

Appendix G: Hydrogeology Report



File: 2012191

June 5, 2021

Attention: [REDACTED]

Re: Preliminary Groundwater Assessment, Section 42, Otter Point Estates

As requested, Hy-Geo Consulting has completed a preliminary assessment of the groundwater conditions at the above property. This report summarizes available information on the groundwater conditions, quantity and quality aspects, prospects and proposed locations for developing water supplies from wells. The subject property was visited on three occasions to examine the general site conditions, local geology, drainage conditions, access conditions for a drilling rig, and to select potential drilling locations.

Land Use Bylaw 2040 (CRD, 2018) requires 1400 litres per day (0.26 USgpm) from a well on each lot and this may be met by submission of the driller's record indicating a yield of this quantity or greater for each well. A water sample for each well would also need to be obtained for submission to the CRD Health officer to prove water potability.

Site Location

The property of interest is situated within the King Creek watershed in the Otter Point area north west of Orveas Bay along the south facing flank of the Sooke Hills (Figure 1). The land parcel is designated as PID 9497790 and is approximately 552151.1 m² (552.15 hectares) in area. Topography across the property slopes moderately south-easterly with elevations falling from 140 to 120 m along the north and north-western boundaries to 80 m at the southeast corner of the property as shown in Figure 1. The property is also close to the eastern topographic divide of the Orveas Creek watershed. The proposed subdivision layout for the property is shown in Figure 2.

There is a relatively large wetland in the south-western quarter of the property that is shown on existing CRD (2021) mapping, draining south-easterly (Figure 3). The drainage from the south end of the wetland, however, is blocked by an abandoned logging road grade from draining towards the southeast. It likely drains north-easterly towards tributaries of King Creek.

