October 20, 2021

Ron Pols
Pols Ltd.
52009 Regional Road 24
Wainfleet, ON L0S 1V0

Re: Hydrogeological Assessment – Draft Plan of Subdivision, 53814 Zion Road, Wainfleet, ON

Dear Mr. Pols,

1.0 Introduction, Background Information and Purpose

Terra-Dynamics Consulting Inc. was retained to complete a Hydrogeological Assessment to assess sewage impacts for six proposed 0.40-0.94 hectare severances (Upper Canada Consultants, 2021, Appendix A) from 53814 Zion Road, located in the Township of Wainfleet (Site, Figure 1). The hydrogeological study is required by the Township of Wainfleet (Township), and Niagara Region, as lots will be proposed that are smaller than 1.0 hectare (Township, 2021a). Relevant municipal zoning by-law and official plan policies to consider include:

1. Township of Wainfleet Zoning By-law, Section 6.2.1 (Township, 2014):

   The minimum lot size shall be 1 hectare unless a hydrogeological study undertaken by an applicant demonstrates that on-site suitable private services can be achieved on a smaller lot with no negative impacts on surface and/or ground water features, in which case the minimum lot size is 4,000 m^2 (1 acre)

2. Niagara Region Policy 5.C.6.4 (Niagara Region, 2014)

   Proposals for rural residential development in the Rural Area must meet the following criteria, in addition to the other requirements of this Official Plan….

   d) Soil and drainage conditions are suitable and permit the proper siting of buildings, the supply of potable water and the installation and long-term operation of an adequate means of waste disposal

   i) …For residential development consisting of up to three lots the minimum lot size will be 1 hectare unless it is determined through a hydrogeological study that considers potential cumulative impacts that a smaller size lot will adequately accommodate private water and sewage treatment facilities for long term operation.

The following documents the hydrogeological assessment of the Site.

It is also noted that the Niagara Peninsula Conservation Authority (NPCA) policy 8.2.3.5 (2019) does not allow a septic system within 30 metres of a wetland. Portions of policy 8.2.3.5 are presented below:

"*Proposed New Development within 30 metres of a Wetland*

a) For new residential development, no new septic systems are permitted within 30m of any wetland.

It is our understanding that the location of the sewage disposal system at Lot 6 (Appendix A) is to be revised before agency submission to comply with this criterion.

2.0 Methodology

The following methodologies were used to investigate the Site:

A. Submission of a Hydrogeological Study Terms of Reference to Niagara Region and the Township.

B. Evaluation of Ministry of Environment, Conservation and Parks (MECP) water well and Ministry of Natural Resources and Forestry (MNRF) well records located within 500 metres of the Site.

C. A site visit that included inspection for any existing water supply wells, collection of four shallow soil-samples by hand-auger and observations of watercourses on-site.

D. A water well and septic system survey of properties within a 250 m radius of the Site (Figure 2).

E. Assessment of geological information using regional mapping of elevation, sediments/overburden, bedrock, geotechnical records and nearby hydrogeological studies.

F. Preparation of a description of the hydrogeological setting using physical/geological information and water levels.

G. Assessment of the aquifer vulnerability completed using (a) provincial procedure D-5-4 (MECP, 1996a) and (b) groundwater vulnerability procedures described by the Niagara Peninsula Source Protection Authority (NPSPA) (NPCA, 2013).

H. A predictive assessment of sewage impacts was completed including a nitrate-nitrogen dilution calculation for the proposed septic systems as per provincial procedure D-5-4 (MECP, 1996a).

Terra-Dynamics Consulting Inc. began the assessment once confirmation of the appropriateness of the Terms of Reference was received from Niagara Region (2021) and the Township of Wainfleet (2021b).

As the new lots will be provided potable water via cisterns, this report does not include a water supply assessment (MECP, 1996b), but it is recommended that a development agreement be implemented that will indicate water supply by cisterns only.

