November 17, 2022

Carringwood Homes
101 Regent Street
Richmond Hill, Ontario
L4C 9P4

Attention: Mr. Rob Fernicola, M.Sc., President

Dear Mr. Fernicola,

RE: Channel Stability and Erosion Hazard Assessments, 10249 Hunsden Sideroad Property, Caledon

1. INTRODUCTION

GEI Consultants Ltd. (GEI) was retained by Carringwood Homes to prepare a Channel Stability Assessment and Erosion Hazard Assessment, for the property located at 10249 Hunsden Sideroad, in the Town of Caledon (herein referred to as the Subject Lands, depicted in **Figure 1** on the following page). The 20.37-hectare (50.34-acre) Subject Lands are generally located southeast of the Hunsden Sideroad and northeast of Mount Pleasant Road and are legally described as Part Lots 25 and 26, Concession 9, in the Town of Caledon, and the Regional Municipality of Peel.

Figure 1: Study Location.

The site is currently an undeveloped area consisting of existing farmland and woodlots. The Beeton Creek lies to the northwest of both the Subject Lands and the Hunsden Sideroad, falling within the jurisdiction of the Nottawasaga Valley Conservation Authority (NVCA). A small first-order channel tributary to the Beeton Creek is located at the northeast corner of the Subject Lands, flowing from agricultural lands northeast of and across the Subject Lands. A second, smaller drainage feature flows from the woodlot within the northeast corner of the Subject Lands, converging with the larger drainage feature noted above. These drainage features are morphologically poorly defined intermittent/ephemeral drainage channels that likely flow only under conditions of higher runoff volumes such as significant precipitation events and/or snow melt (spring freshet). The intermittent/ephemeral nature of the channels on the Subject Lands was confirmed through numerous site visits by GEI ecology staff through 2021 and 2022 in which no flow was observed in the channels, even after a precipitation event in late May of 2022 (GEI Consultants Ltd., 2022). The geomorphic site assessment of November 11, 2022, also saw dry channel conditions. This intermittent/ephemeral drainage feature status is further supported by the NVCA's 2018 Innisfil Subwatershed Health Check (NVCA, 2018), wherein it is noted that the Subject Lands are mapped as being within a significant groundwater recharge area as opposed to a discharge or outflow area.

This report seeks to document the existing (pre-development) geomorphic status of the drainage features on the Subject Lands. An erosion hazard assessment was also undertaken to inform Carringwood Homes of any post-development risk for erosion within the above noted drainage features. Since the drainage courses within the Subject Lands are intermittent/ephemeral, with no well-defined stream corridor (no clear floodplain or valley complex associated with the drainage features), a standardized stream meander belt assessment could not be undertaken. The erosion hazard risk was addressed via a determination of the threshold for erosion within the drainage channels on the Subject Lands. It must be noted that access to neighboring properties was not possible; thus, upstream, and downstream assessments were also not possible, particularly with respect to the Beeton Creek as receiving water for the stormwater outflow from the proposed development via the existing drainage features.

2. EXISTING GEOMORPHIC ENVIRONMENT

2.2 Reach Delineation

Reach delineation is typically based on changes in channel planform and active geomorphological processes, which are directly related to local surficial geology, gradient, hydrology, land use, and riparian vegetation (Montgomery & Buffington, 1997), (Richards, Haro, Johnson, & Host, 1997). Following a GEI fluvial geomorphological site visit on November 11, 2022 (with photo documentation), three reaches were delineated as depicted in **Figure 2**, below.

Figure 2: Reaches within the Subject Lands.

Designated reaches are enumerated and identified as follows:

- ***Reach DC-01***: Begins within the northeast woodlot of the Subject Lands, flowing northwest from the woodlot area towards an existing residence. This short drainage feature consists of less than 120 metres of poorly defined channel. Reach DC-01 terminates at the confluence with Reach DC-02a.

