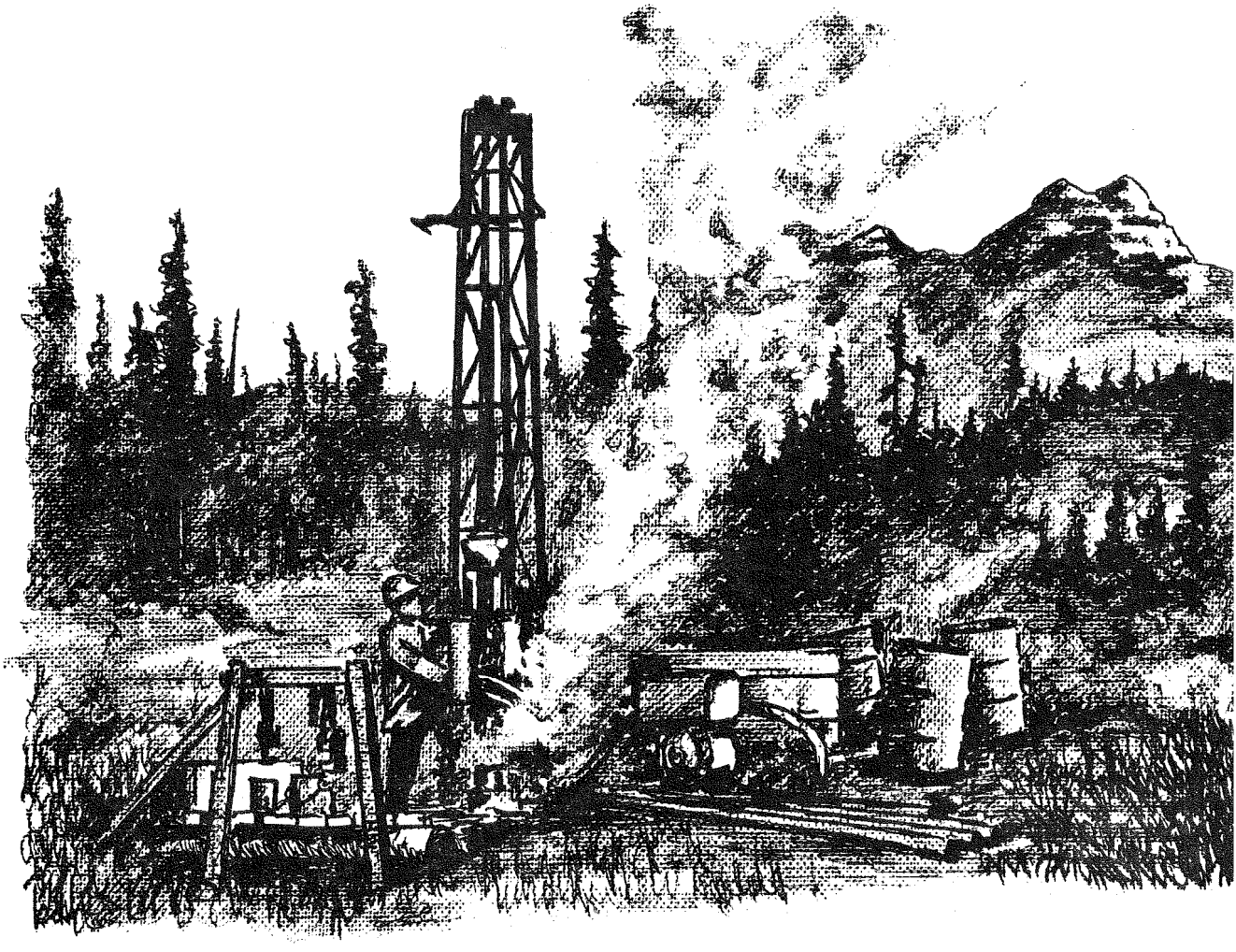
B.C. HYDRO AND POWER AUTHORITY

Report on Preliminary Investigation of the Geothermal Resources of Western Vancouver Island

November , 1975



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REPORT ON PRELIMINARY INVESTIGATION OF THE GEOTHERMAL RESOURCES OF WESTERN VANCOUVER ISLAND.

