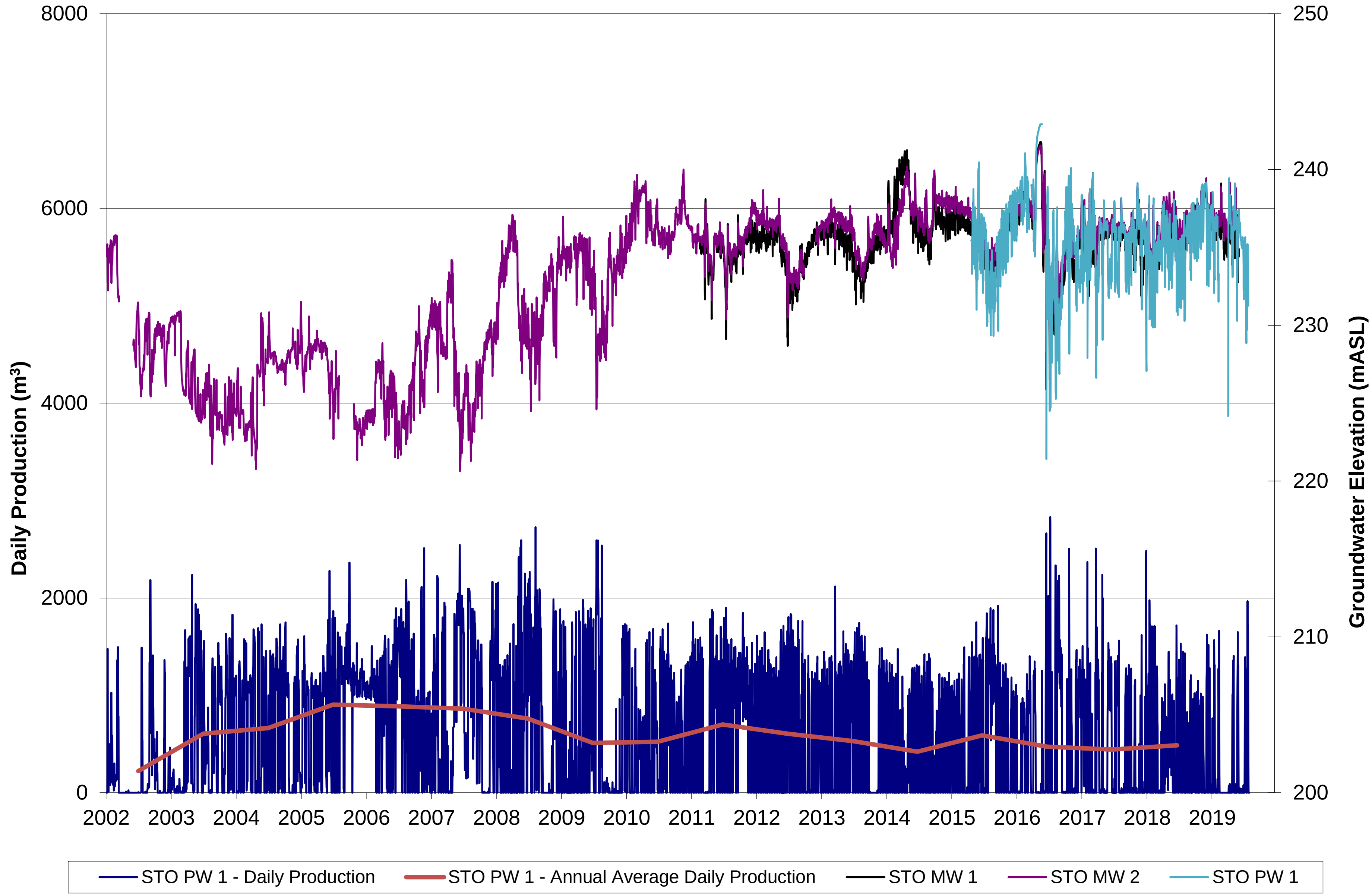


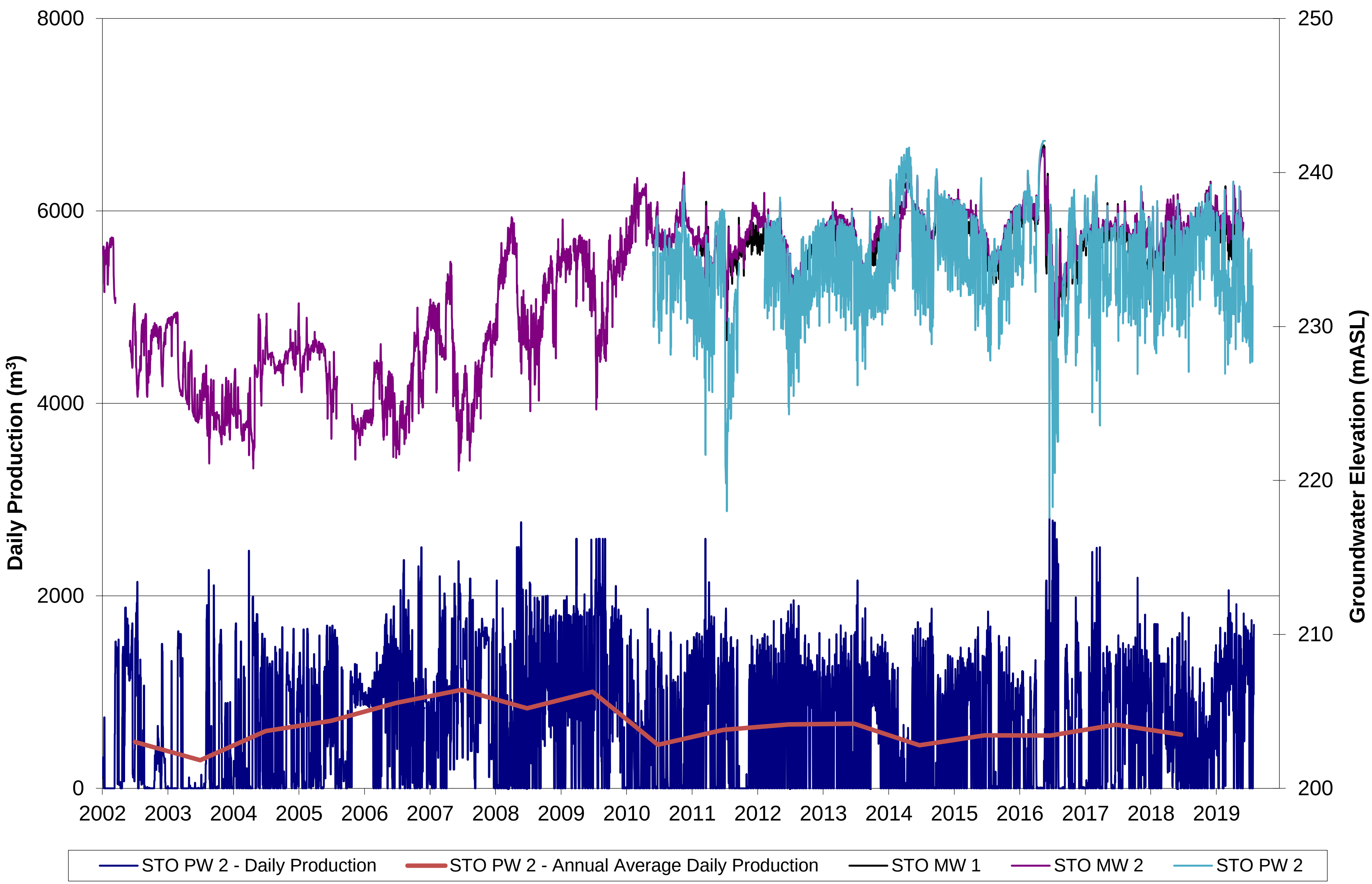
CLIENT	PROJECT
THE MUNICIPAL INFRASTRUCTURE GROUP	PRODUCTION WELL CAPACITY REVIEW STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT	YYYY-MM-DD	2019-11-01
GOLDER	PREPARED	AS
	DESIGN	AS
	REVIEW	JP
	APPROVED	JP

TITLE

GROUNDWATER ELEVATION HYDROGRAPH
STOUFFVILLE PRODUCTION WELL 1

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	3

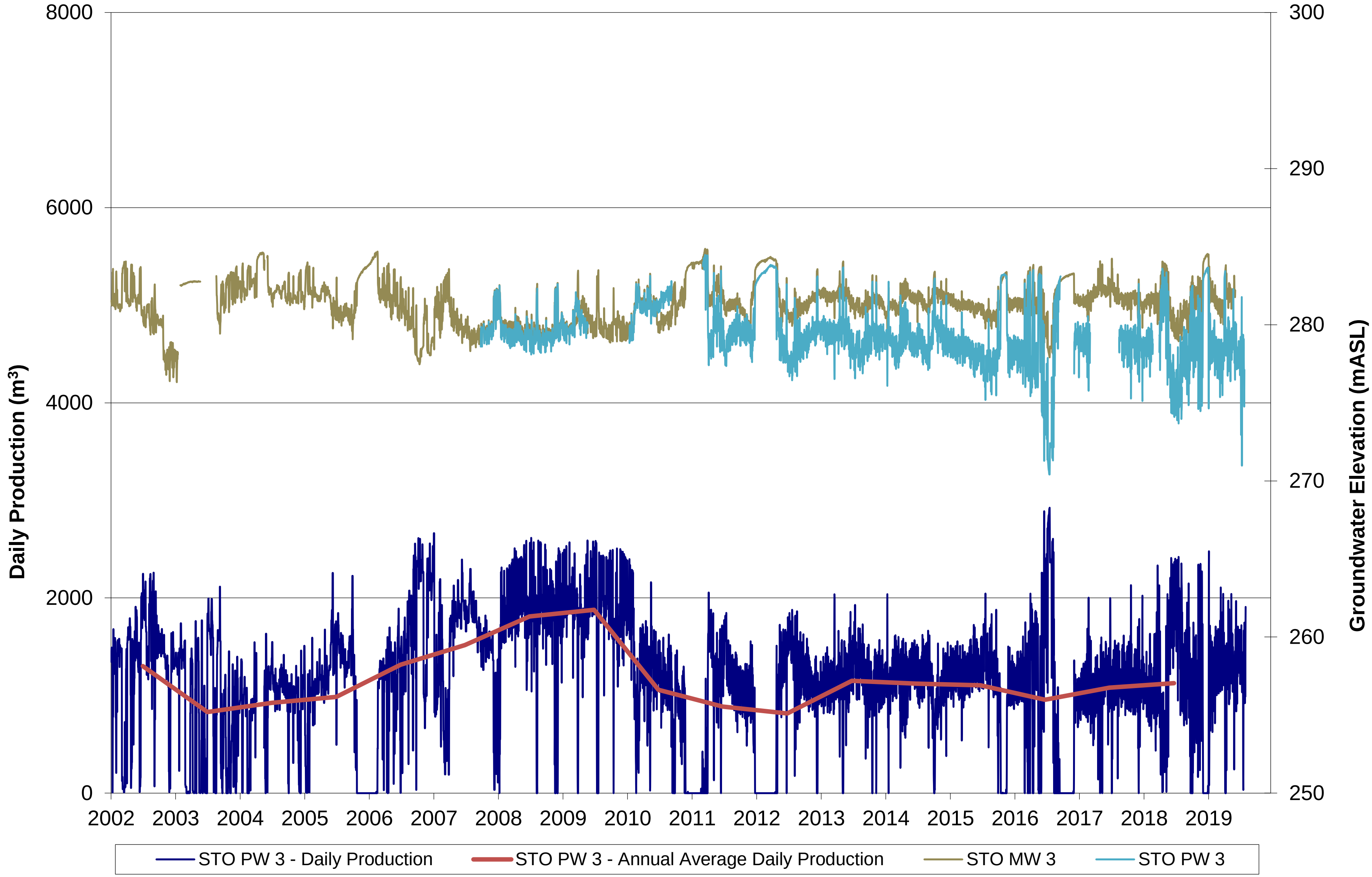


CLIENT THE MUNICIPAL INFRASTRUCTURE GROUP		PROJECT PRODUCTION WELL CAPACITY REVIEW STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA
CONSULTANT GOLDER	YYYY-MM-DD	2019-11-01
	PREPARED	AS
	DESIGN	AS
	REVIEW	JP
	APPROVED	JP

TITLE

GROUNDWATER ELEVATION HYDROGRAPH
STOUFFVILLE PRODUCTION WELL 2

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	4



CLIENT THE MUNICIPAL INFRASTRUCTURE GROUP		PROJECT PRODUCTION WELL CAPACITY REVIEW STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA	
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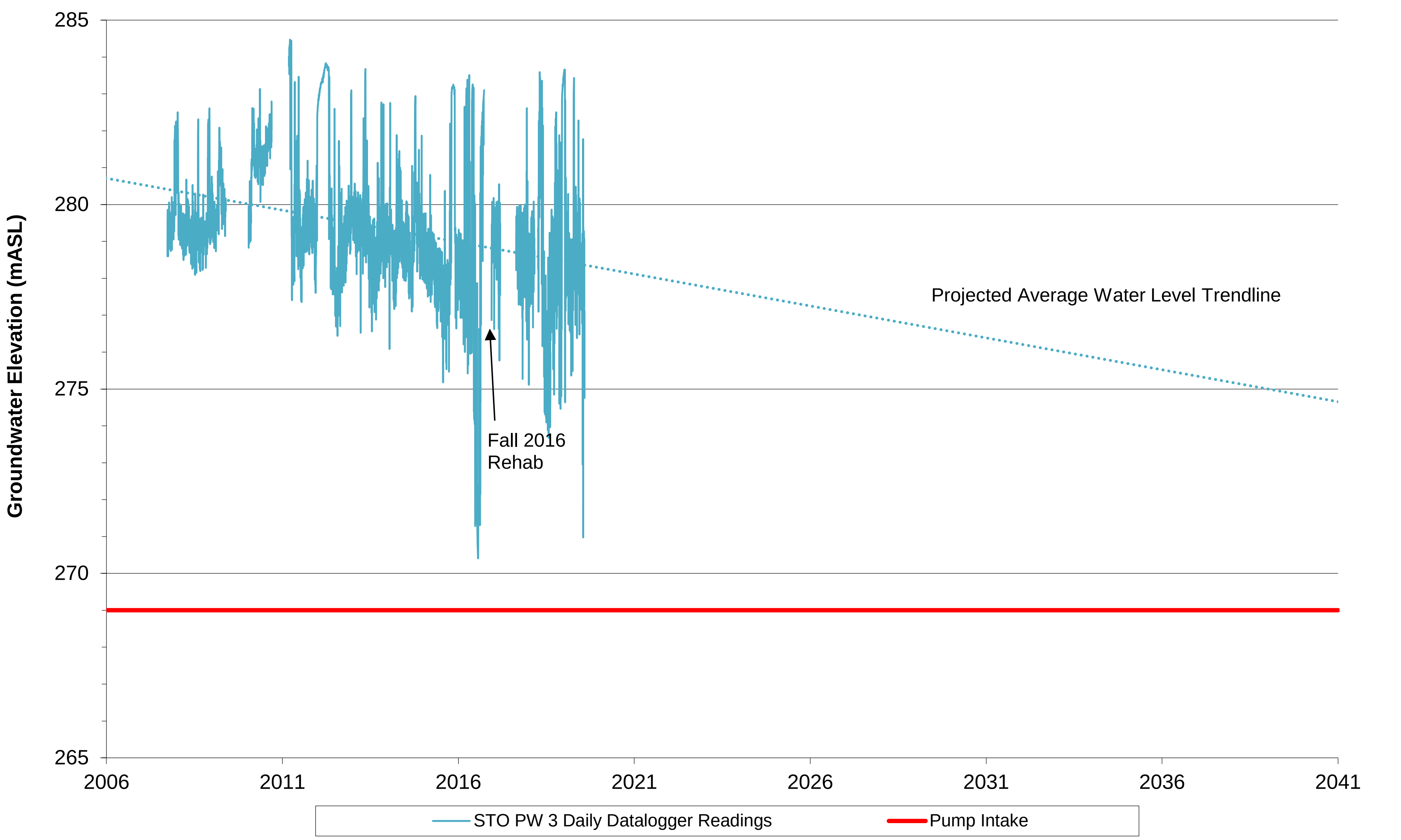
	DESIGN	AS	
	REVIEW	JP	PROJECT No. 1668667 · Phase - · Rev 0 · FIGURE 5A
	APPROVED	JP	



