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ADDITIONAL WATER SUPPLY FOR SIX HOUSEHOLDS AT THE SOUTH END OF PASLEY ISLAND

PACIFIC HYDROLOGY CONSULTANTS LTD.

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Subject: Additional Water Supply for Six Households at the South End of Pasley Island

Dear Sir:

This letter is in reply to your letter of August 12 in which you authorize Pacific Hydrology Consultants to proceed with an investigation of the feasibility of drilling to obtain a supply of groundwater for six households at the south end of Pasley Island. A **Proposal to Investigate the Feasibility of Developing a Groundwater Supply for Six Households at the South End of Pasley Island** was contained in our letter to you of July 24. This letter is further to discussions during Ed Livingston's visit to Pasley Island on August 29. The subject six households occupy Site Numbers 18, 19, 20, 21, 22 and 23 shown on the topographic map of the Island which is included as Figure 1 in the attachments to this letter-report.

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1.0 INTRODUCTION

We understand that the water supply situation for the six households at the south end of Pasley Island is as follows:

1. The Island members who have summer homes in the South Bay area of Pasley Island depend for domestic water on a small water system which consists of a dug well and storage tanks.

2. The source of water for this system is an old hand dug well. The well is a rectangular hole excavated into very compact silty till below a concrete collar and curb.

3. The well is equipped with a small centrifugal pump powered by a gasoline engine. Water is pumped to a stave tank and two large poly' tanks for storage and also to a concrete tank at an higher elevation, from which the water is distributed to the six houses. The stave tank developed a leak resulting in a much lower quantity of water in storage this year than usual.

4. The well provides adequate water in winter and spring but its capacity is inadequate from late June through September.

5. All the other residences on the Island are supplied with water from dug wells, most of which are adequate for domestic purposes under conditions of intense water conservation. There are no drilled wells on the Island.

6. The six households in the South Bay area wish to obtain an additional source of water for the small system which supplies them. Under the occupancy agreement, which covers all residents on the Island, any works outside of the small plots occupied by the residents must be approved by the Island shareholders.

2.0 GEOLOGY

Most of Pasley Island is underlain by plutonic rocks of the Coast Range Complex with a small patch of greenstone of the Bowen Island Group at the south end. These rocks are impermeable except where they are fractured.

The rock is overlain by a very compact silty stony till which was deposited during regional glaciation when ice moved southward down Howe Sound and Georgia Strait. The maximum thickness of the till on the Island is unknown but is probably not more than 20 m. A small inclusion of sea-bottom sediment with many shell fragments, which can be seen in an exposure in a bay on the southwest shore of the Island, clearly shows that the ice advanced into the sea incorporating this inclusion into the till.

At the time when the last glacial ice melted in the area about 10,000 to 12,000 years ago, sea level was much higher than at present. Evidence on Bowen Island, and in numerous places on Vancouver Island, shows that sea level was as much as 100 m above its present level. As the land emerged from beneath the sea, wave erosion of the till produced a thin layer of sand and gravel which covers the till in most places. Scattered small boulders and cobbles, on or just below the ground surface, are part of this material which is often referred to as marine veneer. During the long period when sea level has been at its present level, marine erosion has removed the till cover from the bedrock along the shore except in sheltered small bays and coves where there are gravel beaches.

3.0 HYDROLOGY

All of the fresh water on Pasley Island, whether on surface or below the ground surface as groundwater, comes from precipitation which falls on the Island. There is probably very little surface runoff, even in times of heavy winter rains or during snowmelt. Most of the precipitation is returned to the atmosphere by evaporation and transpiration or percolates into the ground to become groundwater.

Because of the vigorous vegetation and development of soil on the permeable marine veneer, most precipitation is held near the land surface until it:

a. evaporates;

b. is used by plants and returns to the atmosphere by transpiration;

c. moves slowly downward into the till or, where till is absent or very thin, into fractures in bedrock.

Groundwater recharge probably occurs only during part of the year. During the summer drought, there is a soil moisture deficiency and any precipitation is used immediately by plants. The fall rains, after plant growth has virtually stopped, are mostly used up replacing the soil moisture deficiency. Once the soil moisture reaches field capacity, water moves down through the soil and into the unweathered till and the fractured bedrock. Depending on weather, this

recharge probably does not start until early winter and it probably stops in spring as soon as vigorous plant growth starts.

