APPENDIX – OM (ORO MEDONTE)

GENIVAR CONSULTANTS LP (FORMERLY JAGGER HIMS) TECHNICAL MEMORANDUMS

Oro Medonte:

- Technical Memorandum L1 - Drinking Water Issues Evaluation

DILLON CONSULTING LIMITED: WELL HEAD TIME OF TRAVEL CAPTURE ZONE PEER REVIEW EVALUATION RESULTS

- Dillon Consulting Limited WHPA Peer Review Report Memo
- Wellhead Time of Travel Capture Zone Peer Review Evaluation Results
    - Table 1: Horseshoe
    - Table 2: Medonte Hills
    - Table 3: Robin Crest
    - Table 4: Sugarbush
    - Table 5: Warminster

TECHNICAL MEMORANDUM L1

GENIVAR

Date: July 23, 2010

To: Don Goodyear, P.Geo. – South Georgian Bay Lake Simcoe Protection Region

From: Colleen Barfoot/Sarah Dignard/Lloyd Lemon, P.Geo.

Project No.: 071948.07

Subject: Drinking Water Issues Evaluation – Oro-Medonte
Township of Oro-Medonte

OBJECTIVE:

To document the Drinking Water Issues Evaluation for the groundwater supply for the Township of Oro-Medonte in the South Georgian Bay Lake Simcoe Source Protection Region.

OVERVIEW:

Work has been completed to meet the requirements of Technical Rules 114 through 117 of the Technical Rules: Assessment Report, *Clean Water Act, 2006* as provided by the Ontario Ministry of the Environment on December 12, 2008 and as amended in November 2009. The Drinking Water Issues Evaluation portion focuses on identifying recurring water quality impacts or situations with a possibility of impacting drinking water sources in the short-term. This work results in a preliminary list of identified issues to be evaluated.

The approach for the Drinking Water Issues Evaluation is described in more detail in "Technical Memorandum A5 - Drinking Water Issues Evaluation Methods". The steps included:

Step 1: Assemble Available Data

Step 2: Review Data and Identify Potential Drinking Water Issues

Step 3: Evaluate Drinking Water Issues

Step 4: Identify Contributing Area for Drinking Water Issues

Step 5: Prepare List of Drinking Water Issues

Municipal Wells and Aquifers

Canterbury Water Suply

Two alternatively operated groundwater production wells service the Community of Canterbury. Both wells were drilled into a sand and gravel aquifer. Well 1 was constructed with a nominal 203 mm diameter steel casing from surface to 49.7 m with a 1.5 m long 203 mm diameter 25-slot telescoping stainless steel screen. Well 2 was constructed with a nominal 203 mm diameter steel casing from surface to a depth of 49.4 m, with a 203 mm diameter 14-slot telescoping stainless steel screen set from 49.4 to 51.5 mgbl and 53.3 to 54.9 mbgl.

The Canterbury wells are constructed into the confined aquifer composed of sand and gravel which is present at depth west of the Canterbury Water Supply and to the south in the Harbourwood Water Supply area and may also exist to the east as a thin deposit overlying the bedrock. The aquifer pinches out to the east but is interpreted to extend to the north beyond Highway 11 and the airport. The well records indicate that approximately 40-45 m of confining materials of variable composition (clay, silty sand, sandy till) locally overlie the municipal aquifer layer.

Raw water is treated with 12% Liquid Chlorine. The treated water then goes to three pressure tanks located in the pumping station, and is distributed from the pressure tanks, through the chlorine contact main, and to the distribution system. A Chlorine Residual Analyzer and Turbidimeter have been installed for continuous monitoring and recording of free chlorine residual and turbidity. The distribution system consists of 334 m of 150 mm diameter watermains, and 52 m of 300 mm diameter contact mains, which supplies water to 17 homes. According to the Permit to Take Water (PTTW) # 92-P3028, issued on December 18 2001 and which expires on December 15 2011, the rated capacity for the maximum flow rate into the treatment system is 208 m^3/day or 104 m^3/day for each well.

Cedarbrook Water Supply

The Community of Cedarbrook is serviced by a groundwater system with two alternatively operated production wells. Well 1 was constructed with a nominal 152 mm diameter steel casing to a depth of 37.2 m and a nominal 152 mm diameter 1.8 m long 25 and 18-slot stainless steel screen. Well 2 was constructed with a nominal 203 mm diameter steel casing to a depth of 47.2 m. The well record indicates that no screen was installed in the well. The well reportedly flowed at the time of construction.

The Cedarbrook wells are completed in the confined aquifer which is locally present between approximately 200 to 210 masl. This aquifer appears to be thin in the vicinity of the wellfield and may pinch out laterally to the west and east. The thickness of the aquifer apparently increases to the north, however some well records located approximately 6 km to the north of the wellfield indicate that the aquifer pinches out. The driller's log refers to the aquifer material as "boulder clay". The aquifer is locally overlain by approximately 40 m of aquitard materials consisting mainly of clay with boulders and is underlain by approximately 20 m of aquitard material described on driller's logs mainly as sandy clay. According to the Permit to Take Water (PTTW) # 4817-6HJPXP, issued on October 31 2005 and which expires on December 15 2011, the rated capacity for the maximum flow rate into the treatment system and for each of the wells (since they are operated at alternating times) is 196.4 m^3/day.

Craighurst Water Supply

The Craighurst Water Supply consists of three groundwater production wells. Well 1 is a standby well only. Well 2 acts as the lead well, and Well 3 acts as the alternate well. Well 1 was constructed with a nominal 304 mm diameter steel surface casing to a depth of 4.6 m and a nominal 152 mm diameter steel casing from surface to a depth of 24.4 m. A nominal 152 mm diameter 16-slot telescoping stainless steel screen was placed from 24.4 to 27.4 mbgl. Well 2 was constructed with a nominal 152 mm diameter steel casing to a depth of 24 m with a 152 mm diameter 1.8 m long telescoping 20-slot stainless steel screen set from 24 to 25.8 mbgl. Well 3 was constructed with a nominal 152 mm diameter steel casing to a depth of 29 m with a 152 mm diameter 1.8 m long telescoping 12-slot stainless steel screen set from 29 to 30.8 mbgl. According to the Permit to Take Water (PTTW) #4624-6HKPJW, issued on October 28 2005 and which expires December 15 2011 and the Certificate of Approval for this system, the maximum rated capacity for Well 1 is 64 m^3/day, the maximum rated capacity for Well 2 is 140 m^3/day and the maximum rated capacity for Well 3 is 229 m^3/day. Well 1 is a standby well while Well 2 and Well 3 provide the water on a day-to-day basis. The combined total rated capacity for the system is 229 m^3/day.

The Craighurst wells are completed in a confined overburden (sand) aquifer which is locally present at elevations between 230 and 240 masl. The thickness of the aquifer apparently increases to the south, east and locally towards the south. It is present at a depth of approximately 20 to 25 mbgl. It is overlain by approximately 10 m of aquitard materials (clay to silty sand) in the vicinity of the wellfield but is reportedly unconfined to the north and east. A second aquifer is also present beneath the wellfield at elevations of approximately 188 to 193 masl but may pinch out to the west and north.

Raw water enters the pumphouse and is treated with 12% Liquid Chlorine. The treated water is transferred into a two-celled reservoir, located under the pumping station, for a 15 minute contact time. The treated water is them pumped into the distribution system with three high lift centrifugal pumps and one fire pump. A Chlorine Residual Analyzer and Turbidimeter have been installed for continuous monitoring and recording of free chlorine residual and turbidity. The water distribution system supplies water to 51 homes, and consists of 990 m of 150 mm watermains

Harbourwood Water Supply

The Harbourwood Water Supply consists of two groundwater production wells (Wells 2 and 3). Well 3 is approximately 87 m to the north of Well 2. Both wells were drilled into a confined aquifer system. Well 2 is a nominal 229 mm diameter steel cased well constructed to a total depth of 63.1 m. The well has an 8.2 m long 16 and 25-slot telescoping stainless steel screen. Well 3 was constructed to replace Well 1 and has a nominal 203 mm diameter steel casing from surface to a depth of 70.1 m and a nominal 178 mm diameter and 18, 25, and 30-slot stainless steel screen in three 1.2 m lengths (screen set from 70.1 to 73.7 mbgl). According to the Permit to Take Water (PTTW) # 8643-6HKK9K, issued on February 17 2006 and which expires on January 31 2014, the rated capacity for the maximum flow rate into the treatment system is 921 m^3/day.

The Harbourwood Water Supply draws water from a widely distributed sand/gravel aquifer from between 55 and 75 m below grade. The aquifer is confined by several metres of low-permeability clay and till. The aquifer has moderate transmissivity, being about 100 m^2/day, and occurs under artesian conditions. Groundwater is not under the direct influence of surface water sources.