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NEVIN SADLIER-BROWN GOODBRAND LTD.
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REPORT ON PRELIMINARY INVESTIGATION OF THE GEOTHERMAL RESOURCES OF WESTERN VANCOUVER ISLAND.

1.0. SUMMARY

A reconnaissance of the geothermal potential of the west coast of Vancouver Island was initiated during the winter of 1974-75. The program began with an airborne infrared scanning survey of selected areas including those where hot springs were known or suspected. This work was followed up during the summer by field examination of infrared anomalies and other areas where thermal springs were alleged to occur. Three springs on Flores Island and at Refuge Cove were sampled.

Results are considered equivocal and continuation of the present project is not considered justified.

2.0. INTRODUCTION

2.1. Terms Of Reference

Thermal springs are both known and rumoured to occur along the west coast of Vancouver Island from Kyuquot to Sooke (see Drawing V1). Their locations, geological relationships, chemical compositions, and possible geothermal significance were for the most part obscure. Hot springs, however, are considered good indicators for the presence of geothermal energy sources and a study of their distribution and nature is generally accepted as the most practical first step in any geothermal investigation. In December of 1974 the firm of Nevin Sadlier-Brown Goodbrand Ltd. on behalf of B.C. Hydro began such an investigation into the geothermal potential of this area. It was intended as a preliminary program which would involve locating, examining, and sampling the hot springs and possibly carrying out preliminary geological surveys in the more interesting localities. Areas considered to have potential as geothermal sources could then be defined and detailed exploration recommended.

Of the initial steps outlined above, the most challenging has proved to be the first - - locating the springs. Methods included in the terms of reference were library and ground searches, interviews with residents, and airborne infrared surveys.

2.2. Topography, Physiography, and Access

The known and rumoured hot spring localities of Vancouver Island are all on or very near the west coast. The terrain here is generally rugged, but there are limited areas of coastal plain. Both plains and mountains are densely wooded

with typical B.C. coastal species such as Douglas fir, hemlock, red and yellow cedar and a wide variety of smaller plants which hamper travel on the ground. Precipitation is high, averaging in excess of 300 cm per annum.

The west coast is becoming increasingly accessible by road. Two paved highways, route 4 from Alberni to Tofino and route 28 from Campbell River to Gold River provide all-weather access to the general area. In addition,a number of logging roads and trails have proved useful. Among these are the Alberni to Bamfield Road and the West Coast Trail which leads south along the coast from Pachena Bay. For the most part, as in the case of the area between Tofino and Estevan, access is best achieved by boat or aircraft.

2.3. Work Done

During the fall and winter of 1974-75 a search of the literature was made for references to any thermal springs, or areas of recent volcanism. In December 1974 and January 1975 an airborne infrared survey was carried out jointly by Integrated Resources Photography and Nevin Sadlier-Brown Goodbrand Ltd. The survey employed an AGA infrared scanning unit mounted in a Cessna 180 aircraft which was based at Tofino. Scanning was carried out over a wide area with three purposes in mind: to carry out a systematic search for new hot springs; to check smaller areas where hot springs were alleged to occur; and to define areas where they were known to exist.

The results of this work were assessed and field examinations were carried out in most of the areas of interest. Geological observations were made and samples of thermal waters were taken for analysis. Analytical results were used to obtain reservoir temperature estimates in the case of three of the springs.

3.0. GEOLOGICAL SETTING

The west coastal area of Vancouver Island is largely underlain by Mesozoic volcanic and crystalline rocks, mainly of Jurassic age. Triassic volcanic rocks of the Karmutsen Formation tend to lie to the east of the Jurassic belt, and limited areas of Cretaceous sedimentary rocks unconformably overlie it to the west. The Mesozoic rocks are cut randomly by Tertiary intrusive rocks and are overlain along much of the outer coast by Tertiary sandstones and shales of the Tofino Basin.

The area lies close to the boundary between two crustal plates; the American plate to the north and east and the San Juan plate to the south. They are separated by a zone of seismic activity extending southwest from the vicinity of Nootka Island and by the base of the continental slope. The former probably represents a transform fault which truncates the Juan de Fuca Oceanic ridge at its north end while the latter coincides with a zone of crustal subduction.

