Province of British Columbia

Ministry of the Environment
WATER INVESTIGATIONS BRANCH

MEMORANDUM

To: Dr. J.C. Foweraker, Head
Groundwater Section
Hydrology Division
Water Investigations Branch

Date: June 6, 1979

File: 0346052
92-G4 #27

Fr: A.P. Kohut
Sr. Geological Engineer
Groundwater Section

Re: Gabriola Island Community Plan, Fault Zones

As requested by Mr. G. Tonn, Planner with the Islands Trust, a review has been undertaken of available hydrogeologic information pertaining to four "fault zones" designated in the map accompanying the Gabriola Island Community Plan (1978). These linear zones (700-foot wide strip) have been included in the community plan under Resource Protection Areas (20-acre minimum lot size), as "linear areas of rock fracture which allow surface and sub-surface water to penetrate to underground water sources known as aquifers". Available well log data, existing geology and groundwater reports and air photographs were examined in conjunction with a field visit of the area on May 30, 1979 to assess the hydrologic significance of these "fault" designated zones. For purposes of discussion the four linear zones have been arbitrarily designated areas A, B, C and D (Figure 1). A brief description of each zone is given below following a general discussion on fault terminology.

FAULT TERMINOLOGY

Faults are fractures in rocks along which the opposite walls have moved past each other to produce a displacement (Badgley, 1965). Geologic faults have been recognized by geologists mapping the distribution and structural geology of bedrock formations in the Gulf Islands, but the relationship of major faults and the role they may play in affecting groundwater recharge, movement and groundwater discharge (i.e., groundwater flow systems) on the island is not fully understood at this time. Faults may be discernible as lineaments on air photographs and fault evidence is generally recognizable in the field by: the displacement of rock formations adjacent to a fault; repetition or omission of rock strata in an area; abrupt changes in bedding attitudes; occurrence of topographic fault scarps; occurrence of intensely fractured and sheared rock zones; and presence of deformational structures such as slickensides (striated and polished rock surfaces) or presence of fault gouge (layers of ground rock along fault planes).

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Individual faults and/or fault zones may range from a fraction of an inch to several thousand feet in width.

Other prominent linear structural features such as joints and bedding planes are common in the bedrock of the Gulf Islands. Joints and joint systems (fractures or cracks exhibiting no visible displacement of adjacent rock masses) may be associated with faults, folding of strata or may be topographically controlled to some extent as a result of pressure relief from the removal of rock through erosion and uplift or the removal of glacier loading. Joints generally occur in parallel arrays constituting a set (Hills, 1963). Two or more prominent intersecting sets make up a joint system.

The permeability or ability of a fault zone or fracture system to transmit water depends upon the open width, continuity, degree of interconnection and number of fractures per unit volume of rock. The accumulation of groundwater in an area (quantity in storage) depends upon regional fracture patterns, fracture geometry and degree of interconnection between open faults, joints and bedding plane contacts. Depending upon the permeability of a fracture zone and contrasting permeability of adjacent rock masses, faults may act as drains or conduits (high permeability zones) intersecting, for example, joint system controlled aquifers, as subsurface dams (low permeability zones) by juxtapositioning impermeable barriers to the flow of groundwater; and as siphons (Schoeller, 1977). Groundwater flow circulating through fault zones may not be uniform and may frequently be localized because fault zones are not necessarily open at all places or in all directions (Schoeller, 1977). The effectiveness of a fault zone in facilitating groundwater recharge depends in part upon the permeability of the zone, topographic setting and local relief, surface water drainage, and the nature of overlying soil and vegetation cover. In summary, there are several physical factors which determine whether a fault zone may be an important source for groundwater recharge.

