DEVELOPMENT OF THE CANADIAN SEISMOGRAPH NETWORK 1975-1980

by

Basham, Buchbinder, Halliday, Hayman,
Leblanc, Milne, Stevens

Seismological Service of Canada

INTERNAL REPORT 75-1

Seismology Division
Earth Physics Branch
Department of Energy, Mines & Resources

1975

Under active discussion
but general outlines
now seem firm.

GROUP ONE REPORT

Development of the Canadian Seismograph Network 1975-1980

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P.W. Basham
G.G.R. Buchbinder
R.J. Halliday
R.B. Hayman
G. Leblanc
W.G. Milne
A.E. Stevens

DEVELOPMENT OF THE CANADIAN SEISMOGRAPH NETWORK 1975-1980

1. Terms of Reference and Report Outline

The Group was formed to prepare a rational development program for the Canadian Seismograph Network for the five year period up to 1980. For the purposes of the study, the "Network" is defined as consisting of the standard and regional stations, the digital long period stations, the Yellowknife array and the eastern and western telemetered networks.

It became apparent early in the Group discussions that the future development of the network will be dominated by requirements for study of Canadian earthquakes. Thus, the discussions centered on proposals for development of the eastern, western and northern sections of the network as required to provide a better understanding of Canadian earthquakes and seismic hazards in the respective regions. The main body of this report will present the conclusions of these discussions.

Decisions to close, open or change a station of the network will not be made on the basis of our contributions of abstracted data to international epicentre agencies, in insolation from other requirements. Thus, this aspect of our operations does not have a strong influence on network development plans. Types of data exchange that can influence developments are, e.g., the YKA event log and the exchange of local earthquake data with the northeast U.S. coordinated network. Requirements for providing seismograms, copies, microfilm or tape to internal, national and international users does, however, have an influence on developments at some stations, and these will be described.

Only a major recording format change or reduction in number of standard and regional stations would affect adversely the general seismological research on Earth structure undertaken within the Division. As it

was neither anticipated in advance, nor will it be concluded in this report, that such major changes to the Network are required, the general research requirements will not have a strong influence on developments. This obviously does not apply to special research stations such as the digital long-period stations in the Cordillera, the planning and development of which will be influenced primarily by the research requirements. Suggestions were received by the Group from the structural research component of the Division concerning stations that should definitely be maintained, and in some cases new stations that would be useful in some regions; these will be noted in the development plan.

Numerous general and specific problems and alternates were discussed by the Group during deliberations. Most of these will not be noted in this report as it is deemed sufficient to have had them aired for possible future action or consideration.

In the time period between the formation of the Group and the writing of this report, a number of discussions have occurred and decisions made within the Division but outside of the specific terms of reference of the Group. Any of these matters that have a bearing on the Network development will be noted in this report. In the same time period ~~discussions~~ decisions have been made by the Group, in association with other Division staff, concerning changes at some stations, some of which have been implemented; these will also be noted.

The following three sections present the desired network configuration for the monitoring of the three principal seismic regions of the country. Although in many ways these network segments are not ideal, they can be considered as targets for development over the next five years.

The feasibility of this development plan, the priorities and the financial and manpower implications will be described in later sections. For reference, Figure 1 shows the 1974 configuration of the Canadian Seismograph Network.

2. The Western Canadian Network - 1980

The requirements of the western Canadian network (west of Saskatchewan and south of 60°N) are: to provide general location capability of earthquakes of magnitude 3 or greater for all seismic regions of the Canadian west; to provide continuous monitoring of earthquakes at levels below magnitude 3 with high quality hypocentre parameters, and associated assessment of earthquake hazards for regions of high population density; to provide a capability for adequate earthquake hazard analysis in industrial but not heavily populated areas; and to provide adequate data for the general study of active tectonic features of the region. This can be achieved with the network shown in Figure 2, and consisting of six standard stations (triangle), five regional stations (circles), and the Western Canadian Telemetered Network (WCTN) (squares). The recording medium and characteristics for each of the stations will not be considered in detail in this section, but in general the standard stations register six components of SP and LP information. A brief account of each of the stations in the western network follows.

Victoria (VIC). The standard station with the additional three-component torsion system will remain until the move to Patricia Bay (PBIOS) in 1977. At that time the new vault will accommodate photographic recording, but it is most likely that procedures will change to digital data storage, retrieval and display in conjunction with the WCTN processing facilities.

Port Hardy (PHC). The standard station operation will continue. An old helicorder system will be repaired by Victoria staff and placed in operation at the Port Hardy airport office at no extra cost. This will provide 24-hour per day visual phase readings as required.

Penticton (PNT). The standard station operation will continue.

Fort St. James (FSJ). The standard station operation will continue.

Edmonton (EDM). The standard station operation will continue.

Suffield (SES). The standard station operation by the Meteorological Section of the Defence Research Establishment - Suffield (DRES) will continue at least until the summer of 1977. A review of the future of DRES is underway and the Division will be kept informed of plans as they develop for changes that might affect the SES operation. Should it become necessary to discontinue the SES operation, a regional station would be established in southern Alberta or perhaps in the Crowsnest area.

Queen Charlotte City (QCC). The SPZ regional station will contiue operation at its present site until the retirement of the present operator in about two years. Before that time, the Victoria staff will negotiate with MOT to have the recorder again installed at the Sandspit airport, to have the seismometer implaced at their radio navigation site, and arrange for transmission of the signal along the microwave link to the airport.

Mica Creek (MCC). Although the site is noisy at present, the SPZ regional station will continue operation as long as the UBC monitoring array is in operation in the area. If no induced earthquakes occur, the UBC project will likely terminate in 1976. In this case the MCC operation would continue at a nearby quieter site with a local operator, or the signal would be telemetered on the microwave link to Vancouver at BC Hydro expense and then to Victoria by phone line. In anticipation of the latter, an indefinite link

between MCC and Victoria is shown on Figure 2.

Bralorne. An SPZ regional station to provide general coverage of all seismic areas of British Columbia and to monitor earthquakes near the head of Bute Inlet.