4.0. AIRBORNE INFRARED SURVEY

4.1. Method

During December 1974 and January 1975 an airborne infrared survey was carried out over selected areas of the west coast of Vancouver Island. These were Kyuquot Sound, Nootka Island, Hesquiat - Refuge Cove, Flores Island, Tofino Inlet, and Ucluelet. The field work was performed by Mr.P. Williams and Dr.R. Cameron of Integrated Resources Photography Ltd. of Vancouver and by T.L. Sadlier-Brown of Nevin Sadlier-Brown Goodbrand Ltd. An AGA Infrared Scanner vertically mounted in a Cessna 180 aircraft made continuous scans of selected flight paths[1]. An infrared image displayed on the unit's video screen was constantly monitored by an observer seated beside the pilot. Whenever an anomalous I.R. emission appeared on the screen another pass was made over the area of interest and both screen and terrain were simultaneously photographed. Data were presented in the form of 35 mm. photographs of the infrared image on the video screen and vertical visible light air photographs to be used in locating the anomalous areas on the ground.

4.2. Observations

Thermal anomalies were observed and recorded at various locations in all the areas flown including, of course, at Sharp Point and Ahousat where there are known hot springs. Some of these were selected for ground follow-up which was begun in June 1975. Those areas selected on the basis of the infrared survey were:-

1. Sharp Point Hot Spring
2. Ahousat Warm Spring
3. Matilda Inlet (Near Ahousat)
4. Mate Island (Near Sharp Point)
5. Fair Harbour.

Infrared scanning also detected plumes of warm water in the ocean west of Flores Island. These, however, were low contrast anomalies.

By the time the ground follow-up work started a number of additional alleged thermal springs had been reported from various sources, including hikers, hunters, local west coast residents. Added to the list from these sources were:-

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[1] A detailed technical description of the equipment and methods used in this survey is given by P. Williams in the appendix to this report.

6. Hesquiat Harbour Area

7. Kennedy River Area

8. Kootowis River Area

9. Tsusiat River Area

5.0. THERMAL SPRING SAMPLING

Two trips were made during the 1975 summer field season to locate, examine and sample springs both known and alleged to occur on Vancouver Island. Of those tested only one can really be called a hot spring; the Sharp Point Spring near the south end of the Openit Peninsula west of Flores Island. The Ahousat Spring is merely warm while several others detected by the scanner near it on the shores of Matilda Inlet are just sufficiently above ambient temperature to be recorded as anomalies. This was also the case for several other springs and warm patches observed and recorded in the coastal waters themselves. A few of the springs could not be found at all and access problems precluded the locating of others, notably the Kennedy River alleged spring and the one reported to occur near Fair Harbour.

5.1. Sharp Point (Map 92E/8W)

The Sharp Point Hot Spring is about one mile south of the Hot Springs Cove wharf on Refuge Cove. Water at a temperature of 50.5°C issues from the base of an outcrop of diorite about 200 feet from the beach and 1000 feet from Sharp Point at the tip of the Openit Peninsula. Most convenient access is from Tofino by boat or seaplane to Hot Spring Cove, thence on foot along a trail and boardwalk.

A sample taken from the spring for analysis was tested by Chemex Laboratories Ltd. of North Vancouver and gave the following results:

	Value (PPM)
SiO_2	48
Na	144
K	2.1
Ca	16.5
Mg	0.05
Cl	224
HCO_3	32.1
SO_4	28.5

An empirical method developed by Fournier[1] for estimating subsurface temperatures from chemical properties of geothermal waters was applied using the above values. Resulting temperature estimates are 100.6°C using the SiO_2 geothermometer and 57.7°C using the Na-K-Ca method. The disparity, which is considerable, is most probably attributable to a chemical disequilibrium at depth and may indicate that the spring does not meet the criteria necessary for meaningful results.

It has been suggested by Elworthy[2] and others that the Sharp Point thermal water is seawater which has penetrated the sheared diorite country rock to great depths, where it has been heated, then returned to the surface. Presumably the variation in density between the cold sea water and the hot, relatively dilute spring water would easily suffice to raise the latter to the elevation of the vent. Seawater would certainly be the most obvious source, as the spring is surrounded on three sides by the sea.

An objection to the view outlined above is based upon the disparity between the major chemical constituents of the sea and the hot spring water illustrated in the table below.

