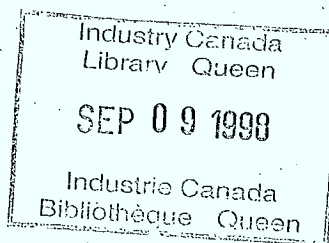


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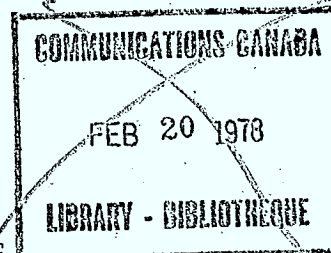


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EFFECTIVENESS OF HF COVERAGE BY FIXED MONITORING STATIONS.

VOLUME 1.

BY

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## CONTENTS.

	Page
SUMMARY OF CONCLUSIONS.....	i
SUMMARY OF RECOMMENDATIONS.....	ii
INTRODUCTION.....	1
OBJECT AND SCOPE OF THE STUDY.....	4
PURPOSE AND SCOPE OF MONITORING.....	6
MONITORING STATION EQUIPMENT.....	9
ECONOMIC CONSIDERATIONS.....	12
HF COVERAGE OF MONITORING STATIONS.....	19
INVESTIGATION OF MONITORING TRENDS.....	24
CONCLUSIONS AND RECOMMENDATIONS.....	38

SUMMARY OF CONCLUSIONS.

1. The summer monitoring coverage is extremely poor, especially at the lower frequencies.
2. There is little or no coverage of northern B.C., Yukon, the Arctic and northern Quebec.
3. The HF coverage areas of Wetaskiwin and Senneterre are covered by other monitoring stations.
4. Both the Acton and Almonte monitoring stations provide HF coverage to approximately the same area of Canada.
5. The St. Remi station is used entirely for VHF/UHF monitoring and its potential for HF monitoring is nil.
6. There is a definite need for improvement of monitoring equipment and antenna systems.
7. Staffing of the monitoring stations is inadequate.
8. There are many complex monitoring problems that require the combined effort and co-operation of both Headquarters and the Regions.
9. Decentralization is not suitable for HF monitoring, and it seems to have accentuated some monitoring problems.
10. Due to propagation of signals in the HF band the monitoring of same must not be restricted to regional boundaries.
11. There is a need for continuous evaluation of monitoring performance to improve monitoring effectiveness.
12. Further studies into LF, MF and VHF/UHF monitoring, as well as foreign Monitoring Services, are needed to improve monitoring effectiveness.

*Conference Monitoring*

SUMMARY OF RECOMMENDATIONS.

1. New monitoring station should be established in the eastern Arctic, and possibly in the western Arctic as well.
2. The monitoring stations at Wetaskiwin, Senneterre, and either Acton VHF. or Almonte should be decommissioned.
3. The station at St. Remi should be considered as a VHF/UHF observation center and its effectiveness evaluated in that respect.
4. Up-to-date equipment standards should be established.
5. A program should be set up to improve monitoring equipment and antenna systems.
6. Recruitment and training of monitoring personnel should be investigated.
7. Serious consideration should be given to the automation of routine monitoring functions.
8. A national committee should be set up to resolve complex monitoring problems.
9. The question of decentralization vs. central control, with respect to monitoring, should be reexamined.
10. The priority of national monitoring objectives, over regional ones, should be ascertained.
11. An improved reporting system should be established to effect better and continuous evaluation of monitoring performance.
12. Further studies should be undertaken to evaluate LF, MF and VHF/UHF monitoring effectiveness, as well as to provide a comparative analysis of advanced foreign Monitoring Services.

## INTRODUCTION.

Monitoring Service has come a long way since its beginning in the early 1920's, when spectrum management consisted of making frequency measurements and the allocation of frequencies. Through the years the electromagnetic spectrum became more and more congested and the upper limit of allocated frequencies has increased from the original 30 MHz to the present 275 GHz, established by the International Telecommunications Union. Services became more varied and equipment grew more sophisticated as a result of technical advances. In order to cope with these developments, and to fulfill its function of spectrum management, Monitoring Service had to go through changes accordingly. As a result, the installation of more complex facilities, the use of more sophisticated equipment, and the application of new and more precise measurement techniques became necessary from time to time.

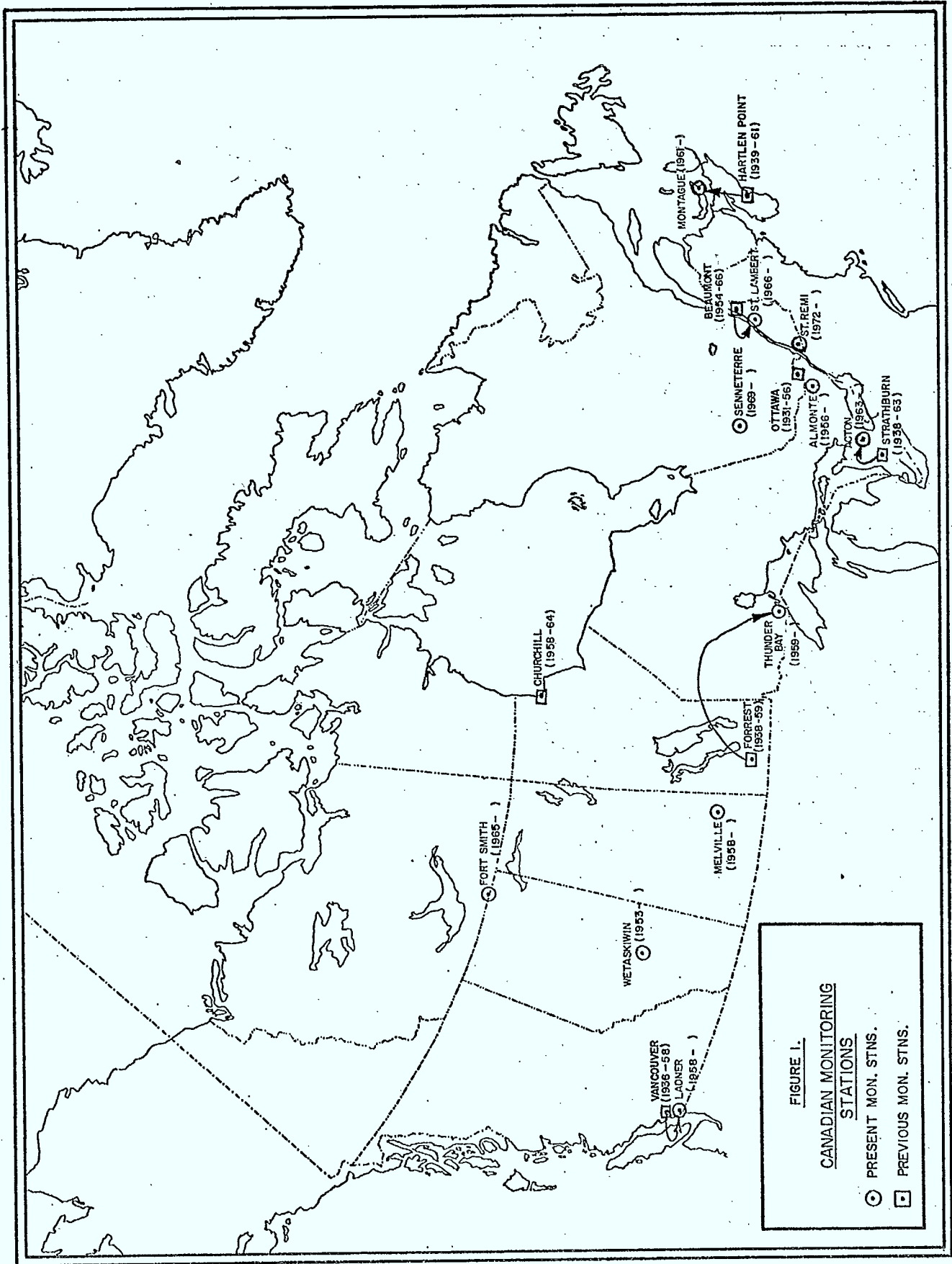
In Canada, Monitoring Service has a comparatively long history, operated first by the Department of Transport and later by the Department of Communications when it was formed in 1969, as it was one of the first such service to be established.

The first Canadian monitoring station was established in a small office in Ottawa, where the first official frequency measurement was made on October 5, 1931. In 1932 this monitoring station was moved to a new location and remained there until the fall of 1941, when a new Ottawa station was commissioned. About 1936 the equipment used at the old Ottawa station was set up in the Point Grey receiving station in Vancouver, to begin monitoring on the West Coast. In 1938, old stations formerly operated by the Canadian Radio Broadcasting Commission at Forrester (Manitoba) and Strathburn (Ontario) were taken over by the Department of Transport and equipped for monitoring work. In late 1939 direction finding equipment was installed in a small building at Hartlen Point (Nova Scotia) for use in "Y" monitoring during World War II, and this constituted the beginning of monitoring on the East Coast. All these monitoring stations performed a very beneficial role in devoting complete facilities and experienced personnel to Canada's war effort from 1939 to 1945. Through these years the five stations were expanded to full monitoring requirements.

Old equipment has been replaced with new and modern devices. Old monitoring stations have been forced to relocate due to urban expansion and its inherent halo of noise. New monitoring stations have been established to satisfy the ever increasing need for more adequate coverage of all classes of the expanding Canadian Radio Services. The location, movement, and the respective commissioning and shut-down dates of the monitoring stations is shown on the map of Figure 1.

At present there are 11 monitoring stations, many field inspection offices and several mobile monitoring units across Canada, using a great variety of electronic equipment for the monitoring and management of one of our major natural resources, the electromagnetic spectrum. However, there is an ever growing demand for frequency assignments by individuals, commercial and government organizations, as well as an increasing probability of interference and a constant improvement of electronic devices used in communications.

Therefore, in order to manage this great resource effectively, it is necessary to have a periodic evaluation of the Monitoring Service to assure that it keeps pace with requirements and to determine areas where improvements are necessary and/or possible. This study was undertaken to effect such an evaluation of HF monitoring by fixed monitoring stations.



## OBJECT AND SCOPE OF THE STUDY.

Constant changes in the number and distribution of frequency assignments, changes in departmental policies, and the new developments in the field of communications necessitate corresponding changes in the Monitoring Service. Therefore, in order to provide management with relevant information for the planning of an effective Monitoring Service, periodic evaluation of its performance is necessary. This report was undertaken to provide such a performance evaluation.

It was realized at the outset of this study that a thorough investigation of the entire Monitoring Service was necessary, however, it was also realized that this would require too long a time to be complete, with available resources, and would therefore be more practical to progress in stages.

In view of the above, it was decided that this study would be restricted to monitoring of the HF band by fixed monitoring stations only, which makes up a major portion of our Monitoring Service. Then the other facets of monitoring can be investigated at a later date, and in combination with this study used to evaluate the overall performance of the Monitoring Service.

The objectives of the study are as follows:

1. To evaluate the individual and combined coverage capabilities of our fixed monitoring stations, in the HF portion of the spectrum, by determining
  - (a) the potential coverage areas, using theoretical considerations based on wave propagation characteristics;
  - (b) observable coverage capabilities of the stations, based on data submitted by the stations;
  - (c) if the existing monitoring stations provide effective coverage of the HF band across Canada, following from (a) and (b) above;
  - (d) the geographical areas where the HF monitoring coverage is redundant, or lacking.
2. To investigate various trends in frequency assignments and corresponding monitoring requirements.
3. To investigate operating procedures, distribution of man-hours, and their effect on monitoring efficiency.
4. To conduct a brief survey of monitoring facilities, their suitability and comparison with state-of-the-art.
5. To investigate the economics of monitoring stations.



6. To provide data, conclusions and recommendations to facilitate future planning and decision making regarding HF monitoring in Canada.

### PURPOSE AND SCOPE OF MONITORING.

In the present trend toward an information-oriented society the role played by radio communications is colossal and, therefore, the efficient use of the radio frequency spectrum is indispensable and contributes greatly to the development of our society.

The radio spectrum is somewhat different from other resources and is characterized by the following properties:

1. It is used, not consumed, and is being wasted when not used effectively.
2. It has dimensions of space, time and frequency, and all three are inter-related.
3. It is an international resource and can only be utilized effectively by all nations in an international framework.
4. It is wasted when assigned to do tasks that can be done as easily in other ways.
5. It is wasted when its parameters are not correctly applied to a task.
6. It is subject to pollution, and radio noise is in fact decreasing its utilization.

The rational use of the radio spectrum is becoming more complex as time goes on. The radio frequency spectrum available is becoming less and less able to accommodate the progressive increase in requirements, despite the tremendous rate of scientific progress and the new possibilities opened up to mankind almost daily by developments in technique. Rational and optimum occupancy of the spectrum is thus a problem of increasing urgency.

In using radio waves, which are transmitted through common space, the power of emission as well as its time, frequency and location have to be taken into consideration. Without such consideration not only would communications be rendered impossible by mutual interference, but it would cause serious problems to vital functions like navigation and emergency services. Therefore, the regulation of telecommunications is a necessity.