3.0 Ministry of Environment, Conservation and Parks (MECP) Water Well Records

MECP water well records within 500 m of the Site were reviewed and fourteen records identified (Appendix B). None of the Provincial records plot at the Site (Figure 2), and no water wells were identified during our site visit, although historical (1934/1965) aerial photos suggest previous dwellings at the Site. Most (12 of 14) of the wells were constructed between 1959 and 1978.

Nine (9) of the wells were constructed in 1969-1970 to the southeast of the Site, for the Ontario Water Resources Commission (OWRC) as monitoring/observation wells. The OWRC wells were completed to

various depths in the bedrock aquifer, and in close proximity to one another (e.g. four records plot at one location: 6602410, 6602771, 6602772, 6602773), with only one record completed in the deep overburden overlying the bedrock (6602774). The remaining Provincial well records were for domestic water supply. Nine (9) of the fourteen (14) Provincial well records indicate completion in bedrock, with the depth to bedrock between 32.9 and 33 metres below ground surface (m BGS). The remaining four (4) overburden wells were completed in either clay and gravel (6602201), sand and gravel (7103206) or gravel (6603229) overburden potentially overlying bedrock.

Water well contractor water quality observations were generally sulphurous or mineral, with some 'heavy' mineral quality noted, and limited observations of 'fresh' conditions at some deep overburden and upper bedrock locations. Also, one Provincial record was for a well abandonment (7104776) because of poor water quality at location 7103206, and Provincial record 6603229 indicates the constructed well was immediately abandoned because of poor water quality.

Two of the Provincial records (6603229 and 7103206) were completed on the Cemetery Sand Dune (Section 5.1, Figure 2) and recorded surficial brown sand of between 4.9-5.4 metres (16-18 feet) thick. Underlying the sand was clay becoming clay till, 30.8-31.8 metres (101-104 feet) thick. These clay and clay till layers protecting the Salina Formation (Armstrong and Dodge, 2007) bedrock aquifer have been identified as a series of aquitard by the Ontario Geological Survey (Burt, 2020).

4.0 Water Supply and Septic System Survey Results

A water supply and septic system survey (Appendix C) was mailed in June 2021 to the twenty-four (24) parcels within 250 m of the Site (Figure 2). Three survey responses were received (Table 1, Appendix C).

Table 1 – Water Well and Septic Survey Results

Addresses	Survey Details
43775 Highway 3	Cistern
43832 Highway 3	Two shallow large (4 foot) diameter wells
43954 Highway 3	Shallow 'spring fed' well, (3 foot) diameter, 12 feet deep

The two shallow wells at 43832 Highway 3 exert 30 metre set-backs from sewage disposal systems (Sharaf, 2013) which extend onto the Site (Figure 2). However, the proposed sewage disposal systems for the Site (Appendix A) are located further than 140 metres away, and no new sewage disposal systems are proposed topographically upgradient of these shallow wells.

5.0 Physical Setting

The Site is within the Big Forks Creek watershed which eventually outlets to the Welland River (AquaResource Inc. and NPCA, 2009). The ground surface slopes from a topographic high of 179-181 metres above sea level (m ASL) to the northwest and southeast to elevations of 178 and 176 m ASL, respectively (Figure 3). Consequently, NPCA have mapped a subwatershed drainage divide across the Site between Big Forks Creek Catchment W300 to the northwest, and the Ellsworth Drain Catchment W100 to the southeast (Figure 2).

NPCA (2017) have mapped two seasonal waterbodies at the Site (Figure 2). One of these seasonal waterbodies is within the Marshville Station Clay Plain Wetland Complex provincially significant wetland

(MNRF, 2009) (Figure 2). The seasonal waterbody within the PSW can outlet to a constructed open ephemeral watercourse (NPCA, 2017) which could flow to the Ellsworth Drain. The Ellsworth municipal Drain is located immediately to the southeast of the Site (Figure 2) and the Department of Fisheries and Oceans (DFO) have identified it as Class F (intermittent) (OMAFRA, 2021). NPCA has reported the intermittent drain as Type 2 – Important Fish Habitat, which may be an error as Ellsworth Drain is not listed in the fish habitat types (MNRF, 2016). The Ellsworth Drain was observed by Terra-Dynamics as flowing adjacent the Site on July 28th with 9.1 mm of precipitation recorded over the previous 7 days (Environment Canada, 2021). Given the size of the upgradient catchment, despite the recent precipitation, this observation 1 day after a rain event may qualify as a baseflow measurement (MacViro, 2009) but the 30 cm depth of surface water was warm at 21°C and no surface water was observed discharging from the constructed open ephemeral watercourse on-site.