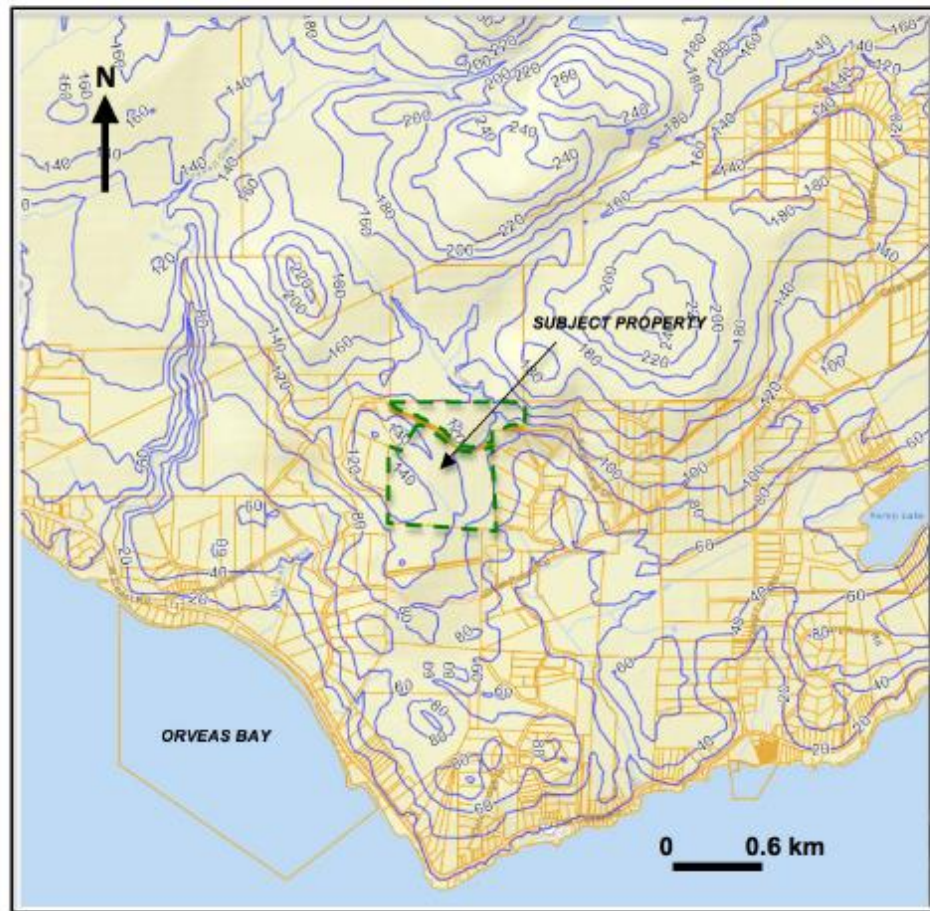


Figure 1. Location of subject property and regional topography. Contour interval = 20 m. Basemap from Province of British Columbia (2021).

Climate

The region is situated in a cool Mediterranean climatic zone with mild wet winters and dry summers. Monthly normal precipitation for the nearby William Head weather station for the 1981-2010 period has been reported by the Government of Canada (2021) for climate station 1018935 as shown in Figure 4. The area receives about 994 mm of precipitation on an annual basis (Government of Canada, 2021). Precipitation normally follows a seasonal cycle, with highest rainfall during the fall, winter and early spring months while the summer months are subject to drought conditions.