CLIENT THE MUNICIPAL INFRASTRUCTURE GROUP	PROJECT PRODUCTION WELL CAPACITY REVIEW STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT

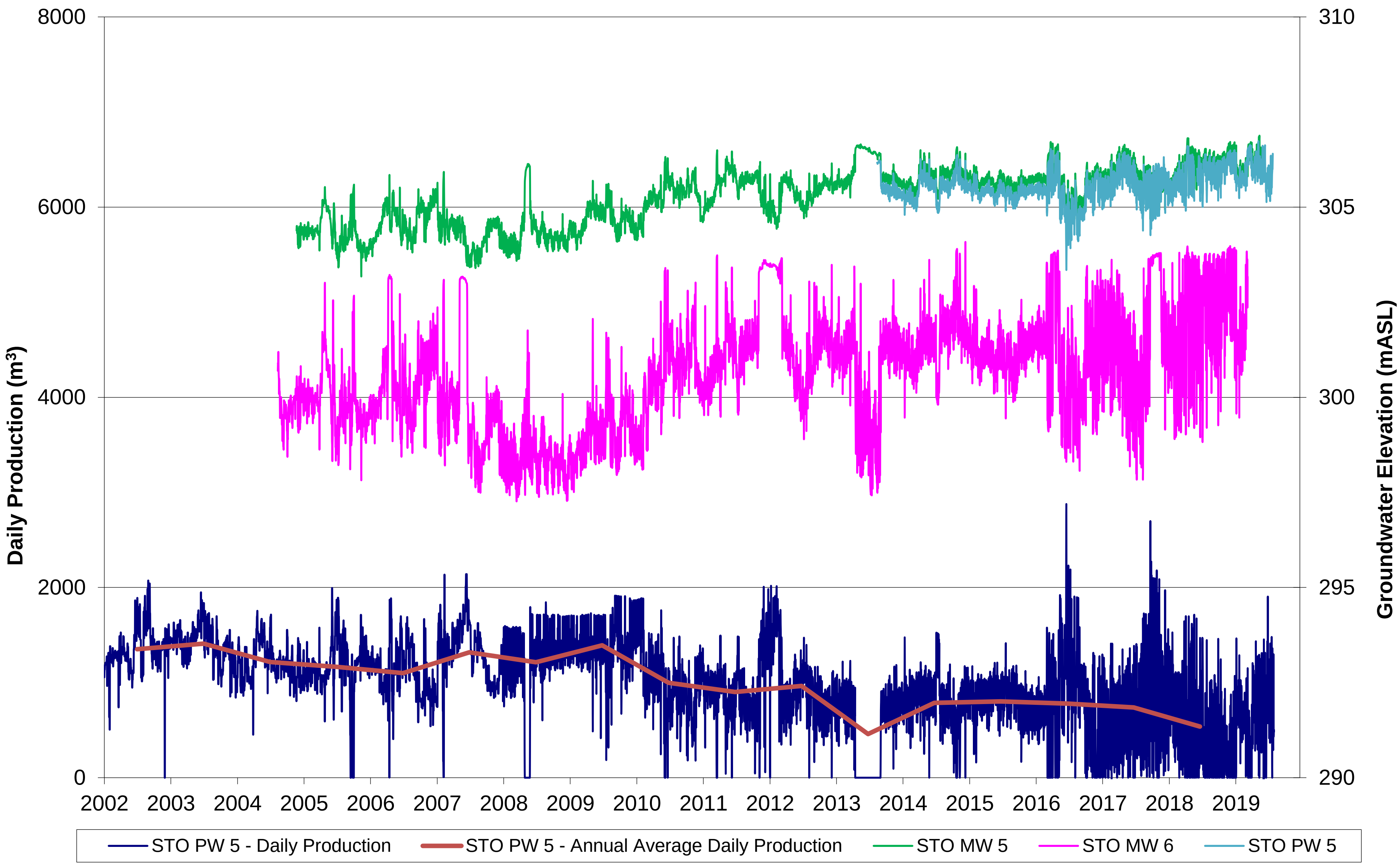
GOLDER

YYYY-MM-DD	2020-01-10
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

TITLE

PROJECTED GROUNDWATER LEVEL TO 2041
STOUFFVILLE PRODUCTION WELL 3

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	5B



CLIENT
THE MUNICIPAL INFRASTRUCTURE GROUP

CONSULTANT

GOLDER

YYYY-MM-DD	2019-11-01
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

PROJECT
PRODUCTION WELL CAPACITY REVIEW
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

TITLE
GROUNDWATER ELEVATION HYDROGRAPH
STOUFFVILLE PRODUCTION WELL 5

PROJECT No.	Phase	Rev	FIGURE
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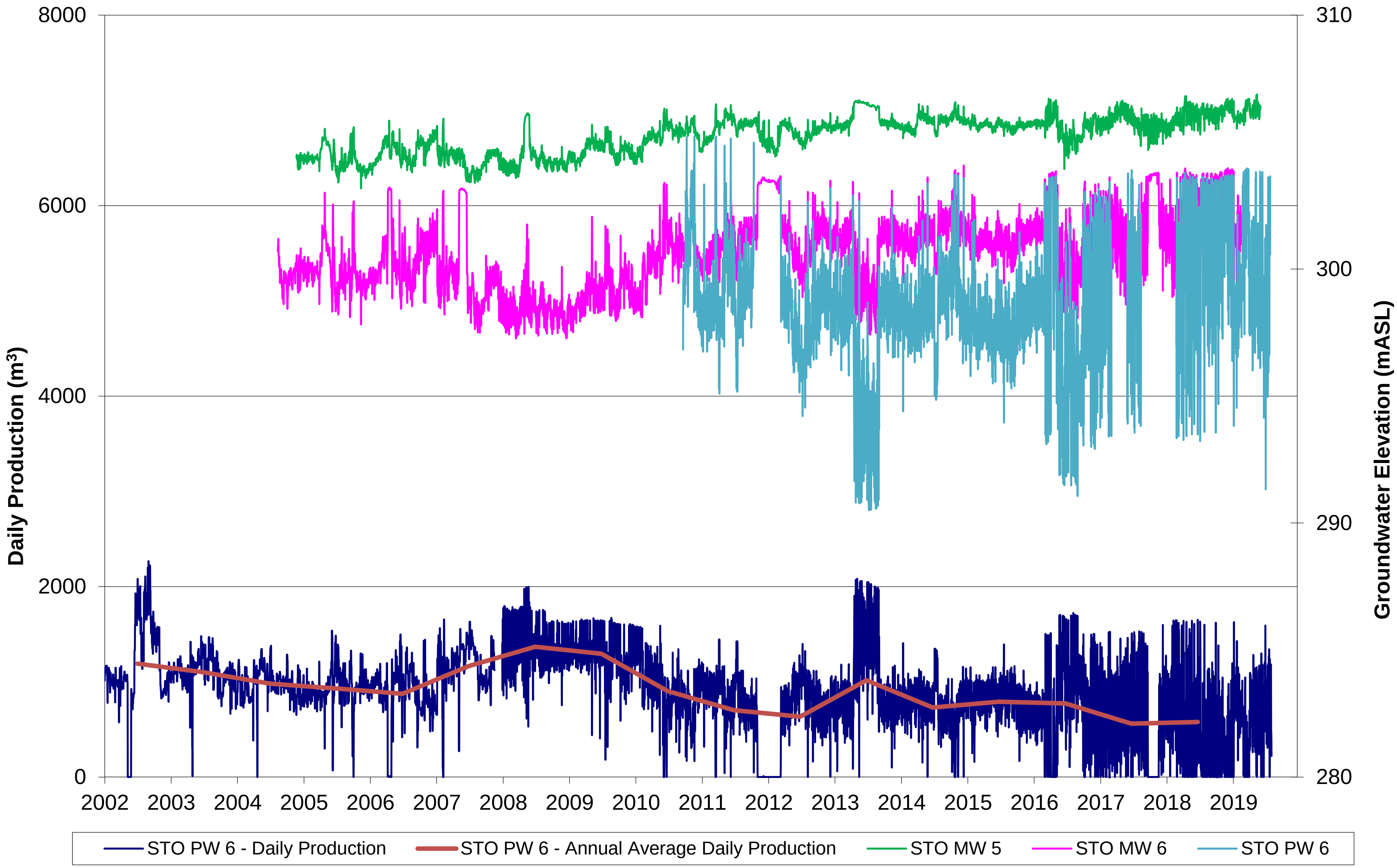

CLIENT
THE MUNICIPAL INFRASTRUCTURE GROUP

CONSULTANT

GOLDER

YYYY-MM-DD	2019-11-01
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

PROJECT
PRODUCTION WELL CAPACITY REVIEW
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

TITLE
GROUNDWATER ELEVATION HYDROGRAPH
STOUFFVILLE PRODUCTION WELL 6

PROJECT No.	Phase	Rev	FIGURE
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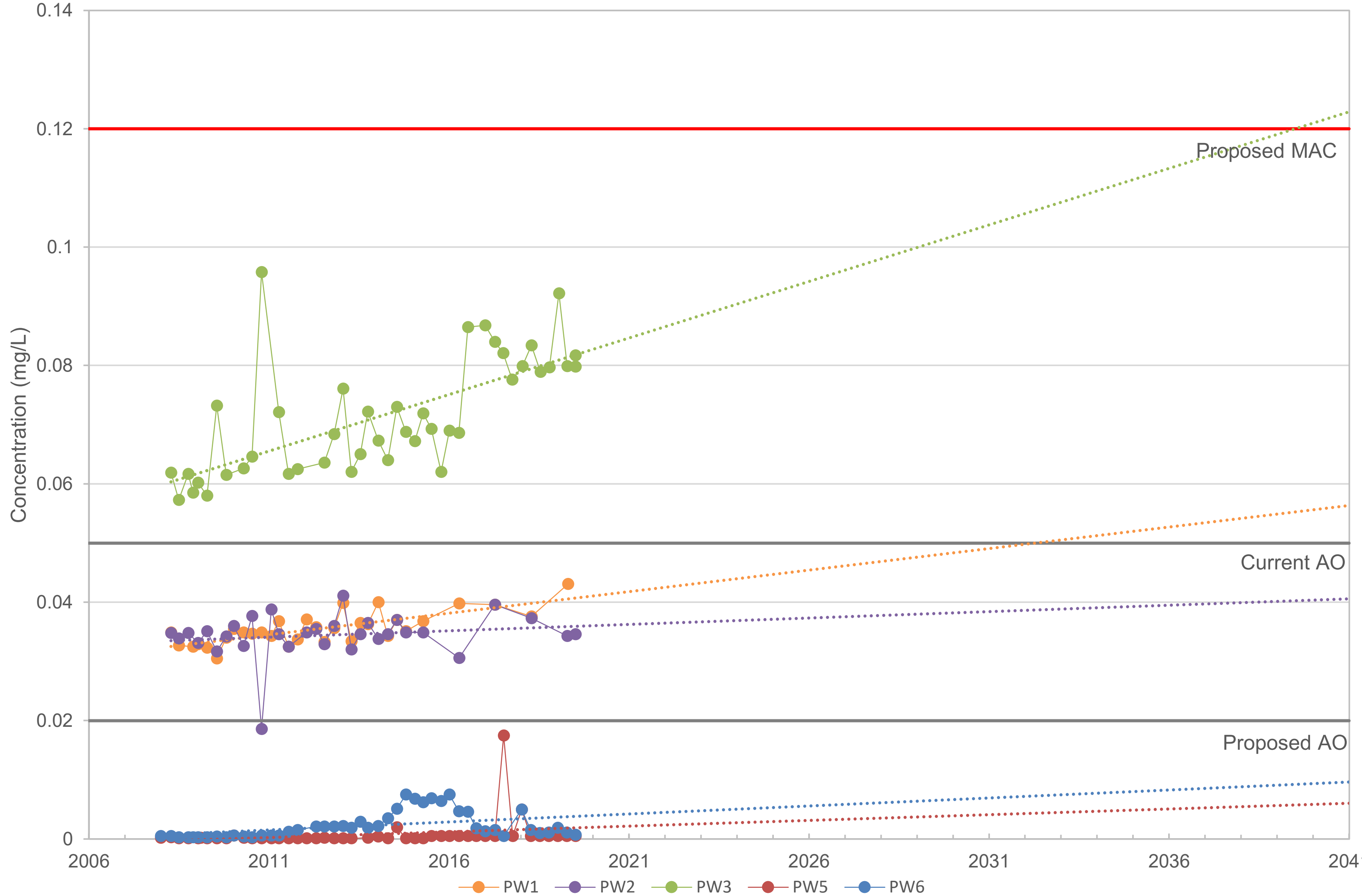


