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CONSULTING

NON-INVASIVE GROUNDWATER ASSESSMENT
Mobile Park
Devon, NS

October 3, 2024

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October 3, 2024

Mr. Blair Van Veld
Twin River Home Builders
2703 Granton Abercrombie Road
New Glasgow, NS B0K 1H0

Dear Mr. Van Veld,

Re: Non-invasive Groundwater Assessment
Mobile Park, Devon, NS

Attached is the Non-invasive Groundwater Assessment report prepared for Mobile Park in Devon, NS.

The report documents our observations, findings, and recommendations.

We trust this to be satisfactory at this time. Once you have had an opportunity to review this correspondence, please contact us to address any questions you may have.

Thank you.

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EXECUTIVE SUMMARY

Strum Consulting was commissioned by Twin River Home Builders to conduct a Noninvasive Groundwater Assessment for a proposed residential Mobile Park in Devon, Halifax, NS. The proposed residential mobile park is located off Old Guysborough Road, within the Halifax Regional Municipality of NS. The construction is anticipated to consist of between 120 and 150 mobile homes, with each mobile home containing up to three bedrooms.

Based on the Non-invasive Groundwater Assessment findings, the following recommendations are forwarded. Please refer to the Report for a complete analysis and a comprehensive list of recommendations.

1. Test pits, as part of the Level II (Invasive) Groundwater Assessment, should be conducted in key areas to determine if any hydrocarbon contamination exists where the abandoned tank and vehicles are located.

2. Should the proposal be approved, it is recommended that the next evaluation phase be undertaken, which is a Level II (Invasive Groundwater Assessment. This will require the installation of a minimum of five test wells. The test well layout should be parallel and perpendicular to major structural trends to consider anisotropy. In addition, the density of wells, effects of linear well placement, and assessment of long-term interference between wells on and off-site should be evaluated.

3. Well depths should be 91 m (300 feet) minimum unless the desired air lift yield is attained at a shallower depth, with two casing lengths or to bedrock (whichever is greater) and grouted in place. Additional depth may be added if the driller's airlift yield is less than 50 Lpm per residence to be supplied. Wells should be spaced at least 30 m minimum from one another or greater at the planning stage and avoid areas where abandoned oil tanks and cars were left within the site.

4. Step drawdown testing, constant rate testing, and analysis that meets current NS Guidelines for Subdivisions should be carried out on each test well. It will be important to confirm available information and verify how many wells can be supported in the given area, the long-term safe yield from each well, and evaluate potential interference effects and long-term trends in water levels in the bedrock aquifer.

5. During step drawdown and constant rate pumping tests, observation wells should be monitored.

6. Water samples should be collected from each test well as part of an Invasive Groundwater Assessment, which would include an analysis of water samples for general chemistry and metals (RCAp-MS), total dissolved solids (TSS), fluoride, Volatile Organic Compounds (VOCs), petroleum hydrocarbons, and bacteria (total

coliform and E. coli by actual count). In addition, water treatment options and management of those options (treatment devices) should be implemented if quality issues exist.

7. Monitoring of any surface water bodies within 60 m should be conducted during the pump test program to assess surface–groundwater interactions.

8. Potential groundwater quality concerns related to the proposed development were noted. These concerns relate to iron, pH, and manganese. Water treatment devices exist for these contaminants and can be implemented if testing determines their presence above applicable guidelines.

9. Available resources through Nova Scotia Natural Resources and Renewable (2013) list the site as containing acid-bearing slates. It is recommended that potential environmental issues relating to acid rock drainage (ARD) be recognized and assessed further if future disturbance or exposure of bedrock is anticipated (i.e., as part of construction work). Any ARD-related issues are governed by the NS Sulphide Bearing Material Disposal Regulations (N.S. Reg. 57/95).

10. An updated layout of lots, per the recommendation of this report, should be developed. This should include locations of proposed homes, wells, and wastewater treatment systems. The design should include a stormwater management plan to minimize impacts to adjacent wetlands and watercourses.

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1.0 INTRODUCTION

Strum Consulting was commissioned by Twin River Home Builders (the "Client") to conduct a Level I (Non-invasive) Groundwater Assessment for a proposed residential Mobile Park in Devon, Halifax, NS. The proposed residential mobile park is located off Old Guysborough Road, within the Halifax Regional Municipality (HRM) of NS (Drawing 1, Appendix A). The subject property comprising the proposed development areas is herein referred to as the "site."

The Non-invasive Groundwater Assessment was completed based on the Level I, Nova Scotia Environment and Climate Change (NSECC) Guide to Groundwater Assessments for Subdivisions Serviced by Private Wells (2011).

The following report presents the findings of the Non-invasive Groundwater Assessment for the proposed residential mobile park.

2.0 SITE DESCRIPTION

2.1 Definition of Study Area

For the purpose of this report, the site comprises the proposed development area, a Mobile Park in Devon, HRM, as described below in Section 2.2. Therefore, "adjacent properties" refers to the remaining portion near the study area, which includes all adjoining lands within 500 m of the site property boundaries.

2.2 The Site

The property [Parcel Identification Number (PID) 41354119, 40705113, 40588212, 00521708, 41396631, 41396623] consists of approximately 24.3 hectares (ha) of land on Old Guysborough Road, in Devon, NS. It is proposed that the residential development will occupy approximately 10 ha of the site, leaving 14.3 ha as green space (Drawing 1, Appendix A). The proposed project intends to construct between 120 to 150 mobile homes. These proposed homes will range between 2-bedroom and 3-bedroom dwellings. Each mobile home will be constructed on 120 x 60 ft (36.6 m x 18.3 m) lots, with a single gravel driveway for each home.

2.3 Proposed Site Development

According to the HRM ExploreHRM Zoning tool, the site is located on a land parcel zoned Mixed-Use [MU] (HRM, 2024a). According to communications with the Client, the development is to be serviced by groundwater wells, with one well to produce water for multiple residences. Multiple wells will be required to provide water for all residences.

3.0 SCOPE AND METHODOLOGY

3.1 Scope

The Non-invasive Groundwater Supply Assessment aims to determine the potential for future residents in the proposed subdivision to have potable water of acceptable quality and quantity for domestic consumption for short- and long-term use. The assessment also addresses the potential that potable water in the subdivision may be affected by contamination from on-site or off-site sources, as well as the potential for water conflicts between existing nearby users and sensitive environmental features. The work scope for a Non-invasive Groundwater Assessment consists of a description of the hydrogeology and characterization of the site, as outlined in Section 2.0 of the NSECC Guide to Groundwater Assessments for Subdivisions Serviced by Private Wells (2011). The overall objectives of completing groundwater assessments for proposed subdivision developments are as follows:

1. To minimize the risk of potable water quality and quantity problems in new residential subdivisions.
2. To minimize potential impacts of subdivision developments on existing groundwater users and the environment.

3.2 Methodology

The Non-invasive Groundwater Assessment involved a historical review of pertinent records and interviews with persons who have relevant knowledge of hydrogeological conditions in the area, as well as the completion of a site visit to collect data on the site and surrounding properties. Given the nature of the anticipated development, information collected or reviewed as part of the assessment was used to provide a preliminary assessment of water quality and quantity.

3.2.1 Historical Data Review

Historical records of the site and its surrounding properties were reviewed as part of the Non-invasive Groundwater Assessment. The primary sources of information included aerial photographs, land use, Geonova Interactive geologic and topographic maps, geochemical information, the NS Well Logs and Pumping Test databases, and online reports.

