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ABSTRACT

Maps are presented giving the one-day extreme rainfalls for the Prairie Provinces with return periods of 2, 5, 10, 25 and 100 years calculated by the Gumbel method. In addition, maps are presented giving the mean and standard deviation of the annual series of maximum one-day rainfalls. These maps are based on all available data prior to 1972 from 1061 stations in the Prairie Provinces equipped with standard, non-recording rain gauges. The general pattern is for the heaviest rainfalls to occur in southwestern Manitoba and along the foothills of the Rocky Mountains in Alberta while the smallest extreme rainfalls occur in the northern regions.

STATISTIQUE DES CHUTES DE PLUIE EXTRÊMES EN UNE JOURNÉE POUR LES PROVINCES DES PRAIRIES

par

D.M. POLLOCK et G.J. GAYE

SOMMAIRE

La présentation est faite à l'aide de cartes donnant les chutes de pluie extrêmes en une journée pour les provinces des Prairies, pour des périodes de retour de 2, 5, 10, 25 et 100 ans, calculées selon la méthode Gumbel. Il y a également des cartes indiquant l'écart absolu moyen et l'écart-type de la série annuelle des chutes de pluie maximales pour une journée. Ces cartes s'appuient sur toutes les données antérieures à 1972, disponibles pour 1061 stations des provinces des Prairies équipées de pluviomètres standards, non enregistreurs. En règle générale, ce sont les régions du Sud-Ouest du Manitoba et les contreforts des Montagnes Rocheuses qui reçoivent les plus fortes chutes de pluie, tandis que dans les régions septentrionales on enregistre les plus faibles chutes de pluie.

1. DATA SOURCE

The maps of one-day extreme rainfall statistics (Figures 1-21) were based on all available data prior to 1972 from 1061 stations in the Prairie Provinces. Most of the observations were taken daily at about 8 a.m. local standard time using the standard Canadian non-recording rain gauge. Table I gives a more detailed breakdown of the data source. Of the 1061 stations, 9 stations had more than 80 years of record. The greatest lack of data was in Saskatchewan north of 55°N where there were only 5 stations with more than 10 years of record and in Northern Manitoba where only 8 stations had more than 10 years of record, although all had more than 30 years of record. By way of contrast 65 stations had more than 10 years of record in Northern Alberta.

TABLE 1.

Number of Observing Stations and Their Record Length

Province	Years of Record		
	Less than 10	10 to 30	more than 30
Manitoba	54	91	44
Saskatchewan	73	191	92
Alberta	183	241	92
Total	310	523	228

The data from the different stations were weighted subjectively when analyzing the maps; the greatest weight was given to the stations with the longest records. This was accomplished by drawing the isohyets so that: a) the analysis agreed with every station with more than 30 years of record unless two such adjacent stations had conflicting statistics, b) the analysis conflicted with not more than one station with 10 to 30 years of record (unless the isohyetal pattern was supported by a station with more than 30 years of record), c) the analysis disregarded data from stations with less than 10 years of record except in sparse-data areas where the shape of the isohyets could not otherwise be readily visualized.

By this subjective method, which gives weight to long-record stations, it was hoped to avoid the inclusion of fictitious rainfall patterns without sacrificing the many details which would result from restricting the analysis to a standard period or length of record. Fictitious rainfall patterns could be caused by sampling errors due to short record lengths, or to the varying periods of records from different stations.

2. CALCULATION METHOD

The basic method was that developed by Gumbel (Kendall, 1959) for analyzing a series of extreme values from a Fischer and Tippet Type I distribution using their mean and standard deviation. The series of extremes used were the annual ones, each consisting of the extreme daily rainfall for each year of record. The one-day rainfalls with different return periods were computed from the mean (X) and standard deviation (S) of the series, using frequency factors (K), which depend on the sample size and the return period, in the following equation:

$$X = \overline{X} + KS$$

The equation and the calculation of the frequency factors were programmed for computer solution (AES Utility Program #26) and the program executed by the Climatic Data Processing Division of the Atmospheric Environment Service. The calculation was performed using each station's data independently. Every year of record was used whether or not the record was complete.

3. USE OF THE MAPS

Using this method of calculation, a rainfall value is said to have a N-year return period if it will be equalled or exceeded in one *year* out of N on the average. Because of the possibility of two or more large rainfalls in one year, a rainfall with a N-year return period must be multiplied by the following factors to convert it to a rainfall which occurs one *time* in N years on the average: 2-year return period, 1.14; 5-year return period, 1.04; 10-year return period, 1.01 (Hershfield, 1961). For longer return periods, the two types of values are almost identical.

Since the basic data set consists of daily rainfall values, the maps give daily rainfall probabilities. These daily rainfall extremes are, in general, less than twenty-four hour rainfall extremes which might occur partially in one day, and partially in the next day. A twenty-four hour rainfall extreme can be approximated by multiplying the daily extreme value taken from these maps by the factor 1.13 (Hershfield, 1961).

The magnitude of a rainfall with a return period which has not been mapped, can be estimated in either of two ways. Firstly, one can use the mean and standard deviation as read from the maps, and a frequency factor from tables (DS-7-70, using an average record length of 40 years) to estimate the rainfall for any return period for which the frequency factor is given. The second possibility is to plot the rainfall values with the given return periods on Gumbel Extreme Value graph paper and estimate for any other return period by interpolation or extrapolation. The relatively short periods of record makes it necessary that any values obtained for return periods of 100 years or longer be treated with caution.

Graphs giving the return period of rainfalls for durations from 5 minutes to 24 hours can be obtained from the Hydrometeorology and Marine Applications Division of the Atmospheric Environment Service for 15 different locations in the Prairie Provinces. These graphs are based solely on data from recording raingauges.

4. EFFECTS OF TOPOGRAPHY

There are substantial variations in rainfall regimes between the tops of hills or mountains and nearby valleys. In Manitoba and Saskatchewan, these variations have been shown because the changes in elevation are gradual, but in areas of Alberta the small scale of the maps precludes the inclusion of all the variations in the rainfall statistics. In addition, most of the observing stations in the mountainous areas are located in the valleys and the rainfall statistics for the mountains are not accurately known. Along the Rocky Mountains in south-western Alberta, the maps have been drawn to represent only the conditions in the valleys. In northern Alberta where the terrain is less severe and most of the reporting stations are forestry lookouts on the top of hills, the maps show the rainfalls expected at the higher elevations and may tend to be over-estimates of the rainfall extremes for valley locations.

The main pattern shown by these maps is for the most intense rainfall to occur in southwestern Manitoba (as a result of the atmospheric transport of moisture from the Gulf of Mexico), and over the foothills in southwestern Alberta due to orographic effects. There is a gradual decrease in rainfall intensity to the north and a rapid decrease westward from the foothills into the mountain valleys. This latter decrease is caused by the mountain barrier which reduces the westward transport of moisture in the lower levels of the atmosphere.

Superimposed on the main pattern are small areas of heavier rainfall caused by hills. In Manitoba, significantly more intense rainfalls occur near Turtle, Riding, Duck, and Porcupine Mountains. The relatively flat terrain in Saskatchewan causes very little variability in rainfall intensity. The major areas which have slightly more intense rainfalls are the Cypress Hills, the Pasqua Hills, and the Cactus Hills. In Alberta the rainfall intensities are quite variable because of the hilly nature of the terrain.

Less intense rainfalls occur on the east side of the major lakes in Manitoba (Lakes Winnipeg and Manitoba), because of the stabilizing effect of the lakes on the atmosphere which causes a decrease in thunderstorm intensity. For similar reasons, slightly less intense rainfalls, occur near Woolaston and Reindeer Lakes in northern Saskatchewan.

5. OTHER PUBLICATIONS

Several other publications present extreme rainfall statistics which can be used to supplement this publication. The Atlas of Rainfall Intensity-Duration-Frequency Data for Canada (Bruce, 1968) is the best single source for those interested in rainfalls of periods of less than one day. The small scale of the maps in that atlas prevents the depiction of the smaller variations in rainfall intensity. A Frequency Analysis of Maximum Two-Day and Three-Day Rainfalls in Saskatchewan, Alberta and Northeastern British Columbia (Storr, 1967) gives 5, 10 and 25 year return period values for these longer durations. Two publications by Storr, Maximum One-Day Rainfall Frequencies in Alberta (and in Saskatchewan), give some information on the seasonal variation of rainfall extremes.

In addition, several publications offer comparable statistics. However they were generally based on far fewer observing stations because the studies were limited to stations with long records during a standard period of years. Because of the much larger data base, this present publication shows a more detailed picture of the pattern of rainfall extremes.

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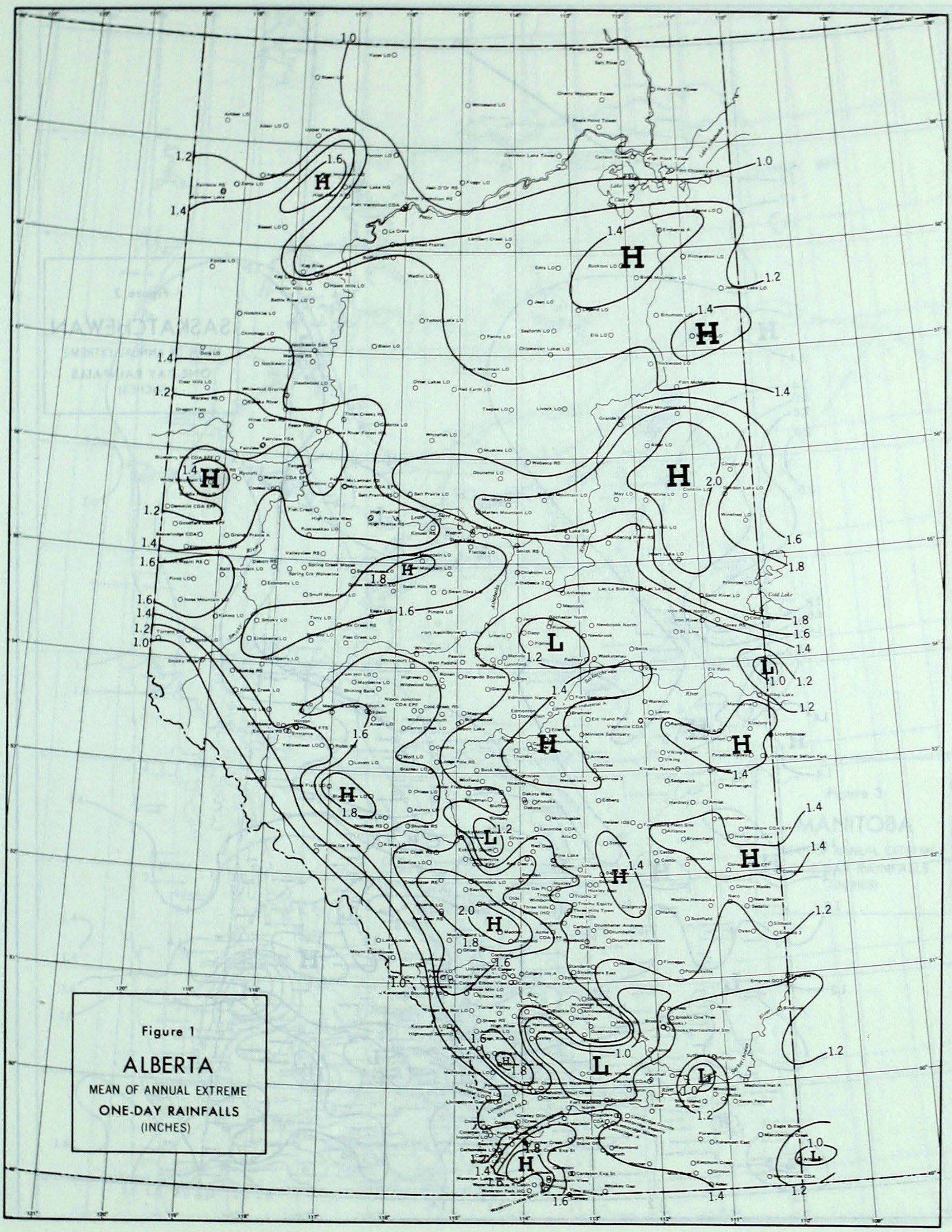