CLIENT
THE MUNICIPAL INFRASTRUCTURE GROUP

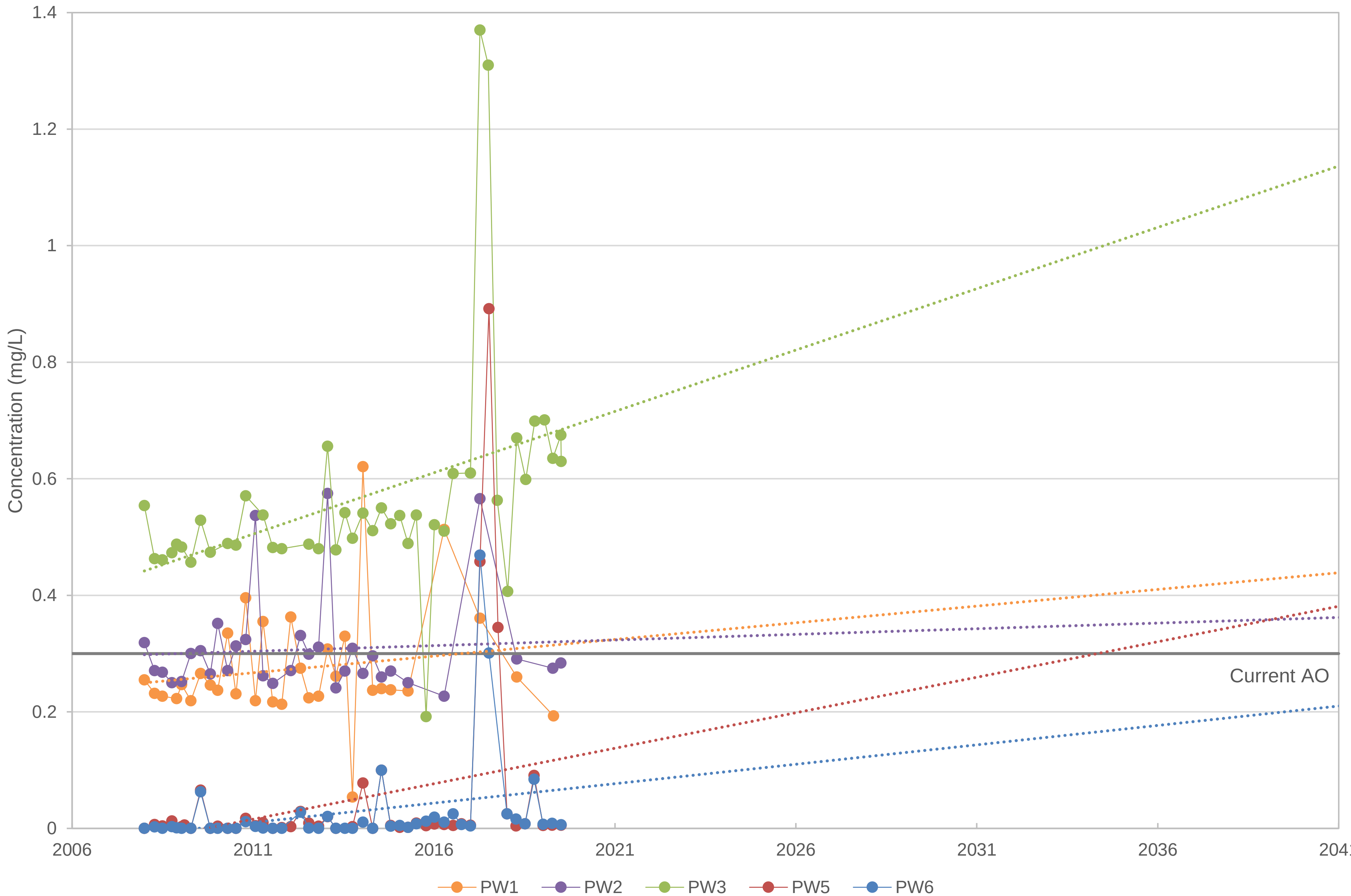
PROJECT
RAW WATER QUALITY ASSESSMENT
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT
GOLDER

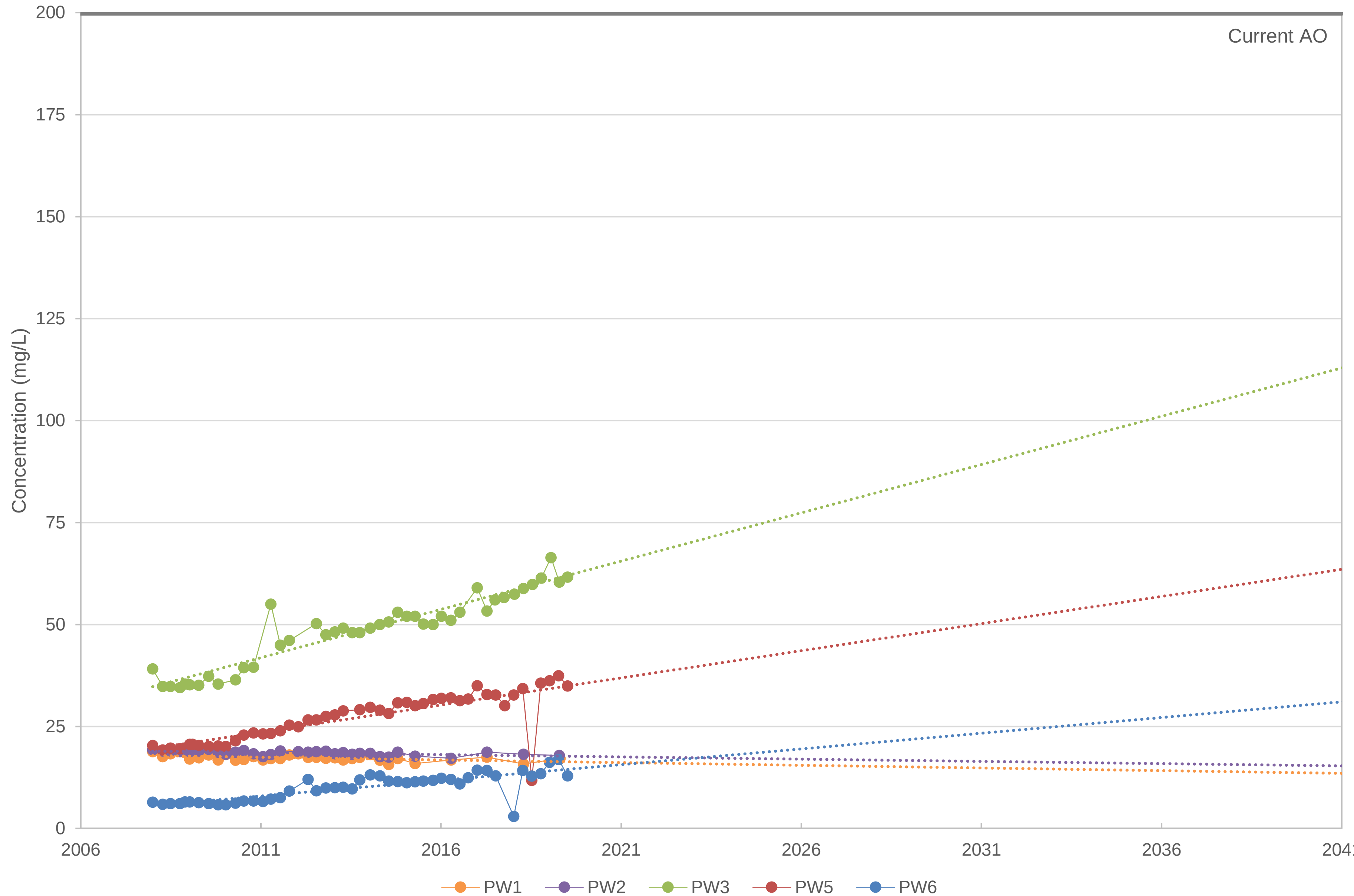
YYYY-MM-DD	01/11/2019
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

TITLE
MANGANESE CONCENTRATIONS PROJECTED TO 2041

PROJECT No.	Phase	Rev	FIGURE
1668667	-	A	8



CLIENT THE MUNICIPAL INFRASTRUCTURE GROUP		PROJECT RAW WATER QUALITY ASSESSMENT STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA
CONSULTANT GOLDER	YYYY-MM-DD 2019-11-01 PREPARED AS DESIGN AS REVIEW JP APPROVED JP	TITLE **IRON CONCENTRATIONS PROJECTED TO 2041** PROJECT No. 1668667 · Phase - · Rev 0 · FIGURE 9



CLIENT	PROJECT
THE MUNICIPAL INFRASTRUCTURE GROUP	RAW WATER QUALITY ASSESSMENT STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT

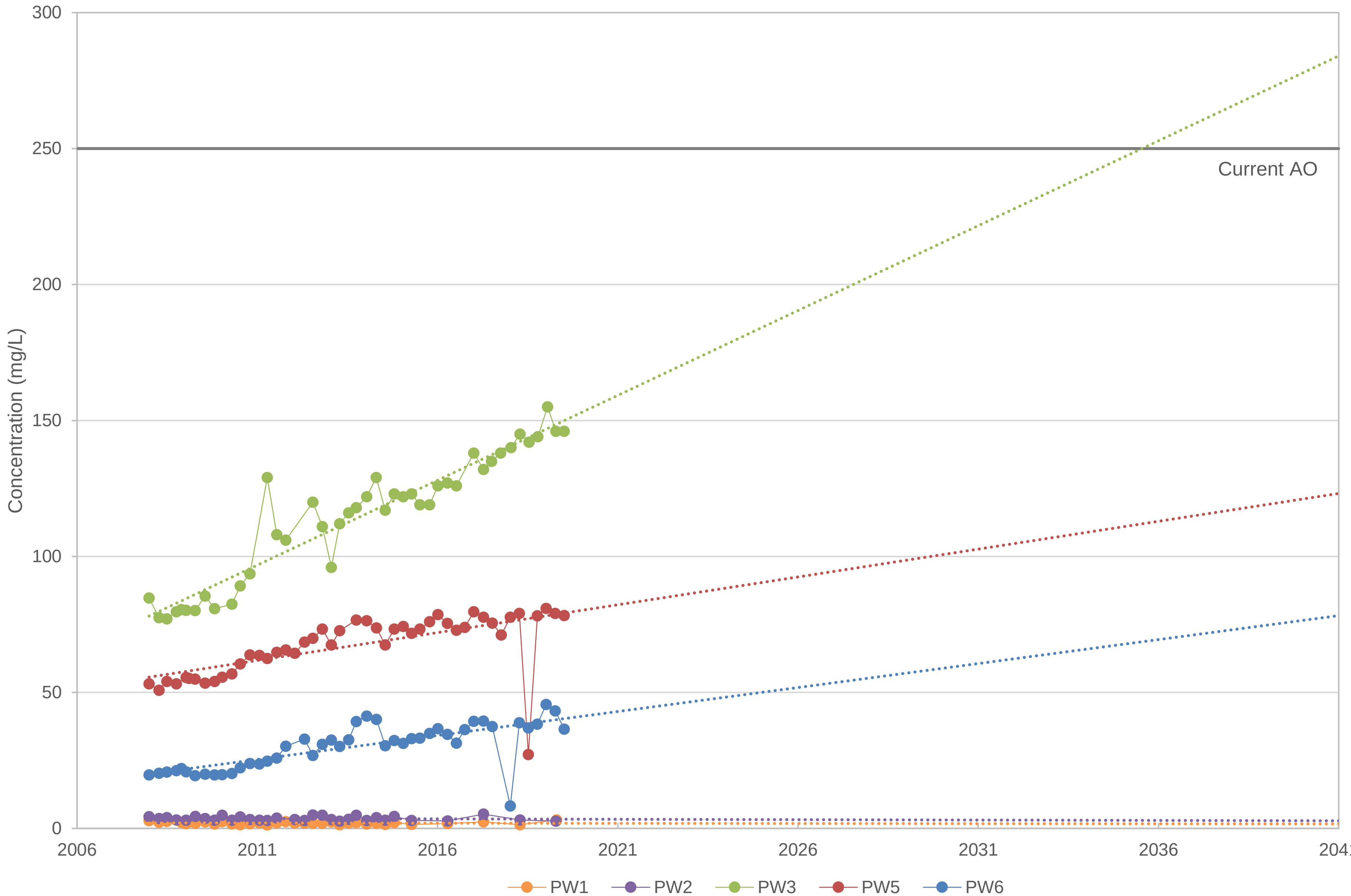
GOLDER

YYYY-MM-DD	2019-11-01
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

TITLE

SODIUM CONCENTRATIONS PROJECTED TO 2041

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	10



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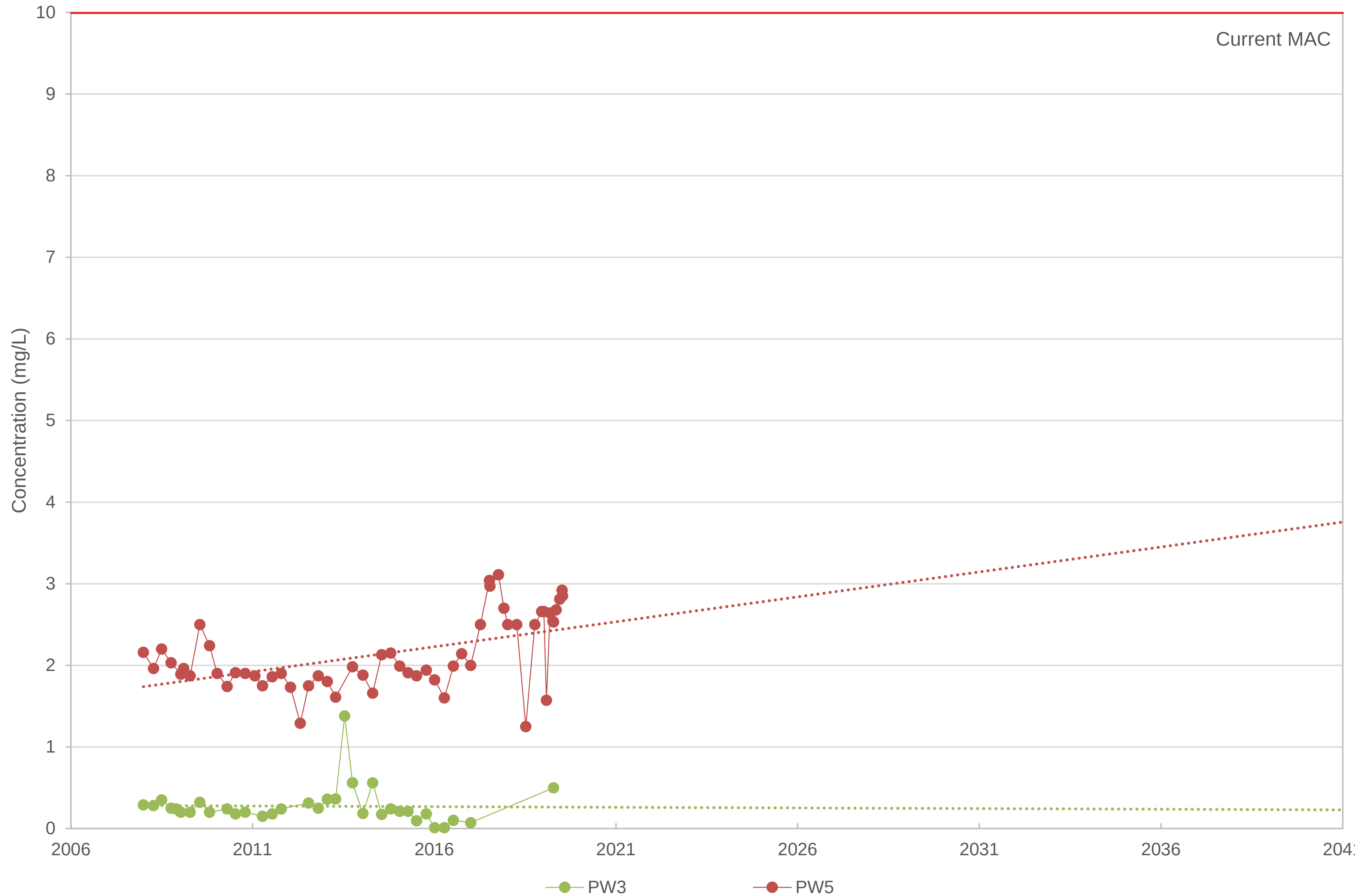
	DESIGN	AS	
	REVIEW	JP	PROJECT No. 1668667 / Phase - / Rev 0 / FIGURE 11
	APPROVED	JP	