Telegraph Creek. An SPZ regional stations to provide a monitor for small earthquakes in a future development area and to provide improved regional coverage of the Yukon, southeastern Alaska and British Columbia.

Ocean Bottom Seismograph (OBS). Although at present in the development stage, the ultimate intention is to have the OBS provide regional coverage on a non-continuous basis at a location near 50°N, 130°W.

Western Canadian Telemetered Network (WCTN). Installation will be completed in February 1975 of SPZ out-stations at, or near, Haney (east of Vancouver), Parkesville (on Vancouver Island) and South Pender Island (in the Strait of Georgia) and the local VIC signal on-line to the PDP11-15. Additional tentative sites have been considered at Campbell River and Powell River. The details of expansion of the WTCN northward in Georgia Strait will be coordinated with the UBC - Georgia Geoscience Project planned stations.

3. The EAstern Canadian Network - 1980

The requirements of the eastern Canadian network (east of Saskatchewan and south of 60°N) are: to provide general location capability of earthquakes of magnitude 3 or greater for all on-shore seismic regions of eastern Canada; to provide continuous monitoring of the Ottawa River-Laurentian and Quebec City-Lower St. Lawrence seismic regions; to provide additional control on lower level seismicity near the centers of each of the two regions; to retain what is at present a minimal capability to detect and locate earthquakes in the eastern Canada off-shore regions; and to provide basic data

for the study of the seismotectonics of eastern Canada. This can be achieved with the standard stations FFC, FCC, LHC, SCB and STJ and regional stations PBQ and "LG2" shown in Figure 1, and the configuration of near-in stations shown in Figure 3. The development of the eastern network, and in partiuclar some of the stations shown in Figure 3, is less certain than is the case for the western network described in the previous section: a) because there are more alternatives that may prove more desirable as developments progress, and b) there is more dependence on the availability of operating funds in deciding on the types of new stations that are to be deployed. Some of the specific alternatives and possible limitations will be described in the account of each station in the following. More general consideration of these problems will be given in a later section.

Flin Flon (FFC). The standard station operation will continue.

Fort Churchill (FCC). The standard station operation will continue in the short term. An SP capability is required at FCC for the monitoring of Hudson Bay earthquakes, but as a standard station it is considered the most expendable of the network. A conversion to an SPZ regional station may be required to save funds for the operation of other stations. With the proposed development plan this may be necessary by 1976.

Thunder Bay (LHC). The standard station operation will continue. Although the SP components are less essential than those of FCC, the general geographic coverage and, in particular, the azimuthal coverage for Arctic earthquake surface waves provided by LHC suggest that it remain.

Scarborough (SCB). The temporary standard station operation will continue as long as station operators are being trained at the DOE-AES training school.

St. John's (STJ). The standard station operation will continue. Recent contract negotiations with Memorial University have led to a questioning of the value of the STJ operation. The present agreement with Memorial runs through FY 1975-76, at which time the mode of operation can change. Although the present station runs at low gain, there are several reasons for keeping a standard station equivalent operation in Newfoundland: a possible recurrence of the seismic activity on the Grand Banks; a generally incomplete knowledge of historical activity in the Newfoundland region; a predictable future need for more detailed seismicity studies and risk evaluation in eastern off-shore resource development areas; the important surface wave azimuthal coverage provided by STJ for eastern Arctic earthquakes; and a renewed interest in Newfoundland seismograph facilities by the staff at Memorial University. The latter may govern the mode of operation after 1976.

Schefferville (SCH). The standard station operation will continue.

St. Féréol (SFA). The station will be closed in July 1975, and the operator position transferred to Ottawa headquarters.

Montreal (MNT). The standard station operation will continue through FY 1976-77. For the FY 1975-76, Jean-de-Brébeuf College will receive an operating contract equivalent to that received by other universities for standard station operation. In 1976 a reassessment will be made of both the Brébeuf staff interest in the station operation and the requirements for the Montreal site in the network configuration. With virtual 24-hour per day contact with Brébeuf staff for visual phase readings, the phone link is not an essential part of the Ottawa monitoring of eastern seismicity. The on-site helicorder will remain for Brébeuf public relations and visual reading purposes, but the phone link should be discontinued when the next link to the east is in place,

unless the MNT signal can be inexpensively incorporated with the more eastern signal. For purposes of the development plan, it is assumed that MNT will be converted to a regional station in 1977.

Ottawa (OTT). The details of development of the standard station in association with the new borehole seismometer have not yet been decided, but the concept is clear. Sufficient seismometers will be installed at a site to be selected on the Earth Physics Branch mine site property (near Buckingham, Quebec) to provide on-line to the Ottawa data lab three components of broadband (nominally 20 Hz to 100 seconds) seismic information. A data handling capability will be included with developments of the data lab and this will include the capability to display the received signals with any of a range of desirable passbands, and to generate continuous digital tape data with format and signal passband required by the US Seismic Data Analysis Center. The present schedule for developments include site selection and hole drilling in 1975 and installation and commissioning in 1976. The OTT standard station operation at the present site will be discontinued once the new system is in operation.

Halifax (HAL). The SPZ regional station will continue operation.

Sept-Isles (SIC). The SPZ regional station is expected to continue operation. The Iron Ore Company has expressed an interest in installing horizontal components at their expense and they will be encouraged to do so.

Sudbury (SUD). The SPZ regional station will continue operation.

Poste-de-la-Baleine (PBQ). Horizontal components will be reinstalled in January 1975 and the 3-component regional stations will continue operation.

La Grande II. The SPZ regional station will commence operation in January 1975, and will continue. It may be possible within a few years to have the signal telemetered to Ottawa at no additional expense; such an arrangement will be encouraged.

La Pocatiére (POC). The SPZ regional station will continue operation. (Note additional comment on horizontal components under La Malbaie below.)

La Malbaie. A regional station to provide close-in coverage and location control for this active seismic region. One of the two stations, POC and La Malbaie, will have SP horizontal components, the choice of which being made on the basis of ease of operation. Horizontal components could be accommodated within the Laval University operation of the POC station, but an as yet undecided mode of operation of the La Malbaie station in a coordinated way with other Earth Physics Branch (Geodynamics and Geomagnetics) activities at that site might lead to a logical operation of the horizontal components on the north shore.