Discussions were also held with the developers to supplement this desktop review.

3.2.2 Site Visit

The objective of the site visit was to observe topographic trends on the site and accessible areas of the adjacent properties, view domestic well sites on the adjacent properties, and assess potential environmental concerns in the area that could negatively impact the site. Detailed observations of these conditions were noted and recorded in a photo log (Appendix B) and discussed in the subsequent sections.

4.0 DESKTOP RECORDS REVIEW AND SITE VISIT

The historical/desktop review and site visit findings are presented in the sections below.

4.1 Records Review Findings

4.1.1 Aerial Photographs

Available Google Earth Pro (2024) aerial imagery from May 2002 to May 2024 were reviewed. The following observations were noted during the aerial photograph review:

- From 2002 to 2020, the site has experienced very little change. The bulk of the site is forested, with four homes/structures along Old Guysborough Road. A couple of dirt roads are found throughout the site.
- From 2021 to 2024, a home is built at 3610 Old Guysborough Road, across from the site.

No environmental concerns which may adversely affect the groundwater in the area were noted during the review of aerial photographs.

4.1.2 Regulatory Information

Strum submitted an NSECC environmental registry request for the properties identified within the study area. Table 4.1 provides a list of property PIDs. The search request results identified an 'On-site Sewage Disposal System Notification Receipt' form relating to a septic system installation at 3610 Old Guysborough Road. This form was created in 2021, corroborating satellite imagery findings. These septic forms are standard for the construction of new homes using septic, and as such, no environmental concerns were noted from the NSECC environmental registry request.

Table 4.1: PIDs Submitted for NSECC Environmental Registry Request

PIDs	
Site	**Off-Site**
41396623	00521856
40705113	40141186
41354119	40620585
40588212	41354101
00521708	41534611
41396631	00521955
-	00521914

4.1.3 Company Records

Company records were requested from the site representative. Company records typically include site development plans, survey plans, and/or building condition and assessment reports.

No company plans or records were provided to Strum by the Client; however, details of the Proposed plan were communicated to Strum in order to conduct this assessment (Section 7.0).

4.1.4 Title Search

A land title search was not completed as part of this assessment.

4.1.5 Previous Environmental Reports

No previous environmental or geotechnical reports were provided to Strum for review as part of this assessment.

4.1.6 Geological Review

Bedrock geology, surficial geology, structural geology, mineral resources, and supporting geological information were also reviewed as part of this assessment. Details of the geological review are discussed in detail in Section 6.0.

4.2 Site Visit Findings

A qualified environmental scientist completed a visit to the site and adjacent properties on September 9, 2024. This site visit was completed without the presence of a Client representative.

4.2.1 Site Observations

The site visit consisted of a walk-through from the northern portion of the site to the southern portion. Additionally, a walk-through of the forested area in the center of the site, along parts of the easternmost and westernmost boundaries, was completed. Refer to the photo log in Appendix B for photos taken during the site visit.

The site is forested throughout, with one major access road running north-south along its western perimeter. Old roadbeds, abandoned vehicles, and culverts (Photos 1-4, Appendix B) indicate historical access roads throughout the site.

Two abandoned vehicles and a domestic oil tank are found within the Site (Photos 3-4, Appendix B). The source of these items is unknown, and it is unknown if any oil or motor oil was released into the environment from these abandoned vehicles and tanks. It is recommended that these be removed from the site and tests pits conducted to confirm if contamination is present as part of the Level II (Invasive) Groundwater Assessment. Well placements should avoid areas directly over top of where these features are situated. Water quality tests will be required once wells are drilled to ensure safe drinking water.

Several abandoned dug wells are found in the northern portion of the site as well as several abandoned homes (Photos 5-8, Appendix B). It is recommended that a qualified well digger decommission the former wells, per the NSECC Water Well Decommissioning Guidelines (2007).

In general, the area slopes from the north to the south, with a watercourse (Paddy's Brook) that enters through the northeastern corner of the site and travels along the center of the site before leaving through the southwestern edge of the site (Drawing 1, Appendix A). Paddy's Brook flows through the site before entering the Clattenburgh Brook Wilderness Area (over 2 km away).

4.2.2 Adjacent Properties

The following section summarizes land use on the adjoining properties located in the study area:

- North – The site abuts Old Guysborough Road. Across the road are a few homes, but mostly privately-owned forested lands. The site's northern portion also abuts several other properties, which contain homes or abandoned homes.
- East – A private road follows most of the eastern side of the site. Beyond this road are privately-owned forested lands.
- South – To the south are forested privately-owned lands, with Clattenburgh Brook Wilderness Area over 2 km away.
- West - To the west of the site, are a few homes and privately-owned forested lands. Some clearing is also seen adjacent to the site

Note: the adjacent properties surrounding the site primarily consist of a few homes and forested areas, with Paddy's Brook flowing south of the site.

4.2.3 Potential Environmental Concerns on the Site and Adjacent Properties

The only environmental concerns noted on or off-site were of the vehicles, tanks, and homes present on the site.

5.0 TOPOGRAPHY, DRAINAGE, AND WATERSHEDS

5.1 Regional Topography, Drainage, and Watersheds

The site lies within the Eastern Interior Ecodistrict, which occupies 457,464 hectares and stretches from Halifax to the community of Guysborough. Lakes, rivers, and wetlands make up a large component of the land area. This area is typically underlain by either poor, shallow soils or deep, well-drained soils. The topography within the ecodistrict can be quite significant, especially where drumlins are present. However, the site is not located within drumlin-concentrated areas (NSNRR, 2019; Keppie et al., 2000).

The primary watershed for the site is the Musquodoboit River watershed, with the secondary watershed being the Porters Lake watershed (Drawing 2, Appendix A). Surface water on the site will be controlled by topography, rivers, streams, and drainage ditches along established

access roads. Drainage throughout the site will be controlled by local topography. This local drainage will likely flow into Paddy's Brook, which flows towards the Clattenburg Brook Wilderness Area, and North Lake.

6.0 HYDROGEOLOGY

The hydrogeology of the proposed development area, including the site, will be discussed in two major sections: surficial and bedrock hydrogeology. Each section contains an overview of geology, water quantity, and water quality.

6.1 Surficial Hydrogeology

6.1.1 Surficial Geology

A single surficial geological unit, a silty till plain (Drawing 4, Appendix A), overlies the site and surrounding area. The silty till plain is formed by ground moraine and streamline drift. These features are compact silt materials transported from local and distant sources by glacial movement and are generally 3 – 30 m in thickness (Stea et al., 1992).

6.1.2 Water Quality from Surficial Deposits

Based on the NS Well Logs Database (2022), no dug wells were found within a 500 m buffer of the site (Table 1, Appendix C). Although two abandoned dug wells were found on the site during the site visit, there are no records of these wells to determine their hydrological characteristics. No surficial aquifers are mapped within or near the site.

With limited available resources on surficial water quality within the site and its surrounding area, it is difficult to determine the expected water quality. In general, hardness, iron, manganese, colour, turbidity, and low pH are the most common chemical parameters which may pose aesthetic issues to the user and may require point-of-entry (POE) treatment. Conventional treatment is available if necessary. Colour may be challenging to treat if it is due to humic substances. Although less common, arsenic and uranium may contribute to additional quality issues in surficial materials. The site is considered a high risk for manganese in surficial water wells (Kennedy, 2021).