ZONE A: (Le Boeuf Bay to Descanso Bay)

The northern portion of this zone which straddles the centre of Section 22 lies along a steep southeasterly facing bedrock escarpment comprised principally of sandstones of the Gabriola Formation (Muller and Jeletzky, 1970) underlain by shales of the Spray Formation. The bedding in the units dips towards the northwest. Apart from the topographic relief which suggests the presence of a fault scarp, it is improbable that this zone acts as a major source for groundwater recharge. The actual fault trace, if present, probably lies at the base of the escarpment. Geologic mapping by Muller and Jeletzky (1970) does not indicate a major fault at this locale. Towards the southwest there is no significant evidence (topographic or geologic) to indicate extension of a fault zone into the Descanso Bay area. From air photograph analysis there are on the other hand numerous structural lineaments evident in the area (Figure 2). These for the most part reflect bedding planes (curved lineaments) and traces of joints the latter of which southwest to northeast and northwest to southeast trending sets are predominant. There is no hydrogeologic evidence for differentiating the Resource Protection Area in the northeast portion of Section 20 from adjacent Rural designated areas (10-acre minimum lot size).

ZONE B: (Descanso Bay to eastern boundary of Section 19)

This east-west trending zone (Figure 1) lies within a major valley trend, paralleling North Road. Muller and Jeletzky (1970) indicate a major fault occurring along this trend. Several domestic wells have been drilled on properties adjacent to North Road and for the most part well yields are low. Some wells up to 212 feet deep in Section 20 adjacent to the fault zone have been reported dry. In Section 19 there is some evidence of good capacity from a deep well (greater than 200 feet in depth) on the north side of the valley. The areal distribution of water levels in existing wells suggests that groundwater recharge is taking place on the upland areas adjacent to the valley and in the upper portions of the watershed and groundwater flow is into the main valley and westerly down the topographic gradient. Local springs are evident in the valley in Section 20. In Section 19 the upper reaches of the valley above elevation 300 feet and underlain by the fault zone may be an important area of groundwater recharge, providing the fault zone is relatively permeable.

ZONE C: (North half of Section 6)

This northeasterly striking zone forms the northern extension of a major structural lineament clearly evident in air photographs of the island. The lineament has been mapped as a major transverse fault by Muller and Jeletzky (1970). In the northeastern part of Section 6 the zone occupies a topographic low (saddle) between two ridges. A few shallow wells (less than 110 feet) have been completed in the zone, showing moderate well yields up to 5 gpm, with water levels ranging from 30 to 50 feet below ground surface. Flowing artesian conditions have been encountered north of the fault zone where it intersects Peterson Road. Where the fault zone intersects the coastline, several parallel embayments occupied by shear joints were observed during the field examination. These zones which parallel the fault trend do not appear particularly permeable (clay gouge observed on shear planes), although the zones are lithologically weaker and more susceptible to erosion than adjacent rock masses. Some saline groundwater having a specific conductance of 4 000 micromhos/cm and chloride concentration of 1 300 mg/L has been delineated along the coast near the fault zone (Figure 2).

ZONE D: (North half of western boundary of Section 5)

This north-south striking zone follows a major structural lineament evident on air photographs of the area, although this feature has not been mapped as a fault by Muller and Jeletzky (1970). This zone has been identified as a fault or fracture zone by Brown and Erdman (1975). The nothern portion of the zone occurs along a topographic divide and may therefore be important as a source area for groundwater recharge for the coastal areas to the north and east, providing the zone is relatively permeable in this area.

SUMMARY AND RECOMMENDATIONS

The hydrologic role of major geologic faults to groundwater flow systems can be varied depending upon topographic considerations, degree of permeability within the fault zone, contrasting permeability between the fault zone and adjacent areas, and hydraulic relationship to other structural bedrock features such as joints and bedding planes. From available evidence the only fault areas examined which may be important sources for groundwater recharge, providing they are relatively permeable, occur in the main valley along North Road in Section 19 and the fault areas designated Zones C and D (Figure 1). Since the permeability of these fault zones is not adequately known at this time, it is difficult to ascertain their importance for recharge. The limited lithologic evidence observed in the fault zone in Section 6 (Zone C) suggests the zone is less permeable than adjacent areas and may therefore act as a barrier to groundwater flow and not as a source for groundwater recharge.