- ***Reach DC-02a***: Begins some 720 metres east of the approximate property line for the Subject Lands. It flows across mostly agricultural lands (with photogrammetric evidence of being tilled or ploughed through) and into the woodlot of the subject lands. The channel is well defined in the woodlot area but exits to a manicured lawn that shows little definition beyond that of a shallow swale. Reach DC-02a flows for approximately 30 metres from the Subject Lands' property line to the confluence with Reach DC-01.

- ***Reach DC-02a:*** Begins at the confluence of Reaches DC-01 and DC-02a, flowing northwestward to the Hunsden Sideroad culvert crossing at the edge of the Subject Lands. This poorly defined channel flows next to manicured lawn areas but is situated at the edge of the Subject Lands' woodlot area.

- All three reaches exhibit regular accumulations of leaf litter with some fallen large woody debris (LWD). There is no evidence of erosional scour within any of the more defined and visible channel segments, with no evidence of entrenchment whatsoever. The accumulation of leaf litter in the channel itself would indicate that little stream power exists within any of the reaches to drive erosional forces.

2.3 General Reach Observations and Evidence for Drainage Feature/Channel Stability

Figure 3 illustrates the photo locations from the November 11, 2022, geomorphic site visit. See **Appendix A** for the photo record.

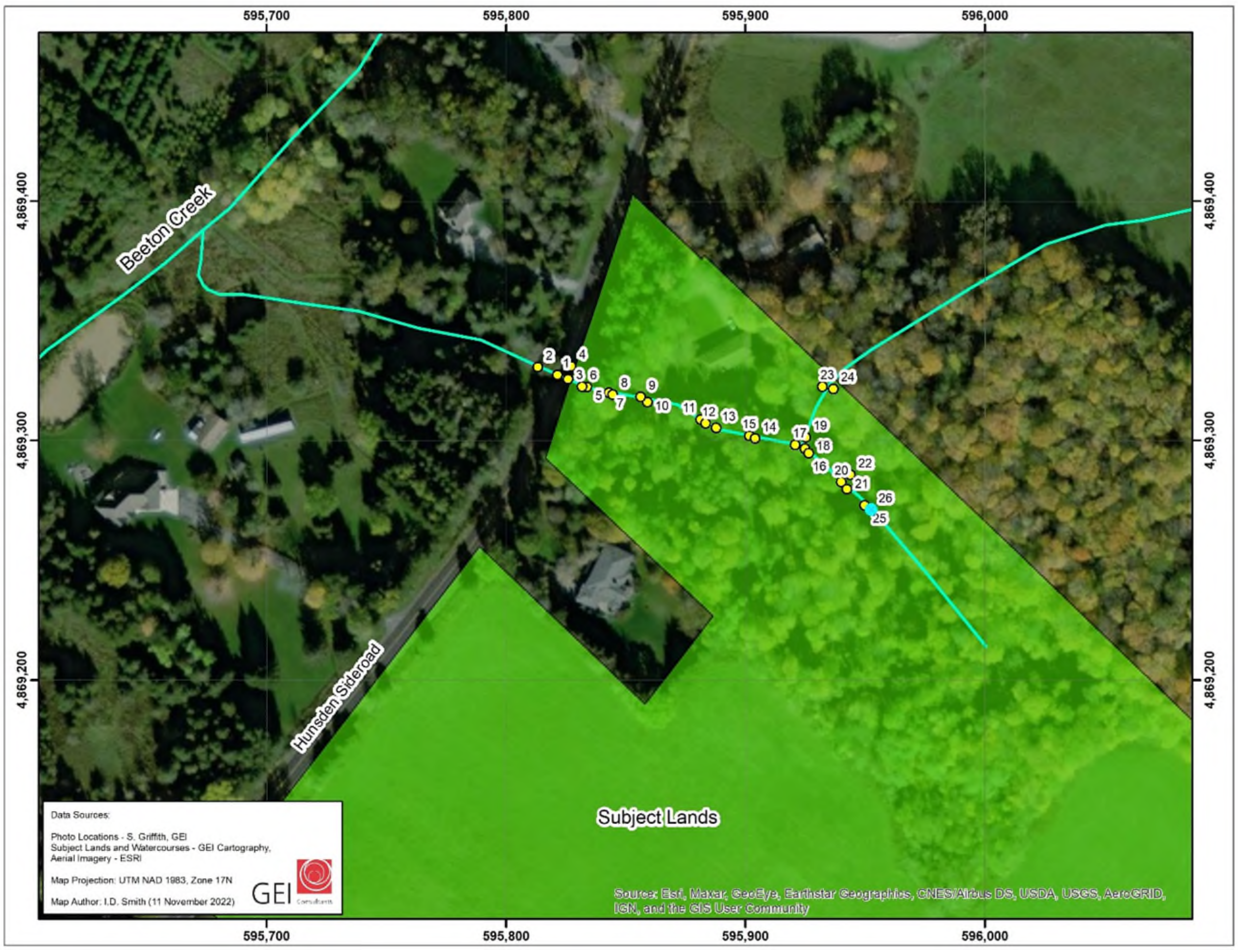

Figure 3: Site Condition Photo Locations Created During the Site Visit of November 11, 2022.

From the photo record, it is apparent that the drainage features that exist within the Subject Lands are currently experiencing no evidence of erosion (degradation) or sediment accumulation (aggradation). All channels, where well defined, appear to be stable in cross section and well graded in slope. Morphologically poorly defined channels and drainage features are similarly stable and graded. Furthermore, there is no evidence of channel widening due to changes in hydrologic driving conditions or evidence of planimetric form adjustment via changing sinuosity due to changes in driving factors.