Chicoutimi. An SPZ regional station to provide additional regional control on earthquakes within both the Ottawa River-Lawrentian and Québec City-Lower St. Lawrence zones, and in addition to improve the geometry of an otherwise rather linear distribution of stations along the St. Lawrence River.

Campbellton. (or some other site near the head of Chaleur Bay). An SPZ regional station to provide improved regional control for earthquakes on the north shore of the Gulf of St. Lawrence, the Gaspé Peninsula and New Brunswick.

Sherbrooke. (or some other site in the Eastern Townships). An SPZ regional station to improve regional control in the Eastern Townships as well as

south-side control of the Montreal and Québec City regions. The development of this station will depend on arrangements that can be made for data exchange with the northeast US coordinated network. A long-term arrangement for receiving phase arrival data from US stations such as Newport and Jackman Station (see Figure 4) would serve as well.

Eastern Canadian Telemetered Network (ECTN). Although the ECTN and WCTN have similar purposes, the on-line monitoring of earthquake activity in the respective regions, they do have different scales: the WCTN has a maximum aperture of about 200 km and will monitor lower level activity in the high population areas of the lower mainland and Vancouver Island; the ECTN has a maximum aperture of about 700 km and will provide a more general earthquake monitoring system for a broader region (see Figure 3). This presents a greater difficulty in development of the ECTN, particularly in respect to costs of data transmission.

In general, the ECTN will provide tripartite station control for the earthquakes down to approximately magnitude 2.5 in each of the Ottawa River-Laurentian and Québec City-Lower St. Lawrence seismic zones, with each of these zones having a station(s) near its center for close-in control. The Ottawa River-Laurentian zone is covered by a triangle composed of Ottawa (OTT), Québec city (CHQ) and Val d'Or (or some other nearby site), with Maniwaki (MNI) near the center. CHQ, MNI and Val d'Or will be SPZ stations and OTT can contribute 3 components in any desirable passband. A previous decision to move the Maniwaki station to a selected site in the Nomininque area has been postponed indefinitely due to an estimated cost to the Division of $8000 to provide the required telephone facilities. This move will be reconsidered after some experience has been gained with ECTN operation. The continuation of operation of the SPZ regional station QCQ in Québec City will be at the discretion of Laval University; this station is not essential to the Division requirements.

The Québec City-Lower St. Lawrence seismic zone is covered by a triangle composed of CHQ, Fredericton (UNB) and Manicouagan, the latter two being SPZ stations. Close-in control of the most active area of this zone is provided by the two regional stations, POC and LaMalbaie. The decision on LPs for UNB is dependent on the future of STJ and MNT and on the availability of data from the northeast US.

4. The Northern Canadian Network - 1980

The requirements of the northern Canadian network (north of 60°N) are: to provide general location capability of earthquakes of magnitude 3 or greater in all regions of the Canadian North; to provide adequate data for an assessment of earthquake hazard to resource development projects, pipeline and transportation facilities, and future industrial and urban centers; and to provide adequate data for the study of the seismotectonics of northern Canada. This can be achieved with the network shown in Figure 5, and consisting of six standard stations, the Yellowknife array and associated equipment, and five regional stations. A brief account of each of the stations in the northern network follows.

Alert (ALE), Mould Bay (MBC), Resolute (RES), Inuvik (INK), Baker Lake (BLC) and Frobisher (FRB). The standard station operations will continue.

Whitehorse (WHC). The regional station was updated to 3 components in December 1974 and this operation will continue.

Igloolik. A 3-component regional station will be installed at the Igloolik Laboratory in the summer of 1975 and this operation will continue for a minimum of two years.

Isachsen. A 3-component regional station to provide additional location control for earthquakes in the northern archipelago.

Cambridge Bay. An SPZ regional station to provide improved regional coverage and location control for earthquakes to the west (Yukon, etc.), north (Queen Elizabeth Islands) and east (Boothia Penn., Baffin Island, etc.).

Clyde. An SPZ regional station to provide improved detection and location control for earthquakes on Baffin Island and in Baffin Bay and the Labrador Sea.

The latter four regional stations represent results of a development plan designed to meet the national program objectives for the northern region as stated in the introductory paragraph of this section. Should supplementary federal or proponent resources be made available for special studies of earthquake hazard in specific regions of the Arctic, e.g., resource development areas or pipeline routes, then additional stations or an accelerated development of the proposed stations would most likely be required.

Yellowknife Array (YKA). The station will consist of the 19-element SPZ array, the 3 element LPZ array with horizontal LPs at the base station and a matched set of 3-component SPs at the base station. The present standard station (YKC) will be discontinued when the above-mentioned facilities are adapted: a) to provide the necessary input data for current seismicity determination using a combination of the CANSAM detection log, the 3-component SP signals and visual monitors; b) to provide uninterrupted and continuous data storage and retrieval capability of all 3-component LP signals of potential future interest (i.e., to provide a replacement for permanent storage of LP data now on photographic records); and c) to provide rapid and convenient hard-copy playout of 3-component LP signals to internal and external users. Each of the above is related particularly to developments of the Divisional data lab at the initiative of the responsible staff. The basic data available would not change significantly but the present redundancy at Yellowknife would be eliminated.