There is insufficient evidence to indicate that the four fault areas designated above are important zones for groundwater recharge and that they should be designated as Resource Protection Areas on this basis alone. In some areas it would appear that the designated fault zones are probably less important for recharge than adjacent areas which have been designated Rural Areas (i.e., in Section 20). In view of the above, consideration should be given to removing the fault designated zones as Resource Protection Areas from the Community Plan and extending watershed protection zones to cover the upper reaches of the watersheds where groundwater recharge is probably occurring. Figure 3 shows the watershed boundaries (from Hodge, 1978) for the Sands, Descanso Bay, Gabriola and Silva Bay Regions in which the fault designated zones are located. In the Sands Region consideration should be given to including the area above elevation 150 feet within the Resource Protection Area. In the Descanso Bay Region elevations above 150 feet in the northeast quarter of Section 20 should be protected and areas above 300 feet in the remaining area of the watershed. In the Gabriola Region, areas above elevation 125 feet should be protected and areas above 100 feet in the Silva Bay Region.

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REFERENCES

Badgley, P.C. 1965. Structural and Tectonic Principles. Harper and Row, New York.

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Hodge, W.S. 1978. A Review of Groundwater Conditions on Gabriola Island. Water Investigations Branch, British Columbia Ministry of Environment.

Muller, J.E. and J.A. Jeletzky. 1970. Geology of the Upper Cretaceous Nanaimo Group, Vancouver Island and Gulf Islands, British Columbia. Geological Survey of Canada, Paper 69-25.

Schoeller, H.J. 1977. Analytical and Investigational Techniques for Fissured and Fractured Rocks in Groundwater Studies. An international guide for research and practice. UNESCO.

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Attachs.

