Quasar
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LAND MOBILE SYSTEMS:
A FORECAST FOR MAJOR URBAN CENTRES

Toronto Ottawa Montreal

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A Report prepared for
the
Department of Communications

July 1977

Toronto Ottawa Montreal

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1.0 INTRODUCTION

1.1 THE REQUIREMENT

The Department of Communications is currently considering possible changes in policies for the use of the 406-960 Mhz band.

The demand for commercial land-mobile radio services, (transportation, police, etc.) has increased to the point where existing spectrum allocations could become saturated in major Canadian urban centres by the 1980's.

The purpose of this study is to forecast the number of land-mobile systems likely to be in operation in the year 2000. These forecasts will assist the Department in developing policies for the use of the UHF band which will provide a reasonable allocation of spectrum for Canadian mobile, broadcasting and other services.

? spectra ?

1.2 THE STUDY

Since the greatest congestion in the radio spectrum is in densely populated areas, it was decided to prepare estimates of the number of land-mobile systems in five of Canada's larger centres. These centres are Vancouver, Edmonton, Toronto, Montreal and Halifax.

Data giving the number of land-mobile systems for each of these centres for 1973-1977 was obtained from the Integrated Radio Licensing System (IRLS). At the same time, data was ob-

tained for 14 other centres. Statistical analysis of this data suggested that an exponentail trend was present. In view of the small number of years of available data, it was necessary to examine other data extending over a longer time period for confirmation or refutation. Data examined from several sources also suggested that the underlying growth was exponential. Further, there is very little evidence in the data of a reduction in the rate of growth - even when examining sectors that were said to be mature in 1973.

The forecast is presented in two parts. It seems likely that the growth in the number of land-mobile systems will continue strong in the short range. This is especially true with the energy crisis and the escalating cost of labour. The use of land-mobile communications can reduce costs in both of these areas [see, for example Plotkin(1974)]. Therefore, it is possible to obtain figures through to 1985 based on current growth. For the period 1985 to 2000, it seems likely that the growth in the number of land-mobile systems will be more closely tied to increases in population than it has been in the past. For this period, we present forecasts based on the number of land-mobile systems per 1,000 population and population forecasts prepared by the Ministry of State for Urban Affairs (MSUA).

These forecasts are presented in detail in Chapter 5.

2.0 DATA DEFINITIONS

This section describes the data used in the study. During the design phase of the study, various parameters related to the data were chosen; the rationale behind these choices is explained.

The purpose of this study is to forecast the number of land-mobile systems to the year 2000 in five cities across Canada. These cities are Vancouver, Edmonton, Toronto, Montreal, and Halifax. The results are intended for use in determining spectrum requirements. With these objectives in mind, we must define "land-mobile systems", and what we mean when we say that a land-mobile system is "in" a city.

We define a land-mobile system to consist of a base station and one or more mobiles, together with a transmission frequency used by the base station. This is applied to simplex, half-duplex and full duplex systems. For example, a base station with two transmission frequencies is counted as two land-mobile systems, even if all the mobiles are equipped to receive both frequencies. The location of the land-mobile system is the location of its base station.

It was decided to forecast the number of land-mobile systems located within 35 miles of each city's centre. The distance of 35 miles was chosen since this is the range of a typical land-mobile base station. The commonly-used distance between base stations which are to broadcast concurrently on the same frequency is 70 miles.

The centre of a city is somewhat difficult to locate precisely. In the interests of standardisation, the centre of a city is defined, for the purposes of this study, as the

population centroid of the associated 1976 Census Metropolitan Area (CMA). These CMAs are defined by Statistics Canada for each census year and vary from census year to census year as the population densities change. The population centroid is that point which minimizes the population-weighted distances to the centres of the Enumeration Areas (EAs) making up the CMA. Unfortunately, the population centroids of CMAs are not published by Statistics Canada, although it is possible to obtain the EA locations and populations. Given the limited resources applied to this study, it was not possible to develop programs to calculate the population centroids of CMAs from their component EAs (in excess of 1,000 EAs make up Toronto CMA, for example). Fortunately, it was possible to derive estimates of the population centroids of the 1971 CMAs [by combining communities from Platts (1977)], and these were used.

It was decided to obtain the counts of the number of land-mobile systems for each city from files extracted from the Integrated Radio Licensing System (IRLS). These files are based on the IRLS year-end tapes, which are generated every March 31st. This extraction system has files based on the year-end tapes for 1973-1977. The files contain one record for each frequency on a licence which lies in the land-mobile bands. Thus a certain percentage of fixed land transmitters are included (for a discussion of this, and a comparison with the Domestic Frequency List (DFL), see Appendix A). Any transmitters in the service categories of Experimental or Amateur Experimental are also excluded from the files. For the extraction criteria used to create the files, see Leguerrier (1976).

Given the limited nature of the time-series data, it was decided that an analysis linking the number of land-mobile base stations to other variables, such as population, could lead to a more accurate forecast. For this, information for all the CMAs in Canada is necessary. There were 23 CMAs in Canada in 1976; however, some of these were discarded on account of significant overlaps with other centres when the 35 mile radius circle was taken. The 23 1976 CMAs are shown in Table 2.1, together with their 1976 populations. Those CMAs excluded are marked with an asterisk. The centres selected for this study had a total population in 1976 of 11,560,179, 50.28% of Canada's 1976 population.

Ideally, the number of land-mobile systems within 35 miles of a CMA centre should be related to the population in that area, together with other economic indicators. With such a relation, and forecasts for the population and the economic indicators, it would be possible to obtain forecasts of the number of land-mobile systems. Unfortunately, while there is a limited amount of information on economic indicators for various centres across Canada, there are no forecasts. There are, however, population forecasts for the 1976 CMAs, prepared by R. Chenier of the Ministry of State for Urban Affairs [Chenier (1977)]. On this basis, it was decided to relate the CMA population to the number of land-mobiles within 35 miles of the CMA. Using the CMA population can be considered to be equivalent to using the population within 35 miles of the CMA under the assumption that the ratio between them remains constant.

In parts of this study, the number of land-mobile base stations is broken down by economic sector. The economic sector of a base station was determined by the

Standard Industrial Classification (SIC code) of the operating body (see Table 2.2).

CMA	POPULATION
Calgary	469,917
Chicoutimi-Jonquière	128,643
Edmonton	554,228
Halifax	267,991
*Hamilton	529,371
*Kitchener	272,158
London	270,383
Montreal	2,802,485
*Oshawa	135,196
Ottawa-Hull	693,288
Québec	542,158
Regina	151,191
*St. Catherines-Niagara	301,921
St. John's	143,390
Saint John	112,974
Saskatoon	133,750
Sudbury	157,030
Thunder Bay	119,253
Toronto	2,803,101
Vancouver	1,166,348
Victoria	218,250
Windsor	247,582
Winnipeg	578,217
TOTAL	12,798,825

Table 2.1: Canadian CMAs in 1976

*indicates CMAs having significant portions of other CMAs within 35 miles.

STANDARD INDUSTRIAL CLASSIFICATION CODE (first 2 or 3 digits)	SECTOR
01	Agriculture
02	Forestry
03	Fishing and Trapping
04	Mining and Quarrying
50 51 52	Manufacturing
06	Construction
071 & 072	Transportation and Storage
073	Communications
074	Public utilities
08	Trade
09	Finance, Ins. & Real Estate
10	Services
111	Federal Admin.
112	Provincial
113	Local
114	Other

TABLE 2.2:

Sectors Showing Their Corresponding SIC Codes

3.0 PRESENT SITUATIONS

This section presents some facts concerning the distribution of land-mobile systems in 1976, the latest year for which population data is available.

The number of land-mobile systems by sector, for each of the selected CMAs, appears in Figure 3. In Figure 3.2, these numbers are expressed as a percentage of the total number of land-mobile systems within each CMA. Figure 3.3 gives the ratio of land-mobile systems to the population of each CMA, by sector.

It can be seen (from Table 3.1) that, in general, the number of systems in a CMA increases with increasing population. From Table 3.3, we can see that the average number of systems per 1,000 population is 1.45; the range is from 0.97 in Montreal to 3.51 in Thunder Bay. In general, the smaller centres have more systems per 1000 population than the larger centres. For example, the Transportation sector has a larger percentage of the total number of land-mobile systems in the larger centres. However, in the smaller centres, the number of systems per 1,000 population is higher. This trend is also evident in the other sectors, Public Administration in particular. This clearly indicates economies of scale in the larger centres.

In most centres, Transportation and Public Administration account for over one third of the total number of systems. Construction and Services are the next largest sectors, followed by Trade and Manufacturing. As is to be expected, the number of systems used for Forestry or Mines and Oils is small. Only a couple of the smaller centres have significant numbers of systems in Forestry (Sudbury, 207 systems (41.24%) and

Thunder Bay, 100 systems (23.87%)).

The percentage distribution found in this study can be compared to that found by A. Zalatan (1974) (See Figure 3.4). However, it should be noted that Zalatan's figures refer to individual mobiles (for example, vehicles) rather than land-mobile systems. The percentage distribution found in this study agrees closely with that found by Zalatan. The differences occur primarily in the areas of Trade and Services, to which our figures give almost twice as large a share.

CENTRE	POPULATION	TRANS-PORTATION	PUBLIC ADMINIS-TRATION	CONSTRUC-TION	MANUFACTURING	SERVICES	TRADE	UTILITIES	COMMUNI-CATIONS	FORESTRY	MINES & OILS	OTHER	TOTAL
TORONTO	2,803,101	566	482	341	227	412	264	146	275	38	17	44	2,812
MONTREAL	2,802,485	625	681	323	160	313	286	115	183	2	5	33	2,726
VANCOUVER	1,166,348	499	325	248	127	203	116	157	150	71	17	23	1,936
OTTAWA-HULL	693,288	155	298	156	48	123	101	57	80	66	3	21	1,108
WINNIPEG	578,217	154	138	109	23	77	55	71	48	0	3	19	697
EDMONTON	554,228	182	158	229	67	214	106	67	74	5	64	24	1,190
QUEBEC	542,158	155	217	109	37	81	53	20	48	36	2	29	787
CALGARY	469,917	137	172	148	56	156	63	22	65	47	78	37	981
LONDON	270,383	159	147	96	52	76	73	70	50	42	25	44	834
HALIFAX	267,991	101	119	79	17	61	31	30	37	25	2	1	503
WINDSOR	247,582	49	94	34	40	64	27	34	17	36	16	12	423
VICTORIA	218,250	112	112	50	19	31	24	25	46	59	1	3	482
SUDBURY	157,030	58	61	34	12	42	10	3	20	207	51	4	502
REGINA	151,191	53	57	44	17	19	12	20	28	0	3	6	259
ST. JOHN'S	143,390	37	57	23	9	17	23	26	24	2	5	1	224
SASKATOON	133,750	29	43	33	7	19	10	9	27	0	8	4	189
CHICOUTIMI-JONQUIERE	128,643	60	89	36	64	31	23	12	23	40	0	14	392
THUNDER BAY	119,253	75	61	52	22	43	19	23	21	100	3	0	419
SAINT JOHN	112,974	42	52	60	26	24	19	24	31	19	1	3	301
TOTAL	11,560,179	3,248	3,363	2,204	1,030	2,006	1,315	931	1,247	795	304	322	16,765

TABLE 3.1: Number of Land Mobile Systems by Economic Sector (1976)

CENTRE	POPULATION	TRANS-PORTATION %	PUBLIC ADMINIS-TRATION %	CONSTRUC-TION %	MANUFACTURING %	SERVICES %	TRADE %	UTILITIES %	COMMUNI-CATIONS %	FORESTRY %	MINES & OILS %	OTHER %	TOTAL %
TORONTO	2,803,101	20.13	17.14	12.13	8.07	14.65	9.39	5.19	9.78	1.35	0.60	1.56	100%
MONTREAL	2,802,485	22.93	24.98	11.85	5.87	11.48	10.49	4.22	6.71	0.07	0.18	1.21	100%
VANCOUVER	1,166,348	25.77	16.79	12.81	6.56	10.49	5.99	2.94	4.13	3.41	0.88	1.19	100%
OTTAWA-HULL	693,288	13.99	26.90	14.08	4.33	11.10	9.11	5.14	7.22	5.96	0.27	1.90	100%
WINNIPEG	578,217	22.09	19.80	15.64	3.30	11.05	7.89	10.19	6.89	0	0.43	2.73	100%
EDMONTON	554,228	15.29	13.28	19.24	5.63	17.98	8.91	5.63	6.22	0.42	5.38	2.02	100%
QUEBEC	542,158	19.70	27.57	13.85	4.70	10.29	6.73	2.54	6.10	4.57	0.25	3.68	100%
CALGARY	469,917	13.97	17.53	15.09	5.71	15.90	6.42	2.24	6.63	4.79	7.95	3.77	100%
LONDON	270,383	19.06	17.63	11.51	6.24	9.11	8.75	8.39	6.00	5.04	3.00	5.28	100%
HALIFAX	267,991	20.08	23.66	15.71	3.38	12.13	6.16	5.96	7.36	4.97	0.40	0.20	100%
WINDSOR	247,582	11.58	22.22	8.04	9.46	15.13	6.38	8.04	4.02	8.51	3.78	2.84	100%
VICTORIA	218,250	23.24	23.24	10.37	3.94	6.43	4.98	5.19	9.54	12.24	0.21	0.62	100%
SUDBURY	157,030	11.55	12.15	6.77	2.39	8.37	1.99	0.60	3.98	41.24	10.16	0.80	100%
REGINA	151,191	20.46	22.01	16.99	6.56	7.34	4.63	7.72	10.81	0	1.16	2.32	100%
ST. JOHN'S	143,390	16.52	25.45	10.27	4.02	7.59	10.27	11.61	10.71	0.89	2.23	0.45	100%
SASKATOON	133,750	15.34	22.75	17.46	3.70	10.05	5.29	4.76	14.29	0	4.23	2.12	100%
CHICOUTIMI-JONQUIERE	128,643	15.31	22.70	9.18	16.33	7.91	5.87	3.06	5.87	10.20	0	3.57	100%
THUNDER BAY	119,253	17.90	14.56	12.41	5.25	10.26	4.53	5.49	5.01	23.87	0.72	0	100%
SAINT JOHN	112,974	13.95	17.28	19.93	8.64	7.97	6.31	7.97	10.30	6.31	0.33	1.00	100%
OVERALL		19.37	20.06	13.15	6.14	11.97	7.84	5.55	7.44	4.74	1.81	1.92	100%

TABLE 3.2: Percentages of Land Mobile Systems by Economic Sector (1976)

CENTRE	POPULATION	TRANS-PORTATION	PUBLIC ADMINIS-TRATION	CONSTRUC-TION	MANUFACTURING	SERVICES	TRADE	UTILITIES	COMMUNI-CATIONS	FORESTRY	MINES & OILS	OTHER	TOTAL
TORONTO	2,803,101	0.20	0.17	0.12	0.08	0.15	0.09	0.05	0.10	0.01	0.01	0.02	1.00
MONTREAL	2,802,485	0.22	0.24	0.12	0.06	0.11	0.10	0.04	0.07	–	–	0.01	0.97
VANCOUVER	1,166,348	0.43	0.28	0.21	0.11	0.17	0.10	0.13	0.13	0.06	0.01	0.02	1.66
OTTAWA-HULL	693,288	0.22	0.43	0.23	0.07	0.18	0.15	0.08	0.12	0.10	–	0.03	1.60
WINNIPEG	578,217	0.27	0.24	0.19	0.04	0.13	0.10	0.12	0.08	0	0.01	0.03	1.21
EDMONTON	554,223	0.33	0.29	0.41	0.12	0.39	0.19	0.12	0.13	0.01	0.12	0.04	2.15
QUEBEC	542,158	0.29	0.40	0.20	0.07	0.15	0.10	0.04	0.09	0.07	–	0.05	1.45
CALGARY	469,917	0.29	0.37	0.31	0.12	0.33	0.13	0.05	0.14	0.10	0.17	0.08	2.09
LONDON	270,383	0.59	0.54	0.36	0.19	0.28	0.27	0.26	0.18	0.16	0.09	0.16	3.08
HALIFAX	267,991	0.38	0.44	0.29	0.06	0.23	0.12	0.11	0.14	0.09	0.01	–	1.88
WINDSOR	247,582	0.20	0.38	0.14	0.16	0.26	0.11	0.14	0.07	0.15	0.06	0.05	1.71
VICTORIA	218,250	0.51	0.51	0.23	0.09	0.14	0.11	0.11	0.21	0.27	–	0.01	2.21
SUDBURY	157,030	0.37	0.39	0.22	0.08	0.27	0.06	0.02	0.13	1.32	0.32	0.03	3.20
REGINA	151,191	0.35	0.38	0.29	0.11	0.13	0.08	0.13	0.19	0	0.02	0.04	1.71
ST. JOHN'S	143,390	0.26	0.40	0.16	0.06	0.12	0.16	0.18	0.17	0.01	0.03	0.01	1.56
SASKATOON	133,750	0.22	0.32	0.25	0.05	0.14	0.07	0.07	0.20	0	0.06	0.03	1.41
CHICOUTIMI-JONQUIERE	128,643	0.47	0.69	0.28	0.50	0.24	0.18	0.09	0.18	0.31	0	0.11	3.05
THUNDER BAY	119,253	0.63	0.51	0.44	0 18	0.36	0.16	0.19	0.18	0.84	0.03	0	3.51
SAINT JOHN	112,974	0.37	0.46	0.53	0.23	0.21	0.17	0.21	0.27	0.17	0.01	0.03	2.66
MEAN		0.28	0.29	0.19	0.09	0.17	0.11	0.08	0.11	0.07	0.27	0.28	1.45

TABLE 3.3: Number of Land Mobile Systems per 1000 People (1976)

SECTORS	NUMBER OF LAND-MOBILES IN 1973 (1)(3)	PERCENTAGE DISTRIBUTION IN 1973 (3)	PERCENTAGE DISTRIBUTION IN 1976 (4)
Transportation (2)	67,309	37.0	32.4
Public Administration	35,907	19.7	20.1
Construction	17,897	9.8	13.1
Manufacturing	12,760	7.0	6.1
Services	11,927	6.5	12.0
Trade	8,308	4.6	7.8
Others	28,020	15.4	8.4
TOTAL	182,128	100.0%	100.0%

TABLE 3.4: Percentage of Land-Mobiles by Sector (1973 and 1976)

NOTES:

(1) These figures represent the number of vehicles rather than the number of systems.