TABLE 1

COMPARISON OF MAJOR CONSTITUENTS OF SEAWATER VS SHARP POINT HOT SPRING ON VANCOUVER ISLAND

	Concentrations in P.P.M.		
		Sharp Point Hot Spring	
Major Constituents	Seawater	A	B
Cl	18,980	206	224
Na	10,561	141.2	144
Mg	1,272	.05	.05
S	884	-	-
Ca	400	17.7	16.5
K	380	2.0	2.1
Br	65	-	-
C	28	-	-
Sr	13	.01	2
B	4.6	-	20
Si	4	25	23
F	1.4	1.3	-
SiO_2	8	52.8	49.0
SO_4	2,700	36	28.5

[1] Fournier, R.O., and Rowe, J.J. 1966
Estimation of Underground Temperature from the Silica Content of Water from Hot Springs and Wet Steam Wells: American Jour. Sci., V.264, pp. 685-697
Fournier, R.O., and Truesdell, A.H., 1973.
An empirical Na-K-Ca Geothermometer for Natural Waters: Geochimica et Cosmochimica Acta, V.37, pp.1255-1275.

[2] Elworthy, R.T. - Hot Springs in Western Canada.
Can.Dept.Min. Bull.No. 699
Investigation of Mineral Resources and the Mining Industry 1925.

Note: Sea water values are taken from Mason, B. Principals of Geochemistry, John Wiley & Son Inc. New York.N.Y. 1960.

A. Geological Survey Results (Souther J.G. Geothermal Potential of Western Canada: in Press, Proceedings, Second United Nations Symposium on the Development and Use of Geothermal Resources San Francisco, California, May 1975).

B. Chemex Laboratories.

The behaviour of the elements in the complex environment that would be envisioned for sea water descending into a geothermal system is well beyond the scope of this report. Our intention here is only to suggest that, in view of the marked dissimilarity between sea and spring waters, other origins for the hot spring water should be considered. These are as follows:

1. The water may in fact be meteoric transported either via fractures in the crystalline rocks or more probably in an aquifer within the Tofino Basin Tertiary sediments that lie along that portion of the coast, both on and off shore. This hypothesis could permit recharge from areas of both the Hesquiat Peninsula and Flores Island.

2. The water may be the product of a diagenetic process within the tertiary sediments. In this model water present at great depths in the marine sediments offshore would be heated and released from the sediments during the rock-forming process. Lithostatic pressures could be sufficient to propel the hot water up the dip of the strata to the fractured crystalline rocks where it gains convenient access to the surface. A major objection to this hypothesis is the lack of salinity in the water which might be expected to be at least as saline as sea water and quite possibly more so.

3. The water may be of meteoric origin, as in case 1 above, but heated by an igneous source such as a cooling magma chamber. This might be related to zones of transform faulting or crustal subduction along the continental margin and would probably constitute the most favourable economic model. Heat flow data available for the region[1], however, suggests normal or low values which tend to discount this hypothesis.

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[1] Souther, J.G., 1975, Geothermal Potential of Western Canada: in press, Proceedings, Second United Nations Symposium on the Development and Use of Geothermal Resources, San Francisco, California, May 1975.

5.2. Ahousat (Map 92E/8E)

The Ahousat Warm Spring is located on the beach at the head of Matilda Inlet one mile south of Ahousat on Flores Island. It is accessible from Tofino by boat or float plane. Water at 24°C issues from a spring and from the bottom of a concrete pool. Samples were taken from the pool and tested by Chemex Laboratories with the following results:-

SiO_2	53 ppm.
Na	35 "
K	.3 "
Ca	1.6 "
Mg	.05 "
Cl	8.3 "
W	.024 "

Temperature estimates using the SiO_2 and Na-K-Ca methods respectively are 104.7°C and 34.2°C. Validity of these values is in question for reasons similar to those suggested for the Sharp Point water. Possible heat source models are also the same.

5.3. Matilda Inlet (Map 92E/8E)

Airborne infrared scanning detected several warm ponds about ½ mile northwest of the Ahousat Spring and on the south shore of a small tidal bay opening on to Matilda Inlet. The ponds are located in a logged off area and are for the most part stagnant and contain considerable rotting vegetation.

Their temperature was 17°C which is 5 or 6 degrees above the value expected for surface waters. The ponds gave off a faint hydrogen sulphide odour.