Groundwater flow through the slowly permeable till and fractured rock takes place by gravity from the uplands of the Island toward the sea. Most discharge to the sea takes place below sea level and cannot be observed. Very slow seepage from till exposures can be observed in one of the small bays on the southwest part of the Island. However, in general, the permeability of the compact till is probably not very different from that of the fractured rock so that a separate flow system is not moving through the till. Figure 2 in the attachments is included to illustrate the concept of groundwater flow on small islands which are surrounded by the sea.

The very low permeability of the groundwater flow system on Pasley Island is shown by the fact that groundwater is available to dug wells throughout the year, in spite of the fact that recharge takes place only during a relatively short period each year. This shows that the drainage process is very slow. Under these conditions, each well has only a small zone of influence and, in general, wells can be expected to have very limited capacities. Further, such wells, which are located above sea level, are not prone to seawater intrusion.

4.0 GROUNDWATER RESOURCES OF PASLEY ISLAND

As it affects the development of a source of groundwater for the South Bay Water System, the preceding comments on the hydrology of Pasley Island show that:

1. Groundwater resources originate only from precipitation on the Island.

2. After groundwater recharge stops in the spring, all groundwater comes from storage in the slow-moving groundwater flow system.

3. The area from which a dug well draws water is quite local in extent.

4. It is very unlikely that a large source of groundwater can be found on the Island.

The amount of groundwater in the groundwater flow system on the Island at any time is quite large. Estimates of the amount of groundwater in the flow system can be made by making a simple assumption about how much of the precipitation which falls on the Island ends up as part of the groundwater flow system. The adjusted 30-year average of annual precipitation at Bowen Bay on Bowen Island for the period 1951 to 1980 is reported by Atmospheric Services of Environment Canada to be 1490 mm (58.7 in). Precipitation at the south end of Pasley Island is probably quite similar. The monthly averages show that 74% of the total precipitation, or 1104 mm, falls during the period of low evaporation and transpiration losses between October and April. If we assume that 1/3 of this, or 368 mm, enters the ground to become part of the groundwater flow system on the

Island, and if we assume that 75% of the 100 hectares (247 acres) of the Island is an effective recharge area, there is potentially 7.4×10^5 L/day of groundwater moving through the system.

The fact that such a large quantity of groundwater moves through the flow system on Pasley Island is a separate issue from the ability to exploit such water by wells. The amount of water being taken from the existing dug wells on the Island is quite insignificant compared to the amount of groundwater flowing through the system. The chance that development of additional groundwater for the South Bay Water System will interfere with existing wells on the Island is very remote.

Rough calculations can be made to relate the groundwater resources of the Island to the demand from the present development of the Island. If we assume that the demand from each residence is 400 L/day and, further, if we assume that all 30 residences are occupied, the total water demand is 12,000 L/day. This is less than 2% of the previously estimated daily flow through the groundwater flow system. While such calculations are based on several assumptions and must be considered to be very approximate, they show the order of magnitude of the quantities involved.

5.0 ADDITIONAL WATER SUPPLY FOR THE SOUTH BAY SYSTEM

The following steps can be carried out in an effort to increase the present supply to the South Bay Water System:

1. Deepen the present dug well to increase its capacity. Increasing the depth in the compact till would have little effect on the capacity; however, if the deepened well encounters even a thin layer of sand and gravel or weathered rock at the contact between the till and the underlying rock, a considerable increase in capacity might result. A program to deepen the present dug well would involve hiring an experienced contractor equipped with compressed air tools and perhaps experienced in the use of explosives.

2. Excavate one or more additional dug wells in the general vicinity of the existing well.

3. In the low terrace area where the existing well is located, drill a 150 mm (6") diameter well to try to obtain water near the contact between the till and the rock or to obtain water from the fractured rock. Since the site is fairly close to the sea on two sides, the hole should not be drilled to a depth greater than 10 m.

4. At a site northeastward from the existing well along the road to the north end of the Island, drill a 150 mm (6") diameter well in the rock. Since the site is about 250 m from shore, at elevation about 30 m amsl, the well can be drilled to 40 m or more with little danger of encountering brackish water. If brackish water is encountered, the hole can be partly filled with cement grout to seal off the poor quality water. A well at such a site would have no measurable effect on existing wells.