Each nation has its own regulatory body that exercises authority and controls telecommunications in its own country. Acting within the scope of international treaties and agreements, these regulatory bodies assign frequencies, provide policing, establish technical rules and standards, control common carrier rates and practices, and safeguard the public interest within their purview.

In Canada the management of the radio spectrum and the regulation of its users were assigned by Parliament to the Department of Communications.

The radio spectrum being a national as well as an international resource of continually increasing importance, the basic objective of the Department is to ensure the equitable and interference free use of it by all Canadians, whether it is used for personal and commercial communications, safety services, national defence, data handling, education, or entertainment.

In view of the above, it is the purpose and responsibility of the Monitoring Service to have the technical capability and the trained personnel

1. to carry out constant surveillance of the radio spectrum;
2. to be able to locate, by radio direction finding techniques, the origin of radiocommunications that can be received and are interfering, or could interfere, with legitimate communications in Canada;
3. to provide the Department of Communications with all technical and operational information that is necessary for effective spectrum management, as well as enforcement of regulations made under the Radio Act and applicable regulations that form part of other Acts;
4. to participate in and exchange information through the International Telecommunications Union, in accordance with international agreements to which Canada is a signatory.

These are the general areas of responsibility of the Monitoring Service as a whole, the duties of the monitoring stations, on the other hand, can be summed up as follows.

1. Surveillance of the radio frequency spectrum

- (a) to see that stations are complying with the procedures pertaining to their particular service;
- (b) to observe the emissions from stations, for compliance with the technical rules that are applicable to their service;
- (c) to carry out policing of the spectrum, ensuring that stations are being used for the purpose for which they are licenced;
- (d) to see that non-licenced stations are promptly detected and reported;
- (e) to see that inter-station interference cases are monitored with a view to effecting alleviation;
- (f) to make studies of spectrum occupancy, for the purpose of finding spectrum space for new assignments;
- (g) to make precise frequency measurements where required, to observe that the operating frequencies of all classes of stations are within the tolerances as prescribed by international regulations, domestic regulations and licencing requirements.

2. Enforcement of technical and operational standards specified in international and domestic regulations.
3. Monitoring of Broadcasting Stations, within the area of responsibility of the monitoring station concerned.
4. To monitor the operation of radio beacons, used in the maritime and aeronautical services, with a view to warning the respective authorities of breakdowns and irregularities.
5. Monitoring stations are required to carry out special assignments on a great variety of subjects. Such assignments may be originated by Headquarters, Regional Offices, or the monitoring stations themselves.
6. Monitoring stations, during routine spectrum surveillance, may intercept distress signals. In such an event, they are to provide all possible assistance.
7. Monitoring stations, because of their versatile receiving facilities, are called upon to investigate certain frequencies, or frequency bands, and make recommendations regarding their suitability for new frequency assignments.
8. Monitoring stations maintain preventive surveillance of foreign stations, to ensure that they will not interfere with Canadian frequency assignments.
9. From time to time monitoring stations are required to carry out investigations of spectrum occupancy, for the International Frequency Registration Board.
10. Monitoring stations are also required to carry out administrative work, such as the preparation of forms, reports and the keeping of up-to-date records, that are the results of and are necessary for the efficient discharge of the above functions.

It should be noted, however, that no such list of duties can claim to be exhaustive, because technical developments and changes in departmental policies give rise to new responsibilities for the monitoring stations.

Recently, the staff of most monitoring stations completed special training courses and received cards of authority to carry out radio inspection duties, and in fact many of the operators are already doing radio inspection work, in addition to their regular duties.

Also, some monitoring stations have been equipped, or are presently being equipped, with HF direction finding facilities for locating sources of interference.

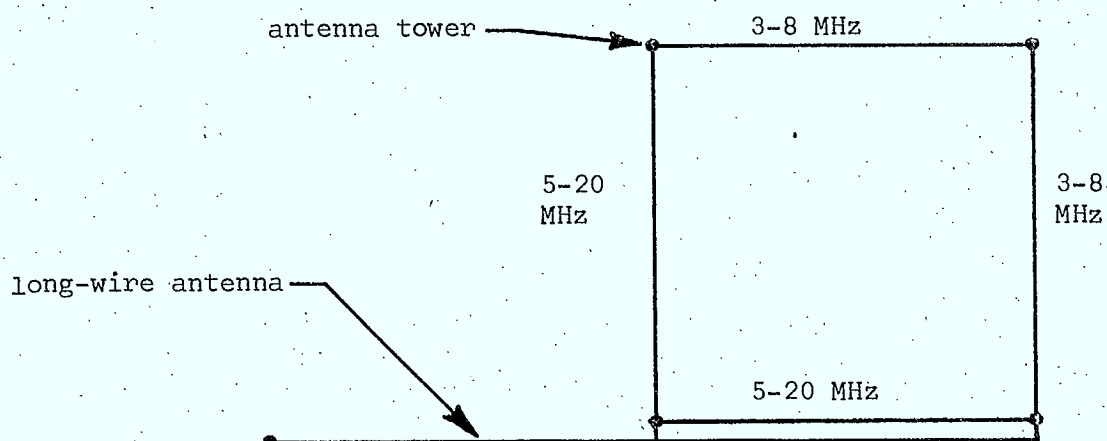
Although the effect of these changes is not fully apparent yet, they will undoubtedly place an additional burden on the monitoring station personnel both in workload and in technical requirements.

### MONITORING STATION EQUIPMENT.

To gain a better appreciation of the monitoring stations, and in order that persons not familiar with the subject will be in a more favourable position to understand and appreciate this report, a brief description of the capabilities and facilities of the monitoring stations is given here. It is not intended to be a detailed list of monitoring equipment, but rather a general description of what facilities make up a monitoring station.

At the present time there are 11 monitoring stations located in relatively noise free areas across Canada, the latest having been established earlier this year at St. Remi. At each monitoring station, reception is provided of radiocommunications from 12.5 KHz to 900 MHz. Outputs from the receivers can be applied as appropriate to headphones, speaker, tape recorder, spectrum analyzer, chart recorder, or teletype converter and printer. Accurate measurements can be made of frequency, frequency deviations, bandwidth, percentage modulation, field intensity, levels of spurious emissions and harmonics, intermodulation products, noise levels, and channel utilization.

All monitoring stations have full HF capability and, aside from minor differences, use the same antenna system. The HF broadband antennas are arranged in a rectangular shape, as shown on the diagram below, although their orientation is generally different at each monitoring station. The efficiency of this antenna system, and the antenna switching arrangement as well, could certainly be improved upon and several monitoring stations have indicated dissatisfaction with their performance.



HF antenna system.

Seven of the eleven monitoring stations have full VHF capability, as they are equipped with sophisticated VHF antennas that compare well with the state-of-the-art. However, the log-periodic antennas, used at most of these stations, should have a higher gain in the 30-500 MHz band, since the gain of these antennas is 12 db between 500 MHz and 1 GHz whereas it is only about 4 db at the lower frequencies. The other four monitoring stations, namely Ft. Smith, Melville, Montague and Senneterre, have limited VHF capability, as they are equipped with simple vertical whip antennas only. As a result, these four monitoring stations can only intercept VHF emissions that originate in their immediate vicinity. However, they are relatively far removed from densely populated areas, where VHF stations are generally concentrated and, therefore, the use of more sophisticated VHF antennas would be impractical.

The majority of the electronic instruments used is housed in standard operating consoles, arranged in functional groups for ease of operation. The photographs of such an operating console are shown in Figure 2. The general equipment types used at the monitoring stations are as follows:

1. HF receivers ( 115 KHz - 30 MHz);
2. VHF receivers ( 30 - 900 MHz);
3. LF converters;
4. Spectrum analyzers;
5. Frequency counters;
6. Oscilloscopes;
7. Tape recorders;
8. Miscellaneous instruments and various switching panels.

Although the Racal HF receivers have been used successfully for many years, steps are now being taken to replace them with the new solid state version of these receivers, or others of similar standard. The other equipment presently used at the monitoring stations are generally satisfactory in fulfillment of their functions.

At present, the establishment of a HF direction finding system is in progress that will be used, when completed, to determine the origin of interferences both in and outside Canada. The installation of the HF direction finding facilities is already complete at Almonte and Ft. Smith, is presently being completed at Montague, and scheduled to be completed in the next fiscal year at Thunder Bay and Cloverdale.

Although a more detailed evaluation of the monitoring facilities, and the establishment of equipment standards would be highly beneficial, it is outside the scope of this report. An independent study of the same should be undertaken.



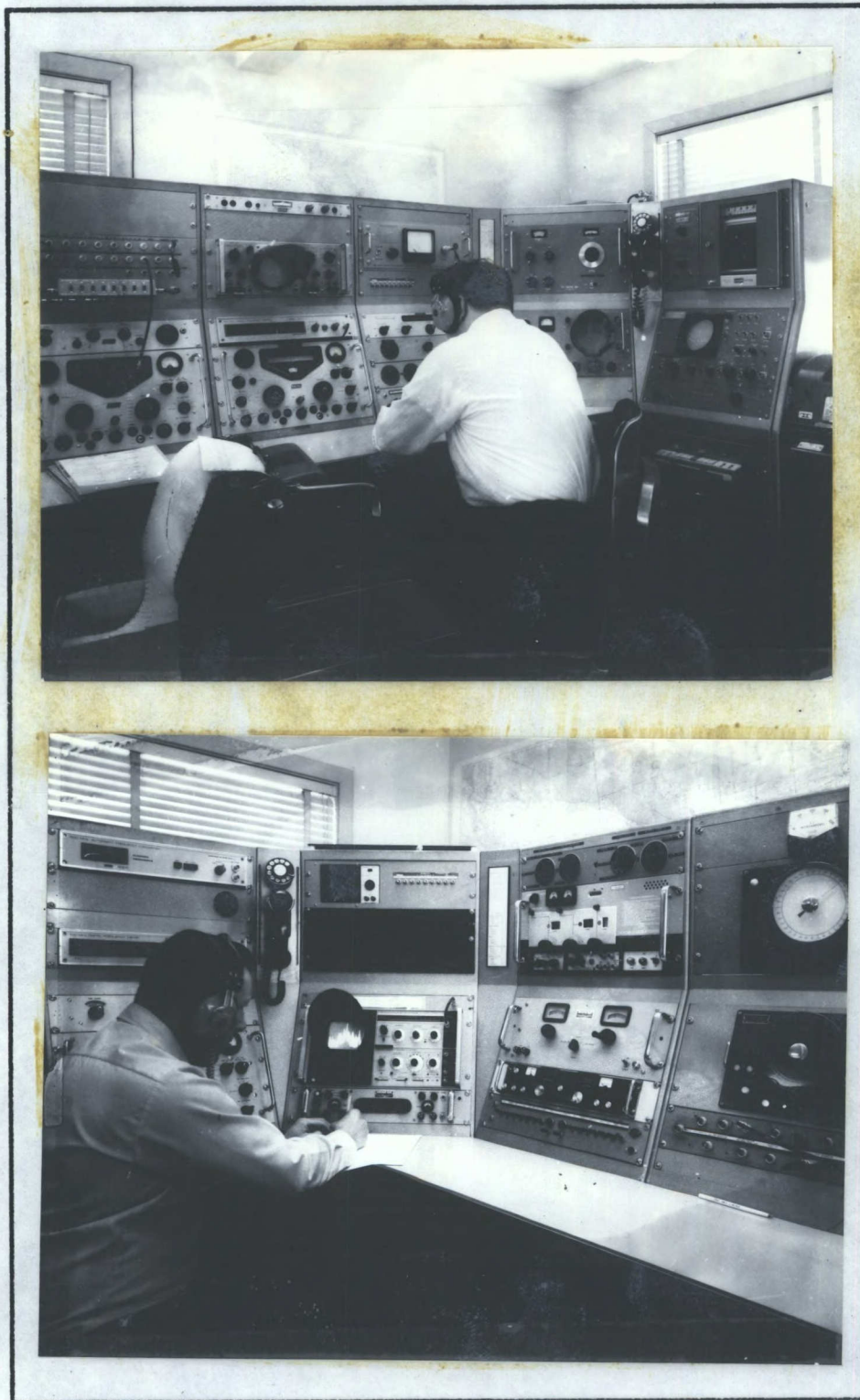


Figure 2. Views of the operating console at the Almonte monitoring station.

### ECONOMIC CONSIDERATIONS.

Economic considerations, such as cost/benefit analysis, are an important part of any performance evaluation and provide a very effective parameter for the evaluation of efficiency. Certain types of businesses naturally lend themselves to such analysis, while others do not. Unfortunately monitoring belongs to the latter group and, since it provides a service not a tangible product, much like the Police Department, to express the benefits derived from such services in dollars and cents is next to impossible.

