

INFORMATION TO USERS

This material was produced from a microfilm copy of the original document. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the original submitted.

The following explanation of techniques is provided to help you understand markings or patterns which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting thru an image and duplicating adjacent pages to insure you complete continuity.
2. When an image on the film is obliterated with a large round black mark, it is an indication that the photographer suspected that the copy may have moved during exposure and thus cause a blurred image. You will find a good image of the page in the adjacent frame.
3. When a map, drawing or chart, etc., was part of the material being photographed the photographer followed a definite method in "sectioning" the material. It is customary to begin photoing at the upper left hand corner of a large sheet and to continue photoing from left to right in equal sections with a small overlap. If necessary, sectioning is continued again — beginning below the first row and continuing on until complete.
4. The majority of users indicate that the textual content is of greatest value, however, a somewhat higher quality reproduction could be made from "photographs" if essential to the understanding of the dissertation. Silver prints of "photographs" may be ordered at additional charge by writing the Order Department, giving the catalog number, title, author and specific pages you wish reproduced.
5. PLEASE NOTE: Some pages may have indistinct print. Filmed as received.

Xerox University Microfilms

300 North Zeeb Road
Ann Arbor, Michigan 48106

76-15,801

DIBA, Mahmoud Hossein, 1946-
THE RESPONSE OF A NATURAL GAS RESOURCE BASE
TO DRILLING ACTIVITY.

The University of Oklahoma, Ph.D., 1976
Engineering, petroleum

Xerox University Microfilms, Ann Arbor, Michigan 48106

© 1976

MAHMOUD HOSSEIN DIBA

ALL RIGHTS RESERVED

THE UNIVERSITY OF OKLAHOMA
GRADUATE COLLEGE

THE RESPONSE OF A NATURAL GAS RESOURCE BASE
TO DRILLING ACTIVITY

A DISSERTATION
SUBMITTED TO THE GRADUATE FACULTY
in partial fulfillment of the requirements for the
degree of
DOCTOR OF PHILOSOPHY

BY
MAHMOUD HOSSEIN DIBA
Norman, Oklahoma
1975

THE RESPONSE OF A NATURAL GAS RESOURCE BASE
TO DRILLING ACTIVITY

APPROVED BY

Paul J. Root

Henry Crivello

Dr. W. M. Craig

J. M. Townsend

Arthur Bernhart

DISSERTATION COMMITTEE

DEDICATION

It is with deep feelings of honor and respect that I sincerely dedicate this dissertation to His Imperial Majesty Mohammed Reza Pahlavi Aryamehr Shahanshah of Iran in gratitude for all His Majesty has done and accomplished for my country, Iran, and its people.

In view of the fact that His Majesty has devoted his life to the country, the brevity of this dedication seems woefully inadequate.

Under His Majesty's leadership, progress has been made in raising the quality of life at all levels in Iran. In particular, the White Revolution His Majesty initiated has been so successful and beneficial that leaders of other countries are trying to imitate the same program and apply the same principles.

In utilization of the nation's natural resources His Majesty's guidance has been extremely brilliant. Under His Majesty's leadership Iran's oil and gas industry has grown from a disorganized and inefficient operation to one of the largest and most effective energy systems in the world. His Majesty's support and guidance of the Organization of Petroleum Exporting Countries (OPEC) was a significant factor in the development of that organization into a powerful

tool for assuring oil producing countries of a fair price for exported raw material and products that tend to counter-balance inflation of needed imports. This provided funds for the development of industrial, educational and military sectors of the country and made it possible for Iran to supply financial assistance to other countries.

Internally, the oil and gas industry is now being managed on the basis that these resources are depletable and therefore careful planning must be used to guarantee maximization of the benefits to Iran. The most striking example of this is His Majesty's insistence on the prevention of the waste of natural gas and promotion of its conservation so that it can be used as a fuel or petrochemical feedstock and exported by pipeline to Russia and potentially to West Germany and perhaps as liquified natural gas or methanol to Western Europe, the United States and Japan.

Finally, I am extremely excited and anxious to return home in order to serve His Majesty and my country.

Mahmoud Hossein Diba

ACKNOWLEDGEMENTS

The author is sincerely grateful to Dr. Paul J. Root, chairman of his committee, for suggesting this area of research and for directing this study. I am especially grateful for having had the opportunity to do research with timely, rapidly-evolving analytical tools that are of importance in resource planning and will be extremely useful in my future services to my King and my country. I would also like to convey my gratitude to Dr. Root for his confidence, encouragement, assistance, and guidance throughout the entire program of my advanced study leading to this work.

I also wish to express my thanks and profound gratitude to Dr. Henry B. Crichlow, Director of the School of Geological and Petroleum Engineering, co-chairman of my committee, and Dr. Arthur W. McCray for the guidance, direction, and encouragement given during and throughout the entire program of my advanced study leading to this work.

Appreciation is extended also to Dr. F. M. Townsend and Dr. Arthur F. Benhart, members of my doctoral committee, for reading the manuscript and making many useful suggestions.

Special thanks are extended to Dr. Sam Sofer, Director of the School of Chemical Engineering and Material Science for his helpful advice on the technical aspects of the study

and for taking time to review the manuscript and attend the final defense of the dissertation.

I am grateful to the Pahlavi Foundation and the Petroleum Engineering Department of the University of Oklahoma for providing partial financial assistance over the course of this research.

Finally, I am sincerely grateful to my father, Dr. Amir Nasser Diba, for giving me the motivation, encouragement, and guidance in order to enable me to receive the best education possible and reach this level of education. I would also like to express my gratitude to my mother, Mrs. Azar Diba, for her patience, guidance, and the sacrifices she has made to enable me to get this education. In addition, special thanks to Miss Dee Roe for her assistance in preparing the manuscript.

ABSTRACT

In order to predict the future supply of natural gas in the U.S. many factors must be taken into account. The complete and detailed study of the physical characteristics, types, and resource base properties of natural gas needs to be considered and discussed. In addition, the mode of origin and accumulation, the past history and background including the number, size, and distribution of gas discoveries, production, demand and remaining reserves are discussed.

A description of the above factors is presented in this dissertation to set the stage for the development of a probability model in which the Monte-Carlo method was used to simulate the development of the gas resources in a number of geologic provinces. The use of the model is demonstrated and the results run for several hypothetical combinations of geological provinces are presented. The applicability of the model in describing the development of the gas resources for a composite resource base is shown and the behavior of such a resource base is analyzed.

TABLE OF CONTENTS

	Page
DEDICATION	iii
ACKNOWLEDGEMENTS	v
ABSTRACT	vii
LIST OF TABLES	x
LIST OF FIGURES	xviii
 Chapter	
I. PHYSICAL CHARACTERISTICS OF PETROLEUM RESOURCES	1
A. Composition and the Btu Content of Natural Gas	2
B. Types of Natural Gas	4
C. Domestic Resources Locations	5
D. Origin and Accumulation	5
E. History and Background	6
F. Natural Gas Production in U.S.	8
G. Demand Considerations	8
II. FUTURE SUPPLY PROJECTIONS FOR THE U.S. THROUGH THE YEAR 1995	12
A. Nuclear Stimulation and Hydraulic Fracturing of Low Permeability Reservoirs	13
B. Production of Natural Gas from Artificial or Substitute Natural Gas	15
C. Massive Exploration and Development of Onshore as Well as Prospective Offshore Areas Owned by the Government	18
D. Increased Pipeline Imports of Gas from Canada and Mexico	20
E. Importation of Liquefied Natural Gas (LNG) and Hydrocarbon Liquids	21
F. Transportation of Alaskan Gas	23
G. Importation of Methanol Manufactured from Foreign Natural Gas Sources and Transported To U.S. by Tanker	24
H. Hydrogen	25

Chapter	Page
III. U.S. RESOURCES OF NATURAL GAS AND NATURAL GAS ESTIMATIONS	26
A. Natural Gas Resource Description	26
B. Natural Gas Resource Base Classifications	27
C. Future Estimate of Potential Gas Supply	30
D. Natural Gas Reserves	31
E. Purpose of Drilling Discovery and Development Wells	33
F. Domestic Resource Quantities	37
IV. METHODS FOR MAKING NATURAL GAS RESOURCE ESTIMATES	41
A. Total Discovered Reserve Estimate	41
B. The Potential Gas Supply Estimates	43
C. Accuracy of the Resource Estimate	61
V. DESCRIPTION OF THE MODEL	64
VI. MATHEMATICAL MODEL	70
VII. ANALYSIS OF A MORE REALISTIC SYSTEM	91
VIII. DISCUSSION OF RESULTS OF THE FIRST PHASE FOR THE ORIGINAL MODEL AND OTHER REALISTIC SYSTEMS	110
IX. DISCUSSION OF RESULTS OF THE SECOND PHASE FOR THE ORIGINAL MODEL AND OTHER REALISTIC SYSTEMS	193
X. SUMMARY AND CONCLUSIONS	384
NOMENCLATURE	391
BIBLIOGRAPHY	394
APPENDIX	
A. FLOW CHARTS AND COMPUTER PROGRAMS	404

LIST OF TABLES

Table		Page
II-1	Projections of Coal Gasification Plant Capacity	17
II-2	Federal Natural Gas Resource Ownership	19
II-3	Projections of LNG Imports	22
III-1	Ultimate Potential Supply	31
III-2	Flow Chart Illustrating Progression of Potential Gas Supplies as a Result of Drilling . .	37
III-3	Natural Gas Resource Data Estimates	38
IV-1	Comparison of Ultimate-Potential Gas Supply Estimates	46
IV-2	Total Natural Gas Supply Estimates by NPC . .	48
IV-3	Total Recoverable Potential Natural Gas Supply Estimates by USGS	51
IV-4	Total Potential Natural Gas Supply Estimates by PGC	52
IV-5	Total Potential Natural Gas Supply Estimates by L. G. Weeks	53
VI-1	Size Stratification of Population Fields . . .	72
VI-2	Initial Field Size Distribution	76
VI-3	Example of the Output from Phase One of the Model	84
VII-1	Size Stratification of Population Fields . . .	91
VII-2	Initial Field Size Distribution	94
VII-3	Values of Empirical Constants and Time Zero for Different Regions (k Regions)	92
VII-4	Size Stratification of Population Fields . . .	96

Table	Page
VII-5 Initial Field Size Distribution	100
VII-6 Initial Field Size Distribution	101
VII-7 Initial Field Size Distribution	102
VII-8 Values of Empirical Constant B and Time Zero for Different Regions (k Regions)	104
VII-9 Values of Empirical Constants A, B, and Time Zero for Different Regions (k Regions)	106
VII-10 Values of Empirical Constant B and Time Zero for Different Regions (k Regions)	109
VIII-1 Field Size Distribution for Number of Wells = 1000	111
VIII-2 Field Size Distribution for Number of Wells = 2000	112
VIII-3 Field Size Distribution for Number of Wells = 3000	113
VIII-4 Field Size Distribution for Number of Wells = 4000	114
VIII-5 Field Size Distribution for Number of Wells = 5000	115
VIII-6 Field Size Distribution for Number of Wells = 6000	116
VIII-7 Field Size Distribution for Number of Wells = 7000	117
VIII-8 Field Size Distribution for Number of Wells = 8000	118
VIII-9 Field Size Distribution for Number of Wells = 9000	119
VIII-10 Field Size Distribution for Number of Wells = 10,000	120
VIII-11 Field Size Distribution for Number of Wells = 100	122
VIII-12 Field Size Distribution for Number of Wells = 200	123
VIII-13 Field Size Distribution for Number of Wells = 300	124

Table	Page
VIII-14 Field Size Distribution for Number of Wells = 400	125
VIII-15 Field Size Distribution for Number of Wells = 500	126
VIII-16 Field Size Distribution for Number of Wells = 600	127
VIII-17 Field Size Distribution for Number of Wells = 700	128
VIII-18 Field Size Distribution for Number of Wells = 800	129
VIII-19 Field Size Distribution for Number of Wells = 900	130
VIII-20 Field Size Distribution for Number of Wells = 1000	131
VIII-21 Field Size Distribution for Number of Wells = 100	132
VIII-22 Field Size Distribution for Number of Wells = 200	133
VIII-23 Field Size Distribution for Number of Wells = 300	134
VIII-24 Field Size Distribution for Number of Wells = 400	135
VIII-25 Field Size Distribution for Number of Wells = 500	136
VIII-26 Field Size Distribution for Number of Wells = 600	137
VIII-27 Field Size Distribution for Number of Wells = 700	138
VIII-28 Field Size Distribution for Number of Wells = 800	139
VIII-29 Field Size Distribution for Number of Wells = 900	140
VIII-30 Field Size Distribution for Number of Wells = 1000	141

Table	Page
VIII-31 Field Size Distribution for Number of Wells = 100	142
VIII-32 Field Size Distribution for Number of Wells = 200	143
VIII-33 Field Size Distribution for Number of Wells = 300	144
VIII-34 Field Size Distribution for Number of Wells = 400	145
VIII-35 Field Size Distribution for Number of Wells = 500	146
VIII-36 Field Size Distribution for Number of Wells = 600	147
VIII-37 Field Size Distribution for Number of Wells = 700	148
VIII-38 Field Size Distribution for Number of Wells = 800	149
VIII-39 Field Size Distribution for Number of Wells = 900	150
VIII-40 Field Size Distribution for Number of Wells = 1000	151
VIII-41 Field Size Distribution for Number of Wells = 100	152
VIII-42 Field Size Distribution for Number of Wells = 200	153
VIII-43 Field Size Distribution for Number of Wells = 300	154
VIII-44 Field Size Distribution for Number of Wells = 400	155
VIII-45 Field Size Distribution for Number of Wells = 500	156
VIII-46 Field Size Distribution for Number of Wells = 600	157
VIII-47 Field Size Distribution for Number of Wells = 700	158

Table	Page
VIII-48 Field Size Distribution for Number of Wells = 800	159
VIII-49 Field Size Distribution for Number of Wells = 900	160
VIII-50 Field Size Distribution for Number of Wells = 1000	161
VIII-51 Results of the Calculation in Phase I for Original Model	163
VIII-52 Results of the Calculation in Phase I for Case I	174
VIII-53 Results of the Calculation in Phase I for Case II, Region 1	182
VIII-54 Results of the Calculation in Phase I for Case II, Region 2	183
VIII-55 Results of the Calculation in Phase I for Case II, Region 3	184
IX-1 Prediction of Future Discoveries for Region 1 (Hyperbolic Curve)	195
IX-2 Prediction of Future Discoveries for Region 2 (Hyperbolic Curve)	202
IX-3 Prediction of Future Discoveries for Region 3 (Hyperbolic Curve)	209
IX-4 Composite Parameters for All k Basins (Hyperbolic Curve)	216
IX-5 Prediction of Future Discoveries for Region 1 (Case I)	227
IX-6 Prediction of Future Discoveries for Region 2 (Case I)	234
IX-7 Prediction of Future Discoveries for Region 3 (Case I)	241
IX-8 Composite Parameters for All k Basins (Case I, Hyperbolic Curve)	248
IX-9 Prediction of Future Discoveries for Region 1 (Case II)	257

Table	Page
IX-10 Prediction of Future Discoveries for Region 2 (Case II)	264
IX-11 Prediction of Future Discoveries for Region 3 (Case II)	271
IX-12 Composite Parameters for All k Basins (Case II, Hyperbolic Curve)	278
IX-13 Prediction of Future Discoveries for Region 1 (Straight Line)	286
IX-14 Prediction of Future Discoveries for Region 2 (Straight Line)	287
IX-15 Prediction of Future Discoveries for Region 3 (Straight Line)	288
IX-16 Composite Parameters for All k Basins (Straight Line)	289
IX-17 Prediction of Future Discoveries for Region 1 (Case I, Straight Line)	296
IX-18 Prediction of Future Discoveries for Region 2 (Case I, Straight Line)	297
IX-19 Prediction of Future Discoveries for Region 3 (Case I, Straight Line)	298
IX-20 Composite Parameters for All k Basins (Case I, Straight Line)	299
IX-21 Prediction of Future Discoveries for Region 1 (Case II, Straight Line)	307
IX-22 Prediction of Future Discoveries for Region 2 (Case II, Straight Line)	308
IX-23 Prediction of Future Discoveries for Region 3 (Case II, Straight Line)	309
IX-24 Composite Parameters for All k Basins (Case II, Straight Line)	310
IX-25 Prediction of Future Discoveries for Region 1 (Logistic Curve)	318
IX-26 Prediction of Future Discoveries for Region 2 (Logistic Curve)	319
IX-27 Prediction of Future Discoveries for Region 3 (Logistic Curve)	320

Table	Page
IX-28 Composite Parameters for All k Basins (Logistic Curve)	321
IX-29 Prediction of Future Discoveries for Region 1 (Case I, Logistic Curve)	329
IX-30 Prediction of Future Discoveries for Region 2 (Case I, Logistic Curve)	330
IX-31 Prediction of Future Discoveries for Region 3 (Case I, Logistic Curve)	331
IX-32 Composite Parameters for All k Basins (Case I, Logistic Curve)	332
IX-33 Prediction of Future Discoveries for Region 1 (Case II, Logistic Curve)	340
IX-34 Prediction of Future Discoveries for Region 2 (Case II, Logistic Curve)	341
IX-35 Prediction of Future Discoveries for Region 3 (Case II, Logistic Curve)	342
IX-36 Composite Parameters for All k Basins (Case II, Logistic Curve)	343
IX-37 Prediction of Future Discoveries for Region 1 (Increasing Drilling Rate Function)	351
IX-38 Prediction of Future Discoveries for Region 2 (Increasing Drilling Rate Function)	352
IX-39 Prediction of Future Discoveries for Region 3 (Increasing Drilling Rate Function)	353
IX-40 Composite Parameters for All k Basins (Increasing Drilling Rate Function)	354
IX-41 Prediction of Future Discoveries for Region 1 (Case I, Increasing Drilling Rate Function)	362
IX-42 Prediction of Future Discoveries for Region 2 (Case I, Increasing Drilling Rate Function)	363
IX-43 Prediction of Future Discoveries for Region 3 (Case I, Increasing Drilling Rate Function)	364
IX-44 Composite Parameters for All k Basins (Case I, (Increasing Drilling Rate Function)	365