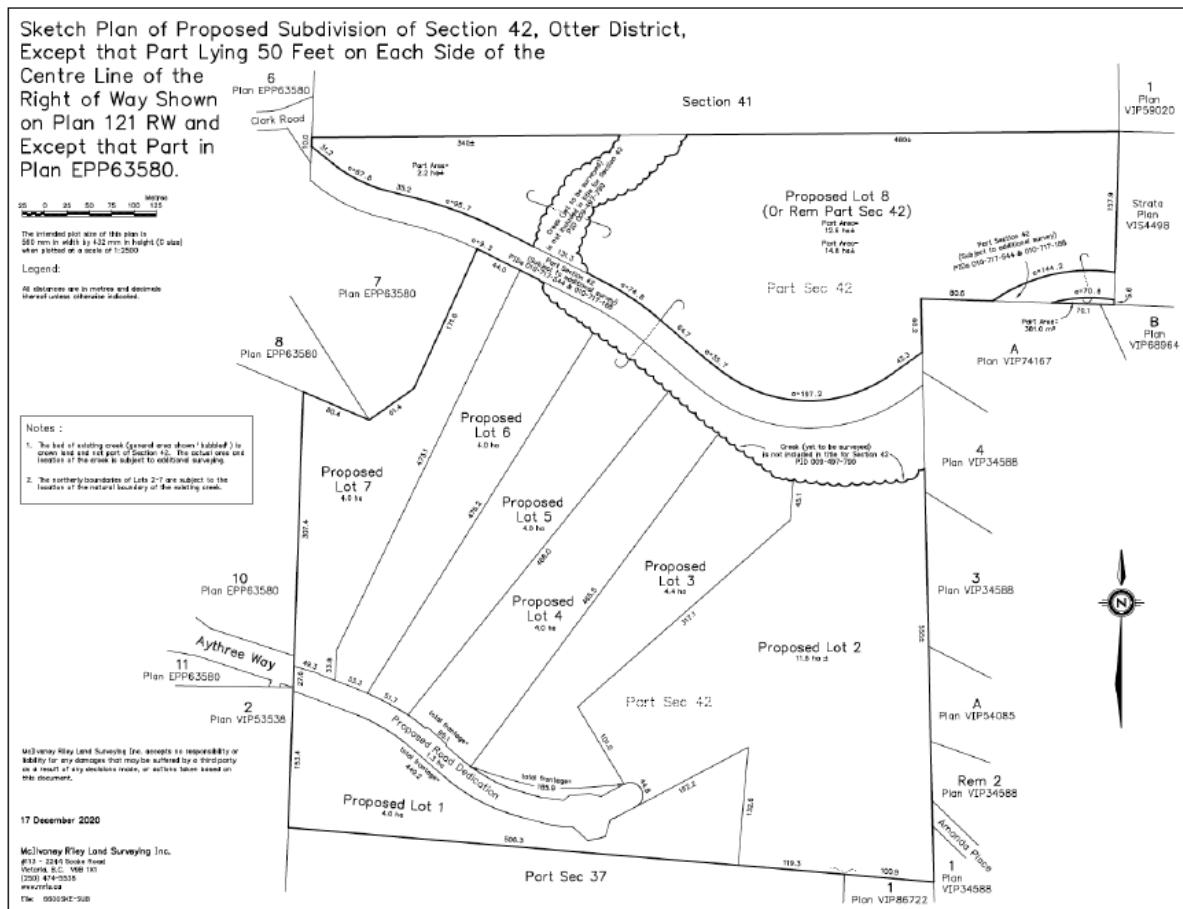


Figure 2. Proposed subdivision layout for the property.



Figure 3. Area of proposed subdivision and location of major wetland. Basemap from Google Maps (2021).

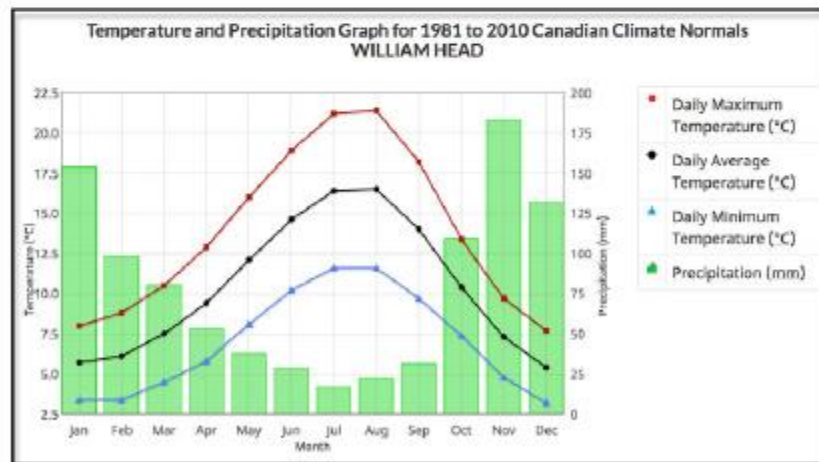


Figure 4. Graph of monthly normal precipitation for William Head station (Climate ID: 1018935). Graph from Government of Canada (2021).

Bedrock Geology and Hydrogeological Setting

The subject property is underlain by a fractured crystalline bedrock aquifer designated as the *Sooke-Metchosin Aquifer 606* (Province of British Columbia, 2021). Aquifer 606 occupies much of the land area in the municipalities of Metchosin, Colwood, Langford and Sooke, including the East Sooke Peninsula. The rocks include gabbroic and basaltic bedrock of Paleocene to Eocene origin, 50-56 million years in age belonging to the *Metchosin Igneous Complex* (Massey, 1994). The *Metchosin Igneous Complex* is a layered gabbro and leucogabbro (light-coloured feldspar and quartz-rich gabbro) including sheeted gabbroic and dioritic dykes that extend upward into fine-grained pillow and flow basalts. The unit also contains minor tuff, breccia, and rare limestone (Massey, 1994; Yorath and Nasmith, 1995).

Groundwater is found primarily in open fractures in the bedrock as they are encountered during drilling of water wells. These fractures constitute the major zones for groundwater storage and movement. Exposures of the volcanic rock in the region generally show relatively massive blocks of tightly fractured rocks with discrete zones of more intense fracturing in some places. See photos 1 to 4 in Appendix A.

Figure 5 shows some of the major bedrock lineaments present in the region that likely represent large fracture zones and joint systems. These lineaments trend in two dominant directions, namely northwest to southeast and southwest to northeast. Larger capacity wells are often situated along or close to these fracture trends and where lineaments intersect.

The fractured bedrock aquifer is classified as a IIIA aquifer with a low level of development and high degree of vulnerability to contamination from surface sources (Province of British Columbia, 2021). Groundwater is likely recharged by infiltration of precipitation, streams and ponds on the slopes of the Sooke Hills with groundwater moving southerly towards lower lying areas and ultimately discharging to the ocean.