One cannot emphasize strongly enough the necessity of an efficient Monitoring Service and the fact that although financial considerations are important they are not the primary factors for such services where the safeguarding of national and public interest is involved. For without the Monitoring Service providing interference free usage of spectrum space for the public, in general, and such vital services as emergency communications, national defence and navigational aids, in particular, a complete chaos in communications would result that would be detrimental to the whole economy and the social development of Canada. To give an appreciation of the importance of communications to the economy, and Canada as a whole, a partial list indicating the major users of radio during 1971/72 is included in Table 1.

Another important point to be considered, before dealing with cost figures, is that the users of Canadian networks and radio systems have a large investment in communications equipment, which runs into billions of dollars. Therefore, it is the responsibility of the Department of Communications as the "spectrum manager" to protect this investment.

To establish the equivalent annual cost of operating the presently existing monitoring stations, the following criteria are used:

1. based on past history the average life of a monitoring station is 20 years;
2. the average life of monitoring equipment is 10 years;
3. at present the number of persons at a fully staffed monitoring station is considered to be five, an Officer in Charge and four operators;
4. since the St. Remi station is used 100% for VHF/UHF monitoring it should not be considered a monitoring station and, therefore, its costs will not be included in determining the cost figures.

To arrive at an equivalent annual cost figure, it is necessary first to determine the components that contribute to the total. These components are as follows:

1. The cost of construction.

The construction costs for the 10 monitoring stations are shown in Table 2.



These construction costs add up to a total of \$ 552,340.

2. The cost of land.

The actual land costs of the monitoring stations are shown in Table 2. These land areas are owned by the Department of Communications, with the exception of the Ladner monitoring station where the land is leased from C.O.T.C. Thus, the cost of land for the monitoring stations where the land is owned by the Department is \$ 25,971, while the cost of rental at Ladner (up to 31 March 1972) is \$ 10,214. Therefore, the total cost of land for all the monitoring stations is \$ 36,185.

3. The cost of monitoring equipment.

The cost of monitoring equipment for the 10 stations is \$ 575,000.

4. The yearly maintenance cost of monitoring equipment.

Although these costs vary from station to station, and also year to year, the yearly maintenance costs per station seldom exceed \$ 1,500 and are generally lower. Therefore, the annual maintenance costs for the 10 monitoring stations add up to \$ 15,000.

5. The yearly wages and fringe benefits of the monitoring staff.

The OIC's of the monitoring stations are at the EL-5 level, ranging in salary from \$ 11,300 to \$ 12,842, with an average annual salary of \$ 12,071. The operators, on the other hand, are generally at the EL-4 level (some are at lower levels) ranging in salary from \$ 10,130 to \$ 11,510, resulting in an average annual salary of \$ 10,820. Therefore, the total yearly wages for the monitoring staff is

$$\begin{array}{r} \$ 12,071 \times 10 = \$ 120,710 \\ \$ 10,820 \times 40 = \$ 432,800 \\ \hline \$ 553,510 \end{array}$$

Fringe benefits paid to monitoring station personnel make up approximately 15% of the yearly wages, which amount to \$ 83,027. Hence, the total amount of yearly wages and fringe benefits is

$$\$ 553,510 + \$ 83,027 = \underline{\$ 636,537.}$$

It should be noted, however, that in reality this cost is somewhat lower than the above amount, partly because some of the operators are at lower levels than the assumed EL-4 level, but mainly because the monitoring stations due to various reasons are hardly ever fully staffed.

Therefore, the equivalent annual cost of the 10 monitoring stations is

1. Maintenance and Operation

a. wages and fringe benefits.....	\$ 636,537
b. maintenance costs.....	\$ 15,000
	<u>\$ 651,537.</u>

2. Amortization of capital cost

- a. building and land (8% - 20yrs) = \$ 588,171 x .10185 = \$ 59,905
- b. monitoring equipment(8%-10yrs) = \$ 575,000 x .14903 = \$ 85,692

EQUIVALENT ANNUAL COST : \$ 797,134

The factors used above take into account the cost of money and depreciation.

The equivalent annual cost of operating the 10 monitoring stations may seem rather high and one might naturally ask if it is justified to spend so much money to operate these monitoring stations. Partly this has already been answered at the beginning of this chapter, when the necessity of monitoring and the staggering amount of money tied up in communications equipment were discussed. On the other hand, to put these yearly expenditures into a realistic perspective, the yearly revenues resulting from licence fees must also be considered. A breakdown of the revenues received from licence fees during the 1971/72 fiscal year, by the Department of Communications, is shown in Tables 3 and 4. It should be noted that while these revenues are inclusive of all the licences in force, as there were no figures available according to frequency bands, the operating expenditures listed above are for the monitoring stations only and do not include Field Offices, Spectrum Observation Centers, etc. One might further argue that such revenues are for the Department as a whole, which is true of course. However, one must not lose sight of the fact that most of these revenues would not be forthcoming without the Monitoring Service, since there would be no way to detect illegal operations or to enforce rules and regulations.

TABLE 1. PARTIAL LIST OF MAJOR USERS OF RADIO DURING 1971/72.

User	Number of licences
Telephone Systems	7,124
Electric Power Systems	10,994
Gas Distribution Systems	1,370
Logging	7,698
Forestry Services	8,572
Mines & Mines Services	4,596
Farms & Agricultural Services	1,641
Fishery Services & Products	908
Petroleum & Gas Wells - Absorption Plants	1,700
Petroleum & Other Prospecting	3,469
Sawmills, Planing Mills, Wood Industries	1,691
Building & Other Construction & Trades	12,033
Highway, Bridge & Street Construction	3,172
Highway & Bridge Maintenance	4,833
Air Transport & Services	10,822
Ships & Water Transport Services	10,969
Railway Transport	8,485
Truck Transport	7,946
Bus & Urban Transport System	993
Taxi Systems	17,860
Pipeline Transport	1,191
Water & Other Utilities	976
Machinery & Equipment Wholesalers	1,065
Lumber & Building Materials Wholesalers	672
Tire, Battery & Accessory Dealers	541
Gasoline Service Stations	436
Motor Vehicle Dealers & Repair Shops	598
Radio, T.V. & Electrical Appliance Repair Shops	580
Fuel Dealers	3,708
Insurance, Real Estate & Investment Cos.	986
Schools, Universities & Related Educational Services	1,127
Engineering & Scientific Services	1,322
Services to Business Management	2,665
Lodging Houses & Residential Clubs	664
Private Investigators	478
Police Services (Federal, Provincial, Municipal)	8,916
Fire Services (Provincial & Municipal)	825
Other Federal, Provincial & Municipal Services	8,344
Civil Defence (EMO Services)	1,127
Pulp & Paper Mills	1,905
Iron & Steel Mills	650
Communications Equipment Manufacturers	383
Ready Mix Concrete Manufacturers	3,718
Amateur Experimental Service	12,607
General Radio Service (including TRS)	66,855

TABLE 2. CONSTRUCTION AND LAND COSTS OF THE MONITORING STATIONS.

Monitoring station	Date established	Cost of construction	Cost of land		Remarks.
			Purchase	Lease	
ACTON	1963	\$ 48,900	\$ 3,002	-	
ALMONTE	1956	\$ 52,000	\$ 5,200	-	
FT. SMITH	1966	\$ 49,300	\$ 644	-	
LADNER	1958	\$ 64,720	-	\$10,214	Land leased from C.O.T.C. 1/6/57 - 31/12/67 @ \$400/year and 1/1/68 - 31/3/72 @ \$1,415/year.
MELVILLE	1958	\$ 56,255	\$ 2,975	-	
MONTAGUE	1961	\$ 52,745	\$ 1,263	-	
SENNETERRE	1969	\$ 95,045	\$ 1,500	-	
ST. LAMBERT	1966	\$ 46,000	\$ 7,612	-	
ST. REMI	1972	\$ 35,000*	\$40,342*	-	*Original construction cost of \$113,736 was incurred by DND. It was not possible to determine the portion of land cost DND incurred.
THUNDER BAY	1959	\$ 56,500	\$ 2,775	-	
WETASKIWIN	1953	\$ 30,875	\$ 1,000	-	
TOTAL:		\$587,340	\$66,313	\$10,214	

TABLE 3. REVENUES RECEIVED FROM LICENCE FEES IN 1971/72.

Service category	Number of licences			Annual licence fee		Total amount received
	Coast	Ship	Land	Mobile	Land	
Private Maritime Mobile	59	-	-	-	-	\$ 1,180
Public Commercial	-	-	1,529	13	\$150	\$ 229,805
Restricted Public Commercial	-	-	319	-	\$100	\$ 31,900
Private Commercial	-	-	18,804	104,316	\$ 20	\$1,158,450
Federal Government	-	-	3,920	9,084	-	-
Provincial Government	-	-	6,595	18,234	-	-
Municipal	-	-	1,566	1,780	\$ 10	\$ 33,460
Experimental	-	-	387	324	\$ 20	\$ 10,980
Amateur Experimental	-	-	12,607	-	\$ 10	\$ 126,070
General Radio Service	-	-	59,734	-	\$ 10	\$ 199,113*
Public Commercial Receiving	-	-	79	-	\$ 15	\$ 1,185
Private Commercial Receiving	-	-	297	141	\$ 10	\$ 4,380
Public Commercial Automatic Repeater	-	-	1,034	-	\$ 75	\$ 77,550
Private Commercial Automatic Repeater	-	-	1,002	-	\$ 10	\$ 10,020
Aircraft Navigational	-	-	-	4	-	\$ 40
Aeronautical Mobile	-	-	1,357	8,218	\$ 20	\$ 150,410
Ship Stations	-	10,010	-	-	\$ 15	\$ 150,150
Ship Stations (Mobile)	-	469	-	-	\$15	\$ 7,035
TOTAL:						\$2,191,728

\*This value is based on the average number of licences for the past 3 years (59,734), at \$10/3yrs.

TABLE 4. REVENUES RECEIVED FROM BROADCASTING STATIONS IN 1971/72.

Type of broadcasting service	Number of stations	Revenues received
AM	333	*
FM	86	*
TV	469	*
LPRT	254	*
SW	9	*
TOTAL:	1,151	\$ 3,604,460.85

\* Figures of revenues received from each broadcasting service were not available.



### HF COVERAGE OF MONITORING STATIONS.

The coverage area of a monitoring station is defined as a geographical area, such that radio emissions originating within its boundaries can be reliably received by the monitoring station. Since there are many continuously varying factors affecting HF reception, many coverage areas must be considered each one specifying the coverage for a different set of parameter values.

To determine the coverage area of the monitoring stations, two methods were available

1. observed coverage, which is derived from the actual performance of the monitoring stations; and
2. theoretical coverage, which is determined by radio propagation theory.

Both of these methods have advantages and disadvantages and, therefore, it was decided that a combination of the two would be most desirable.

#### Observed coverage.

A list of assignments, that have been intercepted by each monitoring station, was collected to determine the observed coverage. After the listed power of the assignments was converted into mean signal power (for more detail on transmitter power ratings and mean signal power refer to Appendix 2), to be comparable with transmitter power levels used to determine theoretical coverage areas, these intercepts were divided into various frequency and power bands. The intercepts in each band were then plotted and a contour line was drawn to encircle them. The resulting observed coverage maps can be found in Appendix 5.

The contour lines should ideally define the coverage area of the monitoring stations for the particular transmitter power and frequency in question, however, in practice several factors must be taken into account to interpret these results properly.

1. A few of the intercepts occur at much greater distances from a given monitoring station than the majority. These had to be considered as 'freak' receptions and, for this reason, were not included inside the coverage contour.
2. There are areas of low assignment density. In these areas it is uncertain whether a lack of intercepts is the result of the low assignment density or, if it is an indication that the area is outside the coverage of the monitoring station. For this reason, to make the interpretation of the observed coverage maps easier and more realistic, a set of assignment density maps and overlays are included in Appendix 5.

3. There are several instances, as can be seen from the maps, where monitoring stations are shown with no coverage area whatever. These situations are due to a complete, or nearly so, lack of interceptions at that particular transmitter power and frequency.
4. Since the time and date of the interceptions were not included in the collected data, there was no possibility of determining the monthly and annual variations in coverage. The time and date of the interceptions are available at the monitoring stations. However, to make use of this information the intercepts would have to be further divided according to month and sunspot number, in addition to transmitter power and frequency, thus reducing the number of intercepts in each band to such a small number as to be useless. Due to the lack of such information, therefore, it is impossible to know with certainty if the indicated coverage represents a maximum, minimum, or an average coverage area, as it varies with these factors. Although, considering monthly variations only, the indicated coverage is in all probability a maximum, since the smaller summer coverage is masked by the greater winter coverage areas.

In general, it appears that many more intercepts would be needed, for each monitoring station, to produce an accurate indication of the coverage area, especially if monthly and sunspot cycle variations in the coverage are to be evaluated also.

#### Theoretical coverage.

To compensate for the shortcomings of the observed coverage, it was felt that a study of the theoretical coverage of monitoring stations would be useful. Knowing the theoretical coverage it is possible to fill in the gaps in the observed coverage, and also to study how the variations in certain parameters such as sunspot number, transmitter power, time of year, etc. affect the coverage area. Although it is impossible to determine an exact coverage area for the monitoring stations with any method, the theoretical results provide an excellent way to compare the relative coverage potential of the stations as well as a sound basis for future planning.