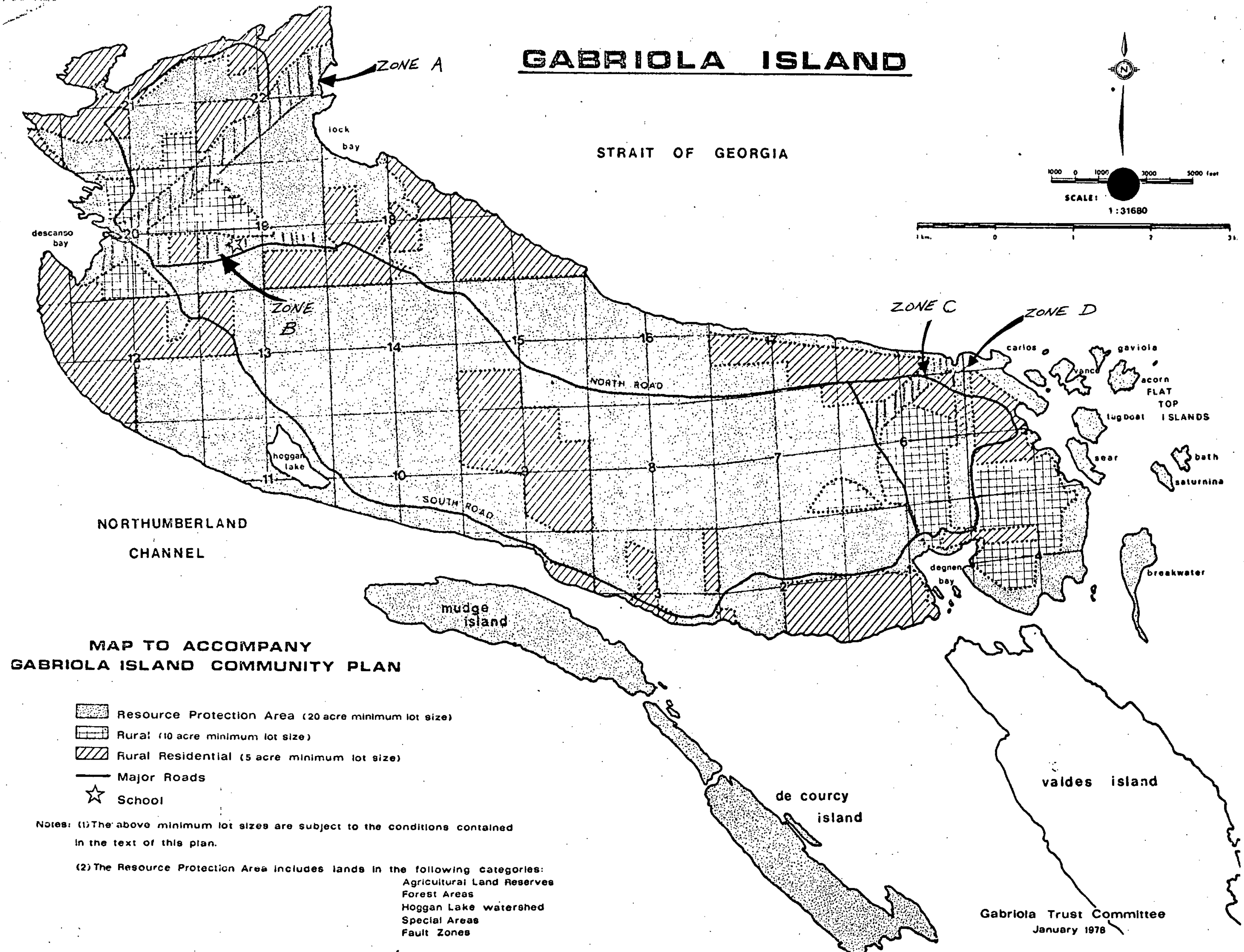