Table	Page
IX-45 Prediction of Future Discoveries for Region 1 (Case II, Increasing Drilling Rate Function) .	372
IX-46 Prediction of Future Discoveries for Region 2 (Case II, Increasing Drilling Rate Function) .	373
IX-47 Prediction of Future Discoveries for Region 3 (Case II, Increasing Drilling Rate Function) .	374
IX-48 Composite Parameters for All k Basins (Case II, Increasing Drilling Rate Function	375

LIST OF FIGURES

Figure		Page
I-1	Selected samples of unprocessed natural gas	3
I-2	U.S. natural-gas production	9
I-3	U.S. natural-gas production (semilogarithmic scale	10
III-1	AAPG and API classification of wells	35
III-2	U.S. natural gas supply, proved reserves and reserves-to-production ratio	39
IV-1	National Petroleum Council's supply regions	47
VI-1	Number of fields and their size distributions for each class	73
VI-2	Flow chart for recalculations of parameters	77
VI-3	Idealized cross section of stratigraphic interval	79
VI-4	Hyperbolic representation of gas well footage vs. time	85
VII-1	Histogram of number of fields and their size distributions for each class	93
VII-2	Histogram of number of fields and their size distributions for each class for first run (k = 1)	97
VII-3	Histogram of number of fields and their size distributions for each class for second run (k = 2)	98
VII-4	Histogram of number of fields and their size distributions for each class for second run (k = 3)	99
VII-5	Straight line representation of gas well footage vs. time	103
VII-6	Logistic curve representation of gas well footage vs. time	105

Figure		Page
VII-7	Increasing drilling rate curve representation of gas well footage vs. time	108
VIII-1	Increment reserves found versus number of wells drilled	164
VIII-2	Cumulative reserves found versus cumulative number of wells drilled	166
VIII-3	Increment reserves found versus number of fields found	167
VIII-4	Cumulative reserves found versus cumulative number of fields found	169
VIII-5	Increment reserves found versus footage drilled	170
VIII-6	Cumulative reserves found versus cumulative footage drilled	171
VIII-7	Incremental reserves/incremental footage drilled versus cumulative footage drilled . .	172
VIII-8	Increment reserves found versus number of wells drilled for Case I	175
VIII-9	Cumulative reserves found versus cumulative number of wells drilled for Case I	176
VIII-10	Increment reserves found versus number of fields found for Case I	177
VIII-11	Cumulative reserves found versus cumulative number of fields found for Case I	178
VIII-12	Increment reserves found versus footage drilled for Case I	179
VIII-13	Cumulative reserves found versus cumulative footage drilled for Case I	180
VIII-14	Incremental reserves/incremental footage drilled vs. cumulative footage drilled for Case I	181
VIII-15	Increment reserves found versus number of wells drilled for Case II	186
VIII-16	Cumulative reserves found versus cumulative number of wells drilled for Case II	187

Figure	Page
VIII-17	Incremental reserves found versus number of fields found for Case II 188
VIII-18	Cumulative reserves found versus cumulative number of fields found for Case II 189
VIII-19	Increment reserves found versus footage drilled for Case II 190
VIII-20	Cumulative reserves found versus cumulative footage drilled for Case II 191
VIII-21	Incremental reserves/incremental footage drilled versus cumulative footage drilled for Case II 192
IX-1	Plot of increment reserve vs. time for Region 1 (Hyperbolic curve) 196
IX-2	Plot of cumulative reserve vs. time for Region 1 (Hyperbolic curve) 197
IX-3	Plot of cumulative discovery rate vs. time for Region 1 (Hyperbolic curve) 198
IX-4	Plot of increment reserve vs. footage for Region 1 (Hyperbolic curve) 199
IX-5	Plot of cumulative reserve vs. cumulative footage for Region 1 (Hyperbolic curve) . . . 200
IX-6	Plot of cumulative discovery rate vs. cumulative footage for Region 1 (Hyperbolic curve) . 201
IX-7	Plot of increment reserve vs. time for Region 2 (Hyperbolic curve) 203
IX-8	Plot of cumulative reserve vs. time for Region 2 (Hyperbolic curve) 204
IX-9	Plot of cumulative discovery rate vs. time for Region 2 (Hyperbolic curve) 205
IX-10	Plot of increment reserve vs. footage for Region 2 (Hyperbolic curve) 206
IX-11	Plot of cumulative reserve vs. cumulative footage for Region 2 (Hyperbolic curve) . . . 207
IX-12	Plot of cumulative discovery rate vs. cumulative footage for Region 2 (Hyperbolic curve) . 208

Figure		Page
IX-13	Plot of increment reserve vs. time for Region 3 (Hyperbolic curve)	210
IX-14	Plot of cumulative reserve vs. time for Region 3 (Hyperbolic curve)	211
IX-15	Plot of cumulative discovery rate vs. time for Region 3 (Hyperbolic curve)	212
IX-16	Plot of increment reserve vs. footage for Region 3 (Hyperbolic curve)	213
IX-17	Plot of cumulative reserve vs. cumulative footage for Region 3 (Hyperbolic curve) . . .	214
IX-18	Plot of cumulative discovery rate vs. cumulative footage for Region 3 (Hyperbolic curve) .	215
IX-19	Composite plot of increment reserve vs. time for original model (Hyperbolic curve)	217
IX-20	Composite plot of cumulative discovery vs. time for original model (Hyperbolic curve) . .	218
IX-21	Composite plot of cumulative discovery rate vs. time for original model (Hyperbolic curve)	219
IX-22	Composite plot of increment reserve vs. footage for original model (Hyperbolic curve) . .	220
IX-23	Composite plot of cumulative discovery vs. cumulative footage for original model (Hyperbolic curve)	221
IX-24	Composite plot of cumulative discovery rate vs. cumulative footage for original model (Hyperbolic curve)	222
IX-25	Plot of increment reserve vs. time for Region 1 (Case I)	228
IX-26	Plot of cumulative reserve vs. time for Region 1 (Case I)	229
IX-27	Plot of cumulative discovery rate vs. time for Region 1 (Case I)	230
IX-28	Plot of increment reserve vs. footage for Region 1 (Case I)	231
IX-29	Plot of cumulative reserve vs. cumulative footage for Region 1 (Case I)	232

Figure	Page
IX-30 Plot of cumulative discovery rate vs. cumulative footage for Region 1 (Case I)	233
IX-31 Plot of increment reserve vs. time for Region 2 (Case I)	235
IX-32 Plot of cumulative reserve vs. time for Region 2 (Case I)	236
IX-33 Plot of cumulative discovery rate vs. time for Region 2 (Case I)	237
IX-34 Plot of increment reserve vs. footage for Region 2 (Case I)	238
IX-35 Plot of cumulative reserve vs. cumulative footage for Region 2 (Case I)	239
IX-36 Plot of cumulative discovery rate vs. cumulative footage for Region 2 (Case I)	240
IX-37 Plot of increment reserve vs. time for Region 3 (Case I)	242
IX-38 Plot of cumulative reserve vs. time for Region 3 (Case I)	243
IX-39 Plot of cumulative discovery rate vs. time for Region 3 (Case I)	244
IX-40 Plot of increment reserve vs. footage for Region 3 (Case I)	245
IX-41 Plot of cumulative reserve vs. cumulative footage for Region 3 (Case I)	246
IX-42 Plot of cumulative discovery rate vs. cumulative footage for Region 3 (Case I)	247
IX-43 Composite plot of increment reserve vs. time (Case I, Hyperbolic curve)	249
IX-44 Composite plot of cumulative discovery vs. time (Case I, Hyperbolic curve)	250
IX-45 Composite plot of cumulative discovery rate vs. time (Case I, Hyperbolic curve)	251
IX-46 Composite plot of increment reserve vs. footage (Case I, Hyperbolic curve)	252

Figure.	Page
IX-47 Composite plot of cumulative discovery vs. cumulative footage (Case I, Hyperbolic curve)	253
IX-48 Composite plot of cumulative discovery rate vs. cumulative footage (Case I, Hyperbolic curve)	254
IX-49 Plot of increment reserve vs. time for Region 1 (Case II)	258
IX-50 Plot of cumulative reserve vs. time for Region 1 (Case II)	259
IX-51 Plot of cumulative discovery rate vs. time for Region 1 (Case II)	260
IX-52 Plot of increment reserve vs. footage for Region 1 (Case II)	261
IX-53 Plot of cumulative reserve vs. cumulative footage for Region 1 (Case II)	262
IX-54 Plot of cumulative discovery rate vs. cumulative footage for Region 1 (Case II)	263
IX-55 Plot of increment reserves vs. time for Region 2 (Case II)	265
IX-56 Plot of cumulative reserve vs. time for Region 2 (Case II)	266
IX-57 Plot of cumulative discovery rate vs. time for Region 2 (Case II)	267
IX-58 Plot of increment reserve vs. footage for Region 2 (Case II)	268
IX-59 Plot of cumulative reserve vs. cumulative footage for Region 2 (Case II)	269
IX-60 Plot of cumulative discovery rate vs. cumulative footage for Region 2 (Case II)	270
IX-61 Plot of increment reserve vs. time for Region 3 (Case II)	272
IX-62 Plot of cumulative reserve vs. time for Region 3 (Case II)	273
IX-63 Plot of cumulative discovery rate vs. time for Region 3 (Case II)	274

Figure		Page
IX-64	Plot of increment reserve vs. footage for Region 3 (Case II)	275
IX-65	Plot of cumulative reserve vs. cumulative footage for Region 3 (Case II)	276
IX-66	Plot of cumulative discovery rate vs. cumulative footage for Region 3 (Case II)	277
IX-67	Composite plot of increment reserve vs. time (Case II, Hyperbolic curve)	279
IX-68	Composite plot of cumulative discovery vs. time (Case II, Hyperbolic curve)	280
IX-69	Composite plot of cumulative discovery rate vs. time (Case II, Hyperbolic curve)	281
IX-70	Composite plot of increment reserve vs. footage (Case II, Hyperbolic curve)	282
IX-71	Composite plot of cumulative discovery vs. cumulative footage (Case II, Hyperbolic curve)	283
IX-72	Composite plot of cumulative discovery rate vs. cumulative footage (Case II, Hyperbolic curve)	284
IX-73	Composite plot of increment reserve vs. time (Straight line)	290
IX-74	Composite plot of cumulative discovery vs. time (Straight line)	291
IX-75	Composite plot of cumulative discovery rate vs. time (Straight line)	292
IX-76	Composite plot of increment reserve vs. footage (Straight line)	293
IX-77	Composite plot of cumulative discovery vs. cumulative footage (Straight line)	294
IX-78	Composite plot of cumulative discovery rate vs. cumulative footage (Straight line)	295
IX-79	Composite plot of increment reserve vs. time (Case I, straight line)	300
IX-80	Composite plot of cumulative discovery vs. time (Case I, straight line)	301

Figure		Page
IX-81	Composite plot of cumulative discovery rate vs. time (Case I, straight line)	302
IX-82	Composite plot of increment reserve vs. footage (Case I, straight line)	303
IX-83	Composite plot of cumulative discovery vs. cumulative footage (Case I, straight line) . .	304
IX-84	Composite plot of cumulative discovery rate vs. cumulative footage (Case I, straight line)	305
IX-85	Composite plot of increment reserve vs. time (Case II, straight line)	311
IX-86	Composite plot of cumulative discovery vs. time (Case II, straight line)	312
IX-87	Composite plot of cumulative discovery rate vs. time (Case II, straight line)	313
IX-88	Composite plot of increment reserve vs. footage (Case II, straight line)	314
IX-89	Composite plot of cumulative discovery vs. cumulative footage (Case II, straight line) .	315
IX-90	Composite plot of cumulative discovery rate vs. cumulative footage (Case II, straight line)	316
IX-91	Composite plot of increment reserve vs. time (Logistic curve)	317
IX-92	Composite plot of cumulative discovery vs. time (Logistic curve)	318
IX-93	Composite plot of cumulative discovery rate vs. time (Logistic curve)	319
IX-94	Composite plot of increment reserve vs. footage (Logistic curve)	320
IX-95	Composite plot of cumulative discovery vs. cumulative footage (Logistic curve)	321
IX-96	Composite plot of cumulative discovery rate vs. cumulative footage (Logistic curve) . . .	322
IX-97	Composite plot of increment reserve vs. time (Case I, Logistic curve)	333

Figure	Page
IX-98 Composite plot of cumulative discovery vs. time (Case I, Logistic curve)	334
IX-99 Composite plot of cumulative discovery rate vs. time (Case I, Logistic curve)	335
IX-100 Composite plot of increment reserve vs. footage (Case I, Logistic curve)	336
IX-101 Composite plot of cumulative discovery vs. cumulative footage (Case I, Logistic curve) .	337
IX-102 Composite plot of cumulative discovery rate vs. cumulative footage (Case I, Logistic curve)	338
IX-103 Composite plot of increment reserve vs. time (Case II, Logistic curve)	344
IX-104 Composite plot of cumulative discovery vs. time (Case II, Logistic curve)	345
IX-105 Composite plot of cumulative discovery rate vs. time (Case II, Logistic curve)	346
IX-106 Composite plot of increment reserve vs. footage (Case II, Logistic curve)	347
IX-107 Composite plot of cumulative discovery vs. cumulative footage (Case II, Logistic curve) .	348
IX-108 Composite plot of cumulative discovery rate vs. cumulative footage (Case II, Logistic curve)	349
IX-109 Composite plot of increment reserve vs. time (Increasing drilling rate function)	355
IX-110 Composite plot of cumulative discovery vs. time (Increasing drilling rate function) . . .	356
IX-111 Composite plot of cumulative discovery rate vs. time (Increasing drilling rate function) .	357
IX-112 Composite plot of increment reserve vs. footage (Increasing drilling rate function) .	358
IX-113 Composite plot of cumulative discovery vs. cumulative footage (Increasing drilling rate function)	359

Figure		Page
IX-114	Composite plot of cumulative discovery rate vs. cumulative footage (Increasing drilling rate function)	360
IX-115	Composite plot of increment reserve vs. time (Case I, Increasing drilling rate function) .	366
IX-116	Composite plot of cumulative discovery vs. time (Case I, Increasing drilling rate function)	367
IX-117	Composite plot of cumulative discovery rate vs. time (Case I, Increasing drilling rate function)	368
IX-118	Composite plot of increment reserve vs. footage (Case I, Increasing drilling rate function)	369
IX-119	Composite plot of cumulative discovery vs. cumulative footage (Case I, Increasing drilling rate function)	370
IX-120	Composite plot of cumulative discovery rate vs. cumulative footage (Case I, Increasing drilling rate function)	371
IX-121	Composite plot of increment reserve vs. time (Case II, Increasing drilling rate function) .	377
IX-122	Composite plot of cumulative discovery vs. time (Case II, Increasing drilling rate function)	378
IX-123	Composite plot of cumulative discovery rate vs. time (Case II, Increasing drilling rate function)	379
IX-124	Composite plot of increment reserve vs. footage (Case II, Increasing drilling rate function)	380
IX-125	Composite plot of cumulative discovery vs. cumulative footage (Case II, Increasing drilling rate function)	381
IX-126	Composite plot of cumulative discovery rate vs. cumulative footage (Case II, Increasing drilling rate function)	382

THE RESPONSE OF A NATURAL GAS RESOURCE BASE TO DRILLING ACTIVITY

CHAPTER I

PHYSICAL CHARACTERISTICS OF PETROLEUM RESOURCES

The petroleum sources are composed primarily of hydrocarbons (compounds containing only hydrogen and carbon) with the chemical series of C_nH_{2n+2} , where n may range from 1 to 40 or more. The first four compounds of this series ($n = 1$ to $n = 4$) are gaseous at surface temperatures and atmospheric pressure. For $n > 4$, the compounds are liquids of increasing densities and viscosities as n increases. Another class of petroleum sources is solid. These are kerogen, which is the hydrocarbon of oil shales, and gilsonite, which occurs in minable veins in Colorado, Utah, and elsewhere.

Natural gas, which occurs in almost every place where crude oil found and in many places where it is not, is composed primarily of methane (CH_4). Methane is found in swamps, in coal mines, in solution hundreds of feet below the surface of the ocean, and even in outer space. Other natural gas compounds are fractionally small but important. They are liquid petroleum gases (LPG) and natural gas liquids

(NGL). The LPG compounds are ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}) which are gaseous at surface temperatures and atmospheric pressure but liquifiable at slightly increased pressure. The NGL compounds are pentane (C_5H_{12}), hexane (C_6H_{14}), and heptane (C_7H_{16}) which are essentially light gasolines obtainable as by-products of natural gas. It should be mentioned that up to 1960, only small amounts of natural gas liquids (NGL) were produced in the U.S., but from 1960 on the production rate of NGL increased progressively. In processing, most of the butane and heavier hydrocarbons (NGL compounds) as well as a portion of the ethane and propane are frequently removed from the gas in the form of liquids. Also other impurities such as water, gaseous sulfur compounds, nitrogen, carbon dioxide would be removed from natural gas in various processing stages.

A. Composition and the Btu Content of Natural Gas

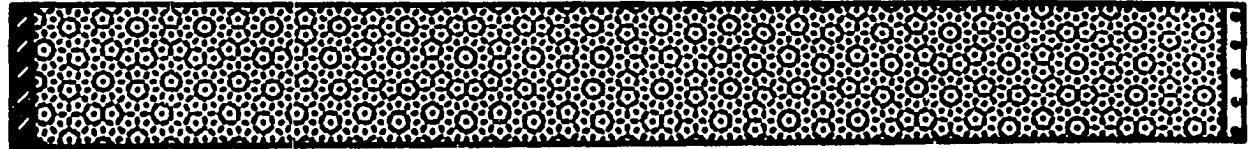
Gas, either natural or manufactured, is an ideal fuel. Its heat content (i.e., Btu per cubic feet) and its chemical composition can in most situations be maintained nearly constant, thereby minimizing or eliminating noticeable changes in burning characteristics.

The composition and the Btu content of unprocessed natural gas produced from different reservoirs varies widely as illustrated in Figure I-1.

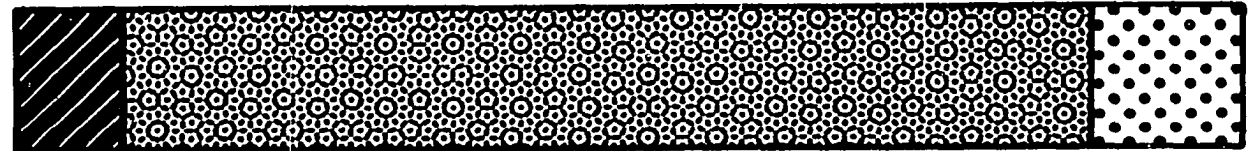
SELECTED SAMPLES OF NATURAL GAS

LOCATION, GEOLOGIC FORMATION
AND HEATING VALUE PER C.F.