A sample of water from one of them was analyzed at Chemex Laboratories Ltd. The results are as follows:-

SiO_2	47 ppm.
Na	32 "
K	0.5 "
Ca	2.2 "
Mg	0.05 "
Cl	7.4 "
W	.019 "

Temperature estimates are 98.9°C using the SiO_2 method and 41.0°C using the Na-K-Ca method.

5.4. Mate Island (Map 92E/8W)

Infrared scanning of the area surrounding Refuge Cove revealed a small but distinct anomaly on the shore of Mate Island which is located on the west side of the entrance to Refuge Cove across from Sharp Point Hot Spring. The anomaly lies on the east shore of a narrow inlet that nearly bisects the island. Upon examination it was found to be a cold spring but, as in the case of the ponds mentioned above, a few degrees above the ambient temperature for surface waters and considerably warmer than the ocean water with which it was being compared by the scanner.

No sample was taken.

5.5. Fair Harbour (Map 92L/3E)

A hot spring has been reported to occur about one mile from the head of Fair Harbour on Kyuquot Sound, northern Vancouver Island. An infrared search of the area, however, failed to locate it. A modest infrared anomaly coinciding with a pond in a logged off area was detected but it lacks the characteristic strong signal of a hot spring. It is, in fact, similar to the stagnant ponds at Matilda Inlet. It was given a low priority and has not been visited.

5.6. Hesquiat (Map 92E/8W)

Warm water is reported to flow from springs in the bottom of a stream which enters Hesquiat harbour one mile southwest of Leclaire Point.

Although minor variations in temperature do occur in the stream a thorough search failed to turn up anything that could not be readily attributed to solar heating of two or three small shallow tributaries to the main creek.

5.7. Kennedy River - Kootowis River (Map 92F/4E).

Hot springs have been reported near the lower rapids on Kennedy River and somewhere along the Kootowis River. The Kennedy River springs are alleged to occur on the north bank a mile or so above the mouth at Kennedy Cove on Tofino Inlet. They are said to be subject to flooding during times of high water. At the time of the visit the water was high and the spring could not be found.

The Kootowis River enters Tofino Inlet at Grice Bay 5 miles southwest of Kennedy Cove. Its valley was explored for the entire length but no thermal springs were found.

5.8. Tsusiat (Map 92C/10W).

Hot springs are rumoured to occur on the Tsusiat River above Tsusiat Falls and just downstream from the outlet to Tsusiat Lake. The area is accessible via the West Coast Trail from Pachena Bay near Bamfield. It was visited and searched but no springs were found.

6.0. DISCUSSION

The highest surface temperature recorded was 50°C from Sharp Point. Temperature-at-depth estimates for this spring are 57.7°C (Na-K-Ca) and 100°C (SiO_2). The disparity between these suggests that they may be predicated upon invalid assumptions with respect to conditions within the hot water system. Although this tends to compromise their value as indicators the temperatures are in accordance with the more probable of the three models proposed in section 4.1. as the possible heating mechanisms. Temperatures of 58°C or more might be reached by water descending to a depth of one or two kilometers within the sedimentary basin. Higher temperatures and a different chemical makeup might be expected from the other models which are considered less likely.

TABLE 2.

COMPARISON BETWEEN MAJOR CONSTITUENTS OF THREE SPRINGS ON VANCOUVER ISLAND

Constituent	Sharp Point	Ahousat	Matilda Inlet
Na	144	35	32
K	2.1	0.3	0.5
Ca	16.5	1.6	2.2
Mg	0.05	0.05	0.05
Cl	224	8.3	7.4
SiO_2	48	53	47

The Ahousat Warm Spring located on Flores Island 10 miles southeast of the Sharp Point Spring differs chemically from the latter[1] and at 24°C is much cooler. Proposed models for possible heat sources are the same as for Sharp Point. The first model, that of meteoric water descending through Tofino basin sediments or fractured crystalline rocks, is tentatively favoured.

The Matilda Inlet ponds have a striking chemical similarity with the Ahousat Spring. They appear to have, as their sources, small springs which appear to be of surface origin. This reinforces the view that the Ahousat Spring is heated meteoric water.