(2) Includes public utilities and communications.

(3) Figures taken from "Demand for Land-Mobiles: A national profile;" A. Zalatan (Zalatan(1974)).

(4) Percentage distribution of Land-Mobile systems rather than the number of Land-Mobiles.

4.0 RECENT TRENDS

This section discusses the recent past (1973-1977). Tables and graphs are presented showing the growth in this period. This and other evidence suggests that growth rates in the past have followed an exponential curve, growing at an average rate exceeding 10% per annum.

what period

Table 4.1 shows the growth for each of the selected CMAs. The overall growth rate has been 14.13% (as determined by an exponential regression with a goodness of fit of 99.77%). The maximum growth rate was achieved by Saskatoon, with a growth of 22.42%; Sudbury had the minimum growth rate of 4.82%. All the remaining growth rates fall in a relatively narrow band, with Thunder Bay (at 11.9%) being the lowest, and Vancouver (at 17.24%) the highest. The low growth rate for Sudbury can, in part, be attributed to its relatively large (51%) proportion of Forestry and Mines and Oils land-mobile systems. However, even excluding these systems, Sudbury still had a relatively low growth rate of 9.75% p.a.

A graph showing the number of systems in Toronto and Montreal for the years 1973-1977 appears in Figure 4.2. The graph suggests an exponential, rather than linear, growth; however, this is clearer in the case of Toronto than in the case of Montreal.

Table 4.3 shows the growth by sector over all selected centres. These figures were obtained by fitting an exponential regression model. This model allows each centre to have a different number of systems, but assumes that the underlying growth rate is the same for all centres. For all sectors, the fit is good. The goodness of fit ranges from 94.54%

(Mines and Oils) to 99.38% (Transportation). The overall figure is 99.53%. As might be expected, the growth in Forestry and Mines and Oils land-mobile systems was quite low. Excluding these sectors, the lowest growth rate found was in the Transportation sector, with 9.28%. The highest growth rate was in the Services sector, with 25.01%. A comparison of these results with those of Zalatan and Simoneau (1972) and Zalatan (1974), also those of Roy (1974), shows that even those sectors considered "mature" by the above authors have grown substantially in 1973-1977. For example, for the Public Administration sector, the projected growth for the years 1973-1980 was 5.3% for a total growth of 51.16% [Roy(1974), p. 82]. However, in the years 1973-1977, this sector has experienced an average growth of 15.76% p.a., for a total growth of 79.26%. Thus it seems that there is little evidence to suggest that any of these sectors are currently mature.

Figure 4.4 shows the growth in the number of "land" licences issued by the department for private commercial service in the years 1963-1977. These licences are issued for all transmitters and receivers which are on land, except those which are hand-held or are located in vehicles. Frequently, one licence will be valid for more than one frequency. The exponential curve shown was obtained by an exponential regression with a goodness of fit of 97.82%. This curve shows a growth rate of 10.07% per year. These figures were obtained from the Registration and Licensing Annual reports, 1963-1977.

For comparison, Figure 4.5 shows growth in the number of mobiles in the U.K. Once again, an exponential curve follows the data closely (with a goodness of fit of 99.51%) although there has been some tailing off in the number of mobiles, probably due to the economic recession in the U.K. The growth rate of the curve is 13.57% p.a.

In conclusion, the data suggests that in recent years growth of an exponential type has been taking place in the number of land-mobile systems. Furthermore, this increase in general exceeds 10% p.a. For comparison, population increases in Toronto (one of the faster growing centres) during the period 1961-1976 averaged 2.62% per year. Thus we can conclude that the increases in the numbers of land-mobile systems are not due to increases in population alone.

CENTRE	1973	1974	1975	1976	1977	Total Growth %	Average Compound Growth Rate %	Exponential Regression Growth Rate %	Goodness of fit %
TORONTO	1974	2147	2479	2812	3264	65.35%	13.40%	13.61%	99.25%
MONTREAL	1851	2062	2348	2726	2939	58.79%	12.25%	12.79%	99.19%
VANCOUVER	1167	1321	1642	1936	2135	82.95%	16.30%	17.24%	98.59%
OTTAWA-HULL	677	775	895	1108	1192	76.07%	15.19%	16.05%	98.45%
WINNIPEG	484	545	605	697	851	75.83%	15.15%	14.74%	98.25%
EDMONTON	717	895	988	1190	1284	79.08%	15.68%	15.61%	97.51%
QUEBEC	534	610	721	787	908	70.04%	14.19%	14.07%	99.32%
CALGARY	636	711	864	981	1136	78.62%	15.61%	15.97%	99.45%
LONDON	609	666	742	834	1007	65.35%	13.40%	13.10%	97.80%
HALIFAX	352	361	440	503	549	55.97%	11.75%	12.98%	96.14%
WINDSOR	283	318	351	423	502	77.39%	15.41%	15.39%	98.37%
VICTORIA	319	339	368	482	546	71.16%	14.38%	15.34%	93.80%
SUDBURY	432	449	483	502	517	19.68%	4.59%	4.82%	97.73%
REGINA	177	201	216	259	298	68.36%	13.91%	13.83%	98.38%
ST. JOHN'S	156	171	189	224	238	52.56%	11.14%	11.79%	98.25%
SASKATOON	122	128	137	189	276	126.23%	22.64%	22.42%	86.73%
CHICOUTIMI-JONQUIERE	271	309	350	392	432	59.41%	12.36%	12.42%	99.67%
THUNDER BAY	289	344	379	419	449	55.36%	11.64%	11.39%	97.12%
SAINT JOHN	198	218	246	301	338	70.71%	14.30%	14.94%	98.49%
	11,248	12,570	14,443	16,765	18,861	67.68%	13.79%	14.13%	99.77%

TABLE 4.1: Total Number of Systems

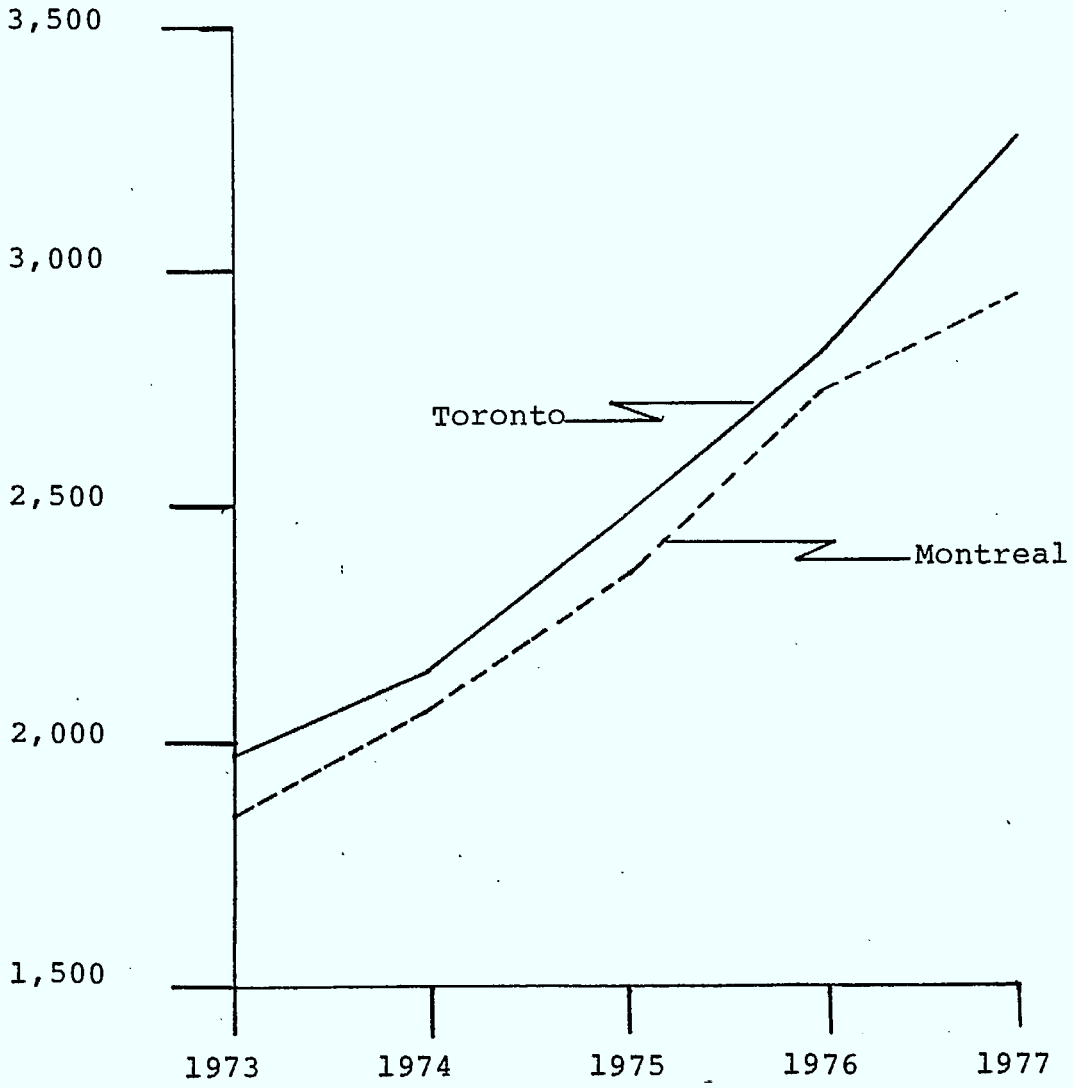

FIGURE 4.2: Number of Land-Mobile Systems, 1973-1977

SECTOR	GROWTH %	GOODNESS OF FIT %
Transportation	9.28%	99.38%
Public Administration	15.71%	98.03%
Construction	22.64%	97.67%
Manufacturing	18.74%	96.79%
Services	25.01%	98.23%
Trade	14.36%	98.08%
Utilities	9.90%	98.20%
Communications	15.72%	98.02%
Forestry	5.16%	99.33%
Mines and Oils	-1.39%	94.54%
Others	18.19%	96.02%
Total	14.08%	99.53%

TABLE 4.3: Growth by Sector Over All Centres

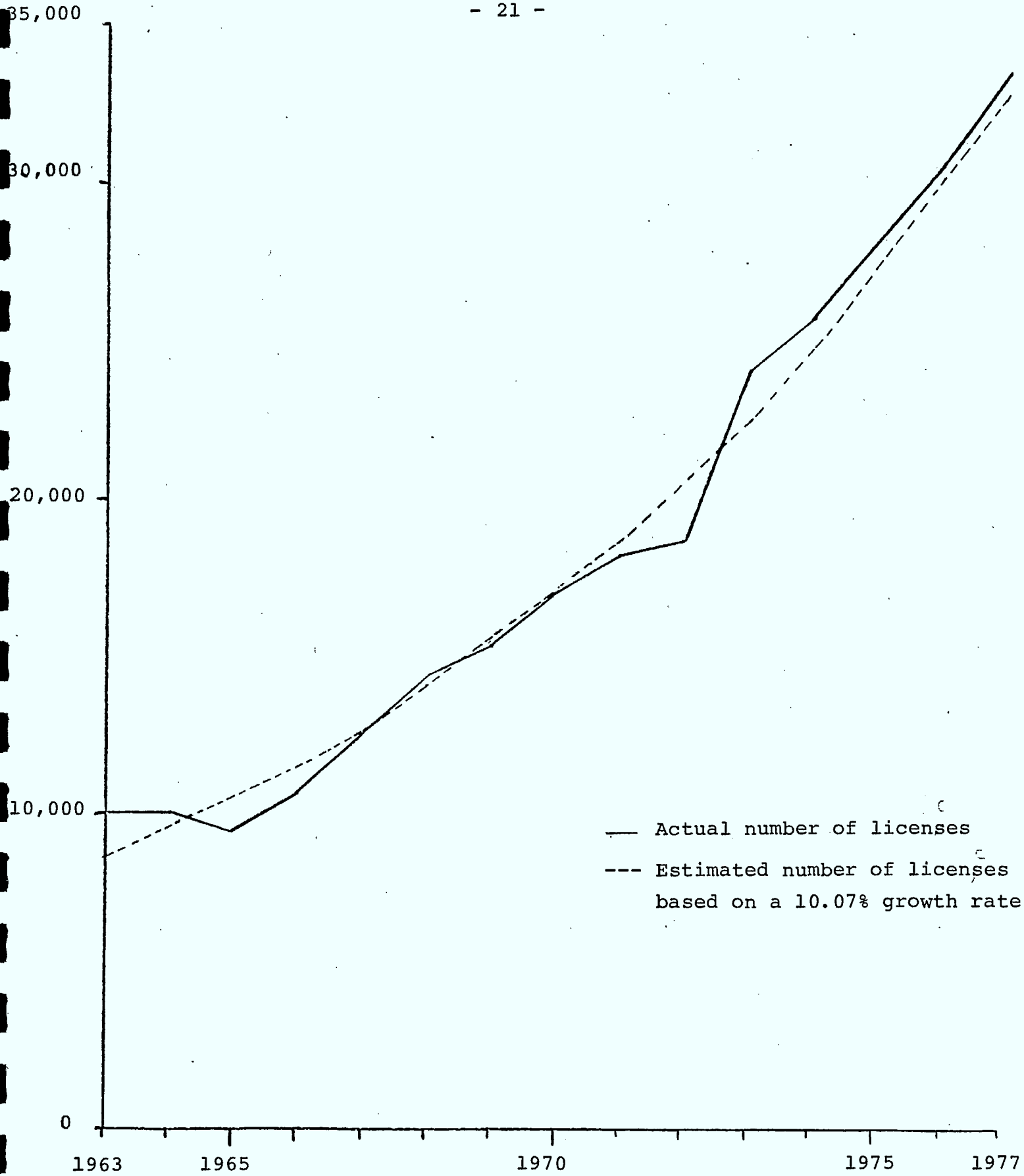

FIGURE 4.4: Number of Private Commercial Land Licences in Force

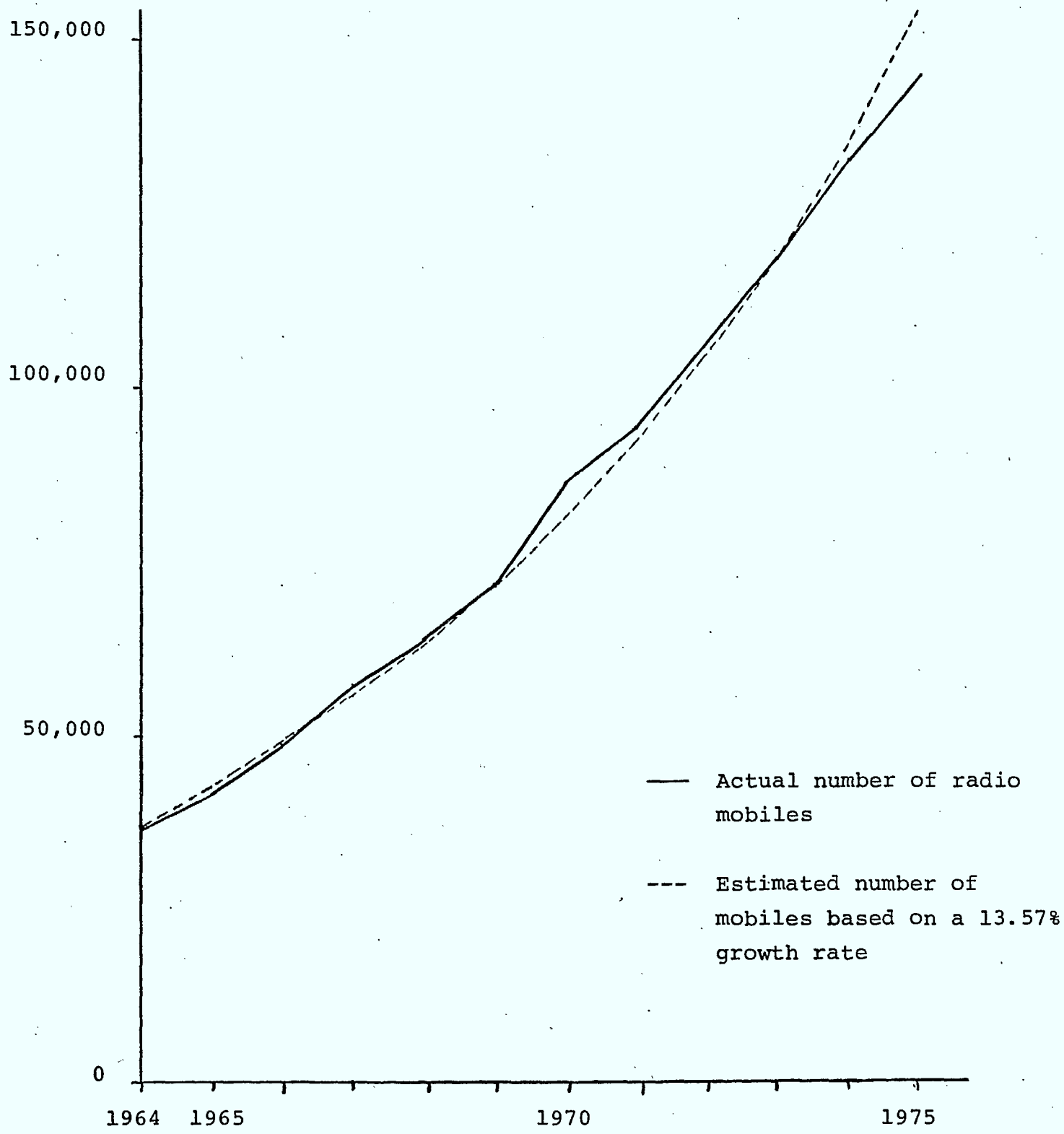

FIGURE 4.5: Number of Radio-Mobiles in the U.K.