Figure 1

ALBERTA

MEAN OF ANNUAL EXTREME ONE-DAY RAINFALLS (INCHES)

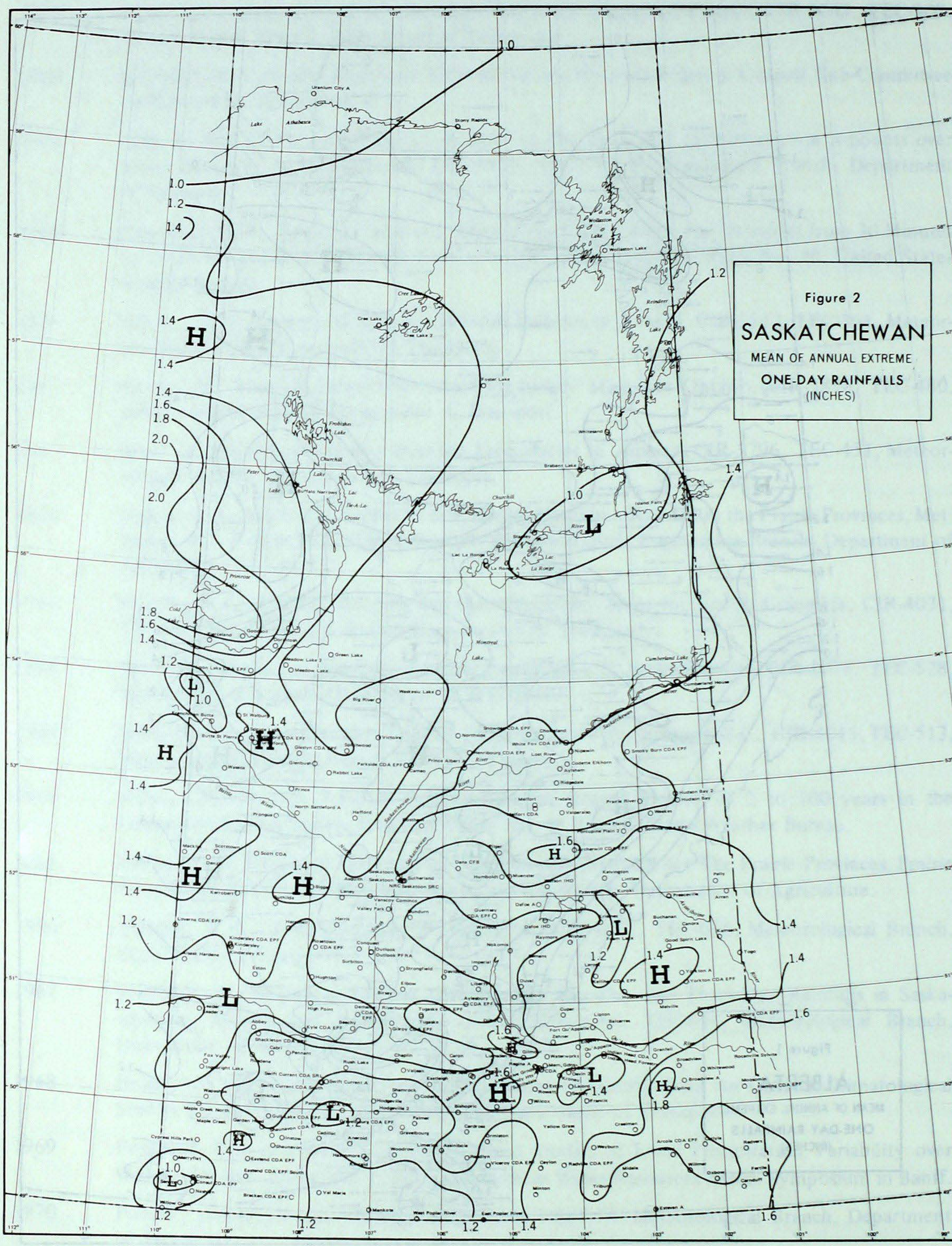


Figure 2
SASKATCHEWAN
MEAN OF ANNUAL EXTREME
ONE-DAY RAINFALLS
(INCHES)

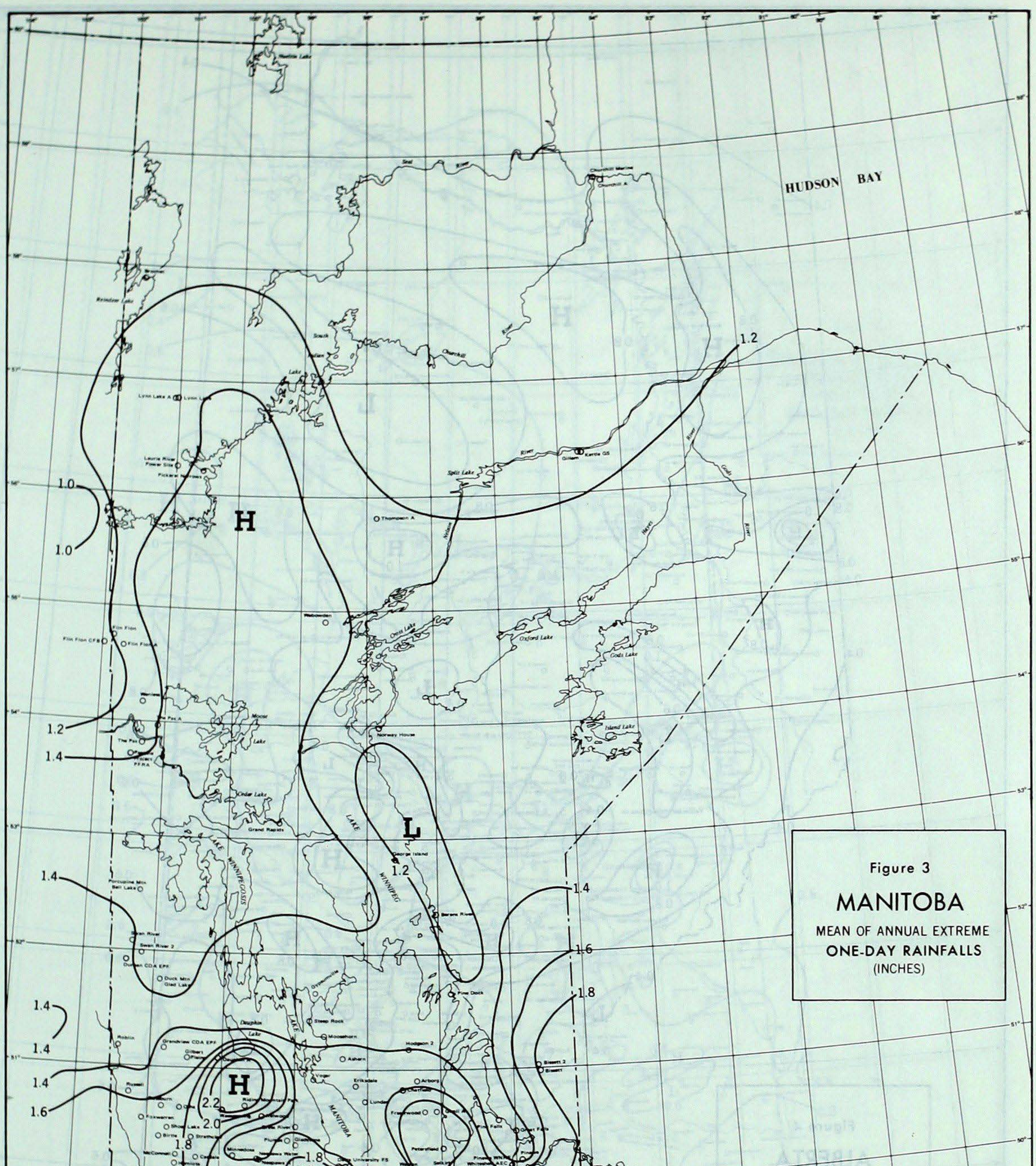


Figure 3

MANITOBA

MEAN OF ANNUAL EXTREME

ONE-DAY RAINFALLS

(INCHES)