5. General Seismological Research Requirements

The foregoing three sections have described network configurations that can provide adequate data for the study of earthquakes and associated hazards in the three regions of the coutnry. A realistic development plan that can achieve this distribution of stations is described in the next section. The other principal use of network data is for general seismological research. The problem with attempting to predict a network configuration that would be of greatest value to general research projects is the obvious one of being unable to anticipate the specific research projects over a five-year period. Thus, the effect of general research requirements on the network development can only be described in general terms, and the following are the main points that have emerged from discussions.

a) The present network configuration provides an invaluable data base for general research, by internal and external users, and stations should be closed only when it is essential for financial and other reasons.

b) One of the greatest assets of the Network is its broard geographical coverage, spanning about 30° for teleseismic events in any azimuth. In order to retain this broad network aperture, any standard station that must be closed should, in general, be restricted to those near the center of the country.

c) Because of the broad geographical distribution and other financial and manpower limitations, there is at present no clear alternative to the photographic recording at a majority of the standard stations. The obvious exceptions to this are standard station equivalent operations associated with developments at Ottawa, Victoria and Yellowknife.

c) Considering the predictable usage of LP data from the standard stations, the present distribution will serve most of the needs. With the closing of

SFA in 1975 and a possible change in status of MNT in 1977, LP components will be considered for UNB at, or about, the time the telemetry link to UNB is established. The reasons for FCC being the most expendable of standard stations relates to its being the most remote from active seismic regions and having other stations that can provide adequate azimuthal coverage for surface wave originating in any of the active seismic regions of the country. FCC does, however, provide central Canadian shield geographical coverage for general research and will be maintained if additional operating funds required (see Table 1) can be found elsewhere.

e) Many research projects have employed and, in future, will require supplementary station deployment for the duration of a project; recent examples are the deployment of short-period stations at critical distances to record Cannikin explosion P waves and the deployment of digital long-period stations in the Cordillera to provide surface wave data for lithosphere structure studies. These successful experiments clearly indicate the direction of future planning for the acquisition of special research data. A stable, national network of standard and regional stations provides the continuity and a framework to which temporary stations will be tied.

f) Special field projects that are undertaken about once per year by Division staff are not considered part of the Seismograph Network operation or development and are not considered further in this report. These include projects like the La Malbaie seismicity project of 1974 and the Williston Lake reflection project of 1975. It should be noted, however, that such projects invariably make extensive use of additional data provided by the permanent network facilities.

6. Network Development Priorities and Operating Costs

The 1980 Canadian seismograph network described in sections 2-4 is, in fact, a desirable network for 1975. The factors preventing instant development are the obvious ones of financial and manpower limitations. Thus, priorities must be assigned to the network changes and estimates made of funds required to support these changes. The target dates for each of the changes and the associated changes in operating funds required will be described in this section, the technical manpower requirements and capital costs in the following section.

Individual target dates, and hence an overall priority order, are assigned to the station changes in Table 1. These span the period from January 1975 to 1978. The rationale behind this order of development is essentially an intermingling of separate development plans for the western eastern and northern segments of the network, bearing in mind the needs of one segment versus those of another, some external constraints beyond our control, and limitations imposed by technical manpower and finances. For planning purposes, the sequence of changes given in Table 1 should be considered the best estimate that can be made at this time. However, it undoubtedly will have to be adapted to unforeseen external requirements, some of which have been noted in the commentary on individual stations.

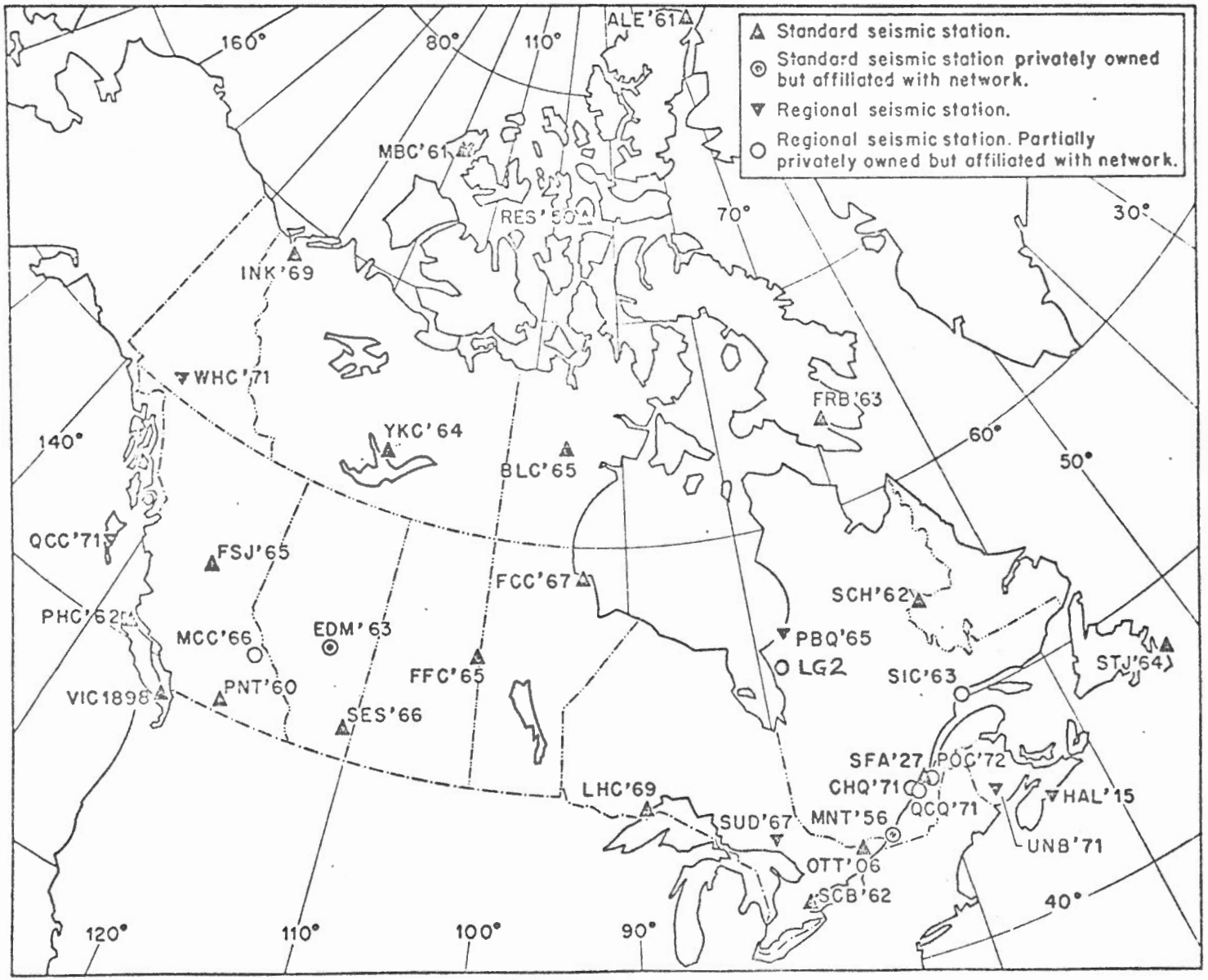
The network operating costs in the FY 1975-76 estimates include $94.1K for station operating contracts, $29.0K for seismogram paper and supplies and $13.9K for dedicated phone line rental, for a total of $137.0K. An estimate of required changes to this total due to station changes is given in Table 1 for the FY's 1975-76 through 1978-79. The net change for each fiscal year added to the 1975-76 estimates gives an approximate