5.0 FORECASTS

This section presents the forecasts. They have been divided into two parts - a short range forecast to 1985, and a long range forecast for the year 2000.

The values for the short range forecast are obtained from the recent trends. The estimate is based on the estimated growth rate of the exponential regression from Table 4.1. The high and low estimates are based on 95% confidence limits for the growth rate. These estimates do not represent the 95% confidence interval for the number of land-mobiles in 1985; nevertheless, they give an indication of the likely range of values. The confidence limits for each of the five selected centres appear in Table 5.1. These confidence limits conform quite closely to minimum and maximum growth rates observed for all centres. Table 5.2 gives the 1985 estimates, based on these growth rates.

When considering a longer range forecast, to the year 2000, many more imponderables enter the equation. Economic items such as energy costs, labour costs and the price of equipment, regulatory items such as licence costs and the availability of spectrum, and other items such as technological change may all have a significant impact over the years. This impact is impossible to estimate at this date without a considerably more exhaustive study. In fact, many of these items may be impossible to analyse quantitatively. It may be necessary to resort to expert opinion (possibly using the Delphi Technique) in order to obtain estimates of the likely impact (and, indeed, the likelihood) of such change.

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Such qualitative analysis is beyond the scope of this study. Therefore, our estimates for the year 2000 are based on hypotheses concerning the rate of growth in market penetration (the number of systems per 1,000 people) over the fifteen year period, 1985-2000. The 1985 market penetration figures are presented in Table 5.3. For comparison, the corresponding figures for the period 1973-1976, together with the growth rates over this period, appear in Table 5.4. The figures for the number of systems in the year 2000 appear in Table 5.5. The population estimates in Table 5.3 and Table 5.5 are from Chenier(1977).

The hypotheses used to create Table 5.5 are as follows:

(1) There will be no growth in market penetration in the year 1985-2000.

(2) There will be 50% total growth (or 2.74% per year) in market penetration in the years 1985-2000.

(3) There will be 100% total growth (4.73% per year) in market penetration in the years 1985-2000.

The first hypothesis represents the pessimistic outlook that the market in all sectors will be saturated by 1985 and no new uses of land-mobile communications will appear. It seems reasonable to suggest that this is the minimum rate at which the number of land-mobile systems will increase, since the number of these systems is closely related to the number of people in an area. In the 3 years for which both the number of systems and the population figures were available (1973, 1974 and 1976), the goodness of fit of a linear regression, population against number of systems in each year, did not fall below 92.17%.

The second hypothesis is 50% growth over the fifteen year period. Since, in the period 1973-1976, the growth in market penetration has exceeded 10% p.a. in each of the five centres, an average (compound) growth of 2.74% per year seems low. However, in the event of market saturation in some sectors, and near saturation in others, a growth of 2.74% p.a. in market penetration would seem reasonable.

The third hypothesis is 100% growth over the fifteen year period. This would correspond to market saturation in some sectors, with growth still occurring in other sectors. If, for example, energy prices continue to escalate, it is possible that the penetration level at which market saturation occurs (i.e. the point at which no new systems are established) would also increase. In this case, there could be continued strong growth even after 1985, and the number of systems may exceed even the high estimate in Table 5.5.

why energy costs?

CENTRE	REGRESSION ESTIMATE	HIGH ESTIMATE	LOW ESTIMATE
Toronto	13.61%	15.95%	11.31%
Montreal	12.79	15.07	10.55
Vancouver	17.24	21.41	13.22
Edmonton	15.61	20.64	10.79
Halifax	12.98	18.17	8.02

TABLE 5.1: 95% Confidence Intervals for the Growth Rates

CENTRE	REGRESSION ESTIMATE	HIGH ESTIMATE	LOW ESTIMATE
Toronto	8,900	11,400	7,000
Montreal	7,800	10,000	6,200
Vancouver	7,800	11,900	5,200
Edmonton	4,200	7,100	2,500
Halifax	1,500	2,500	900

TABLE 5.2: Estimated Number of Land-Mobile Systems in 1985 (rounded to the nearest 100)

CENTRE	POPULATION	NUMBER OF SYSTEMS PER 1,000 POPULATION
Toronto	3,026,166	2.95
Montreal	2,896,190	2.70
Vancouver	1,293,661	6.07
Edmonton	662,353	6.40
Halifax	288,888	5.09

TABLE 5.3: Number of Land-Mobile Systems per 1,000 population in 1985

CENTRE	1973	1974	1975*	1976	YEARLY AVERAGE (COMPOUND) GROWTH (%)
Toronto	0.74	0.79	0.90	1.00	10.65%
Montreal	0.67	0.74	0.84	0.97	13.21%
Vancouver	1.05	1.16	1.43	1.66	16.65%
Edmonton	1.41	1.69	1.82	2.15	15.03%
Halifax	1.40	1.43	1.69	1.88	10.37%

TABLE 5.4: Number of Land-Mobile Systems per 1,000 population (1973-1976)

* estimated

CENTRE	POPULATION	NUMBER OF LAND-MOBILE SYSTEMS (1)	(2)	(3)
Toronto	3,320,141	9,800	14,700	19,600
Montreal	3,019,339	8,200	12,200	16,300
Vancouver	1,473,592	8,900	13,400	17,900
Edmonton	858,163	5,500	8,200	11,000
Halifax	317,518	1,600	2,400	3,200

TABLE 5.5: Number of Land-Mobile Systems in the year 2000

NOTES:

(1) Assuming no growth in market penetration (number of systems per 1,000 population) after 1985

(2) Assuming 50% growth in market penetration from 1985 to 2000 (2.74% per year).

(3) Assuming 100% growth in market penetration from 1985 to 2000 (4.73% per year).

6.0 CONCLUSIONS

In this section we summarise briefly the findings of this study.

The objective of this study is to forecast the number of conventional land-mobile systems* in 5 major urban centres across Canada, namely Vancouver, Edmonton, Toronto, Montreal and Halifax.

As part of this study we considered land-mobile systems in almost all the metropolitan areas across Canada (four were excluded; see Chapter 2). In addition, we looked at various sectors of the economy, including Transportation, Communications, Public Administration and Construction.

In all of the major centres except Sudbury, the growth rate of the number of land-mobile systems exceeded 11% per year. The growth rate in the sectors of Forestry and Mines and Oils was low, as might be expected; in all other sectors the growth rate exceeded 9% per year. The overall growth rate for all the centres was 14.13% per year. This compares with a growth rate of 10.07% per year in the number of land licences in the Private Commercial service category since 1963, and a similar growth in the U.K. of 13.57% in the number of radio-mobile licences issued since 1964.

Two forecasts were prepared; a medium range forecast to 1985, and a long range forecast to the year 2000.

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* New types of land-mobile communications, such as cellular, are not included in these forecasts.

Since the current strong growth in the number of land-mobile systems shows no sign of diminishing, the forecasts for 1985 are based on a continuation of this growth during the intervening period. Growth in Toronto in the period 1973-1977 occurred at a rate which approximates closely an exponential curve with a growth rate of 13.61% per year. Projecting this forward to 1985 we obtain a figure of 8,900 land-mobile systems in Toronto in that year. The comparable figures for Montreal are a growth rate of 12.79% and 7,800 land-mobile systems in 1985 (for full details, see Chapter 5, Figures 5.1 and 5.2, pp. 26-27).

The forecasts for the year 2000 were based on three hypotheses. The first is that the ratio of land-mobile systems to population will remain constant from 1985 to 2000. It should be pointed out that this is somewhat conservative; between 1973 and 1976, in Toronto this ratio increased by 35.46%, or 10.65% per year. The second is that the ratio of land-mobile systems to population will increase by 50% over the period 1985 to 2000, or some 2.74% per year. The third is that the ratio of land-mobile systems to population will increase by 100% (i.e. double) over the period 1985 to 2000; this is equivalent to 4.73% per year.

The second hypothesis leads us to the figure of 14,700 systems in Toronto in 2000. This compares with 9,800 systems under the first hypothesis (no growth), and 19,600 under the third hypothesis. Figures for the other centres show a similar pattern; these appear in Table 5.5, p. 30. An illustration of the growth in Toronto appears in Figure 6.1; growth patterns for the other centres are similar.

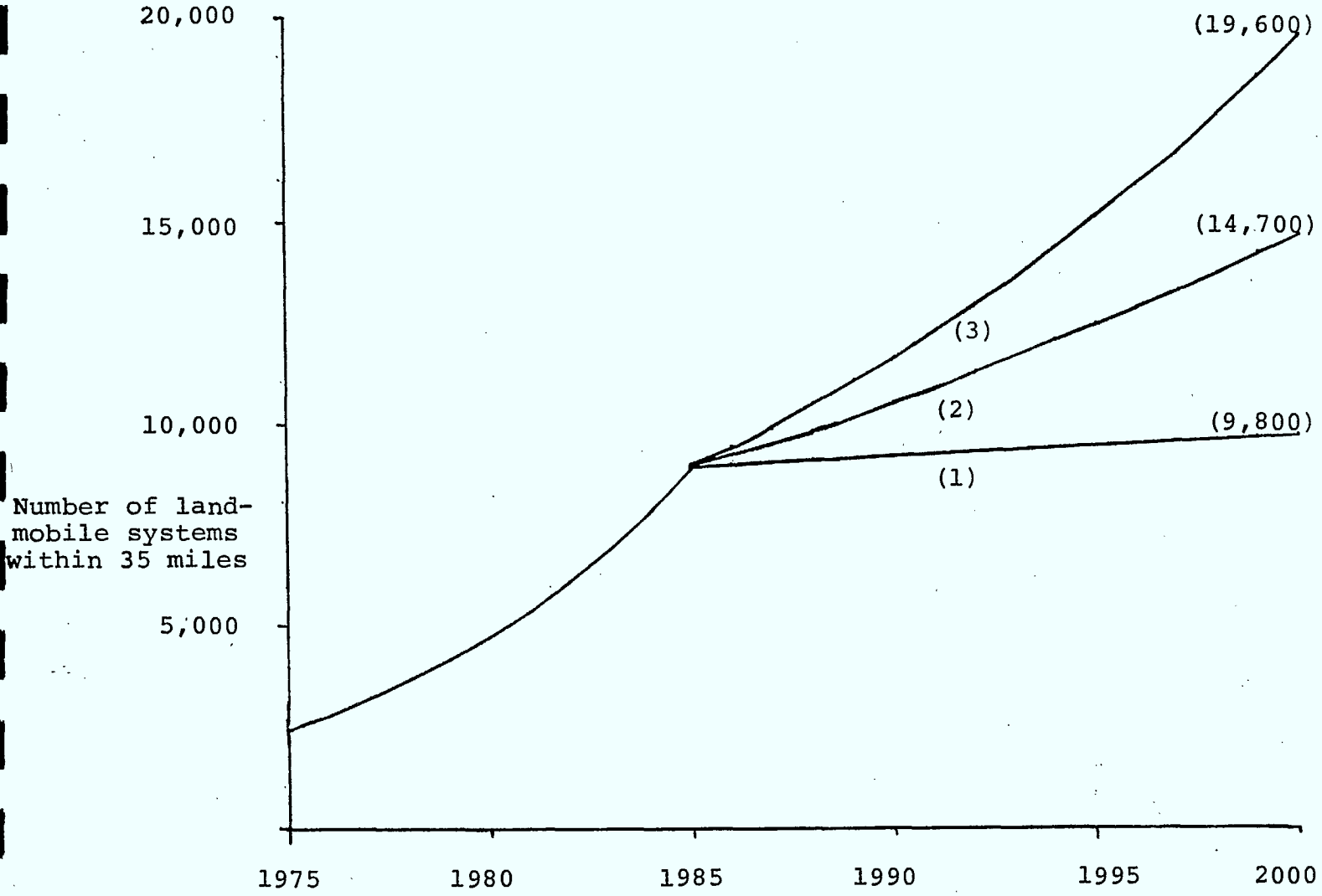

FIGURE 6.1: The Growth in Land-Mobile Systems in Toronto

(for illustrative purposes only)

NOTES:

(1) Assuming no growth in market penetration (number of systems per 1,000 population) after 1985

(2) Assuming 50% growth in market penetration from 1985 to 2000 (2.74% per year)

(3) Assuming 100% growth in market penetration from 1985 to 2000 (4.73% per year).

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Chenier(1977) — Private Communication from R. Chenier, Urban Policy Analyst in Demographic Analysis, Ministry of State for Urban Affairs (June 1977).

Leguerrier(1976) — Department of Communications Land-Mobile Study Production Manual. C. Leguerrier, Computer Services, Department of Communications (February 1976).

The Pannell Report (1976) — A Study of Future Frequency Spectrum Requirements for Private Mobile Radio in the United Kingdom. Pye Telecommunications Inc., Cambridge, England (1976).

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Plotkin(1974) — Saving Fuel with Land-Mobile Radio. H.A. Plotkin, Quantitative Management Science Department, University of Houston (presented at the ORSA/TIMS meeting, San Juan, Puerto Rico, October 1974).

Roy(1974) — Etude de la demande de radio-mobiles au niveau urbain. G. Roy, Université de Sherbrooke (August 1974).

Zalatan(1974) — Demand for Land-Mobiles, A National Profile. A. Zalatan, Director, Economic Policy, Department of Communications (November 1974).

Zalatan and Simoneau (1972) — Demand for Land-Mobile Communications. A. Zalatan and M. Simoneau, Planning Branch, Economic Policy Planning Unit, Department of Communications (December 1972).

APPENDIX A

1.0 INTRODUCTION

This appendix compares the data extracted from the IRLS with similar data extracted from the Domestic Frequency List (DFL), and with data obtained in the course of a survey carried out by H. Dulmage Associates Ltd.

Section 2 compares the figures from the DFL with those from the IRLS. While the figures are not identical, there is a very high correlation between them ($r = 0.9945$).

Section 3 compares the figures from the survey with those from the IRLS. The correlation between the two is poor ($r = 0.7810$). However, the survey was not designed to discover the number of land-mobile systems in the major centres, but rather the usage patterns of the systems.

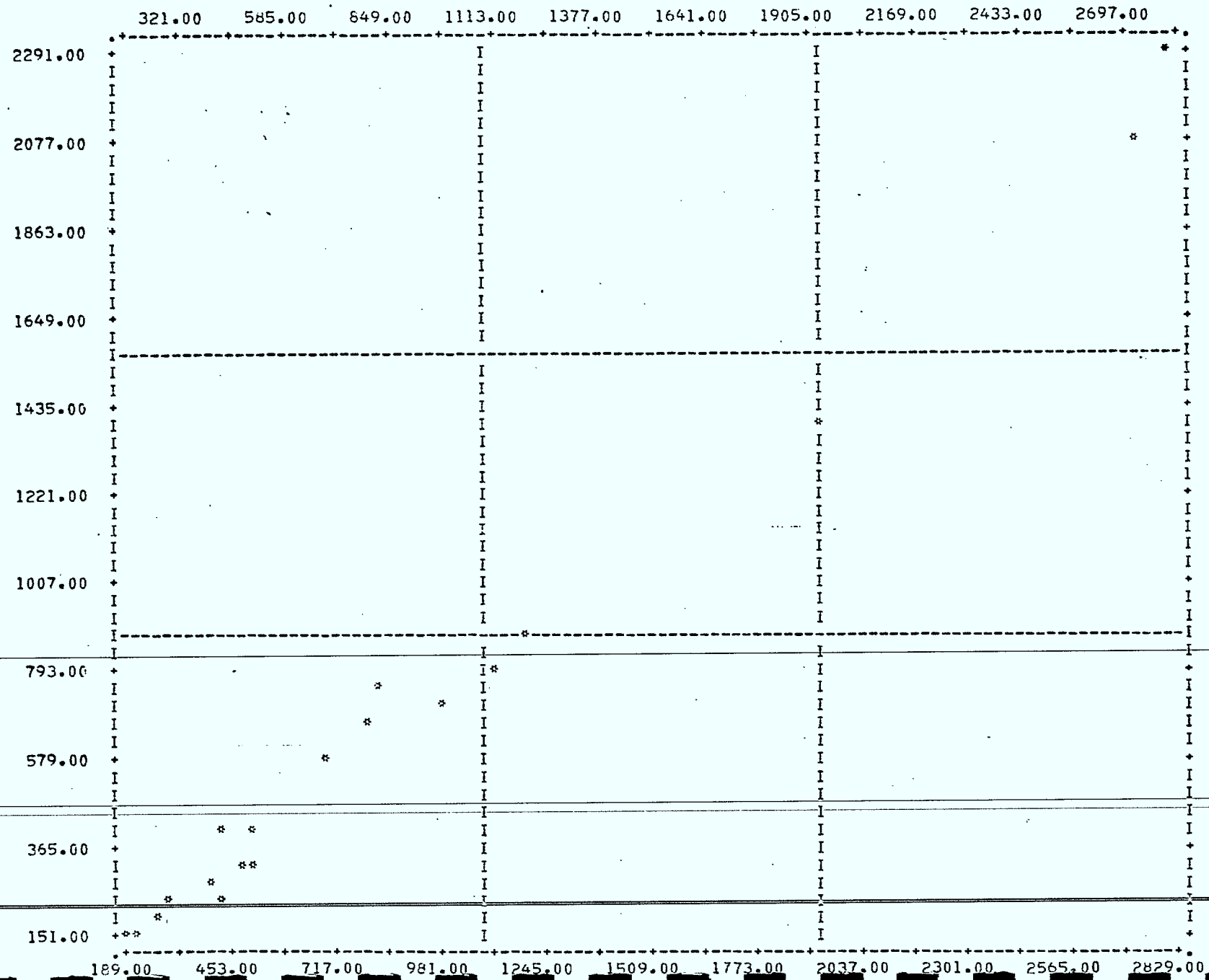
2.0 THE DFL DATA

The Domestic Frequency List is a list of all transmitters in Canada, by frequency. One record is maintained for each frequency at each location. On this record is a code indicating the use to which the transmitter is put, thus making it possible to extract all land-mobile base stations (code FB).