CLIENT
THE MUNICIPAL INFRASTRUCTURE GROUP

PROJECT
RAW WATER QUALITY ASSESSMENT
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT
GOLDER

YYYY-MM-DD	2020-01-03
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

TITLE
NITRATE CONCENTRATIONS PROJECTED TO 2041

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	12

APPENDIX A

Water Well Records – Stouffville Production Wells

Ministry of Environment and Energy
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

11 | 6924458 | Municipality 69015 | Con. CON 10

SHEET 1 OF 2

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
York	former Township Markham	X	35

Owner's surname / First name	Address	Date completed
Region of York - Stouffville	17250 Yonge St. Newmarket.	17 day 3 month 98 year

21 | Zone | Easting | Northing | RC | Elevation | RC | Basin Code | #1

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth – feet From	To
brown	clay			0	6
brown	clay	some sand & gravel,	boulders	6	24
	gravel	some clay & boulders	cemented	24	37
	sand & gravel	some sandy clay	packed	37	45
	gravel & sand		packed	45	65
	clay & gravel		hard	65	148
	clay	sandy, gravel & bldrs	packed	148	236
grey	clay	some gravel	sticky, hard	236	279
grey	clay		hard	279	293
grey	clay	some gravel	hard sticky	293	299
	sand	some clay & gravel.	packed	299	306

31
32

WATER RECORD

Water found at – feet	Kind of water
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth – feet From	To
24	☑ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	.394	+2	299
12	☑ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	.375	260	310
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Sizes of opening (Slot No.)	Diameter	Length
50 slot	12 inches	15 feet

Material and type	Depth at top of screen
st. st. wire wrap	310 feet

PLUGGING & SEALING RECORD

☑ Annular space ☐ Abandonment

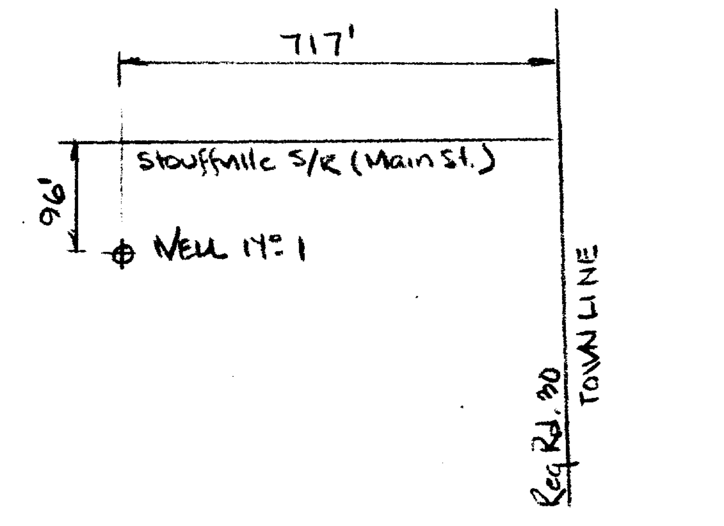
Depth set at – feet From	To	Material and type (Cement grout, bentonite, etc.)
325	278	Moire #3 silica gravel
278	22	cement grout.

PUMPING TEST

Pumping test method ☑ Pump ☐ Bailer	Pumping rate 450 GPM	Duration of pumping 63 Hours ... Mins	
Static level 113½ feet	Water level end of pumping 190' feet	Water levels during #2 WELL on ☐ Pumping ☐ Recovery	
15 minutes 120' feet	30 minutes 121' feet	45 minutes feet	60 minutes 122 feet
If flowing give rate GPM	Pump intake set at feet	Water at end of test ☐ Clear ☐ Cloudy	
Recommended pump type ☐ Shallow ☐ Deep	Recommended pump setting feet	Recommended pump rate GPM	

LOCATION OF WELL #1

In diagram below show distances of well from road and lot line. Indicate north by arrow.



156591

FINAL STATUS OF WELL

☑ Water supply
☐ Observation well
☐ Test hole
☐ Recharge well
☐ Abandoned, insufficient supply
☐ Abandoned, poor quality
☐ Abandoned (Other)
☐ Dewatering
☐ Unfinished
☐ Replacement well

WATER USE

☐ Domestic
☐ Stock
☐ Irrigation
☐ Industrial
☐ Commercial
☑ Municipal
☐ Public supply
☐ Cooling & air conditioning
☐ Not used
☐ Other ....

METHOD OF CONSTRUCTION

☐ Cable tool
☒ Rotary (conventional)
☑ Rotary (reverse)
☐ Rotary (air)
☐ Air percussion
☐ Boring
☐ Diamond
☐ Jetting
☐ Driving
☐ Digging
☐ Other ....

Name of Well Contractor	Well Contractor's Licence No.
International Water Supply	2801
Address: P.O. Box 310 Barrie Ont.	
Name of Well Technician: W Nobes	Well Technician's Licence No.: T-0115
Signature of Technician/Contractor	Submission date 21 day 5 mo 98 yr

MINISTRY USE ONLY

Data source	Contractor 2801	Date received JUL 0 7 1998
Date of inspection	Inspector	
Remarks		CSS. S9

0506 (07/94) Front Form 9

2 - MINISTRY OF ENVIRONMENT & ENERGY COPY

Ministry of Environment and Energy
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

11

6924458

SHEET 2 OF 2

Municipality 69015 Con. CON 10

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
York	former Township of Markham	X	35

Owner's surname	First name	Address	Date completed
Region of York - Stouffville		17250 Yonge St. Newmarket.	17 day 3 month 98 year

21 Zone Easting Northing RC Elevation RC Basin Code #2

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth – feet From	To
	Gravel fin	sand some clay		306	327
grey	clay	sandy		327	333

31

32

41 WATER RECORD

Water found at – feet	Kind of water
10-13	1 ☐ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas
15-18	1 ☐ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas
20-23	1 ☐ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas
25-28	1 ☐ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas
30-33	1 ☐ Fresh 2 ☐ Salty 3 ☐ Sulphur 4 ☐ Minerals 6 ☐ Gas

51 CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth – feet From	To
10-11	1 ☐ Steel 2 ☐ Galvanized 3 ☐ Concrete 4 ☐ Open hole 5 ☐ Plastic			13-16
17-18	1 ☐ Steel 2 ☐ Galvanized 3 ☐ Concrete 4 ☐ Open hole 5 ☐ Plastic			20-23
24-25	1 ☐ Steel 2 ☐ Galvanized 3 ☐ Concrete 4 ☐ Open hole 5 ☐ Plastic			27-30

SCREEN

Sizes of opening (Slot No.)	Diameter inches	Length feet
Material and type		Depth at top of screen feet

61 PLUGGING & SEALING RECORD

☐ Annular space ☐ Abandonment

Depth set at – feet From	To	Material and type (Cement grout, bentonite, etc.)
10-13	14-17	
18-21	22-25	
26-29	30-33	

71 PUMPING TEST

Pumping test method	Pumping rate	Duration of pumping
1 ☐ Pump 2 ☐ Bailer	GPM	.... Hours .... Mins

Static level	Water level end of pumping	15 minutes	30 minutes	45 minutes	60 minutes
feet	feet	feet	feet	feet	feet

Water levels during 1 ☐ Pumping 2 ☐ Recovery

If flowing give rate GPM | Pump intake set at feet | Water at end of test ☐ Clear ☐ Cloudy

Recommended pump type ☐ Shallow ☐ Deep | Recommended pump setting feet | Recommended pump rate GPM

FINAL STATUS OF WELL

1 ☐ Water supply
2 ☐ Observation well
3 ☐ Test hole
4 ☐ Recharge well
5 ☐ Abandoned, insufficient supply
6 ☐ Abandoned, poor quality
7 ☐ Abandoned (Other)
8 ☐ Dewatering
9 ☐ Unfinished
10 ☐ Replacement well

WATER USE

1 ☐ Domestic
2 ☐ Stock
3 ☐ Irrigation
4 ☐ Industrial
5 ☐ Commercial
6 ☐ Municipal
7 ☐ Public supply
8 ☐ Cooling & air conditioning
9 ☐ Not used
10 ☐ Other ....

METHOD OF CONSTRUCTION

1 ☐ Cable tool
2 ☐ Rotary (conventional)
3 ☐ Rotary (reverse)
4 ☐ Rotary (air)
5 ☐ Air percussion
6 ☐ Boring
7 ☐ Diamond
8 ☐ Jetting
9 ☐ Driving
10 ☐ Digging
11 ☐ Other ....

LOCATION OF WELL #1

In diagram below show distances of well from road and lot line. Indicate north by arrow.

See Page #1

156589

Name of Well Contractor	Well Contractor's Licence No.
International Water Supply	2801
Address: P.O. Box 310 Barrie Ont	
Name of Well Technician: W. Nobes	Well Technician's Licence No.: T-0115
Signature of Technician/Contractor	Submission date 21 day 5 mo 98 yr

MINISTRY USE ONLY

Data source	Contractor 2801	Date received JUL 0 7 1998
Date of inspection	Inspector	
Remarks		CSS. S9

0506 (07/94) Front Form 9

2 - MINISTRY OF ENVIRONMENT & ENERGY COPY

Ministry of Environment and Energy
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

11 — 6924459 — Municipality 69015 — Con. CON 10

SHEET 1 OF 2

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
York	Former Township of Markham	X	35

Owner's surname / First name	Address	Date completed
Region of York - Stouffville	17250 Yonge St. Newmarket.	26 day 2 month 98 year

21 Zone Easting Northing RC Elevation RC Basin Code #1

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth – feet From	Depth – feet To
brown	clay			0	5
brown	clay	some gravel		5	21
	gravel	some clay & gravel	cemented	21	33
	sand & gravel	sandy clay	packed	33	38
	clay	sandy, some gravel	packed	38	46
	gravel &	sand, sandy clay	packed	46	57
	clay	sandy, some gravel & bldrs,	packed	57	76
	clay	sandy, gravel & bldrs	packed	76	238
grey	clay	some gravel	sticky, hard	238	302
	sand &	some gravel & clay	packed	302	316

31

32

WATER RECORD

Water found at – feet	Kind of water
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth – feet From	Depth – feet To
24	☑ Steel	.394	+2	302
12	☑ Steel	.375	+259	316
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Sizes of opening (Slot No.)	Diameter	Length
50 slot	12 inches	15 feet

Material and type	Depth at top of screen
st. st.	316 feet

PLUGGING & SEALING RECORD

☑ Annular space ☐ Abandonment

Depth set at – feet From	To	Material and type (Cement grout, bentonite, etc.)
332	288	Marz #3 silica gravel
288	286	bentonite seal
286	4	cement grout

PUMPING TEST

Pumping test method	Pumping rate	Duration of pumping
☑ Pump ☐ Bailer	450 GPM	116 Hours .... Mins

Water levels during ☑ Pumping ☐ Recovery — No. 1 of 2

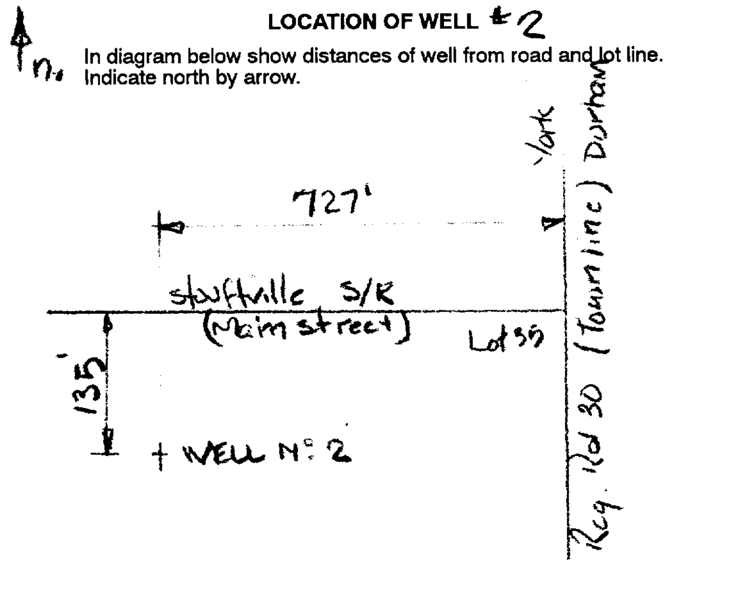
Static level	Water level end of pumping	15 minutes	30 minutes	45 minutes	60 minutes
113½ feet	188 feet	141 feet	142 feet	feet	143 feet

If flowing give rate	Pump intake set at	Water at end of test
GPM	feet	☑ Clear ☐ Cloudy

Recommended pump type	Recommended pump setting	Recommended pump rate
☐ Shallow ☐ Deep	feet	GPM

LOCATION OF WELL #2

In diagram below show distances of well from road and lot line. Indicate north by arrow.