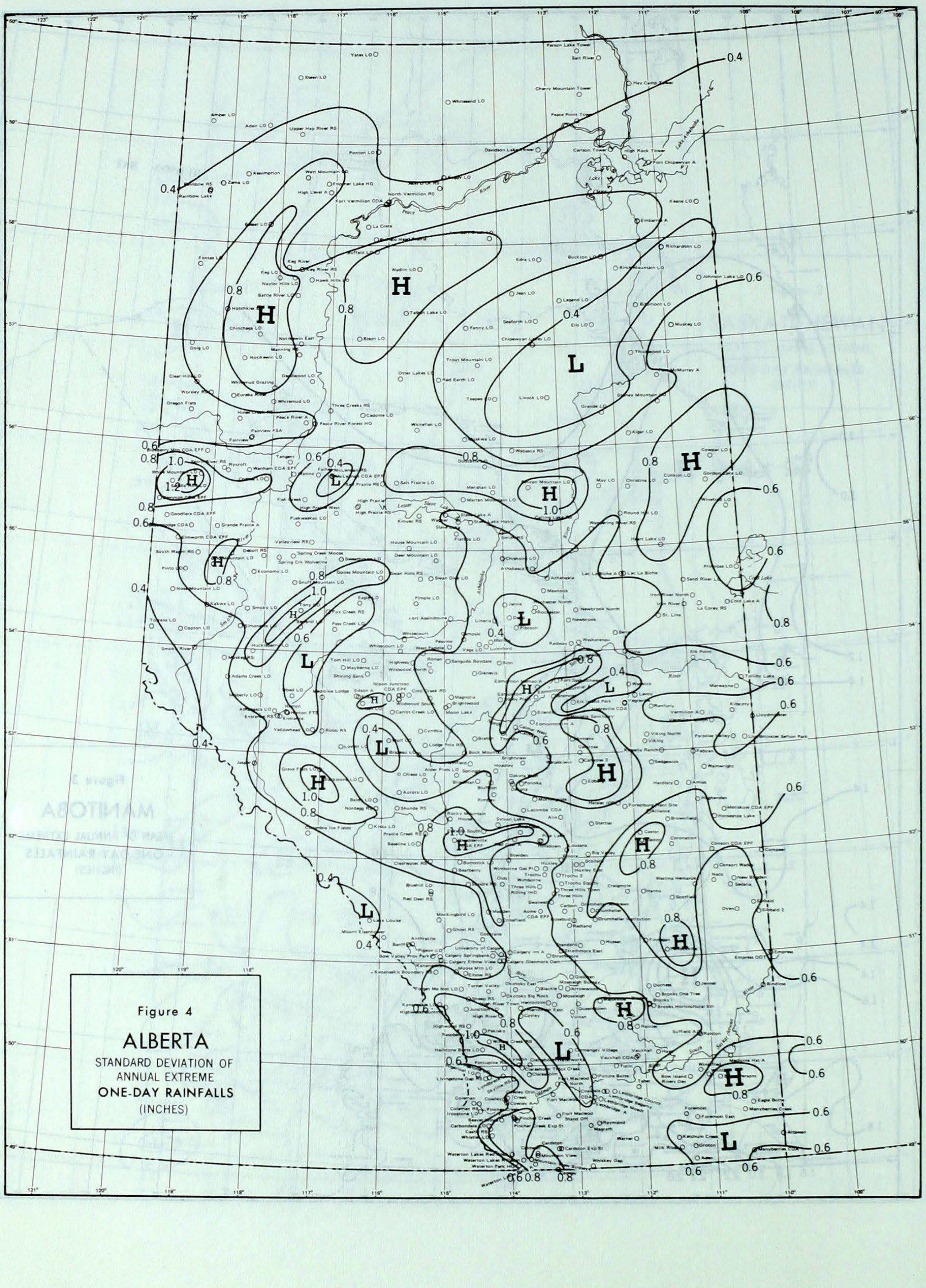
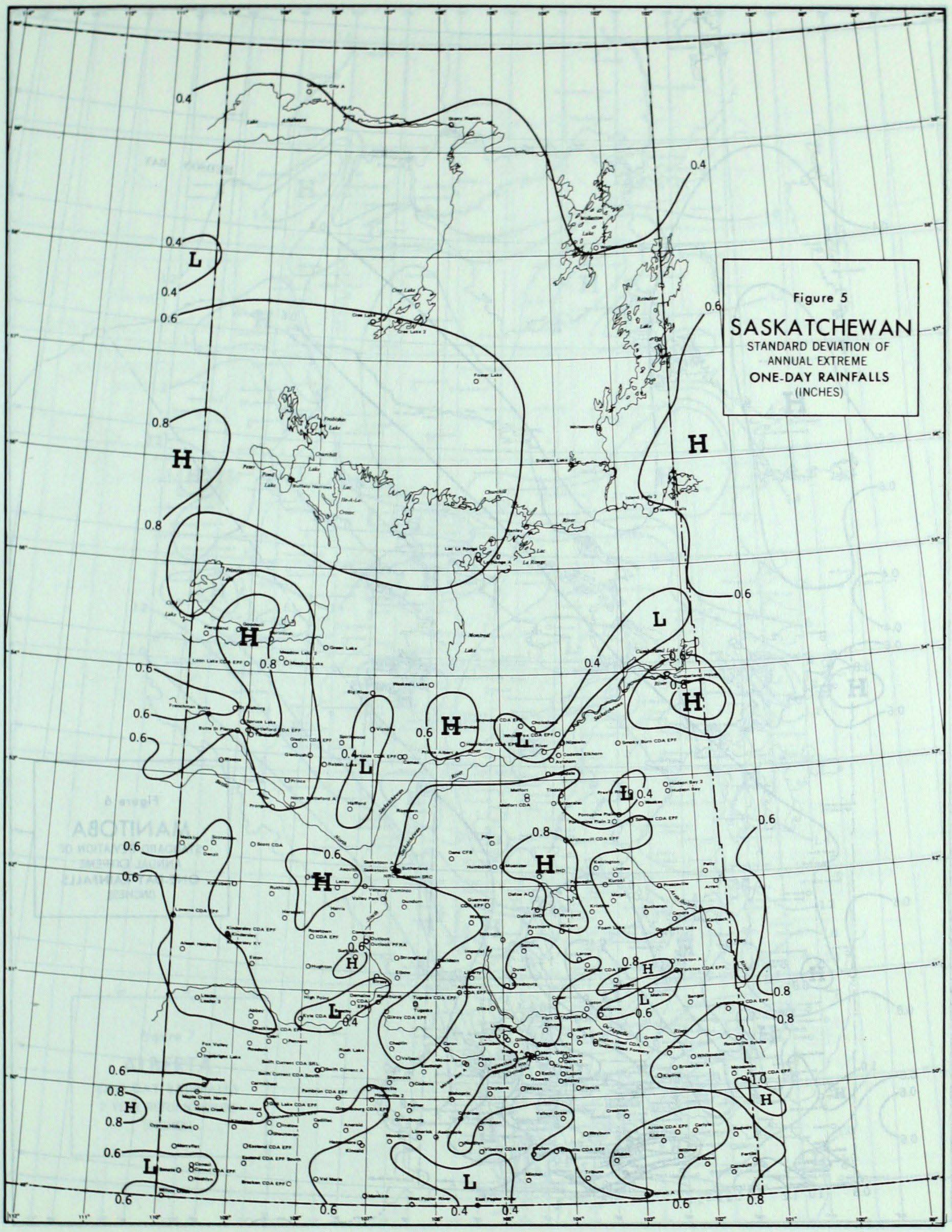


Figure 4

ALBERTA

STANDARD DEVIATION OF ANNUAL EXTREME **ONE-DAY RAINFALLS** (INCHES)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SASKATCHEWAN
STANDARD DEVIATION OF
ANNUAL EXTREME
ONE-DAY RAINFALLS
(INCHES)

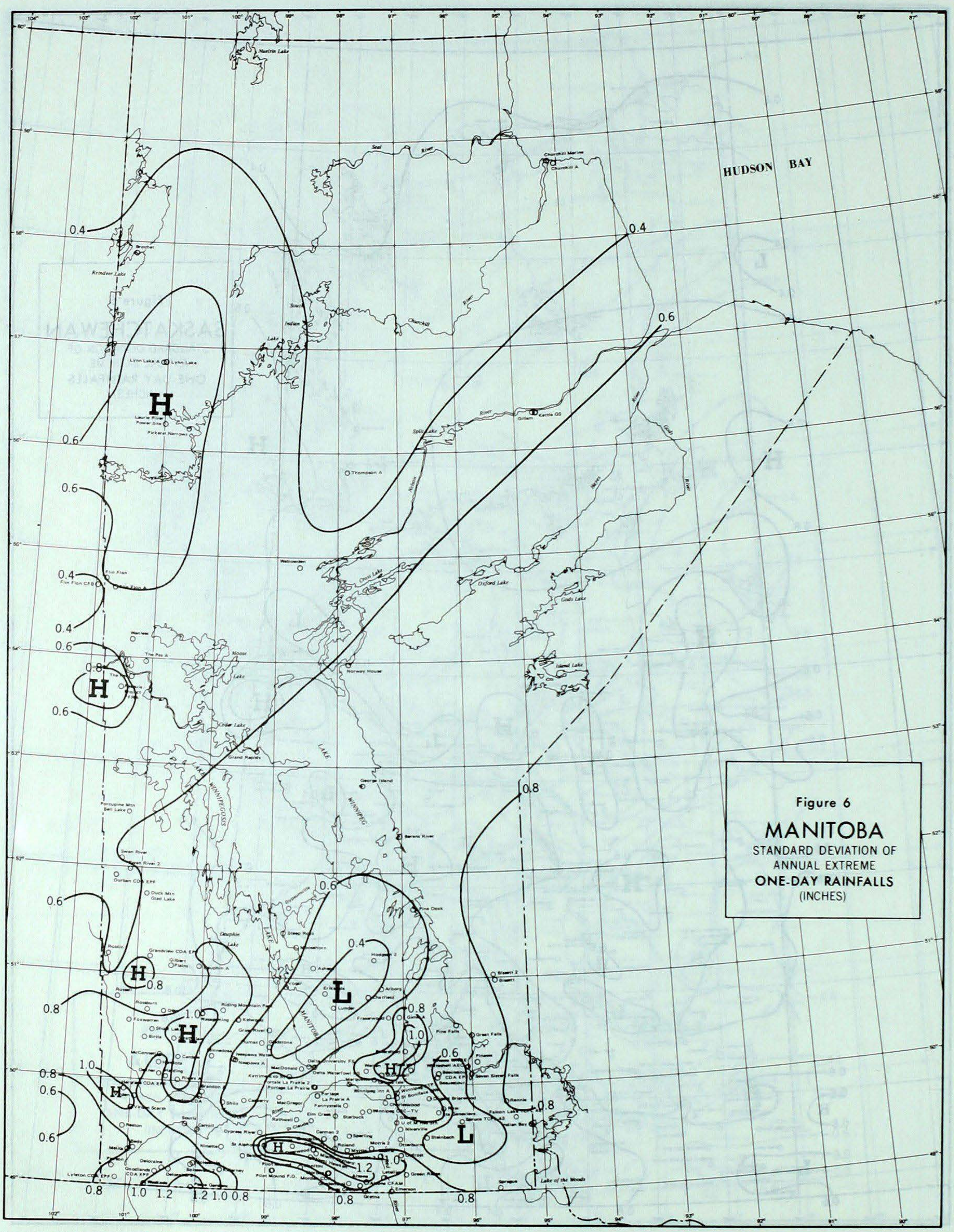


Figure 6

MANITOBA

STANDARD DEVIATION OF ANNUAL EXTREME

ONE-DAY RAINFALLS

(INCHES)