A drilled well requires a different type of pumping system than is used for the dug wells. The following two

pumping systems are feasible for Pasley Island where there is no electric power:

1. An electric submersible pump with a small engine generator to supply power. This can be a simple system started manually as required, or an automatic system can be built to pump when the water level in a storage tank is low. The smallest size pump is 1/3 hp requiring an inexpensive single phase 1 Kva generator.

2. A jet pumping system with the pump powered by a small gasoline engine located at the well head. This is the simplest system but jet systems are more subject to problems and are less efficient than a submersible pump system.

Unconventional systems can also be used. A submersible pump powered by solar panels is a more expensive alternative; such systems are now past the experimental stage and are reported to be quite trouble-free. Wind power can also be used; a wind-power source would have to be placed on a tower or at an high exposed location some distance from the well.

6.0 RECOMMENDED COURSE OF ACTION AND ESTIMATED COSTS

We recommend the following program to increase the water supply to the South Bay Water System:

1. Drill one test-production well near the existing dug well using a cable tool drill or an air rotary drill. If the well finds water, carry out a pump test using a submersible test pump to determine the well capacity.

2. If the hole in Step 1. is not successful, drill a rock well at a site on the road to the north end of the Island about midway between the east and west shores of the Island. A possible well location is shown on the attached plan. The conductivity of any water which is encountered during drilling should be checked in the field with a conductivity meter in order to detect any change which may occur when the hole goes below sea level and there is a chance of encountering brackish water. In any case, the well should not be drilled deeper than about 45 m.

3. Depending on the result of Step 2., move northward 70 m or more and drill another rock well.

The amount of water required for the six households on the South Bay Water System is quite small, especially if the large storage tank is repaired or replaced. Since there are no flush toilets or electrical appliances on the system, the consumption of water per connection is probably not more than 400 L (90 imperial gallons) per day. Thus, when all six homes are occupied, the demand is probably not more than 1.67 litres per minute or 0.37 igpm.

In our opinion, the chances of obtaining 1.67 L/min from a drilled well near the existing dug well are not good. However, such a hole is inexpensive and the costs of putting it into production are minimal so drilling at this site is justified as a first step.

The chances of obtaining the required supply from a rock well at the site proposed in Step 2. are good and the chances of obtaining the required supply from two holes are very good. However, the cost of developing such a site must

include the cost of a pump (or pumps) and about 550 m of pipe to reach the present system from the nearer of the two sites.

We estimate that the cost to carry out all three steps, if necessary, of the recommended program to obtain additional water for the South Bay Water System on Pasley Island will be as follows:

1.	Move drilling equipment and supplies to and from pasley Island	$ 1,500.
2.	Supply and install 4.6 m of surface casing and overlap casing	600.
3.	Supply 150 mm casing shoe	100.
4.	Drill to 15 m near the existing well @ $60./m	900.
5.	Supply and install 4.6 m of surface casing and overlap casing and drill 80 m of hole at two sites to the north	5,500.
6.	Hourly time to move from site to site, etc; 15 hours @ $85./hr	1,275.
7.	Carry out a 48 hour pumping test	3,500.
		$ 13,375.

This estimate is based on a maximum program of drilling. If the first step (which involves drilling a test-production well near the existing dug well) is successful, the total cost of drilling and testing may be as low as **$6,600.**

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We estimate that consulting fees to supervise the drilling by telephone, to visit the Island during pump testing and to prepare a completion report would not exceed **$2500.,** including the cost of a domestic water analysis.

7.0 SUMMARY

We summarize our investigation of the feasibility of drilling to obtain additional water supply for the six households served by the South Bay Water System as follows:

1. Most of Pasley Island is underlain by plutonic rocks of the Coast Range Complex with a small patch of greenstone of the Bowen Island Group at the south end. These rocks are impermeable except where they are fractured.

2. Where it has not been removed by marine erosion along the shore, the rock is overlain by a very compact, silty stony till which was deposited during regional glaciation.

3. The source of surface water and groundwater on Pasley Island is precipitation which falls on the Island. The main recharge to the groundwater flow system on the Island occurs in the period October to April when precipitation is maximum and evapotranspiration losses are low.