The computer facilities and the high frequency prediction program of the Communications Research Center, Department of Communication, were used to determine the theoretical coverage area of the monitoring stations. To make use of this program, it was necessary to provide the following information:

1. location of the transmitter and the monitoring station;
2. time, month, and sunspot number;
3. signal characteristics (transmitter power and frequency);
4. type and bandwidth of emission;
5. antenna characteristics;
6. required signal-to-noise ratio at the monitoring station; and



## 7. local noise levels.

The results of the computer program are in terms of the probability of reception, for a given set of parameter values. For a more detailed description of these parameter values, and how the theoretical coverage maps were arrived at, refer to Appendix 3. For now it will suffice to say that the theoretical coverage maps indicate the area within which there is at least an 80% probability of reception, for at least four hours of the day. The theoretical coverage maps are included in Appendix 5.

### The effect of sunspot number, time of year, transmitter power and frequency on the coverage area.

The extent of the coverage area is influenced by many factors, the most important of which are sunspot number, month (i.e. time of year), transmitter power and frequency. The effect of these factors on coverage area is discussed below.

Sunspot number: Variations in the sunspot number affect the ion density of the ionospheric layers and, therefore, the propagation characteristics and the coverage area. The summer coverage area, as it can be seen from Maps 48, 49, and 50, decreases with increasing sunspot number. This is caused mainly by increased absorption of signals at higher sunspot numbers. The winter coverage area, on the other hand, increases with sunspot number, as shown on Maps 45, 46, and 47. This is because the absorption is relatively small in the winter, while the reflectivity of the F-layer increases with increasing sunspot number.

Month: The variation of coverage area, as a function of the time of year, is shown in Maps 51, 52, and 53. It can be seen that the coverage area is the smallest in June and largest in December. Coverage areas at the time of the two equinoxes (March 21 and September 21) are about the same. The difference in coverage areas indicated for March and September, on the above maps, most probably stems from the fact that these results were calculated for the 15-th of each month. This means that the March results are about a week farther away from the June minimum, while the September results are about a week closer to it, than those for the equinoxes would be. Although this difference in coverage could have been accentuated by other factors as well.

Transmitter power: The coverage area increases with increasing signal power, as indicated by Maps 54 and 55.

Frequency: In general, the coverage area for a given transmitter power level increases with increasing frequency, up to a certain point, since ionospheric absorption is inversely proportional to frequency in the HF band. However, as the frequency is further increased signals with near vertical incidence will not be reflected from the ionosphere and, therefore, the effective coverage area will decrease. The above is not always observable, however, from the coverage maps, since the local noise levels (frequency dependent) and other factors also affect the coverage areas.

A theoretical discussion of these factors, variations in propagation characteristics and propagation in general is included in Appendix 1.

Comparison of observed and theoretical coverage areas.

In most cases it is difficult to compare the theoretical and observed coverage areas, since the theoretical results apply to a specific set of conditions while the observed coverage is integrated over a variety of conditions. Specifically, the theoretical results are presented for definite values of sunspot number and month, while the observed coverage is deduced from data collected over many values of sunspot number and month. Although the observed and theoretical results do not exactly correspond, some comparison can be made. The theoretical results do show the true relative size and shape of the coverage areas and, therefore, by referring to the theoretical, observed and assignment density maps, one can determine how effectively the monitoring stations are covering the country.

Before embarking on any comparison between theoretical and observed coverage areas, however, let us reiterate some important factors that have to be borne in mind for proper interpretation.

1. Some observed coverage areas are limited by low assignment density, or operating schedules that do not coincide with monitoring opportunities and, therefore, do not represent the true coverage capability of the monitoring station, or stations, for that particular transmitter power and frequency band. Excellent example of this are Maps 16 and 17, where for the same frequency band (3-4 MHz) the coverage area of the Fort Smith monitoring station is less for greater than 10 watts signal power than for 3-10 watts power levels. This is an obvious contradiction of which there are other similar instances. It is necessary therefore, to consult the corresponding assignment density maps for proper interpretation of the observed coverage areas.
2. Although it was not possible to determine the summer and winter observed coverage areas, those indicated on the observed coverage maps are in all probability due to winter propagation characteristics. In other words, they represent maximum coverage areas, when the effect of sunspot numbers is not taken into consideration, and should therefore be compared with corresponding theoretical winter coverages.
3. A few of the theoretical coverage maps (specifically the low power, low frequency summer coverage maps) show some of the stations with substantial coverage, while others are shown with no coverage at all. This is generally a true representation of the relative coverage areas of the monitoring stations, but in some cases the situation is accentuated by the choice of averaging method and threshold level. This is unavoidable, since any averaging method and threshold level will result in some anomalous situations.
4. Some of the observed coverage maps indicate coverage areas, where the assignment density maps have no assignments. This is due to the fact that the density maps show assignments as of 31 December 1971, while the interceptions were made during a period of several years.

Although frequencies below 3 MHz are not part of the HF band, observed coverage maps were prepared for these frequencies using the available

interception data provided by the monitoring stations. These observed coverage maps, however, cannot be compared with any of the theoretical coverage maps, because of the different propagation characteristics. It can be seen from the maps that at these frequencies the coverage of emissions with less than 1 watt mean signal power is poor, however, for greater power levels the coverage becomes quite good. An exception to this is the 3-10 watts coverage, which is quite obviously limited by low assignment density.

In the 3-4 MHz frequency band the observed coverage is extremely poor, as even the greater than 10 watts coverage areas are smaller than the corresponding 1 watt theoretical coverage. Although it should be noted that the assignment density is generally low in this band, since 3.5 to 4.0 MHz is reserved for amateur licences for which no interception records are kept by the monitoring stations.

In the 4-5 MHz frequency band the observed coverage is much improved, although even here only the 3-10 watts coverage is comparable to the 1 watt theoretical coverage. The only exceptions to this are Acton and Almonte, which actually show slightly bigger observed than theoretical coverage. This is probably due to the fact that most of the interceptions were made during periods of higher sunspot numbers than the average values assumed for the theoretical considerations.

In the 5-7 MHz frequency band again only the 3-10 watts observed coverage becomes comparable in area to the 1 watt theoretical coverage.

The observed coverage maps for high transmitter powers and frequencies, that is those above 10 watts and above 7 MHz, have been omitted. This has been necessary not for the lack of intercepts but rather because the intercepts are spread thinly over a large part of the country making the distinction between areas of reliable and unreliable coverage impossible.

## INVESTIGATION OF MONITORING TRENDS.

The investigation of trends in any field of activity is important and highly advantageous, for it provides information about the things to come and on the basis of which future planning can be accomplished. This is especially true in the case of monitoring, where the variety of services provided is great. The investigation of such trends provides the necessary tool for management by which the future needs and their relative importance can be assessed.

For this reason the investigation of monitoring trends was undertaken by this study. Although the results obtained are far from being conclusive, due to the lack of data to carry out a thorough investigation, they are important none the less in providing guide lines. Without taking these trends into consideration, decision making and planning for future needs would be rather haphazard.

Monitoring trends can be divided into the following two major categories:

1. Variation of frequency assignments both in total number, operating frequency and power. These indicate not only the general trends in communication, but also the areas where monitoring efforts should be concentrated.
2. Trends in operating procedures and workload, and their correspondence with variations in the frequency assignments.

An overall appreciation of the variation in the number of radio licences in force, from 1945/46 to 1971/72, can be gained from Graph 1. It indicates the continuous increase in the number of licences, amounting to about 3,500% during these 27 years. On the other hand, the yearly increases in the number of frequency assignments across Canada, for the past 7 years, is shown in Graph 2. It can be seen that, although the amount of increase varies from year to year, the total number of frequency assignments is steadily increasing both below and above 30 MHz. The increase, however, is at a greater rate above 30 MHz, i.e. in the VHF and UHF bands.

Next, let us consider the distribution of frequency assignments, as a function of both operating frequency and mean signal power of the transmitters, and compare it with the distribution of interceptions made by the monitoring stations. Before proceeding, however, the limitations of the data, on which these graphs were based, will have to be stated to put them in proper perspective. These limitations are as follows:

1. Assignment figures prior to 1971 have been deduced from the December 31, 1971 frequency assignment list, according to the date of licence issued, as this information is not available in the required breakdown, and therefore do not take into consideration the yearly deletions and amendments. This however is not expected to affect appreciably the relative assignment distribution.

2. Intercept figures mostly refer to 1971, since once a new card is started for the recording of interceptions made on a given assignment the old card is destroyed.
3. Both the intercept and assignment figures refer to fixed private and commercial listings only, and do not include D.N.D., amateur, G.R.S., mobile or navigational aids, as there is either no permanent record kept or the data is insufficient regarding their distribution. However, data on the yearly variation of the number of amateur and G.R.S. assignments was available and is included.

Assignments having frequencies below 3 MHz do not belong to the HF band, however, the required data having been available their variations are also presented here. The number of these assignments is steadily increasing, but only about 20% of them are intercepted by the monitoring stations, as it can be seen from Graph 3. A better insight can be gained from Graph 5, where the distribution as a function of mean signal power is shown. It becomes apparent that the rate of interception is relatively good at powers above 3 watts, at lower powers however, especially in the less than 1 watt group where the majority of the assignments are, the interception rate is extremely poor. This is due to the fact that these assignments are mainly for local communications, the absorption being very high at these frequencies.

In the HF band (3 to 30 MHz) the number of assignments is constantly increasing and the interception rate is quite good, as it is indicated by Graphs 4 and 6. Approximately 50% of the frequency assignments are intercepted in the HF band, with the exception of those that have less than 1 watt mean signal power and are in the 3-4 MHz portion of the band, where the interception rate is rather poor. This can be contributed to the high absorption of the sky waves in the ionosphere and the small surface wave coverage which are characteristic of propagation at these frequencies.

When considering interception rates, one must also bear in mind that there are many frequency assignments which are only used from time to time, or not used at all, and therefore tend to lower the interception rate of the monitoring stations.

The yearly variations in the number of amateur and G.R.S. radio licences are shown in Graphs 7 and 8, respectively. It can be seen from these graphs that although there was a slight decrease in the number of amateur licences, following an increase in licence fee from \$2.50 to \$10, there was an overall increase of about 40% in the past 12 years. On the other hand, the number of G.R.S. licences has decreased somewhat in the last 3 years, but the overall increase none the less amounts to about 330% during the past 10 years.

Now let us consider the monitoring stations themselves, that is the relative changes in their activities and the distribution of their workload. The distribution of man-hours spent on actual operating and other related activities by the monitoring station operators, as well as the time lost, in comparison to the total man-hours possible (full staffed) is shown in Graph 9. The graph indicates that although the time spent on monitoring has increased through the years, partly due to an increase in the number of monitoring stations, there is still a considerable amount of time lost annually (about 1,000 man-hours/station) by being short-staffed.