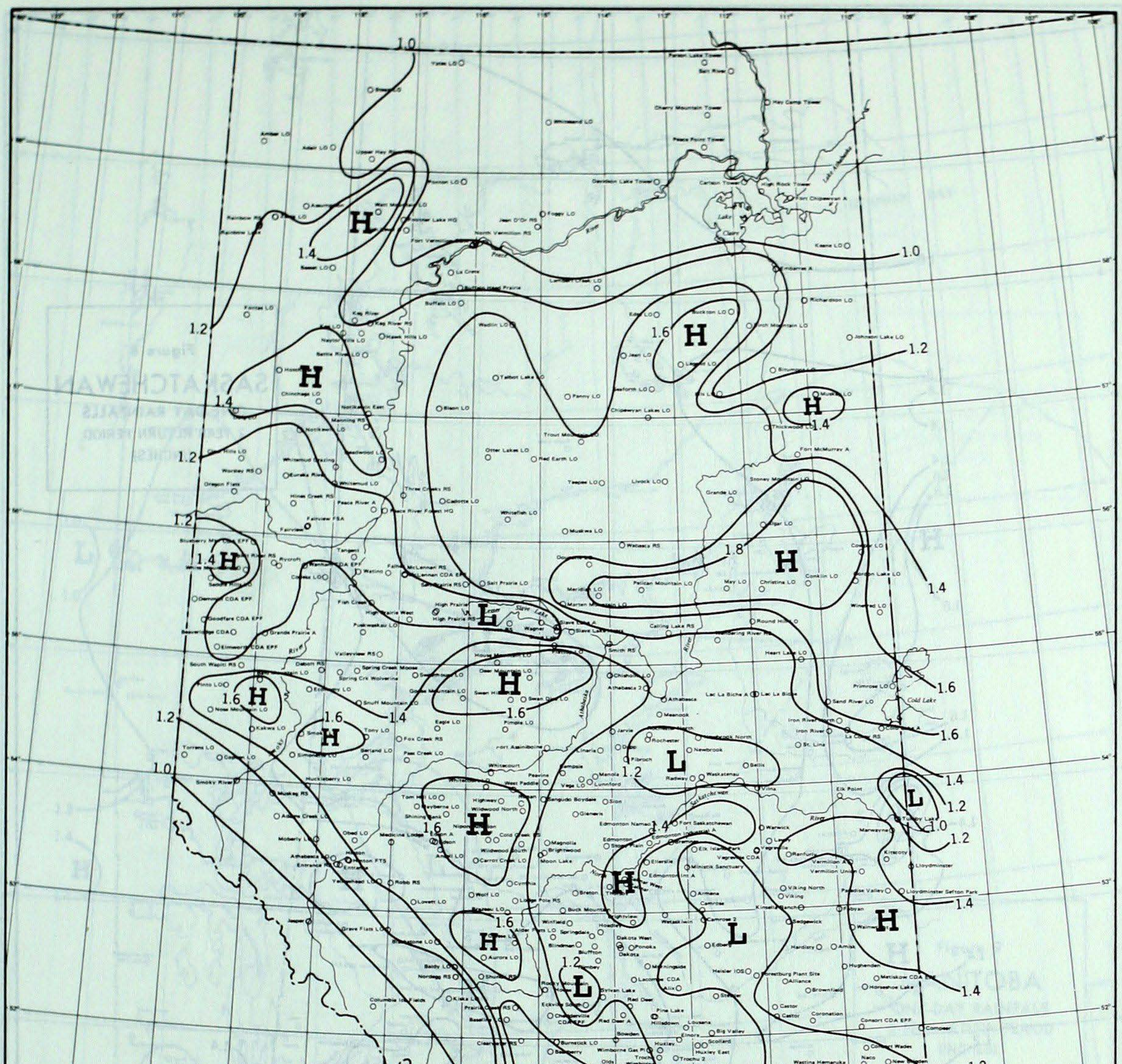


Figure 7
ALBERTA
ONE-DAY RAINFALLS
2 YEAR RETURN PERIOD
(INCHES)

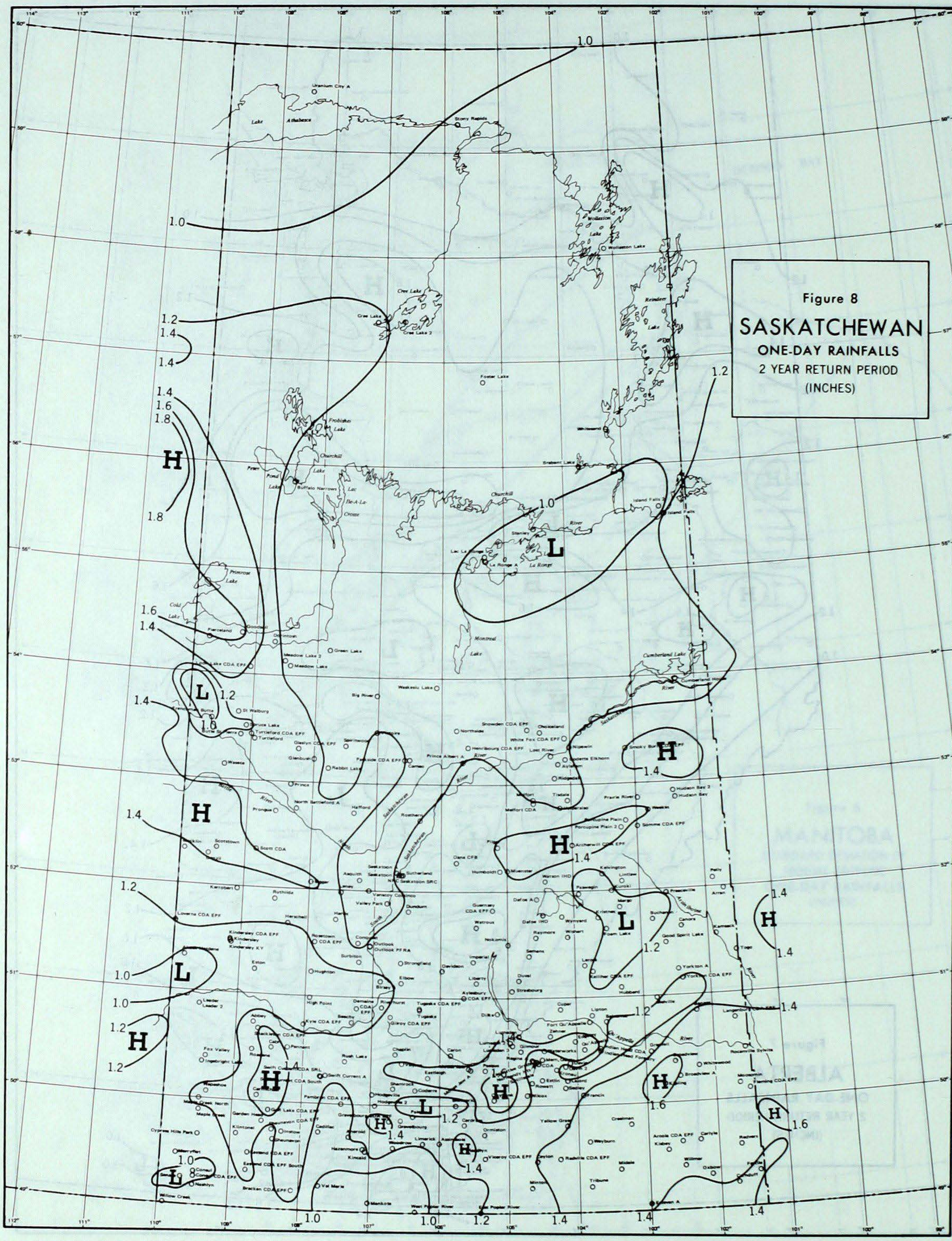
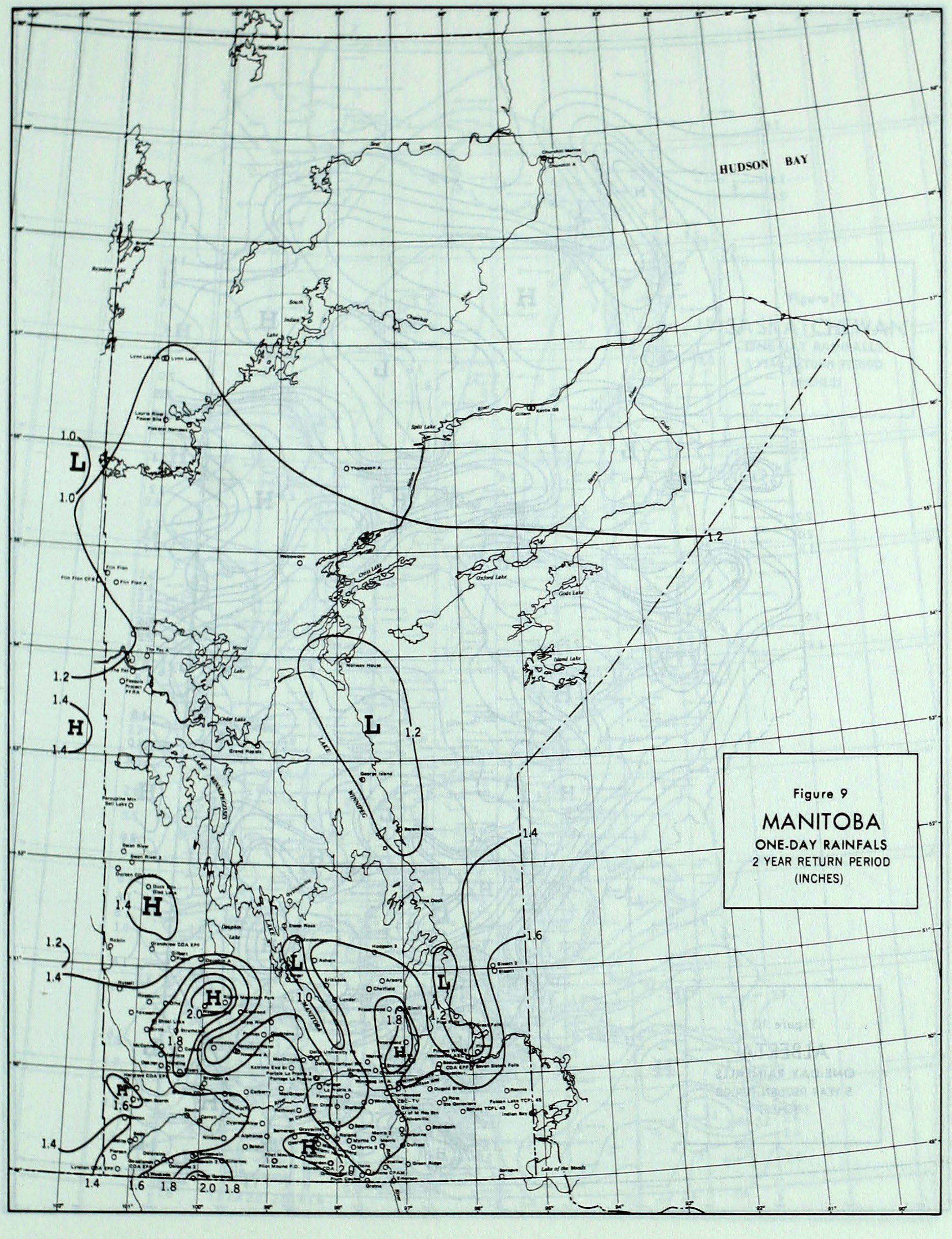


Figure 8
SASKATCHEWAN
ONE-DAY RAINFALLS
2 YEAR RETURN PERIOD
(INCHES)


HUDSON BAY
Figure 9
MANITOBA
ONE-DAY RAINFALS
2 YEAR RETURN PERIOD
(INCHES)