The results of the follow-up work in other areas of the coast remain somewhat inconclusive. Of those examined however, none, including those mentioned above, appears to have characteristics consistent with an economic geothermal source. No high temperatures were either observed or indicated, no volcanic association was observed, available regional heat flow data[2] indicates low values in the broad area, and thermal springs do not appear to be widespread.

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[1] See Table 2.

[2] Souther, J.G, 1975, Geothermal Potential of Western Canada: in press, Proceedings, Second United Nations Symposium on the Development and Use of Geothermal Resources, San Francisco, California, May 1975.

The ocean plumes off Flores Island could not be examined. They are, however, more probably caused by warm ocean currents than by geothermal activity.

7.0. CONCLUSIONS AND RECOMMENDATIONS

Our objective in this investigation has been to identify and evaluate any evidence of high temperature geothermal steam or water systems on Vancouver Island. Work performed to date, however, has not indicated the presence of such a system. Low temperature geothermal fluids of undetermined origin were studied in the Sharp Point and Ahousat areas but several thermal springs alleged to occur elsewhere could not be located.

Continuation of the present investigation would involve expenditures which are not felt to be justified on the basis of our results.

The possibility of locating a geothermal system on the Island, however, cannot yet be completely discounted. Our recommendations therefore are twofold:

1. That the present program be discontinued.

2. That the British Columbia Hydro and Power Authority monitor the progress of any other geothermal studies on Vancouver Island and review them from time to time with an eye toward reopening the question in the event that encouraging information becomes available.

Respectfully Submitted:

NEVIN SADLIER-BROWN GOODBRAND LTD.

TLSB/jrta.

THERMAL INFRARED REMOTE SENSING

This brief describes the airborne use of an AGA Model 680 Thermovision infrared scanner to detect the presence of ground water thermal anomalies on the west coast of Vancouver Island.

AIRCRAFT

Cessna 180 on wheels configured into a light remote sensing vehicle.

NAVIGATION

Closed circuit video with variable forward looking angle for pilot guidance; vertical looking wide angle optical sight for use by the infrared scanner operator.

SENSOR PACKAGE

Infrared sensor

AGA Model 680 Thermovision instrument sensing in the 3 to 5 μm wave band using a 20^{o} field angle lens. The scanner was modified to permit synchronization of the thermal video screen scan rate and the shutter of the camera used to record the video image. The sensor was mounted looking vertically downward.

Visual sensor

Vinten 70mm reconnaissance camera with 40^{0} field angle lens exposing Kodak Tri X aerographic film

Infrared image recording

35mm Nikon F 250 camera

POWER SUPPLY

The infrared scanner was operated from the aircraft electrical system using a solid state power inverter to provide 115 VAC 60 Hz sine wave power. Both photographic cameras were operated from a power supply independent of the aircraft electrical system to prevent thermal image damage by the motorized cameras.

OPERATIONS

The study areas were examined for thermal anomalies by having the scanner operator view the thermal image directly. At his discretion, the operator could take simultaneous photographs of the thermal image and the ground. Thus, the field operations returned only with images of anomalies.