156592

FINAL STATUS OF WELL

☑ Water supply ☐ Observation well ☐ Test hole ☐ Recharge well ☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Abandoned (Other) ☐ Dewatering ☐ Unfinished ☐ Replacement well

WATER USE

☐ Domestic ☐ Stock ☐ Irrigation ☐ Industrial ☐ Commercial ☑ Municipal ☐ Public supply ☐ Cooling & air conditioning ☐ Not used ☐ Other ....

METHOD OF CONSTRUCTION

☐ Cable tool ☐ Rotary (conventional) ☑ Rotary (reverse) ☐ Rotary (air) ☐ Air percussion ☐ Boring ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Other ....

Name of Well Contractor	Well Contractor's Licence No.
International Water Supply	2801
Address: P.O. Box 310 Barrie Ont.	
Name of Well Technician: W. Mohres	Well Technician's Licence No.: T0115
Signature of Technician/Contractor	Submission date: 21 day 5 mo 98 yr

MINISTRY USE ONLY

Data source	Contractor	Date received
	2801	JUL 0 7 1998
Date of inspection	Inspector	
Remarks		CSS. S9

0506 (07/94) Front Form 9

2 - MINISTRY OF ENVIRONMENT & ENERGY COPY

Ministry of Environment and Energy
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

11 6924459

Municipality 69015 Con. CON 10

SHEET 2 OF 2

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
York	former Township of Markham	X	35

Owner's surname First name	Address	Date completed
Region of York - Stouffville	17250 Yonge St. Newmarket	26 day 2 month 98 year

21 Zone Easting Northing RC Elevation RC Basin Code #2

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth – feet From	To
	Gravel f-m	sand some clay		316	333
	Sand f	some clay & gravel	packed	333	339
	clay	sandy gravel f-m	packed	339	345

31

32

41 WATER RECORD

Water found at – feet	Kind of water
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

51 CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth – feet From	To
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Sizes of opening (Slot No.)	Diameter inches	Length feet

Material and type	Depth at top of screen feet

61 PLUGGING & SEALING RECORD

☐ Annular space ☐ Abandonment

Depth set at – feet From	To	Material and type (Cement grout, bentonite, etc.)

PUMPING TEST

71 Pumping test method ☐ Pump ☐ Bailer | Pumping rate GPM | Duration of pumping Hours Mins

Static level	Water level end of pumping	Water levels during ☐ Pumping ☐ Recovery 15 minutes	30 minutes	45 minutes	60 minutes
feet	feet	feet	feet	feet	feet

If flowing give rate GPM | Pump intake set at feet | Water at end of test ☐ Clear ☐ Cloudy

Recommended pump type ☐ Shallow ☐ Deep | Recommended pump setting feet | Recommended pump rate GPM

LOCATION OF WELL #2

In diagram below show distances of well from road and lot line.
Indicate north by arrow.

See Page #1

156593

FINAL STATUS OF WELL

☑ Water supply
☐ Observation well
☐ Test hole
☐ Recharge well
☐ Abandoned, insufficient supply
☐ Abandoned, poor quality
☐ Abandoned (Other)
☐ Dewatering
☐ Unfinished
☐ Replacement well

WATER USE

☐ Domestic
☐ Stock
☐ Irrigation
☐ Industrial
☐ Commercial
☑ Municipal
☐ Public supply
☐ Cooling & air conditioning
☐ Not used
☐ Other

METHOD OF CONSTRUCTION

☐ Cable tool
☑ Rotary (conventional)
☑ Rotary (reverse)
☐ Rotary (air)
☐ Air percussion
☐ Boring
☐ Diamond
☐ Jetting
☐ Driving
☐ Digging
☐ Other

Name of Well Contractor	Well Contractor's Licence No.
International Water Supply	2801
Address: P.O. Box 310 Barrie Ont	
Name of Well Technician: W. Noses	Well Technician's Licence No.: T-0115
Signature of Technician/Contractor	Submission date 21 day 5 mo 98 yr

MINISTRY USE ONLY

Data source	Contractor	Date received
	2801	JUL 0 7 1998
Date of inspection	Inspector	
Remarks		CSS. S9

0506 (07/94) Front Form 9

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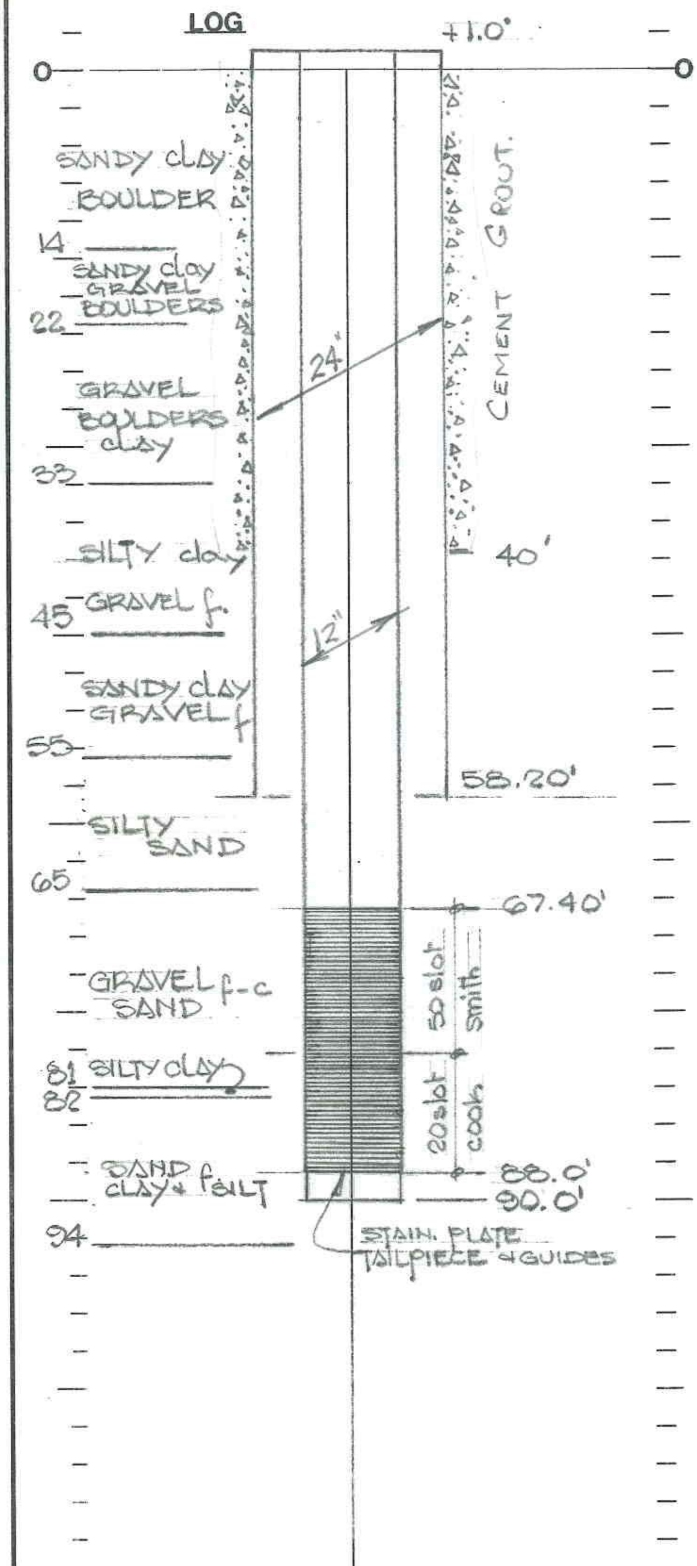
WELL DIAGRAM



WELL MATERIAL

Outer Casing: 24 " dia., .375 " Wall Thk. Matl.: steel

Cemented from 0 ' " to 40 ' "

Inner Casing: 12 " dia., .375 " Wall Thk. Matl.: steel

Screen: Make ~~smith~~ cook smith " dia., Opening & Matl.: 20 slot / 50 slot } s.s.

Plug: Type plate, Matl stain. st., Other:

Gravel: Type silica, Size 1/8 x 10 (8.8), Quantity 6 Tons

WELL TEST DATA

Preliminary Test Date: May 28 / 76 by Tom Kyle

Static Level: 5.49' " below M.P. +1.0'

Pumping Rate IGM: 551

Pumping Duration: 24 hrs. — min.

Pumping Level at Test End: 38.70' "

Performance Plots: dd-t Dwg. A78035, + 036

dd-r Dwg. A78036 A

Final Test: Date by

Rated Well Capacity IGM

Pumping Rate IGM Static level ' "

Pumping level ' " at hrs. min.

Pump pressure: psi: Main pressure psi

Shut off: AGH psi; W.L. ' "

Clear Well Depth from B.P. ' " Air Line ' "

PUMP & MOTOR DATA

Pump Make L+B Rating 525 IGM @ 246 ' TH

Head: Type TF818 S.N. 87473

Column: 60 ' X 8 " X 1 1/2 x 1 ": Shaft Mtl: CRS

Bowl: 10 RKEH Stage 6 : Curve:

Suction: 6 " dia. 5 ' 0 " Long

Special: Zinc Sleeves : Taped Oil Line

Other

Motor Make: USEM Frame: 326TP SN:

50 HP, 575/3 ph, 60 hz, 1760 rpm

Bearing No. Upper

Lower

N.B. Pump Installed 83

Special Equipment

WELL REVISIONS AND REHABILITATION		
DATE	WORK DONE	BY

International Water Supply Limited

SASKATOON – BARRIE – MONTREAL

CLIENT: YORK - STOUFFVILLE

WELL NO: 7 -1-2-12-2418-30

RMOY No 3

DRILLED BY: T. Kyle DATE: May 76 DRAWN: J. Wall

INSTALLED BY: DATE: DATE: Feb. 78

RECORDING CHARTS

212

WATER WELL RECORD

WHITCHURCH - STOUFFVILLE

County or District: York

Township, Village, Town or City: (Whitchurch)

Con.: 8 Lot: 9

Date completed: 1 March 1960 (day, month, year)

Owner: Stouffville Public Utilities Comm. (print in block letters)

Address: Stouffville, Ont.

Casing and Screen Record

Inside diameter of casing: 23 1/8"x 24" O.D.

Total length of casing: 23'10"

Type of screen: 304 Stainless Steel

Length of screen: 19'1" with 3'6" sump

Depth to top of screen: 23'

Diameter of finished hole: 23 1/8"

Pumping Test

Static level: 9' 6"

Test-pumping rate: 700 G.P.M.

Pumping level: 22' 7"

Duration of test pumping: 48 hrs.

Water clear or cloudy at end of test: Clear

Recommended pumping rate: 700 G.P.M.

with pumping level of: 22' 7"

Well Log / Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, sulphur)
Top soil	0	4	18'	8' 6"	Fresh
Brown clay	4	18			
Sand and gravel	18	44'6"			
Hardpan	44'6"	50			

For what purpose(s) is the water to be used? Municipal

Is well on upland, in valley, or on hillside? upland

Drilling Firm: C.H.Rutledge

Address: Nobleton, Ont.

Licence Number: 612

Name of Driller: C.H.Rutledge

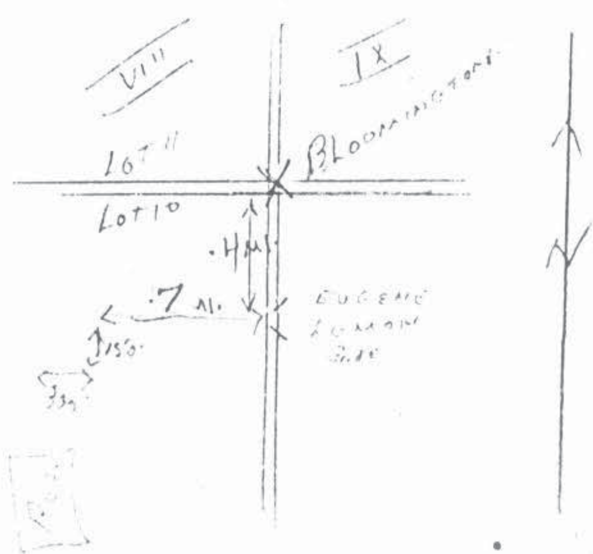
Address: Nobleton, Ont.

Date: May 30th, 1960.

C H Rutledge
(Signature of Licensed Drilling Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



unplottable

30M14F

APL

UTM 9 | 9 9 9 9 9 9 9 E

9 R 9 9 9 9 9 9 9 N

Elev. R

69 № 8211

The Ontario Water Resources Commission Act

WATER WELL RECORD

WHITCHURCH-STOUFFVILLE

Basin 2 4

County or District York ... Township, Village, Town or City (Whitchurch)

Con. 8 ... Lot 8 ... Date completed 13th (day) January (month) 1966 (year)

Owner Stouffville Public Utilities Commission (print in block letters) Address Stouffville, Ontario

Casing and Screen Record		Pumping Test	
Inside diameter of casing	24" Outer 12" Inner	Static level	8'
Total length of casing	45'	Test-pumping rate	~~350~~ 351 G.P.M.
Type of screen	Johnston 35 slot 25' long	Pumping level	59'
Length of screen	25' plus 10' Stainless Steel Pipe	Duration of test pumping	48 hours 24 hrs. recovery
Depth to top of screen	45'	Water clear or cloudy at end of test	clear
Diameter of finished hole	24"	Recommended pumping rate	351 G.P.M.
Gravel Packed.		with pump setting of	65 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Water Record: Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Top soil	0	1		
Grey clay and stones	1	7		
Sand	7	60		
Sand and gravel	60	70	45-70'	Fresh untested

For what purpose(s) is the water to be used? Town supply

Is well on upland, in valley, or on hillside? Upland

Drilling or Boring Firm Faulkner Well Drilling Co.Ltd.

Address 687 Water St. Peterborough, Ont.