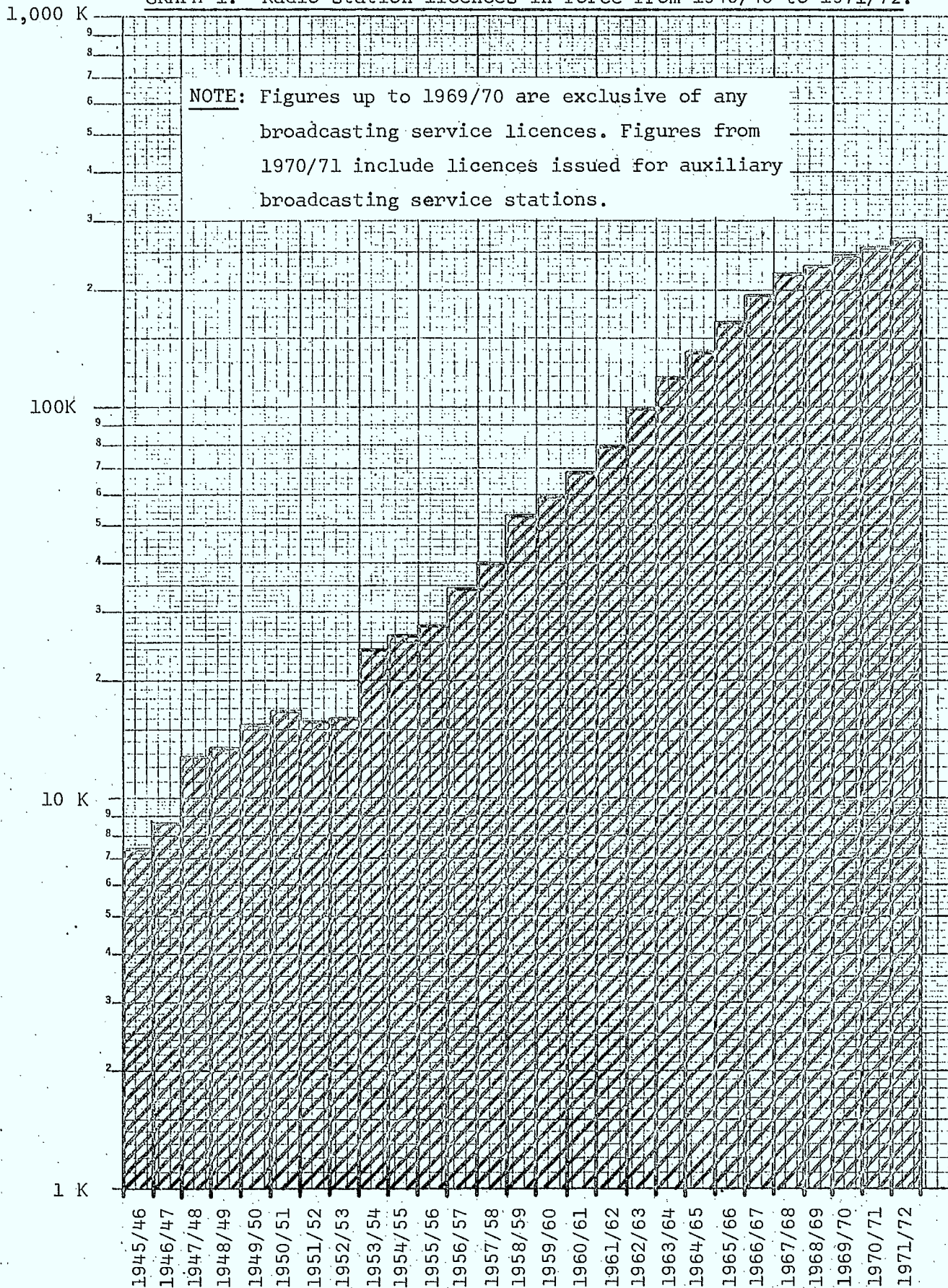
The approximate distribution of the time spent by the monitoring stations on monitoring below 30 MHz, as opposed to VHF and UHF, as well as the time spent on routine surveillance versus special monitoring assignments, is presented in Graph 10. These graphs require no explanation, except that they are based on average figures and may vary from time to time. A further breakdown of special assignments, with regards to their origin, is shown in Graph 11. It can be seen that the number of special assignments originated by the monitoring stations themselves has increased about 100% during the past 10 years, while those originated by the Regional Offices and Headquarters has declined and stayed about the same respectively. The reason for this is twofold, on one hand the overall number of special assignments has increased considerably, while on the other hand more authority is being delegated to the monitoring stations.

Tables of all the values, that were used to prepare graphs 1 to 11, are included in Appendix 4.

The trends discussed above indicate that the burden of the monitoring stations is increasingly greater because of the growing number of frequency assignments that has to be monitored, and also because of the increasing number of special assignments that the monitoring stations have to carry out in addition to the routine surveillance of the spectrum. It is also important to note that, as a result of policy changes in the monitoring service and new technical developments in communications, the monitoring station activities are constantly changing not only in volume but in their relative importance and complexity as well. Such changes presently taking place are the installation of HF direction finding facilities, at several monitoring stations, and the radio inspection work being carried out by monitoring station personnel.

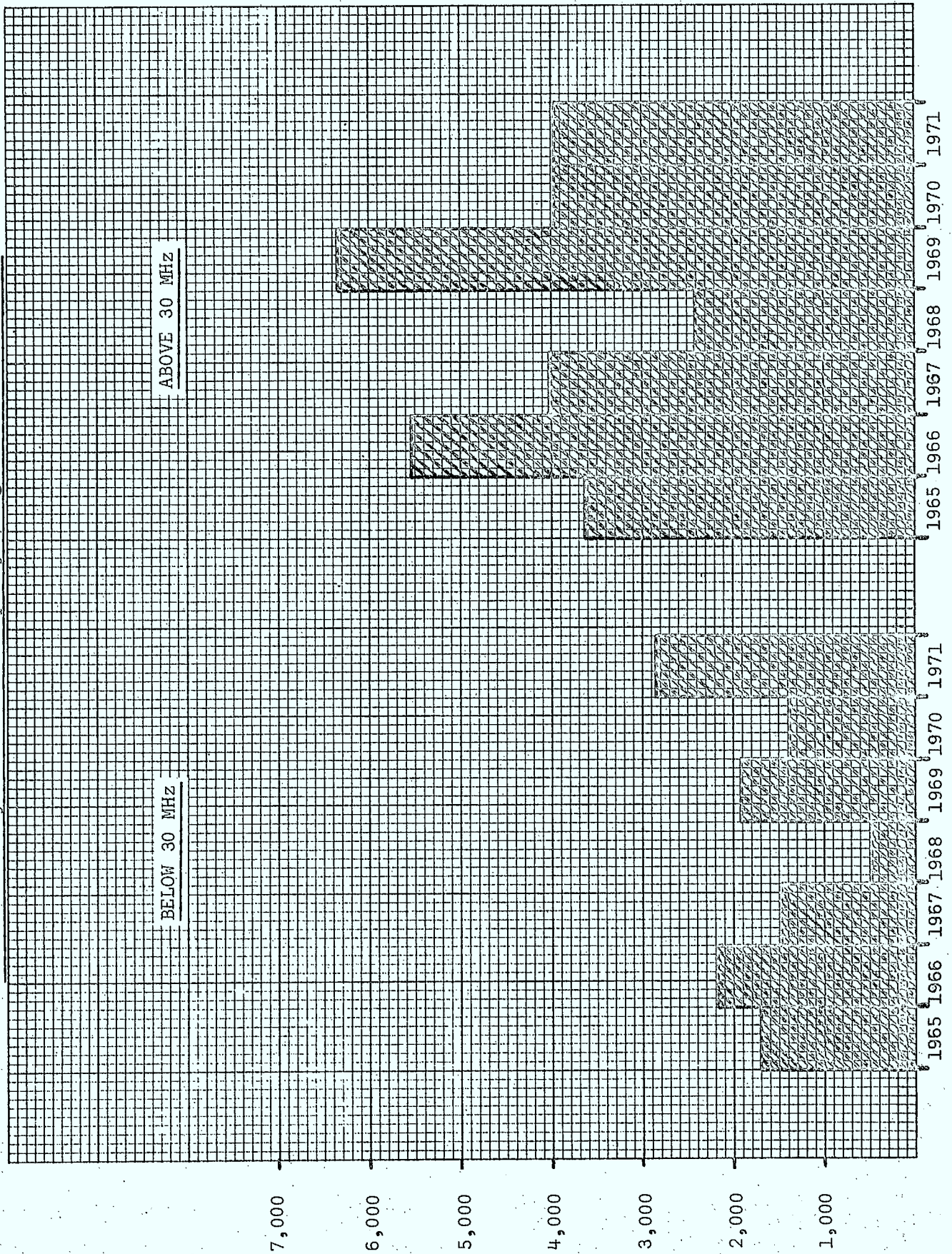
It is evident that these changes not only increase the workload but also require greater technical capability on part of the monitoring station operators. Therefore, it must be realized that unless the quality of monitoring is to deteriorate, the number of monitoring personnel has to increase accordingly, or other similar measures have to be taken, in order to cope with the increased workload.

GRAPH 1. Radio station licences in force from 1945/46 to 1971/72.



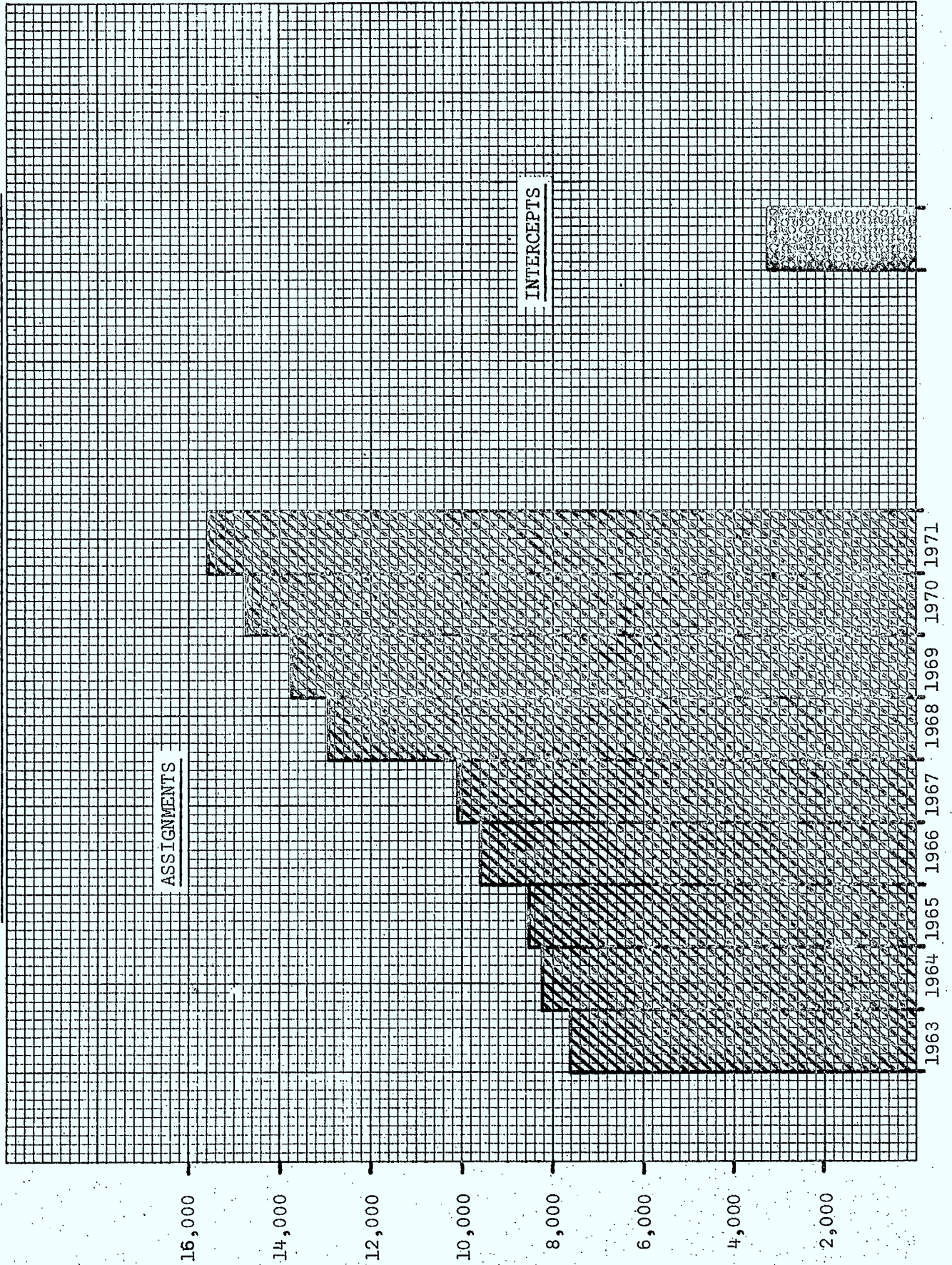


GRAPH 2. Yearly increase in frequency assignments (civil & DND).