Raw water enters the pumphouse and is treated with 12% Liquid Chlorine. The treated water then goes to a steel-bolted, glass-fused standpipe station located behind the pumphouse for a 15 minutes contact time. The treated water is then pumped into the distribution system with three high lift centrifugal pumps. The distribution system consists of 3251 m of 150 mm diameter watermains, and supplies water to 131 homes. A Chlorine Residual Analyzer and Turbidimeter have been installed for continuous monitoring and recording of free chlorine residual and turbidity.

Horseshoe Highlands Water Supply

The Horseshoe Highlands Water Supply consists of two groundwater production wells located south of Horseshoe Valley Road. They are Well 1 (the lead well) and Well 2 (the standby well), which is located about 150 metres from Well 1. Both wells were drilled into a confined overburden aquifer system. Well 1 was constructed with a nominal 305 mm diameter steel casing to a depth of 73.2 m and a nominal 305 mm diameter 13.7 m long 25 and 15, 20-slot telescoping stainless steel screen. The well annulus was sealed with cement grout from surface to 18.3 mbgl. Well 2 was constructed with a nominal 152 mm diameter steel casing to a depth of 73.2 m and a nominal 152 mm 16-slot stainless steel screen set from 73.2 to 79.2 mbgl. According to the Permit to Take Water (PTTW) 0404-5UHQDN issued on January 21 2004 and which expires on December 13 2013, the rated capacity for the maximum rated capacity for Well 1 is 3,371 m^3/day and the maximum rated capacity for Well 2 is 527 m^3/day. Well 1 provides the water on a day-to-day basis while Well 2 is a standby well.

The regional sand aquifer that supplies the municipal system is present between elevations from approximately 220 to 265 masl (approximately 50 to 95 mbgl). The aquifer may be unconfined more than 3 km west of the wellfield (towards Craighurst). The aquifer extends to the east beyond the Sugarbush subdivisions.

Raw water enters the pumphouse and is treated with 12% Liquid Chlorine. The treated water is stored in the water tower with an operating capacity of 1280 m^3 and is gravity fed into the distribution system. The distribution system consists of 8131 m of 300 mm and 150 mm watermains. The water distribution system supplies water to 192 lots and the Carriage Hills Resort. A Chlorine Residual Analyzer and Turbidimeter have been installed for continuous monitoring and recording of free chlorine and turbidity.

Maplewood Water Supply

The Maplewood Water Supply is comprised of one groundwater production well. Well 1 was drilled into a confined sand and gravel aquifer system. It was constructed with a nominal 178 mm diameter steel casing to a depth of 25.3 m and a nominal 127 mm diameter 1.8 m long 18-slot stainless steel screen. Well 1 is a 175 mm, 26.5 m deep drilled groundwater production well, equipped with a submersible deep well pump, which is rated at 164 m3/day. According to the Permit to Take Water (PTTW) # 02-P-1314, issued on October 17 2002 and which expires on October 31 2012, the rated capacity for the maximum flow rate into the treatment system is 164 m^3/day.

The Maplewood well is drilled into an overburden aquifer between elevations of approximately 197 to 200 masl. The aquifer consists of approximately 3 m of sand and gravel overlain by approximately 24 m of confining materials (till, described as clay with a variable sand and gravel content and cemented sand and gravel). The aquifer is interpreted to pinch out near Lake Simcoe. The recharge area for the municipal aquifer is believed to be located west of the wellfield, where the aquifer is thicker and closer to ground surface.

Three in-line aerators are placed in line on the well line to remove sulphur gas. Raw water enters the pumphouse and is treated with 12% Liquid Chlorine and the treated water goes to a two-celled, 20,000 gallon reservoir. The treated water is pumped into the distribution system with three high lift distribution pumps located in the pumping station. The distribution system consists of 1069 m of 150 mm watermains and supplies 45 homes with water. A Chlorine Residual Analyzer and Turbidimeter have been installed for continuous monitoring and recording of free chlorine residual and turbidity.

Drilling of a second well for the Maplewood Water Supply is scheduled for the fall of 2009, which will serve to help out Well 1 as water quantity has been a concern at this system.

Medonte Hills Water Supply

This Medonte Hills Water Supply consists of two groundwater production wells (Wells 1 and 2). One well is located outside of the pumping station and the other well is located inside the pumping station. Medonte Well 1 was constructed with a nominal 152 mm diameter steel casing from surface to 62.2 mbgl, with a 4.88 m long 25-slot stainless steel screen. Medonte Well 2 was constructed with a nominal 152 mm diameter steel casing from surface to a depth of 68.6 m, with a 2.13 m long 152 mm diameter 25-slot stainless steel screen. According to the Permit to Take Water (PTTW) #92-P-3029 issued on December 18 2001 and which expires December 15 2011 for the Medonte Hills Water Supply, the rated capacity for Well 1 is of 327 m^3/day and for Well 2 is of 393 m^3/day. Medonte Wells 1 and 2 alternate to provide water to the subdivision on a day-to-day basis.

The two wellfields that service Moonstone extract water from a confined sand and gravel aquifer identified at approximately 205 to 215 masl (60 to 70 mbgl) at the Medonte Hills Water Supply and approximately 210 to 230 masl (52 to 72 mbgl) at the Robincrest Water Supply. The minimum thickness of the overlying confining layer, approximately 15 m, is encountered at the Medonte Hill wellfield. The aquitard is reported to consist of clayey silt or clay till. At least two more aquifers were identified in the vicinity of the wellfields which are located above the municipal aquifer. An apparent fourth aquifer at the Robincrest Water Supply may be a lower component of the municipal aquifer that is not identified at the Medonte Hills Water Supply because the upper contact of bedrock is locally elevated. The recharge area for the municipal aquifer is believed to be located southwest of the wellfields in the vicinity of Mount St.Louis.

Raw water enters the pumphouse and is treated with 12% Liquid Chlorine which is pumped by two chemical metering pumps to a common discharge header when the well pumps are activated. The wells are hooked up to operate alternatively. The treated water is stored in five 120 gallon pressure tanks. The treated water is distributed from the pumping station through two separate lines. One is for the top zone and the other is for the lower zone. The lower zone pressure is controlled with a pressure-reducing valve located in the pumping station. This valve is required because of the elevation of the subdivision (lower zone) in relation to the pumping station. The distribution system consists of 458 m of 150 mm diameter watermains in the lower zone, and 3199 m of 50 mm watermains and 222 m of 75 mm watermains in the upper zone and serves a population of 432 people. A pumping station was installed in the upper zone to help increase the pressure.

Robincrest Water Supply

The Community of Robincrest is serviced by a water distribution system which is comprised of two groundwater production wells (Wells 1 and 2). Robincrest Well 1 was constructed with a nominal 152 mm diameter steel casing from surface to 62.5 mbgl, with a 3.2 m long 152 mm diameter 105, 80, and 55-slot stainless steel screen. Robincrest Well 2 was constructed with a 203 mm diameter steel casing from surface to a depth of 61.9 m, with a 4.88 m long 203 mm diameter 90, 60, and 30-slot stainless steel screen. According to the Permit to Take Water (PTTW) # 77-P-3033 issued September 11 2000 and which expires September 15 2010, as well as PTTW # 77-79UPRS issued December 21 2007 and which expires on December 13 2017, the rated capacity for Well 1 in the Robincrest Water Supply is 576 m^3/day and for Well 2 is 842 m^3/day.

The two wellfields that supply Moonstone extract water from a confined sand and gravel aquifer identified at approximately 205 to 215 masl (60 to 70 mbgl) at the Medonte Hills Water Supply and approximately 210 to 230 masl (52 to 72 mbgl) at the Robincrest Water Supply. The minimum thickness of the overlying confining layer, approximately 15 m, is encountered at the Medonte Hills wellfield. The aquitard is reported to consist of clayey silt or clay till. At least two more aquifers were identified in the vicinity of the wellfields which are located above the municipal aquifer. An apparent fourth aquifer at the Robincrest Water Supply may be a lower component of the municipal aquifer that is not identified at the Medonte Hills Water Supply because the upper contact of bedrock is locally elevated. The recharge area for the municipal aquifer is believed to be located southwest of the wellfields in the vicinity of Mount St.Louis.

Raw water enters the pumphouse and is treated with 12% Liquid Chlorine and the treated water then goes to a 267 m^3 reservoir. The treated water is pumped into the distribution system with two high lift distribution pumps located in the pumphouse. A Chlorine Residual Analyzer and Turbidimeter have been installed for continuous monitoring and recording of free chlorine residual and turbidity. The distribution system consists of 2001 m of 150 mm watermains. The Robincrest water distribution system supplies 149 homes, the formerly privately serviced Village of Moonstone (approximately 25 residents), and Moonstone Public School with water.