The MNRF (2009) have reported the polygon of the Marshville Station Clay Plain Wetland Complex at the Site as a hardwood community swamp, with tall shrubs as the dominant form and also narrow-leaved emergents (e.g sedge, rushes and grasses).

5.1 Soils

The very fine sandy loam soils (Figure 3) are mapped as primarily (80%) Walsingham soils, with Flamborough Brown Phase soils (20%) limited to the southeast corner (Kingston and Presant, 1989). The soils are described as:

a) Walsingham: developed on eolian deposits (i.e. fine sand parent materials) with imperfect drainage due to "*fluctuating water tables within the B and C horizons*", at least 1 m thick and hydrological soil group A, and
b) Flamborough: developed on loamy fine sand parent materials, moderately to rapidly permeable, and hydrologic soil group 70% C / 30% B. The soils are tile-drained for agriculture south of Highway 3 across from the Site but not at the Site (Figure 3, OMAFRA, 2021).

Soil-samples were collected by hand-auger from four locations to confirm local soil conditions (Figure 3) and the results summarize below:

1. HA-1, 0.5 m deep, at Lot 6, 20 cm of silty sand topsoil overlying clay, non-calcareous
2. HA-2, 1 m deep, at Lot 2, silty sand topsoil to 35 cm becoming very fine silty sand, non-calcareous to 60 cm at a 5 cm clay layer)
3. HA-3, 1 m deep, at Lot 4, very fine silty sand, non-calcareous to 80 cm
4. HA-4, 0.9 m deep, at Lot 4, silty sand topsoil to 36 cm becoming very fine silty sand to 74 cm overlying clay, non-calcareous

5.2 Overburden Geology

The Site is located on the Dunnville Sand Plain (Chapman and Putnam, 1984). A northeast-southwest trending aoelian sand dune (Feenstra, 1984) covers approximately 2/3 of the Site (Figure 2). This 3 km long dune has been named the Cemetery Dune by Pastirik (1985) as there are two cemeteries located on the dune immediately northeast of the Site. Glaciolacustrine nearshore and deltaic silty sand is mapped on the northwest and southeast flanks of the Cemetery Dune at the Site (Figure 2) which was laid down over the glaciolacustrine clay and silt (Pastirik, 1985). The thickness of the dune sand is estimated as 5 metres based upon nearby water well records (Section 3), topographic contours, surficial

geological mapping, and the hand-auger soil sampling and is underlain by a silty clay to clay aquitard as summarized in a Hydrogeologic Schematic (Figure 4).

5.4 Hydrogeologic Setting

5.4.1 Overburden Aquifer

The sand at the Site has been identified as a regressive overburden aquifer by the Ontario Geological Survey (Burt, 2020). The water table in the dune is expected to be fairly flat and not mounded due to expected high hydraulic conductivities for recharge (Haitjema and Mitchell-Bruker, 2005, MECP, 2006). However, the depth to the water table was not able to be determined as it has not been reported by the MECP, encountered during hand-augering or during observations of surface water courses.

Water balance modelling completed for the Niagara Peninsula Conservation Authority (NPCA) estimated the average annual infiltration rates for the proposed lots (Appendix A) as ranging from 135 to 188 mm/year (AquaResource Inc. and NPCA, 2009). These infiltration rates are reasonable (Table 1) for the physical setting as the MECP (1995) reports the range for silty sand to sandy silt as 150-200 mm/year.