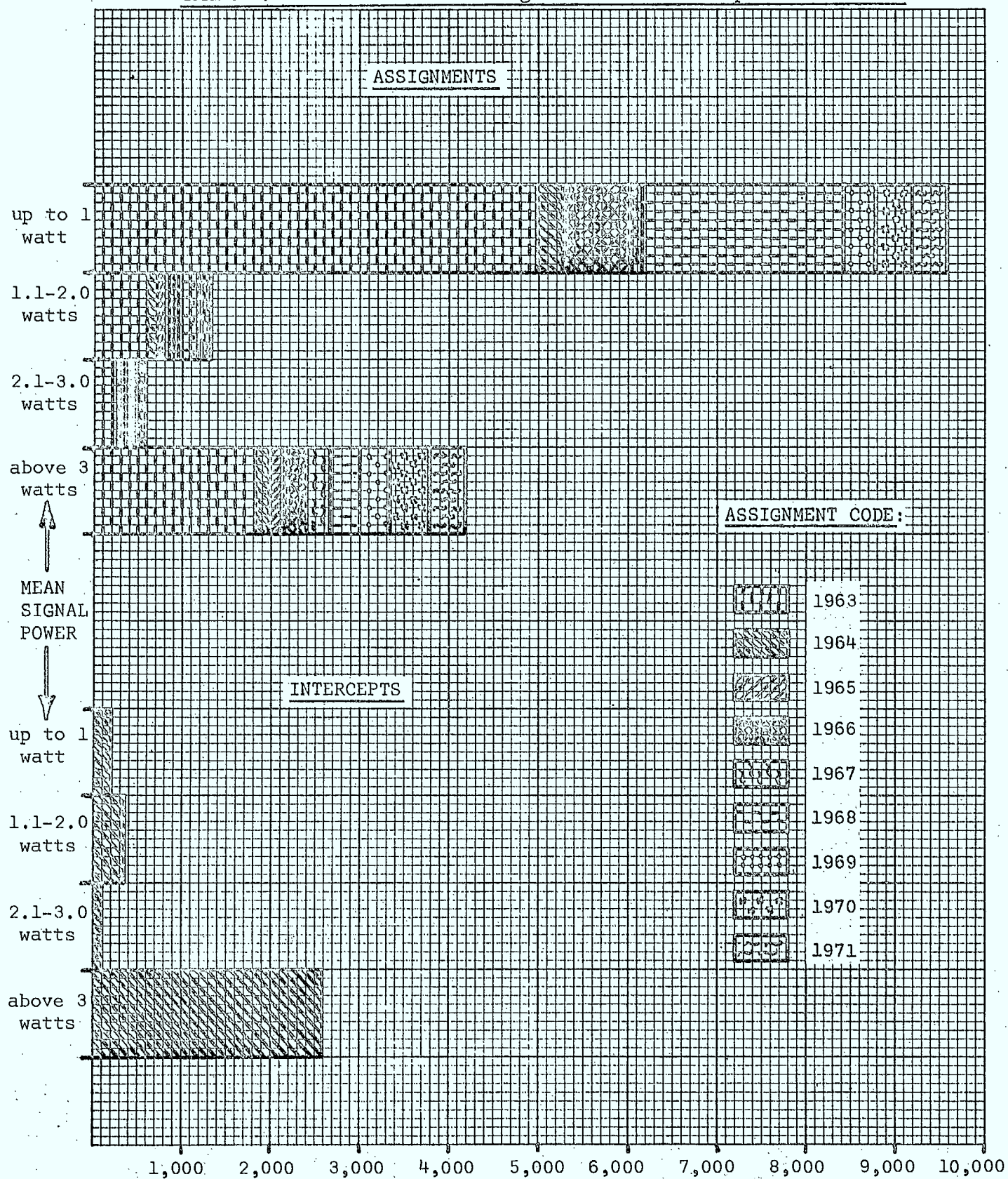
GRAPH 3. Distribution of assignments and intercepts below 3 MHz.



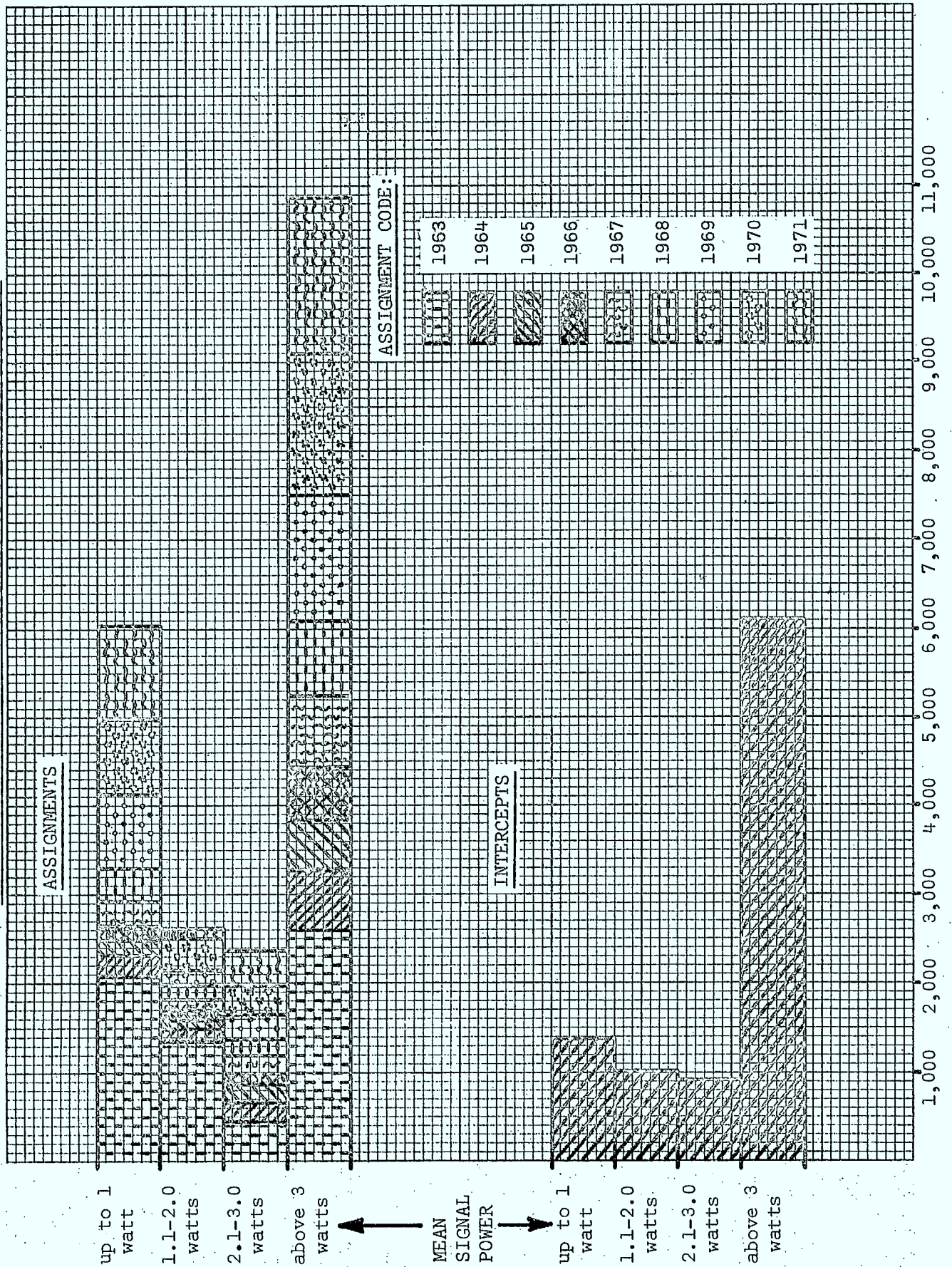




GRAPH 5. Distribution of assignments and intercepts below 3 MHz.

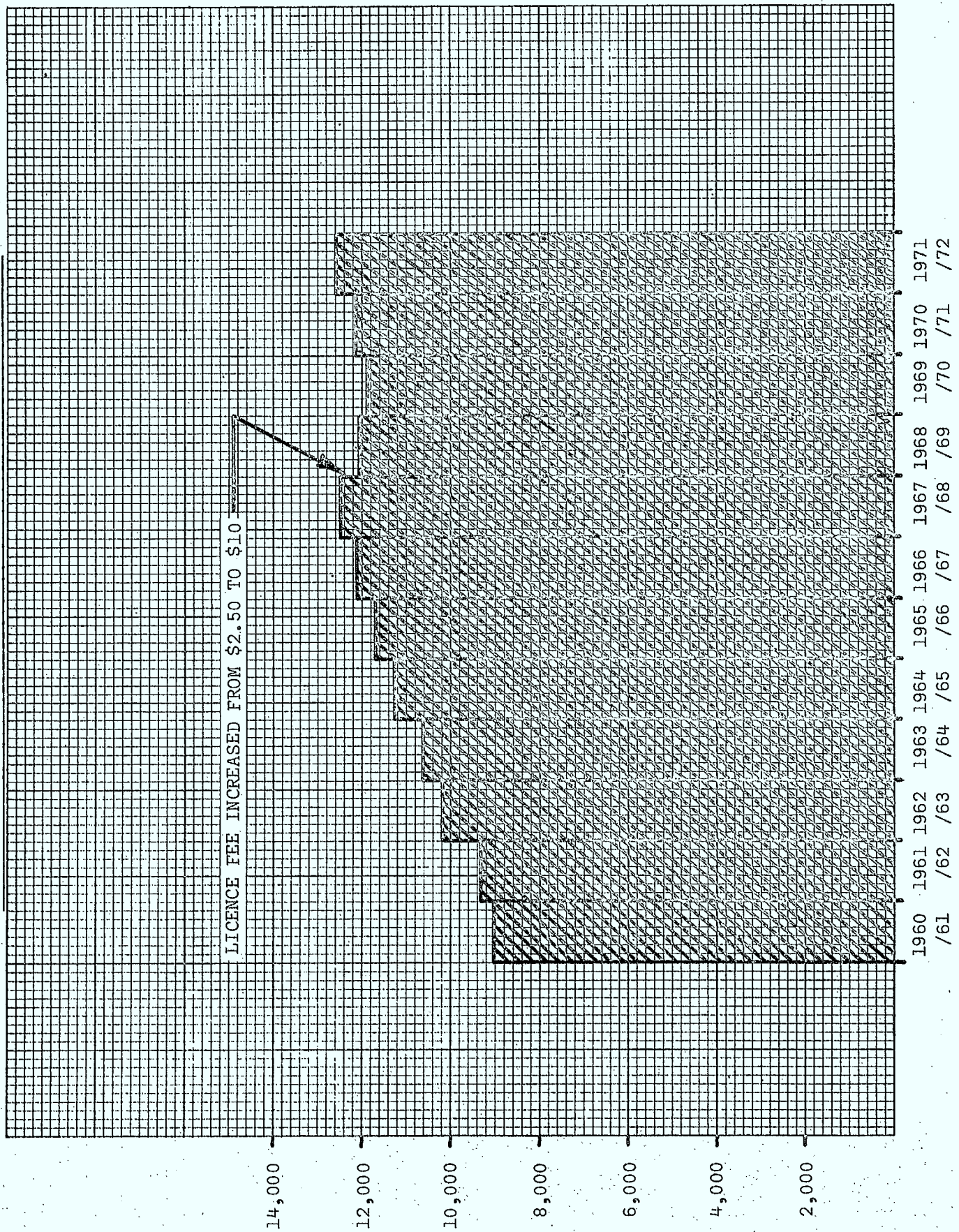


GRAPH 6. Distribution of HF assignments and intercepts.



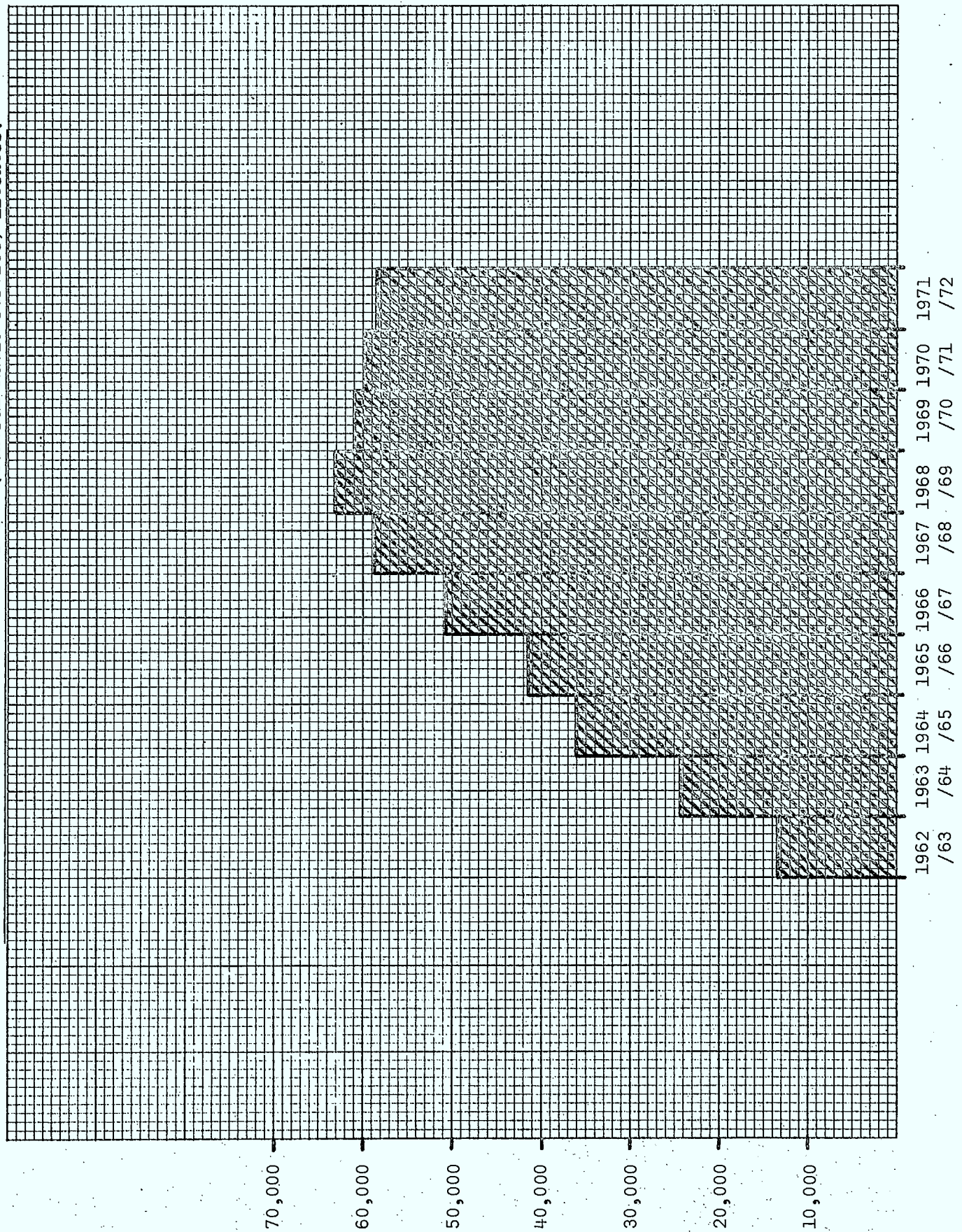


GRAPH 7. Variation in the number of amateur radio licences.