Shanty Bay Water Supply

The Shanty Bay Water Supply consists of three groundwater production wells (Wells 1, 2, and 3). Well 2 was drilled into the upper part of a confined sand and gravel aquifer while Well 1 and Well 3 were drilled into the lower part. Well 1 was constructed with a nominal 152 mm diameter steel casing from surface to a depth of 55.5 m with a nominal 152 mm diameter 20 and 25-slot stainless steel screen set from 54 to 58.5 mbgl. Well 2 was constructed with a nominal 152 mm diameter steel casing from surface to a depth of 40.5 m with a nominal 152 mm diameter 18 and 20-slot stainless steel screen set from 40.8 to 45.4 mbgl. Well 3 was constructed with a nominal 203 mm diameter telescoping 16-slot stainless steel screen, 7.3 metres in length, and was set between 59.1 and 65.8 mbgl. According to the Permit to Take Water (PTTW) #7520-6LJTGX issued on January 31 2006 and which expires on April 30 2015, the rated capacity for Wells 1 and 2 is of 305 m^3/day, while Well 3 has a rated capacity of 610 m^3/day. The total treatment system capacity shall not exceed the maximum flow rate of 1220 m^3/day.

Well 2 is drilled into the upper part uppermost aquifer which consists of sand to sand and gravel and is locally present between approximately 200 to 215 masl (35 to 50 mbgl). This aquifer is overlain locally by aquitard materials described as clay and sand or clay and gravel (till). It is separated from the underlying aquifer by approximately 4 m of clay or clay till. Wells 1 and 3 are completed in the lower part of the uppermost aquifer and is reported to consist of sand at these locations, although also containing silt and a minor component of clay at Well 3. The recharge area for the aquifers is believed to be located north of the wellfield.

Raw water enters the pumphouse and is treated with 12% Liquid Chlorine. The treated water then goes to a steel-bolted, glass-fused standpipe that is located behind the pumphouse and has a capacity of 534 m^3. Treated water is pumped from the standpipe to the distribution system with two high lift centrifugal pumps. The distribution system consists of 1900 m of 150 mm watermains and services 183 homes and Shanty Bay Public School. A Chlorine Residual Analyzer and Turbidimeter have been installed for continuous monitoring and recording of free chlorine residual and turbidity.

Sugarbush Water Supply

This Sugarbush Water Supply consists of two groundwater production wells (Wells 1 and 2). A third well has been constructed (Well 3), but has not been connected to the distribution system. Well 1 was constructed with a nominal 152 mm diameter steel casing from surface to a depth of 76.2 m with a nominal 152 mm diameter 12 and 10-slot stainless steel screen set from 76.2 to 82.3 mbgl. Well 2 was constructed with a nominal 152 mm diameter steel casing from surface to a depth of 75.2 m, with a nominal 152 mm diameter 20-slot stainless steel screen set from 75.2 to 78.0 mbgl. Well 3 construction details have not yet been provided to us as it was connected to the system only very recently. According to the Permit to Take Water (PTTW) # 1483-5MYQ36, issued in July 2003 and which expires on May 31 2013, the rated capacity for Well 1 is 851 m^3/day and the rated capacities for Well 2 and Well 3 are 1,635 m^3/day each.

The wells are completed in sand aquifer which is present beneath the aquitard over the elevation range of 230 to 248 masl (66 to 84 mbgl) at Well 1 and approximately 10 m lower at Well 2. Another shallow aquifer is present above the municipal aquifer. Both aquifers are believed to pinch out east of the wellfield and may be combined as a single unconfined aquifer to the north. The recharge area is believed to be located to the southeast.

Raw water enters the pumphouse and is treated with 12% Liquid Chlorine. The treated water then goes to a booster station and is pumped up the hill to a two-celled in-ground reservoir with a capacity of approximately 301,000 litres. It is stored in this reservoir and is then gravity-fed through the distribution system. A Chlorine Residual Analyzer and Turbidimeter have been installed for continuous monitoring and recording of free chlorine residual and turbidity. The Sugarbush water distribution system supplies 344 homes with water.

Warminster Water Supply

The Warminster Water Supply has one groundwater production well (Well 1). In 2004 Well 2 was decommissioned and abandoned, and Well 3 has been recently drilled to serve as a backup well for Well 1 since 2008. Well 1 was constructed with a nominal 152 mm diameter 9.1 m long 25 and 30-slot stainless steel screen. Well 3 construction details will be incorporated into the final document. According to the Permit to Take Water (PTTW) #2448-7RBQJA, issued on April 22 2009 and which expires on February 15 2018, the maximum rated capacity for Well 1 is 600 m^3/day. Well 1 is the lead well while Well 3 serves as the back-up well.

The wells are constructed in a confined overburden aquifer. An aquifer (sand) is present over the elevation range of approximately 260 to 270 masl (20 to 30 mbgl) at the abandoned Well 2 which was located within the community, where it is overlain by 15 m of aquitard materials recorded as being clay with sand or gravel (till). The aquifer is interpreted to end approximately 2 km north of Warminster, where ground surface slopes downwards to the north. The aquifer in the vicinity of Well 1 and Well 3 is considered to be distinct from that at the abandoned Well 2. At the abandoned Well 2, the aquifer is present between approximately 235 to 245 masl (17 to 27 mbgl) and is reportedly overlain by 10 m of clay. Recharge for the municipal aquifers is believed to be derived locally.

Raw water enters the pumphouse and is treated with 12% Liquid Chlorine and the treated water then goes to the 136 m3 inground reservoir for a 15 minute contact time. The treated water is pumped into the distribution system with two high lift centrifugal pumps. The water distribution system supplies 204 homes, Warminster Public School, and the Warminster Legion. A Chlorine Residual Analyzer and Turbidimeter have been installed for continuous monitoring and recording of free chlorine residual and turbidity. The distribution system consists of 8826 m of 50 mm and 150 mm watermains. Well 1 is a 150 mm diameter, 27.4 m deep drilled production well, equipped with a submersible deep well pump with a rated capacity of 11.3 L/s. According to the PTTW, Well 1 should not exceed the pumping rate of 600 m^3/day.

Step 1: **Assemble Available Data**

The data sources that were reviewed to identify potential issues included:

- Certificates of Approval (2002-2005);
- Permits to Take Water (2000-2008);
- Engineer's Reports (2001);
- Annual Water Supply Water Quality Monitoring Reports (2003-2007);
- Operator Interview.

Ms. Lisa McNiven, Manager of Engineering and Environmental Services for the Township of Oro-Medonte was interviewed to obtain operator insight into potential issues identified in the published data as well as identifying potential issues that may not have been identified in published data to date.

Step 2: **Review Data and Identify Potential Drinking Water Issues**

A set of tables have been prepared to document a series of potential issues from the raw and treated water at the Township of Oro-Medonte as identified from various data sources. The tables are as follows:

Table Number	Township of Oro-Medonte Water Works	Water Type	Water Source
L1-1	Canterbury	Raw and Treated	Well #1 and Well #2
L1-2	Cedarbrook	Raw and Treated	Well #1 and Well #2
L1-3	Craighurst	Raw and Treated	Well #1, Well #2 and Well #3
L1-4	Harbourwood	Raw and Treated	Well #1 and Well #2
L1-5	Horseshoe Highlands	Raw and Treated	Well #1 and Well #2
L1-6	Maplewood	Raw and Treated	Well #1
L1-7	Medonte Hills	Raw and Treated	Well #1 and Well #2
L1-8	Robincrest	Raw and Treated	Well #1 and Well #2
L1-9	Shanty Bay	Raw and Treated	Well #1, Well #2 and Well #3
L1-10	Sugarbush	Raw and Treated	Well #1 and Well #2
L1-111	Warminster	Raw and Treated	Well #1

The tables are designed to document:

1) The source reports or data that result in the identification of a parameter as a potential Drinking Water Issue;
2) Results of comparison of observed parameter concentrations to relevant benchmarks and situations where:
    a. Parameter concentrations exceed the primary benchmark established by the Ontario Drinking Water Quality Standard (ODWQS);
    b. Parameter concentrations exceed a locally established benchmark value (typically a background concentration);
    c. Parameter concentrations exceed the established method detection limit (MDL) [typically applied for organic chemical parameters];
3) Professional judgment on the reliability of the data based on the number of measurements and the relative consistency of the observed occurrence;
4) The nature of observed trends in parameter concentrations;
5) Input from local System Operators and other Stakeholders as to the significance of the parameter as a Drinking Water Issue;
6) Whether treatment is in place for the observed parameters and its effectiveness; and
7) The nature of the source of the parameter listed as a potential issue.

Trends were determined through graphing municipal water supply system water quality data. Parameters listed on the preliminary list of drinking water threats for each well have been assessed graphically for trends. The available data has been provided between 2001 and 2007. No water quality data was provided for new Well 3 of the Sugarbush Water Supply.

Step 3: **Evaluate Drinking Water Issues**

The L1 series of tables have been developed to identify Drinking Water Issues in accordance with the "Decision Process for Identification and Evaluation of Drinking Water Issues" as presented in Figure A5-1 of "Technical Memorandum A5 - Drinking Water Issues Evaluation Methods".