Soils for each of the three Reaches are noted to be dominated by Pontypool type soils, non-colloidal sandy loam soils (Hoffman & Richards, 1953). **Figure 4** shows the soils of the channel (Reach DC-02b at Photo Location 7):

Figure 4: Pontypool type soil, non-colloidal sandy loam within Reach DC-02b, photo location 7.

The culvert crossing of the Hunsden Sideroad consists of an elliptical (or partially deflected) corrugated steel pipe (CSP) that is approximately 0.61 metres in diameter (24 inches). There is no evidence of inlet or outlet scour at the culvert (contraction or expansion pools). The culvert appears to be free of aggraded sediment and appears to have no extra-structural or flanking flow within the culvert bedding or roadbed. **Figure 5 and 6** show the culvert crossing:

Figure 5: Culvert crossing of the Hunsden Sideroad, looking downstream from the Subject Lands, into the culvert inlet.

Figure 6: Culvert crossing of the Hunsden Sideroad, looking downstream from the Subject Lands, at the culvert outlet.

3. EROSION HAZARD ASSESSMENT

3.1 Hydrologic and Hydraulic System Modeling, Existing Conditions (Pre-Development)

GEI has undertaken hydrologic and hydraulic storm water modeling for the Subject Lands and all areas tributary to the Subject Lands (GEI Consultants Ltd., 2022). This Stormwater Management Design Brief (under separate cover, but companion to this report) has derived the following recurrence flow statistics for the Subject Lands' Reaches, as depicted in **Table 1**:

Table 1: Modeled 1:2-Year and 1:100-Year Recurrence Flows

Reach	Representative Model Station	Recurrence Interval	Flow Rate (m^3/s)	Velocity (m/s)	Depth of Flow (m)
DC-01	**1258.11**	1:2-Year	0.17	0.21	0.07
		1:100-Year	3.55	0.07	2.54
DC-02a	**2000**	1:2-Year	0.44	0.94	0.11
		1:100-Year	2.53	0.10	1.04
DC-02b	**1155.57**	1:2-Year	0.61	0.06	0.94
		1:100-Year	1.01	0.04	1.04

As a general observation, velocity of flow in the 1:2-year recurrence flood is low, not exceeding 1.0 m/s. Flow velocity decreases under the higher magnitude 1:100-year recurrence flood events (and the even higher magnitude Regional flood event), due to spillover above existing channels (into a well-vegetated and broad flood zone); thus, decreasing velocity predicted.