Licence Number 1689

Name of Driller or Borer George Babcock

Address 608 Orpington Rd.Peterborough

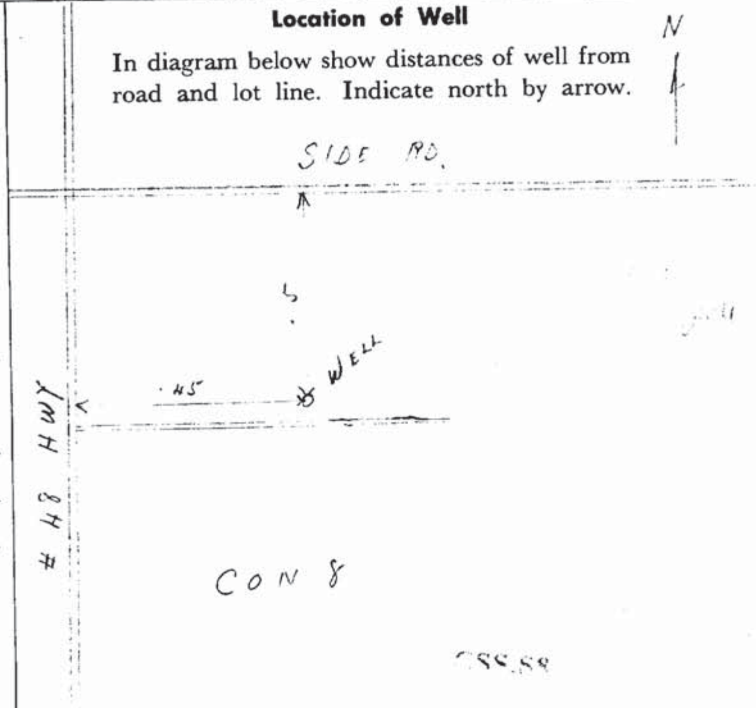
Date January 13th, 1966

F. H. Faulkner

(Signature of Licensed Drilling or Boring Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.

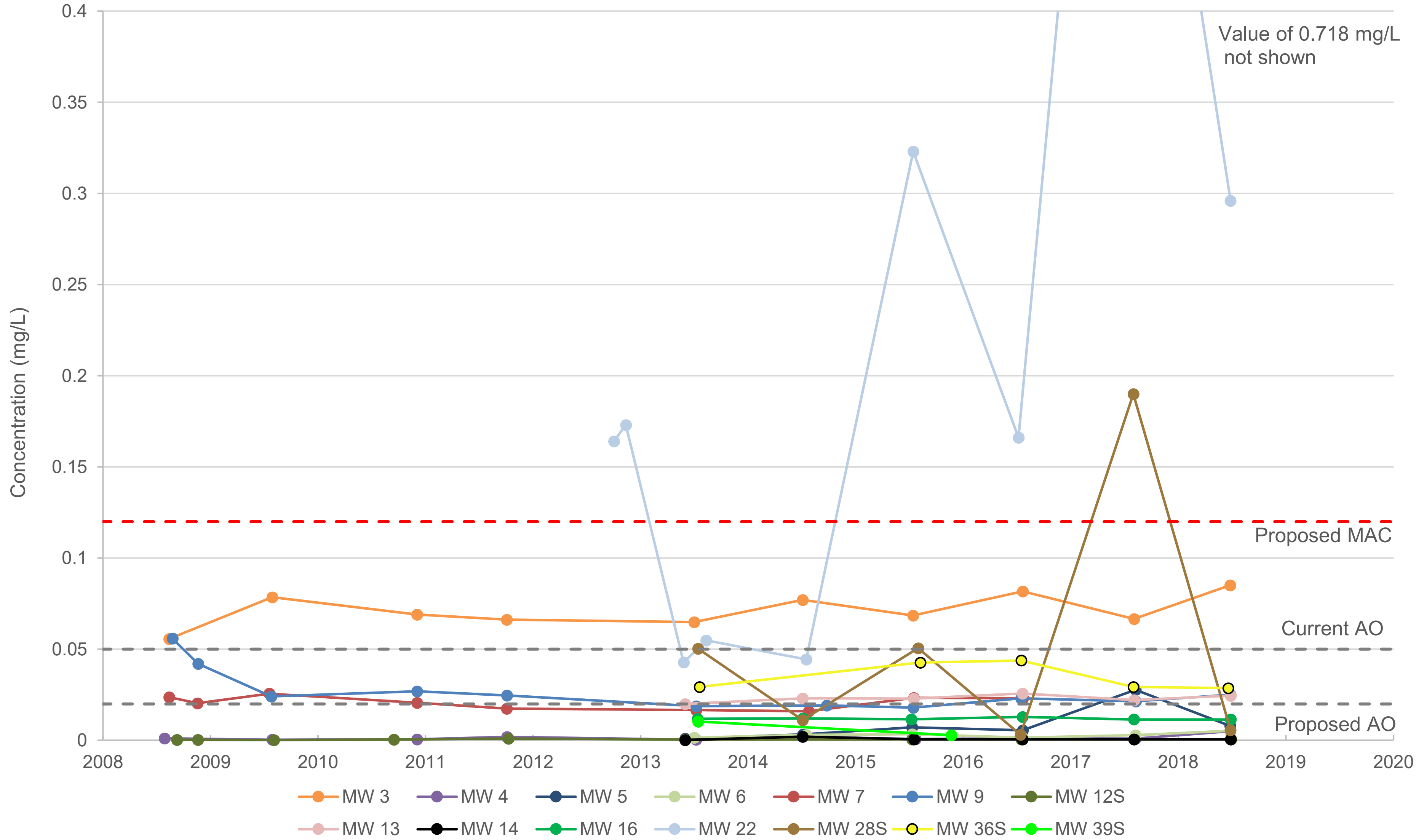


Form 7 15M-60-4138

OWRC COPY

APPENDIX B

Monitoring Well Groundwater Quality



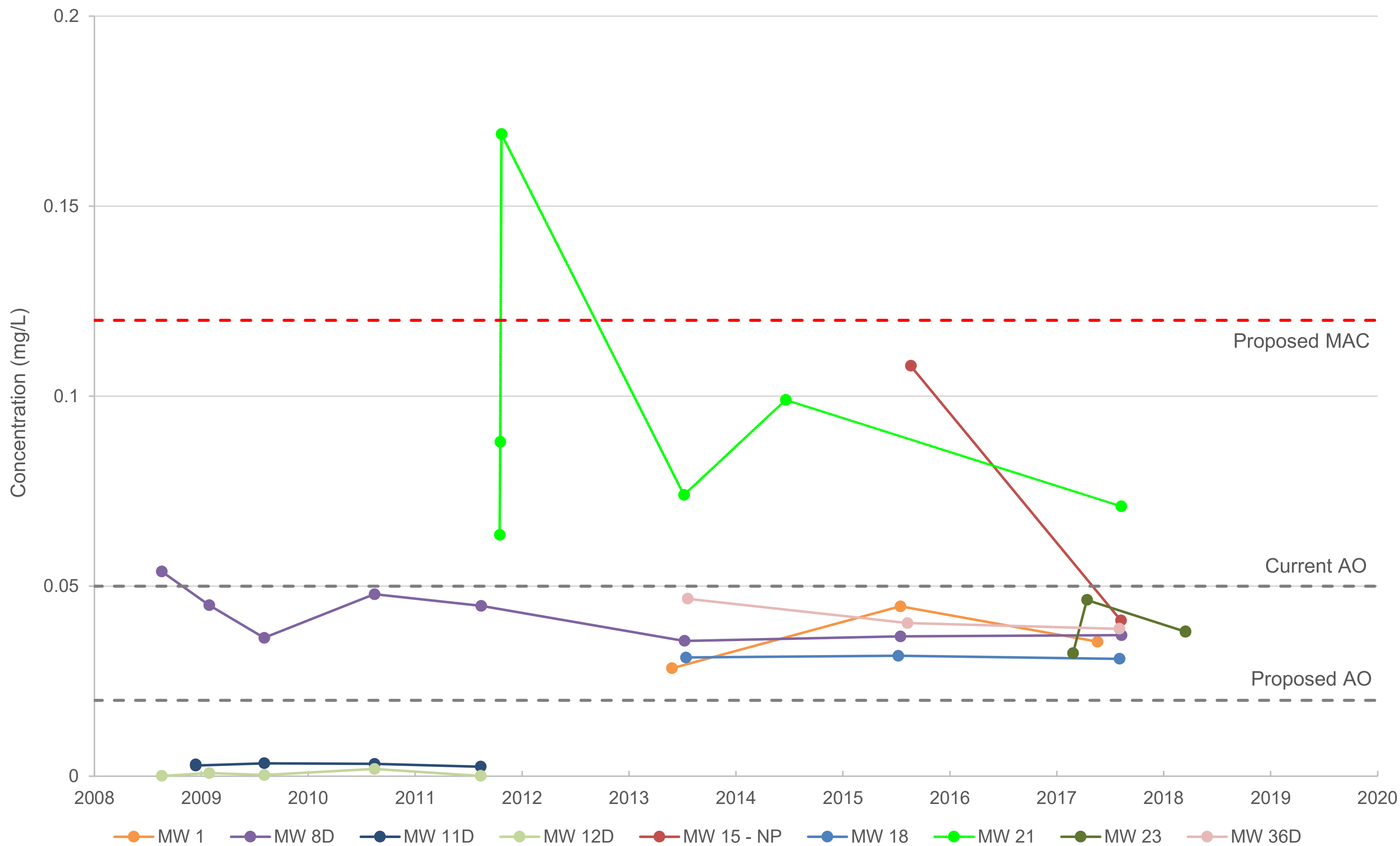
CLIENT THE MUNICIPAL INFRASTRUCTURE GROUP	PROJECT RAW WATER QUALITY ASSESSMENT STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT: GOLDER

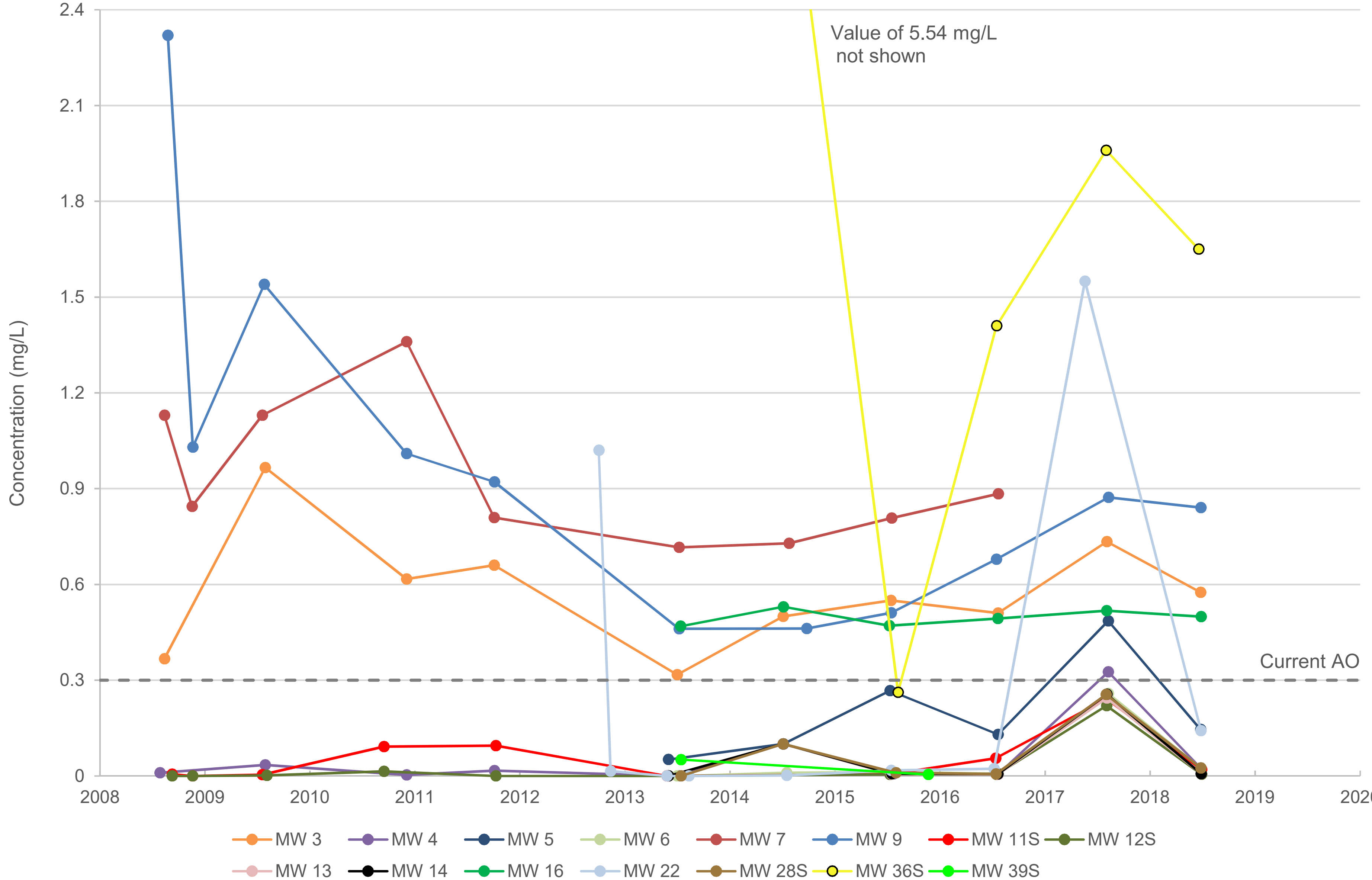
YYYY-MM-DD	05/11/2019
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

TITLE
MANGANESE CONCENTRATIONS
ORAC MONITORING WELLS, 2008 - 2019

PROJECT No.	Phase	Rev	FIGURE
1668667	-	A	B-1



CLIENT		PROJECT	
THE MUNICIPAL INFRASTRUCTURE GROUP		RAW WATER QUALITY ASSESSMENT STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA	
CONSULTANT	YYYY-MM-DD 05/11/2019	TITLE	
GOLDER	PREPARED AS	**MANGANESE CONCENTRATIONS TAC MONITORING WELLS, 2008 - 2019**	
	DESIGN AS		
	REVIEW JP	PROJECT No. 1668667	Phase -
	APPROVED JP	Rev A	FIGURE B-2



CLIENT		PROJECT
THE MUNICIPAL INFRASTRUCTURE GROUP		RAW WATER QUALITY ASSESSMENT STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT

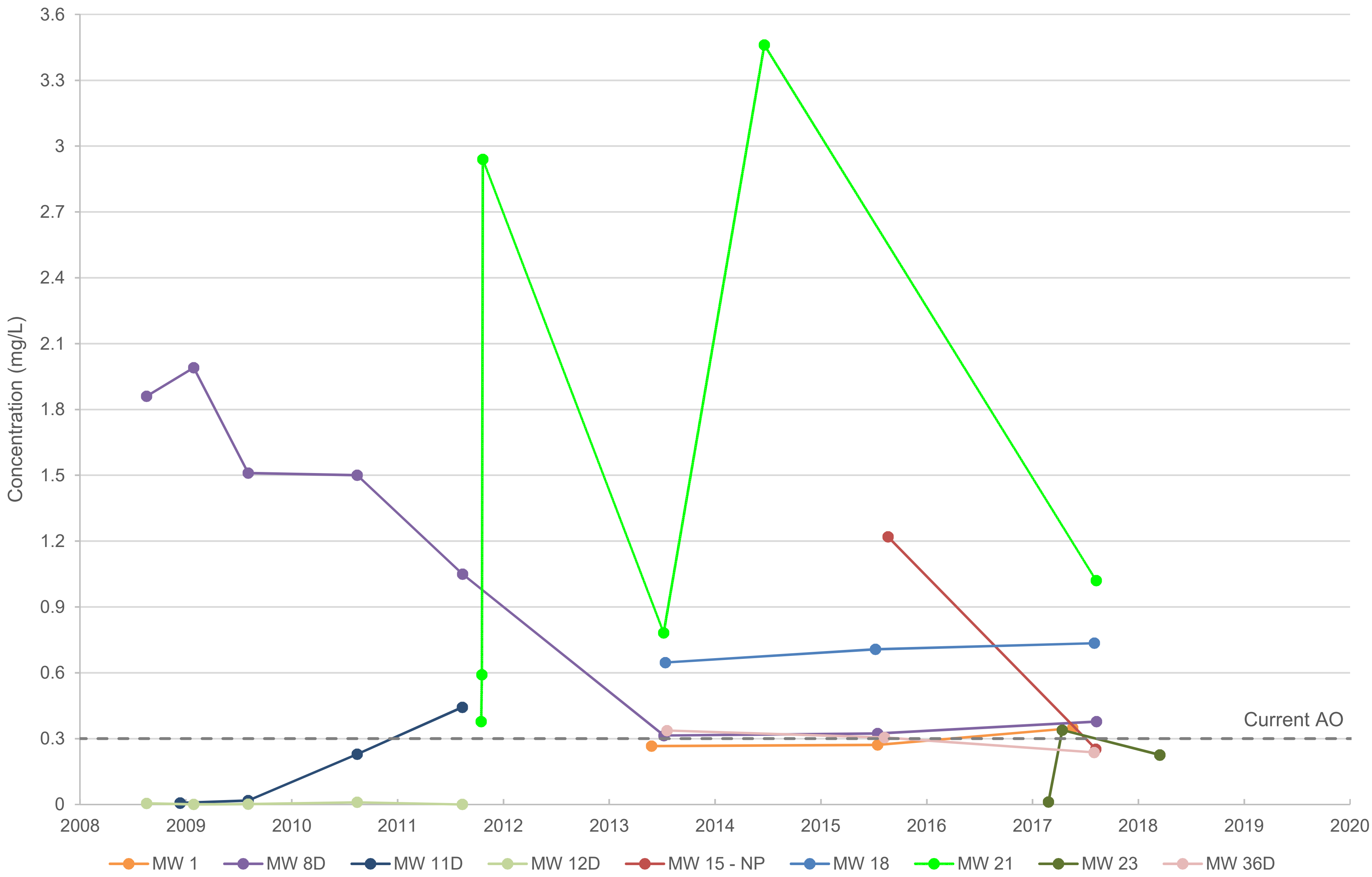
GOLDER

YYYY-MM-DD	2019-11-05
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

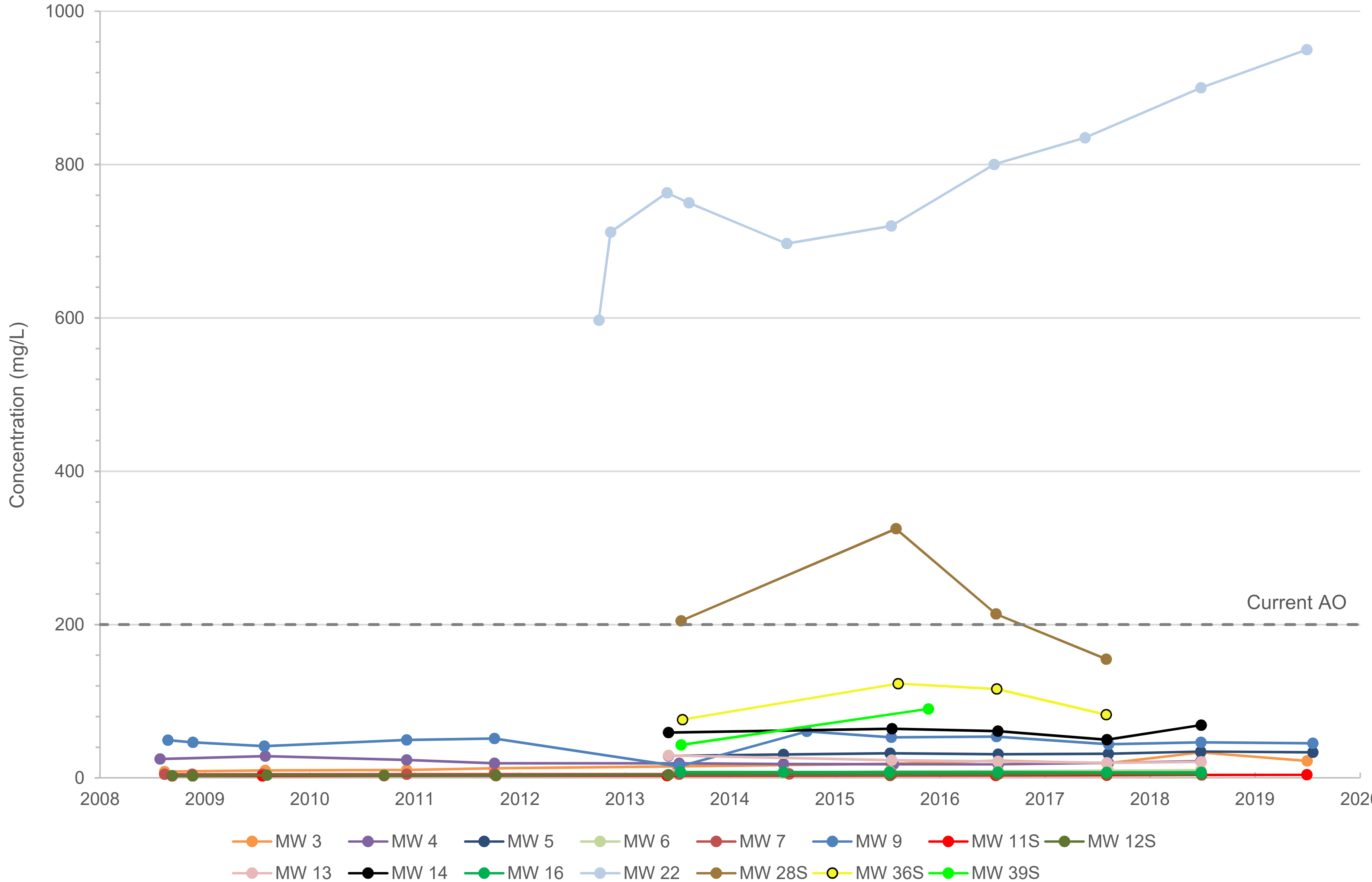
TITLE

IRON CONCENTRATIONS
ORAC MONITORING WELLS, 2008 - 2019

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	B-3



CLIENT THE MUNICIPAL INFRASTRUCTURE GROUP		PROJECT RAW WATER QUALITY ASSESSMENT STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA	
CONSULTANT GOLDER	YYYY-MM-DD: 2019-11-05 PREPARED: AS DESIGN: AS REVIEW: JP APPROVED: JP	TITLE **IRON CONCENTRATIONS TAC MONITORING WELLS, 2008 - 2019**	
		PROJECT No. 1668667 · Phase - · Rev 0	FIGURE B-4



CLIENT
THE MUNICIPAL INFRASTRUCTURE GROUP

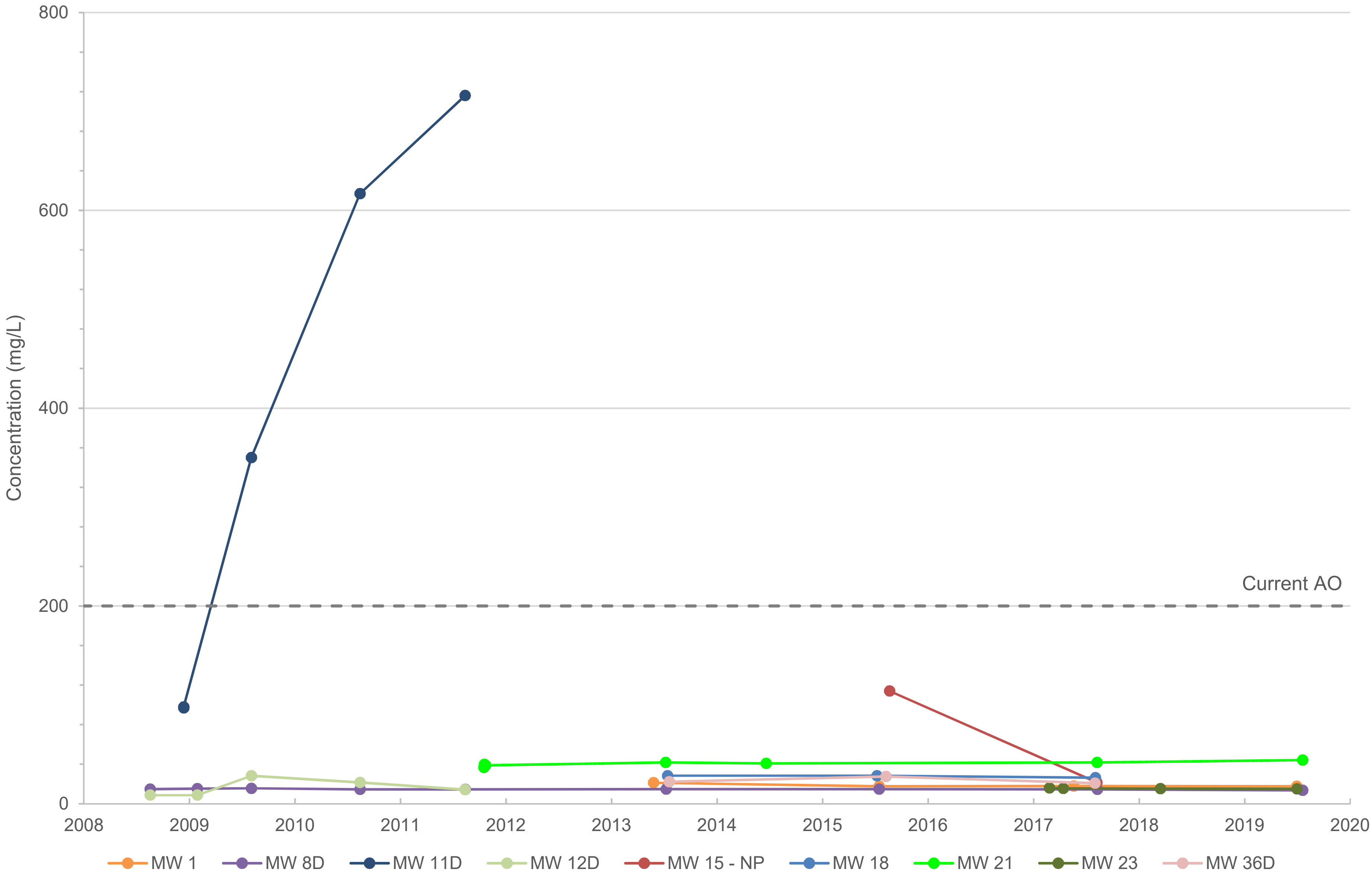
PROJECT
RAW WATER QUALITY ASSESSMENT
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-05
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

TITLE
SODIUM CONCENTRATIONS
ORAC MONITORING WELLS, 2008 - 2019

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	B-5

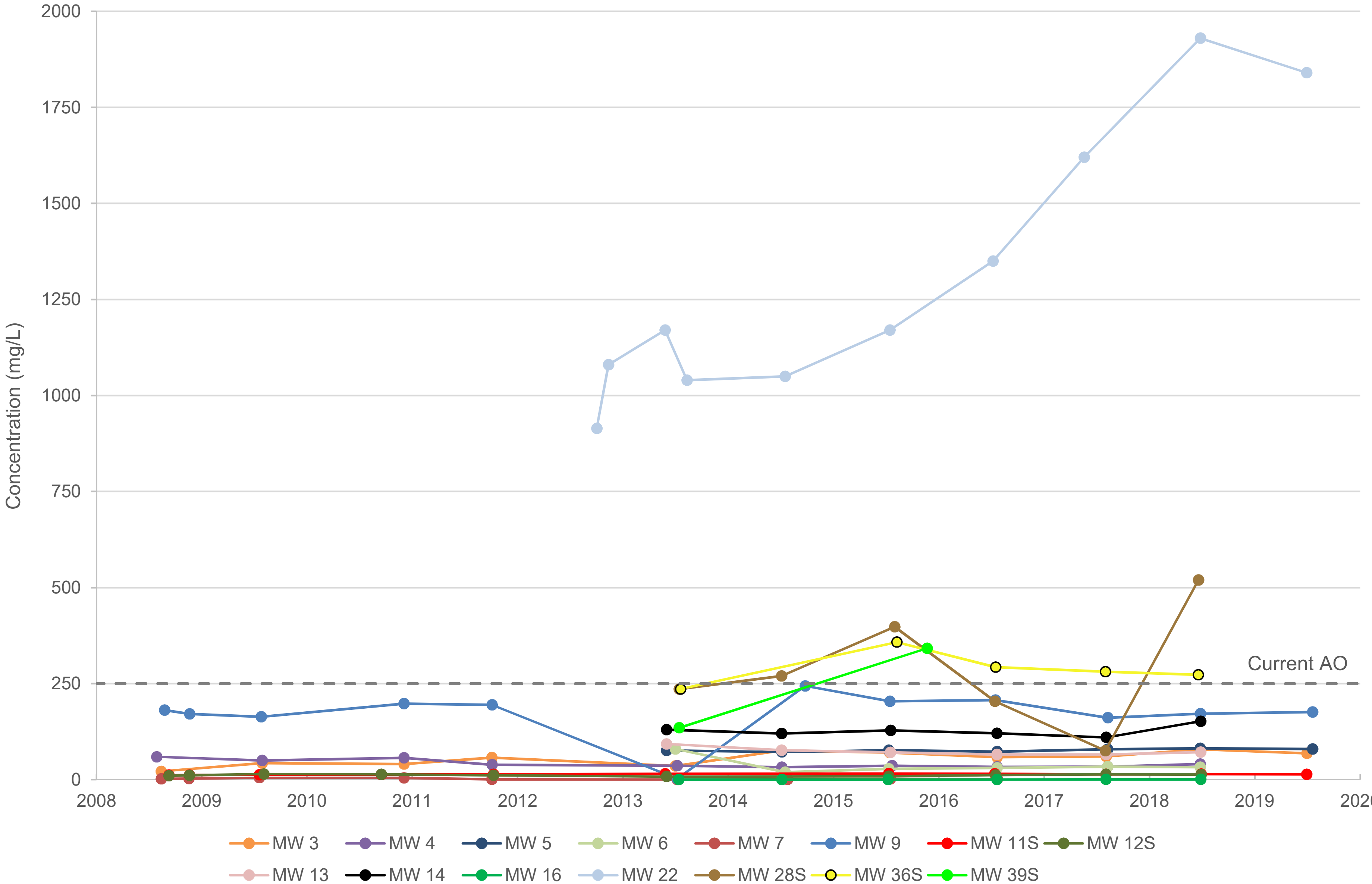


CLIENT		
THE MUNICIPAL INFRASTRUCTURE GROUP		
CONSULTANT	YYYY-MM-DD	2019-11-05
GOLDER	PREPARED	AS
	DESIGN	AS
	REVIEW	JP
	APPROVED	JP