The positive or negative responses entered in the L1 series of tables correspond to the steps in the decision process. Professional judgment was built into the decision process in the evaluation of data reliability to identify anomalous conditions and in the consideration of operational insights. Trend analysis was used to identify parameters that are projected to exceed the ODWQS within approximately 50 years. The L1 series of tables also allow for the identification of the source of the potential Drinking Water Issue, whether treatment is in place, and its effectiveness.

For each of the water works systems, all of the parameters identified in the L1 tables are not considered to be Drinking Water Issues. Parameters common to most systems in the Township of Oro-Medonte that were removed from consideration include:

- Coliforms are typically absent but can be observed on rare occasions in low numbers. The presence of coliforms in the raw water is not persistent or indicative of deterioration of raw water quality. Disinfection is in place and is effective.
- Concentrations of iron at Cedarbrook, Maplewood and Shanty Bay have occasionally exceeded aesthetic or operational objectives. This parameter is considered to be naturally-occurring and is not likely to result in the deterioration of the water quality for use as a drinking water source.

- Levels of turbidity at Canterbury, Cedarbrook and Horseshoe Highlands occasionally exceeded aesthetic/operational objectives. This parameter is considered to be naturally-occurring and is not likely to result in the deterioration of the water quality for use as a drinking water source.
- Organic nitrogen concentrations occasionally exceed ODWQS aesthetic objectives at Cedarbrook. This parameter is not considered to result in the deterioration of the water quality for use as a drinking water source.
- Concentrations of sodium are consistently less than the ODWQS value of 200 mg/L in the raw and treated water from the Township of Oro-Medonte wells. The sodium concentration data usually displays no discerning trend. Sodium is therefore not considered to be a Drinking Water Issue but should be closely monitored. Concentrations have exceeded 20 mg/L at Cedarbrook, Craighurst and Warminster. Sodium is a concern at 20 mg/L as the Medical Officer of Health is to advise individuals on low-sodium diets. Observed concentrations of sodium are variable and the source has not been confirmed, but is typically related to winter de-icing or septic system effluents from water softeners. Reduction of sodium use in the contributing watershed would be beneficial to the drinking water quality.
- Organic parameters, such as bromodichloromethane, bromoform, chloroform, dibromochloromethane and trihalomethanes, are present in trace concentrations in treated water as byproducts of disinfection by chlorination. Concentrations are typically well below ODWQS values and do not display increasing trends.

Step 4: Identifying Contributing Area for Drinking Water Issues

No parameters were identified as Drinking Water Issues at the Township of Oro-Medonte groundwater wells.

Step 5: Prepare List of Drinking Water Issues

No parameters were identified as Drinking Water Issues at the Township of Oro-Medonte groundwater wells.

LAL/SJD:lnc

Table L1-1 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Canterbury
Drinking Water Source: Well #1 and #2 - raw and treated
Issues Review Date: June 18 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability							Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
													Confirm Presence																	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y				Y	Y	Y							Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochlromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Turbidity			Y						Y			Y				Y	N	Y	Y		Y		N	N	NO	Y				

Table L1-2 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Cedarbrook
Drinking Water Source: Well #1 and #2 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability	Confirm Presence						Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y					Y	Y			Y				Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Iron							Y		Y			Y			Y		N	Y	Y			Y	N	N	NO	Y				
Organic Nitrogen							Y		Y			Y			Y		N	Y	Y			Y	N	N	NO			Y		
Sodium					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO			Y		
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Turbidity			Y						Y			Y			Y		N	Y	Y		Y		N	N	NO	Y				

Table L1-3 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Craighurst
Drinking Water Source: Well #1, #2 and #3 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability							Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
													Confirm Presence																	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y				Y		Y			Y				Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Sodium					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO			Y		
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			

Table L1-4 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Harbourwood
Drinking Water Source: Well #1 and #2 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability							Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
													Confirm Presence																	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y				Y	Y	Y			Y				Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Trihalomethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			

Table L1-5 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Horseshoe Highlands
Drinking Water Source: Well #1 and #2 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability	Confirm Presence						Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y				Y	Y	Y			Y				Y	Y	N	Y		Y		N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Turbidity			Y						Y			Y			Y		N	Y	Y			Y	N	N	NO	Y				

Table L1-6 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Maplewood
Drinking Water Source: Well #1 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability	Confirm Presence						Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y					Y	Y			Y				Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Iron			Y						Y			Y			Y		N	Y	Y			Y	N	N	NO	Y				
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			

Table L1-7 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Medonte Hills
Drinking Water Source: Well #1 and #2 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability	Confirm Presence						Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y				Y	Y	Y			Y				Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO	Y	Y			

Table L1-8 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Robincrest
Drinking Water Source: Well #1 and #2 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability							Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
													Confirm Presence																	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y					Y	Y			Y				Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N				Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			

Table L1-9 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Shanty Bay
Drinking Water Source: Well #1, #2 and #3 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability							Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
													Confirm Presence																	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y				Y	Y	Y			Y				Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO			Y		
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO			Y		
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO			Y		
Dibromochloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO			Y		
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO			Y		

Table L1-10 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Sugarbush
Drinking Water Source: Well #1 and #2 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

Parameter	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability	Confirm Presence						Evaluate Trends					Operational Consideration	Drinking Water Issue	Source of Issue			Treatment	
	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years			Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms							Y	Y	Y			Y				Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			

Table L1-11 **Evaluation of Drinking Water Issues**

Municipality: Township of Oro-Medonte
Community: Warminster
Drinking Water Source: Well #1 - raw and treated
Issues Review Date: June 18, 2009

Information Sources:
Watershed Characterization:
Annual Water Quality Reports: 2001-2007
Interview (person/title/date): Lisa McNiven / Manager of Engineering and Environmental Services / August 31 2009

	Identified From							Compare Water Quality Data to Benchmarks				Confirm Data Reliability							Evaluate Trends							Source of Issue			Treatment	
													Confirm Presence																	
Parameter	Watershed Characterization	Operator Interview	Annual Water Quality Reports	Raw Water Quality Data	Treated Water Quality Data	PGMN Data	Other	Raw Water Quality Exceeds ODWQS	Treated Water Quality Exceeds ODWQS	Above Detection Limit	Above Local Background	Sufficent Data	Persistent (Always, <90%)	Majority of Tests (40-90%)	Occasionally (5 - 40%)	Rarely (<5%)	Anomalous Circumstance	Data Reliable	Trend Reviewed	Increasing	Reducing	Constant/Uncertain	Will Exceed ODWQS within 50 Years	Operational Consideration	Drinking Water Issue	Natural	Threat (Known)	Threat (Unknown)	In Place	Effective Mitigation
Pathogens																														
Coliforms			Y				Y	Y	Y							Y	Y	N	Y			Y	N	N	NO			Y	Y	Y
Chemicals																														
Bromodichloromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Bromoform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Chloroform					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Dibromochlromethane					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			
Sodium					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO			Y		
Trihalomethanes					Y					Y		Y	Y				N	Y	Y			Y	N	N	NO		Y			

July 29, 2010

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Attention: Mr. Don Goodyear, Source Protection Manager

WHPA Peer Review Report

Dear Mr. Goodyear:

Dillon Consulting Limited (Dillon) was retained by the Lake Simcoe Region Conservation Authority (LSRCA) to conducted Peer Reviews of well head protection area (WHPA) mapping for 86 municipal groundwater systems. These systems are located in the South Georgian Bay Lake Simcoe Source Protection Region. External management of the project was conducted by Mr. Dave Ketcheson, P.Eng of Azimuth Environmental Consulting Inc. The results of the peer review are issued in the form of digital spreadsheet files that are attached to this letter. The project scope and peer review methodology is summarized in the letter herein.

PROJECT SCOPE

LSRCA retained Dillon to conduct a 'high level' peer review of the WHPAs that were largely delineated as part of previous WHPA or regional groundwater studies, at a time prior to the finalization of the Director Rules. In general, WHPA delineation was based on an assortment of different model types, including fixed radius, 2-D analytical solutions and numerical 3-D flow modeling. In general, more sophisticated models were applied to those systems where more data was available. The focus of the peer review was on whether the methodologies were consistent with those outlined in the Directors Rules, rather than a more traditional technical modeling critique. Evaluations also identified critical issues or deficiencies that would have implications on subsequent steps in the source protection process, so that these may be addressed as part of the Assessment Report. The review also identify long-term opportunities for improvement in subsequent rounds of the process, recognizing the various levels of effort applied in WHPA delineation across the region (i.e., analytical vs. numerical methods), and the availability of data in the various WHPA settings.

Peer reviewers were Rob Kell, M.A.Sc., P.Eng, P.Geo.; Jeff Hachey, M.Sc. and Darin Burr, M.Sc. P.Geo, all hydrogeologists with Dillon.