Table 1 - Lot Average Annual Infiltration Rates (mm/year)

Lot	1	2	3	4	5	6
Infiltration Rate	188	181	179	177	169	135

5.4.2 Unconfined Aquifer Conceptual Model

The information for the Site is summarized in the schematic below, as a conceptual model for the assessment of potential sewage system impacts to groundwater and private wells (Figure 5).

5.4.3 Aquifer Vulnerability

The Site has been mapped as on a Highly Vulnerable Aquifer (HVA) by the Niagara Peninsula Source Protection Authority (NPSPA, 2013). This HVA designated was because of the potential for the Dunnville Sand Plain to be used as a source of potable supply. Although no water well records were identified located showing water takings from the surficial sand aquifer, the water well survey responses for 43832 and 43954 Highway 3 (Section #) show the aquifer is a local source of supply.

Consequently, as a result of the at-surface aquifer being highly vulnerable to at-surface activities (MECP, 1996a) as per Step 2 shown below, a contaminant assessment was completed to see if lot sizes are appropriate, as per Step 3 (Figure 6).

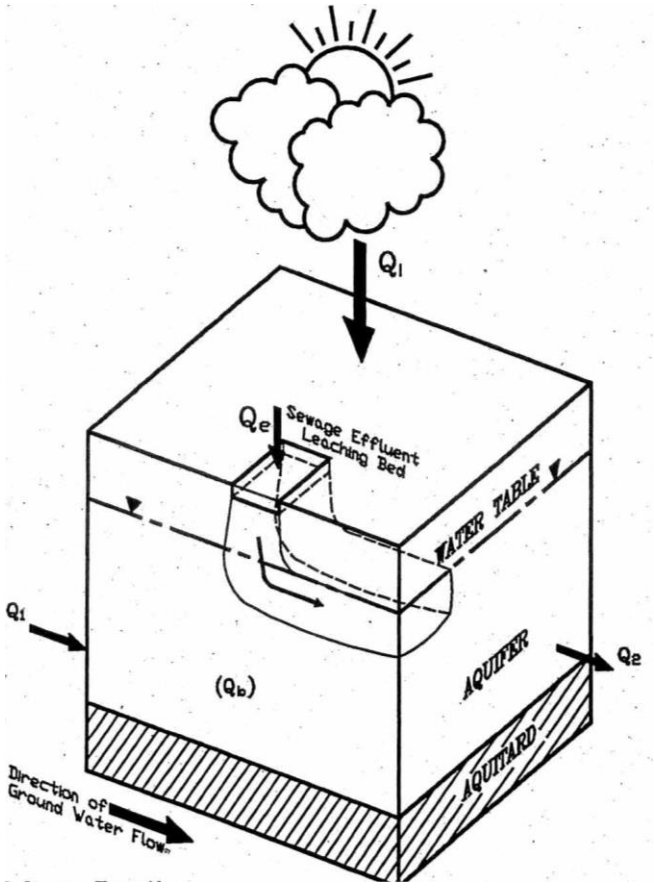

Figure 5 - Unconfined Aquifer Impact Assessment Subsurface Sewage System (MECP, 1995)