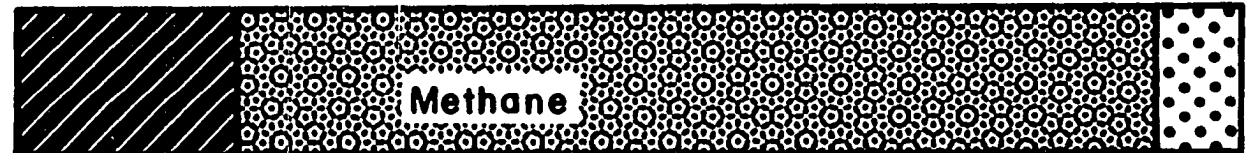
McDowell County, West Va.
Lime and Weir
(1014 BTU)



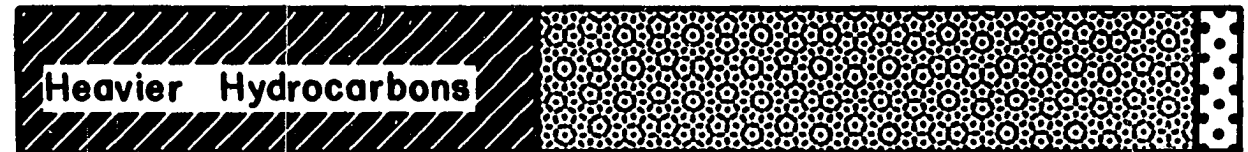
Williams County, North Dakota
Red River
(1032 BTU)



Morgan County, Colorado
D. Sand
(1228 BTU)



Schleicher County, Texas
Straw Reef
(1598 BTU)



San Juan County, Utah
Mississippian
(717 BTU)

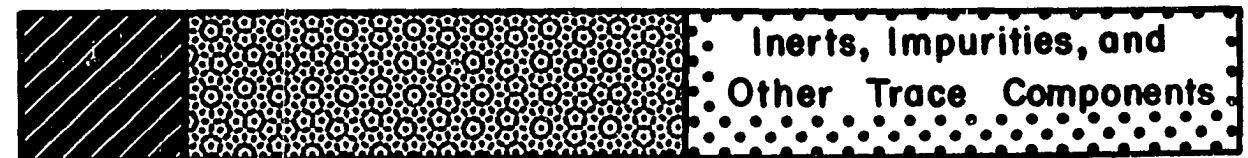


FIGURE I-1: Selected Samples of Unprocessed Natural Gas

Source: FPC, 1974a: 6.

B. Types of Natural Gas

In addition to composition and Btu content, gas is commonly designated in terms of the nature of its occurrence underground and its association with crude oil. Both natural gas and crude oil resources are frequently found associated with each other in the reservoir. The natural gas in the free state frequently occupies the topmost portions of the reservoir overlying the crude oil because natural gas has a lighter specific gravity than oil. This portion of free gas which occurs in the gaseous phase in contact above the crude oil in the reservoir is called gas-cap gas. Alternatively, the gas may be located in the same portions of structure as the crude oil and dissolved directly in it. This type of occurrence is called dissolved gas, and it is frequently in a crude oil reservoir with a gas content in the range of zero (dead oil) to a few thousand cubic feet per barrel. In addition, major quantities of gases exist in formations in which the total hydrocarbon volume occurs in the gaseous phase in the reservoir. This type of free gas accumulation is called non associated gas. Finally, some gases occur as gases in underground reservoirs, but they have a high content of hydrocarbon liquids. These types of gases are called gas condensates or simply condensates. The gas condensate reservoir can approximately be defined as those which produce light colored or colorless stock tank liquids with gravities above 45° API at

gas-oil ratios in the range of 5,000 to 10,000 SCF/bbl.

Overall, approximately 2/3 of recent production in the U.S. has been non associated gas and the other 1/3 has been associated gas with the rate of production of associated gas being entirely dependent upon the rate of crude oil production because this type of gas is normally produced together with oil from the oil wells and may frequently be reinjected into the reservoir.

C. Domestic Resources Locations

Natural gas reserves are known to exist in 24 states, with the states of Texas, Louisiana, New Mexico, Kansas, and Oklahoma containing 88% of the total proved, recoverable reserves in the lower 48 states.

Based on the A.G.A. data for proved reserves and the USGS estimates of potential gas supply, 73% of the gas reserves and 52% of the potential gas are located in the onshore lower 48 states, 14% of the reserves and 22% of the potential gas are located in the offshore lower 48 states and 13% of the reserves and 26% of the potential gas are located in Alaska in both onshore and offshore areas.

D. Origin and Accumulation

Natural gas is believed to be the result of the gradual decomposition of the remains of minute animal and plant life which, together with other sedimentary material,

was deposited in the seas millions of years ago. The genesis of gas was probably influenced by bacterial action in conjunction with high temperature and pressure generated by the overburden resulting from the successive deposition of geologic formations. Gas occurs in many parts of the world under a variety of geological conditions. The primary conditions for existence or accumulation of gas are the following: an original organic source, a suitable porous reservoir rock formation, the trap within which gas is confined, and an impervious layer over the porous rock.

E. History and Background

The first recorded use of natural gas in the United States was in Fredonia, New York in 1821. In the period 1821-1947 the usage of natural gas was localized because of transportation limitations. Gas could only be transported by pipeline and pipelines were few and limited to short distances from the fields where the gas was produced. Often only a small fraction of the produced gas was used in the fields and the remainder was flared or vented. After World War II numerous projects were launched for the laying of large diameter, long distance pipelines for the delivery of natural gas from the Gulf Coast and the Mid Continent to the cities and industrial areas of the Northeast, North-Central, and Pacific Coast areas of the U.S. This resulted in a continuous increase in the consumption of natural gas which

was sustained for over 25 years. The consumption of natural gas in all end use classifications, i.e., residential, commercial, industrial, and power generation, increased markedly during this period (1947-1973).

It increased at an average annual rate of approximately 6.5 percent, reaching 22.2 tcf in the end of this period (1973). This drastic growth of natural gas consumption was caused by several factors, such as: development of new market areas, replacement of coal as fuel for providing space and industrial heat, the use in making petrochemicals and fertilizers, and many others.

The replacement of other sources of energy by natural gas resulted in an increase in the percentage of the U.S. energy consumption supplied by natural gas from 13% in 1945 to 33% in 1970 (Zareski, 1973). The rapid increase in the demand and consumption of natural gas eventually caused consumption to exceed discoveries in 1968. In 1970, the shortage of natural gas was clearly demonstrated in the initial curtailments of firm, industrial contracts. As reported in yearly statistics published by A.G.A., the consumption of natural gas in 1973 was 23.3 tcf. Because of supply limitations the companies couldn't meet the total demand for natural gas. The 1.1 tcf of gas service which was curtailed represents the supply shortfall in 1973.

F. Natural Gas Production in U.S.

The total annual production of natural gas in the U.S. increased almost continuously from 1900 to 1970 as shown in Figure I-2. This figure also demonstrates the more abrupt increase in natural gas consumption following World War II.

The plot of total U.S. production rate versus time on semilog paper is shown in Figure I-3 and yields an almost unbroken straight line. This line represents an average annual increase of natural gas production of 6.73% per year for the same period (1900-1970). For the next three years, since 1970, the growth curve has flattened out, and the 1974 production rate has increased 6 percent. Actually the reduction of production is caused by a supply shortage and not a tempering of demand. The cutting edge of the supply shortage in practical terms started in November 1970, and the supply shortfall has risen steadily since then. The gas shortage caused the U.S. net production to fall from 22.6 tcf to 21.3 tcf in 1974. This is actually the first significant decline in total net gas production reported by A.G.A. since 1946.

G. Demand Considerations

Although there is a lack of agreement as to the actual extent of the gas shortage, there is almost universal acceptance of the fact that current production from conventional sources is not sufficient to satisfy all demands for

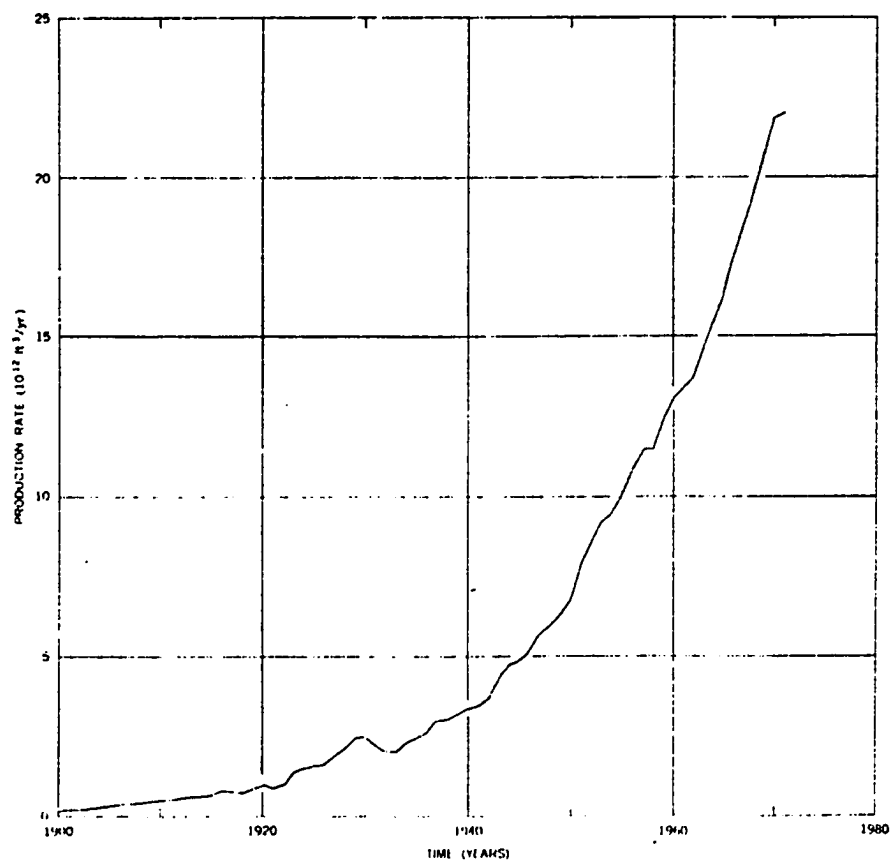


FIGURE I-2. U.S. natural-gas production.

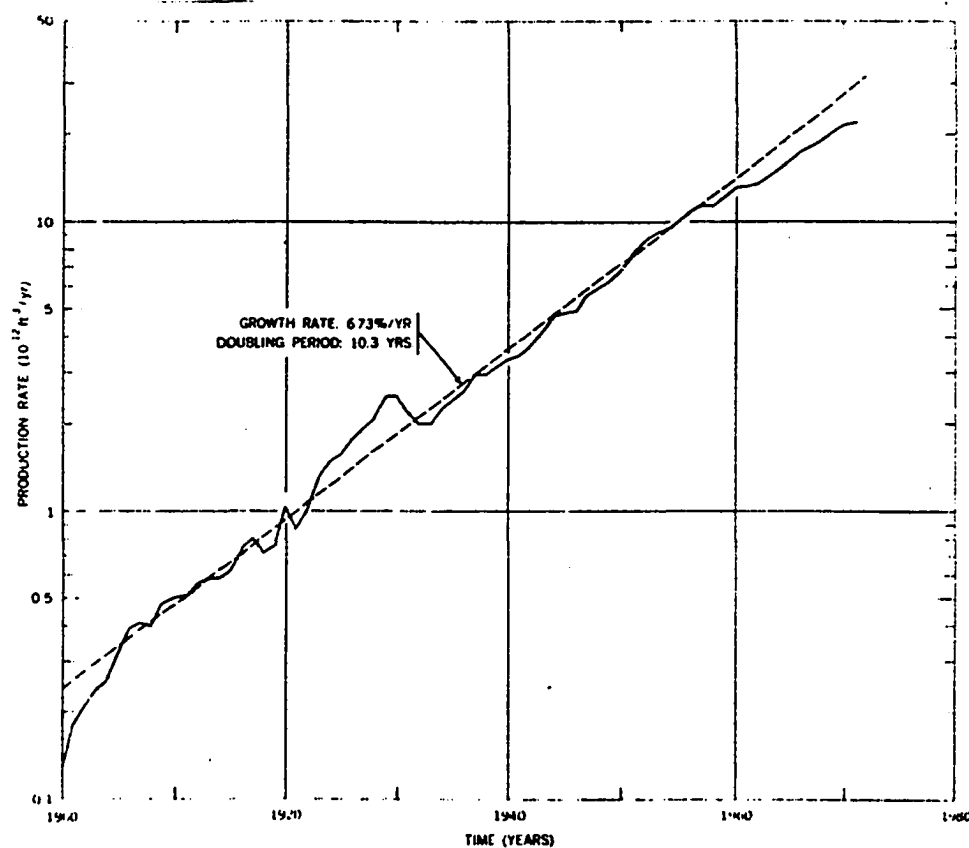


FIGURE I-3. U.S. natural-gas production
(semilogarithmic scale)

natural gas. In addition, the current decrease in production indicates that supply shortfalls will become greater in the future unless additional sources of supply are developed.

Demand projections for natural gas have been made by different groups; only the projections made by the Future Requirement Committee (FRC) will be considered in this dissertation. In 1971 the FRC projections were all based on the assumptions that the supply of gas would be enough or adequate to meet the growing demands and that gas would retain its price advantage over other energy sources (FRC, 1971). On this basis, annual demand for gas in the lower 48 states was projected by FRC to increase to 46.4 tcf in 1990 which means an assumed growth rate of about 3.7% during the 1970-1990 period. With this growth rate of 3.7%, the projected demand for natural gas in 1973 would have been 27.7 tcf, but actual consumption of natural gas in 1973 was 21.3 tcf. This difference is a measure of the supply shortage or production limitation on natural gas. This indicates that, unless additional sources of natural gas are found, future consumption will be limited by supply and not by demand.

CHAPTER II

FUTURE SUPPLY PROJECTIONS FOR THE U.S. THROUGH THE YEAR 1995

Supply projections made by authoritative and knowledgeable agencies and organizations indicate that the amount of gas which will be available from all sources in the future will not meet the projected demand. In order to supply enough natural gas to meet all U.S. needs through the year 1995 from both U.S. sources and foreign supplies, an optimistic projection which relies on major breakthroughs in technology and accelerated development of all supply sources is required. Thus it is fitting to view all alternative sources of natural gas and gaseous fuels as complementary rather than competitive and to try to find the best and most efficient way of producing natural gas from them.

The potential alternative sources are: (1) nuclear stimulation and massive hydraulic fracturing of low permeability reservoirs in the western U.S. in order to make it possible to produce unrecoverable natural gas economically from low permeability rocks; (2) production of large potential quantities of artificial or substitute natural gas, i.e., generating gas by gasifying coal, oil shale, organic

waste and plant material; (3) massive exploration and development of onshore as well as prospective offshore areas owned by the government; (4) increased pipeline imports of gas from Canada and Mexico; (5) importation of liquefied natural gas (LNG) and liquid hydrocarbons by tankers; (6) transportation of Alaskan gas to markets in the U.S.; (7) importation of methanol manufactured from foreign natural gas sources and transported to the U.S. by tanker; (8) hydrogen gas produced from either water or other hydrogen compounds can be potential substitute gaseous fuels.

Major study and research by the universities, private oil companies, and the Federal Government are already underway on all of these alternative sources of natural gas and gaseous fuels. In addition, numerous schemes for maximizing the amount of conventional natural gas found and developed in both the onshore and offshore areas of the U.S. are being considered. These potential sources of future gas supplies will be discussed in more detail in the following sections of the dissertation.

A. Nuclear Stimulation and Hydraulic Fracturing of Low Permeability Reservoirs

The geologic formations of the Green River Basin of Wyoming, the Piceance Basin of Colorado, the Uinta Basin of Utah, and the San Juan Basin of New Mexico contain large quantities of natural gas resources. However, these gas

resources cannot be produced economically because the rock formations are extremely impermeable (tight). It has been estimated by the Supply Technical Advisory Task Force Natural Gas Technology of the FPC's National Gas Survey (FPC, 1973d) that tight formations in these four basins contain more than 600 tcf of natural gas resources.

Two techniques have received considerable attention as being capable of overcoming the problem of increasing the productivity and thus the recovery of gas from low-permeability formations. The first, nuclear stimulation, is accomplished by the underground detonation of a nuclear device which creates a "chimney" of broken rocks. A system of fractures radiates outward from the chimney which could result in greatly increased productivity. The nuclear stimulation has the potential of raising the recovery rate to something between 50 and 80 per cent (17).

The second, massive hydraulic fracturing or the application of special non-nuclear explosives, causes the creation of large and extensive fractures. These fractures are held open by a "proppant" such as sand grains or glass beads and serve as high capacity paths for gas flow into a producing well.

The gas resources in low permeable (tight) reservoirs are not recoverable with today's technology under present economic and operating conditions. For example, nuclear explosive stimulation is costly and may be constrained by

unresolved environmental problems. It is anticipated that with additional technological development these techniques will be applicable and that they eventually can contribute large increments to the nation's available future gas supplies.

B. Production of Natural Gas from Artificial
or Substitute Natural Gas

Coal, oil shale, organic waste and plant material are very promising sources for substitute natural gas. The case for obtaining oil and gas from these sources starts with two significant advantages: (1) the location of the coal and oil shale resources is already known and their extent is enormous; and (2) in the disposal of waste materials the gathering of the gas represents a cost benefit.

In recent years, because of the oil and gas shortages, many efforts are now under way aimed at the production of liquid and gaseous hydrocarbons from various substitute resources. Most of these operations are still in various phases of research and testing. A few of the more promising projects are:

Coal:

The U.S. recoverable coal reserves are estimated to be 1.6 trillion tons (Averitt, 1974). Both oil and gas from coal were commercially marketed in the U.S. before there was a petroleum industry. Oil from coal has long since

disappeared and only a miniscule quantity of gas from coal is made and sold today.