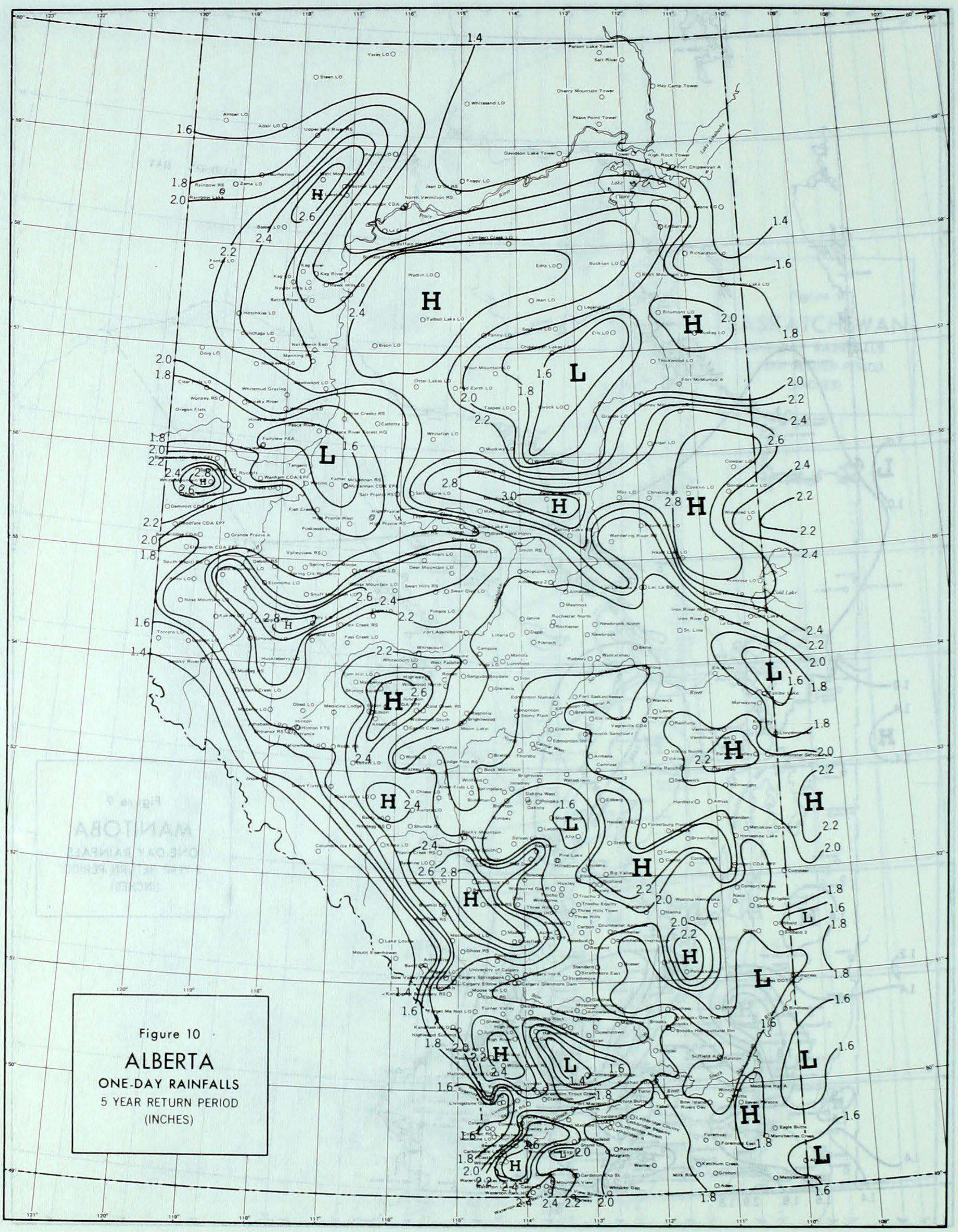
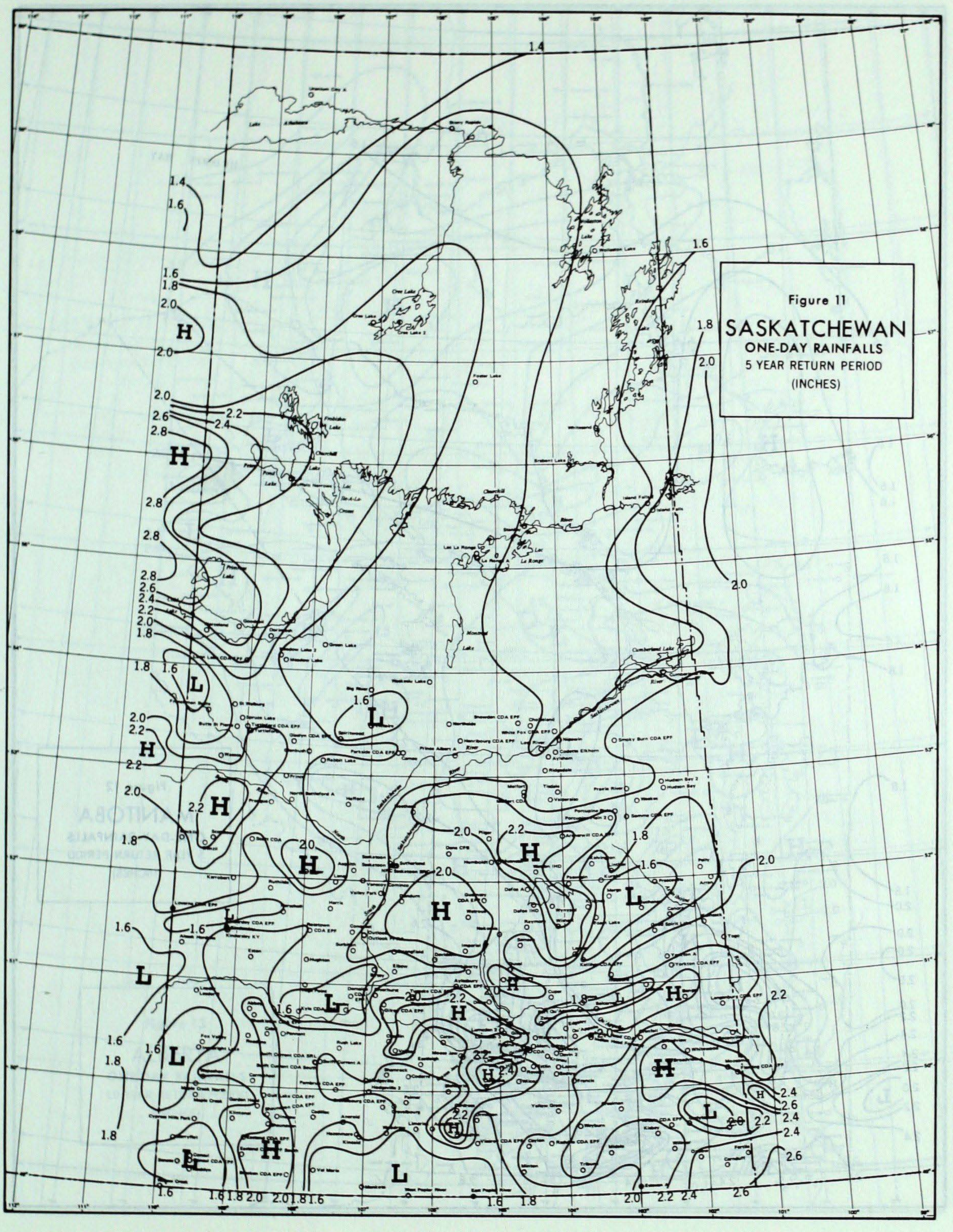


Figure 10
ALBERTA
ONE-DAY RAINFALLS
5 YEAR RETURN PERIOD
(INCHES)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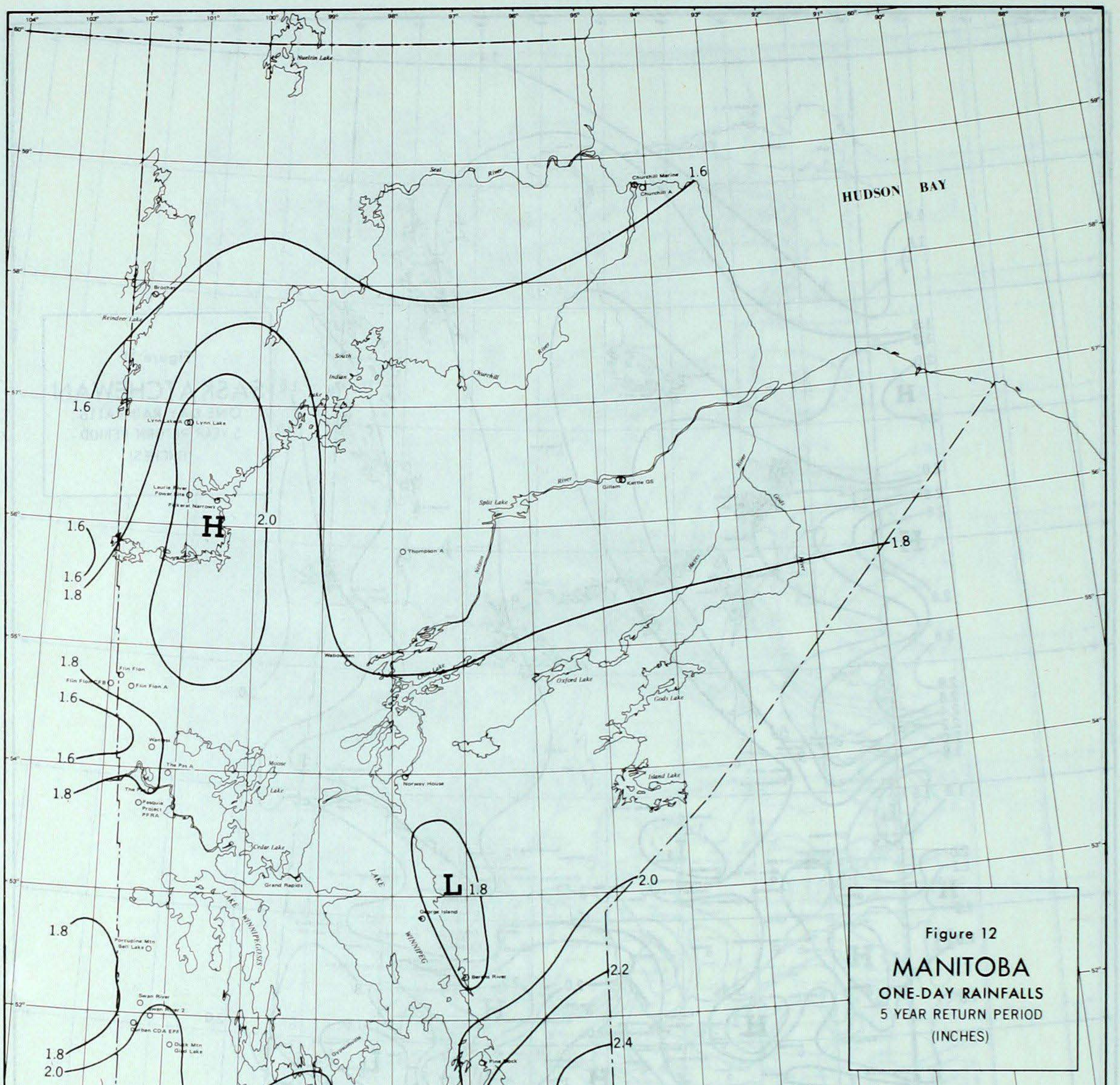
ONE-DAY RAINFALLS
5 YEAR RETURN PERIOD
(INCHES)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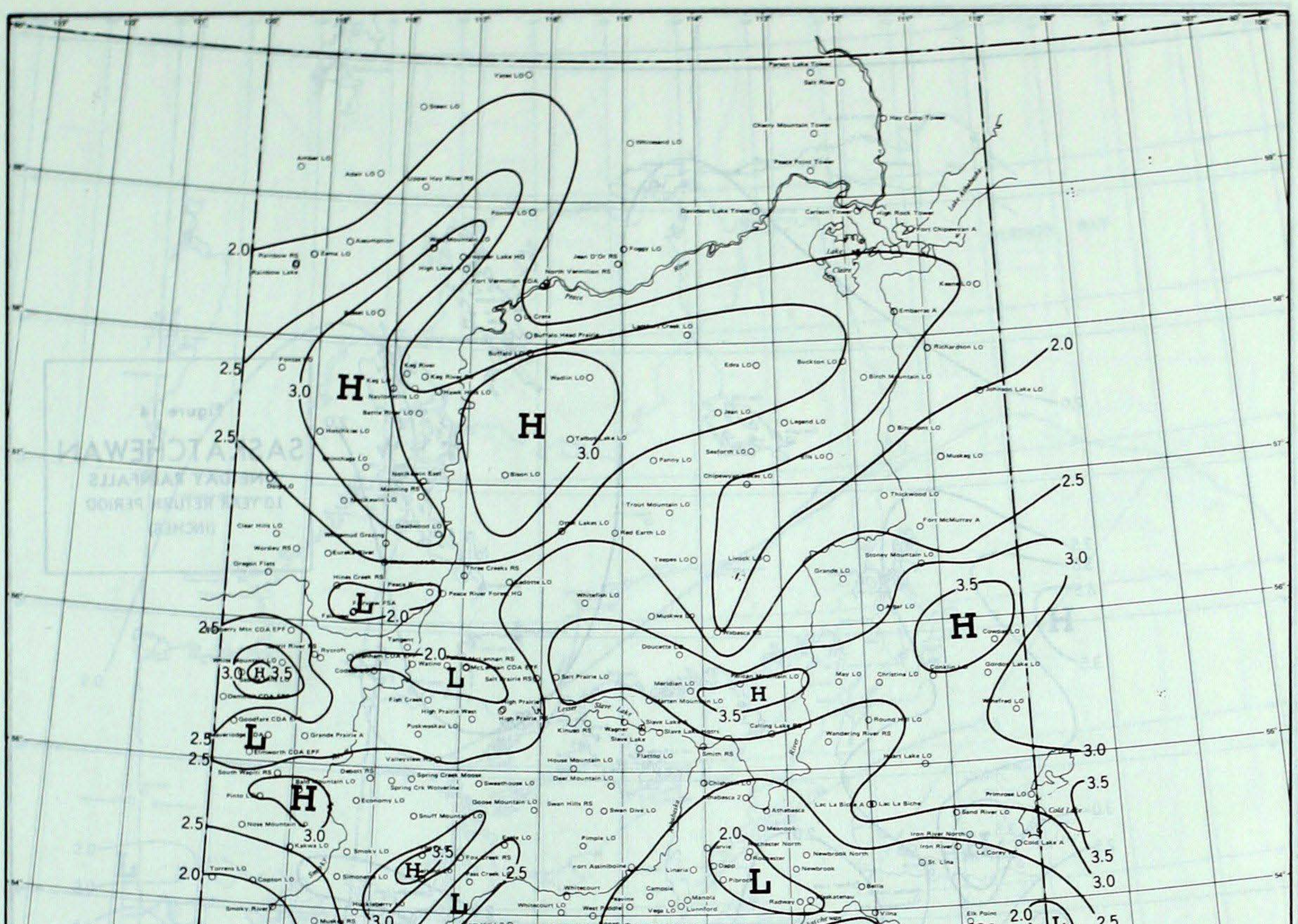
ONE-DAY RAINFALLS
5 YEAR RETURN PERIOD
(INCHES)
HUDSON BAY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ONE-DAY RAINFALLS
10 YEAR RETURN PERIOD
(INCHES)

