FEASIBILITY PILOT STUDY:

RE-SAMPLING MULTILEVEL WELLS
FROM THE 1991-1992 ONTARIO FARM GROUNDWATER
QUALITY SURVEY LOCATED WITHIN THE JURISDICTION OF THE
NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

Prepared by:

NOTTAWASAGA VALLEY CONSERVATION AUTHORITY

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ENVIRONMENT CANADA

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Feasibility Pilot Study: Re-Sampling Multilevel Wells

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1. **INTRODUCTION**

Completed in 1991 and 1992, the Ontario Farm Groundwater Quality Survey (OFGWQS) was a comprehensive study looking at the state of groundwater resources accessed by rural well owners in Ontario (OFGWQS 1992; Goss et al. 1998; Rudolph et al. 1998). The main objectives of the survey were twofold: 1) to determine the quality and safety of drinking water for Ontario farm families and 2) to determine the effect of agricultural land use management on groundwater quality on a provincial scale. Domestic wells were sampled and tested for major potential farm-derived contaminants including nitrate \(\text{NO}_3^-\), pathogenic microorganisms, pesticides, and petroleum derivatives. The network was comprised of 1292 domestic water wells in addition to 144 multilevel wells (MLW) that were installed specifically for the OFGWQS.

The MLW results, aggregated to the provincial level, indicated that there were groundwater quality issues on the rural farm landscape. The conclusions drawn from the results of the domestic well sampling are consistent with conclusions drawn from the MLW data. No correlations were observed between the type of cropping practice and the frequency of groundwater contamination. In addition, highlights of the MLW include:

- At 23% of the sites, concentrations in 50% or more of the monitored intervals exceeded the provincial drinking water standard (MAC) for \(\text{NO}_3^-\) \(10 \text{mg/L NO}_3^-\) during both sampling periods;
- Significantly higher frequencies of total coliforms contamination were encountered in the winter (66%) than in the summer (36%). Farms where manure spreading occurred, however, had significantly higher occurrences of contamination from \(\text{NO}_3^-\) and bacteria than farms where manure was not applied along with commercial N-fertilizer;
- Very few pesticide detections were recorded;
- The average concentration of \(\text{NO}_3^-\) with depth in MLW decreased from approximately 10 mg/L \(\text{NO}_3^-\) near the water table to 3 mg/L \(\text{NO}_3^-\) at a depth of about 6.5 m.

Ontario is in the unique position to be able to use information from the 1991-92 OFGWQ survey as an earlier benchmark to which newly collected data can be compared to gain insights into long-term changes in rural groundwater quality.
The objective of this project was to determine the feasibility of re-sampling the MLW that were installed during the 1991-92 OFGWQS. Additional objectives of this project include:

1. Identify any discernable changes in shallow groundwater quality since 1991-92 under agricultural fields within the NVCA’s boundaries.
2. Develop tools and communication pieces to be used in any subsequent comparative study, e.g. a survey questionnaire to capture historical and current agricultural land management practices including implementation of BMPs.
3. Select sampling methodologies and key parameters for temporal data comparison that can be used in any subsequent comparative study.

This feasibility pilot project focused on re-sampling ten (10) MLWs located within the NVCA’s boundaries. One MLW was installed in the Township of Essa, three MLWs in the Town of Innisfil, four MLWs in the Town of New Tecumseth, and two MLWs in the Township of Adjala-Tosorontio (Figure 1). Multilevel wells (MLW) are monitoring wells with sampling ports at discrete depth intervals, allowing for the assessment of a vertical water quality profile. The original MLWs were completed approximately 18 inches below grade and marked with a 3M 1420 EMS-iD Marker Locator to allow for subsequent locating and sampling opportunities while affording the land owner the freedom to manage the land without interference from the water quality monitoring device.

2. SOUTH SIMCOE COUNTY AGRICULTURAL OVERVIEW

The MLWs were originally installed throughout south Simcoe County, corresponding to the subwatersheds of Innisfil Creek and the Boyne and the middle Nottawasaga rivers. Agriculture dominates much of the south Simcoe County landscape and provides significant economic and social benefits. The area has a land base, climate and a skilled farm community that make agriculture highly productive. The vast majority of this area’s agricultural land is either prime agricultural lands or specialty crop (approximately 80%). The major crops from this area are: alfalfa and hay/fodder, soy beans, corn, sod, wheat, barley, potatoes, carrots and onions.
3. **METHODOLOGY**

The 1991-92 OFGWQS field sheets and associated data for the study area were obtain from the original project custodians at the University of Guelph and University of Waterloo. The field data sheets included location of MLW (lot, concession, township), original owner contact information (phone number), a hand drawn map of the well location referencing key on-site landmarks (e.g. house/barn, etc), and well records including static levels and sampling history.

The MLW landowners were contacted to solicit interest in participating in the feasibility study. Recognizing the 19 year period since the wells were originally installed, farm succession, change in contact information, and redefined area code boundaries, the original phone numbers were referenced against the existing phone numbers (e.g. canada411.com) to determine mailing address. Also, NVCA staff completed a “windshield” survey to cross-reference the addresses and determine current field crops. Initial landowner contact was by mail, which consisted of an introduction letter outlining the feasibility project objectives (refer to Appendix A for the introduction letter). The initial mail contact was followed up with telephone contact with four points of contact used as a cut off point. It is noted that email contact information for all participants was not an available form of contact information.

Where the producers agreed to participate in the project, field staff attempted to locate the buried MLW. A hand drawn map from the 1991-92 survey together with a 3M 1420 EMS-iD Marker Locator plus a trundle wheel (to determine distances) were used to re-locate the buried 3M 1432 Near-Surface (2’ depth) Marker that was secured to the PVC protective cover on the buried MLW.

Once located, the overlying soil was removed for well access and the UTM coordinates of the MLW location were recorded. The well depth for each sampling tube was confirmed against the original field sheet. Water levels in each sampling tube of the MLW were measured with a Solinst water level tape (Model 102 P1/30 M). The individual tubes were purged of three well volumes and sampled using a low volume, battery driven, portable peristaltic pump. Sampling was done from the deepest to the shallowest interval since the deeper levels were expected to have the lowest concentrations of contaminants. Care was taken to minimize cross contamination between intervals and between MLW by using site specific tubing and purging three well volumes from each of the individual levels prior to sampling. It is noted that the same sampling methodology as in the 1991-92 OFGWQS was intentionally maintained.
Following sampling, the well was capped and the 3M 1432 Near-Surface (2’ depth) Marker was secured to the PVC protective cover on the buried MLW and covered with native soil.

Where a MLW was located and sampled, a concise questionnaire was mailed to the landowner only following the sampling. The landowners either faxed or mailed in the completed questionnaire to the NVCA where the responses were analyzed against the original questionnaire data provided in the summary field sheets. This was done to capture information on current and historical on-site management practices. The questionnaire was modeled after the one employed in the 1991-92 study. The sample questionnaire is provided in Appendix A.

All depths of the MLW that were located and yielded sufficient water were sampled. The depths of the MLW were sampled for bacteria (total coliforms and \textit{E. coli}), major anions and cations, and soluble reactive phosphorus. It is noted that one set of duplicates was taken for analysis from one level of one MLW (1020-4). The bacteria samples were submitted to ALS Laboratory Group in Waterloo, Ontario. The samples for bacterial analysis (total coliforms and \textit{E. coli}) were collected in 500 ml plastic bottle containing preservatives. No additional treatment was required following sampling. The samples were refrigerated at approximately 4°C and analyzed within 24 hours after sampling.