...continued

Evaluation of the WHPAs was performed in a systematic fashion following a "score card" approach. The score card contained both objective and subjective criteria that were evaluated for each system. This template approach enabled reviewers to maintain a level of consistency during the reviews, and was suited to the "high level" nature of the evaluation. The criteria that were evaluated is listed below:

Objective Criteria	**Subjective Criteria**
Was modeled pumping rate appropriate?	Complexity of geological Setting
Were approved models and methods used?	Appropriateness of Flow Model
	Reasonableness of input parameters
	Adequate incorporation of natural flow field
	Model Calibration
	Incorporation of Uncertainty

For each criterion, a score between 1 and 10 was awarded. In general, a score <5 for any of the criteria would be given if a critical concern was identified that would either significantly affect the reliability of the WHPAs, or is a contravention of the elements of the Directors Rules. An exception for this rule would be the evaluation of the uncertainty criterion. Failure to adequately incorporate uncertainty into the model results was not deemed a requirement of the Director Rules and therefore would not necessarily cause the system to "fail". Details on conditions that would cause an unacceptable evaluation at the criteria level are presented in the score card sheets.

All systems were given a "pass", "fail" or "conditional pass" result, depending upon the analysis results. A "pass" ranking was given for those systems were the methodology was generally consistent with the Director Rules, and no critical deficiencies were noted. A "conditional pass" was granted, where the potential for considerable uncertainty in the results existed, but either little data was available to improve the accuracy of the results, or it was the reviewer's opinion that the uncertainty on the results would not significantly alter the enumeration of land parcels that may contain significant threats.

...continued

Following criteria scoring, the individual scores were weighted, and summed to produce an overall system score (between 1 and 10) for the WHPA delineation. Higher the score, the more favorable are the results of the evaluation. Please note that this scoring is a relative ranking between the systems, and is not to be interpreted as any type of marking. For example, a score of 6 does not mean a 60% mark, but rather is a system whose delineated WHPAs are deemed more conservatively robust (in lieu of available data) than a system that receives a score of 5. Theoretically, a system evaluated via fixed radius that is very conservative could receive a higher system score than a detailed numerical model result that is not conservative, as the risk of under-representing the area where significant threats may be lower.

RESULTS

The results of the evaluation are presented on digital Excel™ spreadsheets for each system, and are grouped by township or separated municipality name. Rationale for the individual criteria evaluations, along with the criterion scores, overall system scores and recommendations for future improvement are presented on the individual sheets.

LIMITATIONS

This report was prepared exclusively for the purposes, project and site location(s) outlined in the report. The report is based on information provided to, or obtained by Dillon Consulting Limited ("Dillon") as indicated in the report, and applies solely to site conditions existing at the time of the assessment. Although a reasonable assessment was conducted by Dillon, Dillon's assessment was by no means exhaustive and can not be construed as a certification or acceptance of the reviewed reports. Rather, Dillon's report represents a reasonable review of available information within an agreed work scope, schedule and budget. Further review and updating of the peer review reports will be required as local and site conditions, and the regulatory and planning frameworks, change over time.

This report was prepared by Dillon for the sole benefit of our Client. The material in it reflects Dillon's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

...continued

CLOSURE

We appreciate the opportunity to work with LSCRCA on this assignment. If you have any questions about this report, please contact the undersigned.

Yours sincerely,

DILLON CONSULTING LIMITED

Darin Burr, M.Sc., P.Geo.
Project Manager

DTB:amb
Encl.

Table 1: HORSESHOE HIGHLANDS - WELL HEAD TIME OF TRAVEL CAPTURE ZONE PEER REVIEW EVALUATION RESULTS

GENERAL

System Name:	**Horseshow Highlands**
Reviewed Report:	**Groundwater Flow Model and Capture Zone Development-Horseshoe Highlands Well#1 and Well#2, Golder 2010; North Simcoe Groundwater Study WHPA - Township of Oro-Medonte, Appendix F, Golder, May 2005.**
Terms of Reference:	**Ontario Ministry of the Environment and Energy, 2001; Groundwater Studies, 2001/2002, Technical Terms of Reference, November 2001.**
Model Type:	**Local 3-D Modflow**
Score:	**7.4**
Pass:	**Yes**

System Characteristics

Hydrogeological Complexity	Medium - confined deep overburden aquifer. Confining layer spatially discontinuous in lowland areas
Spatial variability in Aquifer Vulnerability	Medium, partially confined (discontinuous).
Known water Quality Issues	Some-Nitrate has been detected in water samples (Golder, 2005) below the ODWS.

EVALUATION RESULTS

Criterion	Awarded Scored	General Comments	Comments / Recommendations: Critical Deficiencies	Comments / Recommendations: Long-term opportunities
Objective Criteria				
1. Were reasonable pumping rates used and documented?	8	The Horseshoe Highlands water supply currently services approximately 400 residential dwellings. The municipal water supply system is comprised of two wells, Well #1 (MOE #5723788) and Well #2 (MOE #5721850), located on the south side of Horseshoe Valley Road. Well #1 provides day-to-day water supply, while Well #2 is designated as a stand-by well. Based on Golder (2010), the current daily maximum and average day demands met by the wellfield are 1,103 m3/day and 446 m3/day respectively. In developing time-of-travel capture zones for Well#1, the expected future average daily demand was used (842 m/day). In order to account for the potential future use of Well #2 as a standby water supply, and to incorporate this well as part of the Well #1 capture zone, a rate of one third the maximum daily pumping for this well was used (537/3= 176 m3/day). It is unclear why a flowrate equal to 1/3 of the maximum allowable daily taking was used for this well, and seems somewhat arbitrary. Regardless, flowrate is deemed acceptable as it is the lesser of planned or permitted rates.	None	Should pumping regime change, then model should be updated.
2. Were rule-approved models and methods used?	Pass	3-D Analytical Solution is permissible	None	Perform continuous updating and verification/validation of the model data.
Subjective Criteria				
3a. Is geological setting complex?	7	Medium complexity - The production wells for Horseshoe Highlands water supply are drilled into the Oro Moraine, a major feature in the Simcoe Uplands. The Oro Moraine is a confined overburden aquifer (Aquifer A2). A considerable portion of the model is overlain by a relatively low hydraulic conductivity mix of surficial material known as the Upper Confining Layer (UC). Below the UC, and often appearing at surface where UC thins out, is the semi-confined sand and gravel aquifer A1. Underlying A1 is the regional and largely continuous clayey confining layer C1. Below C1 lies the regionally extensive sand and gravel Aquifer A2. Again, A2 is the key aquifer system in the model, as the water supply wells are screened in this unit.	None	
3b. Is Geological Model / Understanding Adequate for assessment method selected?	7	Wellfield is located in a confined overburden aquifer (Aquifer A2). A considerable portion of the model is overlain by a relatively low hydraulic conductivity material. Hydraulic conductivity distribution based on cross-sections developed for the area, and is spatially variable based on presence/absence of overburden in model domain. Hydrogeological system (flow fields) may be slightly more predictable due to the presence of groundwater flow divide on southern edge of model domain. It is noted that lateral inflow from area in the southern portion of the model was included, despite that this inflow is not known to exist from direct field measurements (i.e. presumed). The addition of this inflow did improve model calibration, however some basis for its addition (i.e. justification) may be beneficial.	None	Improve geological model by additional borehole construction, and incorporation of more site specific data from within the area of the wellfield. Justification and/or direct measure confirmation for addition on constant head inflow in southern portion of the model may be warranted.