operating cost in 1975 dollars for the developing network up to 1978-79. With the possibility of changes in departmental budgeting, e.g., project costing, the possibility of supplementary resources being made available, etc., the additional operating funds required are sufficiently small that it is not considered worthwhile to do a detailed accounting, particularly for the later years of the development plan.

7. Technical Manpower and Capital Costs

The instrumental changes indicated in Table 1 are extensive, but it is clear they are dominated by requirements for new short-period regional and telemetry stations. As prototype or operational units of these instruments exist at present, there will not be a large development requirement. The technical manpower requirement will be for assembly, testing and installation; the costs will be for capital. A summary of the instrumentation required is given in Table 2 with the date at which each station requirement should be ready, about one month prior to installation. The capital costs of equipment and the FY of capital purchase is given in the last two columns with totals shown for each fiscal year. Costs of capital equipment already on hand or intended for purchase in FY 1974-75 are not included in the Table.

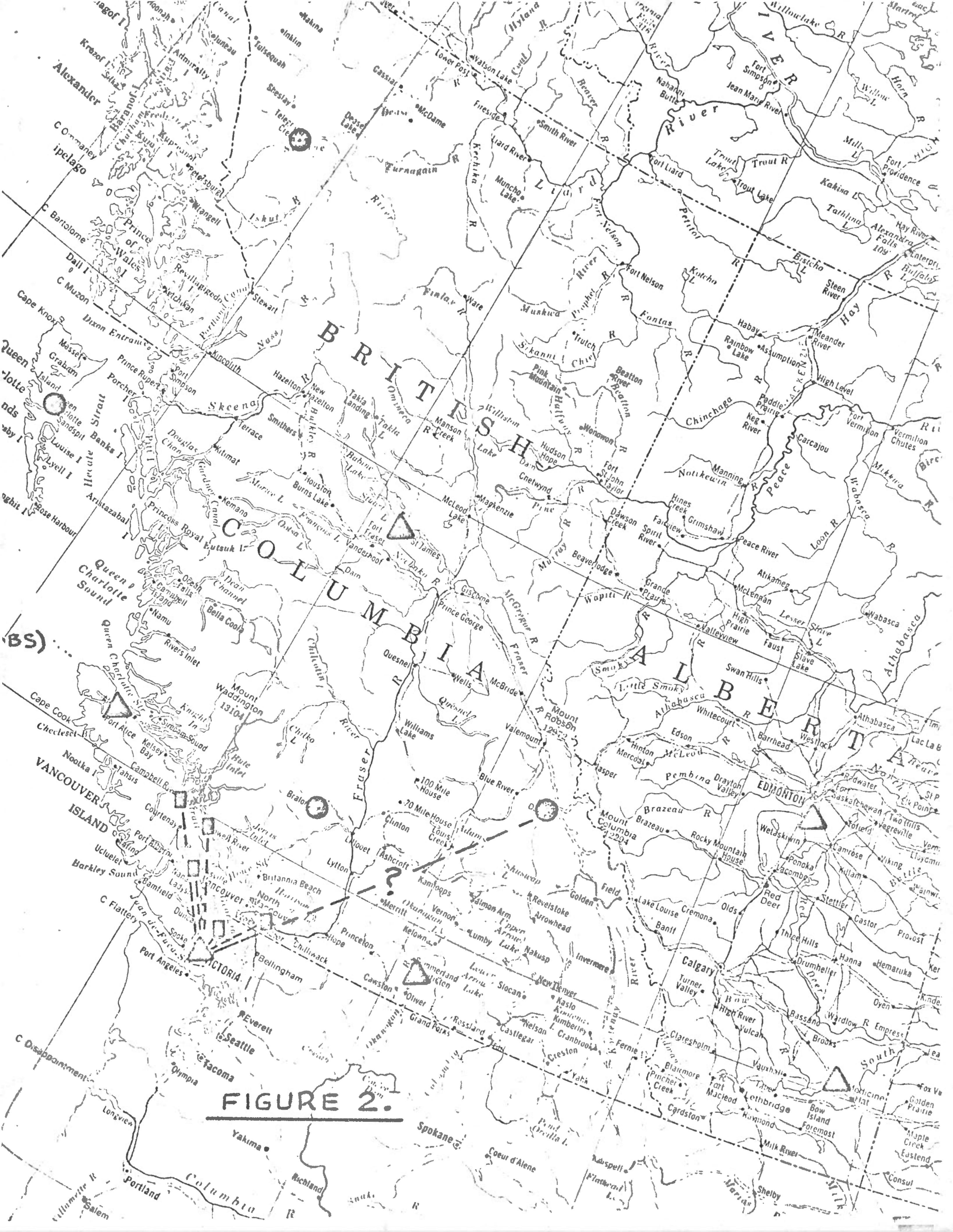
Capital costs of equipment for data lab facilities in Ottawa, Victoria and Yellowknife are not listed here. Many of these costs are appropriate to Division projects not directly associated with network development, but an estimate of network data lab capital costs could be made if required.



CANADIAN SEISMIC NETWORK 1973

FIGURE 1.