PROJECT
RAW WATER QUALITY ASSESSMENT
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

TITLE
SODIUM CONCENTRATIONS
TAC MONITORING WELLS, 2008 - 2019

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	B-6



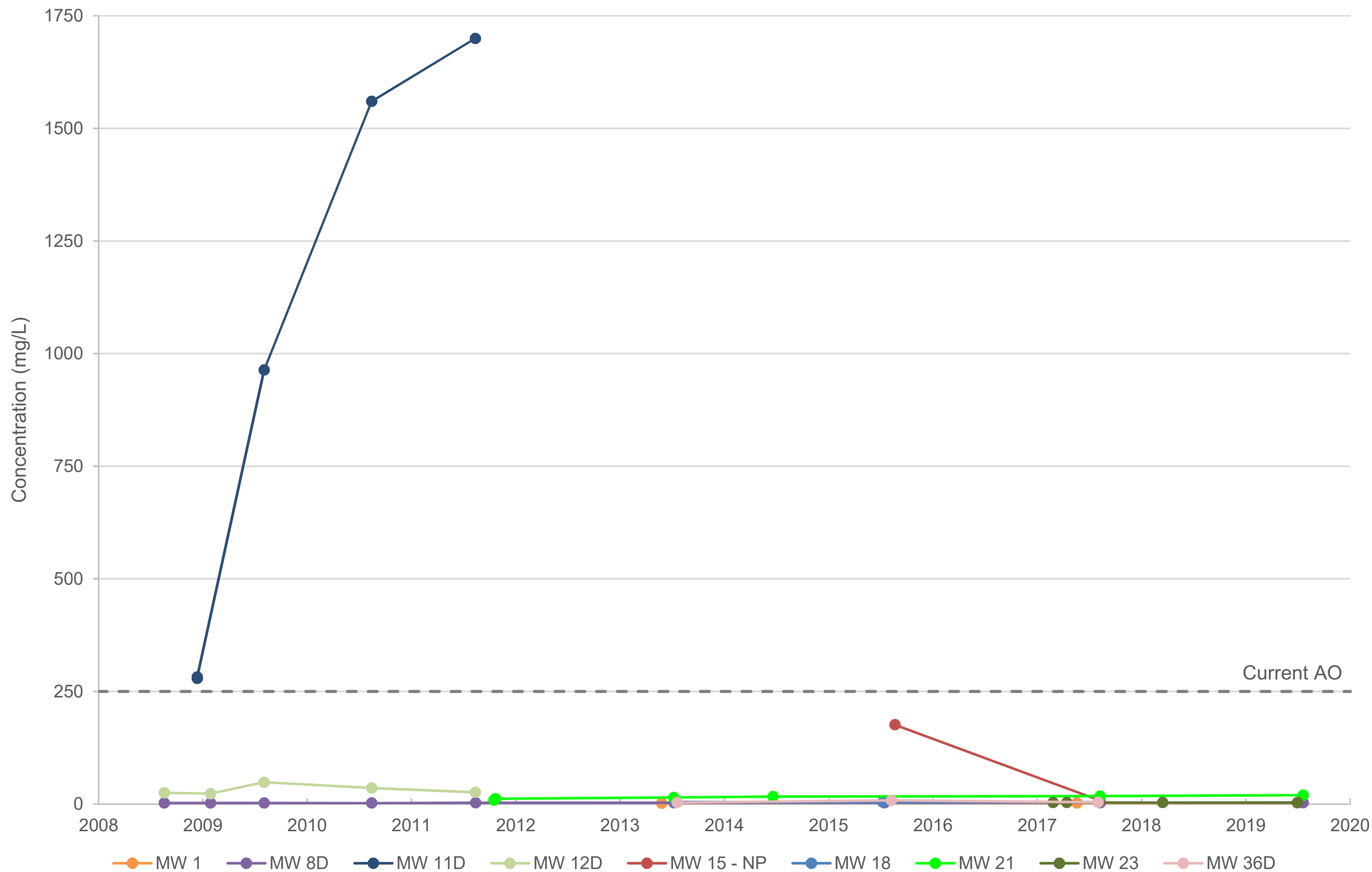
CLIENT		PROJECT
THE MUNICIPAL INFRASTRUCTURE GROUP		RAW WATER QUALITY ASSESSMENT STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT		
GOLDER	YYYY-MM-DD	2019-11-05
	PREPARED	AS
	DESIGN	AS
	REVIEW	JP
	APPROVED	JP

TITLE

CHLORIDE CONCENTRATIONS
ORAC MONITORING WELLS, 2008 - 2019

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	B-7

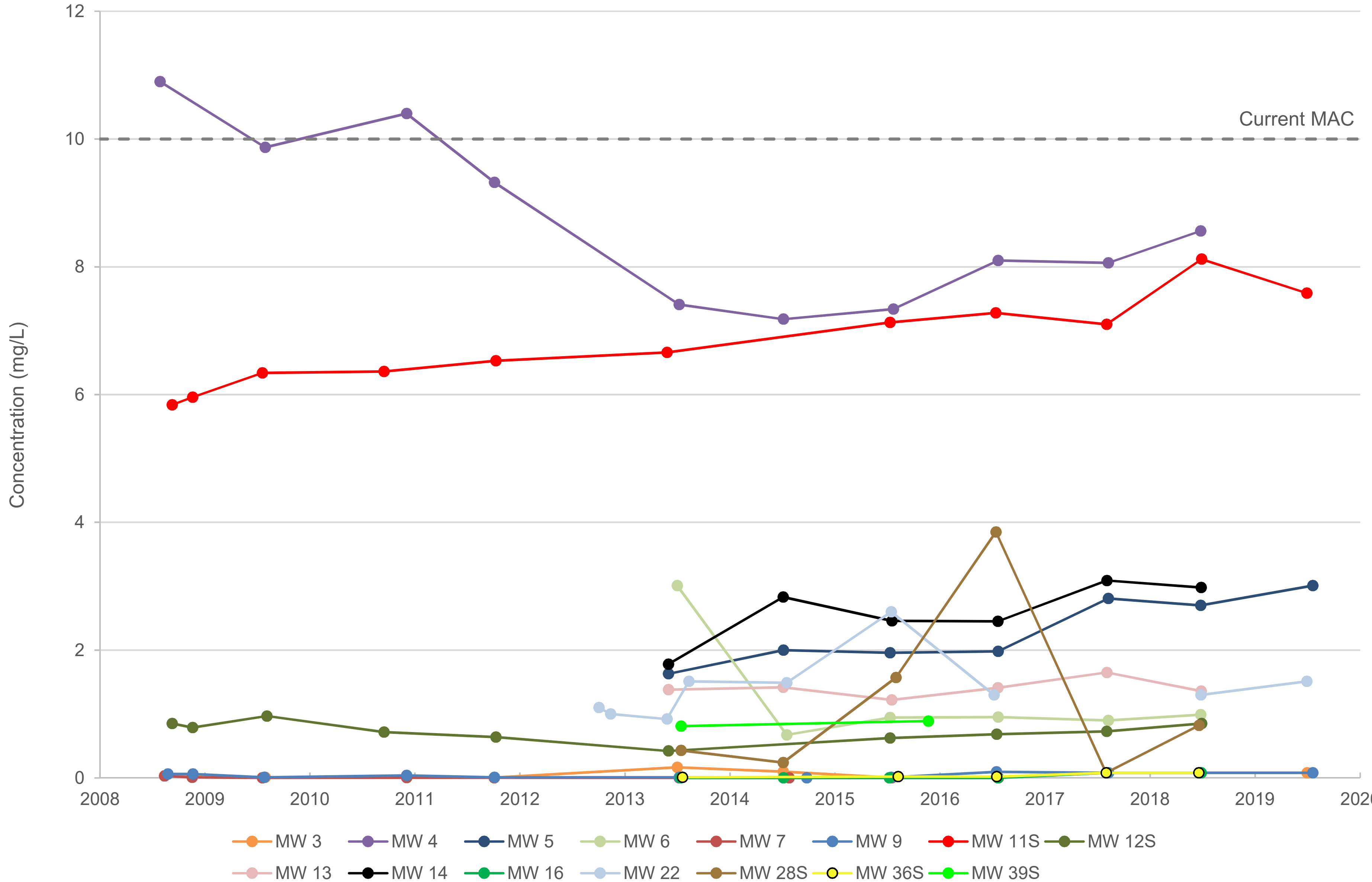


CLIENT THE MUNICIPAL INFRASTRUCTURE GROUP			
CONSULTANT GOLDER	YYYY-MM-DD	2019-11-05	
	PREPARED	AS	
	DESIGN	AS	
	REVIEW	JP	
	APPROVED	JP	

PROJECT
RAW WATER QUALITY ASSESSMENT
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

TITLE
CHLORIDE CONCENTRATIONS
TAC MONITORING WELLS, 2008 - 2019

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	B-8



CLIENT

THE MUNICIPAL INFRASTRUCTURE GROUP

PROJECT

RAW WATER QUALITY ASSESSMENT
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT

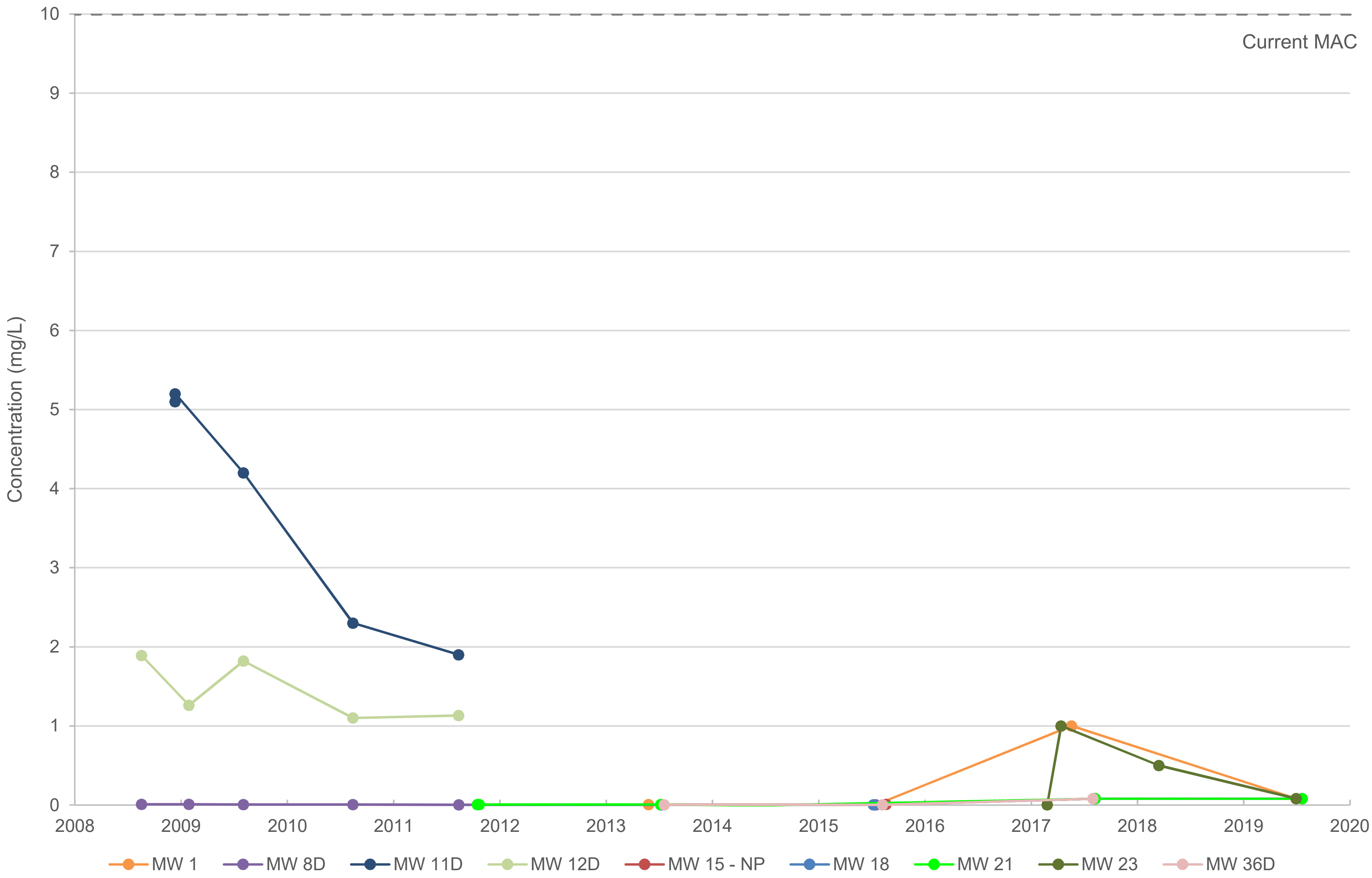
GOLDER

YYYY-MM-DD	2019-11-05
PREPARED	AS
DESIGN	AS
REVIEW	JP
APPROVED	JP

TITLE

NITRATE CONCENTRATIONS
ORAC MONITORING WELLS, 2008 - 2019

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	B-9



CLIENT

THE MUNICIPAL INFRASTRUCTURE GROUP

PROJECT

RAW WATER QUALITY ASSESSMENT
STOUFFVILLE WATER SYSTEM UPGRADES CLASS EA

CONSULTANT

GOLDER

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REVIEW	JP
APPROVED	JP

TITLE

NITRATE CONCENTRATIONS
TAC MONITORING WELLS, 2008 - 2019

PROJECT No.	Phase	Rev	FIGURE
1668667	-	0	B-10

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