All land-mobile base stations were extracted, and a count was obtained of those within 35 miles of each centre. This was done for each year for which a year-end tape of the DFL was available, namely 1974, 1975, 1976 and 1977. The year-end tapes are created on March 31st of each year. These figures were then compared with those obtained from the IRLS. Figure 2.1 is a scattergram showing the DFL data versus the IRLS data for 1976. Table 2.2 gives the data extracted from the IRLS and the DFL for 1976.

A linear regression was performed, relating each year's DFL data to that of the IRLS, and for all the data. The results of this are shown in Table 2.3. The lowest value for a goodness of fit is 98.84%, while the highest is 99.16%. These values are very good; the DFL and IRLS data are highly correlated. However, since the IRLS contains all the transmitters in the land-mobile bands, the IRLS can be expected to have a higher total. The figures suggest that up to 20% of the assignments in the land-mobile bands may be assignments used for purposes other than land-mobile. However, without any further information, it is impossible to tell which of the figures is nearest the true value.

FIGURE 2.1: Data Derived from the DFL (Down)
Against Data Derived from the IRLS (Across) for 1976



CENTRE	IRLS	DFL
Toronto	2,812	2,287
Montreal	2,726	2,090
Vancouver	1,936	1,378
Ottawa-Hull	1,108	783
Winnipeg	697	590
Edmonton	1,190	863
Québec	787	653
Calgary	981	716
London	834	754
Halifax	503	388
Windsor	423	390
Victoria	482	313
Sudbury	502	301
Regina	259	186
St. John's	224	151
Saskatoon	189	158
Chicoutimi-Jonquière	392	299
Thunder Bay	419	224
Saint John	301	228
TOTAL	16,767	12,752

TABLE 2.2: Number of Land-Mobile Systems by Centre (1976)
(Data derived from the IRLS vs. data derived from the DFL)

DATA USED	RATIO (DFL/IRLS)*	GOODNESS OF FIT %
1974	0.8378	98,84
1975	0.8487	98.86
1976	0.7954	98.85
1977	0.8088	99.16
All (1974-1977)	0.8033	98.90

TABLE 2.3: Ratio of Number of Systems by Data Source

* This is the best ratio estimate as calculated by the linear regression. In each case, there is also a small constant term of the order of -20.

3.0 THE DATA FROM THE DULMAGE SURVEY

The survey conducted by H. Dulmage Associates took place over the period July 1975 - July 1976. The survey was sent to a selection of operators licensed to operate a mobile radio in Canada in 1975. For details in the method of selection, see Dulmage(1976).

The questionnaire sent out to the operators did not include a question regarding the location of the transmitter, so it was necessary to use the town indicated on the address as the transmitter location. A list of towns within 35 miles of each centre was obtained from Platts(1977). The values thus obtained were scaled up by the sample ratio and the percentage response by type (business/commercial, federal/provincial, or municipal) and by province. The figures thus obtained appear in Figure 3.1, together with the corresponding figures from the March 31st, 1975 IRLS year-end tape.

As can be seen from a visual inspection of the data, the correlation is not very good. When a linear regression is performed, the goodness of fit is only 60.99%. Some of the figures obtained via the Dulmage survey appear to be varying independently of city size (e.g. Vancouver has a value of 92, whereas Victoria has a value of 148). This suggests the the number of land-mobile systems as estimated using the Dulmage survey data is likely to be of little use in verifying the accuracy of the data derived from the IRLS.

CENTRE	IRLS	DULMAGE SURVEY
Toronto	2,479	692
Montreal	2,348	703
Vancouver	1,642	92
Ottawa-Hull	895	227
Winnipeg	605	0
Edmonton	988	556
Québec	721	124
Calgary	864	566
London	742	189
Halifax	440	318
Windsor	351	70
Victoria	368	148
Sudbury	483	7
Regina	216	0
St. John's	189	0
Saskatoon	137	0
Chicoutimi-Jonquière	350	22
Thunder Bay	379	16
Saint John	246	0
TOTAL	14,443	3,730

FIGURE 3.1: Number of Land-Mobile Systems by Centre (1975)
(Data derived from IRLS vs. data derived from the Dulmage survey)

REFERENCES

Dulmage(1976) A Study of User Needs in Mobile Radio. H. Dulmage et al., H. Dulmage Associates of Ottawa (June 1976)

Platts(1977) See references after body of report.

APPENDIX B

1.0 INTRODUCTION

This appendix presents scattergrams for each of the 1976 CMAs which were also CMAs in 1971 (i.e. all the CMAs except Oshawa).

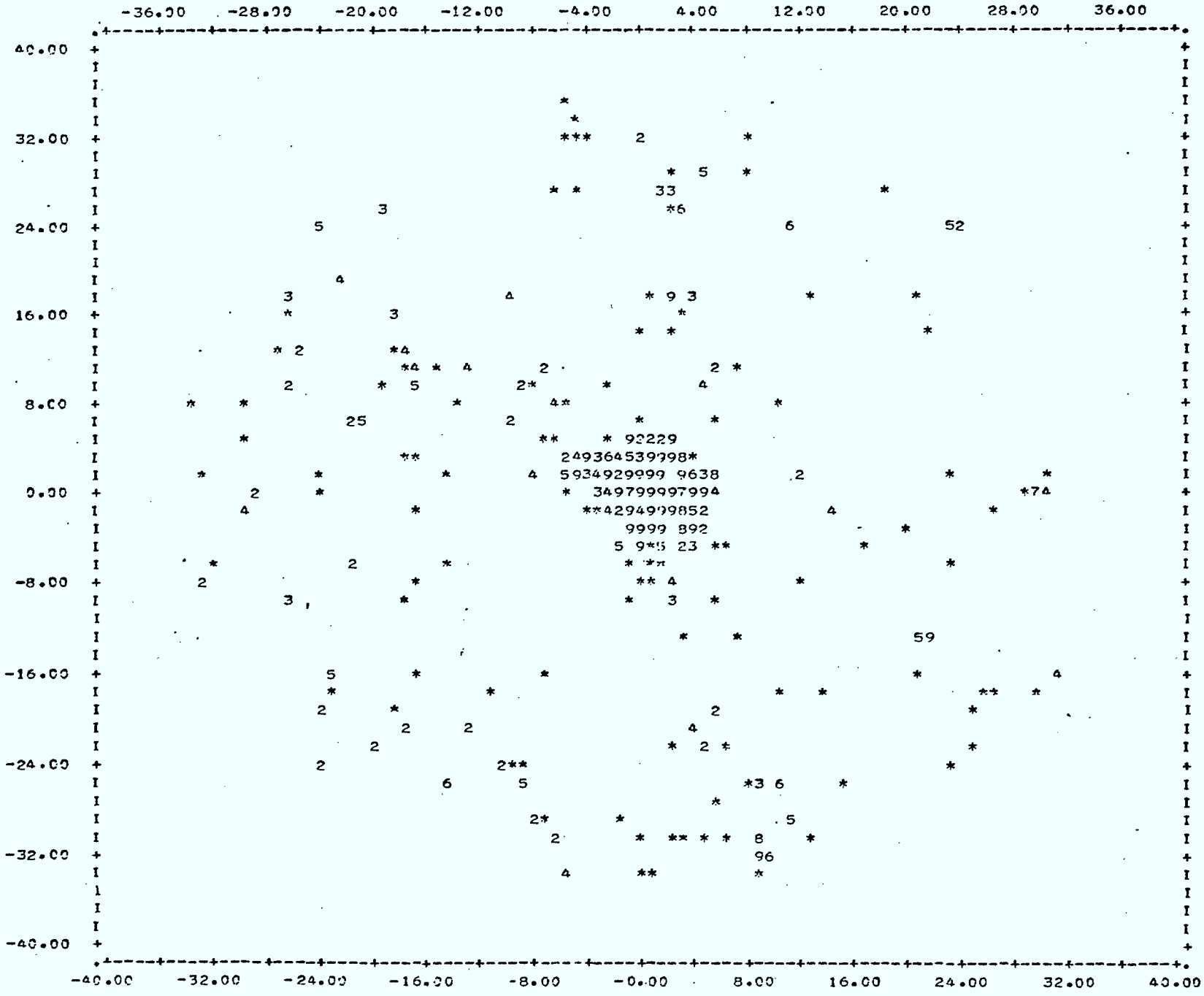
The points on the scattergram represent base station locations for systems in the land-mobile bands extracted from the IRLS (Integrated Radio Licensing System) in 1977. It should be noted that not all the systems are land-mobile systems; a certain percentage may be in land-fixed service (see Appendix A). The only base stations shown are those within 35 miles of the CMA centre, which is located at the centre of the scattergram.

The numbers on the sides indicate miles north (positive) of the city centre, and south (negative) of the city centre. The numbers at the top and bottom indicate miles east (positive) and west (negative) of the city centre.

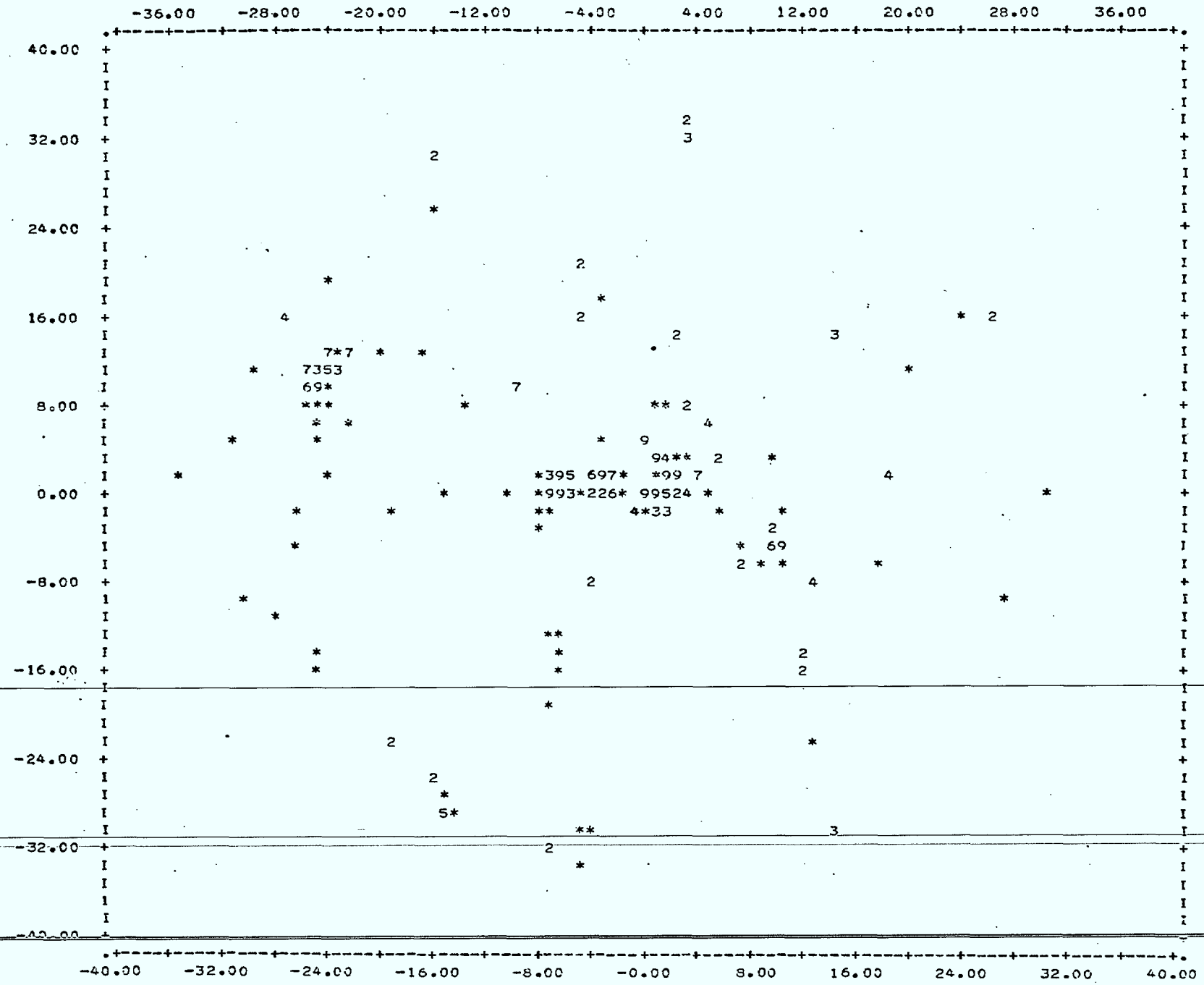
Each scattergram shows a marked concentration of land-mobile base stations at the city centre, with a reduction in density towards the edges. This suggests that small changes in the 35 mile radius (to, say, 30 miles or 40 miles) would not greatly affect the results of this study. The overlaps for those centres excluded from the study (Hamilton, Kitchener and St. Catherines-Niagara) are clearly visible.

2.0 SCATTERGRAMS

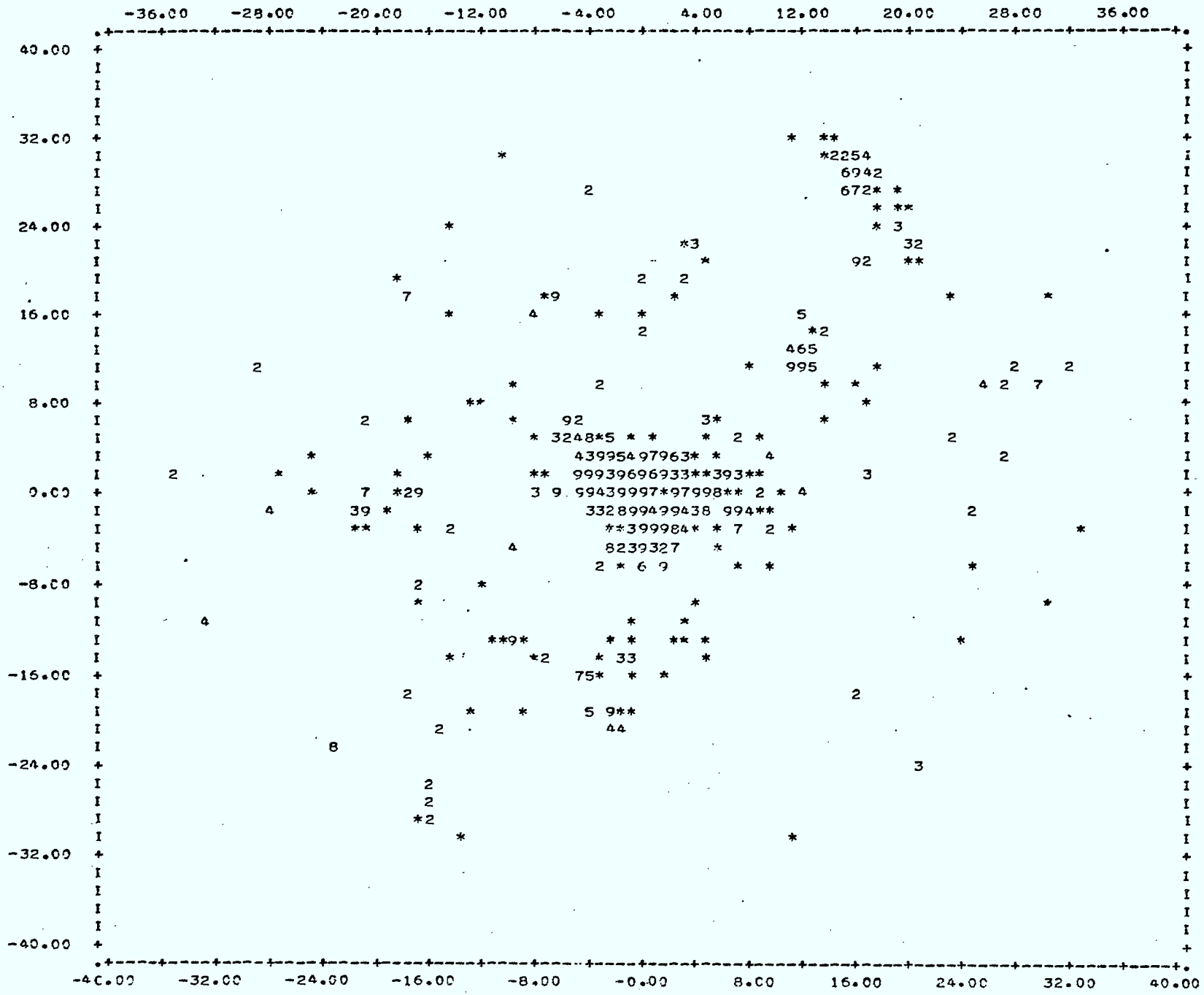
Land-Mobile Base Stations within 35 miles of Calgary (1977)