All other samples were submitted to the lab facilities of the Groundwater Quality and Assessment Section of Environment Canada at the Canada Centre for Inland Waters, Burlington, Ontario, with analysis provided as in-kind support for this project.

The following is a summary of the methodology of sample handling and analysis completed by Environment Canada.

\textbf{Anions:}
Sub-samples for anions (fluoride, chloride, bromide, nitrite, nitrate, sulfate, phosphate) were filtered to 0.45\textmu m and refrigerated until analysis using a Dionex 2500 ion chromatograph. Sample concentrations were calibrated against multi-ion standards that were analyzed with the samples. When necessary, samples were diluted with Milli-Q water to bring their concentration within the working range of the standards.

\textbf{Cations:}
Sub-samples for cations (calcium, magnesium, sodium, potassium, iron) and were filtered to 0.45\textmu m and acidified with nitric acid prior to being refrigerated until analysis by inductively coupled plasma-atomic emission spectroscopy using a HoribaJobin Yvon Ultima 2 ICP.
Sample concentrations were calibrated against multi-ion standards that were analyzed with the samples. When necessary, samples were diluted with Milli-Q water to bring their concentration within the working range of the standards.

Ammonium:
Sub-samples for ammonium analysis were syringe filtered to 0.45 μm and acidified with hydrochloric acid to a pH of approximately 5-6 and stored frozen until analysis. Ammonium concentrations were determined using a colorimetric method (Salicylate-Nitroprusside) by measuring absorbance at 640 nm on a Beckman-Coulter DU720 UV/visible spectrophotometer. Sample values were calibrated against multiple ammonium standards that were analyzed with the samples. When necessary, samples were diluted with Milli-Q water to bring their concentration within the working range of the standards.

Soluble Reactive Phosphorous (SRP):
SRP analysis was done using a modified version of the EPA’s colorimetric method for orthophosphate. Concentrations were determined by measuring absorbance at 885 nm on an Evolution 160 UV/Visible spectrophotometer. Sample values were calibrated against multiple SRP standards that were analyzed with the samples. When necessary, samples were diluted with Milli-Q water to bring their concentration within the working range of the standards.

4. RESULTS

4.1 PROJECT PARTICIPATION

The project aimed to locate and sample ten (10) MLWs located in four municipalities in south Simcoe County. The land owners involved previously farmed a variety of crops including corn, soybean, potatoes, and onions/carrots (Table 1). The farms are mostly family run operations with two fairly large-scale commercial farms.
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Table 1
Summary of project participation, crop patterns and tilling practices for the 10 MLWs located within the boundaries of the NVCA (NA: not available, not applicable or data not collected)

<table>
<thead>
<tr>
<th>Well</th>
<th>Participated in 2010 study</th>
<th>Well found or destroyed</th>
<th>Crop pattern 1991</th>
<th>Crop pattern 1992</th>
<th>Crop pattern 2010</th>
<th>Tilling practices 1992</th>
<th>Tilling practices 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>1009</td>
<td>no</td>
<td>NA</td>
<td>potatoes</td>
<td>wheat</td>
<td>potatoes</td>
<td>minimum till</td>
<td>NA</td>
</tr>
<tr>
<td>1011</td>
<td>no</td>
<td>NA</td>
<td>white beans</td>
<td>wheat</td>
<td>wheat or corn</td>
<td>conventional (no moldboard)</td>
<td>NA</td>
</tr>
<tr>
<td>1020</td>
<td>yes</td>
<td>located and sampled</td>
<td>corn</td>
<td>white beans</td>
<td>corn</td>
<td>minimum till</td>
<td>no till</td>
</tr>
<tr>
<td>1027</td>
<td>yes</td>
<td>destroyed</td>
<td>barley</td>
<td>potatoes</td>
<td>potatoes</td>
<td>disc twice a year</td>
<td>NA</td>
</tr>
<tr>
<td>1029</td>
<td>yes</td>
<td>destroyed</td>
<td>sweet corn</td>
<td>sweet corn</td>
<td>potatoes</td>
<td>chisel plough (fall), spring-reduced till</td>
<td>NA</td>
</tr>
<tr>
<td>1335</td>
<td>yes</td>
<td>located and sampled</td>
<td>white beans</td>
<td>corn</td>
<td>corn</td>
<td>conventional</td>
<td>no till</td>
</tr>
<tr>
<td>1396</td>
<td>yes</td>
<td>destroyed</td>
<td>carrots</td>
<td>carrots</td>
<td>carrots</td>
<td>plough, disc and seed</td>
<td>NA</td>
</tr>
<tr>
<td>1397</td>
<td>no</td>
<td>NA</td>
<td>onion and carrots</td>
<td>onions</td>
<td>onions or carrots</td>
<td>conventional</td>
<td>NA</td>
</tr>
<tr>
<td>1398</td>
<td>yes</td>
<td>destroyed</td>
<td>onions</td>
<td>carrots</td>
<td>onions</td>
<td>roto-tilling between rows</td>
<td>deep ripper</td>
</tr>
<tr>
<td>1399</td>
<td>yes</td>
<td>located and sampled</td>
<td>white beans</td>
<td>wheat</td>
<td>wheat</td>
<td>no till</td>
<td>chisel plough</td>
</tr>
</tbody>
</table>

Using the updated contact information, all ten participants were successfully contacted regarding the project. Farm succession was noted for four farms. One original participant sold the farm to someone outside the immediate family and three changes in farm ownership occurred within the immediate family. This suggests that the contact information in the 1991-92 study is still relevant and would be useful for contacting land owners for follow-up sampling of the other MLWs in the province. It is noted that multiple points of contact were required for each producer for engagement in the project. Furthermore, the most effective means for contact was via telephone.
Of the ten contacted participants, three did not wish to participate in the project. No specific reasons were given for the lack of interest in participating. The remaining seven producers were supportive of the project and allowed project staff to attempt to locate the MLW on their property. Only one participant was aware of the previous study.

Based on gate post signs, the majority of the participants are members of the Ontario Federation of Agriculture, and in some cases, have participated in the Environmental Farm Plan.

It is noted that the project field work overlapped the harvesting period, with potatoes and carrots/onions generally harvested by early to mid-October and corn by late November. The timing of the study was an added challenge during the process of contacting land owners since they were very busy with harvesting operations.

4.2 Well Conditions

Of the seven participating farms with MLWs, three MLWs were located (Figure 2). The located wells were in two fields of corn and one field of wheat. Minimum/conservative plowing/tillage practices are noted in the three cases and the remaining four MLW were unable to be located and herein considered destroyed: in one case the PVC well cap was found on the surface without the 3M 1432 Near-Surface (2’ depth) Marker and in another case expansion of farm infrastructure (e.g. facilities and driveway/roads) was built in the vicinity of the buried MLW. At this later location, it was assumed that surface grading that was reported to be to a depth of four feet below grade likely destroyed the MLW. In the two other locations, the MLW were simply not located and assumed to be destroyed due to tillage practices (Table 1). Two of the four destroyed wells were located on onion/carrot farms and the other two destroyed MLW were located on current potato farms. It is noted that the cropping patterns remained fairly consistent on an individual farm basis over the 20 years.