One difficulty in turning solid coal into liquids and gases directly substitutable for conventional hydrocarbons has always been the cost of hydrogen. Methane, the main constituent of natural gas, contains five times the amount of hydrogen as its equivalent weight in coal (17). Therefore, any attempt to change coal to gas involves supplementing the portion of the coal to be reformed with large quantities of hydrogen. This can be done with hydrogen stripped from the residual portion of the coal or with hydrogen derived from an outside source such as water.

Unfortunately, up to this date, there are no commercial coal gasification plants operating in the U.S. Large scale pilot plants are in operation and several applications for the construction of coal gasification have been submitted to the Federal Power Commission. The cost barrier will undoubtedly be breached in just a few years making gas manufactured from coal a component of the gas supply mix.

The projections of the estimated quantity of gas that may be made from coal through 1990 are shown in Table II-1.

Oil Shale

An oil shale is a fine grained rock containing a waxy, semi-solid, organic substance called kerogen. On

TABLE II-1
Projections of Coal Gasification Plant Capacity
(Trillion cubic feet)

	1980	1985	1990
NPC ^a	0.36	1.3	N.E.
DOI ^b	0.3	1.4	N.E.
NGS ^c	0.3	1.3	2.9

N.E. -- Not estimated

Sources: ^aNPC, 1972

^bDOI, 1972a

^cFPC, 1973e

heating the solid kerogen can be converted to a liquid or a gas depending on the manner in which the heat is applied.

Oil shale deposits occur in thirty states in the U.S. But those of the Green River formation in Colorado, Utah, and Wyoming contain the largest portion of discovered oil shale resources, and appear to be sufficiently valuable to attract interest at the present time.

The USGS (Theobald, 1972) estimated that the discovered U.S. oil shale resources are in excess of 2000 billion barrels of oil in comparison to estimated proved oil reserves of 35 billion barrels at year end 1973.

Some pilot plant operations have been conducted and a substantial amount of engineering development has been done on the process. However, today's technology is not capable

of developing natural gas from oil shale economically. Although additional development work will improve the economics of the process, the future use of oil shale as a source for liquid hydrocarbons seems more likely.

Organic Wastes

Gaseous fuels can be produced by bio-conversion (sometimes called anaerobic digestion), the conversion of organic wastes into gas through the action of microorganisms, or by pyrolysis, the chemical decomposition of waste through the application of heat in the absence of air. The bioconversion process yields a gas with a heat content of about 1000 Btu's/cf which is equivalent to pipeline quality natural gas, while low-Btu gas is produced through pyrolysis. An estimate of the total organic wastes generated in the U.S. is 880 million tons per year of which 136.3 million tons per year are readily collectable (Anderson, 1972:8, 13). If converted completely into natural gas, the readily collectable wastes would yield about 1.36 tcf per year.

This conversion technology is still in the pilot plant or early commercial operation stages, but it has considerable potential in specific situations.

C. Massive Exploration and Development of Onshore as Well as Prospective Offshore Areas Owned by the Government

In the past, the major portion of natural gas resources were developed onshore in the lower 48 states and

were under privately owned lands. There were essentially no constraints on the development because of the availability of large tracts of land to support major exploration and production programs. The high value of the developed hydrocarbon resources and the limited impact on surface land use encouraged natural gas resource development. Lately because of the gas supply shortage and because of the progression toward the exploitation of the lower 48 state offshore and the Alaskan resources, potentially gas-bearing lands owned by the government are becoming increasingly significant. The ownership of natural gas resources shown in Table II-2 clearly indicates that government ownership can play a prominent role in the future development of natural gas resources. The Federal Government owns most of the offshore acreage beyond the three-mile limit (all acreage except that off Texas and Florida, with several other coastal states also claiming ownership beyond three miles), and federal ownership is significant in Alaska and the western states.

TABLE II-2

Federal Natural Gas Resource Ownership
(Figures given are percentages of domestic total)

	Reserve	Resources	Production in 1972
Offshore	15	36	16
Onshore	6	8	6
Total	21	44	22

Source: Ford Foundation, 1973: Chapter VIII, p. 3.

In order to increase the gas supply, exploration incentives and accelerated programs for leasing federal domain lands should be pursued.

D. Increased Pipeline Imports of Gas from Canada and Mexico

Although imports of natural gas have expanded rapidly since 1947, their volume is still small relative to total supply. Gas imports into the lower 48 states by pipeline are primarily from Canada and were in excess of one tcf in 1973. Almost all the imported gas from Canada comes from the western provinces, which contain over 99 per cent of Canada's proved gas reserves (FPC, 1974c:35).

In order to increase the importation of gas from Canada into the U.S., Canadian export authorizations are needed. It seems unlikely that additional gas will be available to permit authorization of additional gas imports to the U.S. from the traditional gas producing provinces of western Canada. On the other hand, these provinces are estimated to contain only 15% of the total ultimate potential supply of natural gas in Canada (FPC, 1974c:39). The bulk of the total is attributed to the frontier provinces. About 31% are estimated to be located in the Arctic Islands, about 12% in Mackenzie Delta, and 35% in the Atlantic offshore (FPC, 1974c:38). Thus increased importation of natural gas through pipeline from Canada seems to depend upon the development of the frontier gas provinces.

The gas imported from Mexico serves Texas exclusively. The imports from Mexico averaged approximately 50 billion cubic feet per year from 1958 to 1969, but it declined to 1.6 billion cubic feet in 1973.

The relatively small natural gas resource base in Mexico would not seem to favor the importation into the U.S. of more gas from this country. But recent discoveries in Mexico might have an impact on this aspect of U.S.-Mexican policy.

E. Importation of Liquefied Natural Gas (LNG) and Hydrocarbon Liquids

The FPC's National Gas Survey identified 21 sources of LNG with adequate reserves for supporting potential long-term import projects to the U.S. (FPC, 1973b:344). Although operational dates for the proposed projects are uncertain and specific projects cannot be identified beyond 1980. Current activity seems to indicate a pattern of long-term importation of LNG into the contiguous U.S. Table II-3 shows various projections of long-term U.S. imports of LNG.

Hydrocarbon liquids can be gasified and used as another source of substitute natural gas. The technology for gasifying light liquid hydrocarbons such as naptha and natural gas liquids to produce a product called reformer gas is currently available and is being used in commercial plants operated in the U.S. Gasification of liquid

Table II-3. Projections of LNG Imports
(trillion cubic feet)

	1980	1985	1990
FPC ^a	2.0	3.0	4.0
DOI ^b	0.9	1.6	N.E.
NPC ^c			
Low-Case	2.3	3.2	N.E.
High-Case	2.3	3.9	N.E.
IGT ^d	1.1	1.6	2.1
A.G.A. ^e	1.7	2.7	3.2
NGS ^f			
Low-Case	0.4	0.4	0.4
High-Case	3.2	3.8	4.7

N.E. - Not estimated

Sources: ^aFPC, 1972:70.

^bDOI, 1972a:32.

^cNPC, 1972:133.

^dLinden, 1973.

^eHardy, 1974.

^fFPC, 1974b:4-5.

hydrocarbons has the advantages of high conversion efficiency, low capital costs, and short construction times. The principle disadvantage of these processes is the shortage and escalating cost of feedstocks. The FEA (formerly FEO) in January, 1974, denied allocations of naptha and other light hydrocarbons derived from crude oil for new reformer plants (FEO, 1974). Natural gas liquids are also in short supply. Thus increased availability of reformer gas depends on increased importation of the feedstocks.

F. Transportation of Alaskan Gas

Gas production in Alaska has been confined to south Alaska, primarily to export LNG to Japan. However, the active geological and geophysical survey over the North Slope and the offshore areas of Bristol Bay and the Gulf of Alaska which was started in 1963 resulted in large gas discoveries in North Slope in 1970. The estimate of proved gas reserves for the Prudhoe Bay area of the North Slope is 26 tcf as compared to total Alaskan proved gas reserves of 31.6 tcf (A.G.A., and others, 1974).

Overall Alaska has great significance as a source of petroleum for the West Coast. The eventual market for the North Slope gas is not as clearly defined at this time. The timing of the completion of a gas pipeline from Prudhoe Bay is extremely important and several alternatives are being considered; they are (a) constructing a gas pipeline

that would transport both Alaskan and Canadian import gas into the Mid-West (FPC, 1974c:41); and (b) construction of a gas pipeline along the same right-of-way as the TAPS oil pipeline as well as liquification and port facilities in Valdez for shipment of LNG to the West Coast. It is also possible that sufficient gas may be found in the North Slope, Naval Petroleum Reserve No. 4, the McKenzie Delta and the Arctic Islands to support both transportation routes.

G. Importation of Methanol Manufactured from Foreign Natural Gas Sources and Transported to the U.S. by Tanker

Some natural gas from foreign countries can be converted to methanol, which is also called methyl alcohol, wood alcohol or methylated spirits, for importation into the U.S. Although methanol conversion plants require larger investments and operating costs, transportation costs are lower and methanol can be shipped and stored in conventional equipment. Methanol can be used as a replacement or substitute for fuel oil, or it can be regasified. However, the regasified methanol is more expensive than LNG unless the shipping distance exceeds 4000 to 7000 miles (FPC, 1974c:96) and requires 20 to 30% more natural gas as raw material.

H. Hydrogen

The potential use of hydrogen as a replacement for natural gas, commonly called the hydrogen economy, has been investigated (Gregory, 1972). Hydrogen gas, H_2 , is not commonly found in nature but can be produced by the electrolysis of water, the thermal decomposition of water, chemical reactions involving hydrogen compounds, or a combination of these processes. Waste heat from other processes may be used in generating hydrogen and the possibility of producing hydrogen while dissipating heat from a nuclear power plant is a definite process benefit. Because of its low heat content, 325 Btu/cf compared to about 1000 Btu/cf for natural gas, combustion equipment specifically designed to burn hydrogen is required. However, hydrogen could be transmitted through transmission and distribution systems similar to those used in natural gas operations. Hydrogen does not contribute significantly to energy supplies at the present time, but it will be an important energy source in the future for filling a portion of U.S. energy needs.

CHAPTER III

U.S. RESOURCES OF NATURAL GAS AND NATURAL GAS ESTIMATIONS

The natural gas shortage, which the U.S. is currently experiencing and which is expected to continue beyond the 1980's, requires a short term need to supply all gas possible. In order to reduce the existing disparity between supply and demand of our existing natural gas resources, we need to stimulate and encourage the unprecedented exploration and development efforts that will be necessary to find and produce the requisite level of new natural gas supplies. In order to present a perspective forecast for the future supply of natural gas, a description of a natural gas resource system and its classifications should be discussed.

A. Natural Gas Resource Description

The petroleum resource base of a country can be defined as the total amount of oil and gas occurring in the rocks lying within its boundaries or subject to its control and disposition, such as those of the continental shelf. Including the continental shelf out to water depth of 600 feet, the U.S. embraces some four million square miles. Of

this total approximately 2 1/2 million square miles, or 60% of it can be considered potentially favorable to the occurrence of petroleum hydrocarbons. It is believed that the sedimentary rocks ranging in thickness from less than 1000 feet to over 40,000 feet in the deepest basins originally contained as much as two thousand billion barrels of crude oil and five thousand trillion cubic feet of gas. This is a resource base, not reserves; it is unlikely that even as much as half of it will ever be found or produced.

For the past 115 years, over two million wells have been drilled in the U.S. with more than 1/3 or over 700,000 currently producing oil and gas. Over this period, between 25-30 thousand oil and gas fields have been identified in 32 states, with total acreage about less than 2 or 3% of the area considered favorable for petroleum occurrence.

B. Natural Gas Resource Base Classifications

The natural gas resource base is classified in numerous ways by different organizations. Generally, it can be divided into three major categories.

(i) Discovered reserves, which consist of natural gas that has been produced (Q_p) plus the remaining discovered gas that can be produced under current economic conditions and present technology. This can also be called proved reserves (Q_R). So the cumulative proved discoveries up to any given time can be defined to be the sum of all the gas

produced up to that time plus the proved reserves. Cumulative discoveries can be given by equation III-1

$$Q_d = Q_p + Q_R \quad \text{III-1}$$

with the corresponding rates of discovery given by equation III-2

$$\frac{dQ_d}{dt} = \frac{dQ_p}{dt} + \frac{dQ_R}{dt} \quad \text{III-2}$$

in which the three terms represent the rates of discovery, of production, and of the increase of proved reserves, respectively. It should be mentioned here that some authors, for example, Cox, called the cumulative discoveries "total proved reserves."

Most of the discovered gas in the U.S. was located in just a few states. For example, three states, Texas, Louisiana, and Oklahoma, contain three-fourths of all the discovered reserves of natural gas in the U.S.

(ii) Undiscovered or potential gas supplies are that portion of natural gas resources that may be found and transferred to the category of reserves for future production. Another definition for the potential gas supplies was developed by the Potential Gas Committee (PGC). They defined it as the gas that will be found and proved productive by test wells. These wells may be drilled in the future under assumed conditions of adequate and normal improvement in technology with reasonable prices. Another way of presenting

the definition for potential gas supply is that undiscovered or potential gas supplies represents an estimate of the portion of the gas resource base that is likely to be converted into proved reserves at some time in the future. Unfortunately, at the present time, technology and economic conditions are such that large volumes of natural gas resources are either unrecoverable or uneconomical to produce.

(iii) Ultimate potential supply is the total quantity of producible natural gas that ultimately would be recovered. This would include the discovered gas reserves, and potential gas supplies. The fact that x trillion cubic feet of gas is in the ground says nothing at all about how much of this quantity will eventually be found and put to use. In other words, the rate at which gas resources will be found and discovered, developed, and produced is determined by the economics and technology. The fact is that the amount of gas that is physically present beneath the surface but is unrecoverable or unproducible under the above definition is also very large indeed. It is probably enough to supply the U.S. until the year 2000. However, with present technology it cannot be brought to the surface at a cost that is economically attractive so the ultimate potential supply excludes this unrecoverable or unproducible gas.

C. Future Estimate of Potential Gas Supply

In order to estimate future potential gas supply, certain assumptions have been made about future conditions, such as the level of exploration activity, the state of technology, and economic conditions. Actually, the impacts of these considerations have been central to the continuing debate over the effect of government regulation on the development of gas supplies.

The potential gas supply was broken down and classified into different categories by PGC and also by the U.S. Geological Survey. The PGC classifications are:

(i) probable supplies associated with existing fields. Includes both discovered and undiscovered gas resources.

(ii) possible supplies which is an estimate of new fields to be found in established productive geologic formations or areas.

(iii) speculative supply which is in untested territories or formations not previously productive. The estimates for speculative supply are based on a minimum amount of information.

The U.S. Geological Survey (U.S.G.S.) recently revised its estimates of potential gas supplies and adopted new definitions for mineral reserves and resources. The new U.S.G.S. classification of indicated-inferred reserves is essentially the same as the probable supply category used by the PGC. The U.S.G.S. classification of undiscovered

recoverable resources is based on two major categories which are "hypothetical" and "speculative" supplies. These two categories by USGS are similar to the possible and speculative supply categories used by the PGC. Table III-1 constructs estimates of the ultimate-potential gas supply, using the discovered supply as estimated by the American Gas Association (A.G.A.) as of the end of 1973 and the potential supply as currently estimated by the PGC and USGS.

TABLE III-1
Ultimate Potential Supply
(Trillion cubic feet)

	<u>PGC</u>	<u>USGS</u>
1. Discovered supply (A.G.A.)	705	705
a. Cumulative production (A.G.A.)	455	455
b. Proved reserves (A.G.A.)	250	250
2. Potential	1,146	1,130-2,250
a. Probable	266	130-250
b. Possible	384	
c. Speculative	496	1,000-2,000
3. Ultimate-potential supply (1 + 2)	1,851	1,835-2,955
4. Remaining ultimate-potential supply (3 - 1a)	1,396	1,380-2,500

D. Natural Gas Reserves

There is a profound difference between resources and reserves. Natural gas reserves can be defined as that portion of the natural gas resource base that has been identified, explored, and delineated with a reasonable degree of certainty,

and which has some prospect of being exploited in the foreseeable future.

Overall, the natural gas reserve estimates for the whole U.S. are complicated and the reliability of the procedures used for arriving at the estimated reserves on an aggregated basis have been questioned. For this reason, recently both the FPC and FEA proposed that the industry must submit more and additional information and data on natural gas reserves in order for them to make an independent estimate of the reserves. This request in turn raised the questions of as to what degree of detail the industry should be required in furnishing information and data to Government agencies. The issue actually revolves around the method of estimating proved reserves and reporting reserves statistics. In order to understand the issue, it is necessary to know exactly what proved gas reserves are.

Proved gas reserves are only estimates; they are based on the best engineering and geologic data available, and the judgement of the estimator. These estimates for the natural gas reserves are made on a reservoir-by-reservoir and recorded on that basis within a field office of a producing company. By contrast, they are generally reported on a field-by-field basis in normal intracompany communications. They are reported on a state-by-state basis in the annual statistical compilations of the A.G.A. Until the preliminary results of the FEA study were recently released,

this was actually the only source of data on the nation's proved reserves available to the public. For this reason FEA requested that the industry provide proved gas reserves data on a field-by-field basis. This should give them a better understanding of the distribution of reserves and a more consistent estimate for the whole country.

E. Purpose of Drilling Discovery and Development Wells

Oil and gas discovery and development wells are drilled in order to convert the potential oil and gas supplies into proved reserve categories.

Development wells, which have the lowest degree of risk, are drilled in order to exploit or develop an oil and gas accumulation already discovered by previous drilling. Within the reservoir boundary or limits, the drilling of development wells does not significantly affect the potential supply. Instead it results in providing additional geological and engineering data. Based on this new information, the proved reserve estimate can be revised either upward or downward.

Wells drilled to extend the known limits of previously discovered reservoirs or to discover new oil and gas deposits are considered to be exploratory wells. Exploratory drilling may be considered to include the five following classes of wells:

1. New-field wildcat

2. New-pool wildcat
3. Deeper-pool wildcat
4. Shallower-pool test
5. Outpost or extension test.

The degree of risk assumed by the operator is the highest for the new-field wildcat category and decreases to the outpost or extension test category, which represents the lowest risk for exploratory wells. The guidelines for these well classifications are described in Figure III-1. A new-field wildcat is defined as a well which is located on a structural feature or any type of trap which has not previously produced oil or gas, or at least two miles from a producing structure. New-field wildcats are extremely important because they can find the new fields that lead to the most significant additions to the supply of oil and natural gas.