6.1.3 Water Quantity from Surficial Deposits

A search of the provincial water well database did not identify any dug wells within 500 m of the site. However, five drilled wells were identified (Drawing 3, Appendix A). From the well logs of these drilled wells, the surficial material is between 5.5 m and 21.3 m thick, with an average thickness of 14.3 m (Table 1, Appendix C). With limited resources on surficial water quantity from the site and its surrounding area, it is difficult to determine the expected water quantity for this proposed development. The whole site is underlain by a silty till plain; this material is a poor conduit for groundwater flow and could negatively affect groundwater quantity, especially for such a large development.

6.1.4 Surficial Hydrogeology Summary

The site is underlain by a silty till plain. This material is likely not sufficient to provide adequate groundwater to the site, considering the proposed site density. Dug wells also require a larger separation distance from potential sources of contamination, such as a septic field, which might constrain the proposed site layout.

While an option, dug wells are not recommended for this development.

6.2 Bedrock Hydrogeology

6.2.1 Bedrock Geology

The site is entirely underlain by slates of the Halifax Formation. These early Ordovician-aged slates are generally greyish-green or black and can be well-bedded with minor sandstones. The slates of the Halifax Formation are generally abundant in pyrite and arsenopyrite, which are sulphide-containing minerals, making the Halifax slates sulphide-bearing slates (Keppie et al., 2000, CSPG Lexicon of Canadian Stratigraphy, 2018). See Drawing 4 (Appendix A).

6.2.2 Bedrock Structure

No faults, folds, fractures, or other major structural features were discovered through available desktop resources.

6.2.3 Bedrock Mineralization

The Mineral Resource Land Use Atlas (MRLUA) and the NS Mineral Occurrence Database (NSNRR, 2000, 2024) were reviewed as part of this assessment. These resources provide locations where bedrock mineralization is known or suspected, such as former or active mines, quarries, gold districts, diamond drill holes mineral occurrences, as well as zones containing sulphide-bearing slates. No economic mineral occurrences were uncovered at or near the site.

The MRLUA indicated that the area underlying the site contains sulphide-bearing slates. Caution should be taken with these slates, as oxidizing them can cause acid rock drainage (ARD). If encountered, rock confirmed to contain sulphide-bearing material is required to be handled and disposed of according to the Sulphide Bearing Material Disposal Regulations, N.S. Reg. 57/95.

6.2.4 Water Quality Data

6.2.4.1 Water Quality from the Bedrock Aquifer

Groundwater derived from drilled wells in metamorphic groundwater regions may contain naturally occurring trace metals, including arsenic, fluoride, iron, manganese, and uranium (Kennedy, 2009).

The NS Groundwater chemistry map series (2021) was reviewed, but no chemistry data was available within 500 m of the site. However, four chemistry wells within Halifax Slates were identified within 8 km of the site (Table 2, Appendix C).

Of these identified chemistry wells, two exceeded the maximum allowable concentration (MAC) and aesthetic object (AO) for manganese per the Health Canada Guidelines for Drinking Water Quality (2024). These same two wells also exceeded the AO for iron, and one of these wells exceeded the AO for pH.

There are relatively few cases in Nova Scotia where bacteria contaminate the aquifer. On-site sewage systems are designed to treat household wastewater and may risk groundwater quality. Installation guidelines provide adequate separation distances to groundwater wells; therefore, contamination is unlikely.

This site is considered a high risk for manganese in bedrock wells, a medium risk for arsenic in bedrock wells, and low risk for uranium in bedrock wells (Kennedy & Drage 2016; Kennedy & Drage 2020; Kennedy 2021). All these contaminants can be treated by conventional treatment, generally, at the point of use (POU) at a single faucet for water for drinking, cooking, and other human consumption uses.

6.2.5 Water Quantity Data

6.2.5.1 Water Quantity from the Bedrock Aquifer

The metamorphic groundwater region is one of the poorest-yielding groundwater regions in the province. This is because well-developed fractures are required to allow water to move through this bedrock type. On average, the metamorphic groundwater region provides a long-term water quantity of 20.0 Lpm based on pump test data (Kennedy, 2009). Therefore, groundwater with sufficient yields for domestic can be found. Many homes in the surrounding area rely on the underlying metamorphic bedrock as a water supply source (Drawing 5 and 6, Appendix A).

A provincial water well database search identified five drilled wells within 500 m of the site (Drawing 6, Appendix A). Short-term driller estimated yields from well logs of wells drilled within the study area completed in bedrock are summarized in Table 1 (Appendix C). These wells show yields between 9.1 Lpm and 90.8 Lpm with an average yield of 31.3 Lpm. Driller yields are estimates based on short-duration airlift tests completed by the driller at the end of the well construction. It is important to note that long-term well production rates are typically 20% to 50% of the drillers' estimates, indicating actual longer-term yields may be in the 1.8 Lpm to 18.2 Lpm range, or less.

The average drilled well depth from the well logs (Table 1, Appendix C) was approximately 62.6 m. The well depths ranged from 37.2 to 91.4 m. The wells were drilled through varying surficial materials, including clay, boulders, stone, and overburden ranging from 5.5 m to 21.3 m in thickness, and all were completed in slate bedrock.

Bedrock fractures in drilled wells in the area appear to provide adequate supply for single-family residential needs and, with sufficient depth, should provide adequate supply for several mobile homes.

6.2.5.2 Drilled Well Data (NS Pumping Test Database)

Longer-term or more continuous safe yields must be evaluated by aquifer testing. Information on aquifer testing can be found on the Nova Scotia aquifer test database (2022). The nearest wells with aquifer testing data within the metamorphic slate bedrock formation are approximately 11 km from the site. Information from the aquifer tests for the two wells located within 11 km of the site, within the Halifax Slates, is presented in Table 3 (Appendix C).

The pumping test statistics in Table 3 (Appendix C) indicate a mean long-term safe yield (Q_{20}) of approximately 26.6 Lpm and a geometric mean apparent transmissivity (T) of 1.0 m^2/d. The Q_{20} and T ranges for the wells are 14.1 Lpm to 50.0 Lpm and 0.5 m^2/d to 2.0 m^2/d, respectively.

6.2.5.3 NS Groundwater Observation Well Network – Simms Settlement Well

An observation well (No. 076) is situated approximately 21 km southwest of the site, in the community of Fall River, which forms part of the Nova Scotia Groundwater Observation Well Network (NSECC, 2015).

According to available data, monitoring of the Fall River well started in 2008. In the Nova Scotia Groundwater Observation Well Network 2015 Report, the Fall River observation well is listed at 61.0 m deep, with 13.1 m of casing and drilled through Halifax Slate bedrock. In 2008, a 4-hour constant rate pumping test was conducted on the well. The results of the pumping test determined a transmissivity of 0.07 m^2/day, a hydraulic conductivity of 1.21 m^2/day and a Q_{20} of 2.13m^3/day. The 2008 field program conducted water chemistry sampling, which included general chemistry parameters, metals, volatile organic compounds (VOCs), and pesticides. No exceedances of Health Canada Guidelines were detected at the time. However, the water pH, iron, and manganese exceeded aesthetic parameters.

6.2.5.4 Municipal Wells

Based on the Nova Scotia Groundwater Atlas (NSNRR and NSECC, 2024) interactive map, no municipal wells are located near the site.