The MLW were completed roughly 18 inches below grade in the 1991-92 study to allow for existing farming practices to continue unimpeded. It is assumed that certain tillage practices, due to their greater depth of influence, resulted in the wells being destroyed.
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Noted tilling practices in the 1991-92 survey include:

1. No till
2. Conservation Tillage or Minimum Tillage (e.g. chisel plough, chisel plough fall (reduced till spring), disc twice a year, minimum till)
3. Conventional tillage (includes primary and secondary tillage, e.g. conventional, conventional no moldboard, and plough, disc and seed)
4. Deep Tillage (includes Deep Ripper, Sub Soiler, etc)

Locating the three MLW provided the following information:

- The maps provided in the original field sheets are adequate for locating the wells;
- The 3M 1432 Near-Surface (2’ depth) Marker is still functional and can be used to locate the MLWs in combination with the 1991-92 field datasheets;
- MLWs located in fields where certain types of low impact tillage practices are used have a higher probability of being located; and
- The located MLWs were in good condition and easily sampled. There was no damage to the well casing, the 3M 1432 Near-Surface (2’ depth) Marker or the individual tubes inside the PVC cover. The original well markings written in permanent marker were still legible.

4.3 WATER QUALITY

The following tables present the data, the method detection limit (mdl) and the Ontario Drinking-water Quality, Standards, Objectives and Guidelines (ODWQSOG) where available. The groundwater at the MLW is considered to be a potable groundwater source for the land owner so the ODWQSOG were selected as the comparative standard. The ODWQSOG have health related standards that are denoted in the tables as a Maximum Allowable Concentration (MAC) and non-health related parameters denoted in the table as Aesthetic Objectives (AO) or Operational Guidelines (OG). Where no standard, objective or guideline exists for a particular parameter, the tables denote NA (Not Available).

Given the limited number of samples no statistical analysis has been completed on the data however the following general observations can be made.
Table 2 provides a summary of the MLW construction details, the stratigraphy the location of the MLW and water levels in 2010 compared to historical water levels. In two out of three cases the water levels have increased since the early 90s and in the third case the water level is essentially the same. The magnitude of change in water levels is approximately the same as the difference between the water levels noted in the winter of 1991-92 and the summer of 1992 which may suggest that the difference in water level is primarily a seasonal fluctuation. Due to the change in ground surface elevation due to tillage practices on the field the depth to water in the MLW is measured as metres below top of casing (mbtoc) while the depth of the well when installed was measured as metres below ground surface.

Table 2
Multilevel well (MLW) depth in meters below ground surface (mbgs) and depth to water in metres below top of casing (mbtoc)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Depth (mbgs)</th>
<th>Stratigraphy</th>
<th>Depth to water (mbtoc)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Winter 1991</td>
</tr>
<tr>
<td>1020-1</td>
<td>2.90</td>
<td>Silt</td>
<td>2.20</td>
</tr>
<tr>
<td>1020-2</td>
<td>3.81</td>
<td>Silt</td>
<td>2.20</td>
</tr>
<tr>
<td>1020-3</td>
<td>5.03</td>
<td>Silt</td>
<td>2.20</td>
</tr>
<tr>
<td>1020-4</td>
<td>6.25</td>
<td>Silt</td>
<td>2.21</td>
</tr>
<tr>
<td>1020-5</td>
<td>7.47</td>
<td>Silt</td>
<td>2.21</td>
</tr>
<tr>
<td>1020-6</td>
<td>8.99</td>
<td>Silt</td>
<td>2.48</td>
</tr>
<tr>
<td>1335-P1</td>
<td>1.52</td>
<td>Top Soil</td>
<td>Dry</td>
</tr>
<tr>
<td>1335-P2</td>
<td>2.90</td>
<td>Clay</td>
<td>2.23</td>
</tr>
<tr>
<td>1335-P3</td>
<td>4.27</td>
<td>Clay</td>
<td>2.23</td>
</tr>
<tr>
<td>1399-P1</td>
<td>Broke/ Removed</td>
<td>Sand</td>
<td>NA</td>
</tr>
<tr>
<td>1399-P2</td>
<td>2.90</td>
<td>Clay</td>
<td>1.90</td>
</tr>
<tr>
<td>1399-P3</td>
<td>4.42</td>
<td>Clay</td>
<td>1.79</td>
</tr>
</tbody>
</table>

The groundwater quality data for the MLW, including anion, cation, soluble reactive phosphorous (SRP) chemistry and bacteria, is presented in Tables 3, 4, 5 and 6 respectively. No health related parameters exceeded the ODWSOG with the exception of nitrite and nitrate at site 1335 and E. coli and total coliforms at site 1020.
The aesthetic objective of sulphate exceeded the ODWQSOG at all three sites suggesting that this might be a natural water quality issue in the area. It is worth noting that *E. coli* and total coliforms were detected at the site where the MLW was installed in silt while the sites where the MLW were installed in clay the groundwater sample did not have any *E. coli* or total coliforms detected. This is inconsistent with the historical data presented in Table 7 and discussed below.

Table 3
Anion chemistry for groundwater samples. The minimum detection limit (mdl) for each parameter is given at the bottom of the table

<table>
<thead>
<tr>
<th>Sample</th>
<th>Date</th>
<th>Fluoride (mg/L)</th>
<th>Chloride (mg/L)</th>
<th>Bromide (mg/L)</th>
<th>Sulfate (mg/L)</th>
<th>Nitrite (mg N/L)</th>
<th>Nitrate (mg N/L)</th>
<th>Phosphate (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1020-2</td>
<td>18-Nov-10</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1020-3</td>
<td>18-Nov-10</td>
<td>0.15</td>
<td>65.6</td>
<td>&lt;0.02</td>
<td>132.9</td>
<td>&lt;0.003</td>
<td>&lt;0.016</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>1020-4</td>
<td>18-Nov-10</td>
<td>0.13</td>
<td>38.0</td>
<td>&lt;0.02</td>
<td>164.9</td>
<td>&lt;0.003</td>
<td>&lt;0.016</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>1020-4 dupl.</td>
<td>18-Nov-10</td>
<td>0.13</td>
<td>38.7</td>
<td>&lt;0.02</td>
<td>163.9</td>
<td>&lt;0.003</td>
<td>&lt;0.016</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>1020-5</td>
<td>18-Nov-10</td>
<td>0.16</td>
<td>28.9</td>
<td>&lt;0.02</td>
<td>147.6</td>
<td>&lt;0.003</td>
<td>&lt;0.016</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>1020-6</td>
<td>18-Nov-10</td>
<td>0.19</td>
<td>14.4</td>
<td>&lt;0.02</td>
<td>72.5</td>
<td>0.021</td>
<td>0.20</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>1335-P2</td>
<td>8-Nov-10</td>
<td>0.09</td>
<td>4.5</td>
<td>&lt;0.02</td>
<td>25.7</td>
<td>&lt;0.003</td>
<td>15.23</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>1335-P3</td>
<td>8-Nov-10</td>
<td>0.10</td>
<td>15.0</td>
<td>&lt;0.02</td>
<td>73.1</td>
<td>2.916</td>
<td>15.05</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>1399-P2</td>
<td>5-Nov-10</td>
<td>0.27</td>
<td>61.2</td>
<td>0.24</td>
<td>0.4</td>
<td>&lt;0.003</td>
<td>0.06</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>1399-P3</td>
<td>5-Nov-10</td>
<td>0.30</td>
<td>47.9</td>
<td>0.45</td>
<td>&lt;0.05</td>
<td>&lt;0.003</td>
<td>&lt;0.016</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>ODWQSOG</td>
<td>(mg/L)</td>
<td>1.5 (MAC)</td>
<td>250 (AO)</td>
<td>NA</td>
<td>0.05 (AO)</td>
<td>1.0 (MAC)</td>
<td>10.0 (MAC)</td>
<td>NA</td>
</tr>
<tr>
<td>mdl</td>
<td>(mg/L)</td>
<td>0.004</td>
<td>0.01</td>
<td>0.02</td>
<td>0.05</td>
<td>0.003</td>
<td>0.016</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Table 4
Cation chemistry for groundwater samples. The minimum detection limit (mdl) for each parameter is given at the bottom of the table