The new-pool wildcat is a well drilled to explore for a new pool on a structural feature or any type of trap already producing oil or gas but outside the known limits of the presently producing area. The deeper-pool tests and shallower-pool tests are wells drilled within the productive area of a pool or pools previously developed.

The outpost or extension test is a well drilled in order to extend the productive area of a partially developed pool. These various classes of wells play the part of converting potential supplies to proved reserves. This is simply shown in Table III-2.

AAPG and API Classification of Wells

OBJECTIVE OF DRILLING				INITIAL CLASSIFICATION WHEN DRILLING IS STARTED	FINAL CLASSIFICATION AFTER COMPLETION OR ABANDONMENT			
					SUCCESSFUL ● ⚙ ⚙		UNSUCCESSFUL ◇	
Drilling for a new field on a structure or in an environment never before productive				1. NEW-FIELD WILDCAT	NEW-FIELD DISCOVERY WILDCAT		DRY NEW-FIELD WILDCAT	
Drilling for a new pool on a structure or in an environment never before productive	NEW POOL TEST	Drilling outside limits of a proved area of pool		2. NEW POOL (PAY) WILDCAT	NEW-POOL DISCOVERY WELLS (Sometimes extension wells)	NEW-POOL DISCOVERY WILDCAT (Sometimes an extension well)	DRY NEW-POOL TESTS	DRY NEW-POOL WILDCAT
		Drilling inside limits of a proved area of pool	For a new pool below deepest proven pool	3. DEEPER POOL (PAY) TEST		DEEPER POOL DISCOVERY WELL		DRY DEEPER POOL TEST
			For a new pool above deepest proven pool	4. SHALLOWER POOL (PAY) TEST		SHALLOWER POOL DISCOVERY WELL		DRY SHALLOWER POOL TEST
Drilling for long extension of a partly developed pool				5. OUTPOST or EXTENSION TEST	EXTENSION WELL (Sometimes a new pool discovery well)		DRY OUTPOST OR DRY EXTENSION TEST	
Drilling to exploit or develop a hydrocarbon accumulation discovered by previous drilling				6. DEVELOPMENT WELL	DEVELOPMENT WELL		DRY DEVELOPMENT WELL	

Diagram illustrating the AAPG and API Classification of Wells:

- NEW-FIELD WILDCAT (1):** Located outside the structure.
- NEW POOL (PAY) WILDCAT (2):** Located within the structure but outside the known productive limits.
- DEEPER POOL (PAY) TEST (3):** Located within the structure and within the known productive limits, deeper than the previous pool.
- SHALLOWER POOL (PAY) TEST (4):** Located within the structure and within the known productive limits, shallower than the previous pool.
- OUTPOST or EXTENSION TEST (5):** Located outside the known productive limits.
- DEVELOPMENT WELL (6):** Located within the known productive limits.

Legend for well status:

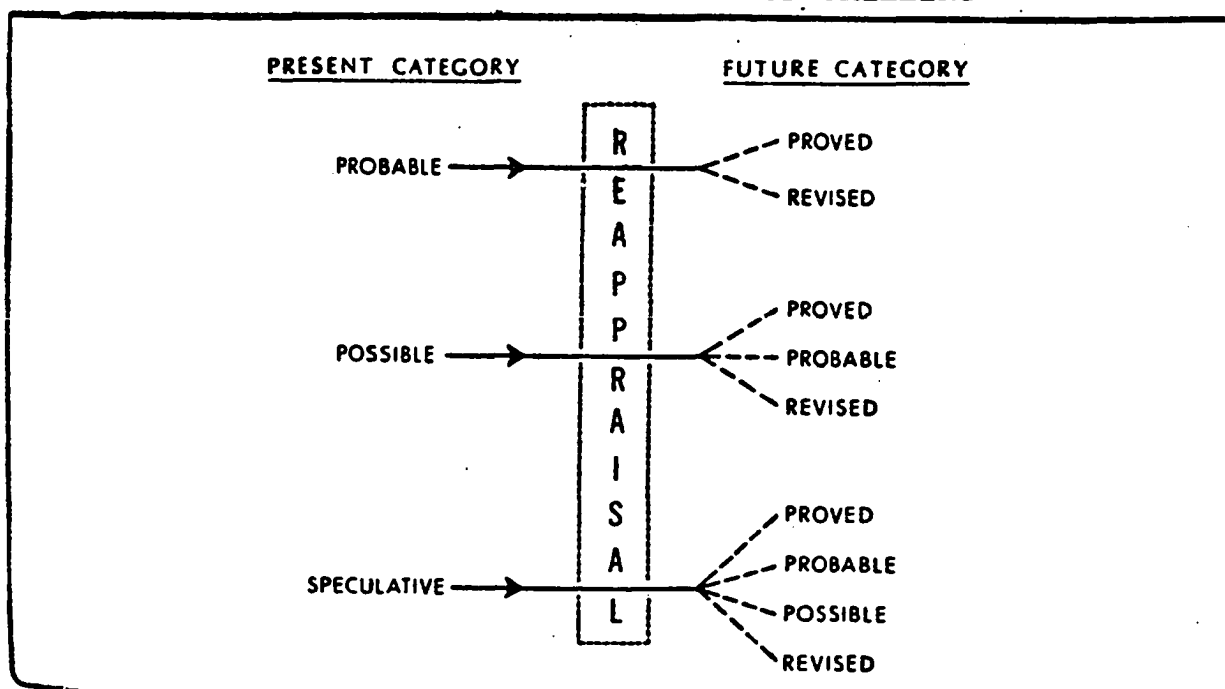
- (Solid Circle): Successful
- (Open Circle): Successful
- ⚙ (Gear): Successful
- ◇ (Diamond): Unsuccessful

FIGURE III-1

Source: The American Association of Petroleum Geologists, August 1973, p. 1401

TABLE III-2

FLOW CHART ILLUSTRATING PROGRESSION OF POTENTIAL
GAS SUPPLIES AS A RESULT OF DRILLING



Source: Potential Supply of Natural Gas in the United States,
A Potential Gas Committee Report, November 1973, p. 36.

F. Domestic Resource Quantities

The estimates of domestic ultimate supply made since 1950 range from about 200 trillion cubic feet (tcf) to 2,995 tcf, with more recent estimates ranging from 572 to 1,396 tcf (FPC, 1974b:14, 168). The estimates of proved and potential natural gas supply for the lower 48 states onshore, lower 48 states offshore, Alaska, and total U.S. are summarized in Table III-3.

According to the American Gas Association (A.G.A.) statistics, a total of 705 tcf of recoverable natural gas had been found in the U.S. as of December 1973. Of this amount, 455 tcf or about 65% had been already produced, leaving approximately 250 tcf of proved remaining recoverable reserves.

According to Table III-3, of this 250 tcf, 218.3 tcf of the remaining proved reserves are in the lower 48 states in which 36.1 tcf of it are offshore and 182.2 tcf onshore. The remaining proved recoverable reserves of 31.6 tcf are located in Alaska.

The variation of proved reserves with time over the period 1946-1973 is shown in Figure III-2. It is based on statistics compiled by the American Gas Association (A.G.A.) (A.G.A. and others, 1973). Figure III-2 also presents a plot of reserves to production ratio (R/P) vs. time which is very important even though a production or cumulative production is primarily of historic interest, but production

TABLE III-3. Natural Gas Resource Data Estimates (trillions of cubic feet)

Area	Proved Reserves A.G.A. ^a	Potential Gas Supply	
		PGC ^b	USGS ^c
Lower 48 states			
Onshore: 0 to 15,000 feet ^d	--	413	--
below 15,000 feet ^d	--	137	--
TOTAL	182.2 ^e	550	246 - 453
Offshore: 0 to 600 feet ^f	--	203	--
600 to 1,500 feet ^f	--	27	--
TOTAL	36.1 ^e	230	26 - 111
Lower 48 states total	218.3	780	272 - 564
Alaska	31.6	366	24 - 137
TOTAL U.S.	250.0	1,146	322 - 655

Sources: ^aBased on year end 1973 statistics published by A.G.A. (A.G.A. and others, 1974).

^bPotential Gas Committee (PGC, 1973).

^cU.S. Geological Survey (DOI, 1974).

^dRefers to drilling or formation depth.

^eBased on the ratio of lower 48 states offshore to lower 48 states total reserves in 1972 of 16.5 percent.

^fRefers to water depth. Applies to PGC data only (PGC, 1973). USGS water depth limitation for undiscovered recoverable resources is 200 meters.

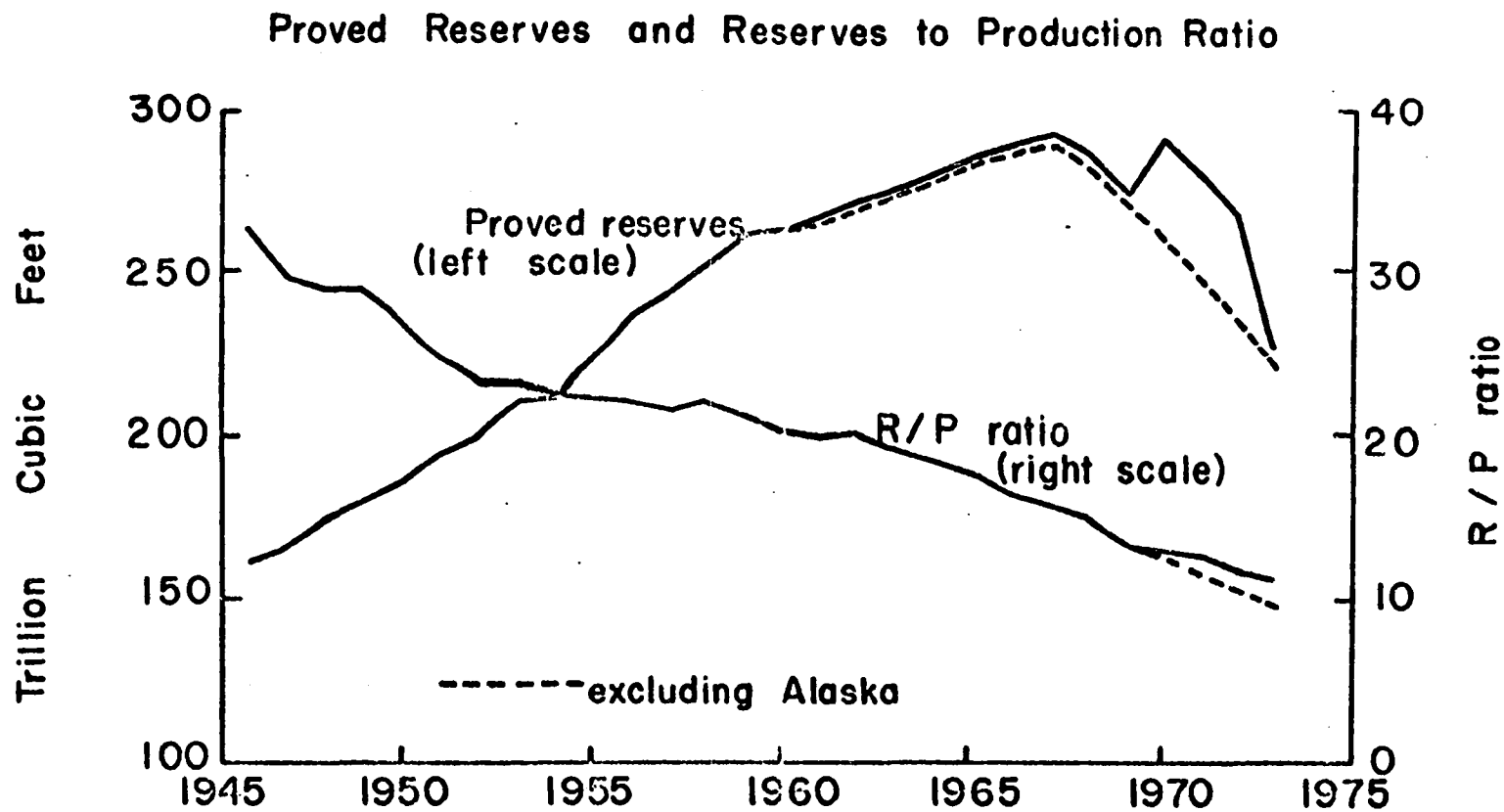


FIGURE III-2. U.S. natural gas supply, proved reserves and reserves-to-production ratio

Source: FPC, 1974b:22

data would enable us to find the R/P ratio for each year, and with the known production rate we can find the life of reserves. For example, for the current annual rate of production of about 22.6 tcf, the life of the proved reserves to production (R/P) ratio is 9.7 years with Alaska excluded and 11.1 years with Alaska included.

As we can see from Figure III-2, the R/P ratio has declined steadily for the last 30 years. The first year that more gas was produced than found in the lower 48 states was 1968, with similar deficits since then for each succeeding year. It should be noted also that the overall quantity of domestic gas produced was more than twice the quantity found in the lower 48 states during the period 1968-1973. The accelerated decline in the R/P ratio during that period (1968-1973) reflects both the decreasing reserves base and an increasing production rate.

CHAPTER IV

METHODS FOR MAKING NATURAL GAS RESOURCE ESTIMATES

The present estimates of resources onshore are limited by formation depth and offshore by water depth. There is no doubt that additional oil and gas will eventually be found and produced from the deeper wells onshore and from deeper waters of the continental slopes. Improved geology and technology should make it possible to obtain more information and perform oil and gas operations under more demanding conditions with the result that more reserves will undoubtedly be discovered. In order to study how to estimate the total natural gas resources in the U.S., the discovered reserves and potential gas supply must be estimated individually. The basis for making these estimates will be discussed in the following sections of the dissertation.

A. Total Discovered Reserve Estimate

As stated previously, discovered reserves are defined as the sum total of volumes of cumulative production (Q_p) and the proved reserves (Q_R). The magnitude of the cumulative production (Q_p) of natural gas up to any given year is calculated simply by summing the values for past

production published by the A.G.A. The magnitude of proved reserves (Q_R) for a given reservoir is estimated by techniques falling into two broad categories, those based on the volumetric method and those based on analysis of production data. The volumetric method is used early in the life of a reservoir when little or no production data are available. Basically, this method consists of two steps. Each step requires the use of professional judgement in applying geological and engineering techniques. In the first step, well data, test results, records, maps and other basic raw data are the basis for estimating the volume of gas-in-place in the reservoir. In the second step, the portion of the gas that will be recovered is estimated using an appropriate recovery factor or abandonment pressure.

In the performance methods, past trends in production data are used in making the reserves estimates. These methods are used during latter stages in the life of a reservoir or an older field. Even though these techniques use standardized methods of extrapolating the production data, some judgement is still exercised in interpreting of the data.

It should be mentioned that the extrapolation of production data, when applicable, is the more accurate and reliable of the two methods.

B. The Potential Gas Supply Estimates

Most of the past estimates of potential gas supply have been generally based on two basic methods, a volumetric (geologic) calculation or a mathematical projection. Recently, the Mobil Oil Corporation estimates by J. D. Moody and those by the USGS have been based on a probability model. In the volumetric (geologic) calculation, the volume of sedimentary rock remaining to be explored is multiplied by the ratio of the total amount of gas already discovered to the volume of sedimentary rock which has been explored. The volumetric calculation was used in the past by the National Petroleum Council (NPC), the Potential Gas Committee (PGC), the U.S. Geological Survey (USGS), L. G. Weeks, T. W. Nelson and C. A. Burk, and many others.

The mathematical projection relies entirely upon statistical records of past exploration and production and does not consider the geology of the area. It uses mathematical equations to describe past discovery, reserves and production data. Standard techniques are applied in evaluating the constants in the equations and extrapolating the historical data. The mathematical projection was used by M. K. Hubbert, C. L. Moore, M. A. Elliott and H. R. Linden and others.

In the probability model, individual prospects are identified. The gas that may be discovered if a prospect is drilled is based on a combination of the available data

and subjective judgements and is expressed as a "probability profile", i.e., the specification of the probabilities that the amount of gas discovered may exceed various values. Finally, a program in which all prospects are drilled is simulated and the results are expressed either by giving an overall "probability profile" or by stating the expected value of the amount of gas that may be discovered.

Most of the estimators used the mentioned techniques for estimating the potential oil supply resources. Then in order to estimate the natural gas resources they have used the gas-oil ratio method. In this application the gas-oil ratio is the ratio of the cumulative quantity of gas that has been found to the cumulative quantity of oil that has been found. This method is based upon applying the gas-oil ratio to the estimated oil resources, and has been used by many estimators, including USGS, M. K. Hubbert, L. C. Weeks, Nelson and Burk, and many others.

Some estimators used another technique in which energy resources are related to the amount of exploratory footage that has been drilled. This method was used by N. G. Rios, J. J. Arps, M. Mortada, and A. E. Smith, and many others.

Comparisons between these mentioned methods or even between techniques suggested by different estimators are very difficult to make. The estimates using each of the basic methods by different estimators vary greatly. In

general, estimates made using the volumetric method exceed those made using mathematical extrapolation. The more recent results obtained by use of probability models agree reasonably well with those from mathematical extrapolation.

In order to get a better feeling and understanding about these different techniques, some individual estimates are shown in Table IV-1 and will be discussed in the following sections of the dissertation.

1. Estimate by National Petroleum Council (NPC)

The National Petroleum Council (NPC) is composed principally of industry specialists. By the request of the Assistant Secretary—Mineral Resources, NPC was assigned to study and prepare an estimate for future petroleum resources in the U.S.

The phase of the study relating to crude oil estimates was completed by Miller and others (1970). However, the resource estimates for natural gas were found to be too incomplete to be useful. Consequently, it was decided to adopt the estimates made by the Potential Gas Committee (1969), which were then interpreted by I. H. Cram (1971).

To carry out the assigned project, NPC divided all potential favorable areas in the U.S. into 11 regions. The geographic locations of these regions which are designed to incorporate areas of similar geology are shown in Figure IV-1.