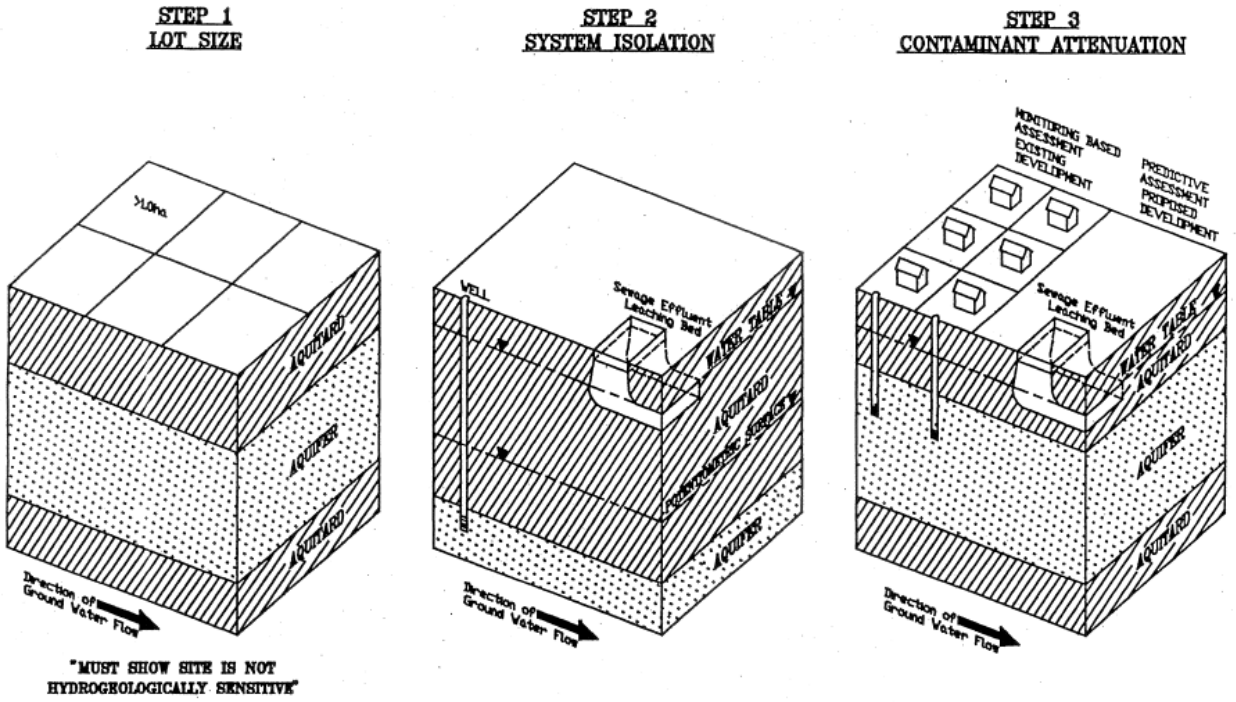

Figure 6 – Three Step Water Quality Assessment Process (MECP, 1995)

6.0 Prediction of Contaminant Attenuation

6.1 Off-Site Nitrate-Nitrogen Assessment

Using Provincial Procedure D-5-4 (MECP, 1996a), an assessment was completed to calculate the per lot property boundary nitrate-nitrogen (NO_3-N) groundwater concentrations. The calculations are presented in Appendix D and summarized herein:

1. For the purposes of predicting the potential for groundwater impacts a concentration of 40 mg/L nitrate-nitrogen is used for sewage effluent for a Class IV system, i.e. without Level IV (or tertiary treatment) nitrogen reduction (MECP, 1996a).
2. Average, not peak, sewage loading rates are used, which is 1,000 Litres/day for a three-bedroom homes, and for four- and five-bedroom homes average rates of 1,200 and 1,400 Litres/day, respectively (City of Hamilton, 2013).

3. Each entire lot was considered for dilution of the sewage effluent to calculate if 40 mg/L of nitrate-nitrogen (NO_3-N) is diluted below the drinking water standard of 10 mg/L (i.e. Safe Drinking Water Act, 2002).

4. Infiltration rates were extracted from NPCA water balance modelling (Section 5.4.1, Table 1).

Nitrate-nitrogen concentrations for standard Class 4 septic systems generally exceeded the 10 mg/L criterion except at Lot 6 for a 3-bedroom home (Table 2).

Table 2 – Nitrogen Dilution Loading Calculations (mg/L)

Lot	1	2	3	4	5	6
3-bedroom (1,000 L/day sewage loading)						
Class 4	**10.9**	**11.2**	**11.6**	**11.4**	**9.9**	8.9
50% Nitrogen Reduction (N-I)	5.4	5.6	5.8	5.7	4.9	4.5
4-bedroom (1,200 L/day sewage loading)						
Class 4	**12.4**	**12.7**	**13.2**	**12.9**	**11.3**	**10.3**
50% Nitrogen Reduction (N-I)	6.2	6.4	6.6	6.5	5.6	5.1
5-bedroom (1,400 L/day sewage loading)						
Class 4	**13.7**	**14.1**	**14.5**	**14.3**	**12.6**	**11.5**
50% Nitrogen Reduction (N-I)	6.9	7	7.3	7.1	6.3	5.7