<table>
<thead>
<tr>
<th>Sample</th>
<th>Date</th>
<th>Calcium (mg/L)</th>
<th>Iron (mg/L)</th>
<th>Potassium (mg/L)</th>
<th>Magnesium (mg/L)</th>
<th>Sodium (mg/L)</th>
<th>Ammonium (mg N/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1020-2</td>
<td>18-Nov-10</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1020-3</td>
<td>18-Nov-10</td>
<td>84.71</td>
<td>&lt;0.02</td>
<td>2.15</td>
<td>47.11</td>
<td>29.54</td>
<td>1.610</td>
</tr>
<tr>
<td>1020-4</td>
<td>18-Nov-10</td>
<td>96.81</td>
<td>0.10</td>
<td>2.37</td>
<td>35.55</td>
<td>34.86</td>
<td>1.310</td>
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<tr>
<td>1020-4 dupl.</td>
<td>18-Nov-10</td>
<td>119.50</td>
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<td>2.22</td>
<td>36.31</td>
<td>34.17</td>
<td>1.330</td>
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<tr>
<td>1020-5</td>
<td>18-Nov-10</td>
<td>95.23</td>
<td>0.02</td>
<td>1.68</td>
<td>43.95</td>
<td>22.78</td>
<td>1.520</td>
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<td>18-Nov-10</td>
<td>54.45</td>
<td>0.11</td>
<td>1.64</td>
<td>36.12</td>
<td>17.01</td>
<td>1.290</td>
</tr>
<tr>
<td>1335-P2</td>
<td>8-Nov-10</td>
<td>128.40</td>
<td>&lt;0.02</td>
<td>1.44</td>
<td>17.19</td>
<td>8.92</td>
<td>0.040</td>
</tr>
<tr>
<td>1335-P3</td>
<td>8-Nov-10</td>
<td>74.29</td>
<td>&lt;0.02</td>
<td>2.44</td>
<td>31.48</td>
<td>27.02</td>
<td>0.070</td>
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<tr>
<td>1399-P2</td>
<td>5-Nov-10</td>
<td>55.92</td>
<td>&lt;0.02</td>
<td>1.35</td>
<td>24.87</td>
<td>48.12</td>
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<td>27.28</td>
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<td>0.93</td>
<td>14.46</td>
<td>54.43</td>
<td>0.150</td>
</tr>
<tr>
<td>ODWSOG</td>
<td>(mg/L)</td>
<td>NA</td>
<td>0.3 (AO)</td>
<td>NA</td>
<td>NA</td>
<td>200 (AO)</td>
<td>NA</td>
</tr>
<tr>
<td>mdl</td>
<td>(mg/L)</td>
<td>0.020</td>
<td>0.020</td>
<td>0.10</td>
<td>0.020</td>
<td>0.10</td>
<td>0.020</td>
</tr>
</tbody>
</table>

Table 5
Soluble reactive phosphorus (SRP) concentrations for groundwater samples. The minimum detection limit (mdl) is given at the bottom of the table

<table>
<thead>
<tr>
<th>Sample</th>
<th>Date</th>
<th>SRP (μg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1020-2</td>
<td>18-Nov-10</td>
<td>NA</td>
</tr>
<tr>
<td>1020-3</td>
<td>18-Nov-10</td>
<td>5.7</td>
</tr>
<tr>
<td>1020-4</td>
<td>18-Nov-10</td>
<td>4.9</td>
</tr>
<tr>
<td>1020-4 dupl.</td>
<td>18-Nov-10</td>
<td>6.5</td>
</tr>
<tr>
<td>1020-5</td>
<td>18-Nov-10</td>
<td>7.3</td>
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<td>1020-6</td>
<td>18-Nov-10</td>
<td>5.5</td>
</tr>
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<td>1335-P2</td>
<td>8-Nov-10</td>
<td>5.3</td>
</tr>
<tr>
<td>1335-P3</td>
<td>8-Nov-10</td>
<td>6.2</td>
</tr>
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<td>1399-P2</td>
<td>5-Nov-10</td>
<td>8.9</td>
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<tr>
<td>1399-P3</td>
<td>5-Nov-10</td>
<td>7.3</td>
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<tr>
<td>ODWSOG</td>
<td>(mg/L)</td>
<td>NA</td>
</tr>
<tr>
<td>mdl</td>
<td>(mg/L)</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Table 6
Total Coliforms and *E. coli* for groundwater samples given in units of colony forming units (CFU) per 100 milliliters of sample. Certificate of Analysis for the bacteria data can be found in Appendix B.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Date</th>
<th><em>E. coli</em> (CFU/100mL)</th>
<th>Total Coliforms (CFU/100 mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1020-2</td>
<td>18-Nov-10</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1020-3</td>
<td>18-Nov-10</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>1020-4</td>
<td>18-Nov-10</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1020-4 dupl.</td>
<td>18-Nov-10</td>
<td>4</td>
<td>700</td>
</tr>
<tr>
<td>1020-5</td>
<td>18-Nov-10</td>
<td>0</td>
<td>120</td>
</tr>
<tr>
<td>1020-6</td>
<td>18-Nov-10</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>1335-P2</td>
<td>8-Nov-10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1335-P3</td>
<td>8-Nov-10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1399-P2</td>
<td>5-Nov-10</td>
<td>0</td>
<td>&lt;2</td>
</tr>
<tr>
<td>1399-P3</td>
<td>5-Nov-10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ODWSOG</td>
<td>CFU</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 7
Comparison of bacteria and nitrate results to fall/winter 1991/1992 bacteria and nitrate results for groundwater samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Date</th>
<th>E. coli (CFU/100mL)</th>
<th>Total Coliforms (CFU/100 mL)</th>
<th>Nitrate as N (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1020-2</td>
<td>29-Jan-92</td>
<td>NA</td>
<td>NA</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>29-Jul-92</td>
<td>NA</td>
<td>NA</td>
<td>0.044</td>
</tr>
<tr>
<td></td>
<td>18-Nov-10</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1020-3</td>
<td>29-Jan-92</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>29-Jul-92</td>
<td>NA</td>
<td>NA</td>
<td>12.72</td>
</tr>
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<td></td>
<td>18-Nov-10</td>
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<td>18</td>
<td>&lt;0.016</td>
</tr>
<tr>
<td>1020-4</td>
<td>29-Jan-92</td>
<td>0</td>
<td>0</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>29-Jul-92</td>
<td>0</td>
<td>0</td>
<td>0.121</td>
</tr>
<tr>
<td></td>
<td>18-Nov-10</td>
<td>0</td>
<td>2</td>
<td>&lt;0.016</td>
</tr>
<tr>
<td>1020-4 dupl.</td>
<td>18-Nov-10</td>
<td>4</td>
<td>700</td>
<td>&lt;0.016</td>
</tr>
<tr>
<td>1020-5</td>
<td>29-Jan-92</td>
<td>0</td>
<td>0</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>29-Jul-92</td>
<td>0</td>
<td>0</td>
<td>0.164</td>
</tr>
<tr>
<td></td>
<td>18-Nov-10</td>
<td>0</td>
<td>120</td>
<td>&lt;0.016</td>
</tr>
<tr>
<td>1020-6</td>
<td>29-Jan-92</td>
<td>0</td>
<td>0</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>29-Jul-92</td>
<td>0</td>
<td>0</td>
<td>0.068</td>
</tr>
<tr>
<td></td>
<td>18-Nov-10</td>
<td>0</td>
<td>6</td>
<td>0.20</td>
</tr>
<tr>
<td>1335-P1</td>
<td>6-Feb-92</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>30-Jul-92</td>
<td>0</td>
<td>8</td>
<td>57.2</td>
</tr>
<tr>
<td></td>
<td>8-Nov-10</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1335-P2</td>
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<td>81</td>
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<tr>
<td></td>
<td>30-Jul-92</td>
<td>0</td>
<td>24</td>
<td>39.73</td>
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<td>8-Nov-10</td>
<td>0</td>
<td>0</td>
<td>15.23</td>
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<td>1335-P3</td>
<td>6-Feb-92</td>
<td>0</td>
<td>35</td>
<td>9.72</td>
</tr>
<tr>
<td></td>
<td>30-Jul-92</td>
<td>NA</td>
<td>0</td>
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<tr>
<td></td>
<td>8-Nov-10</td>
<td>0</td>
<td>0</td>
<td>15.05</td>
</tr>
<tr>
<td>1399-P2</td>
<td>6-Feb-92</td>
<td>NA</td>
<td>NA</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>29-Jul-92</td>
<td>NA</td>
<td>NA</td>
<td>0.046</td>
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<td>&lt;2</td>
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<td>6-Feb-92</td>
<td>NA</td>
<td>NA</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>29-Jul-92</td>
<td>NA</td>
<td>NA</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>5-Nov-10</td>
<td>0</td>
<td>0</td>
<td>&lt;0.016</td>
</tr>
</tbody>
</table>
For each well that was located and sampled, the landowner was provided with a short summary of the water quality results. An example of the one-page summary is provided in Appendix C.