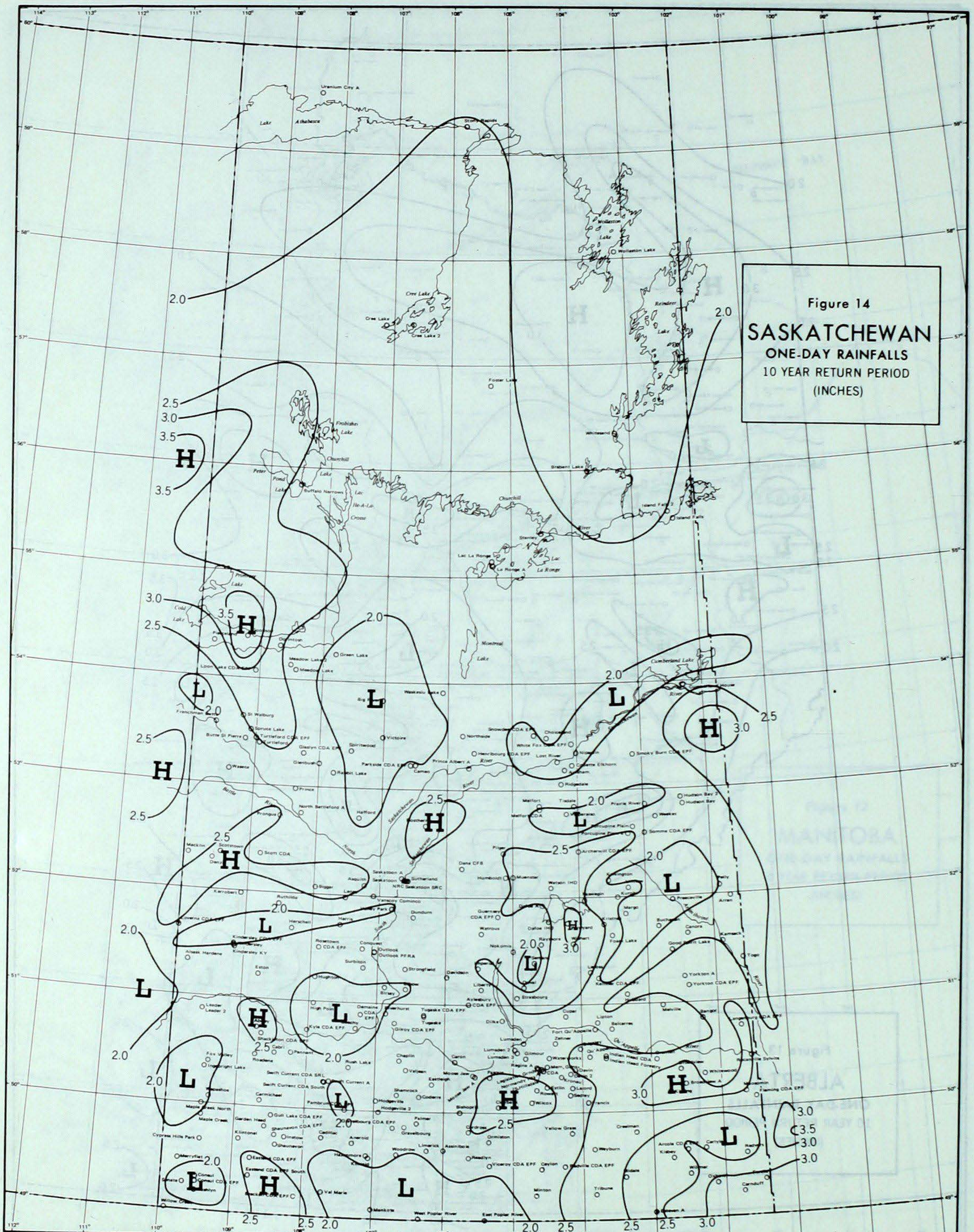


Figure 14
SASKATCHEWAN
ONE-DAY RAINFALLS
10 YEAR RETURN PERIOD
(INCHES)

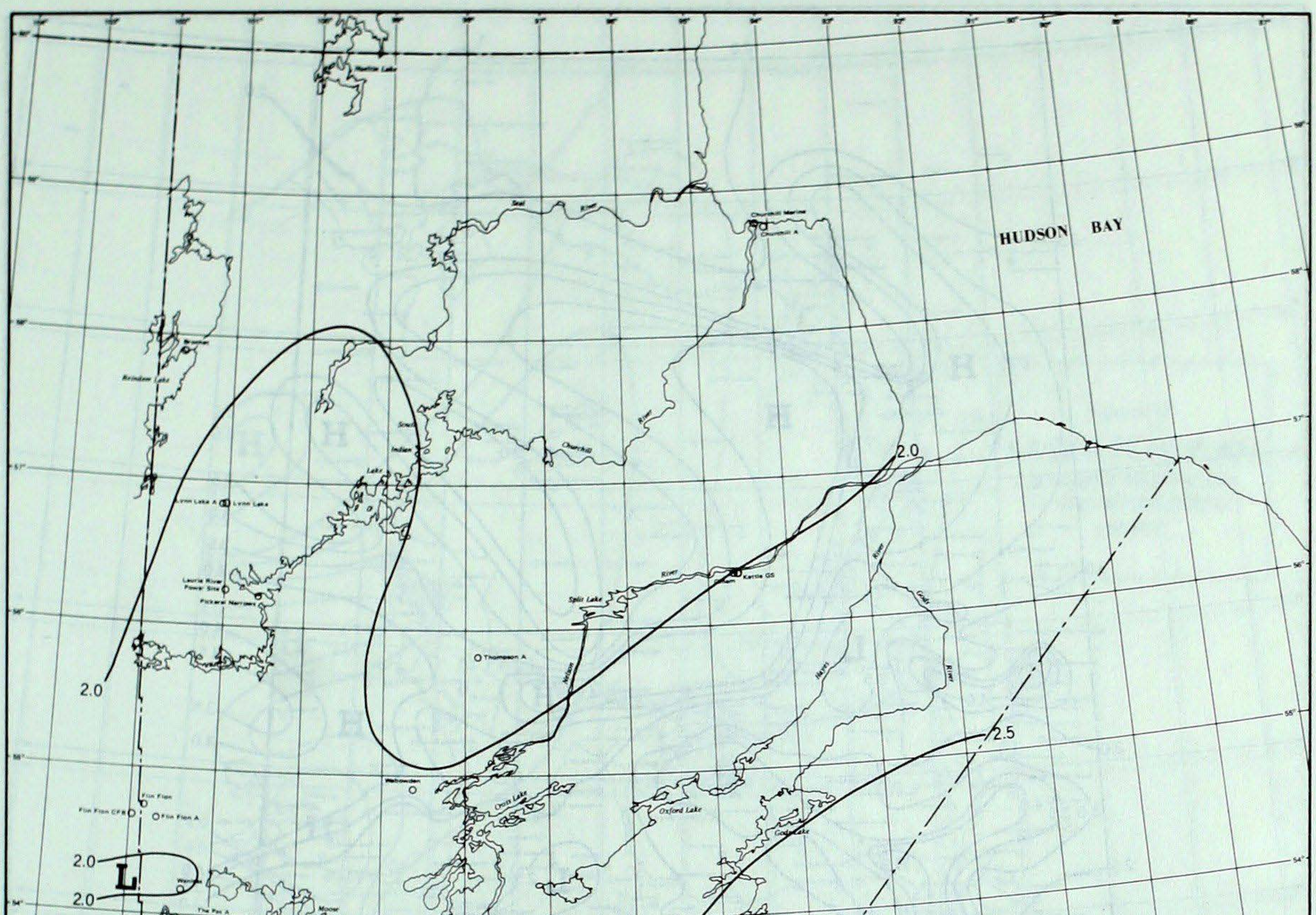


Figure 15
MANITOBA
ONE-DAY RAINFALLS
10 YEAR RETURN PERIOD
(INCHES)