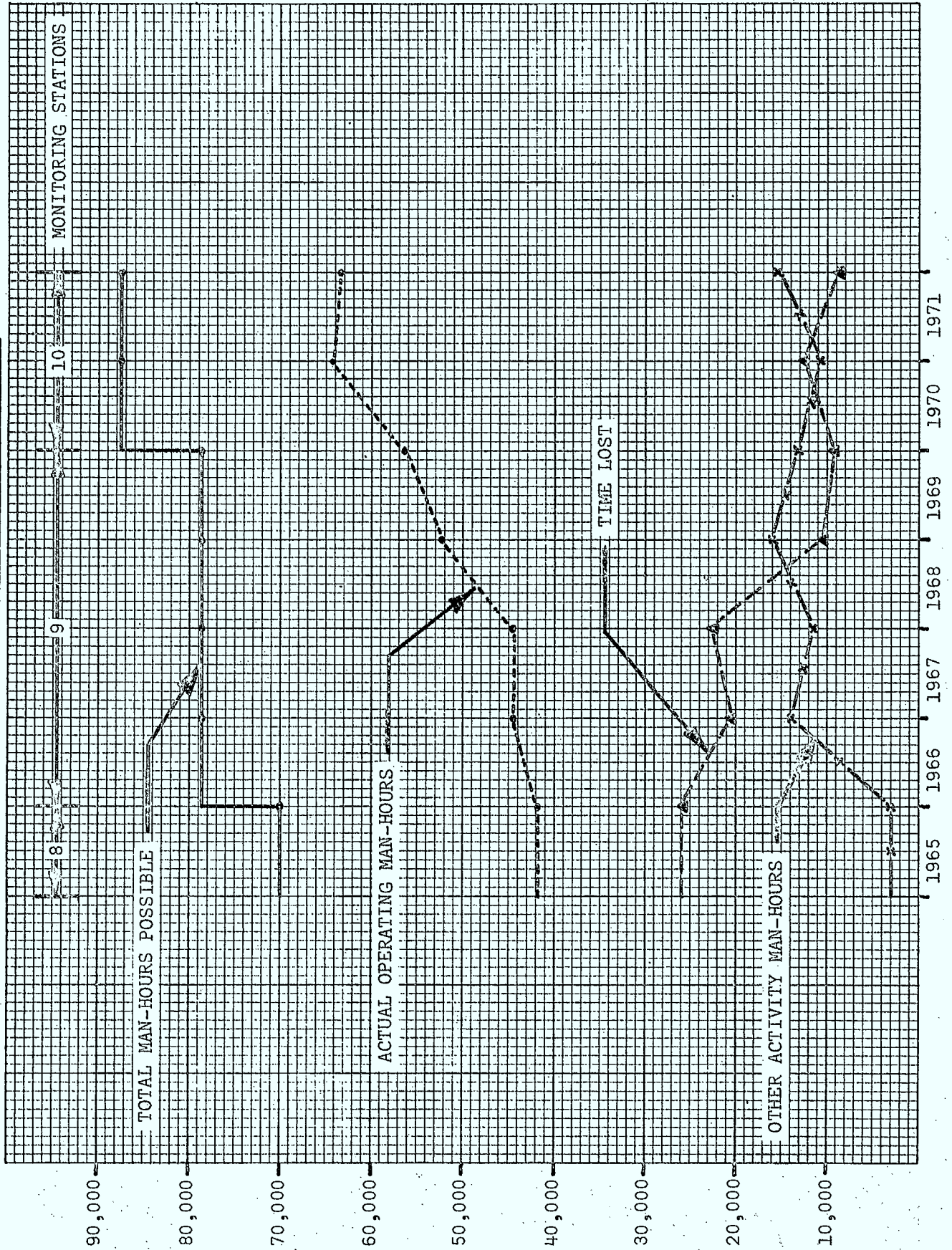




GRAPH 8. Variation in the number of GRS (General Radio Service) licences.

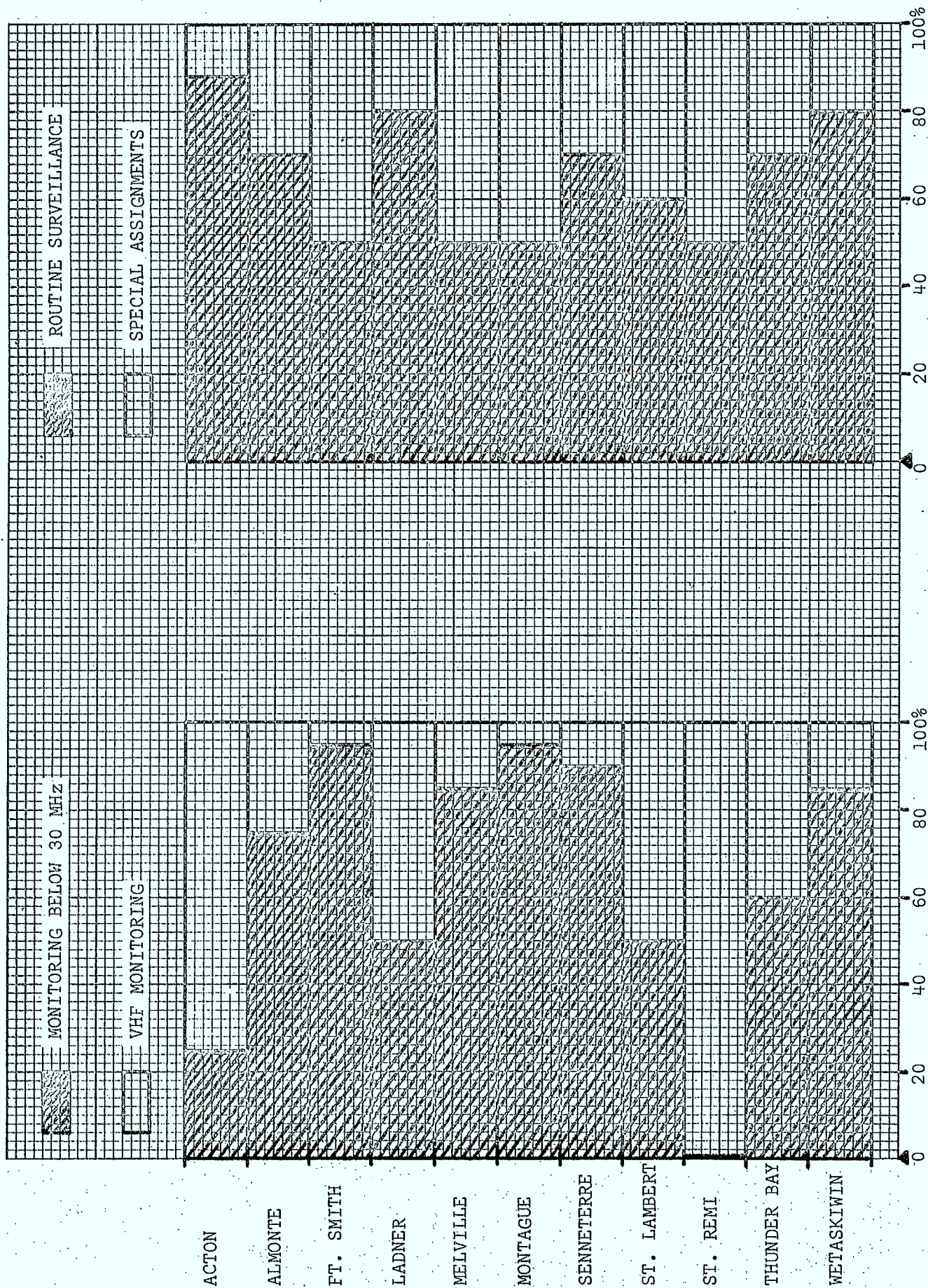


GRAPH 9. Distribution of operator activities.



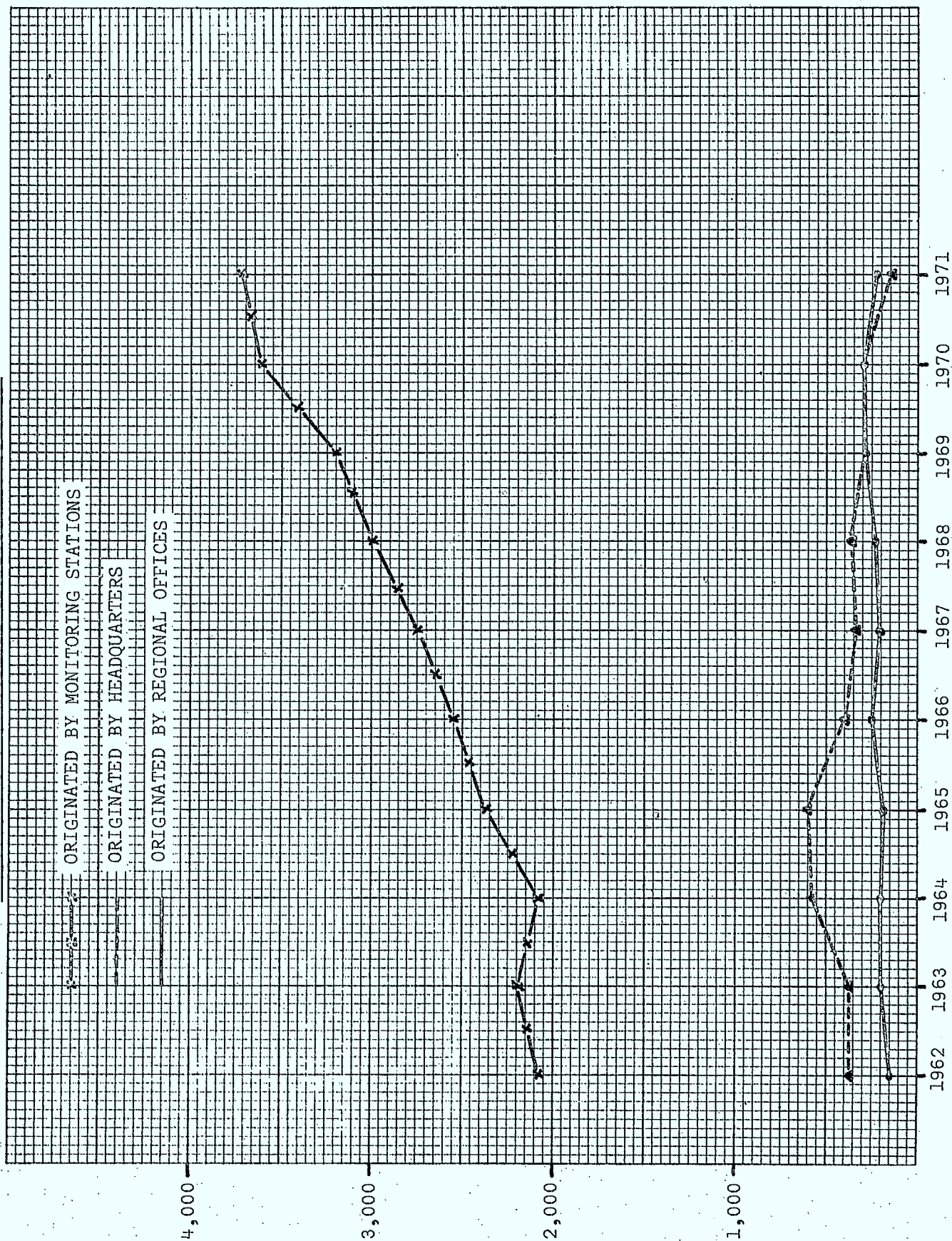


GRAPH 10. Approximate distribution of time spent on monitoring.





GRAPH 11. Distribution of special assignments.



## CONCLUSIONS AND RECOMMENDATIONS.

After careful consideration of the various factors affecting the effectiveness of monitoring coverage in the HF band, and analysis of the coverage and density maps, several conclusions have been reached. These will be discussed in the following, although one must bear in mind that since the study was restricted to monitoring of the HF portion of the spectrum, the conclusions and recommendations are necessarily restricted to the same. However, some consideration has to be given to the effect on monitoring of LF, MF (navigational aids and broadcast) and VHF/UHF bands, since these are also carried out at the same monitoring stations.