TABLE IV-1
Comparison of Ultimate-Potential Gas Supply Estimates *
(Trillion Cubic Feet)
As of December 31, 1973

Area	Cumulative Production (1)	Proved Reserves (2)	Discovered Supply (1) + (2) (3)	Potential Supply (4)	Ultimate Potential Supply (3)+(4) (5)	Source Date (6)
	(AGA 12-31-73)					
Lower 48 States	455	218	673	780	1,453	PGC (V)
Alaska	1	32	32	366	398	
Total U. S.	456	250	705	1,146	1,851	1973
Lower 48 States	455	218	673	840-1,670	1,513-2,343	USGS ** (V)
Alaska	1	32	32	290-580	322-612	
Total U. S.	456	250	705	1,130-2,250	1,835-2,955	1974
Lower 48 States	455	218	673	377	1,050	Hubbert (M)
Alaska	1	32	32	118	150	
Total U. S.	456	250	705	494	1,200	1969
Lower 48 States	455	218	673	380-553	1053-1226	Linden (M)
Alaska	1	32	32	179-135	211- 167	
Total U. S.	456	250	705	558-687	1264-1393	1972
Total U. S.	456	250	705	294	1,000	Weeks (M) 1959
Total U. S.	456	250	705	841	1,547	Moore (M) 1970

Note: Totals may not add due to rounding.

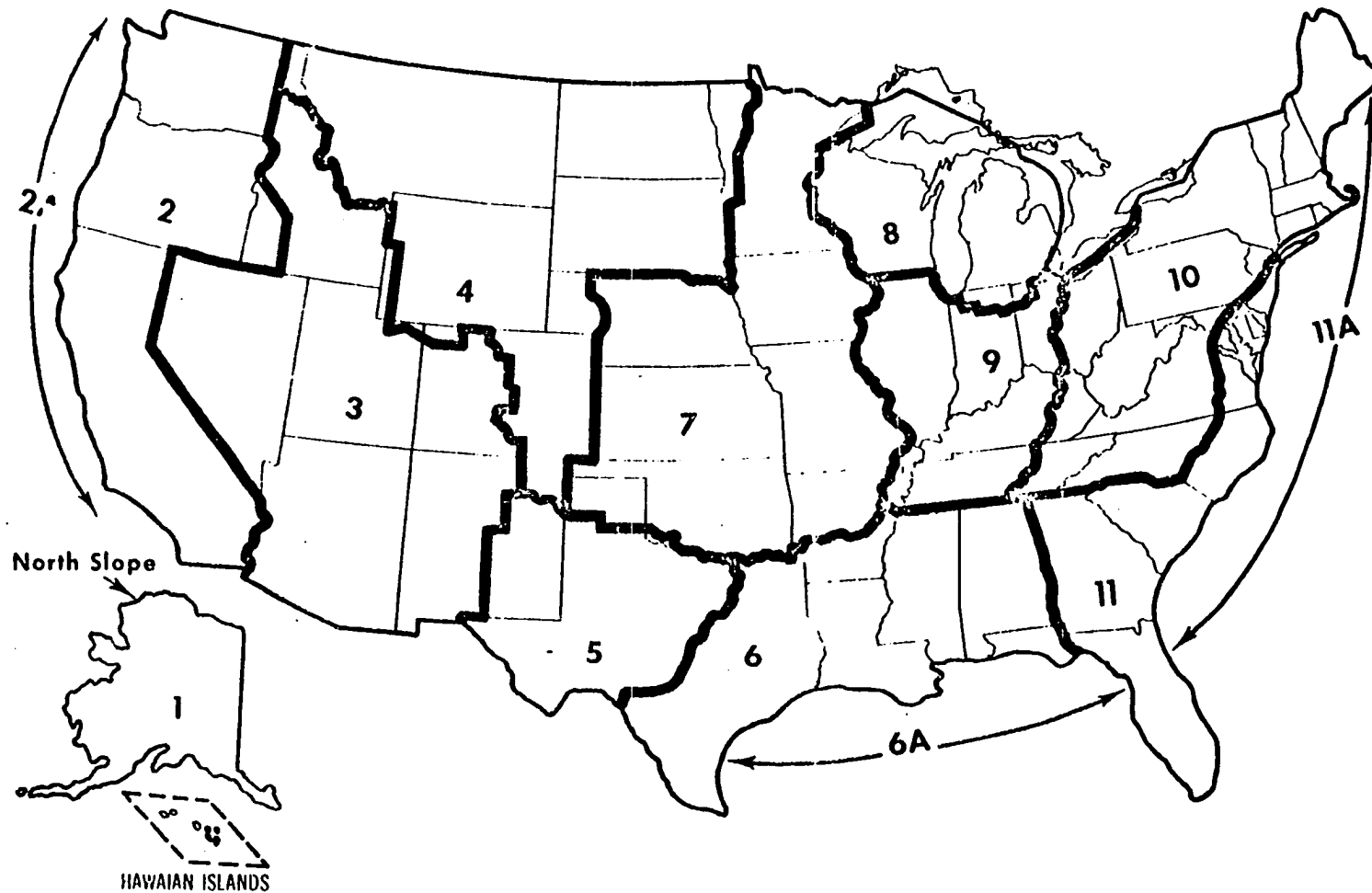
* Adapted in part from "Energy Resources of the United States" Geological Survey Circular 650, Figure 16, p. 16.

** Includes only estimated recoverable resources to 200 meters water depth.

(V) Volumetric or geological method.

(M) Mathematical projection.

NATIONAL PETROLEUM COUNCIL'S SUPPLY REGIONS



Source: NPC Future Petroleum Provinces of the United States (July 1970).

FIGURE IV-1

In preparing the NPC report, a team consisting of geologists with years of personal experience in their assigned regions studied a variety of geologic methods. These methods included extrapolation and interpolation along trends, Comparison of similar areas and strata, evaluation of structures determined by geophysical prospecting, evaluation of the undrilled parts of known fields and pools, and assignment of average oil or gas incidence to rock volumes.

The estimate for each of the 11 regions was based on three categories; probable, possible, and speculative reserves. The final results of the study, as interpreted and modified by Cram to yield natural gas supply estimates, are shown in Table IV-2.

TABLE IV-2

Total Natural Gas Supply Estimates by NPC

(Trillion cubic feet)

	<u>Probable</u>	<u>Possible</u>	<u>Speculative</u>	<u>Total</u>
Potential Natural Gas Supply	260	335	632	1227
Ultimate Natural Gas Potential				
Conterminous U.S.				1305
Alaska				238
Total				<u>1543</u>

This study is considered as the most authoritative and informative compendium on petroleum geology of the U.S. and probably the most detailed estimate of potential oil

reserves that has been made for the U.S. to date. However, it does not present as detailed an analysis of natural gas resources as can be found in other references.

2. Estimates by the United States Geological Survey (USGS)

One of the two most widely quoted estimates of potential gas supply is the estimate by the USGS which has had the reputation for many years as one of the nation's best and most authoritative mappers and measurers of natural resources. The estimate of potential natural gas supply is determined or based on applying a gas-oil ratio (GOR) to estimated or approximated quantities of crude oil resources.

The USGS estimates for crude oil are basically geologic and were developed by A. D. Zapp and T. A. Hendricks. The methodology is described on page 21 of Geological Survey Circular 650. The method involves applying the historical results of past exploratory drilling to unexplored rocks on an equal basis for all of the favorable strata of the U.S., including Alaska and the continental margins to a water depth of 2500 meters (8250 feet).

The resulting USGS estimate gives the total original oil-in-place from which the various other categories can be calculated by applying suitable finding and recovery factors. It is assumed with current exploration technology five-eighths of the oil-in-place can be found, but only 40% of the oil found can be produced. By multiplying estimated quantities of crude oil by a gas-oil-ratio (GOR) of 2500 ft³ of gas

for each barrel of oil in place, the original gas-in-place can be determined. (the GOR ratio used by USGS is much lower than those used by other estimators, e.g., M. K. Hubbert. The reason is that USGS used a ratio of gas-in-place to oil-in-place, but Hubbert used a production GOR which reflects the higher recovery factor for gas.)

It is assumed 80% of the original gas-in-place is recoverable. From this, cumulative gas discoveries are subtracted to find the total recoverable potential gas supply.

In reporting resource quantities, the USGS also uses categories referred to as para- and sub-marginal resources which are defined as those either not recoverable, or not found and recoverable because of either size and location or recovery technology and low price. Future advances in recovery technology or increase in price could make some of these known and undiscovered para- and submarginal resources recoverable. Table IV-3 shows the recoverable potential gas supply estimates in trillion cubic feet as prepared by the USGS.

3. Estimates by the Potential Gas Committee (PGC)

The PGC (Colorado School of Mines Foundation, Inc., Potential Gas Agency) is another one of the more widely quoted estimates of potential gas supplies. These estimates, like USGS estimates, are based on the volumetric (geologic) method, but the basic approach differs somewhat from that used by the USGS.

TABLE IV-3
Total Recoverable Potential Natural Gas
Supply Estimates by USGS
(Trillion cubic feet)

<u>Area</u>	<u>Recoverable Potential Natural Gas Supply</u>
Lower 48 States	840-1670
Alaska	290-580
Total U.S.	1130-2250

The PGC estimates of potential gas are made for the large possibly favorable areas. This is similar to the USGS methodology; however, the gas resource estimates are made independently of oil resource estimates and there is no need to apply a gas-oil ratio.

The PGC approach is described in detail on page 25 of the November 1973 issue of the Committee's publication, The Potential Supply of Natural Gas in the U.S. The basic technique was the comparison of the factors that control known occurrences of gas with factors present in prospective areas. Known occurrences are expressed as the volume of natural gas ultimately recoverable per unit volume of reservoir rock, within an adequately explored portion of a geologic province. This relationship with appropriate adjustment for variations in geological and reservoir conditions is then attributed to incompletely explored or totally unexplored sedimentary rocks in the same or in a similar geologic province.

The potential natural gas estimates by PGC for 12 geographic areas of the U.S. are based on three categories of probable, possible and speculative figures. Except for Alaska, the estimates are reported by two drilling depths on land and by two water depth zones offshore. The PGC estimates are shown in Table IV-4.

TABLE IV-4
Total Potential Natural Gas Supply Estimates by PGC
(Trillion cubic feet)

<u>Area</u>	<u>Potential Gas Supply Estimates</u> <u>(Trillion cubic feet)</u>			<u>Total</u>
	<u>Probable</u>	<u>Possible</u>	<u>Speculative</u>	
Onshore: 0-15000 ft.	121	153	139	413
below 15000 ft.	33	45	59	137
Offshore: 0-600 ft.	58	74	71	203
600-1500 ft.	0	18	9	27
Total 48 states	212	290	278	780
Alaska	54	94	218	366
Total U.S.	266	384	496	1,146

4. L. G. Weeks' Estimates

The estimates of ultimate production made by Weeks (1958, 1959) are not fully described. It is not really known whether the estimates are based on the geologic method or mathematical projection; nor did he specify whether his estimate of ultimate gas production was based on a gas-oil ratio. A limited possible favorable area was used for this

estimate. The area which was covered included conterminous U.S. and Alaska combined land and offshore areas. He neglected to include areas such as the Atlantic Coast mainly because sufficient exploration experience for this area was not available. The estimates for offshore areas were carried to a water depth of 1000 feet which is only slightly deeper than the seaward edge of the continental shelf. His estimates are shown in Table IV-5.

TABLE IV-5
Total Potential Natural Gas Supply Estimates
by L. G. Weeks
(Trillion cubic feet)

Potential supply of Natural Gas	318 tcf
Ultimate potential supply of Natural Gas	1000 tcf

5. T. W. Nelson and C. A. Burk Estimates

The Nelson and Burk estimates are based on geologic methods, but their methods are not fully explained. The area they covered was limited to the undeveloped and unfound petroleum reserves of U.S. continental margins. Their estimates do not include the Alaska shelves. They deal with the U.S. continental shelf, or the zone where the water depth ranges from 0 to 2000 meters. They reported resource quantities under the categories as prospective and speculative reserves. They estimated that the ultimate natural gas production would range from 88 to 168 tcf.

6. M. King Hubbert Estimates

Hubbert is one of the leading proponents of mathematical projection for estimating ultimate potential resources. His estimate of the ultimate potential production of crude oil is based on the mathematical extrapolation of historical data on crude oil reserve additions and production for the conterminous U.S. and its contiguous continental shelves.

His method actually involves fitting a particular mathematical function (the logistic curve) to historical data on cumulative gross additions to crude oil reserves as reported by the API. He then uses this equation to estimate total ultimate recovery. The logistic curve which he fitted to cumulative gross reserves additions (or in his terminology "cumulative discoveries") had an upper limit of 170 billion bbl. Thus on the basis of the logistic curve, this figure represents the total estimate for ultimate crude oil discovery and production for the U.S.

Hubbert did not make an independent estimate for ultimate potential gas production, but calculates it by using a gas-oil ratio (GOR) technique. He multiplied the estimated ultimate crude oil production of 170 billion bbl by a GOR of $7500 \text{ ft}^3/\text{bbl}$ which is approximately the historical ratio of cumulative gas production to cumulative crude oil production. The value for estimated ultimate potential gas production that he obtained was 1184 tcf. Of this figure 1050 tcf or 89% is located in the conterminous U.S. and 134

tcf or 11% in Alaska. Hubbert projected that peak production of natural gas for the lower 48 states would be approximately 21 tcf in about the year 1978. This figure was based on his estimate of 1050 tcf of ultimate potential production.

7. M. A. Elliott and H. R. Linden Estimates

Other leading proponents of mathematical projection for estimating future natural gas are Elliott and Linden of the Institute of Gas Technology (IGT). Their study of future gas supply is based on the IGT model which projects future natural gas production and discoveries from historical data. This technique expresses parameters such as annual production and discoveries, proved reserves, and ratio of proved reserves to annual production (R/P) as implicit functions of time expressed in calendar years. In order to project the future supply of natural gas all of these historical parameters of natural gas were used as input into the IGT model which was programmed for computer solution. The output was a set of empirical constants that could be used to calculate and project the future supply of natural gas. Elliott and Linden's results and projections based on the IGT model were as follows: The total potential production ranged from 1264 tcf to 1393 tcf for the whole U.S. (including Alaska). Of this total, 1053-1226 tcf is attributed to the lower 48 states and 211-167 tcf to Alaska. They also indicated a production capability of 25-26 tcf per year between 1979-1982 for the lower 48 states. The total U.S. production

was also projected to peak at 27 tcf between 1983-1985, at an R/P ratio of about eight years.

8. C. L. Moore Projection

The estimates presented by C. L. Moore of the Department of Interior's Office of Oil and Gas were based on mathematical projection. The approach is very similar to that of M. K. Hubbert except that the Gompertz curve is used rather than the logistic curve. Moore also presents an independent estimate for natural gas instead of basing them on estimates for crude oil and a historical gas-oil ratio. Moore projected a potential ultimate production by fitting a historical data to a Gompertz curve. His estimate was 1547 trillion cubic feet for potential ultimate U.S. production of natural gas.

9. Energy Policy Staff (EPS) Projection

A different approach was used by energy policy staff (EPS) of the Department of Interior. The energy policy staff estimates for the oil and natural gas resources were given as discovered and undiscovered figures.

The known or discovered oil and gas resource quantities were obtained from the API data for oil and the A.G.A. data for natural gas. The estimated known natural resources at that time amounted to 268 tcf.

In order to estimate the undiscovered natural gas resources, the EPS used and multiplied the estimated undiscovered oil resource quantities derived by A. D. Zapp of

the USGS by the historical gas-oil ratio (GOR).

The result of this multiplication gave an estimate of 2050 tcf of natural gas resources. Of this quantity, 1200 tcf of it is recoverable and can be produced under current economic conditions and 850 tcf of it is marginal undiscovered natural gas resources which are not recoverable under current economic conditions.

10. A. R. Martinez Method

A. R. Martinez (1963) presented a method on estimation of the magnitude and duration of petroleum resources. In order to estimate the duration of given oil or gas resources, he proposed the integral technique of prediction. This technique is based on the Hubbert mathematical method (logistic curve). It is actually simple mathematical relationships between the cumulative production, the proved reserves, the cumulative discoveries, and their time derivatives. As for the magnitude of oil or gas resources, he defined the resources as the sum total of four different volumes: the production, the proved reserves, the supplementary reserves, and the undiscovered reserves.

He suggested that a key factor in estimating the magnitude of oil or gas resources was a detailed study of the geology of the sedimentary basin as well as all geological history of basins for the four types of resources mentioned above should be done.

Also Martinez applied his approach to statistics for Venezuela in order to estimate the magnitude and duration of the petroleum resources of that country. He did not extend his work to estimation of natural gas resources.

11. J. J. Arps, M. Mortada, and A. E. Smith

Arps, Mortada, and Smith presented an exploration performance method by setting up a mathematical model, which provides an effective tool for the evaluation and projection of future recoverable reserves. This model relates exploratory results, in terms of proved reserves, to exploratory effort, in terms of exploratory footage drilled. The model consists of many interrelated parameters and incorporates two important considerations. The first consideration is the concept of an economic limit in the context of an exploratory program. The second consideration makes full use of the A.G.A. and API reserve classifications and statistics. The data from these sources would permit an evaluation of the declining effectiveness or decay of new field reserves added by incremental exploratory footage drilled and also would give the growth of reserves in previously discovered new fields. Basically their exploration model can be used to

1. forecast future trends in results of exploratory effort.
2. evaluate and predict potential recoverable hydrocarbon reserves in mature geological basins or areas.

3. predict ultimate economically recoverable reserves for variable oil and gas price level by imposing a realistic and appropriate economic limit and factors on results of the exploration model.

Overall this method is considered to be one of the most adequate tools for predicting economically recoverable ultimate recovery for a given area.

12. J. J. Arps and T. G. Roberts Method

J. J. Arps and T. G. Roberts presented an economic analysis for a sample area on the east flank of the Denver-Julesburg basin based on observed statistical data. The Denver-Julesburg basin was chosen because it was large in areal extent and sizable statistical information was available. The sample area covers 5.7 million acres with hundreds of lower cretaceous fields and thousands of wells. Because of the sizable statistical sample and large area, the economic and statistical analysis used for the Julesburg basin can be applied for any other geologic province. Arps and Roberts concluded that this study would provide a tool for making a forecast of the probable results to be expected from future exploratory drilling.

13. Nelson G. Rios Model

Rios introduced a model which involves the use of exploratory and production data. His exploratory footage model relates energy resources discovered to the amount of

exploratory footage drilled. Rios fitted the exploratory model to the historical data for the Seminole area of Oklahoma (Hughes, Pottawatomie, and Seminole counties) in order to predict the future economically recoverable reserves. He concluded that this model can be used for any area as long as the exploratory activity in the area was in the mature stage.