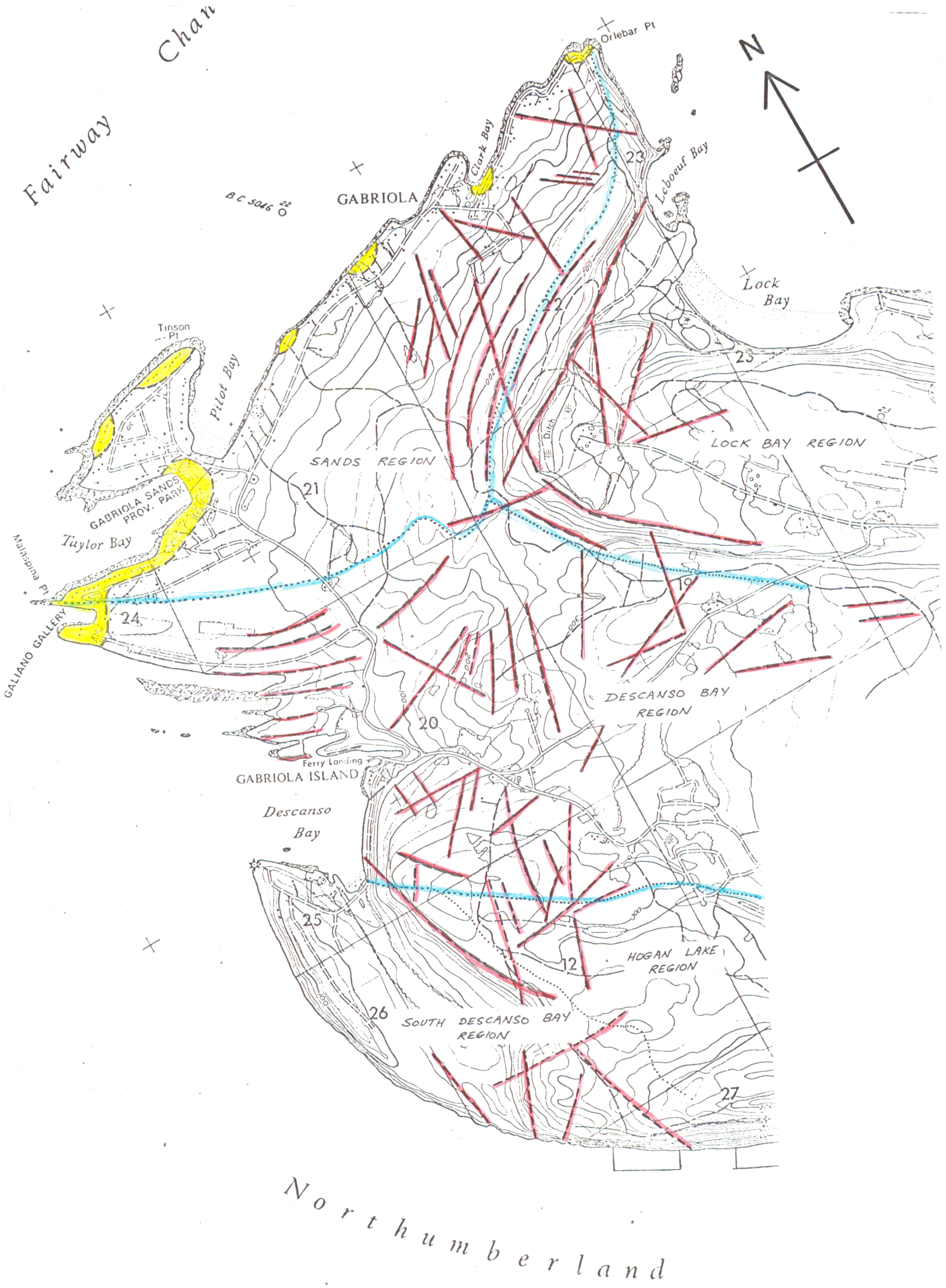