In general, the monitoring coverage is extremely poor during the summer at most frequencies, especially the lower frequencies, since high atmospheric noise levels and high ionospheric absorption are characteristic. As northern stations are less effected by atmospheric noise and absorption, the establishment of some monitoring stations in the far north would improve the coverage considerably. Although the winter coverage of the monitoring stations is satisfactory, there are areas where improvement is necessary, such as

1. northern British Columbia and Yukon;
2. the Arctic, especially the eastern Arctic and northern Quebec.

The Ft. Smith monitoring station covers part of the western Arctic and with an improved antenna system could provide coverage to most of the western Arctic, northern B.C. and Yukon. Coverage of the eastern Arctic and northern Quebec, however, requires the establishment of a new monitoring station in that area.

An examination of both observed and theoretical coverage maps, as well as the assignment density maps, indicated that there are relatively few assignments that Wetaskiwin can cover uniquely in the HF band. The winter coverage area of this station is completely overlapped by that of the other monitoring stations, while the number of assignments covered by Wetaskiwin alone, during the summer months, is quite small. In light of the above, and considering the amount of money involved in maintaining a monitoring station operational, the Wetaskiwin monitoring station should be decommissioned. It is realized that such a move would cause problems in monitoring the broadcast stations that are the responsibility of Wetaskiwin at the present. However, as indicated by the Central Region, the recent increase in the transmitter power of CFCW Camrose, from 10 KW to 50 KW, and the proposed increase in the transmitter power of CJOI Wetaskiwin, from 1 KW to 10 KW, would seriously hamper the monitoring of broadcast band from the present location in any case and, therefore, other means of monitoring broadcast stations in that area have to be arrived at.

It is also quite apparent from the monitoring coverage maps that the Senneterre monitoring station should be relocated to a more suitable location. It was realized that the observed coverage of this station does not give a true picture of its coverage potential, since the monitoring station only became operational in 1969 and all operators had to be trained having neither the ex-

perience nor the practical knowledge in radiocommunications. For this reason, only the theoretical coverage maps were considered, which indicated that the coverage area of Senneterre is in most cases overlapped by that of other stations and the number of assignments covered by Senneterre alone is very small. On the other hand, vast areas of the eastern Arctic and northern Quebec, representing approximately 1,100 assignments, are not covered by any monitoring station. Therefore, it would be far more advantageous to have a monitoring station in the eastern Arctic as opposed to the present location at Senneterre. A possible site for relocation would be Frobisher Bay. Preliminary investigation of the possible coverage areas of a monitoring station at Frobisher Bay indicates, as can be seen from Maps 56 to 65 in Appendix 5, that the coverage potential by far surpasses that of the present location and is comparable to that of Ft. Smith which is the most effective monitoring station at the present. A monitoring station at this site would not only be able to monitor the 1,100 assignments, that are not covered at the present time, but would also partially overlap the coverage areas of other monitoring stations providing more reliability in those areas and improving the monitoring coverage during the summer. This move would be especially important in light of the increasing oil and mineral exploration activities, arctic sovereignty, the possible establishment of an oil pipeline and a northern shipping route, the increasing number of HF assignments in the area, and the recent emphasis on the social and cultural development of the North. However, before a definite decision is made regarding a new monitoring site in the eastern Arctic, further investigation of other possible sites should be undertaken.

Considering the HF portion of the spectrum alone, both the Acton and Almonte monitoring stations have nearly the same coverage potential and, although the actual coverage of Acton is somewhat better, they provide monitoring for essentially the same area of Canada. Hence, from an HF point of view, one of these two monitoring stations is redundant. However, there are other factors that have to be taken into consideration as well. The Acton monitoring station, as it has been indicated by the Ontario Region, is important for the monitoring of the VHF/UHF band, the large number of broadcasting stations in southern Ontario, the large number of maritime mobile stations (mainly VHF), and navigational aids in the Great Lakes area. On the other hand, the local noise levels (both man-made and atmospheric) are very high in this area and Acton is seldom used for HF monitoring, while just recently a new Spectrum Occupancy Center became operational in Toronto that could also be used to monitor the broadcast band. Almonte, while not effective for VHF/UHF monitoring, has recently been equipped with HF/DF facilities making it an important link in the DF network at the present time. It should be noted, however, that the DF was planned for a 5 year definite and 10 year indefinite life, since the site is not ideal for direction finding, and consideration should be given to relocation when the lease expires. As far as the overall deployment of the monitoring stations across Canada is concerned, the Acton location (or preferably a nearby site having the same advantages of location but lower noise levels) is more favourable for effective monitoring. Even though the HF coverage of one of these monitoring stations is redundant and the decommissioning of either one of them would result in a negligible loss of HF coverage, the question of monitoring priorities has to be settled between Headquarters and the Region before a decision can be reached in this regard.



The St. Remi station is used entirely for VHF/UHF monitoring and was established for that purpose alone, as was emphasized by the Quebec Region in comments to the final draft of this report. Its potential for monitoring the HF band is null since other monitoring stations, St. Lambert in particular, already provide satisfactory coverage in that part of Canada. Consequently, station at St. Remi should not be considered as a monitoring station but rather as a VHF/UHF observation center and its effectiveness should be evaluated in that respect.

A major factor affecting monitoring effectiveness, and being directly responsible for the coverage capability of a station, is the monitoring equipment and antenna system used. A survey of the monitoring stations, regarding HF equipment and antenna systems, indicated a definite need for improvement. Several stations expressed dissatisfaction with the performance of the present antenna system, and the antenna switching arrangement as well, stating that better results are being obtained using a long-wire or a simple whip antenna than the double-doublers that were specifically designed for the HF band. Also, the Racal HF receivers, used successfully for many years, have outlived their usefulness and need to be replaced with modern state-of-the-art receivers, as some of the monitoring stations are already in the process of doing. In view of the above, it is imperative that an evaluation of monitoring facilities, the establishment of up-to-date equipment standards, and the setting up of a program to improve antenna systems be undertaken as early as possible.

Another major factor affecting monitoring effectiveness is the operating personnel, and it is a well known fact that monitoring stations are constantly understaffed. The installation of HF direction finding facilities at several monitoring stations, and the radio inspection work now carried out by most of the monitoring stations, further compound this already serious problem. Operators have progressively less time to spend on actual monitoring and, consequently, the efficiency of the monitoring has to suffer. Although the elimination of the midnight shift, which in most cases contributes little to the amount of work done, might ease the situation somewhat none the less better means for the staffing of monitoring stations has to be found. Alternately, since the recruiting and training of qualified personnel in sufficient numbers is difficult and time consuming, and since wages and fringe benefits make up by far the largest portion of the monitoring cost, the automation or semi-automation of routine monitoring functions has to be seriously considered.

There are many complex monitoring problems that need immediate attention and which, due to their complexity, require the combined effort and co-operation of both Headquarters and the Regions. To resolve these problems to the mutual satisfaction of both, a national committee should be set up composed of Headquarters and Regional members, as it was recommended by the Pacific Region in response to the final draft of this report. Such a committee would provide guidelines to

1. establish monitoring priorities;
2. set operating standards and procedures;
3. determine coverage needs and capabilities;

4. set equipment standards and arrange for bulk purchase of equipment where economically advantageous;
5. plan for modernization and up-dating of facilities at all stations;
6. determine staffing requirements, training needs and standards;
7. plan for utilization of mobile vans and integration with the fixed monitoring service;
8. plan for career development of monitoring personnel as part of the whole Telecommunications Regulation organization;
9. prepare capital programs, including development of a national DF system with intercommunication facilities and whatever is needed to make such a system efficient;
10. reactivate planning for a system to gather data on spectrum utilization.

Such a committee would also provide the basis for better co-ordination and understanding between Headquarters and the Regions, as well as among the Regions themselves. However, it must be borne in mind that such a committee can only be successful with the full co-operation of the participants, otherwise it would become a waste of both time and effort without solution to these problems.

It is fully realized that the policy of the Department is to decentralize its services and to give the Regions more responsibility in carrying out its functions. This is a basically sound idea, however, this does not in any way mean that such policy should be followed without discretion. Some services like monitoring, particularly in the HF band, are more effective when centrally controlled and, therefore, should remain that way. Also, decentralization seems to have accentuated the constant one-upmanship among the Regions, as well as the purchasing of unnecessarily expensive equipment and the inefficient use of the mobile vans. Such attitude is hardly conducive to effective monitoring. The Monitoring Service must function as a unit, for the effective management of the spectrum, and not as a collection of different factions competing to get a bigger slice of the cake.

In light of the above, the following must be realized if effective monitoring is to be meaningful:

1. There has to be a greater spirit of unity on the part of all segments of the Monitoring Service; and
2. The central control of the monitoring stations has to be retained, at least for the monitoring of the HF band, despite the Department's decentralization policy.

Since this is expected to receive opposition from the Regions, regardless of the arguments presented in support, the final decision should be arrived at by the above proposed national committee.

During the course of investigation into the monitoring activities



we were informed by the Atlantic Region that the Montague monitoring station primarily monitors only those HF emissions that originate within its own Region. This is a basic misconception and is totally unacceptable if effective monitoring is to be achieved. As it is stated in the Monitoring Service Manual (MS-1-3, page i), the propagation of signals in the HF band is such that regional boundaries or discrete geographical areas do not lend themselves as practical means of delineating areas of responsibility for assignment to any particular monitoring station. Hence, it is extremely important, in order to have effective monitoring, that all monitoring stations operate under a uniform standard across the country rather than satisfying regional objectives. Although regional objectives are important, they must not take priority over those of the Monitoring Service as a whole. The importance of this is underlined by the establishment of an HF direction finding system, and is further necessitated by international agreements to which Canada is a signatory through the International Telecommunication Union.

In order to effect a better and continuous evaluation of the actual performance of the monitoring stations, an improved reporting system should be established. The monitoring stations could be provided with a proper form on which to enter the relevant information regarding intercepts made, at the same time these are entered into the cardex system. These forms would then be sent to RRS-M in Ottawa, at the end of each month. Such reporting system would take up little time of the monitoring personnel and would provide a solid data bank for the continuous evaluation of the monitoring effectiveness, seasonal and sunspot cycle variations in the coverage, and the performance of monitoring equipment and antenna system.

Canada is among the leading users of communications and electronic equipment and yearly investments in the same represent millions of dollars. On the other hand, the same cannot be said about our Monitoring Service as even less well-to-do nations like Portugal and Italy, to name only a few, have Monitoring Services that surpass our own. It is only common sense of economics, therefore, that such a large investment be properly safeguarded, especially because of its importance to such vital sections of the economy as industry and commerce, in addition to navigational aids, national defence and emergency services. It is important, therefore, to evaluate the whole Monitoring Service with an aim to improve its performance. Thus, similar studies should be undertaken to

1. evaluate LF, MF and VHF/UHF monitoring effectiveness as well as the organization of the Monitoring Service as a whole;
2. provide a comparative analysis of advanced foreign Monitoring Services, evaluating the technologies, methods and systems developed by them, determining their relative advantages and how they or any combination of them could be adapted in order to improve our own Monitoring Service and our participation in the International Monitoring System.

Based on the above conclusions, it is strongly recommended that immediate attention be given to the following proposals and the necessary steps be taken for their implementation.

1. The Wetaskiwin monitoring station should be decommissioned and other means of monitoring broadcast stations in that area should be determined.

2. The Senneterre monitoring station should be decommissioned.
3. An investigation should be undertaken to arrive at a suitable site for the establishment of a new monitoring station in the eastern Arctic, and to determine the need for another monitoring station in the western Arctic.
4. Considering that the HF monitoring coverage of either Acton or Almonte is redundant, a decision has to be reached as to which of these two should be decommissioned, depending on monitoring priorities.
5. In the future, the station at St. Remi should not be considered as a monitoring station but as a VHF/UHF observation center.
6. A thorough evaluation of monitoring facilities and the establishment of up-to-date equipment standards should be carried out.
7. A program should be set up for the improvement of antenna systems at all monitoring stations.
8. Better means of staffing the monitoring stations and the setting up of a program for the recruitment and training of monitoring personnel should be investigated.
9. A national committee should be set up to resolve complex problems that cannot be effectively dealt with by either Headquarters or the Regions alone.
10. The automation of routine monitoring functions should be investigated as soon as possible. The try-out of such automatic system could be effected at the proposed monitoring station in the eastern Arctic.
11. As it is felt that central control of HF monitoring is important, this question should be reexamined by the proposed national committee.
12. It should be made certain that all monitoring stations operate under a uniform standard and that regional objectives do not take priority over those of the Monitoring Service as a whole.
13. An improved reporting system should be established, with respect to intercepts made by the monitoring stations, in order to effect a better and continuous evaluation of their performance.
14. Similar studies should be undertaken to
  - a. evaluate the effectiveness of LF, MF and VHF/UHF monitoring and the organization of the Monitoring Service as a whole;
  - b. provide a comparative analysis of advanced foreign Monitoring Services with a view to improve our own Monitoring Service and our participation in the International Monitoring System.

It is sincerely hoped that serious and objective consideration will be given to this report in general, and its recommendations in particular, in order to effect an overall improvement of the Monitoring Service.