14. J. D. Moody Method

J. D. Moody developed a statistical approach. His technique employs an elaborate computer program to combine the geologic and production characteristics of known (and possible) oil and gas reservoirs with the instincts of Mobil's explorationists in the field. The result is a series of probability profiles that project the output of known and suspected deposits in each of the U.S. 14 oil and gas provinces. The area covered for this estimate was all U.S. territory, onshore and offshore to water depths of 6000 feet. Mobil's estimate was much lower than the estimate made by the USGS for oil as well as natural gas. Their estimate for undiscovered recoverable oil and gas in the U.S. was 34 billion bbls of oil and 605 trillion cubic feet of natural gas for onshore and 54 billion bbls of oil and 443 trillion cubic feet of natural gas for offshore areas.

C. Accuracy of the Resource Estimate

The variation in resource estimates by different estimators seems to indicate that these forecasts are only order of magnitude figures and can serve as little more than a basis for rough, pragmatic analysis of energy policy alternatives. The estimates of potential gas supplies are only "indicators" of gas that may be found and produced. These different methods all have some degree of uncertainty and the estimates given by them should be used cautiously by governmental and corporate policy makers. These methods all have certain inadequacies, limitations, and weaknesses. For example, the estimates based on mathematical projection are unrealistic because they are built entirely upon the past and do not consider any future changes in economical, political, and social factors that can entirely and drastically change all the future estimates on discoveries, reserves, and production.

The only way to get a realistic estimate for this approach is to assume that economical, political, technical and social factors remain unchanged, and the area under consideration is a well developed area, such as the lower 48 states onshore. One of the main reasons that the mathematical projection estimate can be low is because it ignores the undeveloped areas, i.e., Atlantic offshore, or continental shelf of the Gulf Coast.

Other weaknesses of the mathematical approach were pointed out by J. M. Ryan. In rejecting this method, Ryan stated that there is no logical basis for assuming that future activities will be constrained to follow Hubbert's logistic function, or Moore's Gompertz function, or any other function. He argued that the mechanical curve fitting approaches used by Hubbert and Moore and other estimators are not logical, and it cannot physically represent the estimate for ultimate oil and gas recovery. He concluded that these approaches are essentially arbitrary, and the best way of giving any estimates is by massive and detailed subsurface studies and exploratory drilling for all geographic areas in the U.S.

The estimate based on geologic (volumetric) methods is also unrealistic in that we lack the quantitative data necessary to produce estimates with any reasonable accuracy. For example, the recent USGS estimate has been reduced significantly because of the combination of the introduction of more data and critical re-evaluation of the method previously used. F. K. North in viewing this method stated that the method has no scientific or economic meaning and is not a measure of any thing tangible. Actually an estimate developed with this method is based upon whatever assumptions the estimator chooses to adopt. One of the main reasons that future projections made with the volumetric or geologic method are generally higher than the mathematical projections

is because they normally include calculations for potential resources of all sediments to a given depth on dry land, and for a given water depth on the continental shelves. As North stated, the estimate based on the volumetric method are too large for the following reasons:

1. the probable reserves are generally overstated;
2. the speculative reserves are generally wholly suppositional and should not be counted on;
3. undiscovered potential estimates are questionable because such areas as the Atlantic offshore have not been demonstrated to contain economically recoverable hydrocarbons.

The probability approach developed by the Mobil Oil Corporation also has its drawbacks since in this approach someone, somewhere in the company must at least conceive of a "play" or prospect of oil and gas before it enters the calculations. According to McKelvey, Mobil researchers fail to take all the available data or prospects into consideration, especially all the small scattered deposits that could add up to a significant quantity of oil and gas

However, as mentioned previously, most of the methods for making estimates of gas resources have limitations and weaknesses. All of these deficiencies are caused by the lack of engineering, geological, economical, technological, and social data. In order to get a better estimate, government and industry must continue to make more investments to revise and apply these methods as more data becomes available.

CHAPTER V

DESCRIPTION OF THE MODEL

For many years natural gas has been one of the most important sources of U.S. energy, and it provides more than 40 percent of today's total consumption [54]. For many years the discoveries of natural gas exceeded the amount needed and the nation's proved reserves increased even as more gas was being produced (including the amounts consumed, used in the field and flared and vented). However, in 1968, more gas was produced than found. Since then the total U.S. reserves have dropped at a rapid rate and during the seven-year period 1968-1974 the quantity of gas consumed was approximately 2-1/2 times the amount found. Clearly, steps are needed that, at a minimum, will equalize future finding and production rates, i.e., balance the supply-demand factors. The effectiveness of these efforts depends on the adequacy of the methods used to project future levels of finding rates and reserves. As discussed in a previous chapter, many methods for forecasting gas resource availability were introduced in the last two decades by different people or organizations. The estimates of reserves and predictions of future discoveries of oil and natural gas obtained from

each method with its recognized limitations can produce relevant results, but no single technique has universal application. The strengths and weaknesses of each technique must be considered in choosing the method or methods to be used in making an estimate of hydrocarbon potential of a specific area.

The technique or the model used in this study actually combines a statistical description of the reserves of the fields in the region and an assumed or extrapolated future drilling activity relationship to forecast the future discovery rate. In this model a large population of fields made up the resource base used. In the initial runs this population contained 6358 fields which were separated into seven classes. In later runs (Case I and Case II) the total population contained fewer fields but the relative frequencies of those used in the initial runs were retained. Each class contains M_1 fields of size class one and M_2 fields of size class two, and so on. The smallest class contained fields with reserves less than 1 Bcf, the largest fields with reserves greater than 400 Bcf. For this population a probability calculation was carried out using essentially the same procedure suggested by Arps and Roberts and discussed in detail by A. W. McCray in his 1971 class notes [52]. The purpose and objective of this model was to determine the number of fields which would be found upon drilling W wells. This was accomplished by calculating for each pass through the simulation model the probability that a field from any of the classes

would be found. These probabilities were computed on the basis of the field size distributions of the fields remaining to be found. A random number generated in the simulation pass was used to indicate whether or not a field was discovered, and if so, the field size. The total number of fields discovered and the total quantity of reserves discovered were accumulated. The Monte Carlo technique described above was adapted to translate separate probability judgements into a form useful for evaluating reserves assessments for individual regions and the total resource base, and to determine statistical valid ranges of reserves estimate summations.

Similar techniques were used to assess the total footage drilled. In the drilling of each well, the depth was either considered to be a random variable or a function of two random variables. Each dry exploration well was assumed to penetrate the interval containing the productive zones. In the drilling of each of these wells the depth to the bottom of the target interval, i.e., the depth of the well, was considered to be a random variable. In the drilling of each successful gas well, the depth was considered to be a function of two random variables. The first was the depth to the bottom of the target interval, the other the location of the producing formation within this interval. The operation in this section of the model resulted in the computation of the dry hole footage, gas well footage, and their respective cumulative values. By using all the previous results and

known footage the reserves, ratio of reserves per number of wells drilled, number of gas fields found, number of dry holes, dry hole footage, and gas well footage for all the n classes combined are found in an increment of drilling activity or on a cumulative basis after W wells are drilled. The results also indicate the productivity figure which is a ratio of reserves per foot drilled. The calculation was further carried out to find a relationship between reserves and number of fields found.

The next step or phase in this model is the application of performance or behavioristic extrapolation methods based upon historical and available data. From previous calculations we already have the values of reserves as a function of footage drilled for each region. By assuming that the future footage being drilled each year will follow some path such as hyperbolic, straight line, logistic, or increasing drilling rate, values of footage can be calculated for each of the next 20 years. For the initial run the footage was assumed to follow the hyperbolic curve, but footage was also calculated using other curves. Using values of reserves from previous calculations and future footage drilled, the future reserves discoveries can be found and interpolated for each region as a function of time. Also the discovery rate, which is a ratio of future reserves discovered per foot drilled, and cumulative discovery rate, which is a ratio of future cumulative reserves discovered per cumulative footage drilled can be calculated for each region as a function of time.

By summing the results for all regions (3 regions) the future reserves discoveries, cumulative discoveries, discovery rate, and cumulative discovery rate for all the collection of regions as a function of time for the next 20 years was calculated. It should be mentioned that the future reserves discovery rates were very sensitive to the assumptions that were made as to future drilling rates. As will be discussed in detail in the result section, it was found that the discoveries changed significantly depending on both the type of relationships assumed and the values assigned to the empirical constants.

The combined use of the reserves and drilling data or the use of the productivity data or discovery rate data could serve as the basis for economic or price calculations which should be considered in future evolutionary development of the model. These could include inclusion of forecasts of economic parameters as either deterministic relationships or random variables so that escalation of future drilling costs could be simulated. These drilling costs expressed in terms of dollars per foot could be used in conjunction with the productivity expressed in Mcf per foot in economic assessment of the exploration activities. The economic calculations could either predict the quantity of reserves that will be found for a given set of economic parameters or conversely the ratio of gas price to drilling costs required to develop a specified quantity of reserves. In addition

to the costs resulting from the total footage drilled, other costs such as lease acquisition, operating costs, etc., could be included in the total costs.

CHAPTER VI

MATHEMATICAL MODEL

This model consists of two phases. The primary phase uses a sizable statistical sample as the basic unit in a Monte Carlo simulation of the response of the gas resource base to drilling activity. The field size distribution of the undiscovered fields is used to calculate the following parameters for each class: the class mark, the product of the class mark and the frequency, and the probability of finding a field from the class. The latter probability is given by:

$$P\{\text{finding a field from class } i\} = \frac{x_i f_i}{\sum_{j=1}^n x_j f_j}$$

The class mark represents the size of the discovery. The depth of each well was a random variable and the depth of each well was generated from a random number for each individual simulation of the drilling of an exploratory well. Thus each well was either dry or successful, was associated with a specific drilling depth and each successful well was associated with a specific field size. Also in the primary phase calculations were made of other parameters, i.e.,

productivity which will be discussed in detail later in this chapter.

The second phase of this model is based on output from the primary phase. It uses mathematical projection (curve fitting) in order to convert the future results such as reserves discoveries, and other parameters from functions of footage drilled to functions of time.

All of the data and assumptions are based on the previous work published by Federal Governmental agencies and their professional staff or agents since theirs is the most accurate and comprehensive available.

The statistical sample which is shown in Table VI-1 and as a histogram in Figure VI-1 is the population of non-associated and associated gas fields reported in the FPC's National Gas Reserves Study Report. All initial field size distributions used in this study were patterned after the distribution shown in Table VI-1. Except for the first and the last (seventh) classes, the class mark was the geometric mean of the upper and lower class boundaries shown in Table VI-1. For the first class, a lower class boundary of 0.1 was assumed and for the seventh class an upper class boundary of 4000 was assumed; the class mark for these classes was again represented by the geometric mean since they are log normally distributed.

The class mark for Class I is equal to the square root of the upper limit of Class I times the upper limit of the previous class, Class I-1. This is shown in equation VI-1.

TABLE VI-1
Size Stratification of Population Fields
(All volumes in billions of cubic feet)

<u>Classes</u>	<u>No. of Fields</u>	<u>Population Strata Range</u>
1	1879	$0 \leq \text{Field} \leq 1$
2	1822	$1 < \text{Field} \leq 5$
3	719	$5 < \text{Field} \leq 10$
4	1200	$10 < \text{Field} \leq 50$
5	509	$50 < \text{Field} \leq 200$
6	121	$200 < \text{Field} \leq 400$
7	108	$400 < \text{Field}$

Source: Arthur Young & Company from data provided by A.G.A. as well as from public sources.

$$c_{i,k} = \sqrt{u_{i,k} u_{i-1,k}} \quad \text{for } i = 2, \dots, n-1 \quad \text{(VI-1)}$$

$$k = 1, \text{NR}$$

where NR = number of runs. In order to calculate the class mark for $i = 1$ or $i = n$, equations VI-2 and VI-3 should be used:

$$c_{1,k} = \sqrt{\alpha_k u_{1,k}^2} \quad \text{for } k = 1, \text{NR} \quad \text{(VI-2)}$$

$$c_{n,k} = \sqrt{\beta_k u_{n-1,k}^2} \quad \text{for } k = 1, \text{NR} \quad \text{(VI-3)}$$

where α_k and β_k are assumed to have values of 0.1 and 10 respectively.

An important aspect of this study is the fractional occurrences (number of fields) which might be found in each

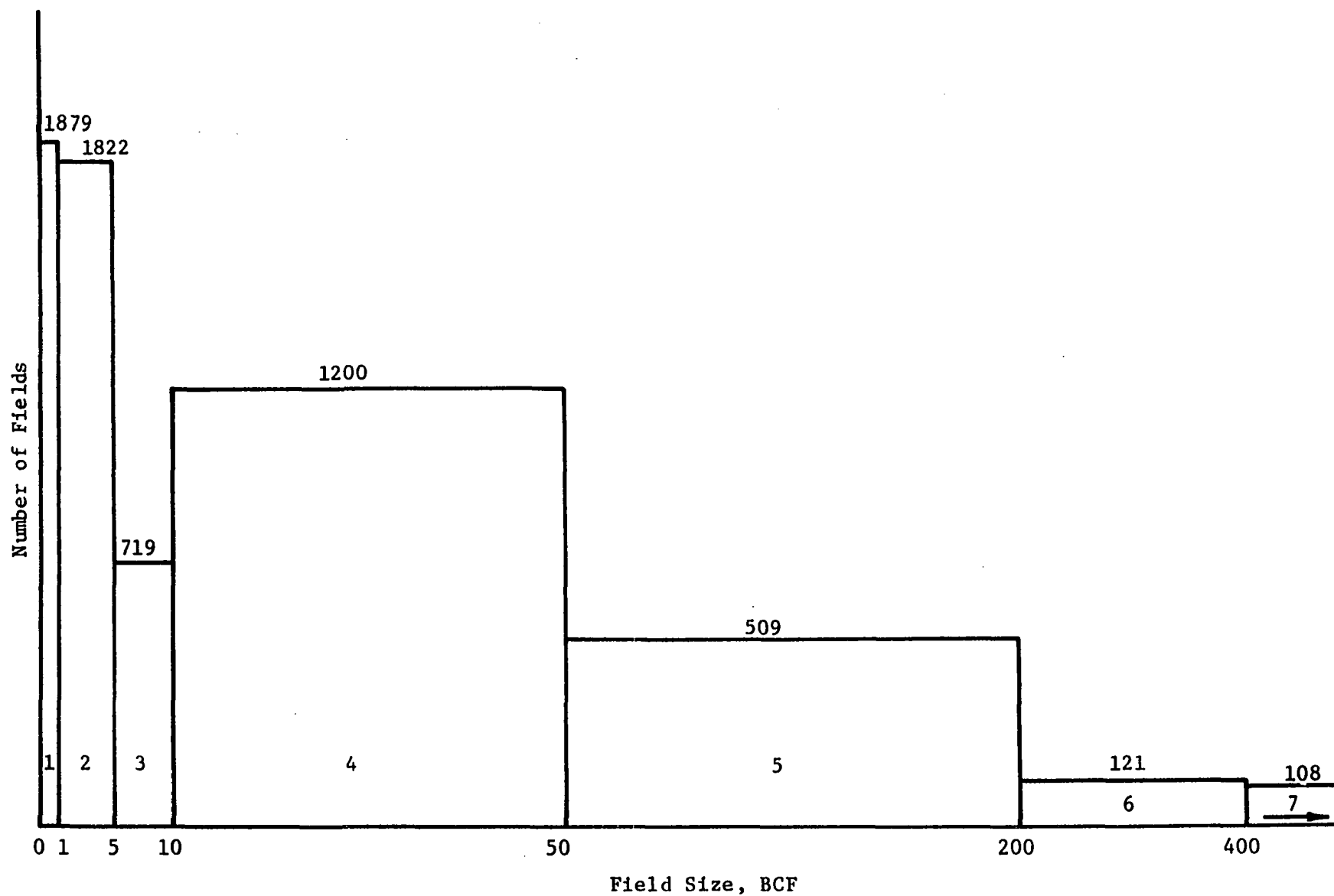


FIGURE VI-1. Histogram of number of fields and their size distributions for each class.

class. Therefore, the frequency distribution of the number of fields found is of particular interest. Equation VI-4 is the calculation of the frequency distribution for each class, each number of wells drilled, and each run.

$$f_{i,w,k} = \frac{F_{i,w,k}}{\sum_{j=1}^n F_{j,w,k}} \quad \text{for } \begin{matrix} i = 1, n; \\ w = 1, W1; \\ k = 1, NR \end{matrix} \quad (\text{VI-4})$$

An important question will be the size of each field which might be found. The probability of finding a field of a given size is proportional to the product of the field size and number of fields of that size. This product for each class, each number of wells drilled, and each run is calculated by using the results from equations VI-1, VI-2, VI-3, and VI-4 to generate the probability of occurrence in each class. This product term is calculated as follows:

$$P_{i,w,k} = f_{i,w,k} C_{i,k} \quad \text{for } \begin{matrix} i = 1, n; \\ w = 1, W1; \\ k = 1, NR. \end{matrix} \quad (\text{VI-5})$$

The probability of finding a gas field or gas well is dependent on the probability of drilling a dry hole. The probability of a dry hole was assumed to be 90% throughout this study. Thus the equation for the probability of finding the gas field or gas wells is as follows:

$$P_{i,w,k} = \frac{P_{i,w,k}(1 - PD_{w,k})}{\sum_{j=1}^n P_{j,w,k}} \quad \text{for } \begin{matrix} i = 1, n; \\ w = 1, W1; \\ k = 1, NR. \end{matrix} \quad (\text{VI-6})$$

and the probability of finding the dry field (dry hole) is:

$$P_{n+1,w,k} = PD_{w,k} \quad \text{for } w = 1, W1; \quad (VI-7) \\ k = 1, NR.$$

The summation of equation VI-6 gives the cumulative probabilities of finding a gas field (gas well) which is shown in equation VI-8.

$$CP_{i,w,k} = \sum_{j=1}^i P_{j,w,k} \quad \text{for } i = 1, n; \quad (VI-8) \\ w = 1, W1; \\ k = 1, NR.$$

By adding the cumulative probability of finding a gas field (gas well) to the probability of a dry hole, a total cumulative probability can be calculated which is shown in equation VI-9.

$$CP_{n+1,w,k} = CP_{n,w,k} + P_{n+1,w,k} \quad \text{for } w = 1, W1; \quad (VI-9) \\ k = 1, NR.$$

Initially no wells have been drilled and then the reserve and number of fields found initially are zero. All of these conditions for initial field distribution are shown in Table VI-2. The subsequent drilling W wells and performing random selections of fields we can calculate the number of fields and reserves found from each class. The procedure is shown in Figure VI-2 and the following equations.