Existing Water Wells

Reported water wells at and in the vicinity of the subject property reported in the *British Columbia Water Resources Atlas* (Province of British Columbia 2021) are shown in Figure 6. Each well has an assigned well tag number (WTN) or well identification number (WID) in the provincial WELLS database. The wells shown in Figure 5 do not necessarily comprise all existing wells in the area and all well locations have not been necessarily verified in the field. As the available data is historic it may not necessarily represent current conditions in the area. A summary of all the wells in the vicinity of the subject property as shown in Figure 6 is provided in Table 1.

The geometric mean well yield of the 32 reported bedrock wells is 0.089 L/s (1.42 USgpm). The median depth of the 32 bedrock wells is 170.8 metres (561 feet) while the range of bedrock well depths is from 30.48 to 396.24 metres (100 to 1300 feet). Generally speaking, well yields in the volcanic rocks in the region tend to be relatively

Table 1. Summary of well record information at and in the vicinity of the subject property.

Well Tag Number	Well ID Plate	Street Address	Year Drilled	Finished Well Depth (ft)	Finished Well Depth (m)	Diameter (in)	Diameter (cm)	Water Depth (ft)	Water Depth (m)	Bedrock Depth (ft)	Bedrock Depth (m)	Well Yield (Usgpm)	Well Yield (L/s)	Comments
46477		4090 Otter Point Road	1980	125		6.25	15.88					0.5		gravel and clay to 124 ft
50544		AMANDA PL	1982	225	68.58	6	15.24	195	59.44	11	3.35	3	0.190	sandstone 11-32 ft, limestone 32-195 ft, and granite 195-225 ft. 3 gpm at 195 ft
50545		AMANDA PLCE	1982	300	91.44	6	15.24			21	6.40	2	0.126	sand and gravel 0-21 ft, limestone 21-178 ft, granite 178-300 ft. 0.5 gpm at 178 ft. 1.5 gpm at 270 ft
65208		OTTER POINT ROAD	1979	30	9.14	6.125	15.56	8	2.44			3		gravel 15-20 ft
71910		OTTER POINT ROAD	1980	290	88.39	6	15.24	30	9.14	13	3.96	2	0.126	bedrock 13-290 ft, 0.5 gpm at 50 ft, 1 gpm at 110 ft, 2 gpm at 150-290 ft
71911		OTTER POINT ROAD	1980	350	106.68	6	15.24			35.5	10.82	2	0.126	bedrock 35.5 to 350 ft, 0.5 gpm at 310 ft, 2 gpm at 330 ft
80683		CLARK ROAD	1989	780	237.74	6	15.24			95	28.96	3	0.190	volcanic rock 100-640 ft, 3 gpm at 765 ft
80688		OTTER POINT ROAD	1989	450	137.16	6	15.24			25	7.62	6	0.379	volcanic rock to 25-400 ft, 1 gpm at 405 ft, increased to 6 gpm at 430 ft
80719		OTTER POINT PLACE	1990	760	231.65					5	1.52	0.5	0.032	0.5 gpm at 600 ft
80730		4470 OTTER POINT ROAD	1990	620	188.98	6	15.24			5	1.52	0.75	0.047	hard rock, 0.75 gpm at 585 ft
80731		4500 OTTER POINT ROAD	1990	860	262.13	6	15.24			6	1.83	0.40	0.025	hard rock to 800 ft, softer rock 800-840 ft, 0.33 to 0.5 gpm from 800-860 ft
80736		OTTER POINT ROAD	1990	560	170.69	6	15.24			5	1.52	0.75	0.047	0.75 gpm at 540 ft
81771		4520 Otter Point Road	2002	385	117.35	6.625	16.83			15	4.57	8	0.505	volcanic rock 45-220 ft, 1 gpm at 240-280 ft, increasing to 8 gpm at 370 ft