4. Because of the very low permeability of the groundwater flow system on Pasley Island, each dug well has only a small zone of influence and, in general, the capacity of such dug wells is limited. The location of these wells above sea level rules out the possibility of sea water intrusion.

5. Rough calculations based on several assumptions show that there is potentially 7.4×10^5 L/day of groundwater

moving through the flow system on Pasley Island. If the demand from each residence on the Island is assumed to be 400 L/day, the total demand when the 30 residences are occupied is 12,000 L/day, or less than 2% of the daily flow through the groundwater flow system on the Island.

6. The following steps can be taken in an effort to increase the present water supply to the South Bay Water System:

   a. Deepen the existing dug well to increase its capacity.

   b. Excavate other dug wells in the general area of the existing well.

   c. Drill a well in the low terrace area near the existing dug well.

   d. Drill a well at a site northeastward from the existing dug well, along the road to the north end of the Island.

7. The following program is recommended to increase the source of water to the South Bay System:

   a. Drill one test-production well near the existing dug well and, if successful, carry out a pumping test to determine the capacity.

   b. If a. is unsuccessful, drill a rock well at one or more sites on the road to the north end of the Island about midway between the east and west shores of the Island.

   c. Depending on the results of b., move northward 70 m or more and drill another rock well.

8. The chance of obtaining a source capacity of 1.67 L/min from a drilled well near the existing dug well is not good but drilling of such a hole is justified because costs are minimal. The chance of obtaining the required supply from a rock well at sites on the road to the north end of the Island is good.

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9. The cost of a maximum test-production drilling program is estimated to be **$13,375.;** the cost of a minimum program is estimated to be **$6,600.** Consulting fees are estimated to not exceed **$2,500.**

Yours truly,

PACIFIC HYDROLOGY CONSULTANTS LTD.

