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October 6, 1981

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Professional Engineers
715 Canada Avenue
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ATTENTION: Mr. R. D. Wright, B.C.L.S.

SUBJECT: GROUNDWATER RESOURCE STUDY
TRANSTIDE INDUSTRIES LTD.
HIGHLAND DISTRICT PROJECT

Dear Sirs:

A survey of the hydrogeology of the Highland District has been carried out to establish the potential groundwater source available to the Transtide development project. This study has included a site reconnaissance with Mr. Ken Boyd, a review of the drill logs from the Phase 1 area, a review of pertinent projects in our files and an air photo analysis.

PHASE 1 DRILLING PROGRAM

The attached plan shows the locations of forty wells drilled on the Phase 1 development area. According to the driller's logs, the per well yield from the drill rig airlift ranged from 1/2 gpm to over 200 gpm as compiled in the attached table. The cumulative yield from these wells totals 770 gpm with no allowance for interference or sustained pumping drawdown. Our experience dictates that an airlifted discharge from bedrock wells should be regarded as an optimistic indication of sustained yield and we understand that well tests are to be carried out by controlled pumping. The driller's reports do indicate that sufficient quantities of water can be obtained for a single domestic residence on almost any lot in the project and that, collectively, the water obtained to date should exceed the demands of the Phase 1 and Phase 11 developments.

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HYDROGEOLOGY

The geology of the Highland District has been mapped as the Colquitz Group (quartz diorite gneiss) and the Wark Group (gabbro diorite gneiss) by C. H. Clapp (1910). Limestone is present to the north of the Highlands at Tod Inlet and Brentwood and it is possible that some limestone underlies the project area as logged by the driller. Where sandstone is entered in the well logs, we assume it to be weathered gneiss and where granite is mentioned, this is probably diorite gneiss, since the mineral composition is similar.

Our experience in the area shows that the diorite gneiss fractures cleanly forming a pattern of open joints for the passage of groundwater. Limestone can also be expected to have a pronounced pattern of joints with some fracture enlargement due to groundwater solution of the carbonate rock. The large per well yield which would be expected from these rock types has been confirmed by the Phase 1 drilling.

The attached plan shows the major fracture traces which are evident from a study of the air photos. Many of these traces are seen to be longitudinally continuous through the project area and we conclude that the successful completion of wells in Phase 1 can be projected to Phase 11, considering that the same rock types and fracture density are continuous.

The fracture traces shown on the plan can be used in conjunction with ground reconnaissance in selecting potential drill sites. In addition to the fracture trace location, the attitude (strike and dip) of a fracture plane with its associated zone of minor fractures must be determined in the field to obtain the highest probability of intercepting water-bearing zones at depth. This method of selecting well sites has been used extensively throughout British Columbia with considerable success where cleanly fracturing rock types exist such as those underlying the Highland District.

GROUNDWATER RECHARGE

Available climate records show that the mean annual precipitation at the Victoria Highland weather station was 46.12 inches per year over the 30-year period from 1941 to 1970. We normally consider a recharge factor of 10% of rainfall to be a workable estimate of the groundwater availability in a given area. A study completed for the District of Central Saanich in 1976 determined that actual recharge to known aquifers on the peninsula ranged between 11% and 17% which shows that the 10% estimate is reasonable.

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The Highland District covers an area of about 10 square miles of which approximately 4 square miles is included in the Transtide property. An inch of water on one square mile contains a volume of 17.4 million U.S. gallons so that the total annual recharge to this area is as follows:

$$\frac{46.12\ \text{inches}}{\text{year}} \times 0.10 \times \frac{17.4 \times 10^{6}\ \text{U.S. gal.}}{\text{m}^{2}\ \text{inch}} = 80.2\ \text{million}\ \frac{\text{U.S. gal.}}{\text{mi}^{2}\ \text{year}}$$

This is equivalent to about 150 U.S. gpm per square mile for a total District groundwater source of 1500 U.S. gpm and Transtide source of 600 U.S. gpm.

Some prevalent theories speculate that groundwater from distant regions reaches Vancouver Island via fault and fracture conduits, but no scientific evidence is available to substantiate a recharge source from the Olympics or even from the Malahat and this study considered precipitation only as the source of groundwater available to the immediate area.

PROJECT WATER REQUIREMENTS

We understand that Transtide plans to develop about 350 lots pending approval from the Regional District. The generally rough topography and shallow soil over most of the property preclude a significant demand for irrigation of lawns or gardens and the accepted requirement of 1/2 gpm per domestic residence should be adequate for the project. The total water needed to supply the project is therefore in the order of 175 U.S. gpm under full development. This amount of groundwater can easily be supplied by the annual recharge within the project boundaries and the wells drilled to date for Phase 1 show that this source can be readily developed.

In summary, we conclude the following:

1. A conservative estimate of the groundwater recharge within the boundaries of the Transtide project is 600 U.S. gpm based upon the known average rainfall and a recharge rate of 10% of precipitation.

2. The planned development of 350 lots will require a total of 175 U.S. gpm based upon the accepted demand of 1/2 gpm per lot.

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3. Wells drilled to date for Phase 1 show that the amount of water required for 350 lots can be readily developed within the project boundaries. Individual well yields are yet to be confirmed by pumping tests.

4. The geology of the project area is favourable for the development of wells on individual lots in Phase 11.

Please call if we can provide amplification on any of the above or if we can provide further assistance on this project.

Yours truly,

BROWN, ERDMAN & ASSOCIATES LTD.

H. W. Reed, P. Eng.

HWR/dh

Attachments

PROFESSIONAL
PROVINCE OF
H. W. REED
BRITISH COLUMBIA
ENGINEER

SUMMARY OF WELLS DRILLED ON PHASE 1 LOTS

WELL. NO.	LOT NO.	BEDROCK TYPE	AQUIFER DEPTH (FT.)	AIRLIFT YIELD GPM
1	22	SS/GR, GR	168, 234	2
2	22	SS/GR	158	21
3	278	SS/GR	240	2.5
4	23	GR	184	10
5	24	SS/GR	148	4
6	24	SS/GR	280	1.5
7	25	GR	470	1
8	25	SS	245	0.5
9	25	SS/GR	230	1
10	3	GR	272	1
11	3	SS, SS/GR	167, 272	1.5
12	29	SS/GR	160	30
13	28	SS/GR	178	10
14	30	SS/GR	121	15
15	31	GR	186	10
16	32	SS/GR	180	4
17	27	SS/GR	184	3
18	26	GR	256	1.5
19	26	SS/GR	265	2
20	2	SS	161	6
21	4	LS/GR	204	40
22	5	SS	145	60
23	5	SS	137	60
24	12	LS/GR	238	20
25	6	SS/LS, LS	76, 165	2
26	23	SS/GR	271	1.5
27	23	LS	228	12
28	23	LS	158	30
29	20	LS	312	20
30	9	LS	82	15
31	19	LS	134	25
32	18	SS	174	60
33	17	LS	204	12
34	13	LS	136	20
35	14	LS	136	30
37	11	LS	124	16
38	10	LS	112	4
39	8	LS	109	200+
40	21	LS	105, 181	4

SS = Sandstone (probable weathered diorite gneiss)
LS = Limestone
GR = Granite (probable diorite gneiss)