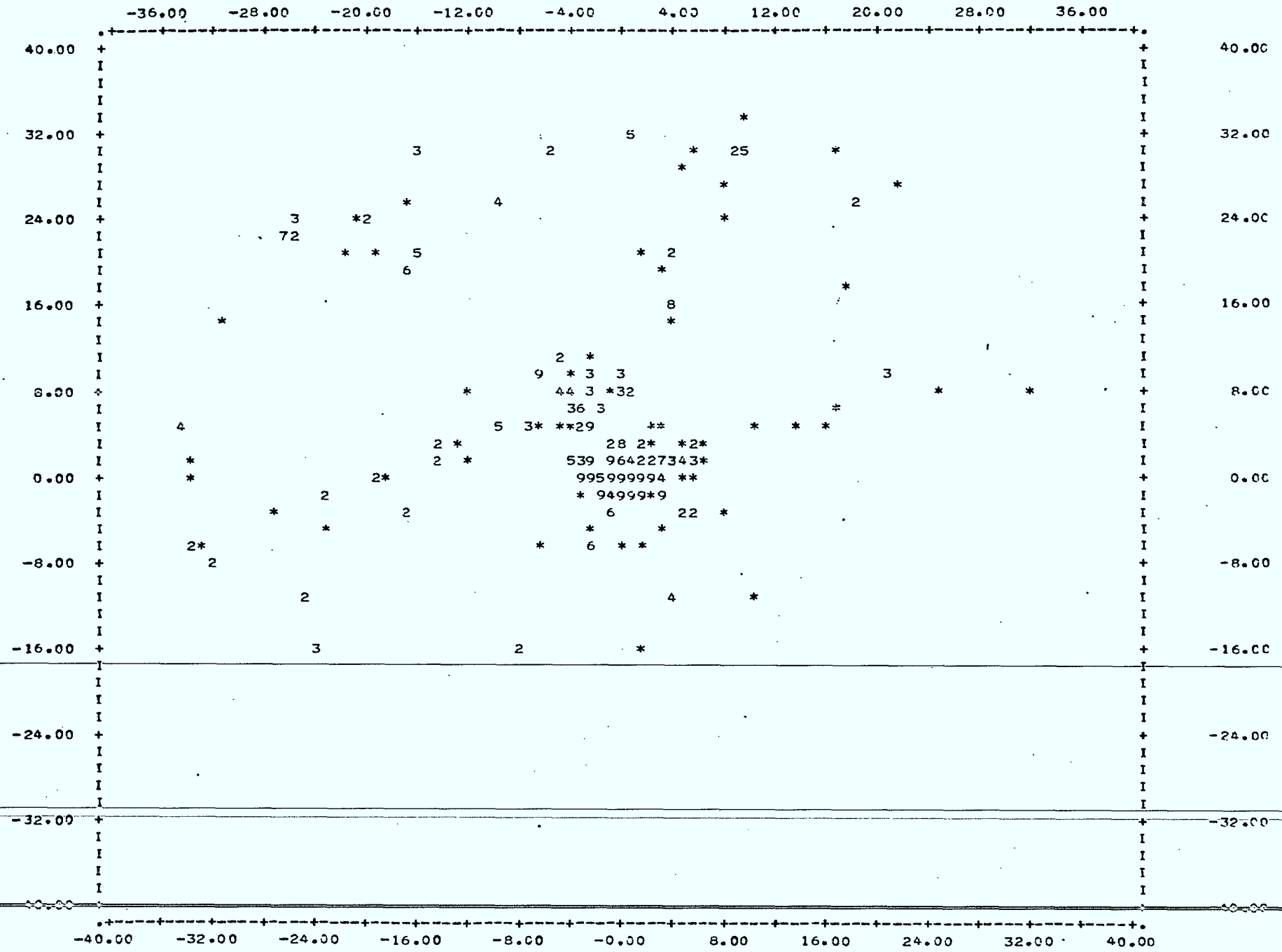
Land-Mobile Base Stations within 35 miles of Chicoutimi-Jonquière (1977)



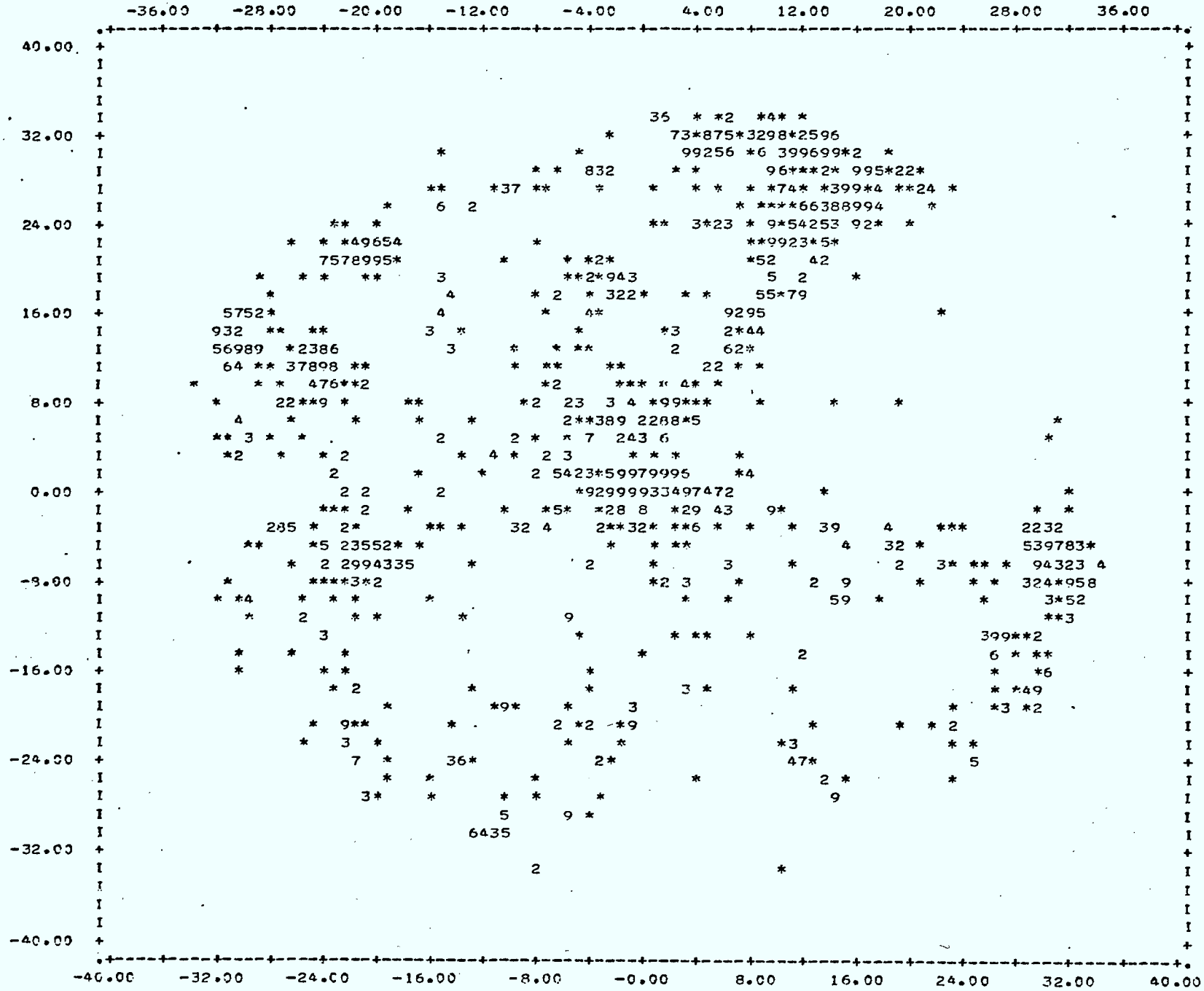
Land-Mobile Base Stations within 35 miles of Edmonton (1977)



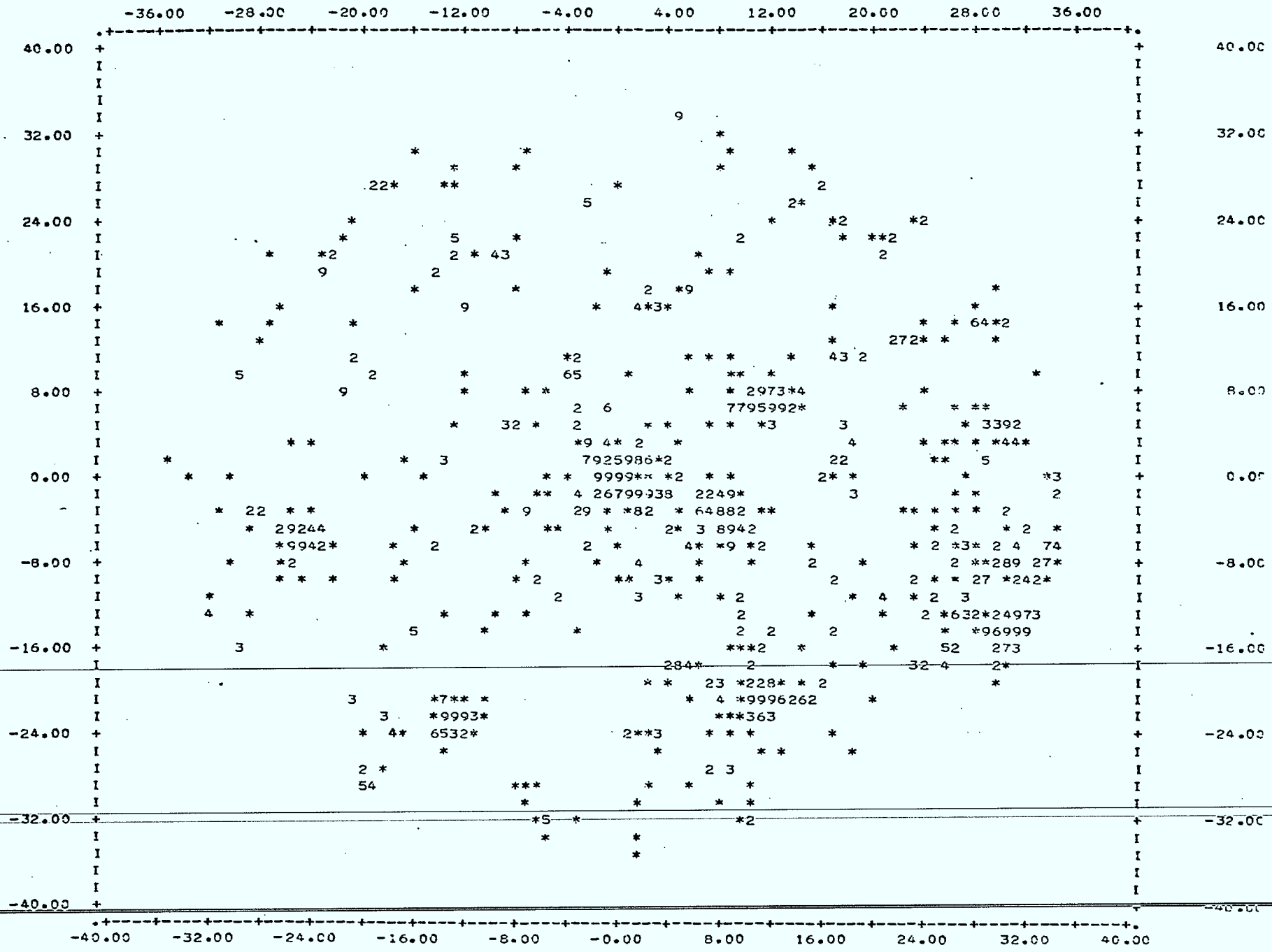
Land-Mobile Base Stations within 35 miles of Halifax (1977)



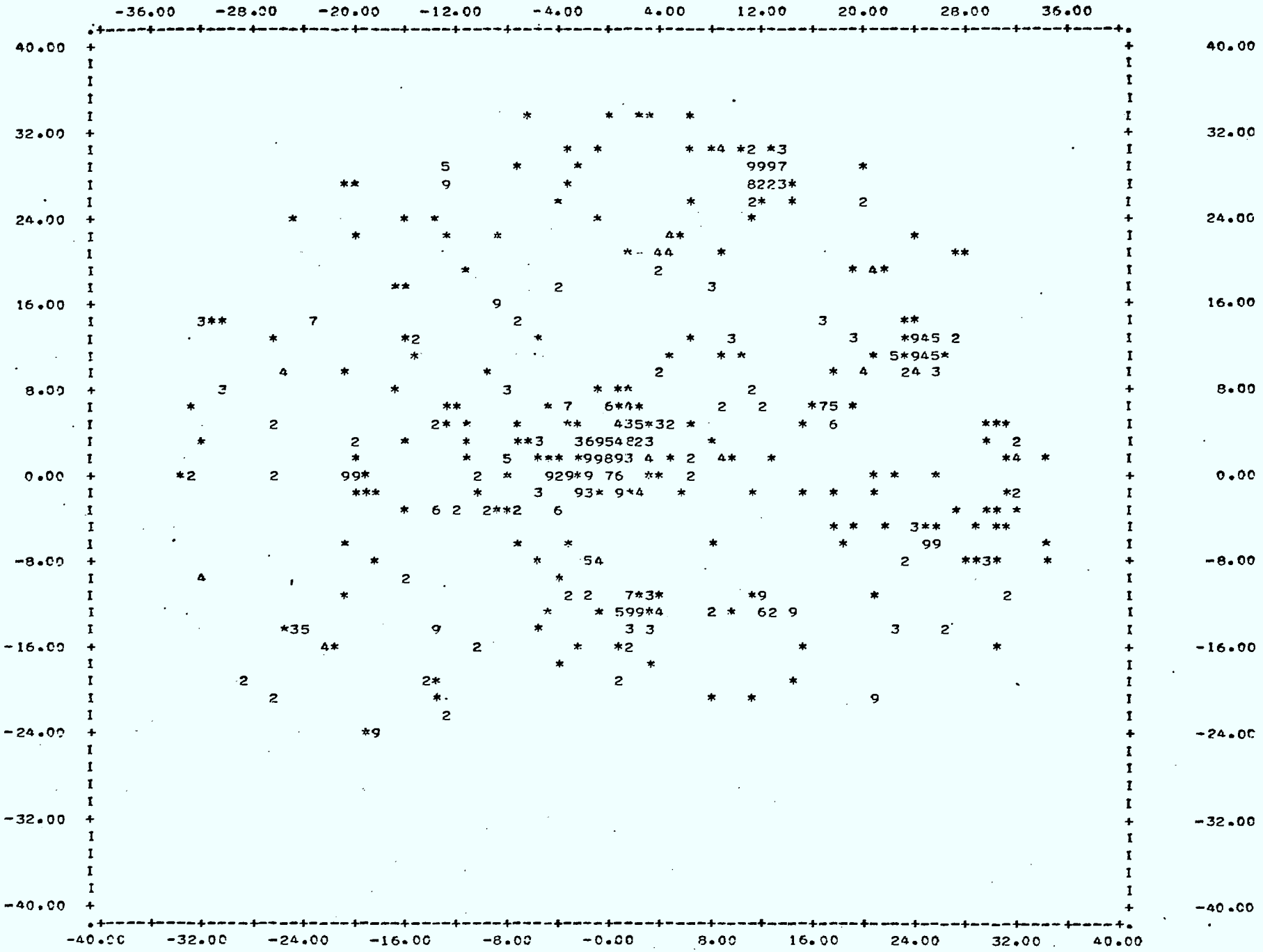
Land-Mobile Base Stations within 35 miles of Hamilton (1977)



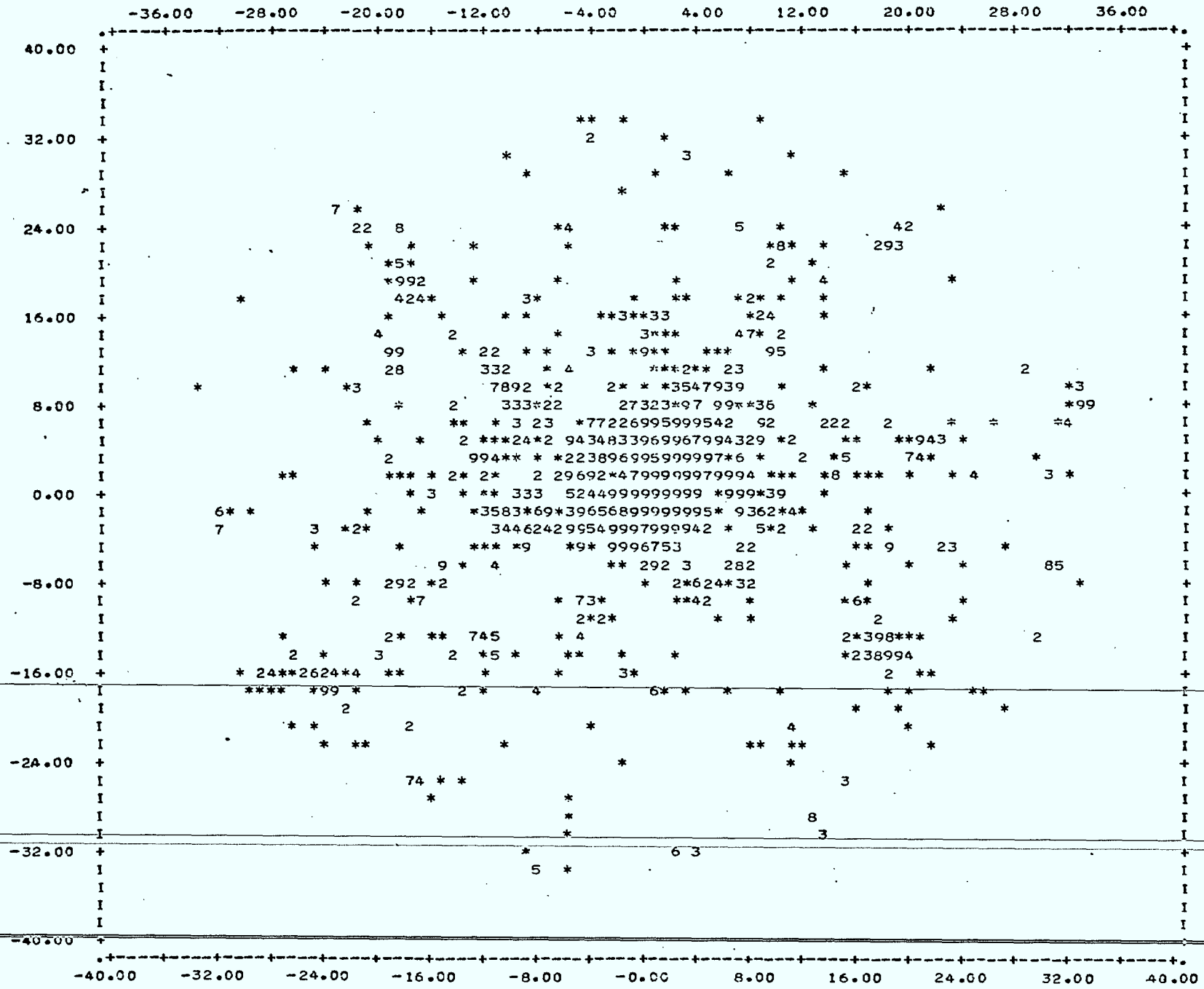
Land-Mobile Base Stations within 35 miles of Kitchener (1977)