The historical results presented in Table 7 compares the fall 2010 data from the three sites sampled to the data from the winter of 1991-92 and the summer of 1992. In general, the current nitrate data shows similar results to the original survey data, specifically the site where the highest concentration of nitrate was detected in the 1991-92 survey is the same site where the highest concentration of nitrate was detected in the current study.

The *E. coli* and total coliforms data from the 1991-92 study is limited to two of the three sites sampled in the current study. When comparing the historical and current results for these two sites the silty site had no detectable *E. coli* or total coliforms historically and the site where the MLW was completed in clay had detectable *E. coli* and total coliforms historically. This is opposite to the current results. More sites would need to be sampled to make any conclusive comparative statements about the bacterial data.

It is worth noting that nitrate concentrations at the site where an EFP was noted as having been completed (see Section 4.4) have decreased at the shallower depth (P2) while the nitrate concentrations have increased at the deeper depth (P3) of the MLW. Furthermore, the *E. coli* and total coliforms are not detected in the current samples but were detected in the historical samples at this same MLW. There is insufficient data to make any conclusive statements about these observations; however, the data does not rule out the possibility that the EFP has contributed to improvements in the shallow groundwater quality at this site. The observed improvement in groundwater quality however could also be attributed to the absence of livestock and manure compared to the presence of livestock and manure in 1991-92.

### 4.4 Land Use Practices

The cropping pattern has largely remained consistent among the ten farms where the MLWs are located (Table 1). Three distinct crop rotations are apparent: onion-onion/carrot, wheat-white bean/corn and potato-wheat. Only one producer changed cropping rotations from sweet corn to potato. Where information is available, it is noted that some tilling practices have changed, which may have resulted in some MLWs being destroyed.
Feasibility Pilot Study: Re-Sampling Multilevel Wells

Farm practices were determined from the questionnaires that were provided to the landowners where the MLWs were successfully located and sampled. Two out of the three questionnaires were completed and faxed or mailed back to the NVCA. At the third location observations were noted by NVCA staff in the field. The site reportedly has completed an Environmental Farm Plan (EFP) as noted by a farm gate sign.

Tillage practices range from no/minimal till to chisel plough. In general, soil sample tests are taken every 3-4 years and mineral fertilizer is applied as per recommendations based on crop type and soil test results. In one case, the land owner noted that the mineral fertilizer application rate has not changed since the MLW was installed. No manure or biosolids have been applied to the subject properties since the MLWs were installed. It is noted that historically one of the farms reportedly had beef cattle; however, this farm no longer have livestock present and it is therefore assumed that manure has not recently been applied to the field where the MLW is located.

5. SUMMARY AND NEXT STEPS

This pilot study was designed to be the first step of a multi-stage approach. Stage one was intended to assess the feasibility of re-sampling all accessible MLWs on a limited basis (this study). Building on these results, the next phase (stage two) is to conduct a comparative study between two different agricultural settings/management practices in different settings across the province (i.e. a 2 watershed comparative analysis). Based on the output of the two previous stages (pilot and comparative), additional studies may be pursued with the intent to resample all accessible MLW installed during the 1991-92 OFGWQ survey.

The MLW data from the original study proved extremely useful in the overall survey. These installations are essentially permanent with capital costs already covered in the original study; they can be located and re-sampled at anytime with the cooperation of the land owner at minimal capital cost.

In general, the land owners in this study were cooperative and willing to participate in the study as demonstrated by the fact that, even during a busy season, seven out of ten land owners were willing to allow the study team to have access to the land. Six out of the seven participating land owners contacted were unaware of the well installation completed as part of the original study. MLWs were located on three out of seven participating farms.
The cropping practices where the MLWs were located were typically corn, soybean, and grain crops and where minimal tilling practices are typically employed. Once located, the integrity of the MLW was close to the original condition of the well.

There is insufficient data to make any conclusive statements about the implications from any changes in water quality however the data does not rule out the possibility that the EFP has contributed to improvements in the shallow groundwater quality at the site where an EFP was noted being completed. The observed improvement in groundwater quality at this site however could also be attributed to the absence of livestock and manure compared to the presence of livestock and manure in 1991-92.

The successes and failures in locating the MLWs suggest that any future initiatives to locate and sample other MLWs from the OFGWQS should target areas where minimal or no tillage practices are highly probable.

It should be noted that obtaining landowner permission and locating the MLWs is a time consuming initiative, approximately 4 hours per MLW. This suggests that areas should be selected where the probability of the MLW being located in good condition is maximized, hence areas where minimal or no till is a common practice.

Prior to undertaking additional field-based sampling, the current results suggest that the 1991-92 data set should be reviewed in detail to identify the crop types and tillage practices for the fields where the MLWs were installed. This will improve the probability of successfully locating the MLW. The use of current satellite imagery (e.g. Google Earth) could also be used to verify that original MLW locations are still accessible and have not been destroyed by development.