4. Is Flow Model Complexity Appropriate?	8	Yes - locally scaled 3D numerical flow model used (MODFLOW), model is deemed adequate. There seems to be a good number of calibration wells across the model domain, however a figure showing distribution of calibration points may be appropriate to ensure that the calibration point distribution is appropriate. Information obtained from MOE WWR was QA/QC'd and filtered for increased model accuracy. Site specific information (e.g. results from production well pumping tests) have been checked against calibrated conductivity values. Large PTTW wells which fell within the model domain, to increase accuracy of modeling. It is noted that the capture zones developed as part of the 2010 modelling, are similar shape to those developed in 2005 (Golder, 2005).	None	Additional monitoring wells positioned upgradient of well field would be beneficial to validate model. Some information regarding the potential vertical gradients between aquifer A2 and the upper confining unit may be appropriate, to ensure that aquifer A2 is adequately protected from potential anthropogenic contamination sources (locally). If any other large PTTW wells become active within model domain, model should incorporate these and be re-run/re-evaluated.
5. Are model input parameters (recharge, porosity, K) reasonable?	8	Generally yes - Although detailed information regarding aquifer properties in the vicinity of the Horseshoe Highlands wellfield was relatively scarce and in some cases (e.g. hydraulic conductivities of different hydrogeologic units) professional judgment was needed. Previously conducted pumping tests at each production well (Well #1, and Well#2) were consulted, and in used to obtain best estimates for aquifer hydraulic properties. All other input parameters are deemed acceptable.	None	Additional field work would improve estimates. Ideally, hydraulic properties obtained from recent pumping tests could be used to better approximate capture zones from municipal wells.
6. Was natural flow field adequately incorporated into model? (Numerical Model)	8	Yes - observed head values (from MOE wells and other wells in the area) and natural flow field were used to calibrate the model, boundary conditions appear acceptable. It is noted that streams within the model limits were assigned as "drain" boundary conditions. Although common practice, streams within the model domain could be simulated using the "stream" boundary condition within MODFLOW. There are 4 different levels of recharge incorporated into the model, ranging from 100 to 350 mm/yr, depending one topography and overburden geology. As noted above, all other boundary conditions are deemed acceptable. Also, it is noted that different boundary conditions appear in different model layers. Some rationale for this may be appropriate.	None	Further validation for assigning drain, and constant head boundaries to major surface water features could be discussed. It is unclear if boundary conditions were adjusted in model calibration.
7. Was natural flow field adequately incorporated into model? (Analytical Model)				
8. Was the Model Calibrated?	7	Yes- Water level and screen information from the MOE database, were used to establish groundwater elevation targets for the numerical model. The information obtained from the MOE WWR was reviewed prior to model import. Select calibration statistics are found in report (Golder, 2010), however notable statistics include a model RMS of 5.2%, which is acceptable (generally RMS values <10% are deemed acceptable), absolute residual mean of 5.7 m, and a residual mean of 1.7 m. Golder (2010) indicates that the primary calibration parameters used were hydraulic conductivity and recharge. It is unclear if boundary conditions (particularly constant head boundary conditions) were adjusted during model calibration. Overall, model is deemed to be calibrated appropriately.	None	Model was calibrated to the local hydrogeological system, and results of calibration process are presented. Calibration to gauged streams in the area (baseflow measurements) could provide an alternate calibration technique (assuming gauged streams are present in the model domain), which may lead to additional confidence in model results. Any updated information for the area could be incorporated into the flow model.
9. Was Uncertainty considered in the analysis?	6	Limited uncertainty analysis, performed by using "shape factors" which increase the length and width of capture zones by 20%, which may be arbitrary. Also the orientation of capture zones was adjusted by 5% about the centreline to account for uncertainty in flow direction. A more classical approach to uncertainty/sensitivity could be performed (and is preferred), by varying recharge, and hydraulic conductivity/porosity to create "composite capture zones".	None	Discussion of sensitivity of model on boundary conditions (constant head, drain, etc.) could be included. Result of sensitivity analysis could be incorporated into capture zones to create "composite" capture zones.
10. What is the Uncertainty?	High	Designation not provided in report, but Dillon recommends that it be assessed as high	None	

Table 2: MEDONTE HILLS - WELL HEAD TIME OF TRAVEL CAPTURE ZONE PEER REVIEW EVALUATION RESULTS

GENERAL

System Name:	**Medonte Hills - Moonstone**
Reviewed Report:	**North Simcoe Groundwater Study, WHPA-Township of Oro-Medonte, Appendix F**
Terms of Reference:	**Ontario Ministry of the Environment and Energy, 2001; Groundwater Studies, 2001/2002, Technical Terms of Reference, November 2001.**
Model Type:	**US EPA WhAEM2000**
Score:	**6.7**
Pass:	**Yes**
Critique Ref:	**Sent to Client_Peer Review Score Card Results_043010_1**

System Characteristics

Hydrogeological Complexity	Low, confined overburden aquifer within estimated ZOI
Spatial variability in Aquifer Vulnerability	Low
Known water Quality Issues	None

EVALUATION RESULTS

Criterion		Awarded Score	General Comments	Comments / Recommendations	
				Critical Deficiencies	Long-term opportunities
Objective Criteria					
1. Were reasonable pumping rates used and documented?		7	Both wells are within 15 m of each other, with a PTTW average of 164 m3/day, and 2001 average usage of 34 m3/day. The wells were modeled as a single well at a rate of 164 m3/day, which is the average yield listed in the PTTW, and is well above the 2001 average day usage. However, modelled rate is <30% of permitted max. No documentation of planned service. A higher score would be given if documentation was present	None	Determine committed population requirements to ensure that it is within permitted rate. Confirm with municipality that modelled rates represent likely conditions. Should pumping regime change, then model should be updated.
2. Were rule-approved models and methods used?		Pass	2-D Analytical Solution is permitted by technical rules	None	Perform continuous updating and verification of the model data
Subjective Criteria					
3a. Is geological setting complex?	10	8	Low to medium complexity. Aquifer is well confined, with an estimated aquitard thickness of 15 m. Pumped aquifer is the regional A3 aquifer.	None	
3b. Is Geological Model / Understanding Adequate for assessment method selected?	10	5	Model based primarily on water well records and geological mapping. Few high quality data points available. Confined nature of system and low pumping rate allows a simple conceptual model to be adequate	None	
4. Is Flow Model Complexity Appropriate?	10	5	Yes - 2D analytical flow model used, however, considering predictable groundwater flow direction, and confined nature of aquifer, model is deemed adequate. The 2-D solution does not take into account interference between the Medonte and nearby Robincrest systems; however, it appears that the approach was conservative, in that the modelled rates for both systems were much higher than current usage. Nevertheless, a lower score is given as a result of possible well interference effects	None	Should higher pumping rates be required in the future, a more detailed numerical model is warranted
5. Are model input parameters (recharge, porosity, K) reasonable?	5	8	Generally yes - K values are based on pumping tests, and porosity is reasonable. Recharge is 100 mm, which is deemed conservative.	None	

6. Was natural flow field adequately incorporated into model? (Numerical Model)	10	N/A		None	
7. Was natural flow field adequately incorporated into model? (Analytical Model)	10	8	Generally Yes - Analytical model results use natural flow field as input, and takes into account variation in gradient direction. The accuracy of this model type is highly dependant on correctly mapping gradient directions. No boundary condition effects applicable for this model solution. The well field is located along the side of a hill, with dominant up-slope topography to west, therefore upgradient directions are more predictable.	None	Confirm gradient direction in the pumped aquifer via water level survey of wells that intercept this aquifer. The construction of additional water level monitoring wells may be required
8. Was the Model Calibrated?	5	7	2-D Analytical model cannot be calibrated; however, actual data (potentiometric surface) is used in analysis.	None	
9. Was Uncertainty considered in the analysis?	5	7	Uncertainty analysis was applied to each capture zone through the application of shape factors	None	
10. What is the Uncertainty?		High	Designation not provided in report, but Dillon recommends that it be assessed as high	None	

WELL HEAD TIME OF TRAVEL CAPTURE ZONE PEER REVIEW EVALUATION TEMPLATE

GENERAL

System Name:	**Robincrest**
Reviewed Report:	**North Simcoe Groundwater Study, WHPA-Township of Oro-Medonte, Appendix F; Oro-Medonte Capture Zone and Equipotential Surface Review, 2010**
Terms of Reference:	**Ontario Ministry of the Environment and Energy, 2001; Groundwater Studies, 2001/2002, Technical Terms of Reference, November 2001.**
Model Type:	**US EPA WhAEM2000**
Score:	**6.2**
Pass:	**Conditional Pass**
Critique Ref:	**Sent to Client_Peer Review Score Card Results_090810_1**

System Characteristics

Hydrogeological Complexity	Low, confined overburden aquifer within estimated ZOI
Spatial variability in Aquifer Vulnerability	Low
Known water Quality Issues	None (elevated nitrate (4.3 mg/L), but <ODWS).

EVALUATION RESULTS

Criterion		Awarded Score	General Comments	Comments / Recommendations: Critical Deficiencies	Comments / Recommendations: Long-term opportunities
Objective Criteria					
1. Were reasonable pumping rates used and documented?		7	Both wells are within 30 m of each other, with a PTTW max of 851 m3/day (Well 2), PTTW average of 545 m3/day, and 2001 average usage of 103 m3/day (total of both wells). The wells were modeled as a single well at a rate of 425 m3/day, which is well above the 2001 average day usage, but below the PTTW average and max. No documentation of planned service. A higher score would be given if documentation was present	None	Determine committed population requirements to ensure that it is within permitted rate. Confirm with municipality that modelled rates represent likely conditions. Should pumping regime change, then model should be updated.
2. Were rule-approved models and methods used?		Pass	2-D Analytical Solution is permitted by technical rules	None	Perform continuous updating and verification of the model data
Subjective Criteria					
3a. Is geological setting complex?	10	8	Low to medium complexity. Aquifer is well confined, with an estimated aquitard thickness of 15 m. Pumped aquifer is the regional A3 aquifer.	None	
3b. Is Geological Model / Understanding Adequate for assessment method selected?	10	5	Model based primarily on water well records and geological mapping. Few high quality data points available. Confined nature of system and low pumping rate allows a simple conceptual model to be adequate	None	
4. Is Flow Model Complexity Appropriate?	10	5	2D analytical flow model used. The 2-D solution does not take into account potential interference between the Medonte and nearby Robincrest systems; however, it appears that the approach was conservative, in that the modelled rates for both systems were much higher than current usage. Capture zones are consistent with contoured water level data for the pumped aquifer; however, little water level appears upgradient of well	Yes	Confirm potentiometric surface elevation in pumped aquifer, especially upgradient of well field. This system could benefit from a more detailed model that can be calibrated to natural flow field.
5. Are model input parameters (recharge, porosity, K) reasonable?	5	8	Generally yes - K values are based on pumping tests, and porosity is reasonable. Recharge is 100 mm, which is deemed conservative.	None	