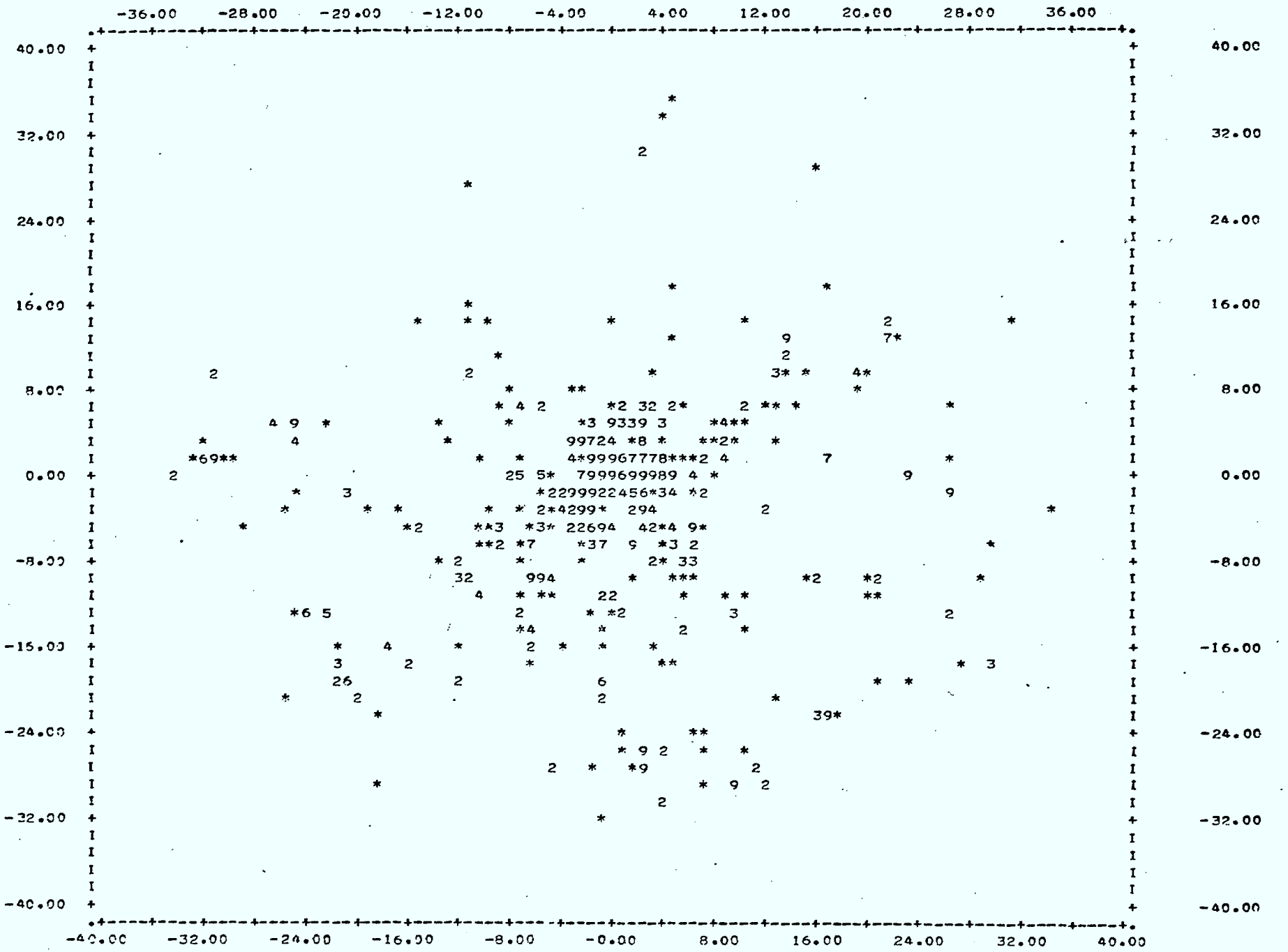
Land-Mobile Base Stations within 35 miles of London (1977)



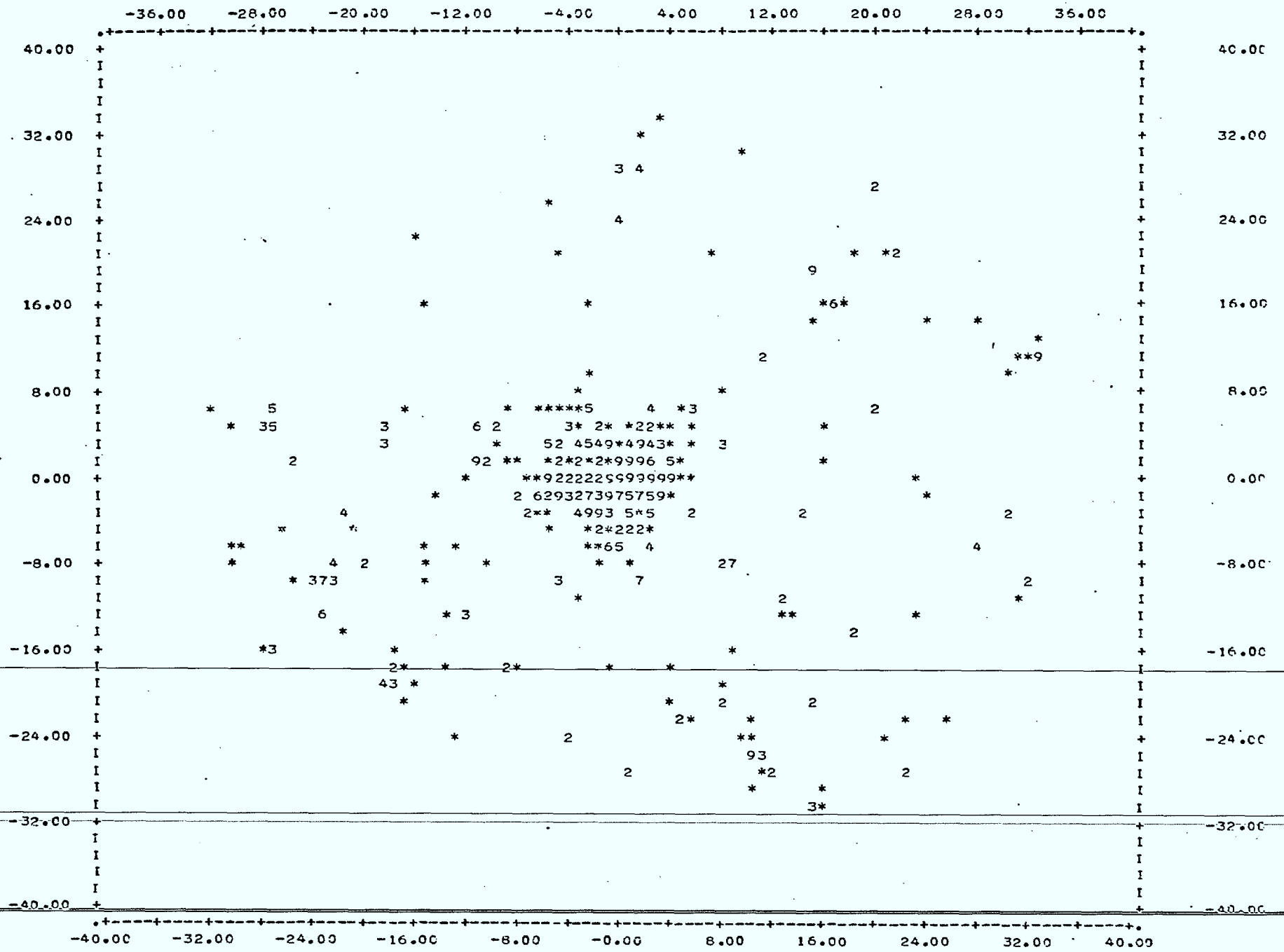
Land-Mobile Base Stations within 35 miles of Montreal (1977)



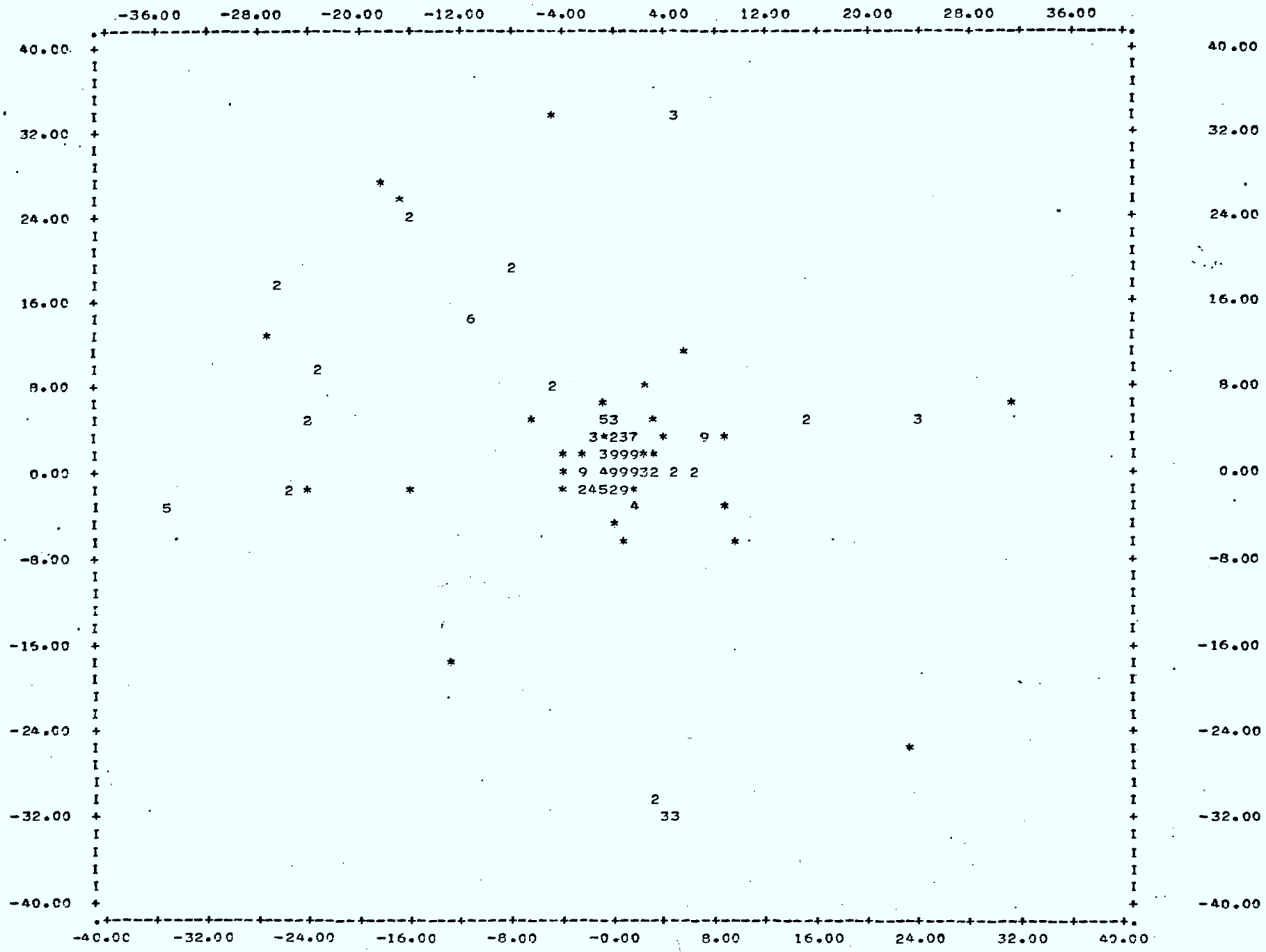
Land-Mobile Base Stations within 35 miles of Ottawa-Hull (1977)



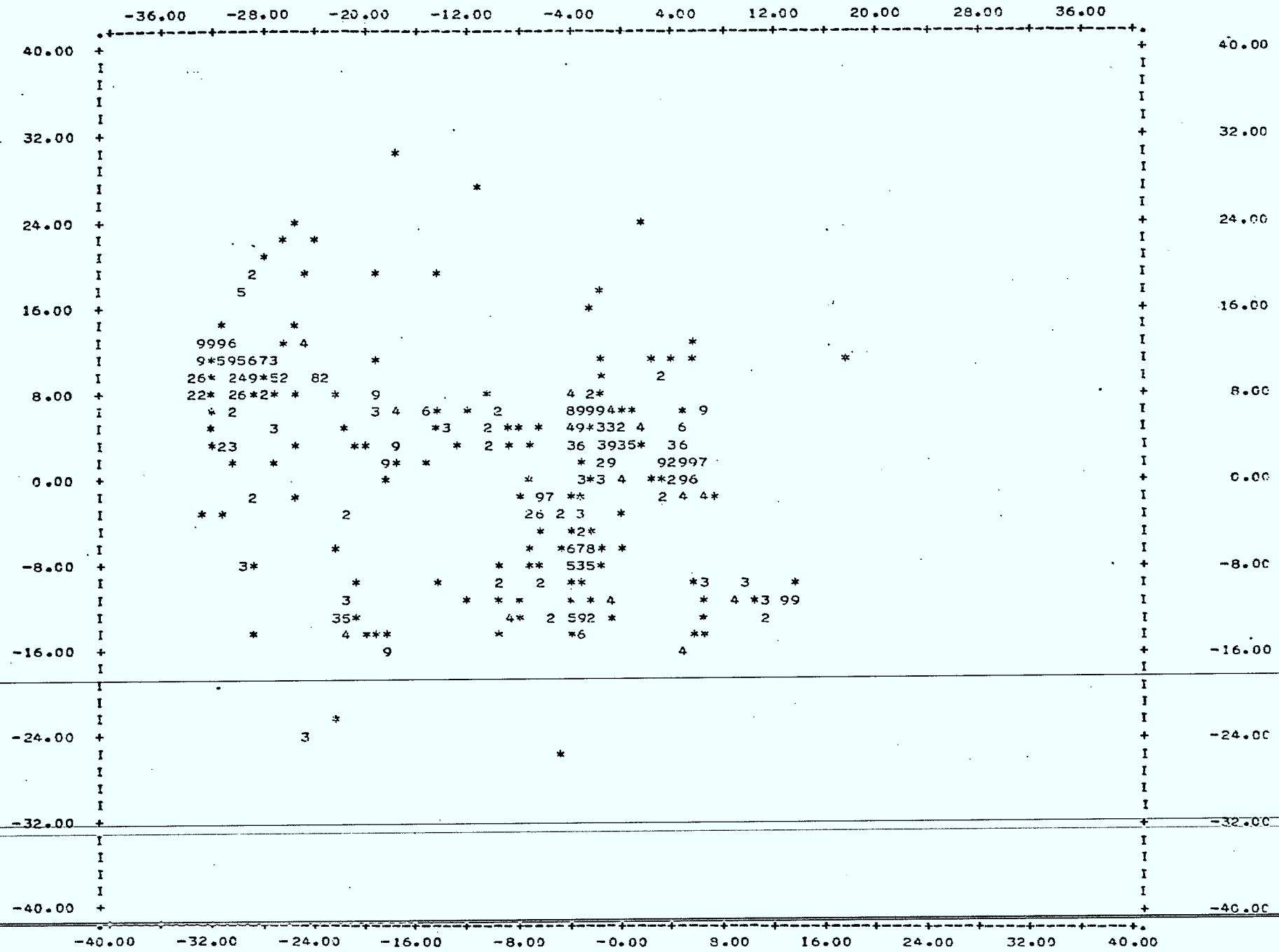
Land-Mobile Base Stations within 35 miles of Québec (1977)



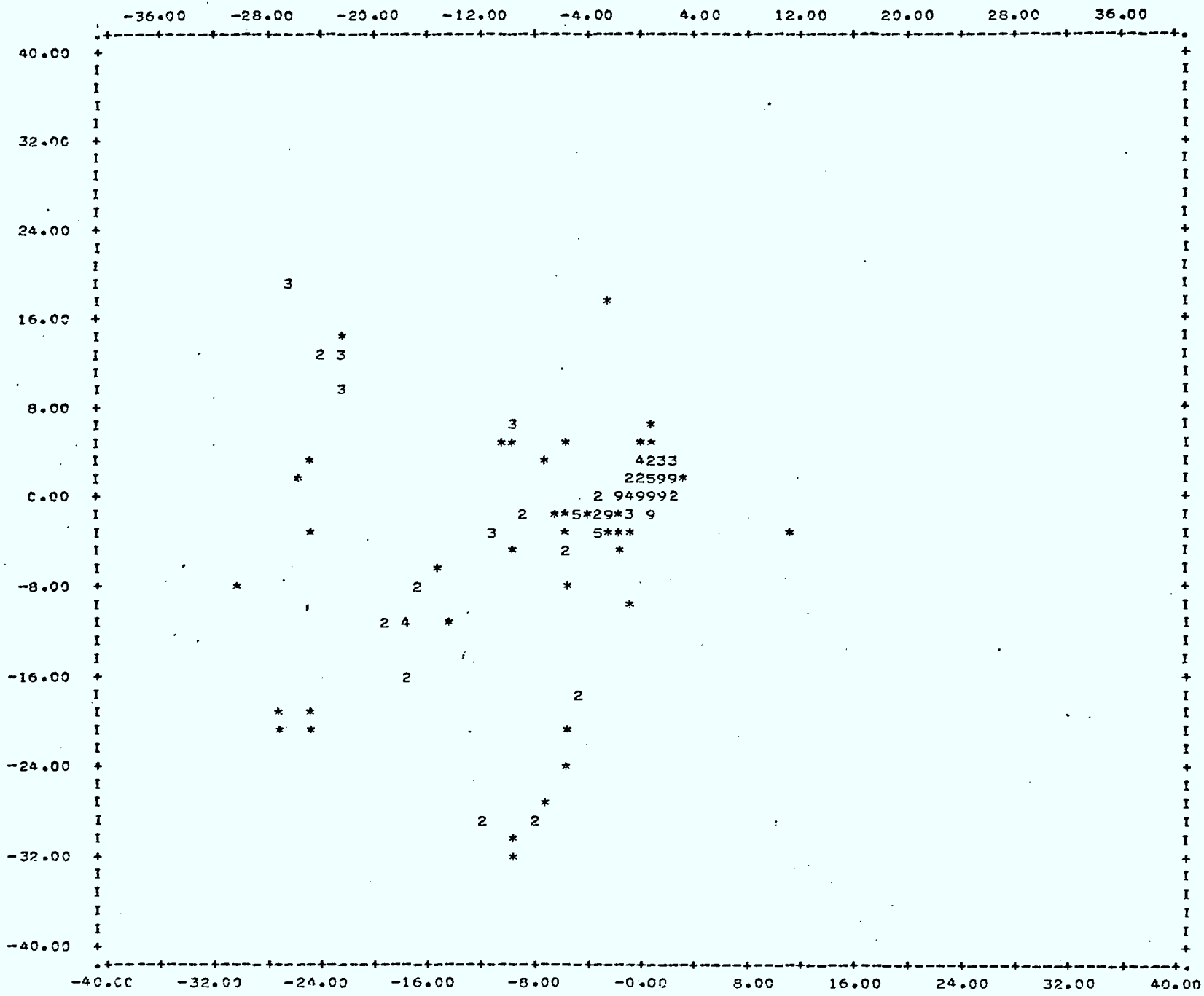
Land-Mobile Base Stations within 35 miles of Regina (1977)