6.2.5.5 Potential Water Shortages, Well Construction, and Well Interference

The site is situated in an area with limited available resources to estimate potential well performance. The proposed development is large and raises questions about whether well interference and water shortages could be an issue at this site. This development is anticipated to exceed 23,000 litres per day (Lpd) and will, therefore, require a Groundwater Withdrawal Application. This application will necessitate further invasive groundwater studies to better quantify the potential impacts on the aquifer and surrounding well users.

7.0 WATER BALANCE

Per NSECC (2011), each well serving a single-family residential household should be able to provide at least 1,350 Lpd continuously. The NSECC (2011) requirement to provide 1,350 Lpd for single residential households is an estimation based on the average home, yet does not make any distinctions when considering the size of the home. Based on the Proposed Development's water needs, a conservative estimate of approximately 1,350 Lpd per mobile home is required.

Per Halifax Water Design Specifications & Supplementary Standard Specifications for Water, Wastewater & Stormwater Systems (2023), water distribution systems are designed to accommodate an average daily demand of 375 Lpd per person. The design population for a single-unit dwelling (similar to the proposed mobile homes) is 3.35 people per home. Given these specifications, the estimated water supply requirement is 1,256.25 Lpd per mobile home.

Per the NSECC On-Site Sewage Disposal Systems: Technical Guidelines, Appendix F (2013), a three-bedroom residential unit's average septic flow rate is 1,000 Lpd. It can be assumed that the inputs and outputs of the groundwater withdrawal and septic flows are equivalent (i.e., water withdrawal from the site is disposed of within an on-site septic). Therefore, despite the unknown design of any on-site wastewater treatment, the daily water withdrawal rates can be assumed based on the NSECC (2013) guidance document.

A simplified water balance calculation was used to estimate whether the available groundwater on each lot in the proposed development area would meet the target water demand of 1,000 Lpd, 1,256.25 Lpd or 1,350 Lpd. The calculation and definitions below are based on those outlined in the NS Guide to Groundwater Assessments for Subdivisions Serviced by Private Wells (NSECC, 2011). According to NSECC (2011):

"The calculation assumes that the available groundwater is equal to the groundwater recharge that occurs on the lot, minus the amount of groundwater reserved for ecological use. Ecological use refers to groundwater that helps maintain ecological habitats by discharging as baseflow to surface waterbodies. Ecological use is assumed to be 50% of the groundwater recharge."

$$Q_{lot} = \frac{IA_{lot}E_{use}}{365\ days} \quad (1)$$

Where: Q_{lot} = Available groundwater from each lot (Lpd)
I = Groundwater recharge rate (mm/year)
A_{lot} = Lot area contributing to recharge, excludes impermeable areas (m^2)
E_{use} = Percentage for recharge reserved for baseflow/ecological support (%)

$$A_{lot} = A_{avg} - (A_{avg} \times ISP) \quad (2)$$

Where: ISP = Percentage of impervious surface area in subdivision development (%)
A_{avg} = Average area of development lot (m^2)

Through communications with the Client, the proposed development intends to construct between 120 and 150 mobile homes. These homes will vary in size; however, the largest unit will encompass a footprint of 16 ft x 74 ft, or 1,184 square feet (sqft) [110 m^2], used in the recharge calculations below. Each home will be situated on a lot with a minimum lot size of 120 ft x 60 ft (7,200 sqrt) [669 m^2]. The homes will include a gravel driveway which would be susceptive to groundwater recharge.

7.1 Groundwater Recharge

7.1.1 Site Recharge

With 150 homes, the total area of this development would encompass 10.035 ha, leaving 14.265 ha as green space. In this scenario, the ISP for the entire site would amount to 7%. If fewer homes were to be developed within the site and the footprint of the mobile homes remained the same, the ISP would decrease with respect to the number of mobile homes (Table 7.1).

Table 7.1: Parameters for Water Balance Calculation – Site Area

Site Area	I (mm/Y) *	A_{avg} (m^2)	E_{use} (%)	ISP (%)	A_{Lot} (m^2)	Q_{Site} (Lpd)	Q_{Lot} (Lpd)
150 Homes	241	1,620.0	50	7	1,506.6	74,608	497
120 Homes		2,025.0		6	1,903.5	75,410	628
100 Homes		2,430.0		5	2,320.7	76,212	762
77 Homes		3,155.8		4	3,028.5	77,014	1,000
61 Homes		3,983.6		3	3,864.1	77,817	1,276
57 Homes		4,263.2		3	4,135.3	77,817	1,365

* Based on recharge from the Musquodoboit River Watershed [Drawing 4, Appendix A] (Kennedy et al., 2010).
Q_{Site} = The total available recharge for the Site.

From Table 7.1, the groundwater recharge available to the Site (Q_{Site}) increases as the number of mobile homes decreases. This is because the ISP decreases as the number of proposed mobile home units decreases. The groundwater recharge available for each mobile home (Q_{Lot}) increases with respect to a reduction in mobile housing units. This is caused in part by the reduction in ISP, but the largest driver is the increase in the proportion of available area for groundwater recharge relative to the number of housing units. Fewer mobile homes will increase the effective area of groundwater recharge available across the Site (A_{avg}) and, therefore, the recharge available for each home (Q_{Lot}).

The site has an estimated recharge of between 74,608 and 77,817 Lpd, depending on the ISP. Based on the anticipated groundwater supply required for a mobile home of 1,000 Lpd to 1,350 Lpd (NSECC, 2011; NSECC, 2013; HRM, 2023), the number of homes that the Site can support is between 57 and 77.

7.1.2 Local Catchment Area Recharge

The groundwater recharge available to the site is theoretically insufficient to support the proposed number of mobile homes (120 to 150). However, this does not consider recharge across the local area. Therefore, a Local Catchment Area (LCA) was delineated based on a Geospatial analysis, which considered topography and local hydrological characteristics. This local catchment area is 166.9 ha (Drawing 6, Appendix A), allowing for new values of Q to be calculated for the proposed development (Table 7.2). Based on the zoning of the land in the LCA [zoned MU] (HRM, 2024b) and the Land Use By-Laws for the area, the maximum lot coverage for residential use is 35%. Therefore, a conservative ISP (35%) was considered to account for built structures within the LCA. This estimate assumes a realistic but conservative scenario for recharge to the Site concerning current Land Use planning.

Table 7.2: Parameters for Lot Water Balance Calculation – Local Catchment Area

Site Area	I (mm/Y) *	Number of Existing Homes[1]	A_{avg} (m^2)	E_{use} (%)	ISP (%)	A_{Lot} (m^2)	Q_{Local} (Lpd)	Q_{lot} (Lpd)
150 Homes	241	24	9,593	50	35	8,633	358,216	2,058
120 Homes			11,592			10,431		2,487

* Based on recharge from the Musquodoboit River Watershed [Drawing 4, Appendix A] (Kennedy et al., 2010).
(1) The number of homes was calculated based on satellite imagery. Structures and clearings which appeared to be for housing development were conservatively counted.
Q_{local} Total water availability (based on recharge) across the LCA.

The calculated Q_{Lot} for the proposed 150-home development is greater than that of the NSECC, 2011; NSECC, 2013; and HRM, 2023 guidelines at 2,058 Lpd, and the 120-home scenario provides even more available recharge at 2,487 Lpd. Therefore, when considering the conservative scenario for recharge within the LCA, it is sufficient for the proposed development. The Q_{local} is defined as the amount of recharge available across the LCA. This conservative scenario would support up to 265 homes within the LCA (including the proposed homes within the Site) at a water demand of 1,350 Lpd. It should be cautioned that the recharge calculation is based on a catchment area outside of the Site. Land use changes are possible, which may impact the future sustainability of the project.