3.2 Threshold for Channel Erosion

"In a threshold channel, movement of the channel boundary is minimal or non-existent for stresses at or below the design flow condition." (United States Department of Agriculture, Natural Resources Conservation Service, 2007). Since all reaches being examined as a part of this analysis consist of non-colloidal (non-cohesive) sandy-loam soils, the channel boundary can be considered a 'non-rigid boundary system' (United States Department of Agriculture, Natural Resources Conservation Service, 2007). Thus, a reasonable design approach for any potential channel alterations and any channel impacts downstream of the subject property must consist of careful consideration of channel morphology such that stresses experienced during design conditions be kept below allowable stress for the channel boundary. The design condition of greatest importance is that of the bank-forming flow event. "The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels." (Dunn & Leopold, 1978). In the area of the subject property, the recurrence interval/frequency of the bank forming flow event is typically approximated by that of the spring freshet, or a flood with a recurrence of 1:2-years (probability = 0.50).

In the case of stream boundary materials being smaller than or near 'sand size', the USDA recommends that threshold channel design considerations be based upon the concept of "Allowable Velocity" during the bank-forming event (United States Department of Agriculture, Natural Resources Conservation Service, 2007). Furthermore, the USDA notes that non-colloidal stream bed/bank materials such as sandy loam show an allowable ***threshold velocity of 1.75 m/s*** without any stabilizing vegetation present (United States Department of Agriculture, Natural Resources Conservation Service, 2007). Sandy loam channels that are fully vegetated with grasses, such as those in many portions of the existing drainage features offer much greater erosion resistance. Turf (aka lawn) can withstand flow velocities between 3.5 m/s and 6.0 m/s depending on the grass species and root depths, while deeply rooted, long native grasses can resist flow velocities between 4.0 m/s and 6.0 m/s (Fischenich, 2001). Soil bioengineering approaches such as coir matting and live brush mattresses can offer far greater thresholds based upon allowable velocities ranging from 9.5 m/s to 12.0 m/s (Fischenich, 2001).

Within the context of the existing channel morphologies and contributing areas, and recalling that the evaluation of current channel stability and grading as being 'in-regime' is as expected, given the predicted or modeled velocities of flow during the bank-forming event (aka 1:2-year recurrence event) for current conditions as follows:

- ***Reach DC-01***: Existing 1:2-year velocity = 0.21 m/s compared to the threshold velocity of 1.75 m/s,
- ***Reach DC-02a***: Existing 1:2-year velocity = 0.94 m/s compared to the threshold velocity of 1.75 m/s, and
- ***Reach DC-02b***: Existing 1:2-year velocity = 0.06 m/s compared to the threshold velocity of 1.75 m/s.

Carrying this forward, it is important to note that the post-development stormwater management strategy for the Subject Lands must not lead to runoff velocities in the receiving channels that will exceed the 1.75 m/s threshold (in the case that the receiving channels are to remain unvegetated). Should stormwater runoff be predicted to exceed this threshold velocity, the receiving water channels should be bio-engineered using locally appropriate vegetation and/or stabilizing strategies such as coir matting and live brush mattresses, where feasible.

4. CLOSURE

This report has addressed the following issues in relation to the drainage features/channels within the Subject Lands:

- Current geomorphic status of the drainage features is noted to be 'in-regime' at the present time, and
- A velocity threshold for erosion was found with respect to the Subject Lands.

It should be noted that this analytical effort and its resultant outcomes are based upon the assumption that the flow regime and geomorphic status of the drainage features/channels in the vicinity of the Subject Lands will change only due to the stormwater management design undertaken for the proposed residential subdivision design on the Subject Lands. Thus, anthropomorphic impacts upon the system's hydrology and hydraulics driven by urbanization and land use change upstream and/or adjacent to the Subject Lands will be limited via threshold for erosion determination and design. Not included in this supposition are any impacts due to longer-term climate change and its impact upon system hydrology.