NOTE: Research and Telemetered stations are not shown.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Fort St John
Dawson Creek
Grande Prairie
Peace River
Jasper
Banff
Lethbridge
Medicine Hat
Red Deer
Seattle
Tacoma
Bellingham
Port Angeles
Spokane
Yakima
Portland
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Wells
Bralorne
Stewart
Ketchikan
Wrangell
Petersburg
Juneau
Sitka
Prince of Wales I
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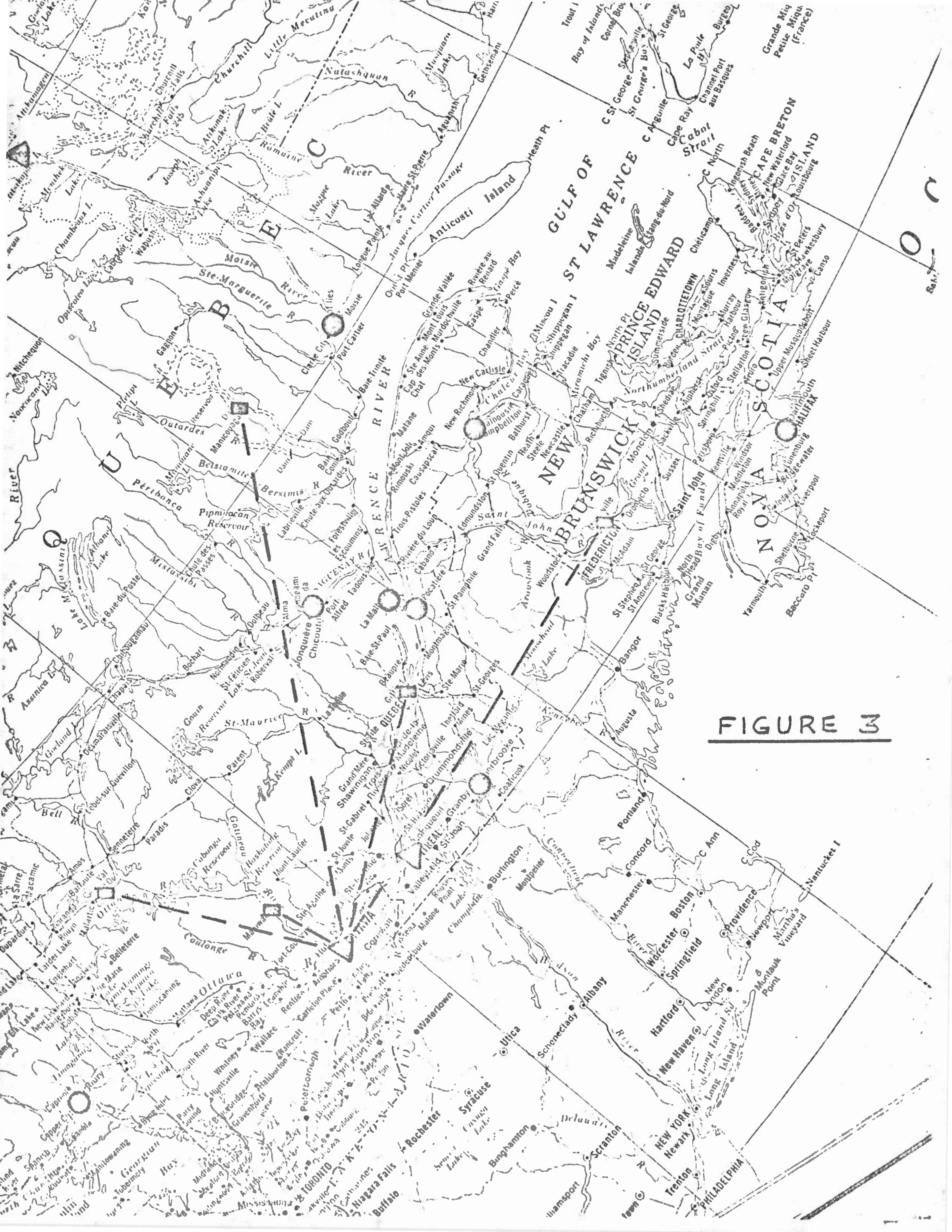
C Flattery
Strait of Juan de Fuca
(BS)
?