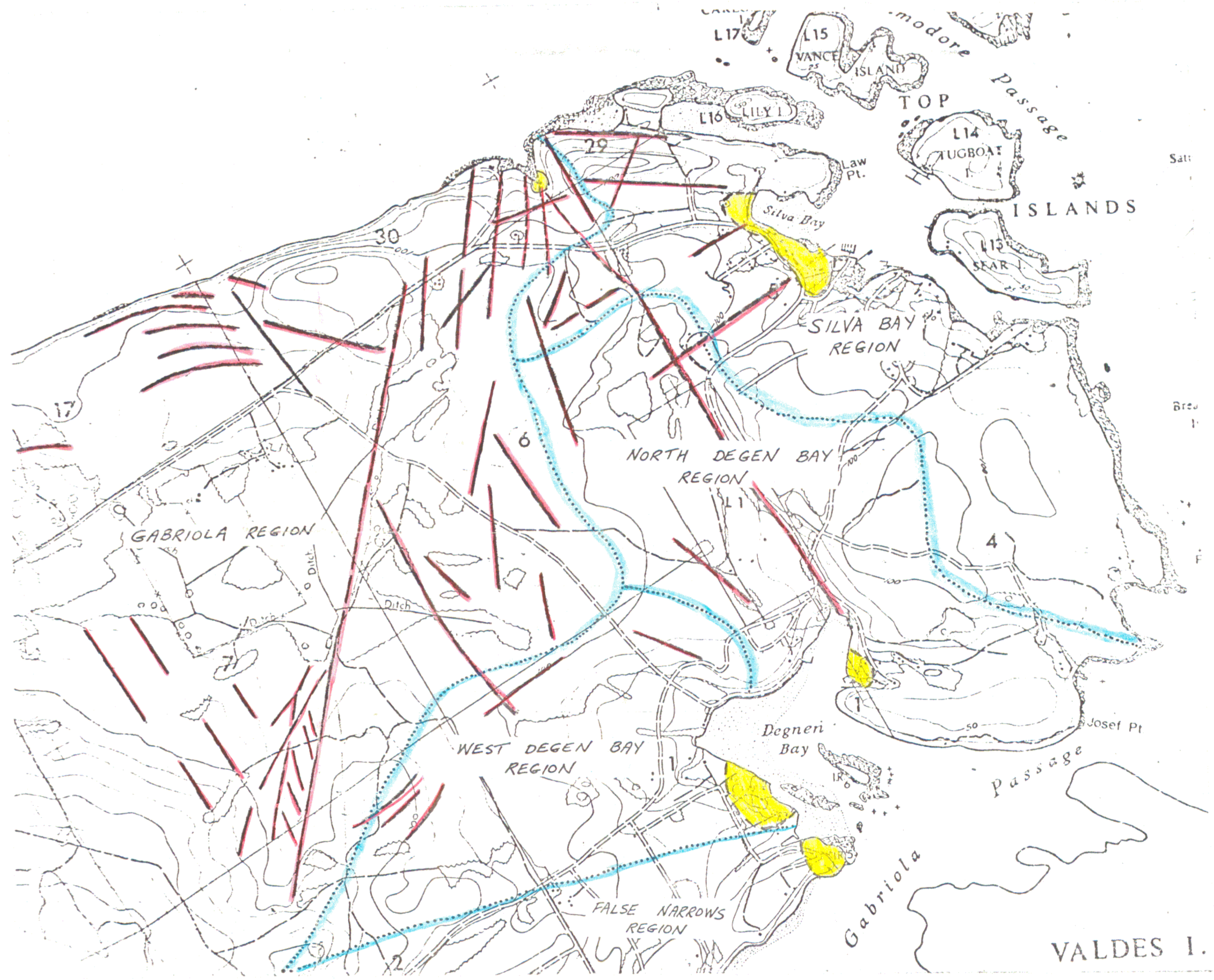