6. Was natural flow field adequately incorporated into model? (Numerical Model)	10	N/A		None	
7. Was natural flow field adequately incorporated into model? (Analytical Model)	10	5	The accuracy of this model type is highly dependant on correctly mapping gradient directions. Since the well field is near the top of the crest in the potentimetric surface, there is high uncertainty in the interpreted upgradient direction. No boundary condition effects applicable for this model solution. Overall, gets a lower score than nearby Medonte Hills where the gradient is more predictable.	Yes	Confirm gradient direction in the pumped aquifer via water level survey of wells that intercept this aquifer. The construction of additional water level monitoring wells may be required
8. Was the Model Calibrated?	5	7	2-D Analytical model cannot be calibrated; however, actual data (potentiometric surface) is used in analysis.	None	
9. Was Uncertainty considered in the analysis?	5	7	Uncertainty analysis was applied to each capture zone through the application of shape factors	None	
10. What is the Uncertainty?		High	Designation not provided in report, but Dillon recommends that it be assessed as high	None	

Table 4: SUGARBUSH - WELL HEAD TIME OF TRAVEL CAPTURE ZONE PEER REVIEW EVALUATION RESULTS

GENERAL

System Name:	**Sugarbush**
Reviewed Report:	**Groundwater Flow Model and Capture Zone Development-Sugarbush Municipal Supply Wells, Golder 2010; North Simcoe Groundwater Study WHPA - Township of Oro-Medonte, Appendix F, Golder, May 2005.**
Terms of Reference:	**Ontario Ministry of the Environment and Energy, 2001; Groundwater Studies, 2001/2002, Technical Terms of Reference, November 2001.**
Model Type:	**Local 3-D Modflow**
Score:	**7.2**
Pass:	**Yes**

System Characteristics

Hydrogeological Complexity	Medium - confined deep overburden aquifer. Confining layer spatially discontinuous in lowland areas
Spatial variability in Aquifer Vulnerability	Medium, partially confined (discontinuous).
Known water Quality Issues	Some-Nitrate has been detected in water samples (Golder, 2005) below the ODWS.

EVALUATION RESULTS

Criterion	Awarded Scored	General Comments	Comments / Recommendations: Critical Deficiencies	Comments / Recommendations: Long-term opportunities
Objective Criteria				
1. Were reasonable pumping rates used and documented?	10	The community of Sugarbush (located in the central part of the Township of Oro-Medonte) is serviced by a municipal water supply system comprised of three wells; Well #1 (MOE #5735626), Well #2 (MOE #5710941) and Well #3 (MOE #5737335). Based on 2007 and 2008 data, the system currently services approximately 350 residential dwellings, resulting in an average water taking of approximately 257 m3/d. The future average day demand for the Sugarbush supply wells is estimated at approximately 600 m3/day; based on a forecast average day demand of 346 m3/day established by others for the Diamond Valley Estates subdivision (which is in addition to the current pumping required to supply the Sugarbush / Forest Heights subdivision). Based on Golder (2010), capture zones developed for the supply wells were based on a combined pumping rate of 900 m3/day following discussion with the Township of Oro-Medonte (e-mail from Lisa McNiven, January 11, 2010). This will provide a conservative estimate of the capture zone for the Sugarbush wells, as this rate is approximately 50% larger than the future expected average day demand. This demand is deemed adequate.	None	Should pumping regime change, then model should be updated.
2. Were rule-approved models and methods used?	Pass	3-D Analytical Solution is permissible	None	Perform continuous updating and verification/validation of the model data.
Subjective Criteria				
3a. Is geological setting complex?	7	Medium complexity - Similarly to the Horseshoe Highlands water supply, the Sugarbush water supply wells are drilled into the Oro Moraine, a major feature in the Simcoe Uplands. The Oro Moraine is a confined overburden aquifer (Aquifer A2). A considerable portion of the model is overlain by a relatively low hydraulic conductivity mix of surficial material known as the Upper Confining Layer (UC). Below the UC, and often appearing at surface where UC thins out, is the semi-confined sand and gravel aquifer A1. Underlying A1 is the regional and largely continuous clayey confining layer C1. Below C1 lies the regionally extensive sand and gravel Aquifer A2. Again, A2 is the key aquifer system in the model, as the water supply wells are screened in this unit.	None	
3b. Is Geological Model / Understanding Adequate for assessment method selected?	7	Wellfield is located in a confined overburden aquifer (Aquifer A2). A considerable portion of the model is overlain by a relatively low hydraulic conductivity material. Hydraulic conductivity distribution based on cross-sections developed for the area, and is spatially variable based on presence/absence of overburden in model domain. Hydrogeological system (flow fields) may be slightly more predictable due to the presence of groundwater flow divide on southern edge of model domain (flow will generally be from south to north, based on inferred groundwater elevation map for aquifer A2). It is noted that a constant head boundary condition was used in the northern section of the model to represent groundwater discharge to tributary streams. The assumption that the northern portion of the model domain acts as a large groundwater sink could be verified, as this feature dictates groundwater flow in the model.	None	Improve geological model by additional borehole construction, and incorporation of more site specific data from within the area of the wellfield. Justification and/or direct measure confirmation for addition on constant head outflow in northern portion of the model may be warranted.

4. Is Flow Model Complexity Appropriate?	8	Yes - locally scaled 3D numerical flow model used (MODFLOW), model is deemed adequate. There seems to be a good number of calibration wells across the model domain, however a figure showing distribution of calibration points may be appropriate to ensure that the calibration point distribution is appropriate. Information obtained from MOE WWR was QA/QC'd and filtered for increased model accuracy. Site specific information (e.g. results from production well pumping tests) have been checked against calibrated conductivity values. It is noted that newest capture zones are oriented approximately 10-15 degrees further south than those developed using 2-D methods in 2005 (Golder, 2005), despite applying the 20% shape factors to the newest capture zones.	None	Additional monitoring wells positioned upgradient of well field would be beneficial to validate model. Some information regarding the potential vertical gradients between aquifer A2 and the upper confining unit may be appropriate, to ensure that aquifer A2 is adequately protected from potential anthropogenic contamination sources (locally). It is unclear if any other large PTTW wells are actively pumping aquifer A2 within model domain, however if any are identified, model should incorporate these and be re-run/re-evaluated. Also, land use practices within the new capture zone areas
5. Are model input parameters (recharge, porosity, K) reasonable?	8	Generally yes - Pumping test data was used to estimate the hydraulic characteristics of the primary aquifer in the area (A2). Detailed information regarding hydraulic properties of other hydrostratigraphic units was relatively scarce and in these cases, professional judgment was needed. Previously conducted pumping tests at production well# 3 were consulted, and used to obtain best estimates for aquifer hydraulic properties. All other input parameters are deemed acceptable.	None	Additional field work would improve estimates. Ideally, hydraulic properties obtained from recent pumping tests could be used to better approximate capture zones from municipal wells. Also, information relating to the hydraulic characteristics of other geological units would be preferred to assigning published values for the medium.
6. Was natural flow field adequately incorporated into model? (Numerical Model)	7	Yes - observed head values (from MOE wells and other wells in the area) and natural flow field were used to calibrate the model, boundary conditions appear acceptable. It is noted that streams within the model limits were assigned as "drain" boundary conditions. Although common practice, streams within the model domain could be simulated using the "stream" boundary condition within MODFLOW. There are 4 different levels of recharge incorporated into the model, ranging from 100 to 350 mm/yr, depending one topography and overburden geology. As noted above, all other boundary conditions are deemed acceptable. Also, it is noted that different boundary conditions appear in different model layers. Some rationale for this may be appropriate, although it is assumed that this is based on DEM data. Finally, as noted above, there is a constant head boundary assigned in the northern portion of the model domain. It may be more appropriate to assign this as a "general head" boundary within the MODFLOW GUI.	None	Further validation for assigning drain, and constant head boundaries to major surface water features could be discussed. It is unclear if boundary conditions were adjusted in model calibration.
7. Was natural flow field adequately incorporated into model? (Analytical Model)				
8. Was the Model Calibrated?	7	Yes- Water level and screen information from the MOE database, were used to establish groundwater elevation targets for the numerical model. The information obtained from the MOE WWR was reviewed prior to model import. Select calibration statistics are found in report (Golder, 2010), however notable statistics include a model RMS of 8.0%, which is acceptable (generally RMS values <10% are deemed acceptable), absolute residual mean of 4.2 m, and a residual mean of 1.6 m. Golder (2010) indicates that the primary calibration parameters used were hydraulic conductivity and recharge. It is unclear if boundary conditions (particularly constant head boundary conditions) were adjusted during model calibration. Overall, model is deemed to be calibrated appropriately.	None	Model was calibrated to the local hydrogeological system, and results of calibration process are presented. Calibration to gauged streams in the area (baseflow measurements) could provide an alternate calibration technique (assuming gauged streams are present in the model domain), which may lead to additional confidence in model results. Any updated information for the area could be incorporated into the flow model.
9. Was Uncertainty considered in the analysis?	6 High	Limited uncertainty analysis, performed by using "shape factors" which increase the length and width of capture zones by 20%, which may be arbitrary. Also the orientation of capture zones was adjusted by 5% about the centreline to account for uncertainty in flow direction. A more classical approach to uncertainty/sensitivity could be performed (and is preferred), by varying recharge, and hydraulic conductivity/porosity to create "composite capture zones".	None	Discussion of sensitivity of model on boundary conditions (constant head, drain, etc.) could be included. Results of sensitivity analysis could be incorporated into capture zones to create "composite" capture zones.
10. What is the Uncertainty?	Medium	Designation not provided in report, but Dillon recommends that it be assessed as high	None	