FIGURE 2.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Anticosti Island
NEW BRUNSWICK
PRINCE EDWARD ISLAND
NOVA SCOTIA
CAPE BRETON ISLAND
Cabot Strait
Northumberland Strait
Bay of Fundy
Magdeleine Islands
Grande Miquelon
Petite Miquelon
(France)
ST LAWRENCE RIVER
CHARLOTTETOWN
HALIFAX
FREDERICTON
Saint John
QUEBEC
MONTREAL
Sherbrooke
Trois Rivières
Shawinigan
Chicoutimi
Jonquière
Port Cartier
Moisie
Sept Iles
Rimouski
Matane
Campbellton
Dalhousie
Bathurst
Moncton
Gaspé
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Providence
Hartford
New Haven
Albany
Schenectady
Utica
Syracuse
Rochester
Binghamton
Scranton
Buffalo
Niagara Falls
TORONTO
NEW YORK
Newark
Trenton
PHILADELPHIA
Burlington
Montpelier
Lake Champlain
Long Island
Nantucket I
Martha's Vineyard
C Cod
C Ann
Montauk Point
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Lake Mistassini
Manicouagan
Outardes
Bersimis
Péribonca
St-Maurice
Gatineau
Ottawa
Coulonge
Val d'Or
Amos
Churchill Falls
Labrador City
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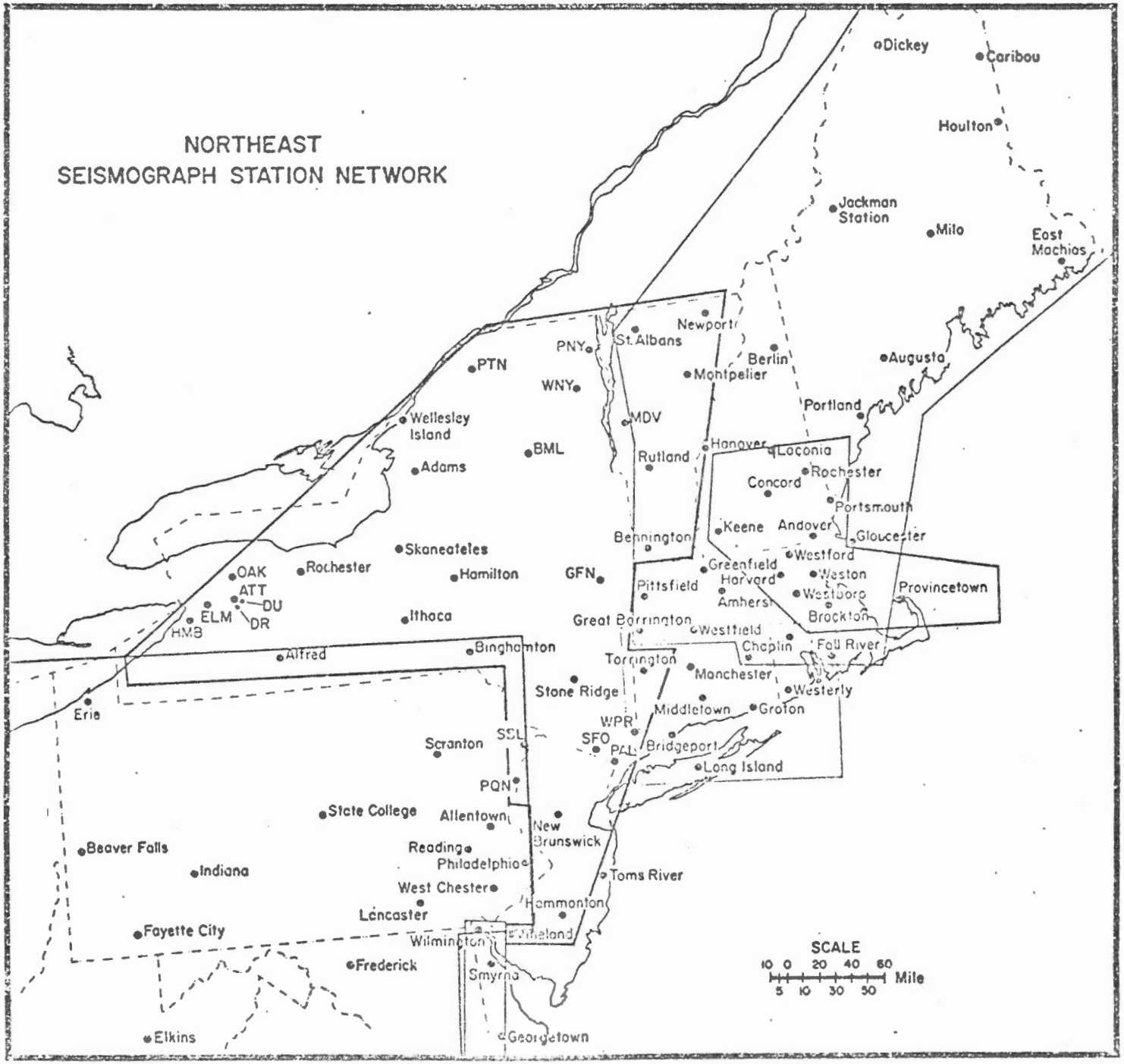
Hull
Ottawa
Kingston
Cornwall
Watertown
Sudbury
Lake Ontario
FIGURE 3

FIGURE 4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Caribou
Houlton
Jackman Station
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Newport
St. Albans
PNY
PTN
WNY
Montpelier
MDV
Wellesley Island
BML
Adams
Rutland
Hanover
Laconia
Rochester
Concord
Portsmouth
Keene
Andover
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Skaneateles
Rochester
OAK
ATT
DU
DR
ELM
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Hamilton
GFN
Ithaca
Pittsfield
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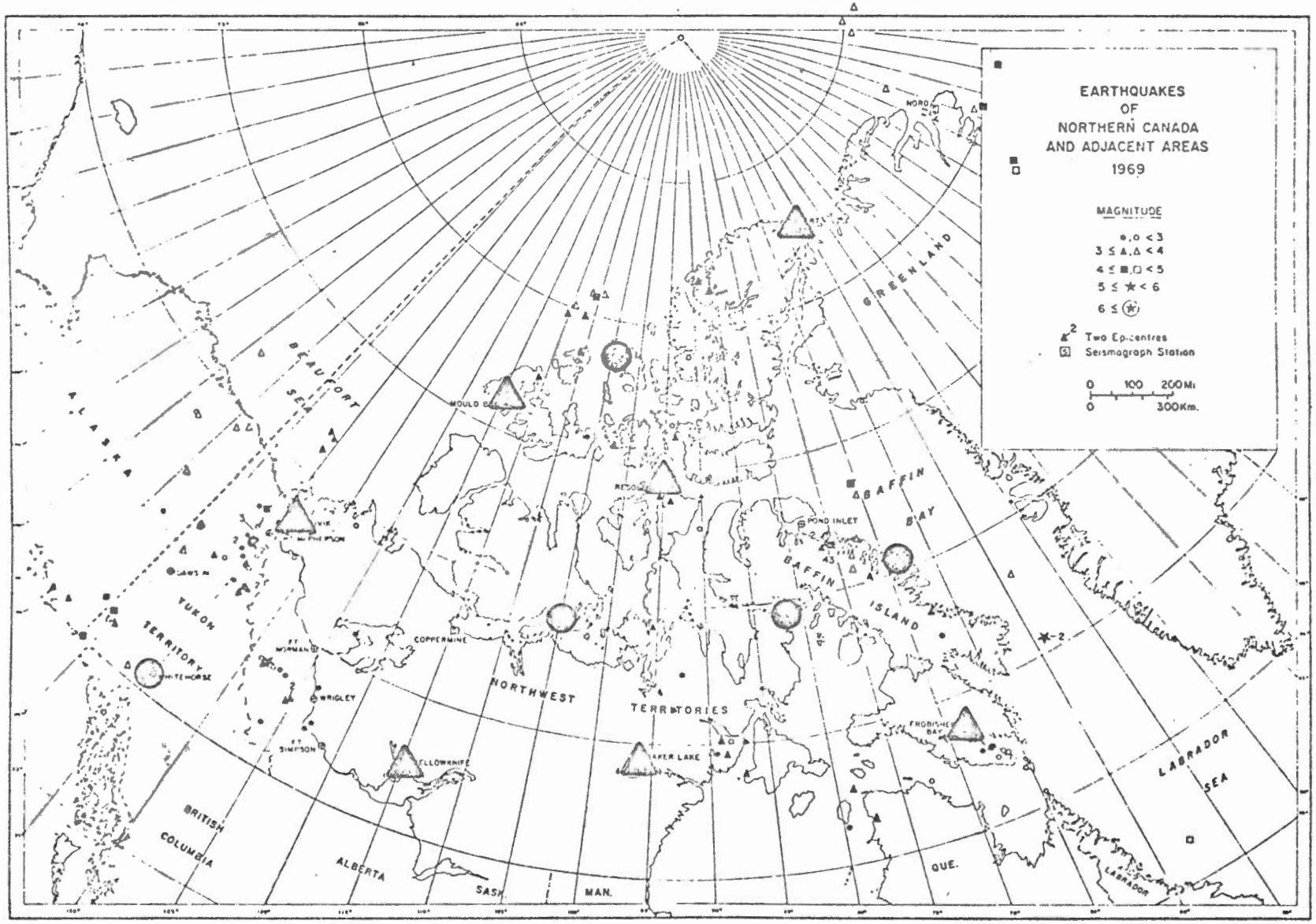