Yours truly,
GEI Consultants

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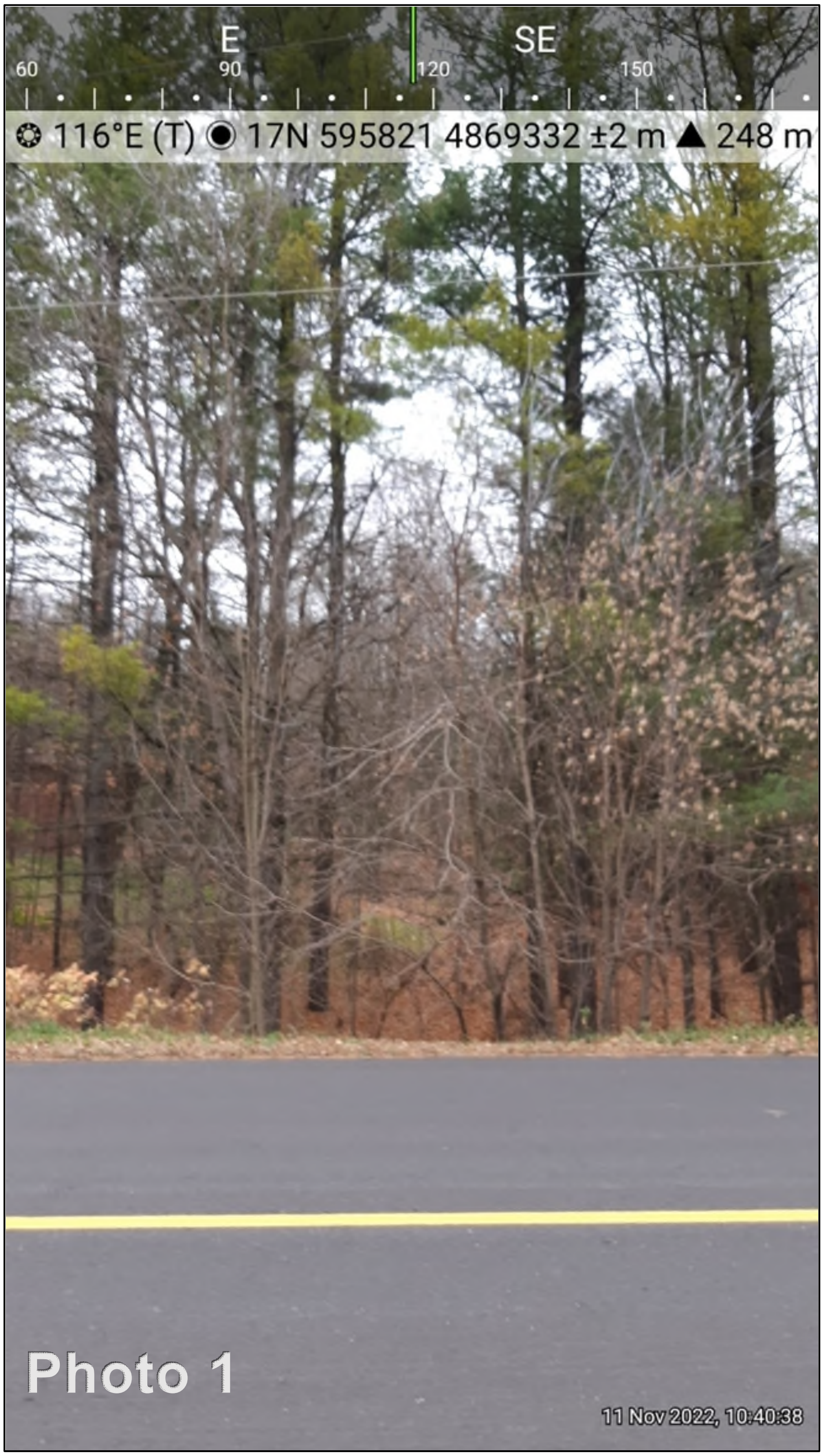
Appendix A – Subject Lands Drainage Features Photo Record, November 11, 2022