The development is considered sustainable when considering the LCA and its recharge to the underlying aquifer. However, an invasive groundwater investigation would be required to support these findings and to determine if there is an adequate and safe groundwater supply on site.

8.0 CONCLUSIONS

The proposed development area comprises a residential area of approximately 24.3 ha. A total of 120 to 150 mobile homes are proposed for development, each with a lot area of approximately 669 m^2. It is understood that the site is to be developed for residential purposes (i.e., no commercial or industrial uses) and that the Client will own the groundwater withdrawal, treatment, and distribution system for the site. Road access to the site is gained through Old Guysborough Road and a few access roads throughout the site.

Two dug wells were found on the site on the former properties of abandoned homes. They must be decommissioned per the NSECC Water Wells Decommissioning Guidelines (2007). Furthermore, abandoned vehicles and a domestic oil tank were found on-site. These should be removed, test pits should be conducted to assess for potential contamination, and groundwater well placements should be avoided in the areas where these are situated. Groundwater wells should be tested for water quality upon completion of the drilling program.

Although two dug wells were found on the site, no surficial wells are found within the study area, per the Nova Scotia Well Log Database. Surficial wells require a greater clearance from septic systems and are generally more likely to be impacted by surface or near-surface contaminants. Dug wells are not recommended for this site.

There is insufficient data on water quality to determine whether adequate water can be found on the site. However, any water issues can likely be treated. The four chemistry wells within Halifax Slates within 8 km of the site are flagged for pH, iron, and manganese as issues concerning water quality.

Short-term driller well tests from the five wells within the study area show that well yields, on average, are 31.3 Lpm. Based on pump tests from two drilled wells within 11 km of the site within Halifax slates, the average yield from the bedrock aquifer is 26.6 Lpm. The proposed development intends to build up to 150 mobile homes. Conservative estimates of water demand (Section 7.0) indicate a reasonable water demand for the site would be between 120,000 and 202,500 Lpd. The available desktop data, therefore, shows that the proposed development water consumption can be achieved with a series of wells; however, lower water yields are possible. An invasive groundwater investigation will be required to determine the yields available at the site.

A simplified water balance calculation estimated the available groundwater for the proposed development to be less than the required 1,000 Lpd (NSECC, 2013), 1,256.25 Lpd (HRM, 2023), or 1,350 Lpd (NSECC, 2011), when considering the Site only. Therefore, there are too many residences in the proposed development to support the appropriate groundwater recharge for the site. However, all 150 mobile homes can be supported within the proposed development area, when considering the LCA. It is important to note that as the density of homes and wells increases in any area, there is more potential for change in well yields and

water levels in the aquifer with time. Therefore, assessing such effects on the proposed development and surrounding homes in the study area should be considered. Given expected yields and water balance assessment, wells placed for this development are expected to be sustainable. Assuming wells provide similar yields when drilled, and are adequate in depth, minimal effect is anticipated on surrounding users on drilled wells.

Potential environmental concerns related to the proposed future development were noted during the site visit, historical records review, or previous assessment. These concerns relate to iron, pH, and manganese. Recommendations concerning this are provided in Section 6.2.4.

Given the size of the proposed development, an Invasive Groundwater Assessment is required.

9.0 RECOMMENDATIONS

Based on the findings of the Non-invasive Groundwater Assessment, the following recommendations are forwarded:

1. Test pits, as part of the Level II (Invasive) Groundwater Assessment, should be conducted in key areas to determine if any hydrocarbon contamination exists where the abandoned tank and vehicles are located.

2. Should the proposal be approved, it is recommended that the next evaluation phase be undertaken, which is a Level II (Invasive) Groundwater Assessment. This will require the installation of a minimum of five test wells. The test well layout should be parallel and perpendicular to major structural trends to consider anisotropy. In addition, the density of wells, effects of linear well placement, and assessment of long-term interference between wells on and off site should be evaluated.

3. Well depths should be 91 m (300 feet) minimum unless the desired air lift yield is attained at a shallower depth, with two casing lengths or to bedrock (whichever is greater) and grouted in place. Additional depth may be added if the driller's airlift yield is less than 50 Lpm per residence to be supplied. Wells should be spaced at least 30 m minimum from one another or greater at the planning stage and avoid areas where abandoned oil tanks and cars were left within the site.

4. Step drawdown testing, constant rate testing, and analysis that meets current NS Guidelines for Subdivisions should be carried out on each test well. It will be important to confirm available information and verify how many wells can be supported in the given area, the long-term safe yield from each well, and evaluate potential interference effects and long-term trends in water levels in the bedrock aquifer.

5. During step drawdown and constant rate pumping tests, observation wells should be monitored.

6. Water samples should be collected from each test well as part of an Invasive Groundwater Assessment, which would include an analysis of water samples for general chemistry and metals (RCAp-MS), total dissolved solids (TSS), fluoride, Volatile Organic Compounds (VOCs), petroleum hydrocarbons, and bacteria (total coliform and E. coli by actual count). In addition, water treatment options and management of those options (treatment devices) should be implemented if quality issues exist.

7. Monitoring of any surface water bodies within 60 m should be conducted during the pump test program to assess surface–groundwater interactions.

8. Potential groundwater quality concerns related to the proposed development were noted. These concerns relate to iron, pH, and manganese. Water treatment devices exist for these contaminants and can be implemented if testing determines their presence above applicable criteria.

9. Available resources through Nova Scotia Natural Resources and Renewable (2013) list the site as containing acid-bearing slates. It is recommended that potential environmental issues relating to acid rock drainage (ARD) be recognized and assessed further if future disturbance or exposure of bedrock is anticipated (i.e., as part of construction work). Any ARD-related issues are governed by the NS Sulphide Bearing Material Disposal Regulations (N.S. Reg. 57/95).

10. An updated layout of lots, per the recommendation of this report, should be developed. This should include locations of proposed homes, wells, and wastewater treatment systems. The design should include a stormwater management plan to minimize impacts to adjacent wetlands and watercourses.

10.0 STATEMENT OF QUALIFICATIONS AND LIMITATIONS

This Report (the "Report") has been prepared by Strum Consulting (the "Consultant") for the benefit of Ramar Developments Limited (the "Client") in accordance with the agreement between the Consultant and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations, and conclusions contained in the Report (collectively, the "Information"):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations")
- represents Consultant's professional judgement in light of the Limitations and industry standards for the preparation of similar reports
- may be based on information provided to Consultant which has not been independently verified
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued
- must be read as a whole and sections thereof should not be read out of such context
- was prepared for the specific purposes described in the Report and the Agreement
- in the case of subsurface, environmental, or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time

Consultant shall be entitled to rely upon the accuracy and completeness of information that was provided and has no obligation to update such information. Consultant accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, environmental, or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

Consultant agrees that the Report represents its professional judgement as described above and that the Information has been prepared for the specific purpose and use described in the Report and the Agreement, but Consultant makes no other representations, or any guarantees or warranties whatsoever, whether express or implied, with respect to the Report, the Information or any part thereof.

The Report is to be treated as confidential and may not be used or relied upon by third parties, except:

- as agreed in writing by Consultant and Client
- as required by law
- for use by governmental reviewing agencies

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This Statement of Qualifications and Limitations forms part of the Report and any use of the Report is subject to the terms hereof.