Figura 2

FIGURE 5

Table 1.

Target Dates for Station Changes and Incr ntal Changes in Operating Funds

Station	Change	Target Date	Operating Cost Item	Increment on FY Estimate in 1975 $K				Remarks
				75/6	76/7	77/8	78/9	
Poste-de-la Baleine	new horizontal SPs	Jan. 1975	paper & supplies					—— in 75-76 estimates and continue
La Grande II	SPZ commissioned	Jan. 1975	nil					
WCTN	three outstations commissioned	Feb. 1975	telemetry					—— in 75-76 estimates and continue
Montreal	contract increase	Apr. 1975	contract	+5.0	+5.0			—— station reassessed summer 1977
Quebec City	no telemetry FY 75-76		telemetry cost saved	-4.0				—— in 75-76 estimates
St. Fereol	station closed	Jul. 1975	paper & supplies saved	-1.5	-2.0	-2.0	-2.0	
Igloolik	3-comp. station commissioned	Jul. 1975	paper & supplies	+0.5	+0.5	+0.5	+0.5	—— includes training costs in 1975
La Malbaie	3-comp. station commissioned	Sep. 1975	contract, paper	+1.5	+2.0	+2.0	+2.0	—— may include changes at POC
Quebec City	commence telemetry	winter 75-76	telemetry		+4.0	+4.0	+4.0	—— Laval contract assumed unchanged
Fort Churchill	collapse to SPZ regional	spring 1976	contract & paper saved		-11.	-11.	-11.	
Val d'Or	SPZ commissioned	spring 1976	telemetry (est)		+6.0	+6.0	+6.0	
Isachsen	SPZ commissioned	summer '76	contract		+1.0	+1.5	+1.5	
Yellowknife	YKC discontrinued	summer '76	nil					—— assume costs balance
WCTN	two outstations commissioned	fall 1976	telemetry (est)		+0.5	+1.5	+1.5	
Ottawa	borehole system commissioned	fall 1976	telemetry		+0.5	+1.0	+1.0	
Chicoutimi	SPZ commissioned	spring 1977	contract			+1.5	+1.5	
Cambridge Bay	"	summer 1977	contract			+1.5	+1.5	
Victoria	move to PBIOS	summer 1977	nil					—— assume costs balance
Bralorne	SPZ commissioned	fall 1977	contract			+1.0	+1.5	
Mica Creek	move and/or telemetry	fall 1977	nil assumed					—— change in costs unknown
Fredericton	commence telemetry	fall 1977	telemetry, contract saved			+2.0	+5.0	
Campbellton	SPZ commissioned	spring 1978	contract				+1.5	
Clyde	"	summer 1978	contract				+1.5	
Telegraph Creek	"	fall 1978	contract				+1.5	
Suffield	SES closed and new SPZ commissioned	1978	costs balance					—— timing indefinite
Sherbrooke	SPZ commissioned	1978					+1.5	
			Net	+1.5	+6.5	+9.5	+19.0	

Table .

Seismic Instrumentation Required for Station Changes 1975-1978

Station	Instruments Req'd	Required by:	Capital Cost	FY of Capital
Igloolik	3-C reg.*	June 1975		
La Malbaie	3-C reg.	Aug. 1975		
Quebec City	SPZ tele. (SPZ reg. released)	Jan. 1976		
Fort Churchill	SPZ reg. (stan. stn. released)	Apr. 1976		
Val d'Or	SPZ tele.	May 1976		
Isachsen	SPZ reg.	June 1976		
WCTN	two SPZ tele.	Aug. 1976		
Ottawa	complete borehole & tele. instruments	Aug. 1976		
Chicoutimi	SPZ reg.	Apr. 1977		
Cambridge Bay	SPZ reg.	Jun 1977		
Bralorne	"	Aug. 1977		
Fredericton	SPZ tele. (SPZ reg. released)	Aug. 1977		
Campbellton	SPZ reg.	Apr. 1978		
Clyde	"	June 1978		
Telegraph Creek	"	Sep. 1978		
Sherbrooke	SPZ reg.	Sep. 1978		

*3-c reg. - a complete 3-component SP regional station.

SPZ tele. - outstation equipment for SPZ telemetry station

SPZ reg. - a complete SPZ regional station

Totals: FY75-76 -
FY76-77 -
FY77-78 -
FY78-79 -