E. Livingston

E. Livingston, P. Eng.

Attachments

ATTACHMENTS

FIGURE 1 PASLEY ISLAN

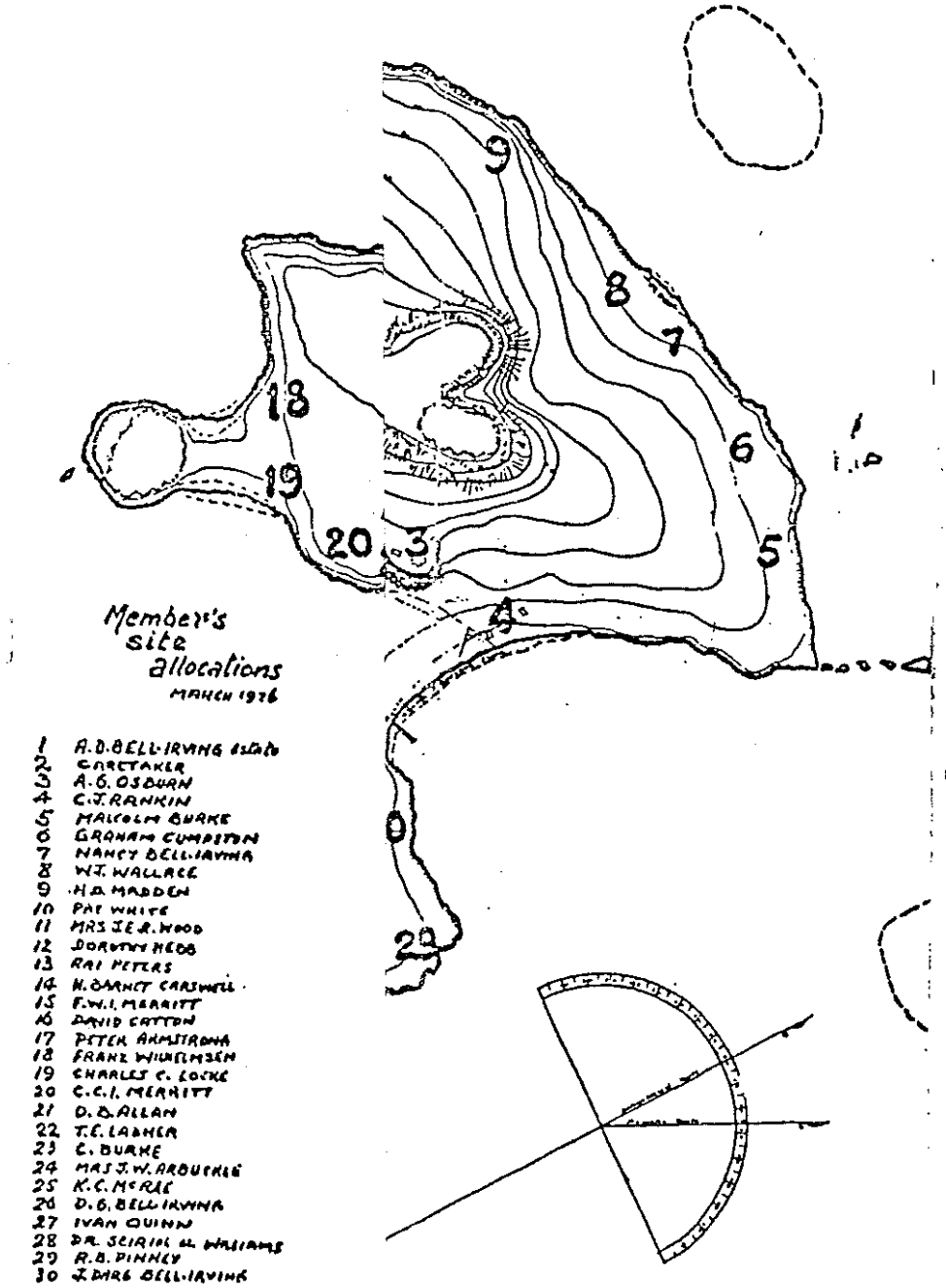
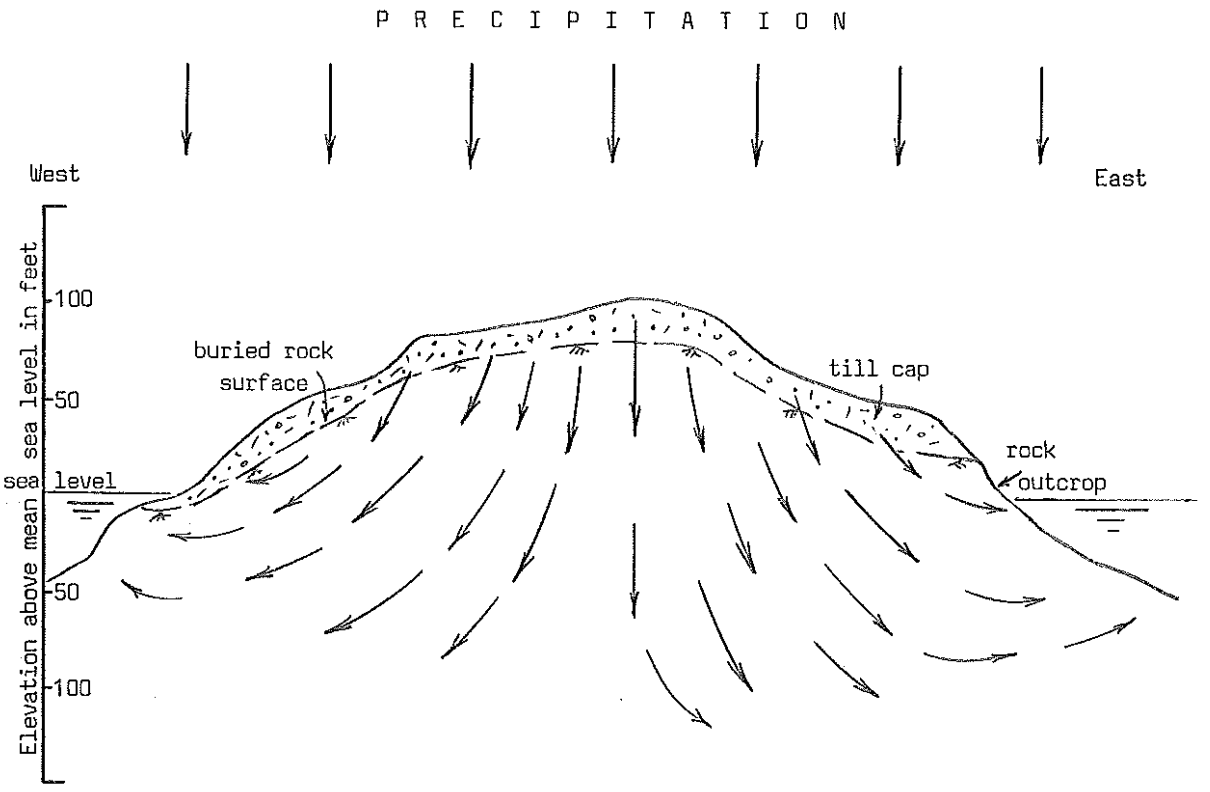