Next steps should take advantage of the documents and tools that were developed as part of this study, including an introductory cover letter, questionnaire, comparative water analysis summary template, in addition to the sampling methodologies.

For the longer-term, the MLWs that were located in this project could be re-sampled on a more frequent basis to help in the understanding of the benefits of BMP on shallow groundwater quality.
Feasibility Pilot Study: Re-Sampling Multilevel Wells

The following recommendations are encouraged to be undertaken as the next steps in this project:

**Recommendation:** Working with the original project data custodians, develop an updated database of the participants’ contact information, cross-referencing the original data with canada411.ca for all MLWs that were completed as part of the original study. This updated database would also consist of the georeferenced original 91/92 well information and associated data to collectively provide context of: well distribution regarding historical cropping patterns, wells with a high probability of being relocated to focus future re-sampling efforts on, and updated contact information.

**Recommendation:** Future studies should focus on wells located in fields that have minimal tillage impacts and corresponding crops of corn, soybean, grains; however, also include a limited number of additional ‘outlier’ crops that may use deep tilling practices as a way of confirming the current results that indicate that well survival is very limited in these farming environments.

**Recommendation:** The methodology used for locating wells is consistent with the methodology used in the original study: the 3M 1432 Near-Surface (2’ depth) Marker is still functional and useful for locating the MLWs in combination with the 91/92 field datasheets. Future well locating exercises should continue to use the 3M 1420 EMS-iD Marker Locator available through the University of Guelph. It is recommended that future studies provide UTM coordinates on the well location.

**Recommendation:** Initiate future fieldwork during the period between end of harvest and first snowfall or after the spring melt and prior to planting.

**Recommendation:** Future studies should use the sampling protocol that was developed in the original study and also used for this study. The well depth for each sampling tube was confirmed against the original field sheet. Water levels in each sampling tube of the MLW were measured with a Solinst water level tape (Model 102 P1/30 M). The individual tubes were sampled using a low volume, battery driven portable peristaltic pump. Sampling was done from the deepest to the shallowest interval since the deeper levels were expected to have the lowest concentrations of contaminants. The individual sampling tubes were purged of roughly 3 well volumes prior to sampling.
Recommendation: Future analysis of OFGWQS MLWs to include, as a minimum, nitrate, bacteria (total coliforms and \(E.\ coli\)) with analysis completed by an accredited laboratory for comparison with the original study. Further, it is recommended seeking involvement of collaborators (e.g. Environment Canada) to get additional specialized analyses contributed in-kind and to get value-added results from the sampling efforts.

Recommendation: The landuse survey should be done with all participants immediately following the completion of the sampling instead of mailing out the survey and requesting the land owner to send in a response.

Recommendation: Long-term sampling arrangements/relationships should be developed with the landowners so that the MLWs can be sampled at more frequent intervals (e.g. every 5 years).

Recommendation: The participating agencies should develop a strategic action plan for rural-agricultural groundwater quality research and monitoring that can be statistically used to determine temporal impacts related to various programs and BMP implementations.

6. ACKNOWLEDGEMENTS

Staff at Environment Canada, Agriculture and Agri-Food Canada, Nottawasaga Valley Conservation Authority, OMAFRA, Ontario Federation of Agriculture, University of Guelph, University of Waterloo, and the Ontario Farm Environmental Coalition contributed both time and expertise to the project’s success. Support in the form of in-kind water quality analysis was provided by Environment Canada.

Further, we would like to acknowledge the cooperation of all the landowners that participated in this project. Without their support and collaboration, this project would not have been possible.

Funding for this project has been provided by Agriculture and Agri-Food Canada through the Canadian Agricultural Adaptation Program (CAAP). In Ontario, this program is delivered by the Agricultural Adaptation Council.
7. DISCLAIMER

Agriculture and Agri-Food Canada (AAFC) is committed to working with industry partners. Opinions expressed in this document are those of the authors and not necessarily those of AAFC.

Respectfully Submitted,

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8. REFERENCES


This map has been produced for illustrative purposes only. While every effort has been made to accurately depict the information, data/mapping errors may exist.

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Legend

Well Location Status
- Found
- Did not participate
- Destroyed

Hydrological Soil Group
- A
- B
- C
- D

This information is provided as a public service by the Government of Ontario, Canada.
APPENDIX A

Letter of Introduction and Questionnaire
Dear Sir or Madam:

The Nottawasaga Valley Conservation Authority (NVCA) in partnership with the Ontario Federation of Agriculture and the Ontario Farm Environmental Coalition are undertaking a study to determine the feasibility of resampling the buried multilevel monitoring wells (MLWs) that were installed during the 1991-1992 Ontario Farm Groundwater Quality Survey in the south Simcoe County area.

The purpose of the project is to compare results from 1991-1992 to 2010 and to get an aggregated understanding of any discernible change in shallow groundwater quality since the early 1990s, before the Environmental Farm Plan and associated Best Management Practices publications, workshops, and demonstration projects were initiated in this area. The outcome of this exercise will also help to determine the feasibility of re-sampling all 144 multilevel wells that were installed as part of the original project across the province of Ontario.

Based on the original records from the Ontario Farm Groundwater Quality Survey, we have identified a buried multilevel monitoring well on your property.

The NVCA and their consultants WESA Inc. (WESA) are requesting permission to access your property for the purpose of locating the buried well and collecting water samples from it.

The final report and a one page summary outlining the analysis of the water from your multilevel well compared to the 1992 analysis results will be provided to all participating landowners.

What Will I Be Asked To Do?
Staff from WESA and the NVCA require one-time access to locate and sample the buried multilevel monitoring well on your property during October at a time convenient for you. Once located, staff will access the buried well by removing a minimal amount of the soil cover using a hand shovel. Water levels will be taken and samples collected after the wells have been purged of stagnant water. The samples will be analyzed for water quality parameters including bacteria and nitrate.
It will take approximately 4 hours potentially over a 2 day period to locate and sample the multilevel well. In addition, we would complete a short 15 minute questionnaire to determine changes in your general land management practices over the last 20 years.

Benefits to participating landowners include:
- receiving up to date indication of shallow surface water conditions on your property including nitrate concentrations,
- gaining a greater understanding of the natural groundwater system in your community, and contributing to the development of sustainable water resource management strategies in your watershed.

What Happens to the Information I Provide?
The project is not seeking individual field results but an aggregated understanding of any discernable change in shallow groundwater quality since the early 1990s. Individual participating producers’ confidentiality will be ensured with only aggregated data disseminated in the final report. The outcome of this exercise will be to determine the feasibility of resampling all 144 multilevel wells that were installed as part of the original project across the province of Ontario. The raw data will be retained until it is no longer required for research purposes at which point it will be destroyed.

We are planning to carry out the site visits during October at a time that would be the most convenient for you.

If you have further questions or if you wish to arrange a time for us to access your property, please contact Ryan Post during normal business hours:

Ryan Post
Hydrogeologist
Phone: (705) 424-1479, extension 249
E-mail: rpost@nvca.on.ca

Your time and participation in this project would be greatly appreciated.

Best regards,

Ryan Post
COVER LETTER- QUESTIONNAIRE

Month day, year December 10, 2010

Address

Re: Ontario Farm Groundwater Quality Survey Feasibility Study Questionnaire.

Dear Sir or Madam:

Thank you once again for participating in the Ontario Farm Groundwater Quality Feasibility project; allowing us to locate and sample the buried multilevel monitoring well that was install on your property back in 1991 as part of the original project.