90566	18559		2006	420	128.02	6.625	16.83			7	2.13	2	0.126	grey medium-hard volcanic
92509		4559 OTTER POINT ROAD & OTTER POINT PLACE	1999	775	236.22	6	15.24			20	6.10	2	0.126	fracture at 660 ft, fracturing 50, 100, 225 and 325 ft
93450		OTTER POINT ROAD	1980	510	155.45	6	15.24			26	7.92	0.75	0.047	bedrock
100176		4179 OTTER POINT ROAD	1991	540	164.59	6.125	15.56			51	15.54	1.5	0.095	volcanic 51-400 ft, 0.25 gpm at 400 ft, increasing to 1.5 gpm at 510 ft
101915		OTTER POINT ROAD	1980	250	76.20	6	15.24	25	7.62	13	3.96	12	0.758	bedrock 13-250 ft, 1 gpm at 230 ft, 12 gpm at 230-250 ft
105846	26568	2565 AMANDA PLACE	2009	180	54.86	6.625	16.83			5	1.52	9	0.569	volcanic, 7 gpm at 150 ft, 2 gpm at 175 ft
105890	26524	2660F EAGLE CREST DRIVE	2009	400	121.92	6.625	16.83			6	1.83	1	0.063	volcanic, 0.5 gpm at 220 ft, 0.5 gpm at 380 ft
111280	42516		2015	600	182.88	6	15.24			20	6.10	0.33	0.021	grey to green bedrock, 0.5 L at 290-300 ft, 1 L at 300-430 ft, 1.75 L at 430-600 ft
111282	42457		2015	601	183.18	6	15.24			5.5	1.68	0.75	0.047	grey to green bedrock, fractured increased well yield from 0.125 to 0.75 gpm
111404	40576		2016	660	201.17	6	15.24	18	5.49	4	1.22	4	0.253	volcanic green bedrock, artesian flow
111405	40578		2016	901	274.62	6	15.24			22	6.71	0.2	0.013	green bedrock, fractured at 800 ft, hydrofractured
111427	42525		2015	660	201.17	6	15.24			34	10.36	0.1	0.006	grey and green bedrock
111432	42535		2015	34	10.36	6	15.24	4.66	1.42	33.5	10.21	20	1.263	sand and gravel 21-33.5 ft
111433	42542		2015	100	30.48	6	15.24	8.5	2.59	14	4.27	2.5	0.158	grey and green bedrock, 0.5 gpm at 36 ft, 1.5 gpm at 60 ft, 2 gpm at 80 ft, 2.5 gpm at 100 ft
111434	42451		2015	160	48.77	6	15.24			29	8.84	1.5	0.095	green and grey bedrock, 0.75 gpm at 120 ft, 1.5 gpm at 140 ft, 2 gpm at 160 ft
111435	42543		2015	920	280.42	6	15.24			13	3.96	2	0.126	grey, green volcanics, 2 gpm at 890 ft
112814	42446	CLARK RD	2015	561	170.99	6	15.24	36.3	11.06	8	2.44	10	0.632	grey and green rock, 10 gpm at 537 ft
112815	42544	CLERK RD	2015	600	182.88	6	15.24			13	3.9624	3	0.190	grey and green, fracture 576-578 ft
112816	40577	CLARK RD	2016	1020	310.90	6	15.24			21	6.40	0.2	0.013	bedrock
112830	42524		2015	1140	347.47	6	15.24			12	3.66	0.2	0.013	green, grey rock, fractured increased yield from 0.1 to 0.2 gpm
62880		Aythree Way	2021	1300	396.24	6	15.24			3	0.91	0.13	0.008	green and grey volcanic rock
62882		Aythree Way	2021	385	117.35	6	15.24	40	12.19	3	0.91	2.5	0.158	1.5 gpm at 225 ft, 2 gpm at 280 ft, 2.5 gpm at 345 ft, 3 to 150 ft, orange siltstone/shale, 150 to 385 ft, green volcanic, 4 inch liner from 2 to 385 ft, perforated from 185 to 385 ft

low for the most part, although there are some exceptions. A number of the low-producing wells have been hydro-fractured to improve yields.