Should additional information become available, Strum requests that this information be brought to our attention immediately so that we can re-assess the conclusions presented in this report. This report was prepared by Alex Scott, BSc., EPt, Environmental Scientist and reviewed by A. Bruce Strum, P.Geo., Senior Hydrogeologist.

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Sulphide Bearing Material Disposal Regulations, N.S. Reg. 57/95

APPENDIX A
DRAWINGS


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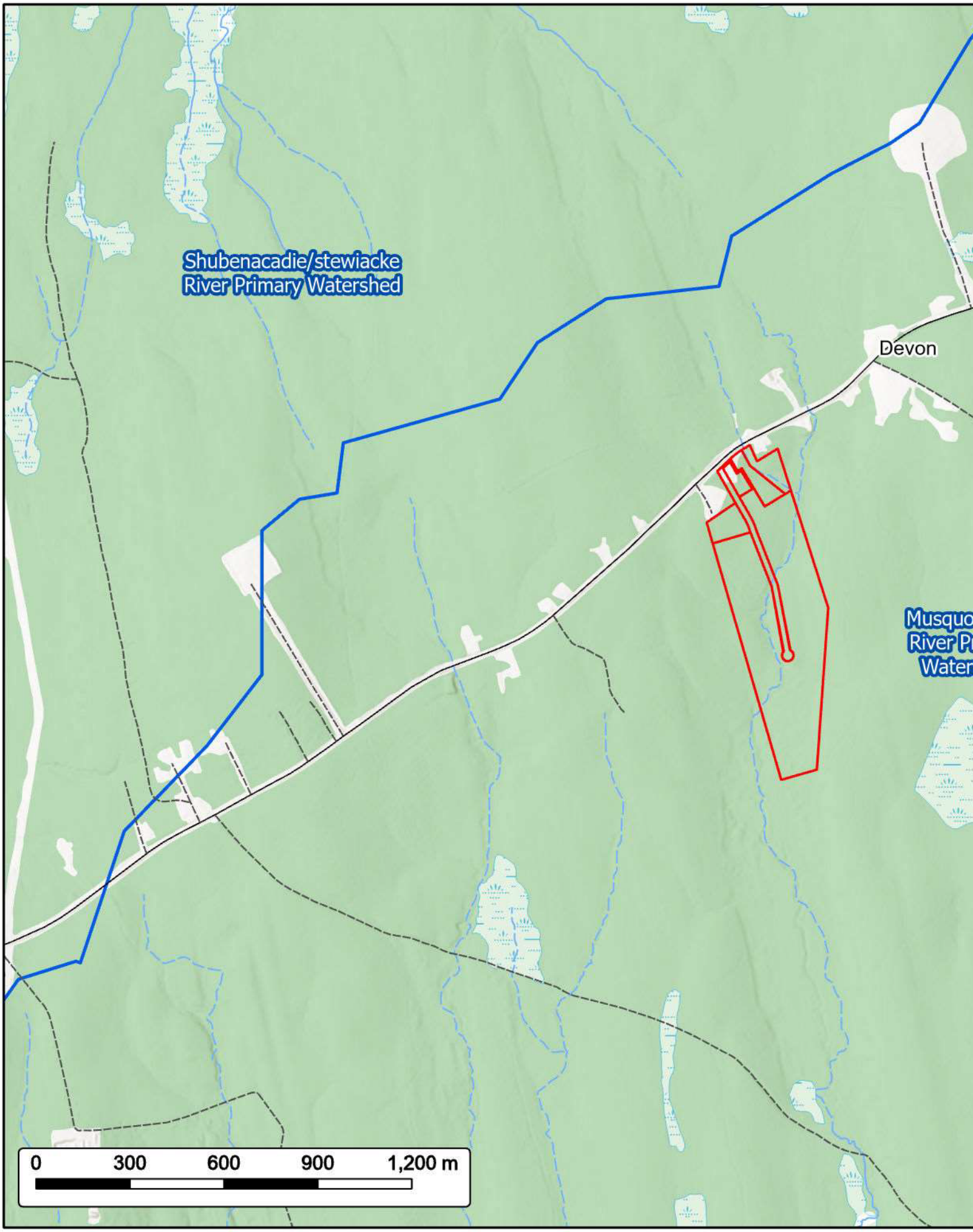
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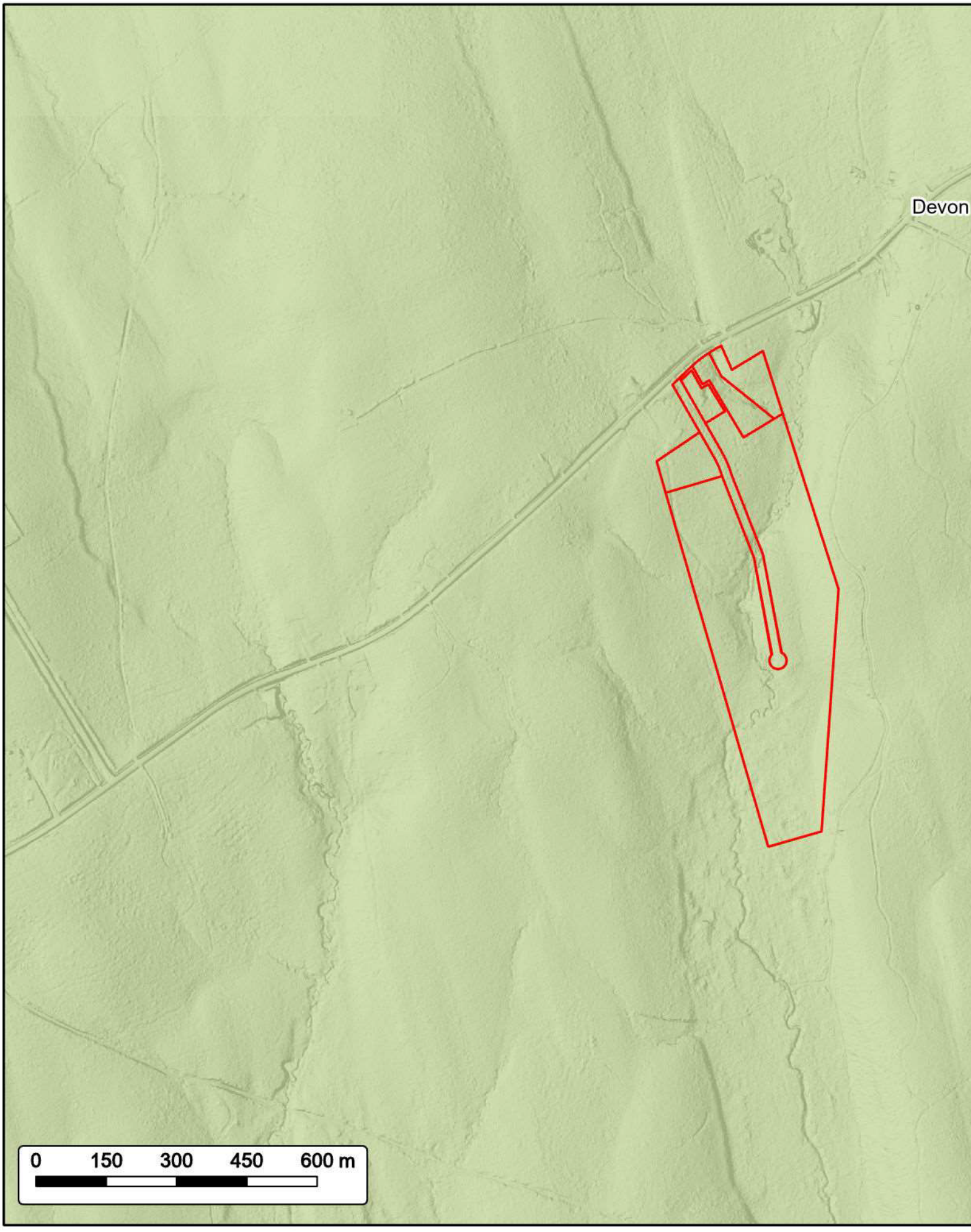
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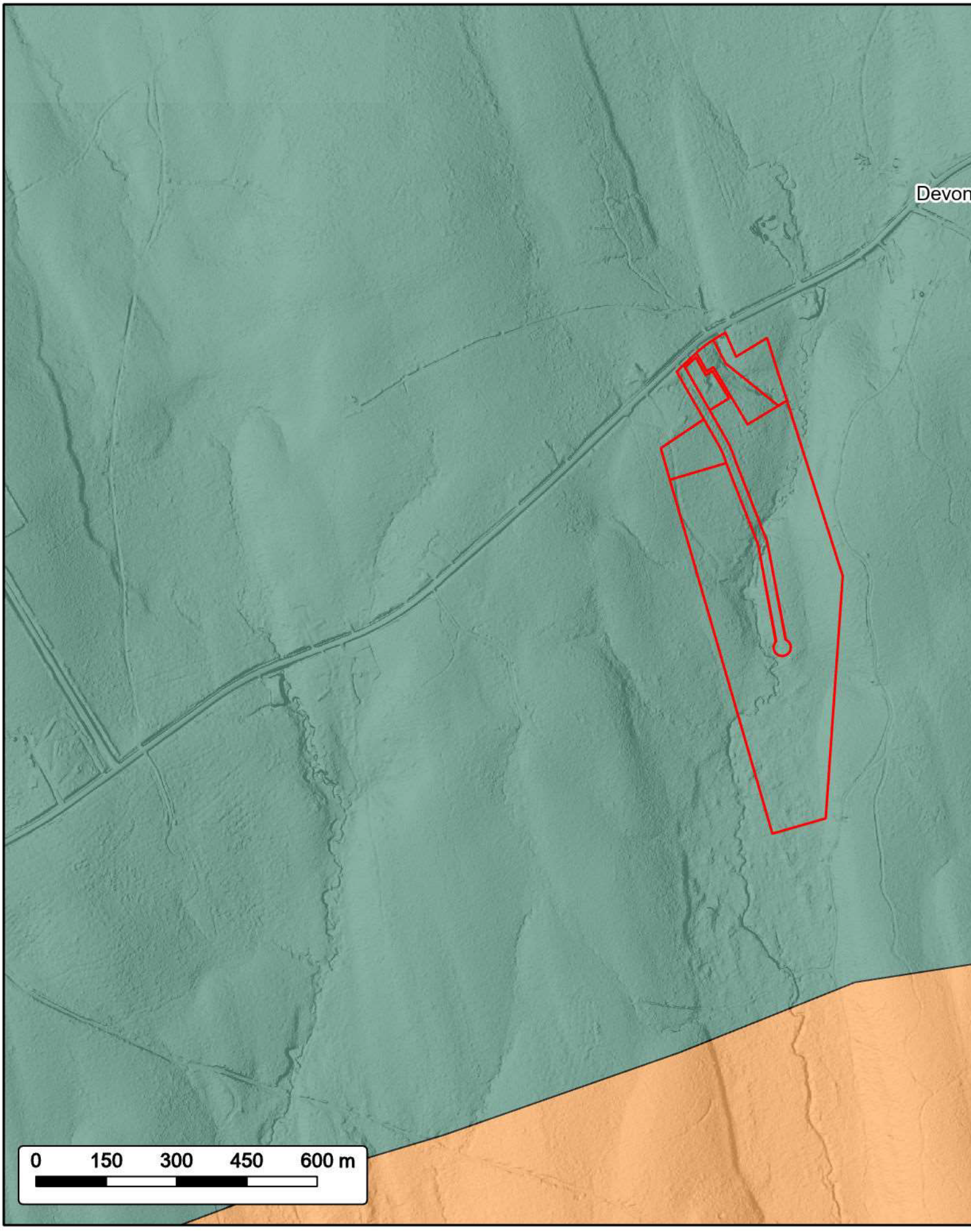
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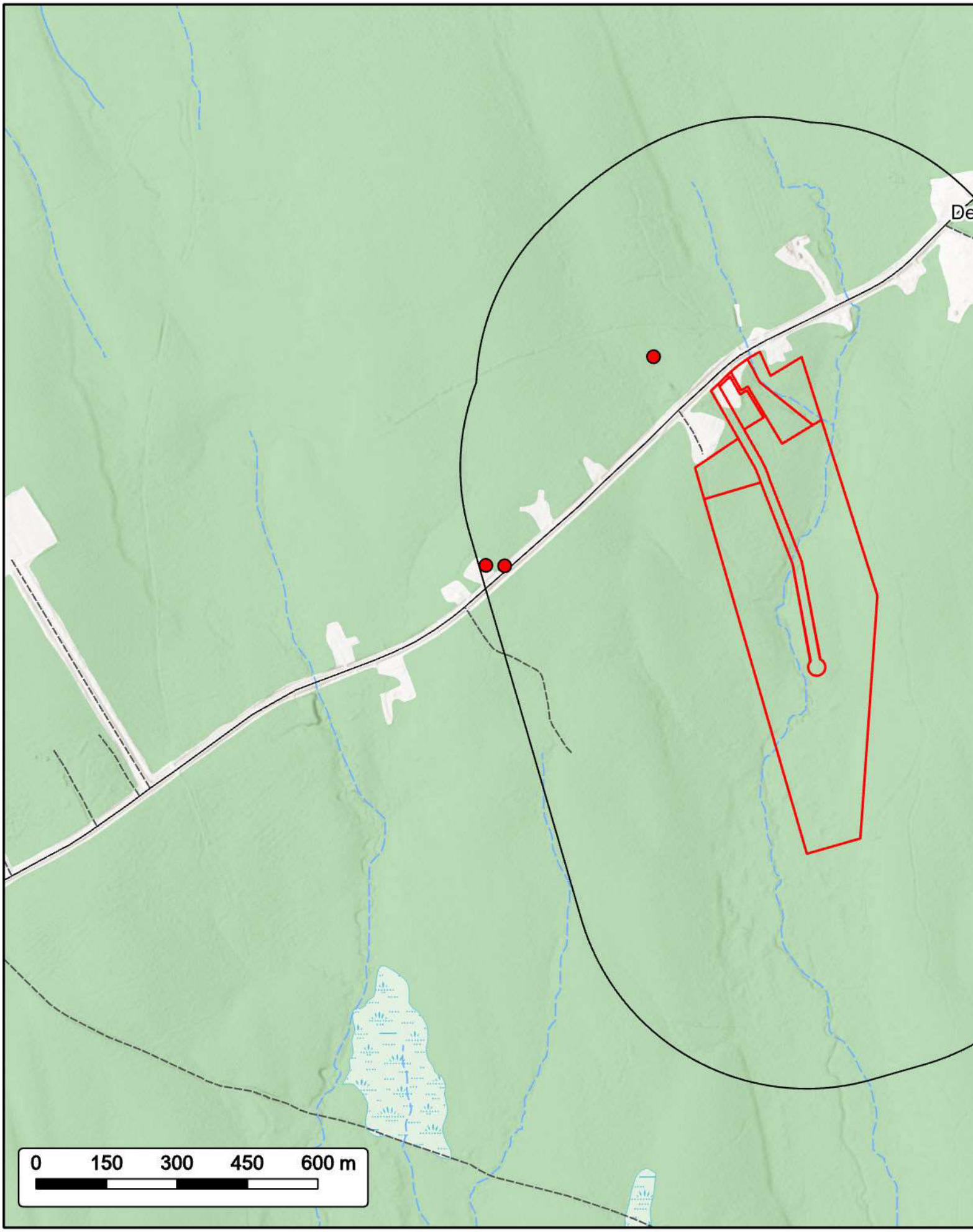
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APPENDIX B
PHOTOGRAPH LOG