E
SE
60
90
120
150
116°E (T) 17N 595821 4869332 ±2 m 248 m
Photo 1
11 Nov 2022, 10:40:38


W
NW
240
270
300
330
285°W (T) 17N 595820 4869333 ±2 m ▲ 249 m
Photo 2
11 Nov 2022, 10:40:44


NE
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114°E (T) 17N 595830 4869331 ±2 m ▲ 249 m
Photo 3
11 Nov 2022, 10:40:59


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280°W (T) 17N 595829 4869331 ±2 m ▲ 249 m
Photo 4
11 Nov 2022, 10:41:04


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119°E (T) 17N 595834 4869327 ±8 m ▲ 249 m
Photo 5
11 Nov 2022, 10:42:28


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302°W (T) 17N 595835 4869329 ±4 m ▲ 245 m
Photo 6
11 Nov 2022, 10:42:38


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183°S (T) 17N 595833 4869323 ±2 m 246 m
Photo 7
11 Nov 2022, 10:43:00


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121°E (T) 17N 595833 4869323 ±3 m 246 m
Photo 8
11 Nov 2022, 10:44:28


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292°W (T) 17N 595859 4869307 ±10 m ▲ 273 m
Photo 9
11 Nov 2022, 10:44:31


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196°S (T) 17N 595859 4869316 ±5 m ▲ 255 m
Photo 10
11 Nov 2022, 10:44:35


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108°E (T) 17N 595870 4869293 ±7 m ▲ 272 m
Photo 11
11 Nov 2022, 10:45:51


SW
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284°W (T) 17N 595870 4869293 ±6 m ▲ 272 m
Photo 12
11 Nov 2022, 10:45:55


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186°S (T) 17N 595870 4869298 ±4 m ▲ 265 m
Photo 13
11 Nov 2022, 10:46:00


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102°E (T) 17N 595901 4869298 ±8 m 257 m
Photo 14
11 Nov 2022, 10:47:23


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272°W (T) 17N 595893 4869291 ±6 m 254 m
Photo 15
11 Nov 2022, 10:47:28


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74°NE (T) 17N 595931 4869300 ±3 m 251 m
Photo 16
11 Nov 2022, 10:48:23


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266°W (T) 17N 595931 4869299 ±3 m 252 m
Photo 17
11 Nov 2022, 10:48:27


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175°S (T) 17N 595931 4869299 ±3 m ▲ 252 m
Photo 18
11 Nov 2022, 10:48:30


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359°N (T) 17N 595931 4869300 ±4 m ▲ 250 m
Photo 19
11 Nov 2022, 10:48:35


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89°E (T) 17N 595941 4869299 ±5 m ▲ 258 m
Photo 20
11 Nov 2022, 10:50:06


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270
181°S (T) 17N 595941 4869299 ±5 m ▲ 258 m
Photo 21
11 Nov 2022, 10:50:12


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NE
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2°N (T) 17N 595941 4869298 ±5 m ▲ 258 m
Photo 22
11 Nov 2022, 10:50:18


N
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52°NE (T) 17N 595917 4869318 ±4 m ▲ 250 m
Photo 23
11 Nov 2022, 10:50:45


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270
225°SW (T) 17N 595916 4869317 ±3 m 253 m
Photo 24
11 Nov 2022, 10:50:49


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161°SE (T) 17N 595956 4869284 ±3 m ▲ 257 m
Photo 25
11 Nov 2022, 10:51:47


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240
270
300
330
0
279°W (T) 17N 595956 4869284 ±3 m ▲ 256 m
Photo 26
11 Nov 2022, 10:51:50