Two wells recently drilled on the property (WID 62880 and WID 62882) were completed to depths of 1300 and 385 feet (396.2 and 117.4 m) respectively. WID 62880 was very low yielding, 0.13 USgpm (0.008 L/s) while WID 62882 was more productive at 2.5 USgpm (0.158 L/s) at a shallower depth. These wells illustrate the high variability that can occur in the region.

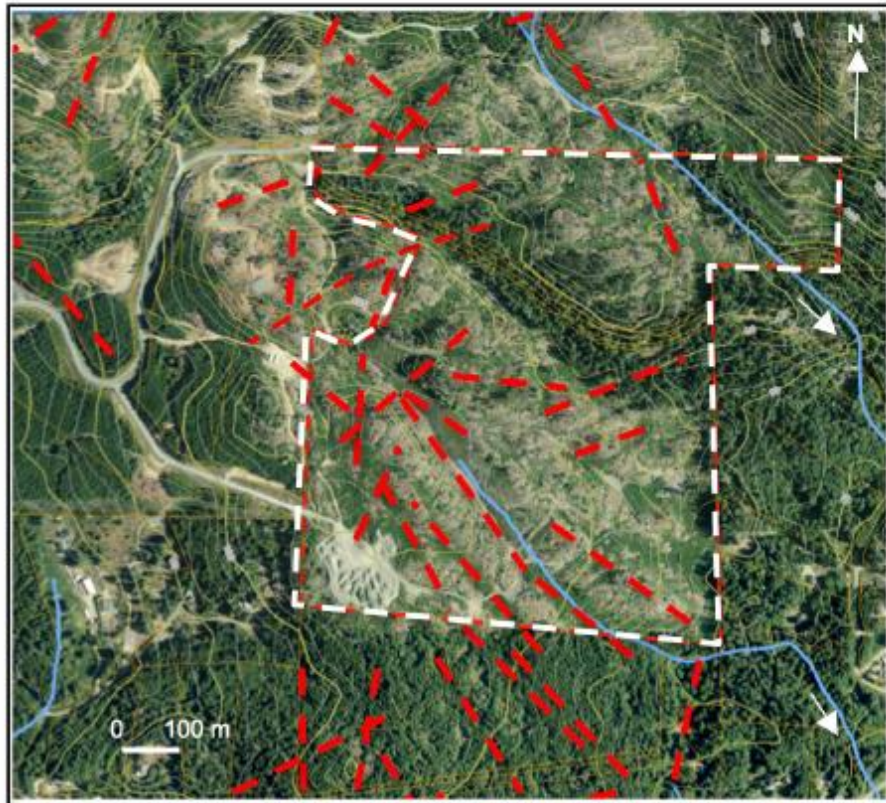


Figure 5. Interpreted major bedrock lineaments in region. Basemap from CRD (2021).

Groundwater Quality

Groundwater quality in the region may vary significantly depending upon well depths and might be expected to be moderately mineralized with total dissolved solids < 300 mg/l, low in sodium and chloride and with moderate levels of calcium and magnesium. Iron and manganese is often a common constituent in groundwater in the region.