FIGURE 2

SCHEMATIC HYDROGEOLOGICAL CROSS-SECTION

ILLUSTRATING GROUNDWATER FLOW ON PASLEY ISLAND



Notes:

1. Vertical scale: as shown.
2. Horizontal scale: not to scale.
3. Vertical exaggeration: approximately 4 x.
4. The line of the schematic hydrogeological cross-section is shown on Figure 1.

FIGURE 2

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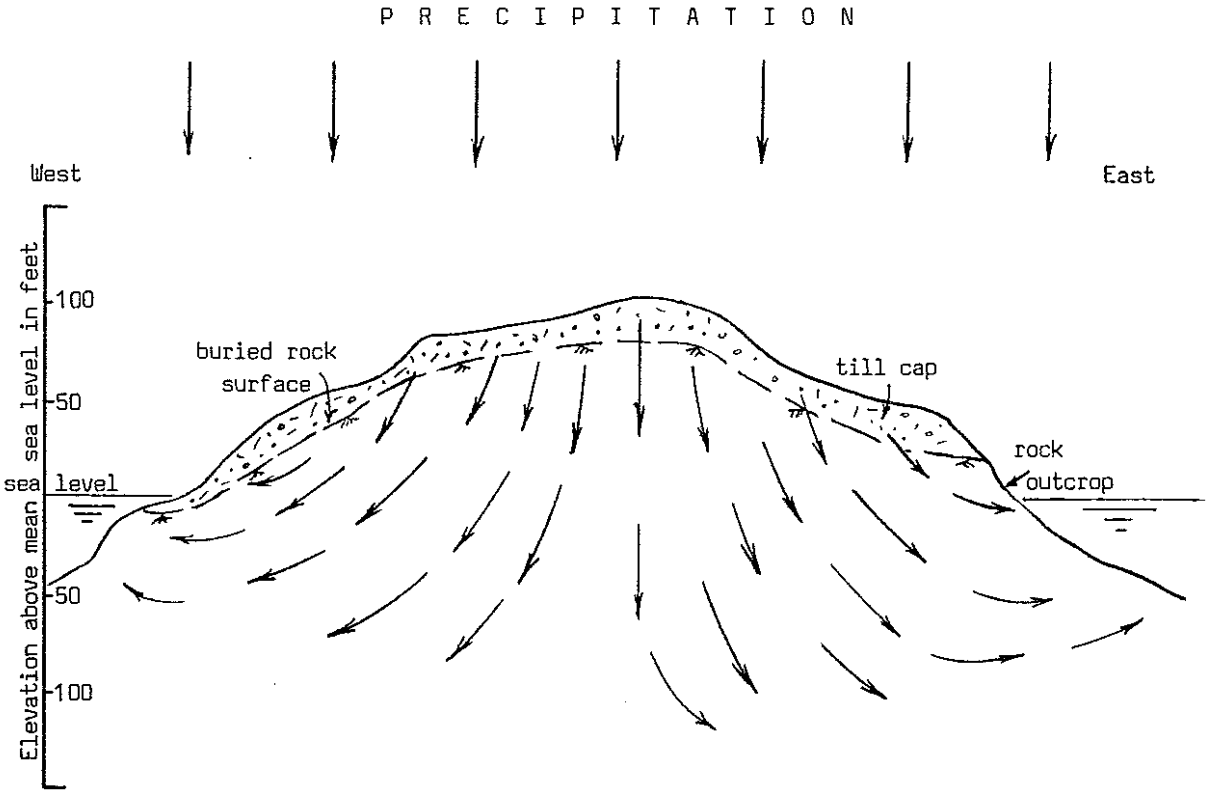

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