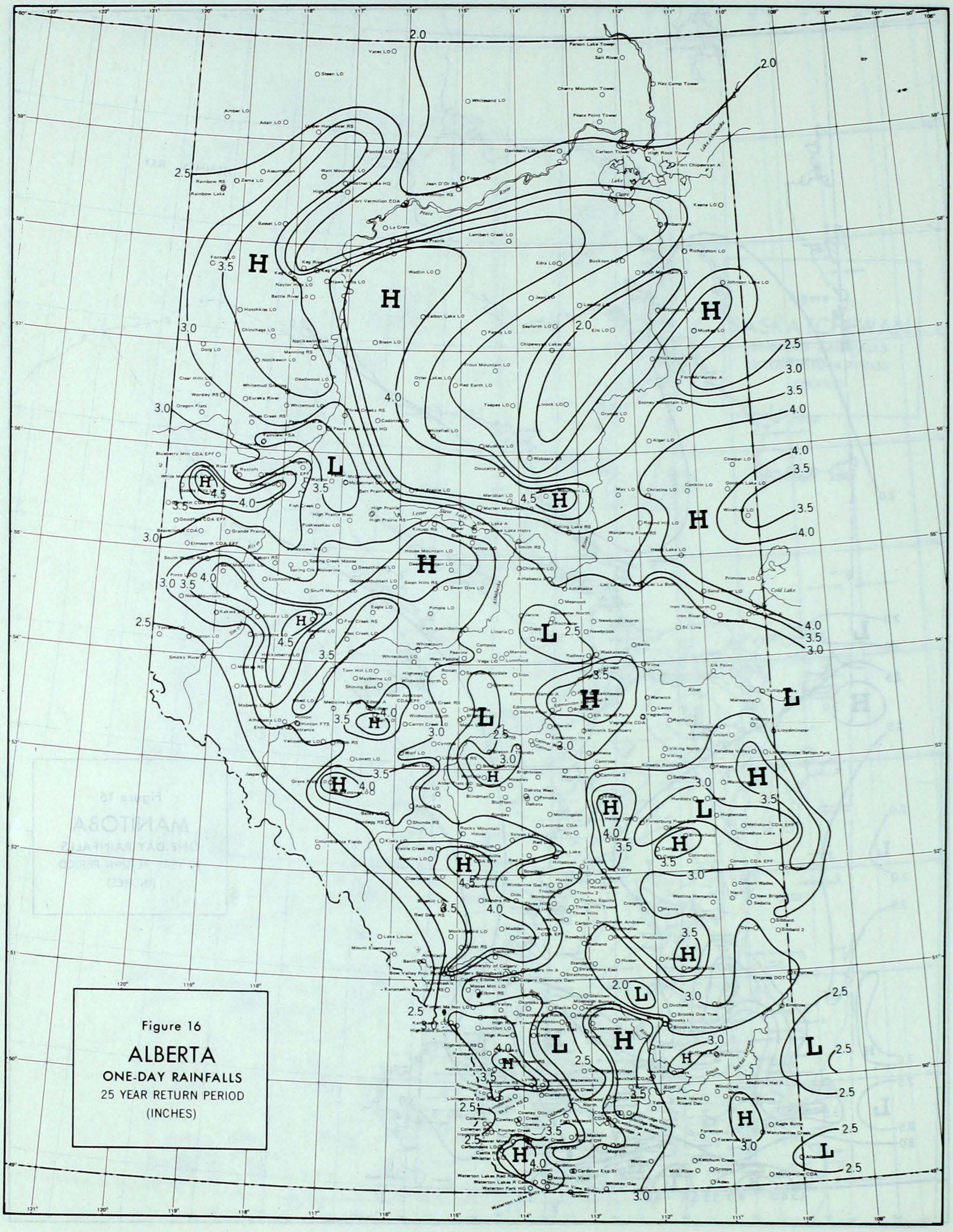


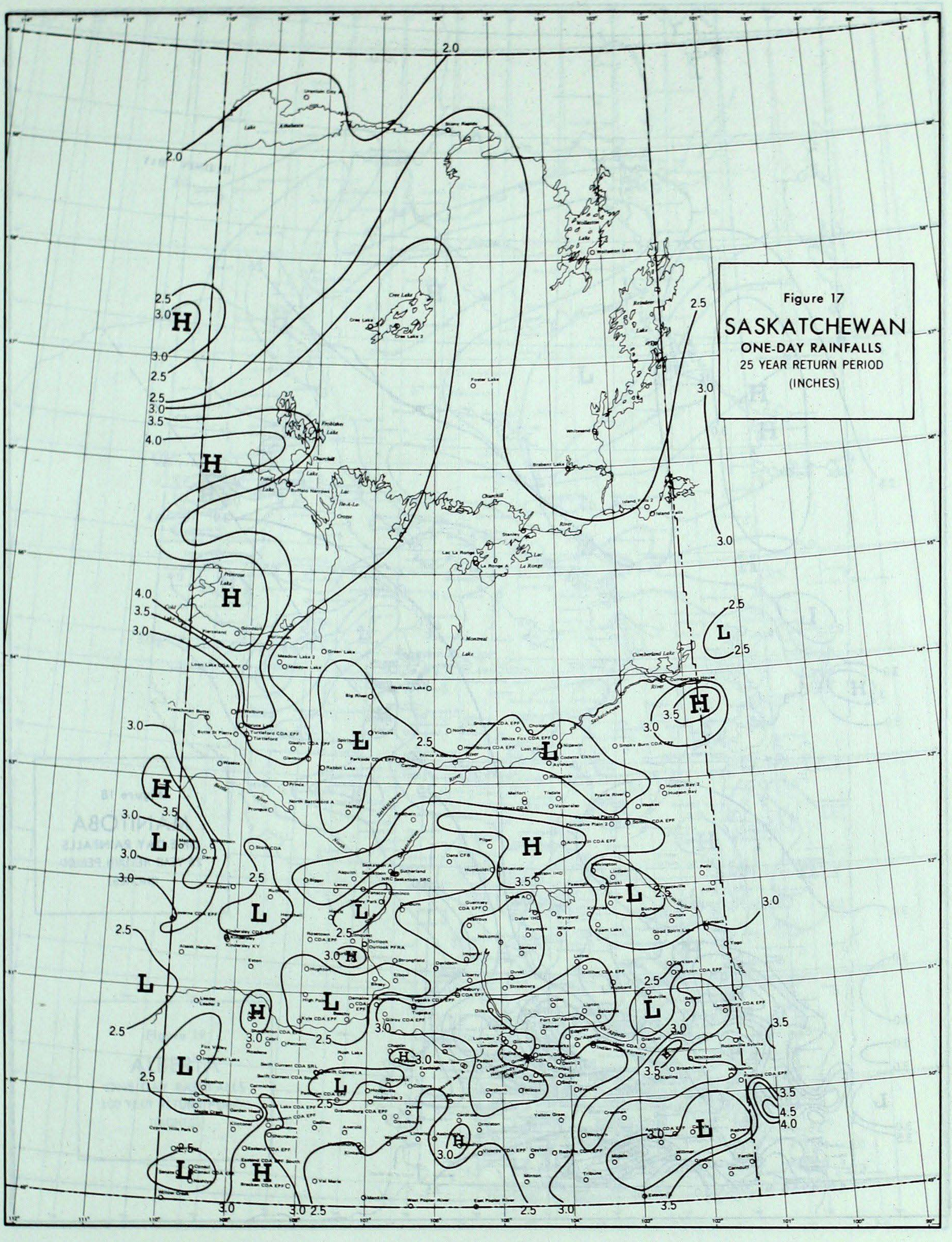
Figure 16

ALBERTA

ONE-DAY RAINFALLS

25 YEAR RETURN PERIOD

(INCHES)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ONE-DAY RAINFALLS
25 YEAR RETURN PERIOD
(INCHES)

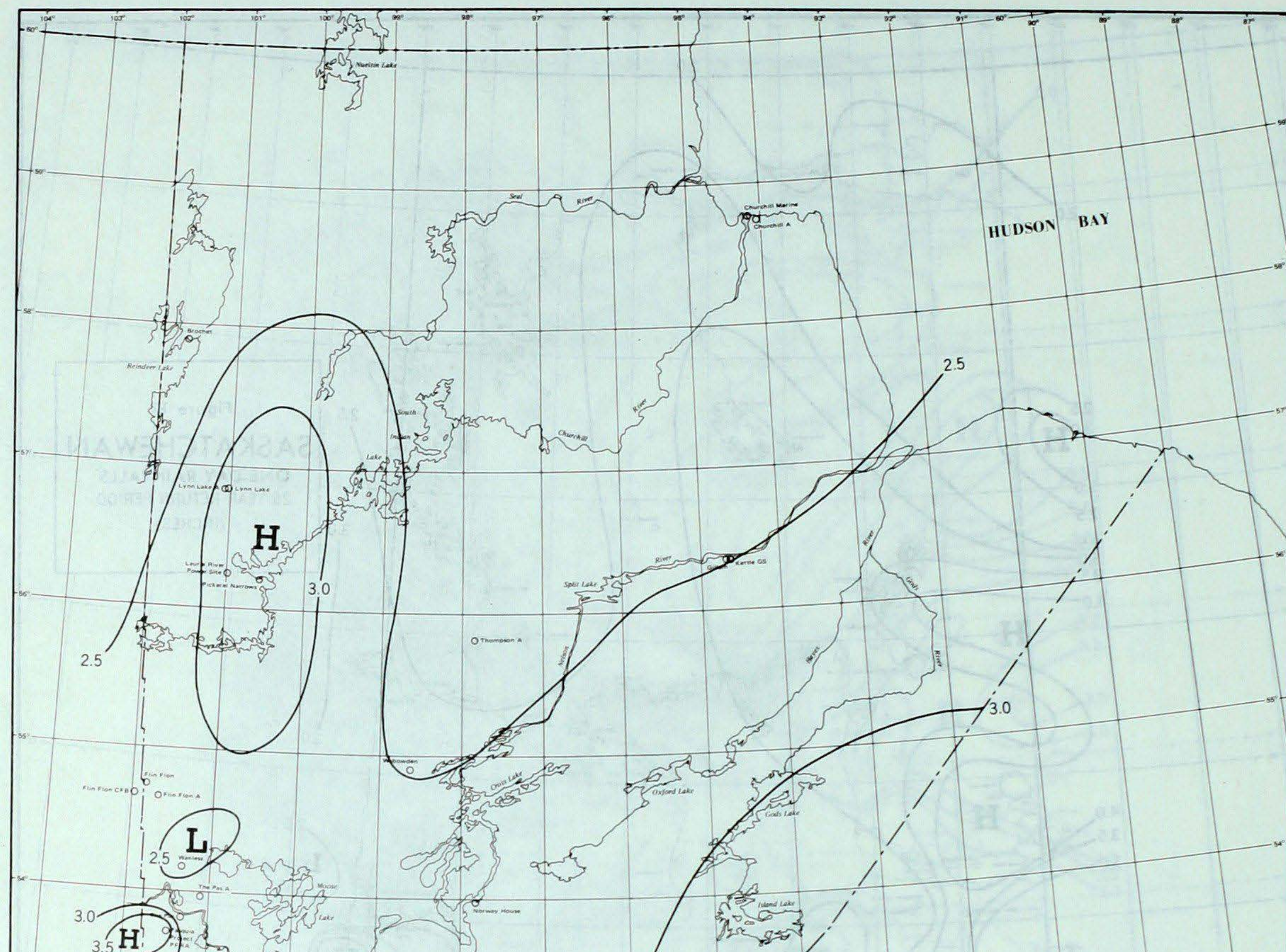

Figure 18

MANITOBA

ONE-DAY RAINFALLS

25 YEAR RETURN PERIOD

(INCHES)