Table 5: WARMINSTER - WELL HEAD TIME OF TRAVEL CAPTURE ZONE PEER REVIEW EVALUATION RESULTS

GENERAL

System Name:	**Warminster**
Reviewed Report:	**Groundwater Flow Model and Capture Zone Development-Warminster Well#1 and Well#3, Golder 2010; North Simcoe Groundwater Study WHPA - Township of Oro-Medonte, Appendix F, Golder, May 2005**
Terms of Reference:	**Ontario Ministry of the Environment and Energy, 2001; Groundwater Studies, 2001/2002, Technical Terms of Reference, November 2001.**
Model Type:	**Local 3-D Modflow**
Score:	**7.4**
Pass:	**Yes**

System Characteristics

Hydrogeological Complexity	Medium - confined deep overburden aquifer. Confining layer spatially discontinuous in lowland areas
Spatial variability in Aquifer Vulnerability	Medium, partially confined (discontinuous).
Known water Quality Issues	Some-Organic Nitrogen has been detected in water samples (Golder, 2005) and above the ODWS (Operational Guideline). Also, nitrate has been detected in water samples (Golder, 2005), however below the ODWS.

EVALUATION RESULTS

Criterion	Awarded Scored	General Comments	Comments / Recommendations: Critical Deficiencies	Comments / Recommendations: Long-term opportunities
Objective Criteria				
1. Were reasonable pumping rates used and documented?	10	Warminster has a population of over 600 persons and is entirely dependent upon groundwater for its water supply. Warminster currently obtains its water from Warminster Well 1 (MOE #5708757). An alternate supply well (Warminster Well 3; MOE #DHL0321) has been constructed but has not yet been commissioned. Both wells are located southeast of the Warminster Sideroad -Town Line intersection. Based on 2007 data, the daily maximum and average water takings for the Warminster supply system are 631 m3/d and 233 m3/d, respectively (Golder, 2007). Although it has been determined that Well No. 1 is sufficient to meet the future water supply demands, Well No. 3 (MOE #DHL0321) has been constructed to act as an alternate supply well, and will not operate in tandem with Well No. 1. For the steady state calibration of the groundwater model, the current average daily demand of 233 m3/d was used. However, in developing the time-of-travel capture zones at Wells 1 and 3, the expected future average daily demand of 320 m3/d was used. The flowrate is deemed adequate, as it is the larger of planned and permitted rates.	None	Should pumping regime change, then model should be updated.
2. Were rule-approved models and methods used?	Pass	3-D Analytical Solution is permissible	None	Perform continuous updating and verification/validation of the model data.
Subjective Criteria				
3a. Is geological setting complex?	7	Medium complexity - The production wells for the Warminster water supply are drilled into a confined overburden aquifer (Aquifer A2). A considerable portion of the model is overlain by a relatively low hydraulic conductivity mix of surficial material known as the Upper Confining Layer (UC). Below the UC, and often appearing at surface where UC thins out, is the semi-confined sand and gravel aquifer A1. Underlying A1 is the regional and largely continuous clayey confining layer C1. Below C1 lies the regionally extensive sand and gravel Aquifer A2. Again, A2 is the key aquifer system in the model, as the water supply wells are screened in this unit.	None	
3b. Is Geological Model / Understanding Adequate for assessment method selected?	7	Wellfield is located in a confined overburden aquifer (Aquifer A2). A considerable portion of the model is overlain by a relatively low hydraulic conductivity material. Hydraulic conductivity distribution based on cross-sections developed for the area, and is spatially variable based on presence/absence of overburden in model domain. Hydrogeological system (flow fields) may be slightly more predictable due to the presence of groundwater flow divide on western edge of model domain.	None	Improve geological model by additional borehole construction, and incorporation of more site specific data from within the area of the wellfield.

4. Is Flow Model Complexity Appropriate?	8	Yes - locally scaled 3D numerical flow model used (MODFLOW), model is deemed adequate. There seems to be a good number of calibration wells across the model domain, however a figure showing distribution of calibration points may be appropriate to ensure that the calibration point distribution is appropriate. Information obtained from MOE WWR was QA/QC'd and filtered for increased model accuracy. Site specific information (e.g. results from production well pumping tests) have been checked against calibrated conductivity values. It is noted that the capture zones developed as part of the 2010 modelling, are similar shape to those developed in 2005 (Golder, 2005).	None	Additional monitoring wells positioned upgradient of well field would be beneficial to validate model. Some information regarding the potential vertical gradients between aquifer A2 and the upper confining unit may be appropriate, to ensure that aquifer A2 is adequately protected from potential anthropogenic contamination sources (locally).
5. Are model input parameters (recharge, porosity, K) reasonable?	8	Generally yes - Although detailed information regarding aquifer properties in the vicinity of the Warminster wells was relatively scarce and in some cases (e.g. hydraulic conductivities of different hydrogeologic units) professional judgment was needed. Previously conducted pumping tests at each production well (Well #1, and Well#3) were consulted, and is used to obtain best estimates for aquifer hydraulic properties. All other input parameters are deemed acceptable.	None	Additional field work would improve estimates. Ideally, hydraulic properties obtained from recent pumping tests could be used to better approximate capture zones from municipal wells.
6. Was natural flow field adequately incorporated into model? (Numerical Model)	8	Yes - observed head values (from MOE wells and other wells in the area) and natural flow field were used to calibrate the model, boundary conditions appear acceptable. It is noted that streams within the model limits were assigned as "drain" boundary conditions. Although common practice, streams within the model domain could be simulated using the "stream" boundary condition within MODFLOW. There are 3 different levels of recharge incorporated into the model, 225, 267, and 18 mm/yr, however there is no discussion relating the rationale for these levels of recharge. Given the large difference between some of these values, an explanation may be appropriate (although it is noted that the majority of the model domain is assigned a recharge value of 225 mm/yr). As noted above, all other boundary conditions are deemed acceptable.	None	Further validation for assigning drain, and constant head boundaries to major surface water features could be discussed. It is unclear if boundary conditions were adjusted in model calibration.
7. Was natural flow field adequately incorporated into model? (Analytical Model)				
8. Was the Model Calibrated?	7	Yes- Water level and screen information from the MOE database, as well as from a number of other wells identified in Burnside (2006) were used to establish groundwater elevation targets for the numerical model. The information obtained from the MOE WWR was reviewed prior to model import. Select calibration statistics are found in report (Golder, 2010), however notable statistics include a model RMS of 8.14%, which is acceptable (generally RMS values <10% are deemed acceptable), absolute residual mean of 4.33m, and a residual mean of -0.452. Golder (2010) indicates that the primary calibration parameters used were hydraulic conductivity and recharge. It is unclear if boundary conditions (particularly constant head boundary conditions) were adjusted during model calibration. Overall, model is deemed to be calibrated appropriately.	None	Model was calibrated to the local hydrogeological system, and results of calibration process are presented. Calibration to gauged streams in the area (baseflow measurements) could provide an alternate calibration technique (assuming gauged streams are present in the model domain), which may lead to additional confidence in model results. Any updated information for the area could be incorporated into the flow model.
9. Was Uncertainty considered in the analysis?	6	Limited uncertainty analysis, performed by using "shape factors" which increase the length and width of capture zones by 20%, which may be arbitrary. Also the orientation of capture zones was adjusted by 5% about the centreline to account for uncertainty in flow direction. A more classical approach to uncertainty/sensitivity could be performed (and is preferred), by varying recharge, and hydraulic conductivity/porosity to create "composite capture zones".	None	Discussion of sensitivity of model on boundary conditions (constant head, drain, etc.) could be included. Results of sensitivity analysis could be incorporated into capture zones to create "composite" capture zones.
10. What is the Uncertainty?	High	Designation not provided in report, but Dillon recommends that it be assessed as high	None	