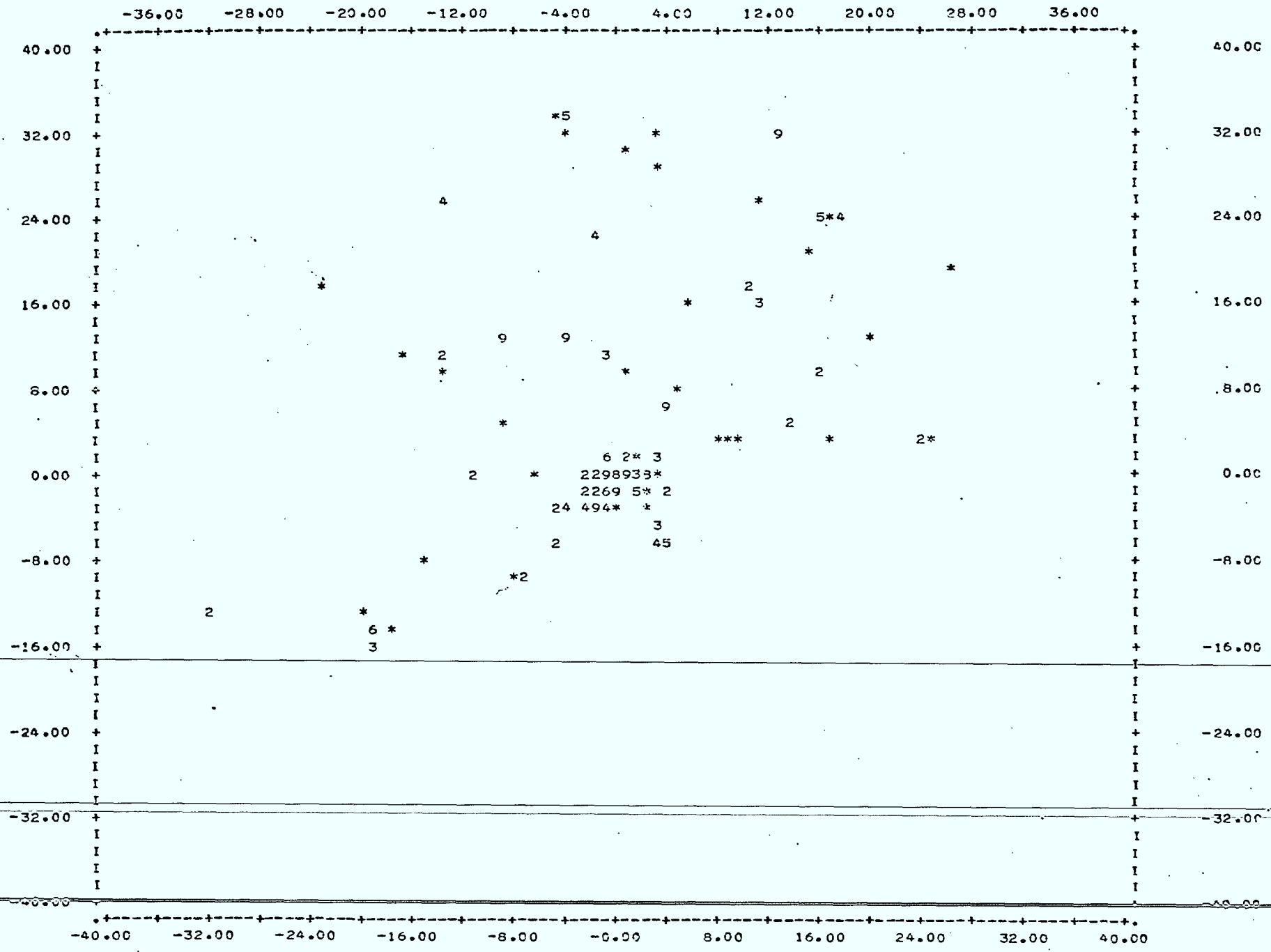
Land-Mobile Base Stations within 35 miles of St. Catherines-Niagara (1977)



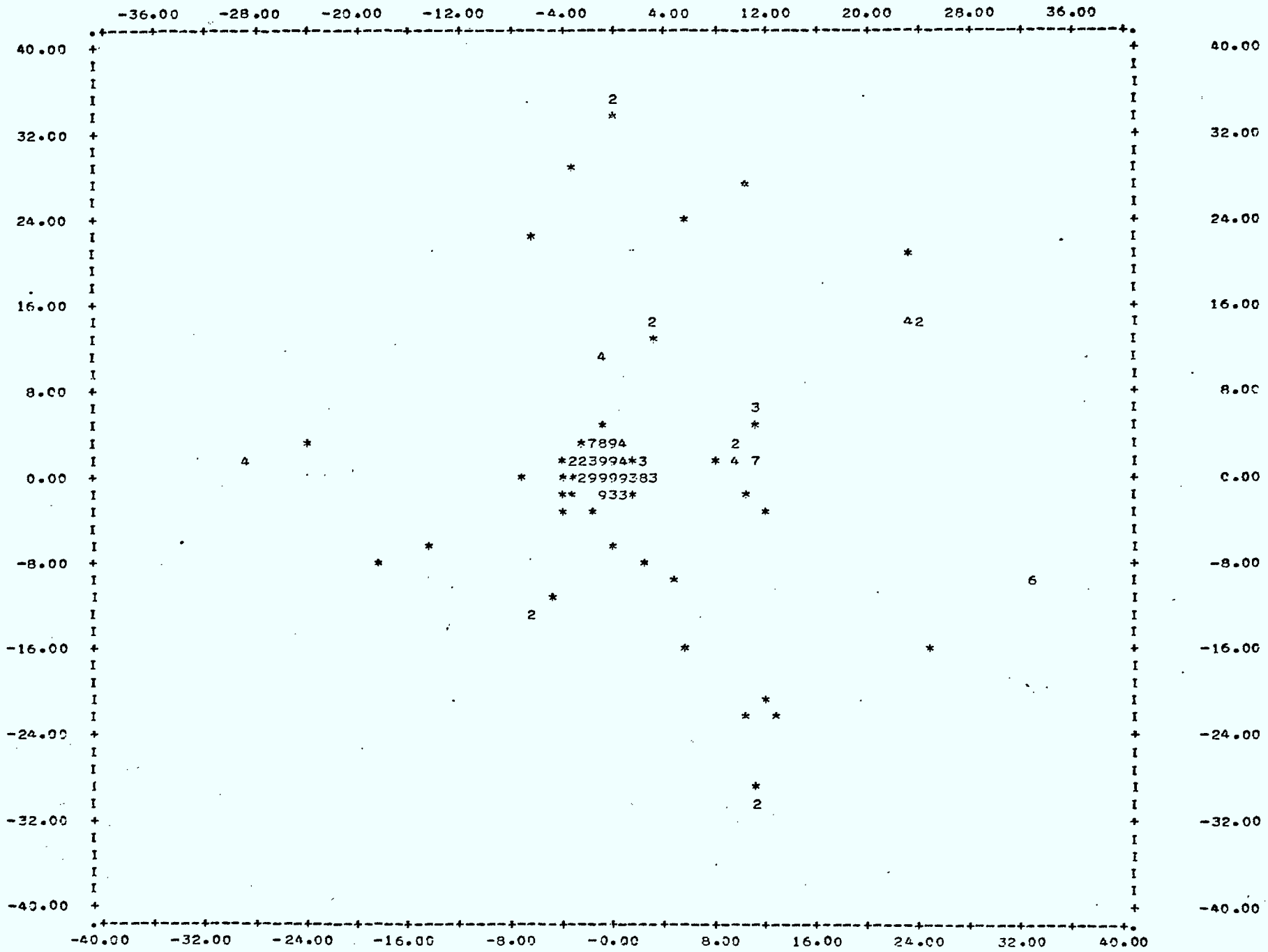
Land-Mobile Base Stations within 35 miles of St. John's (1977)



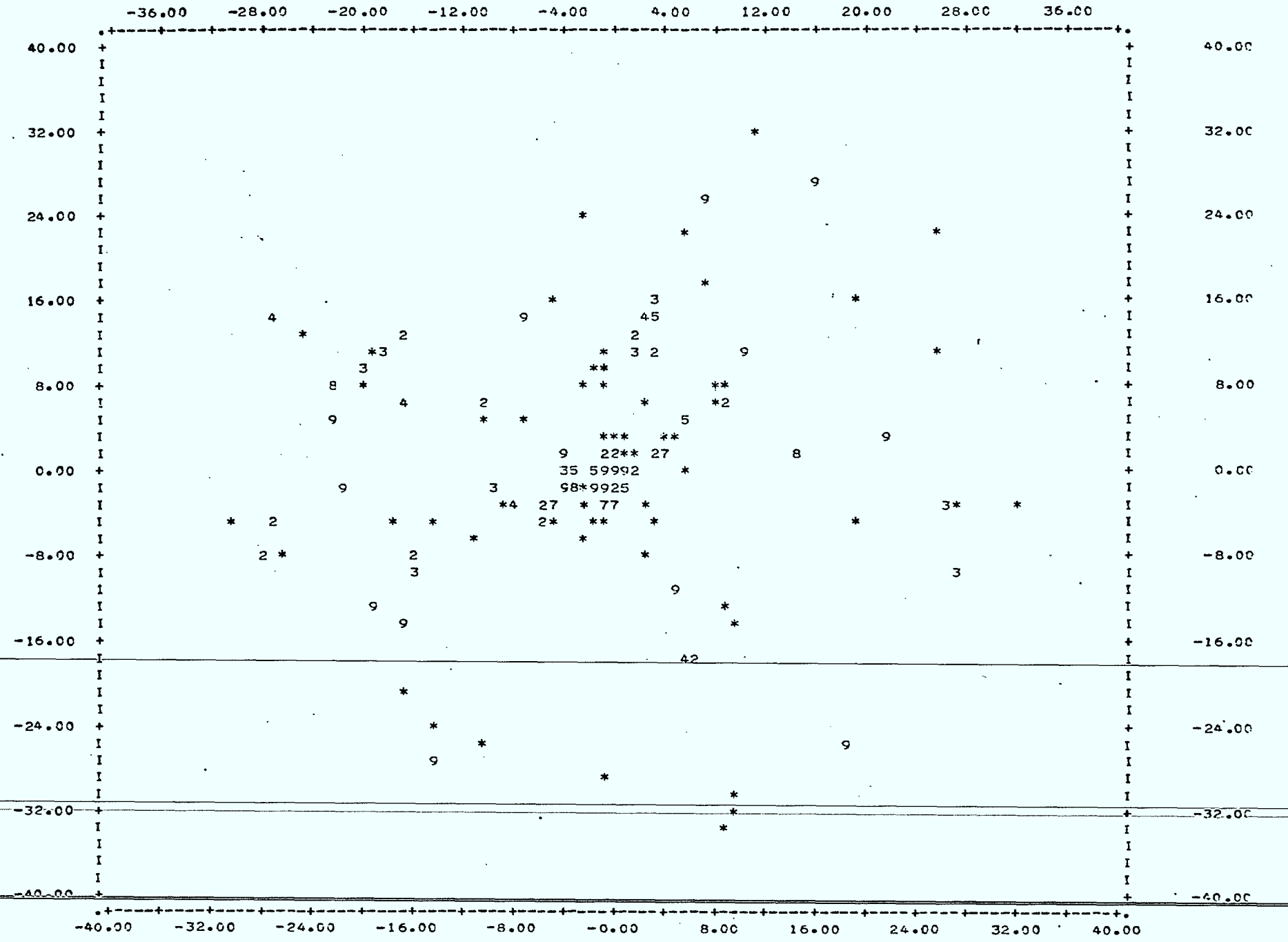
Land-Mobile Base Stations within 35 miles of Saint John (1977)



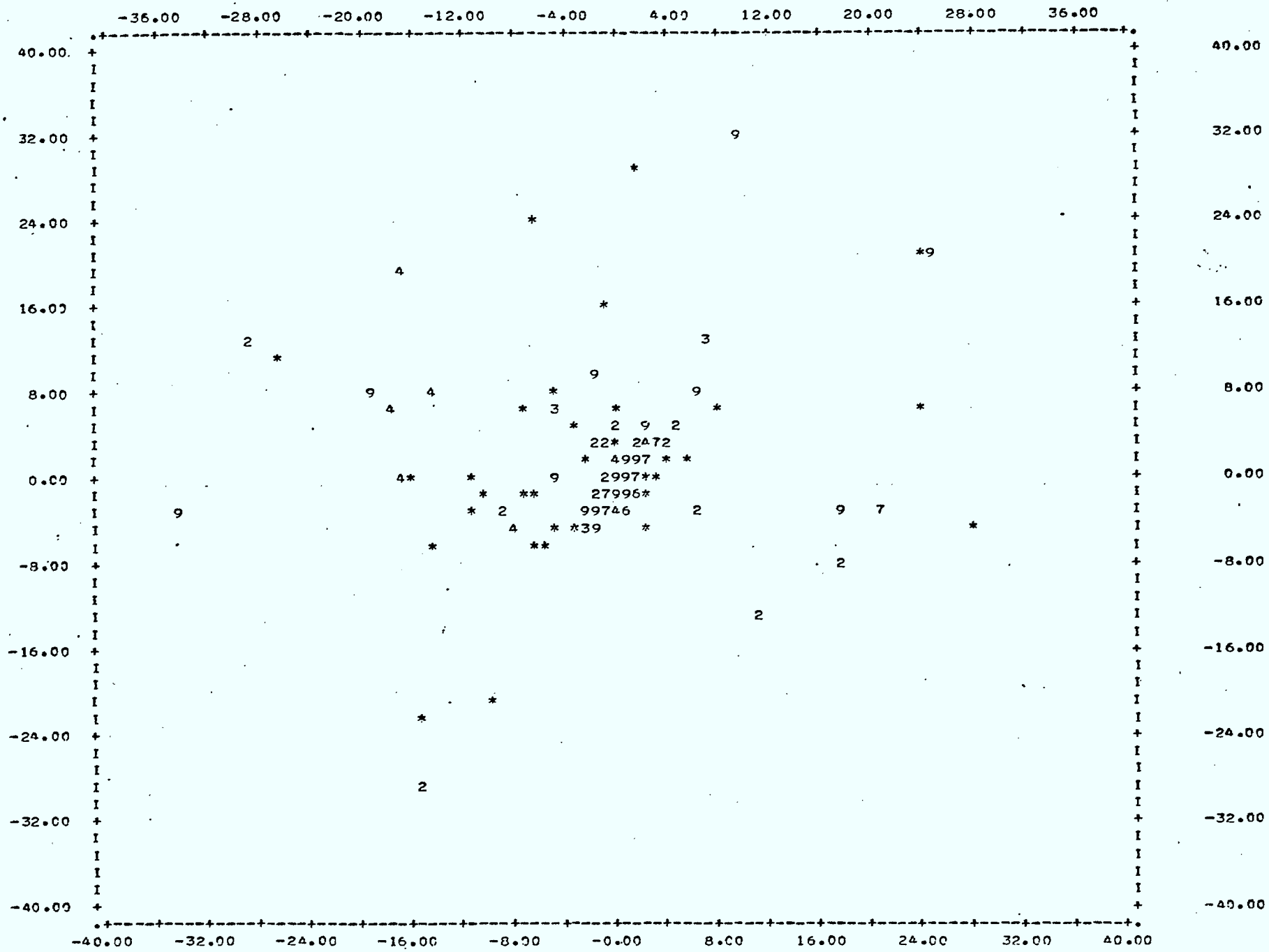
Land-Mobile Base Stations within 35 miles of Saskatoon (1977)