Photo 1: Grassy dirt road at northwestern end of site. Photo looking south.

Photo 2: Remnants of a culvert across an old dirt road. Center west end of site.

Photo 3: An old bus left in the woods. Center west portion of the site.

Photo 4: Remnants of an old car in the northern part of the river which crosses the site.

Photo 5: Abandoned Dug well along northern portion of the site.

Photo 6: Abandoned Dug well along northern portion of the site.

Photo 7: Abandoned home, with dug well. The northern portion of site.

Photo 8: Remnants of an old structure. The northeast portion of site.

Photo 9: Abandoned domestic oil tank. Northern portion of the site.

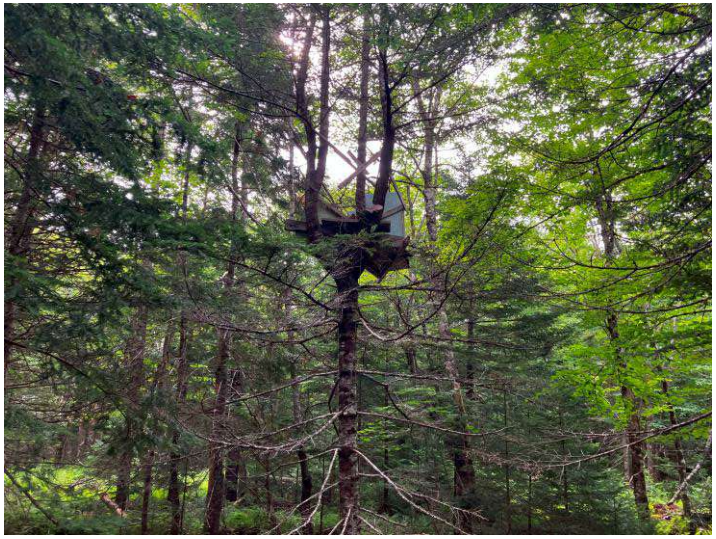

Photo 10: A former hunting blind. Center portion of the site.

Photo 11: Old-makeshift outhouse. The north end of the site.

Photo 12: Shipping/storage container along northwestern portion of site.

APPENDIX C
DATA TABLES

Table 1: Summary of Drilled Well Data from the NSECC Well Log Database (for properties located within a 500 m radius of the site) *Project# 24-10294*

DRILLED WELL LOCATION				DRILLED WELL INSTALLATION DETAILS						GEOLOGICAL AND HYDROGEOLOGICAL DETAILS FROM WELL LOGS			
Well Number	Address	Community	County	Date	Depth (m)	Casing (m)	Bedrock (m)	Static (m)	Estimated Drillers Yield (Lpm)	Till Depth (m)	Till Lithology	Bedrock Lithology	Water Bearing Fractures (m)
130085	3434 Old Guysborough Road	Devon	Halifax	73.1	73.1	18.3	13.7	N/A	11.4	13.7	clay and boulders	slate	N/A
130197	3434 Old Guysborough Road	Devon	Halifax	91.4	91.4	36.5	17.7	N/A	9.1	17.7	clay	slate	N/A
150910	28 Miller Road	Devon	Halifax	50.2	50.2	24.4	21.3	3.04	90.8	21.3	clay	slate	30.5, 45.7
200357	12 Miller Road	Devon	Halifax	60.9	60.9	18.3	13.4	N/A	13.6	13.4	overburden	slate	N/A
992032	3367 Old Guysborough Road	Devon	Halifax	37.2	37.2	12.2	5.5	N/A	31.8	5.5	clay, stone	slate	12.8, 26.8

Table 2: Summary of Groundwater Chemistry from Drilled Wells within Halifax Slates located nearest to the Site *Project # 24-10294*

Sample ID	Sample Date	Groundwater Region	Alk (mg/L)	HCO3 (mg/L)	CO3 (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	F (mg/L)	SO4 (mg/L)	Cl (mg/L)	Hardness (mg/L)	TDS (mg/L)	pH	NO3 - NO2N (mg/L)	As (ug/L)	U (ug/L)	Fe (ug/L)	Mn (ug/L)
Reg3276	1993-09-29	Metamorphic	121	120	0.71	36.3	1.5	54.5	5.8	-	104	6.7	160	-	7.8	0.025	2	2.9	40	10
Reg1335	2004-10-21	Metamorphic	41	41	0.5	5.4	0.4	12.4	2.6	-	8	10	41.7	74	6.6	0.025	1	0.1	7400	**540**
Reg5889	2010-09-28	Metamorphic	120	115	1	47.9	1.61	75.1	6.26	0.2	170	10	210	388	7.97	0.05	3	2.59	86	6.3
Reg3311	2012-10-26	Metamorphic	52	52	5	5.5	0.5	14.1	2.8	0.2	7	10	46.7	86	7.1	0.025	1	0.05	14500	**671**
Health Canada Drinking Water Guidelines			-	-	-	**200 (AO)**	-	-	-	**1.5 (MAC)**	**500 (AO)**	**250 (AO)**	-	**500 (AO)**	**7.0-10.5 (AO)**	**10 (MAC)**	**10 (MAC)**	**20 (MAC)**	**300 (AO)**	**120 (MAC) 20 (AO)**

Notes:
MAC = Maximum Concentration, **AO** = Aesthetic Objective
*** MAC, and AO values based on Guidelines for Canadian Drinking Water Quality (Health Canada, 2024)**
Shading indicates AO exceedance
Bold/Shading indicates MAC exceedance

Table 3: Summary of Pumping Test Data - Wells Drilled Through Slate Bedrock Located nearest to the Study Area *Project # 24-10294*

Pumping Test ID	Well Number	County	Community	Test For	Test Start	Test End	Geology HU	Depth (m)	Casing Diameter (mm)	Static (m)	Pump Setting (m)	Available Drawdown (m)	Tapp (m2/d)	Q20 (Lpm)
HAL-72	N/A	Halifax	Enfield	HIAA - Airport Hotel, S. Jachimowicz Ltd	1977-01-07 1:30	1977-01-10 1:30	Slate	76.2	152.4	0.334	70.1	67.06	2.01	50
HAL-93	752221	Halifax	Enfield	HIAA – Tourist Bureau, NS Dept of Tourism	1975-02-25 6:00	1975-02-28 6:00	Slate	91.4	152.4	5.18	76.2	71.02	0.52	14.1