However, with nitrogen effluent reduction treatment of 50% which corresponds with a sewage effluent nitrogen concentration of 20 mg/L or less, all proposed lots provided sufficient dilution for 3-, 4- or 5-bedroom homes. The 50% nitrogen effluent reduction criterion corresponds with the CAN-BNQ 3680-600 standard of N-I (50%) total nitrogen reduction (Ministry of Municipal Affairs and Housing, 2011).

6.2 Off-Site Phosphorus Considerations

The proposed locations, and the physical setting of the sewage disposal systems should be sufficient to attenuate sewage effluent phosphorus before any discharge at the Zion Road ditch, the closest surface downgradient water body. This conclusion is based upon: (i) the sewage disposal systems being

between 15-45 m from the Zion Road ditch, (ii) on non-calcareous soils, (iii) and (iv) sufficient iron and aluminum in the sands (Pastirik, 1985). As stated by Roberston et al (1998) in their review of phosphate mobility and persistence in 10 Septic System Plumes "….*smaller scale phosphate plumes (<3 m in length) are present at the acidic sites on noncalcareous sands and on silt- and clay-rich sediments*".

6.3 Effluent Treatment

The Township of Wainfleet is the local approval authority for Part 8 Ontario Building Code septic system permits and allows the use of Level IV/Tertiary treatment to improve septic effluent quality (De Guire, 2019).

In Ontario, certification of systems for nitrogen removal had begun through the application of the CAN-BNQ 3680-600 standard (Ministry of Municipal Affairs and Housing, 2011). The available systems with certified 50% (or referred to as N-I) nitrogen removal are listed on the Ontario On-site Wastewater Association (https://www.oowa.org/consumer-information/options-onsite-residential-wastewater-treatment-technologies/). There is currently one treatment provider with these specifications, Norweco Inc. (https://www.norweco.com/). However, there are also other systems which have test data showing system performance of reducing effluent nitrogen to greater than 75% nitrate-nitrogen such as Bionest with a DE-OX unit has a reported total nitrogen effluent quality of 6 mg/L (Gauther, 2019) , or a Waterloo Biofilter Unit with WaterNOx^{TM} (an advanced nitrogen removal filter) is expected to be less than 5 mg/L total nitrogen (https://waterloo-biofilter.com/products/nutrient-removal/nitrogen-removal-products/waternox/).

6.4 Other Considerations

Development agreements should be completed that cisterns will be used for water supplies on the severances.

Future sewage system effluent disposal locations (e.g. raised leaching or filter bed) are constrained by the Part 8 Ontario Building Code set-back of 15 metres from a cistern (referred to as a reservoir in the code).

Recommend sewage disposal bed mantles should be sloped to the west.

7.0 Summary of Recommendations

The proposed lots (Appendix A), can be safely serviced by private sewage systems with the implementation of the following recommendations:

1. All lots be equipped with sewage systems that provide at least 50% nitrogen reduction of septic sewage effluent Level IV/tertiary treatment;

2. Future sewage disposal systems observe the required Ontario Building Code set-backs from water supplies and surface water;

3. A development agreement should be completed with the Township indicating water supply will be by cistern(s); and

4. Recommend sewage disposal bed mantles should be sloped to the west.

We trust this information is sufficient to your present needs. Please do not hesitate to contact the undersigned if you have any questions.

Yours truly,

TERRA-DYNAMICS CONSULTING INC.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer

cc. William Heikoop, Upper Canada Planning & Engineering Ltd.

Attachments
Figure 1 - Location of Site
Figure 2 – Site Details
Figure 3 – Soils
Figure 4 – Hydrogeologic Cross-Section
Appendix A – Draft Plan of Subdivision
Appendix B – MECP Water Well Logs
Appendix C - Water Use and Septic System Surveys
Appendix D – Nitrogen Dilution Calculations

8.0 References

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