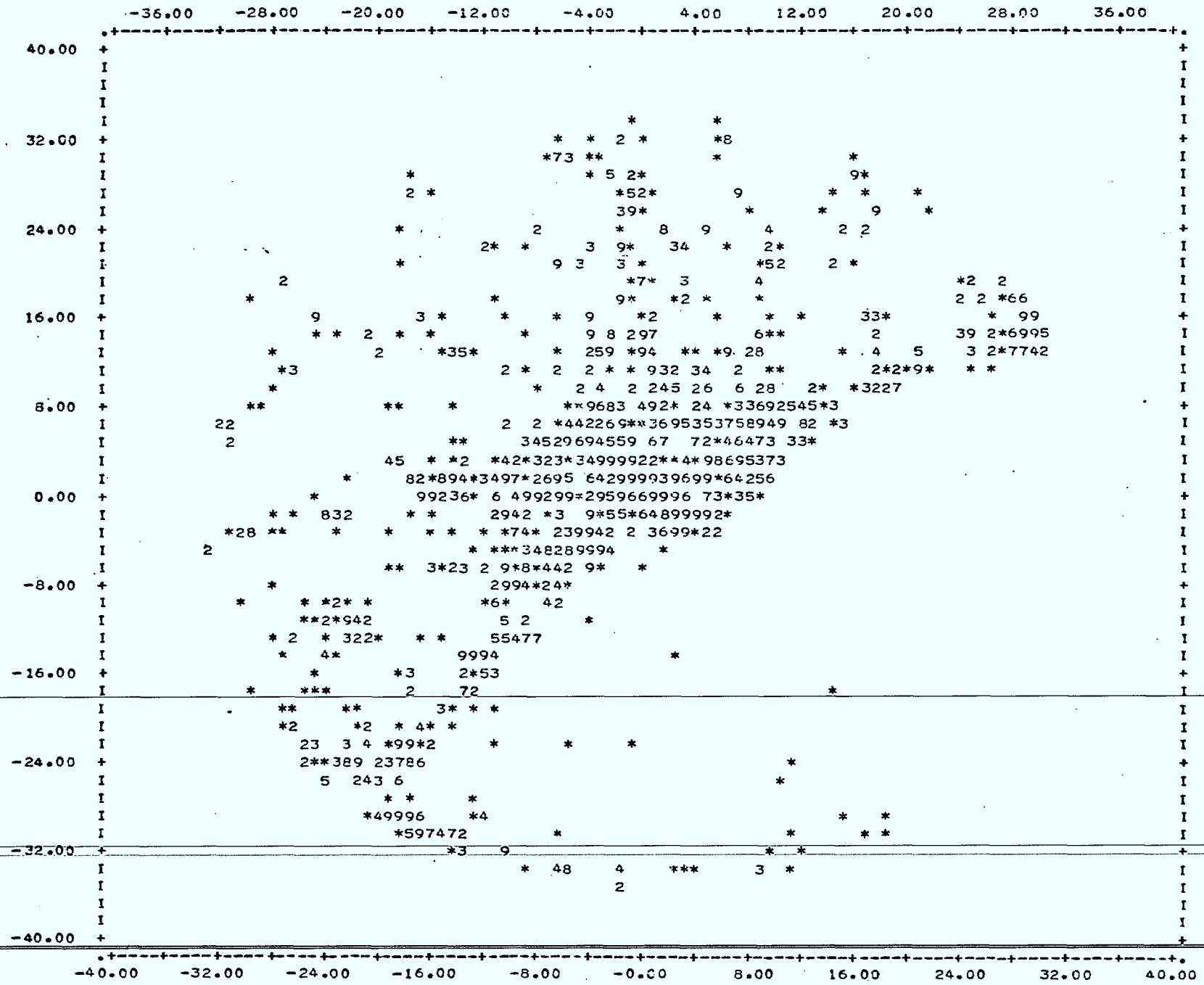
Land-Mobile Base Stations within 35 miles of Sudbury (1977)



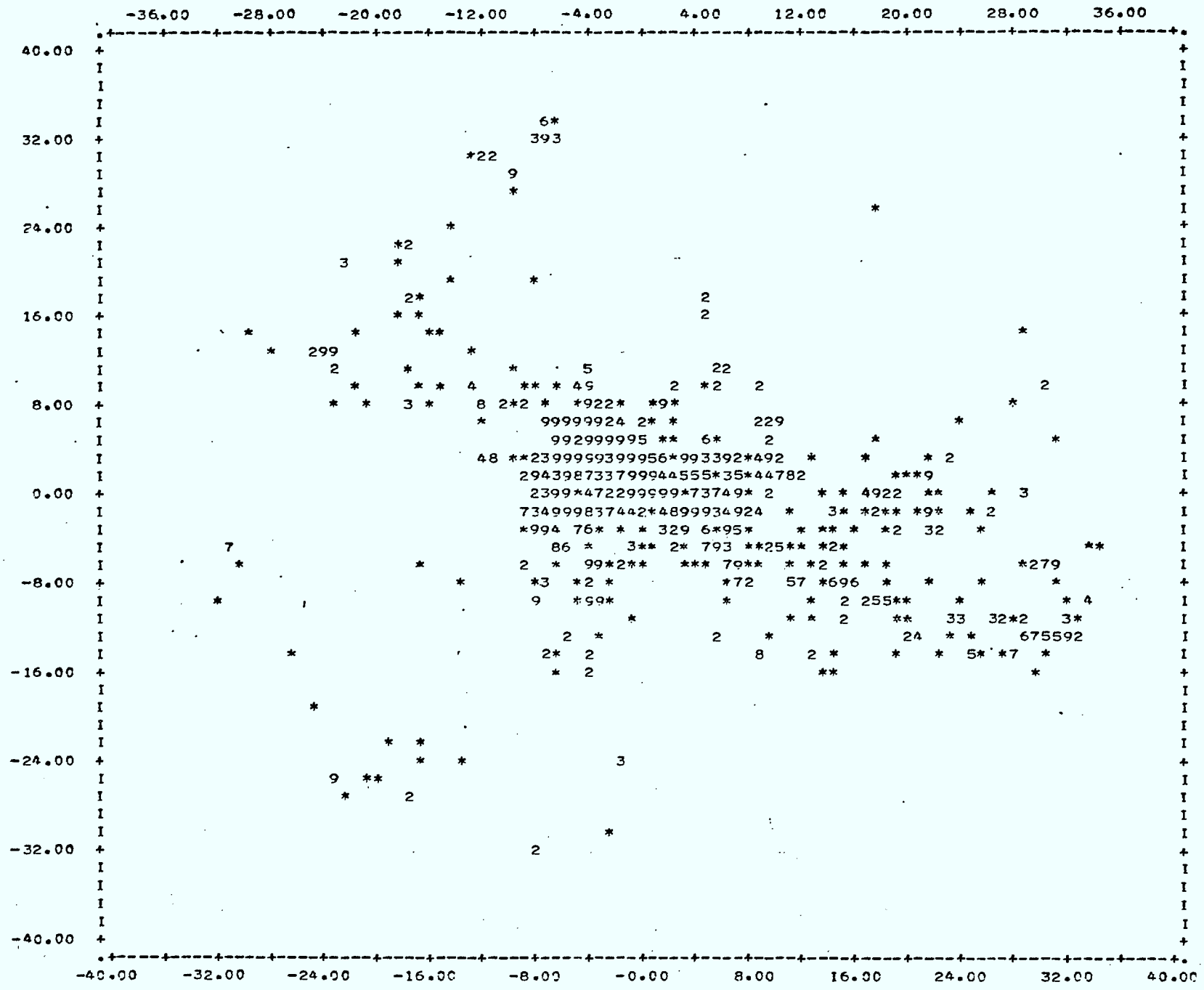
Land-Mobile Base Stations within 35 miles of Thunder Bay (1977)



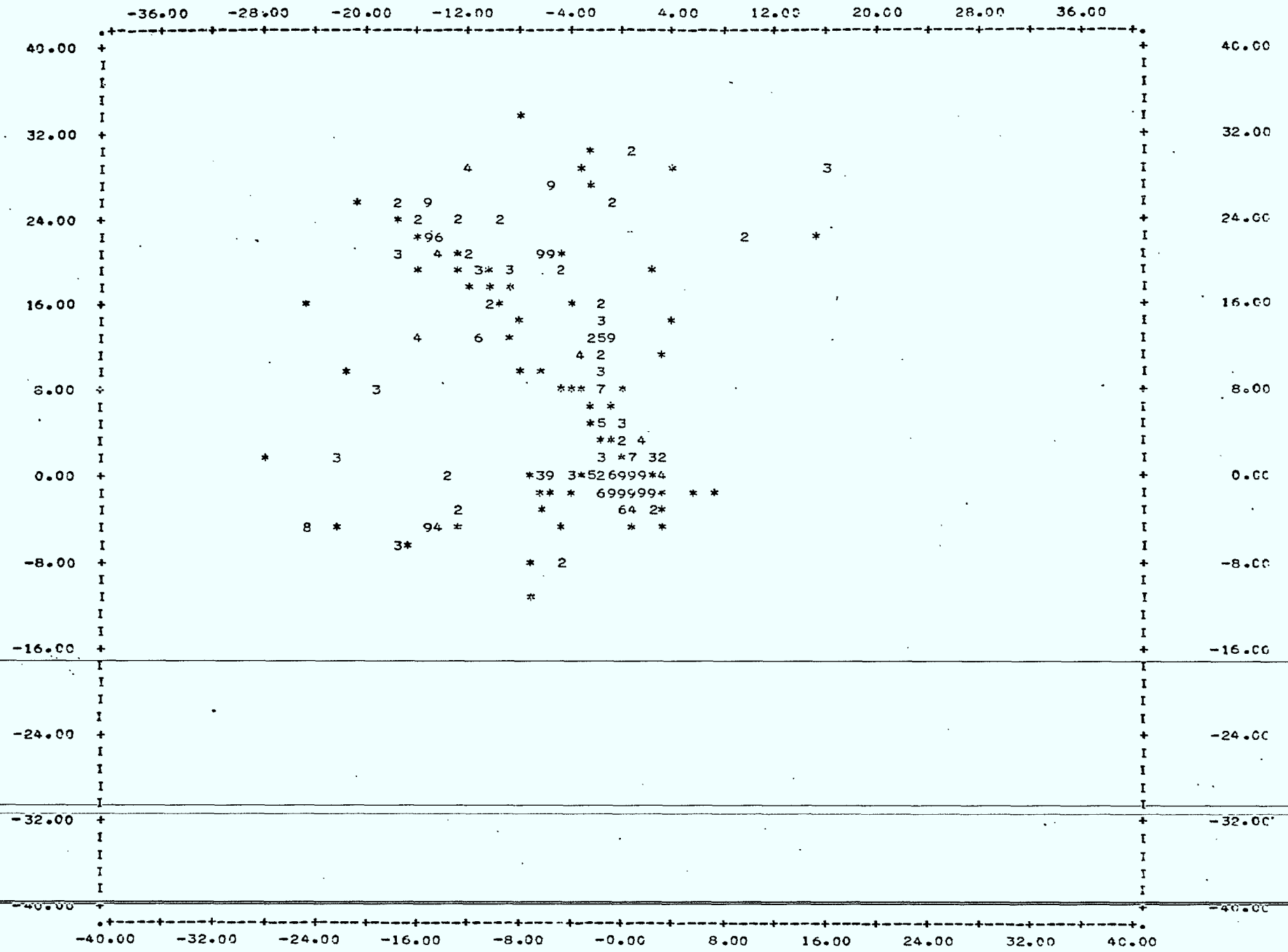
Land-Mobile Base Stations within 35 miles of Toronto (1977)



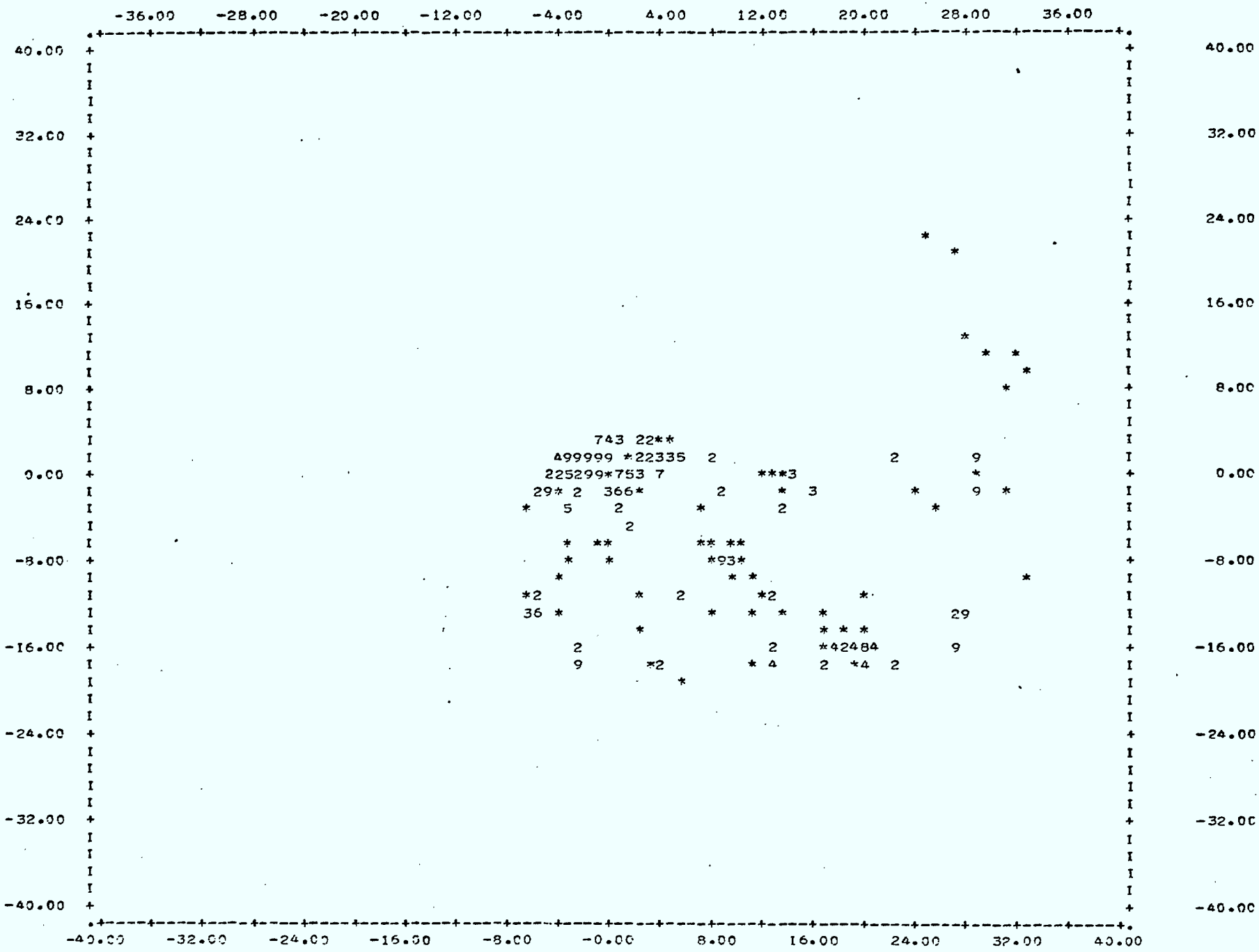
Land-Mobile Base Stations within 35 miles of Vancouver (1977)



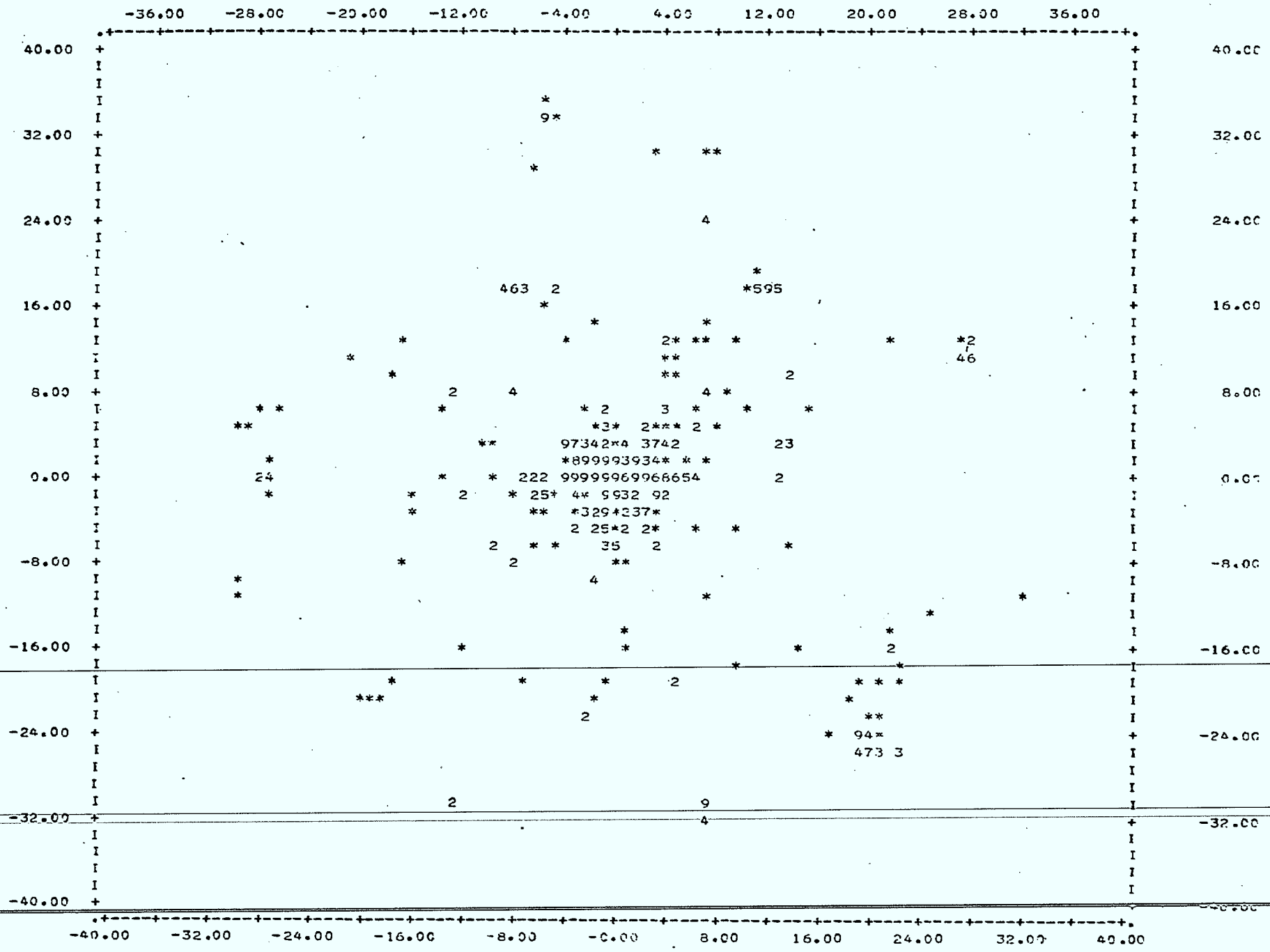
Land-Mobile Base Stations within 35 miles of Victoria (1977)



Land-Mobile Base Stations within 35 miles of Windsor (1977)



Land-Mobile Base Stations within 35 miles of Winnipeg (1977)



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