The purpose of this project is to compare results from 1991-1992 to 2010 and to get an aggregated understanding of any discernable change in shallow groundwater quality since the early 1990s, before the Environmental Farm Plan and associated Best Management Practices publications, workshops, and demonstration projects were initiated in this area. The outcome of this exercise will also help to determine the feasibility of resampling all 144 multilevel wells that were installed as part of the original project across the province.

The last component of this project is to complete a questionnaire with you to capture information on current and historical on-site management practices where the buried multilevel well is located to determine how potential land use changes may changed the in-field water quality gained from sampling the well.

You are asked to complete the enclosed questionnaire to the best of your ability. The questions are to be answered as they apply to the managed lands surrounding and including the field where the multi-level well is located.

The final report and a one page summary outlining the analysis of the water from your multilevel well compared to the 1992 analysis results will be provided to you in January.
Once completed, please mail to:

Ryan Post
Nottawasaga Valley Conservation Authority
8195 8th Line
Utopia, Ontario
L0M 1T0

What Happens to the Information I Provide?
The project is not seeking individual field results but an aggregated understanding of any
discernable change in shallow groundwater quality since the early 1990s. Individual participating
producers’ confidentiality will be ensured with only aggregated data disseminated in the final
report. The outcome of this exercise will be to determine the feasibility of resampling all 144
multilevel wells that were installed as part of the original project across the province of Ontario.
The raw data will be retained until it is no longer required for research purposes at which point it
will be destroyed.

If you have further questions or if you wish to arrange a time for us to complete the
questionnaire with you, please contact Ryan Post during normal business hours:

Ryan Post, Hydrogeologist
Phone: (705) 424-1479, extension 249
E-mail: rpost@nvca.on.ca

Your time and participation in this project would be greatly appreciated.

Sincerely,

Ryan Post
QUESTIONNAIRE

Ontario Farm Groundwater Quality Survey Questionnaire Fall 2010

Cooperating farm landowners are asked to complete this questionnaire to the best of their ability. The questions are to be answered as they apply to the managed lands surrounding and including the field where the multi-level well is located.

Name:
Address:
Telephone
Email
Lot
Concessions
Township
County

Field characteristics specific to the field that the well is in:
field acreage
Predominant agricultural land use system
Crops: grains; oilseeds; vegetables; fruits; forages
Crop adjacent to well in 2010: grains; oilseeds; vegetables; fruits; forages
Presence/absence of livestock
Type and number of livestock
Soil characteristics
Is this field subsurface drained? If yes, what percentage of the land is drained?
Is this field irrigated

Google map of field and multi-level well
Farmstead
Please identify on the above map buildings, septic system, manure storage facilities, milkhouse, waste treat facility, pesticides handling locations, water courses, wells, fuel storage, etc, (if any) show in field above.

_____________________________________________________________________________

Best management practices
Do you have an environmental farm plan? When was it peer reviewed?
Are there any BMPs which have been implemented on your farm?
in the past 5 years
10 years
20 years?

If yes, which ones?

Do you use soil testing to determine nutrient application rates? If yes, how often do you typically take soil samples?
What has the cropping pattern/rotation been on this field over the last period of time
10 years
20 Years

Mineral Fertilizers:
Type applied:
Approximate application rate:
How has fertilizer use on this field changed over time since 1992?

Manure:
Is manure applied on this field? If so, what years?
Is the manure system solid or liquid. If so, what type (beef, hog, etc.)
Rate of application?

Biosolids:
Have biosolids been applied. If so, what year(s)?
Rate of application?
Do you fertilize in accordance with soil test recommendations (yes/no)
General comments on water quality in your municipality
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

APPENDIX B

Bacteria Certificate of Analysis
Certificate of Analysis

Lab Work Order #: L952118
Project P.O. #: NOT SUBMITTED
Job Reference: WB 9222-00
Legal Site Desc: 095033
C of C Numbers: 095033

Date Received: 09- NOV- 10
Report Date: 11- NOV- 10 07:28 (MT)
Version: FINAL
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* Detection Limit for result exceeds Criteria Specific Limit. Assessment against Criteria Limit cannot be made.

** Analytical result for this parameter exceeds Criteria Specific Limit listed on this report.

Ontario DW Std O.Reg 169/03 JUNE 2007
A 100mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5±0.2°C for 24±2h.

Method ID: WT-TM-1200

A 100mL volume of sample is filtered through a membrane, the membrane is placed on mENDO LES agar and incubated at 35±0.5°C for 24±2h.

Method ID: WT-TM-1200

Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
<table>
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The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.
### Chain of Custody / Analytical Services Request Form

#### Instructions
- **Instructions:**
  - Complete all fields as necessary.
  - Review the form for accuracy before submission.
  - Ensure all information is legible and complete.
  - Please provide a copy of the original data or product/packaging for reference.

#### Analysis Request
- **Sample Information**
  - **Type:**
    - **Sample Name:**
      - **Sample Code:**
    - **Location:**
    - **Sample Collection:**
    - **Sample Description:**
  - **Sample Condition:**
  - **Special Instructions/Comments:**

- **Number of Containers:**
  - **Condition:**
  - **Type:**
  - **Date Collected:**
  - **Time Collected:**
  - **Prepared By:**
  - **Received By:**
  - **Prepared Date:**
  - **Received Date:**

- **Analysis Request**
  - **Sample Analysis:**
    - **Test:**
      - **Test Code:**
    - **Test Description:**
  - **Sample Preparation:**
    - **Preparation Method:**
    - **Preparation Notes:**

- **Certification**
  - **Sample Certification:**
    - **Certification Code:**
    - **Certification Notes:**

- **Company Information**
  - **Company Name:**
    - **Address:**
    - **Phone:**
    - **Fax:**
  - **Contact Person:**
    - **Title:**
    - **Phone:**
    - **Fax:**

#### Signature
- **Signature:**
  - **Date:**
  - **Position:**

#### Additional Notes
- Any additional notes or information that may be relevant to the sample analysis.

---

### Additional Details
- **Page:**
  - **Version:**
  - **Document Name:**
  - **Creator:**
  - **Date Created:**
  - **Date Modified:**
  - **Status:**
  - **Revision:**

---

### Contact Information
- **Phone:**
  - **Fax:**
  - **Email:**

---

**Note:** All information should be entered accurately to ensure the integrity of the sample analysis process.
Certificate of Analysis

Lab Work Order #: L951502
Project P.O. #: NOT SUBMITTED
Job Reference: WB9222-00
Legal Site Desc:
C of C Numbers: 095032

Nancy Graham
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]
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* Detection Limit for result exceeds Criteria Specific Limit. Assessment against Criteria Limit cannot be made.

** Analytical result for this parameter exceeds Criteria Specific Limit listed on this report.

Ontario DW Std O.Reg 169/03 JUNE 2007
A 100mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at @44.5±0.2°C for 24±2h.
Method ID: WT-TM-1200

A 100mL volume of sample is filtered through a membrane, the membrane is placed on mENDO LES agar and incubated at 35±0.5°C for 24±2h.
Method ID: WT-TM-1200

Methods Listed (if applicable):

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Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

095032

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

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<tr>
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<th>Laboratory Definition Code</th>
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<tr>
<td>WT</td>
<td>ALS LABORATORY GROUP - WATERLOO, ONTARIO, CANADA</td>
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</table>

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Application of criteria limits is provided as is without warranty of any kind, either expressed or implied, including, but not limited to fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information.
## Test Results

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Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

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2

Comments:

SUBMISSION # 105102

DATE RECO'D

2/11/10

ENTR'D BY

88

RECEIVED # 1517.01

REF:

R-03

NOTE:

- The water samples received are to be prepared for human consumption.
- If yes, no unauthorized drinking water C.O.C. has been used for this submission.
- Any sample taken from a regulated OW system?