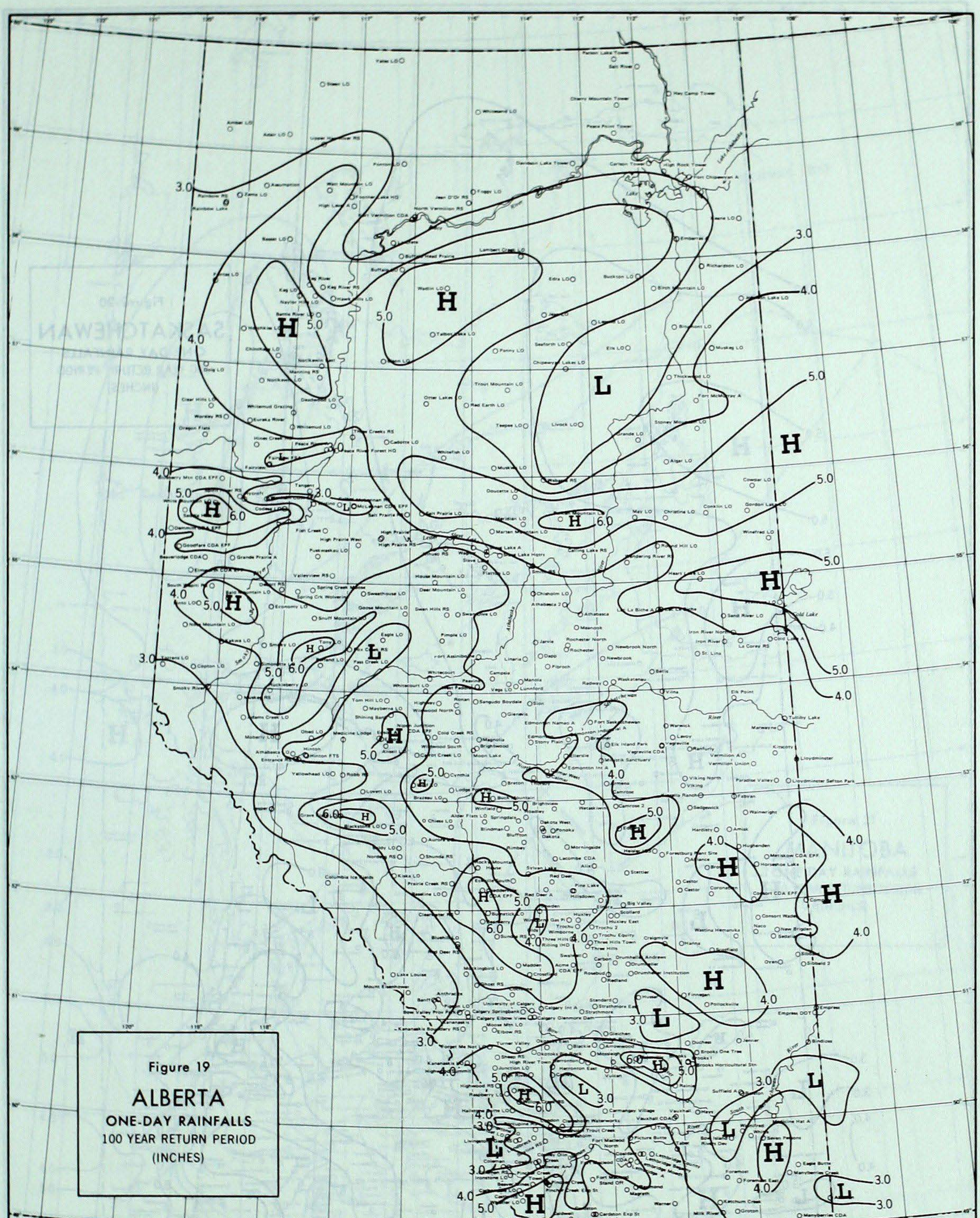

Figure 19

ALBERTA

ONE-DAY RAINFALLS
100 YEAR RETURN PERIOD
(INCHES)

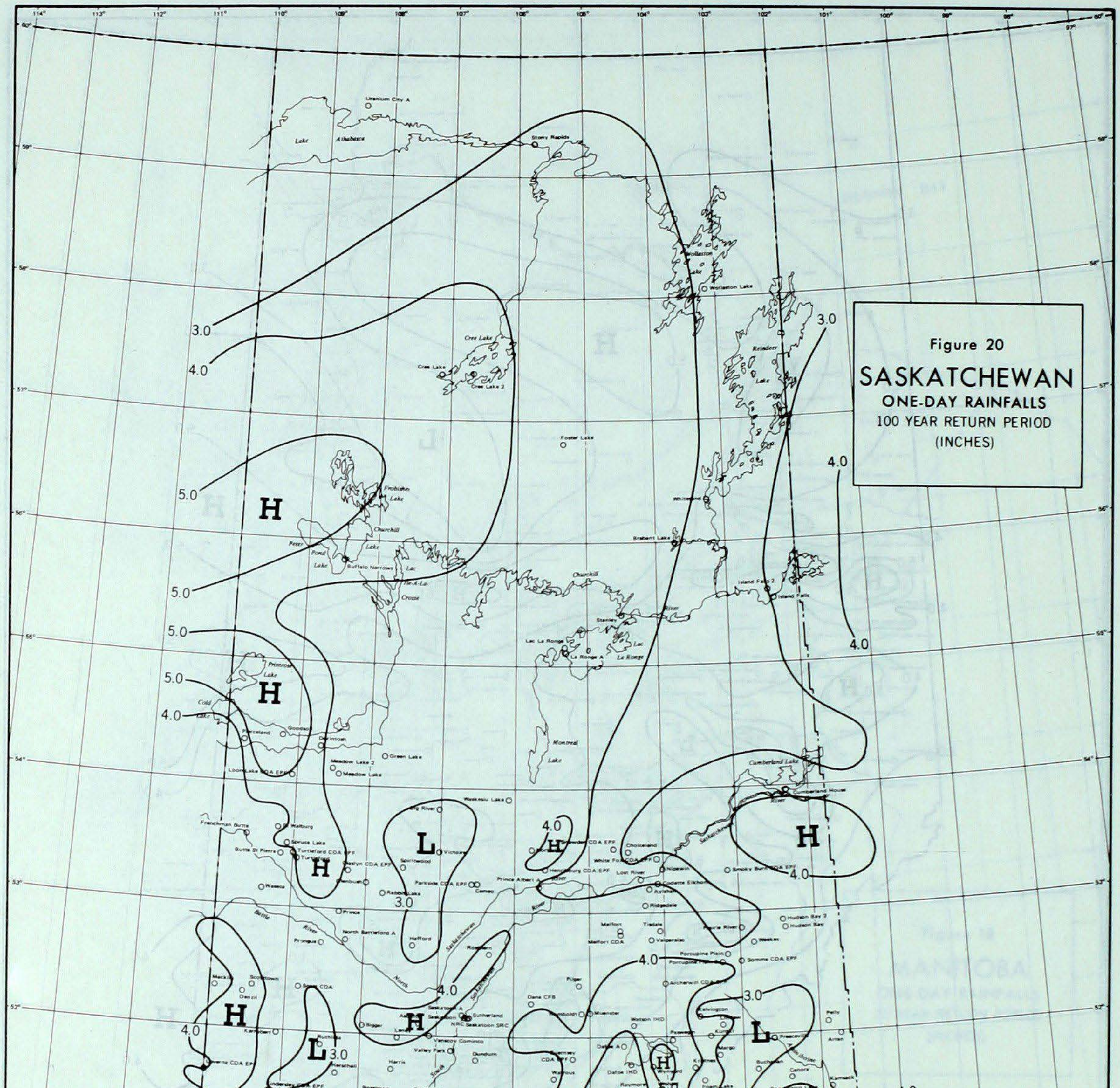

Figure 20
SASKATCHEWAN
ONE-DAY RAINFALLS
100 YEAR RETURN PERIOD
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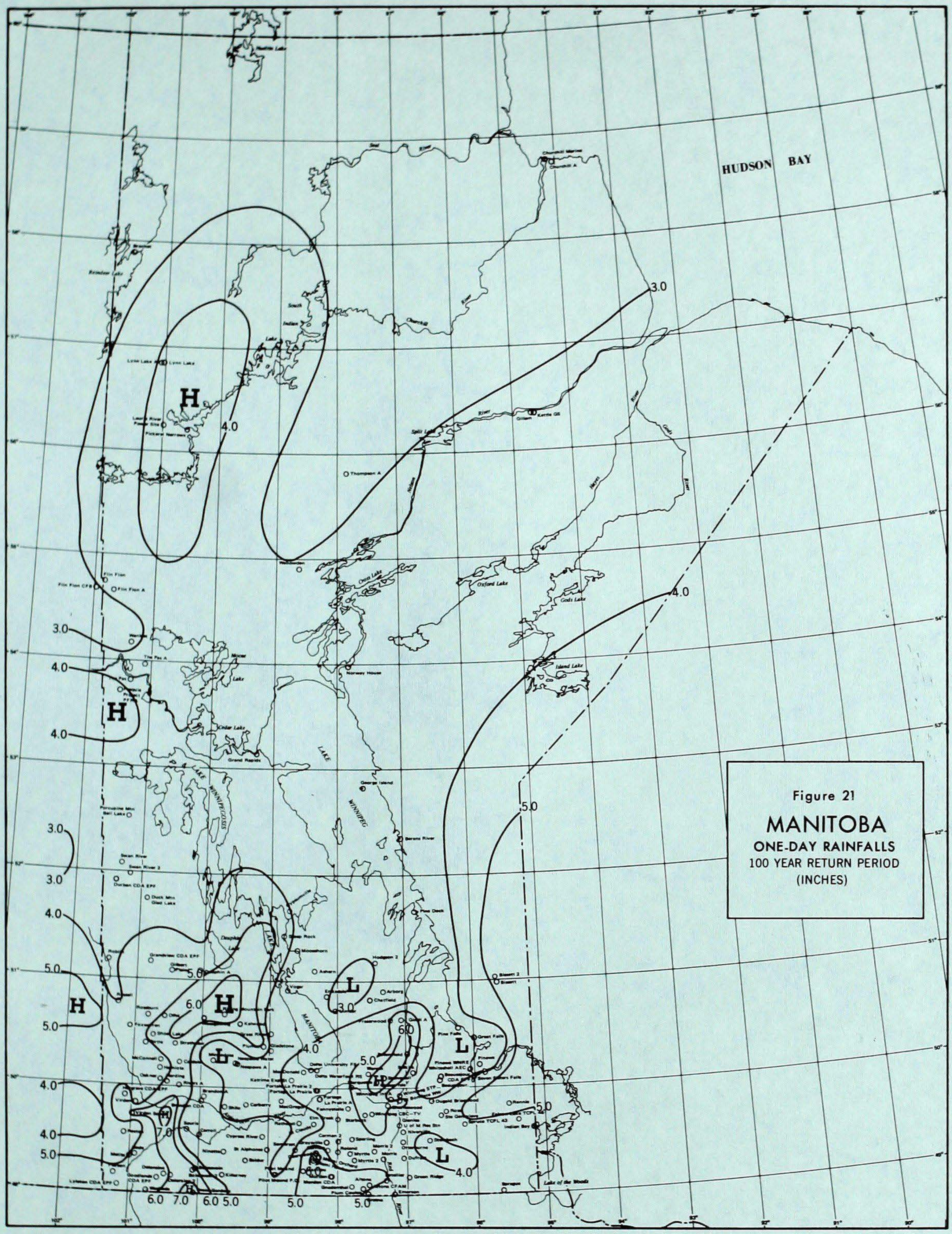

Figure 21

MANITOBA

ONE-DAY RAINFALLS

100 YEAR RETURN PERIOD

(INCHES)