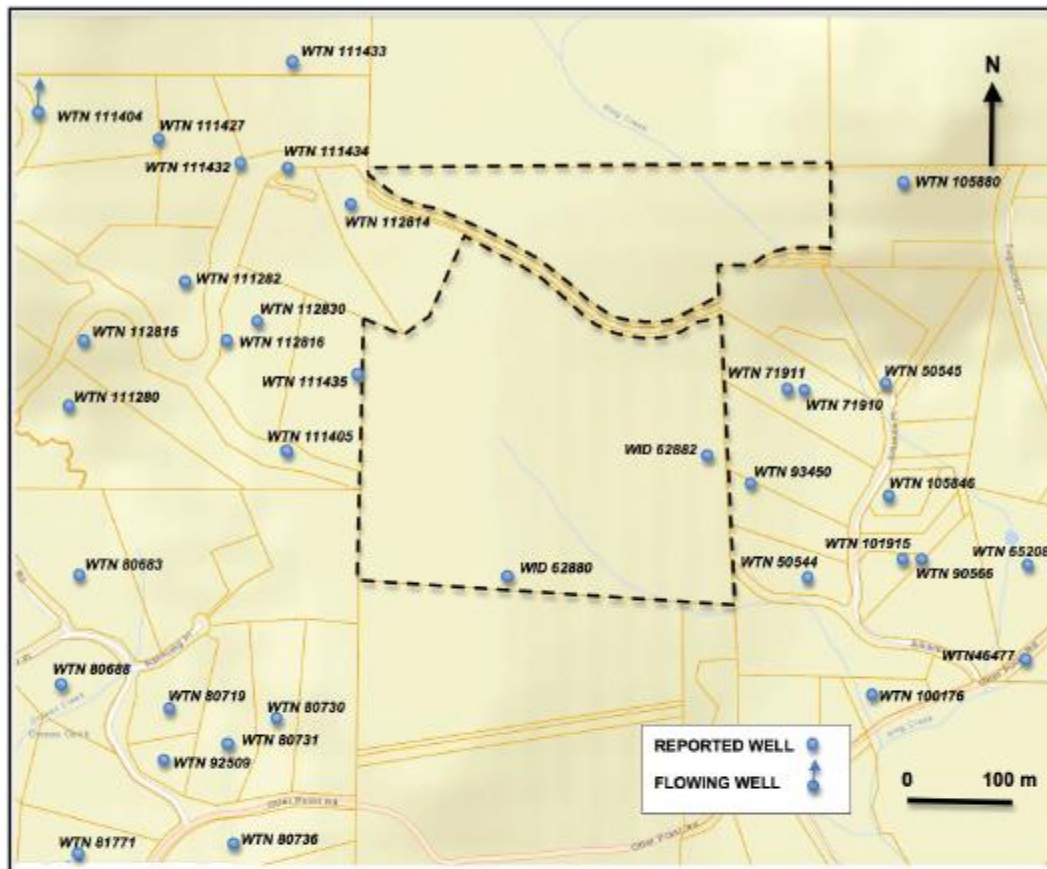


Figure 6. Location of subject property and reported neighbouring wells. Basemap from Province of British Columbia (2021).

Potential Well Drilling Sites

Based on the current proposed subdivision layout and geologic conditions observed in the field a number of recommended potential drilling sites are shown in Figure 7. It may not be necessary to drill at all of these locations.

Approximate coordinates for the proposed well locations are:

Site A: 48° 22.863' N, 123° 49.583'W Lot 7

Site B: 48° 22.846' N, 123° 49.613'W Lot 7

Site C: 48° 22.814' N, 123° 49.562'W Lot 6



Figure 7. Proposed test drilling sites. Basemap from Province of British Columbia (2021).

Site D:	48° 22.806' N,	123° 49.537'W	Lot 5
Site E:	48° 22.768 N,	123° 49.484'W	Lot 4
Site F:	48° 22.751 N,	123° 49.488'W	Lot 1
Site G:	48° 22.757 N,	123° 49.415'W	Lot 3
Site H:	48° 22.741 N,	123° 49.332'W	Lot 1
Site I:	48° 22.778 N,	123° 49.295'W	Lot 2
Site J:	48° 22.858 N,	123° 49.192'W	Lot 2
Site K:	48° 22.900 N,	123° 49.159'W	Lot 2
Site L:	48° 22.896 N,	123° 49.194'W	Lot 3

Each of the sites except Site J has been marked in the field with blue tapes. Currently most sites should be relatively accessible for a drilling rig with minimal road fill, grading and/or culvert installations. Access to site L would require some road work due to steepness of the slope. The sites should be inspected by the drilling contractor prior to mobilizing the drilling rig.

Conclusions

The following conclusions can be made regarding the groundwater conditions on the property and neighbouring region.