GABRIOLA ISLAND
STRAIT OF GEORGIA
NORTHUMBERLAND CHANNEL
ZONE A
ZONE B
ZONE C
ZONE D
lock bay
descanso bay
hoggan lake
NORTH ROAD
SOUTH ROAD
degnen bay
mudge island
de courcy island
valdes island
carlos
gaviola
vance
acorn
FLAT TOP ISLANDS
tugboat
sear
bath
saturnina
breakwater
SCALE: 1:31680
MAP TO ACCOMPANY GABRIOLA ISLAND COMMUNITY PLAN
Resource Protection Area (20 acre minimum lot size)
Rural (10 acre minimum lot size)
Rural Residential (5 acre minimum lot size)
Major Roads
School
Notes: (1) The above minimum lot sizes are subject to the conditions contained in the text of this plan.
(2) The Resource Protection Area includes lands in the following categories:
Agricultural Land Reserves
Forest Areas
Hoggan Lake watershed
Special Areas
Fault Zones
Gabriola Trust Committee
January 1978

FIGURE 1.





LEGEND

STRUCTURAL LINEAMENT (includes faults, joints and bedding traces)

WATERSHED BOUNDARY

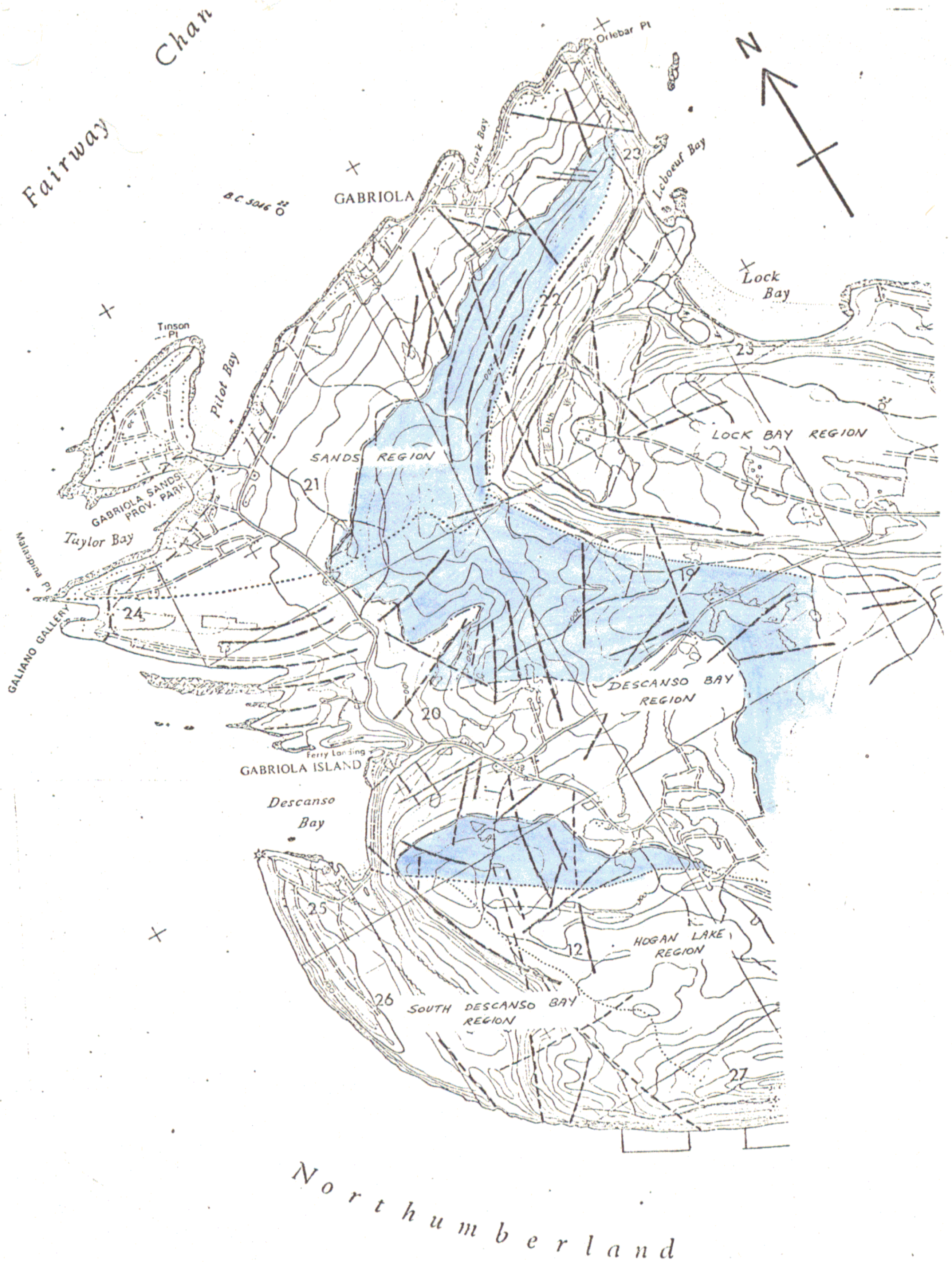
AREAS WHERE CHLORIDE CONCENTRATIONS IN GROUNDWATER EXCEED 100 MG/L

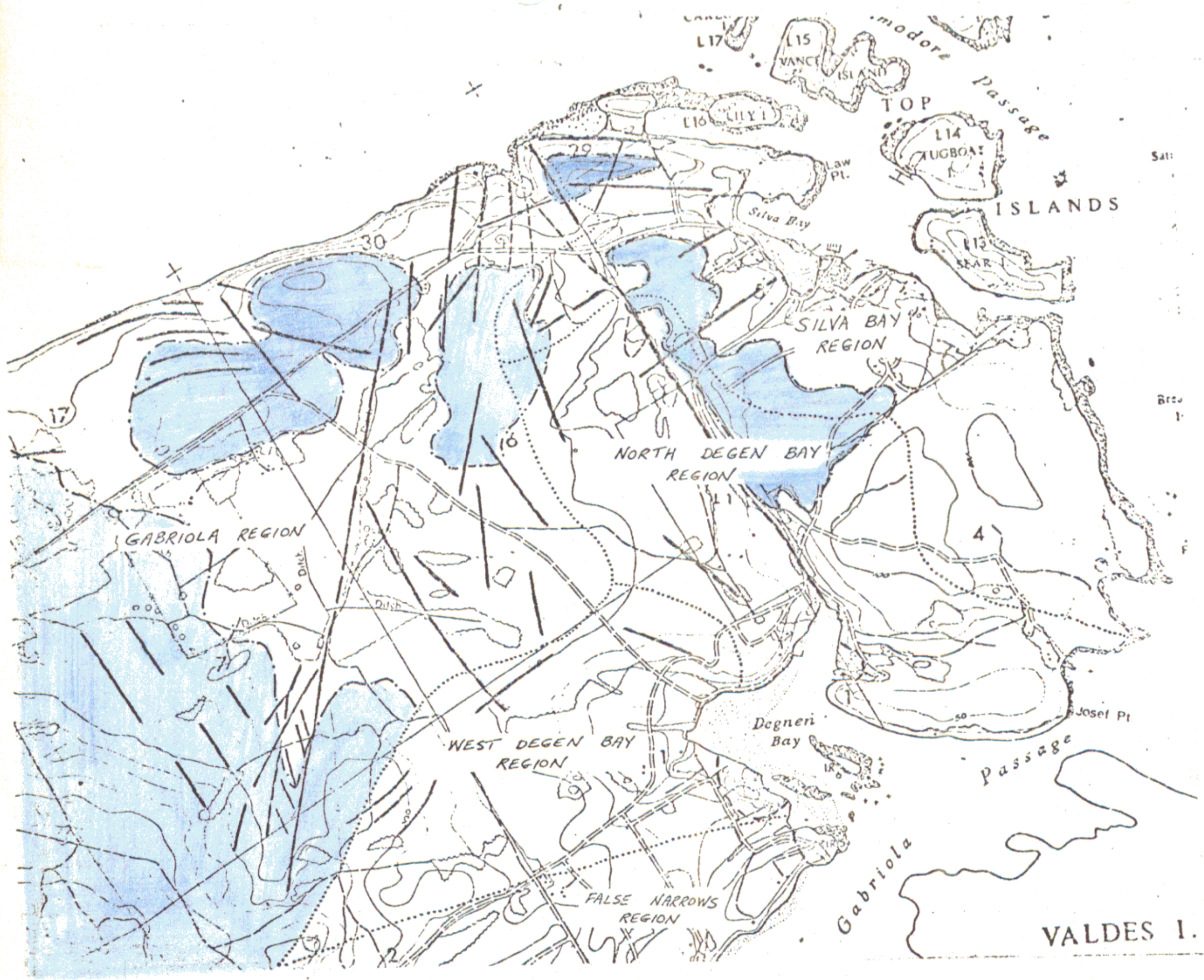
SCALE

0 1000 2000 3000 4000 5000

IN FEET

Province of British Columbia Ministry of the Environment ENVIRONMENTAL AND ENGINEERING SERVICE WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON GABRIOLA ISLAND COMMUNITY PLAN
SCALE: VERT. .... HOR. AS SHOWN — DATE MAY, 1979	A.P.K. ENGINEER FILE No. 92G4 ... DWG. No. FIGURE 2





LEGEND

SUGGESTED WATERSHED PROTECTION AREAS
FOR GROUNDWATER RECHARGE IN THE
SANDS, DESCANSO BAY, GABRIOLA AND SILVA BAY REGIONS

SCALE

0 1000 2000 3000 4000 5000

IN FEET

Province of British Columbia Ministry of the Environment ENVIRONMENTAL AND ENGINEERING SERVICE WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON GABRIOLA ISLAND COMMUNITY PLAN
SCALE: VERT. HOR. AS SHOWN — DATE MAY, 1979	A.P.K. ENGINEER FILE No. 92 G 4 #22 DWG. No. FIGURE 3.