THE QUESTIONS BELOW MUST BE ANSWERED FOR WATER SAMPLES (CHECK YES OR NO):

- Any sample taken from a regulated OW system?
- If yes, no unauthorized drinking water C.O.C. has been used for this submission.

SAMPLE INFORMATION/COMMENTS:

- Sample Description to appear on report
- Sample information to appear on report
- Report form / distribution

ANALYSIS REQUEST:

- 3-Day T.R (100%)
- 5-Day ( Reignard)
- 2-Day T.R (65%)
Certificate of Analysis

Lab Work Order #: L955565
Project P.O. #: NOT SUBMITTED
Job Reference: WB92222-00
Legal Site Desc: 095031C
C of C Numbers: 095031

Nancy Graham
Account Manager

WESA
ATTN: TIFFANY SVENSSON
171 VICTORIA STREET, SOUTH
KITCHENER ON N2H 5C5
Phone: 519-742-6685

Date Received: 19- NOV-10
Report Date: 22- NOV-10 10:14 (MT)
Version: FINAL

[This report shall not be reproduced except in full without the written authority of the Laboratory.]
### Sample Details/Parameters

<table>
<thead>
<tr>
<th>Sample Details/Parameters</th>
<th>Result</th>
<th>Qualifier</th>
<th>D.L.</th>
<th>Units</th>
<th>Criteria Specific Limits</th>
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<td>CFU/100mL**</td>
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</table>

**Analytical result for this parameter exceeds Criteria Specific Limit listed on this report.**

**Detection Limit for result exceeds Criteria Specific Limit. Assessment against Criteria Limit cannot be made.**

---

* Ontario DW Std O.Reg 169/03 JUNE 2007*
A 100mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at @44.5±0.2°C for 24±2h.

Method ID: WT-TM-1200

A 100mL volume of sample is filtered through a membrane, the membrane is placed on mENDO LES agar and incubated at 35±0.5°C for 24±2h.

Method ID: WT-TM-1200

Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Chain of Custody numbers:

095031

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.

< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory. UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Application of criteria limits is provided as is without warranty of any kind, either expressed or implied, including, but not limited to fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information.
<table>
<thead>
<tr>
<th>Test</th>
<th>Matrix</th>
<th>Reference</th>
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<th>Units</th>
<th>RPD</th>
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Legend:

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<tr>
<th>Qualifier</th>
<th>Description</th>
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</thead>
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<tr>
<td>Limit</td>
<td>99% Confidence Interval (Laboratory Control Limits)</td>
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<td>DUP</td>
<td>Duplicate</td>
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<td>RPD</td>
<td>Relative Percent Difference</td>
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<td>N/A</td>
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<td>LCS</td>
<td>Laboratory Control Sample</td>
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<td>SRM</td>
<td>Standard Reference Material</td>
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<td>MS</td>
<td>Matrix Spike</td>
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<td>MSD</td>
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<td>Average Desorption Efficiency</td>
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<td>MB</td>
<td>Method Blank</td>
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<td>IRM</td>
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<td>CRM</td>
<td>Certified Reference Material</td>
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<tr>
<td>CCV</td>
<td>Continuing Calibration Verification</td>
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<td>CVS</td>
<td>Calibration Verification Standard</td>
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<td>LCSD</td>
<td>Laboratory Control Sample Duplicate</td>
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Sample Parameter Qualifier Definitions:

<table>
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<th>Qualifier</th>
<th>Description</th>
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<tbody>
<tr>
<td>RPD-NA</td>
<td>Relative Percent Difference Not Available due to result(s) being less than detection limit.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Sample Condition</th>
<th>Sample Description to Appear on Report</th>
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</thead>
<tbody>
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</tbody>
</table>

**Notes and Conditions**
- Please use the correct sample types for water analysis.
- Ensure all samples are properly labeled and dated.
- Submit samples within 24 hours of collection.

**Special Instructions/Comments**
- Any known or suspected hazards relating to the sample must be noted.
- Ensure all samples are properly preserved for testing.

**Sample Data**
- **E. coli and total coliforms**
  - 1000-1
  - 1000-2
  - 1000-3
  - 1000-4

**Sample Submission**
- **Date of Collection**
  - 10/04/09

**Analysis Request**
- **Company Name**
  - ABCD
- **Address**
  - 123 Main St.
- **Phone**
  - 555-1234
- **Fax**
  - 555-4321

**Analysis Services Request Form**
- **Chain of Custody**
  - Signed by: 
  - Date: 10/04/09

**Page 1 of 3**
- **Document Control**
  - 095031
APPENDIX C

Participant Comparative Analysis Summary
ADDRESS

Re: Water Quality Results from the Ontario Farm Groundwater Quality Survey sampled Multilevel Well.

Dear Mr. _____

The Nottawasaga Valley Conservation Authority and WESA would like to thank you for your cooperation in participating in our study to determine the feasibility of re-sampling multilevel wells installed on your farm during the 1991-92 Ontario Farm Groundwater Quality Survey. Without your support and collaboration, this project would not have been possible.

The buried multilevel well located on your property consisted of ____ levels, of which samples were obtained and analyzed from depths ranging from ___ to ____ meters below the ground surface.

Please find below the summary results of the E.coli, total coliforms and nitrate analysis from the buried multilevel well located on your property. The table below includes the data from the original sampling events completed in the fall and winter of 1991 and 1992 and the summer of 1992 as well as results from the recently completed sampling event in the late fall, 2010.

<table>
<thead>
<tr>
<th>Well and level</th>
<th>Water quality results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Winter, 1991</td>
</tr>
<tr>
<td>Nitrate</td>
<td>E. Coli</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Feasibility Pilot Study: Re-Sampling Multilevel Wells

It is noted that this well is not a source for potable private drinking water. Please note that it is generally recommended that you test your private potable drinking water supply approximately 3 times a year; please contact the local health unit at (705) 721-7330 to find the nearest location for the testing.

If you have any questions regarding the sampling and analysis of the well or wish to receive a copy of the final report, please contact Ryan Post at 705-424-1479 ext 249 or via email at rpost@nvca.on.ca.

Thank you,

Ryan Post

Tiffany Svensson, M.Sc., P.Geo. Senior Hydrogeologist
WESA Inc. - 171 Victoria Street North, Kitchener, Ontario, Canada N2H 5C5
APPENDIX D

Photographs from site visits and sampling events
Locating buried well using a 3M 1420 EMS-iD Marker Locator.

Multilevel wells were in near original condition when located and uncovered.
Sampling techniques and equipment were the same or similar to those used during the 1991/92 survey.
Sites where chisel plows or rippers were noted as being used the MLW were not successfully located.

At site 1029 the PVC well casing cap was found at surface. The MLW was therefore deemed to be unrecoverable since the 3M 1432 Near-Surface (2' depth) Marker which was originally attached to the PVC well cap would no longer be associated to the location of the MLW.