1. The subject property and region are underlain by a fractured crystalline bedrock aquifer designated as the *Sooke-Metchosin Aquifer 606* comprised of gabbroic and basaltic rocks of the *Metchosin Igneous Complex*. These rocks are fairly massive with discrete fracture zones that may be water-bearing.
2. The area is especially challenging for drilling as many of the existing wells tend to be very deep and very low producing.
3. Bedrock exposures on the property show discrete zones of intense fracturing in several areas. These zones where encountered at depth may be favourable targets for obtaining sufficient groundwater to meet the individual residential water requirements of 1400 L/day (0.26 USgpm).
4. Twelve drilling sites are proposed that are situated in proximity to zones of intense fracturing.

5. Groundwater quality on the property is anticipated to be low in overall mineralization with total dissolved solids < 300 mg/L with the possibility of iron and manganese being present.

Recommendations

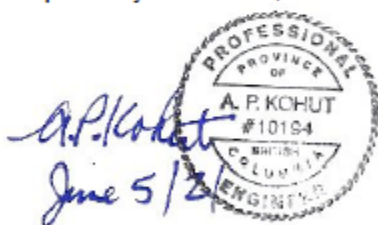
The following recommendations are provided for consideration:

1. Test drilling a number of individual wells to depths of 121.92 m (400 feet) may be more advantageous than drilling wells below this depth if sufficient water is not encountered within this depth zone.
2. The specific location of the test drilling sites may need to be adjusted to ensure adequate separation distances of 30 m from any planned septic disposal areas are achieved.

Closure

This report was prepared in accordance with generally accepted engineering, hydrogeological and consulting practices. It is intended for the prime use of the property owner in connection with its purpose as outlined under the scope of work for this project. This report is based on data and information available to the author from various sources at the time of its preparation and the findings of this report may therefore be subject to revision. Data and information supplied by others has not been independently confirmed or verified to be correct or accurate in all cases. Any errors, omissions or issues requiring clarification should be brought to the attention of the author. The author retains full copyright of the material contained in the report. The author and Hy-Geo Consulting accepts no responsibility for damages suffered by any third party as a result of any unauthorized use of this report.

Respectfully submitted,



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Principal and Senior Hydrogeologist

HY-GEO CONSULTING

References

- CRD. 2018. Bylaw 2040. Juan de Fuca Land Use Bylaw, 1992. Consolidated for Convenience Only, March 14, 2018. Victoria, British Columbia.
- CRD. 2021. *CRD Regional Map*. Internet website
<https://maps.crd.bc.ca/Html5Viewer/?viewer=public>
- Google Earth. 2021. <https://www.google.com/earth/>
- Government of Canada. 2021. *Canadian Climate Normals*. 1981-2010 Climate Normals & Averages. Internet website
https://climate.weather.gc.ca/climate_normals/index_e.html
- Massey, N.W.D. 1994. Geological Compilation, Vancouver Island, British Columbia (NTS 92 B, C, E, F, G, K, L, 102 I) (1:250,000). Map. Victoria, BC: B.C. Ministry of Energy, Mines and Petroleum Resources, Open File 1994-6, digital files and legend.
- Province of British Columbia. 2021. *British Columbia Water Resources Atlas*. Internet website: <https://maps.gov.bc.ca/ess/hm/wrbc/>
- Yorath, C.J. and Nasmith, H.W. 1995. The geology of Southern Vancouver Island. Victoria, BC: Orca Book Publishers.

APPENDIX A

Site Photographs



Photo 1. Outcrop of fractured basalt looking northwesterly along north side of Aythree Way extension near entrance to Otter Point Estates, April 25, 2021.



Photo 2. West side of large near vertical fault zone with soft pulverized rock looking northerly near western boundary of proposed Lot 2, April 25, 2021.



Photo 3. East side of large near vertical fault zone with soft pulverized rock looking northerly near western boundary of proposed Lot 2, April 25, 2021.



Photo 4. Fractured basalt in central portion of proposed Lot 2, April 25, 2021.