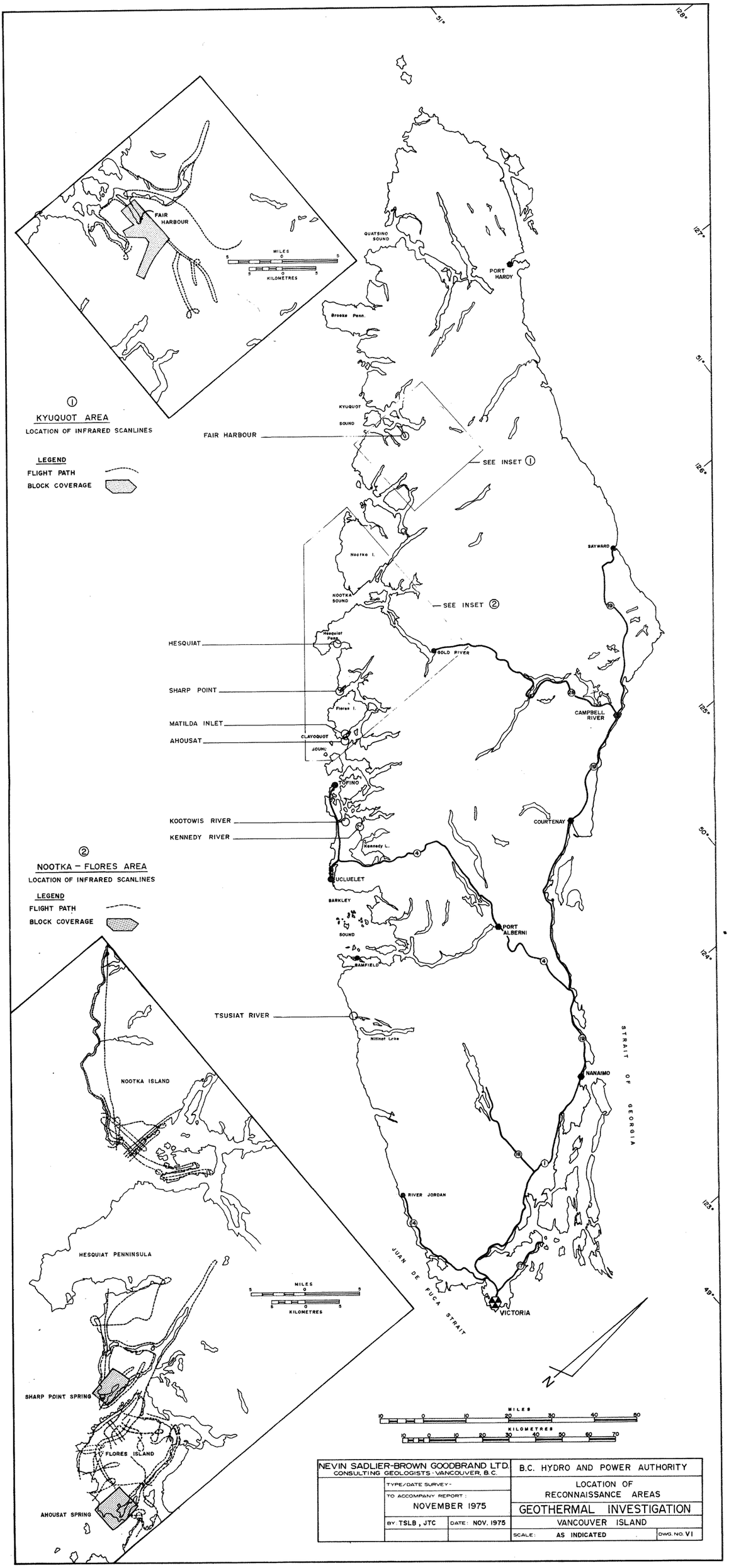
OPERATIONS (cont)

On the north and east shores of Flores Island, the operator detected numerous slight temperature contrasts in the sea water, in the form of faint whisps on the video screen,whereas the sea appeared to be of uniform temperature in all other areas studied. These thermal contrasts were such that they appeared insignificant in the photographs of the video screen, but their presence was noted visually.

SOURCE OF INFRARED SCANNER

The cooperation of the Director of the Pacific Forest Research Centre of the Department of the Environment, Victoria is gratefully acknowledged. He made his centre's Thermovision instrument available to the B.C. Hydro & Power Authority for this study of thermal anomalies on the west coast of Vancouver Island.

INTEGRATED RESOURCES PHOTOGRAPHY Ltd.


FAIR HARBOUR
MILES
KILOMETRES
① KYUQUOT AREA
LOCATION OF INFRARED SCANLINES
LEGEND
FLIGHT PATH
BLOCK COVERAGE
QUATSINO SOUND
PORT HARDY
Brooks Penn.
KYUQUOT SOUND
FAIR HARBOUR
SEE INSET ①
Nootka I.
NOOTKA SOUND
SEE INSET ②
SAYWARD
HESQUIAT
Hesquiat Peak
GOLD RIVER
SHARP POINT
Flores I.
MATILDA INLET
AHOUSAT
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KENNEDY RIVER
Kennedy L.
COURTENAY
② NOOTKA – FLORES AREA
LOCATION OF INFRARED SCANLINES
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JUAN DE FUCA STRAIT
VICTORIA
SHARP POINT SPRING
FLORES ISLAND
AHOUSAT SPRING
MILES
KILOMETRES
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LOCATION OF RECONNAISSANCE AREAS
GEOTHERMAL INVESTIGATION
VANCOUVER ISLAND
SCALE: AS INDICATED
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