By testing the random number against the array of cumulative probabilities, the following calculations are made:
If:

$$CP_{i-1,w,k} \leq RN \leq CP_{i,w,k} \quad (VI-10)$$

TABLE VI-2
INITIAL FIELD SIZE DISTRIBUTION

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD REMAINING
0.2955332E 00	0.3162278E 00	0.9345579E-01	0.2300222E-03	0.2300222E-03	0.0000000E 00	0.0000000E 00	0.1879000E 04
0.2865680E 00	0.2236068E 01	0.6407855E 00	0.1577162E-02	0.1807184E-02	0.0000000E 00	0.0000000E 00	0.1822000E 04
0.1130857E 00	0.7071068E 01	0.7996378E 00	0.1962144E-02	0.3775322E-02	0.0000000E 00	0.0000000E 00	0.7190000E 03
0.1867386E 00	0.2236067E 02	0.4220321E 01	0.1038745E-01	0.1416278E-01	0.0000000E 00	0.0000000E 00	0.1200000E 04
0.8005661E-01	0.1000000E 03	0.8005660E 01	0.1970429E-01	0.3386706E-01	0.0000000E 00	0.0000000E 00	0.5090000E 03
0.1903114E-01	0.2822425E 03	0.5382815E 01	0.1324269E-01	0.4711575E-01	0.0000000E 00	0.0000000E 00	0.1210000E 03
0.1698647E-01	0.1264911E 04	0.2148636E 02	0.5282426E-01	0.9999996E-01	0.0000000E 00	0.0000000E 00	0.1080000E 03
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00

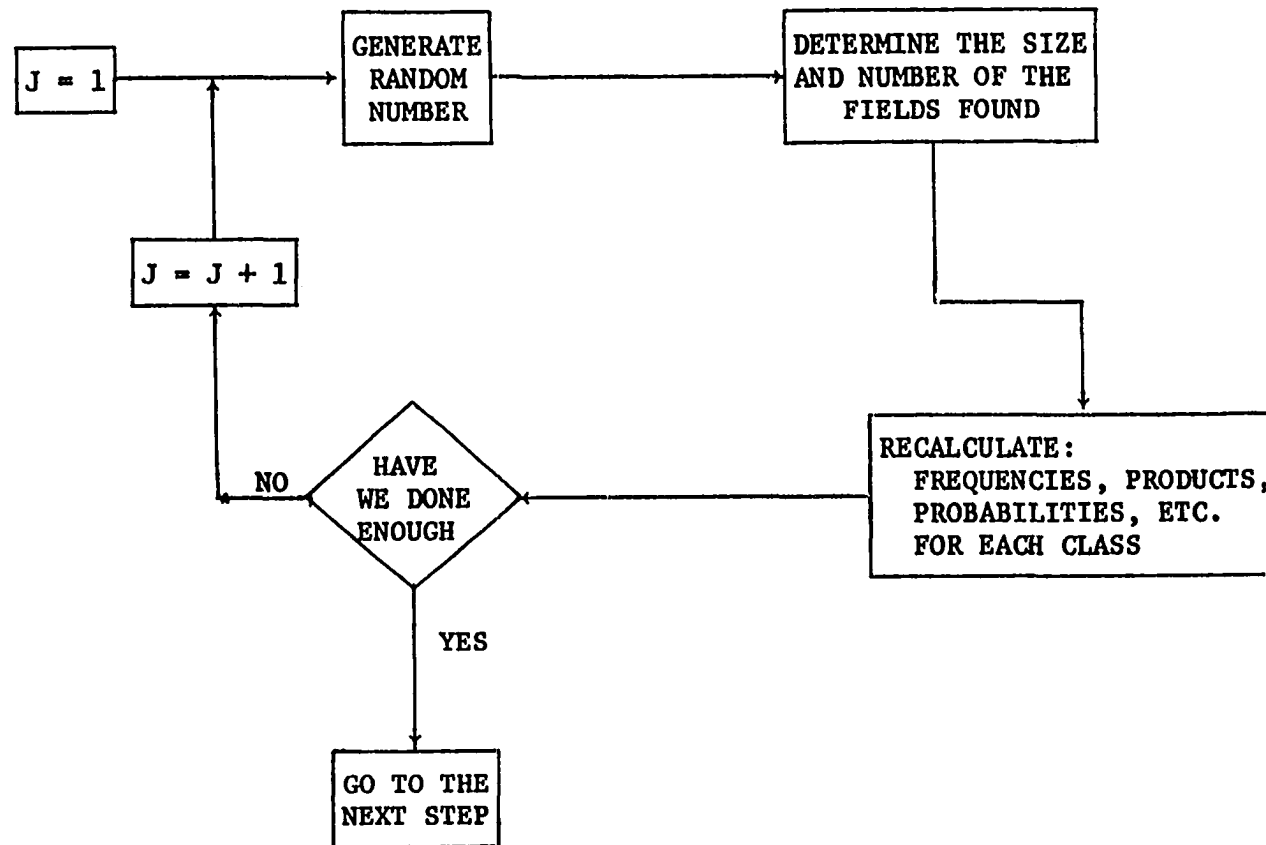


FIGURE VI-2. Flow Chart for Recalculations of Parameters.

set:

$$FF_{i,w,k} = FF_{i,w,k} + 1 \quad (VI-11)$$

$$F_{i,w,k} = F_{i,w,k} - 1 \quad (VI-12)$$

$$RF_{i,w,k} = RF_{i,w,k} + c_{i,k} \quad (VI-13)$$

For all other classes set

$$FF_{i,w,k} = FF_{i,w,k} \quad (VI-14)$$

$$F_{i,w,k} = F_{i,w,k} \quad (VI-15)$$

$$RF_{i,w,k} = RF_{i,w,k} \quad (VI-16)$$

In the present study the minimum and maximum penetrations (thicknesses) of the sedimentary interval for successful (gas) wells are considered as well as a range of depths for either a successful gas well or a dry well, and for the total interval (Fig. VI-3) the following equations apply during a simulation run.

The depth to the basement for each run is generated from a random number by using equation VI-17:

$$D_{w,k} = DMIN_{w,k} + RN(DMAX_{w,k} - DMIN_{w,k}) \quad (VI-17)$$

for $w = 1, W1; k = 1, NR$

For calculation of thickness, dry hole footage, gas hole footage, and their cumulative values, the number of the class indicated by the random number to be the outcome of the trial is designated by the variable I_c . If I_c exceeds the

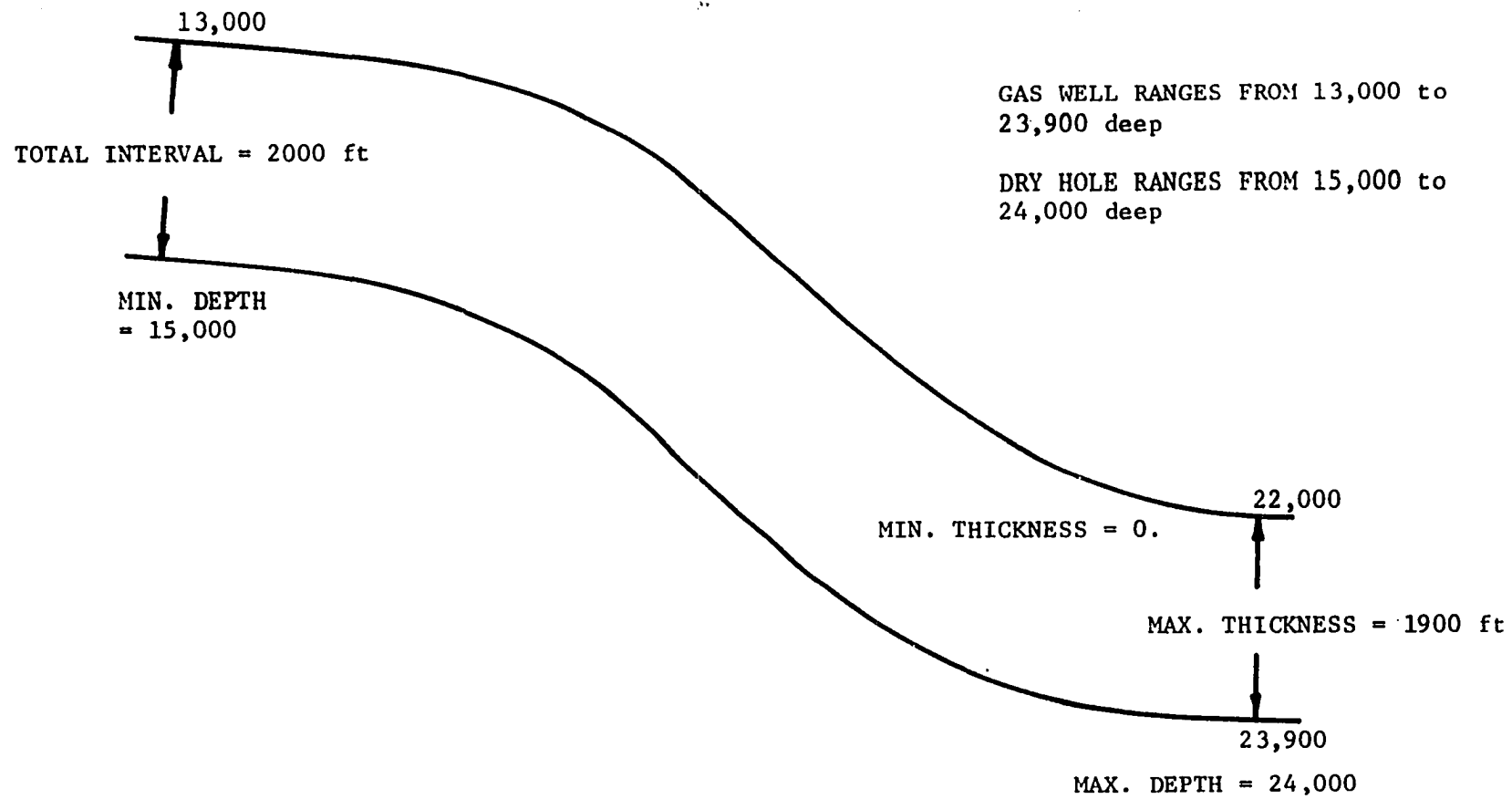


FIGURE VI-3. Idealized cross section of stratigraphic interval.

number of classes in the field size distribution; i.e.,

$$I_c > n \quad (VI-18)$$

then the trial does not result in the drilling of a successful well so this well is a dry hole. We can write:

$$DF_{w,k} = D_{w,k} \quad \text{for } w = 1, W1; k = 1, NR \quad (VI-19)$$

The cumulative dry hole footage is the summation of $DF_{w,k}$ which is

$$CDF_k = \sum_{w=1}^{1000J} (J-1)+1 DF_{w,k} \quad (VI-20)$$

$$\text{for } J = 1, JS; k = 1, NR$$

Because we are dealing with an unsuccessful well (dry hole), the thickness of the sedimentary interval and gas well footage for this case ($I_c > n$) are zero.

$$H_{w,k} = 0 \quad (VI-21)$$

$$GF_{w,k} = 0 \quad (VI-22)$$

On the other hand, if

$$I_c \leq n \quad (VI-23)$$

then the trial results in the drilling of a successful well (gas well). The thickness of the sedimentary interval, gas well footage and their cumulative values must be calculated. In order to perform the calculation, we need to generate random numbers and use equation VI-24

$$H_{w,k} = HMIN_{w,k} + RN(HMAX_{w,k} - HMIN_{w,k}) \quad (VI-24)$$

The gas well footage is calculated by using equation VI-25

$$GF_{w,k} = D_{w,k} - TI_{w,k} - H_{w,k} \quad (VI-25)$$

and the cumulative gas well footage is the summation of $GF_{w,k}$ which is

$$CGF_k = \sum_{w=1000(J-1)+1}^{1000J} GF_{w,k} \quad (VI-26)$$

In the case of a successful well when ($I_c \leq n$) the dry hole footage is zero.

$$DF_{w,k} = 0 \quad (VI-27)$$

The next step in this primary phase is the calculation of the cumulative reserve found, cumulative number of gas fields found, cumulative number of dry fields, cumulative dry hole footage, and cumulative gas well footage for all of the n classes after W wells have been drilled. These calculations are shown in equations VI-28 through VI-32.

$$CRF_{j,k} = \sum_{i=1}^n RF_{i,k} \quad \text{for } j = 1, JS; k = 1, NR \quad (VI-28)$$

$$CFF_{j,k} = \sum_{i=1}^n FF_{i,k} \quad \text{for } j = 1, JS; k = 1, NR \quad (VI-29)$$

$$CDFI_{j,k} = FF_{n+1,k} \quad \text{for } j = 1, JS; k = 1, NR \quad (VI-30)$$

$$CDF_{j,k} = CDF_k \quad \text{for } j = 1, JS; k = 1, NR \quad (VI-31)$$

$$CGF_{j,k} = CGF_k \quad \text{for } j = 1, JS; k = 1, NR \quad (VI-32)$$

By using equations VI-28 to VI-32 all the increments for the above parameters can be calculated as shown in eqns.

VI-33 to VI-42:

$$RF_{j,k} = CRF_{j,k} - CRF_{j-1,k} \quad \text{for } j \geq 2 \quad (VI-33)$$

$$RF_{1,k} = CRF_{1,k} \quad \text{for } j = 1 \quad (VI-34)$$

$$FF_{j,k} = CFF_{j,k} - CFF_{j-1,k} \quad \text{for } j \geq 2 \quad (VI-35)$$

$$FF_{1,k} = CFF_{1,k} \quad \text{for } j = 1 \quad (VI-36)$$

$$DFI_{j,k} = CDFI_{j,k} - CDFI_{j-1,k} \quad \text{for } j \geq 2 \quad (VI-37)$$

$$DFI_{1,k} = CDFI_{1,k} \quad \text{for } j = 1 \quad (VI-38)$$

$$DF_{j,k} = CDF_{j,k} - CDF_{j-1,k} \quad \text{for } j \geq 2 \quad (VI-39)$$

$$DF_{1,k} = CDF_{1,k} \quad \text{for } j = 1 \quad (VI-40)$$

$$GF_{j,k} = CGF_{j,k} - CGF_{j-1,k} \quad \text{for } j \geq 2 \quad (VI-41)$$

$$GF_{1,k} = CGF_{1,k} \quad \text{for } j = 1 \quad (VI-42)$$

The calculation of the increment of reserves found per increment in the number of fields found and cumulative reserve found per cumulative number of fields found for all of the n classes after W number of wells drilled are shown in equations VI-43 and VI-44.

$$RPFI_{j,k} = \frac{RF_{j,k}}{FF_{j,k} + DFI_{j,k}} \quad \text{for } \begin{matrix} j = 1, JS \\ k = 1, NR \end{matrix} \quad (VI-43)$$

$$CRPFC_{j,k} = \frac{CRF_{j,k}}{CFF_{j,k} + CDFI_{j,k}} \quad (VI-44)$$

The equations for productivity (increment of reserve found per increment of footage drilled) and cumulative productivity (cumulative reserve found per cumulative footage drilled) in all of the n classes after W number of wells drilled are shown in the following:

$$\text{Productivity} = \text{RPF} = \frac{\text{RF}_{j,k}}{\text{GF}_{j,k} + \text{DF}_{j,k}} \quad (\text{VI-45})$$

$$\text{Cumulative Productivity} = \text{CRPF} = \frac{\text{CRF}_{j,k}}{\text{CGF}_{j,k} + \text{CDF}_{j,k}} \quad (\text{VI-46})$$

This completes the operations in phase one. Upon completion of this phase, the response of the gas resource base to the drilling of W wells is tabulated. The results are illustrated in Table VI-3 which shows the results from phase one in a segment of one of the programs executed during this study.

As mentioned previously, the second phase of this model recasts the results of the drilling activities on a time basis. This projection is made by assuming that the gas well footage drilled in the future will follow a particular mathematical function (hyperbolic, linear, logistic or an increasing drilling rate curve). The idealized hyperbolic plot is shown in Fig. VI-4. This function has an equation of the following form:

$$y = \frac{t - t_0}{A + B(t - t_0)} \quad (\text{VI-47})$$

where for practical purposes y would represent the gas well

TABLE VI-3

Example of the Output from Phase One of the Model

RESERVE CUM.	FIELD CUM.	DRY HOLE CUM.	RESERVE INC.	FIELD INC.	DRY HOLE INC.	INC.RES/WELLS	CUM.RES/CUM.W
0.6342245E 05	0.9800000E 02	0.9020000E 03	0.6342245E 05	0.9800000E 02	0.9020000E 03	0.6342244E 02	0.6342244E 02
0.1134966E 06	0.1950000E 03	0.1805000E 04	0.5007411E 05	0.9700000E 02	0.5030000E 03	0.5007411E 02	0.5674828E 02
0.1508643E 06	0.3090000E 03	0.2691000E 04	0.3736769E 05	0.1140000E 03	0.2860000E 03	0.3736768E 02	0.5028807E 02
0.1660701E 06	0.3910000E 03	0.3609000E 04	0.1520588E 05	0.8200000E 02	0.9180000E 03	0.1520587E 02	0.4151752E 02
0.1773018E 06	0.4900000E 03	0.4510000E 04	0.1123163E 05	0.9900000E 02	0.5010000E 03	0.1123162E 02	0.3546034E 02
0.1851554E 06	0.5630000E 03	0.5417000E 04	0.7653813E 04	0.9300000E 02	0.5070000E 03	0.7653812E 01	0.3085925E 02
0.1928050E 06	0.6930000E 03	0.6307000E 04	0.7729438E 04	0.1100000E 03	0.8900000E 03	0.7729437E 01	0.2755499E 02
0.1995134E 06	0.7930000E 03	0.7207000E 04	0.6628375E 04	0.1000000E 03	0.5000000E 03	0.6628374E 01	0.2493916E 02
0.2053459E 06	0.8850000E 03	0.8115000E 04	0.5832563E 04	0.9200000E 02	0.5000000E 03	0.5832562E 01	0.2281621E 02
0.2106765E 06	0.9800000E 03	0.9020000E 04	0.5330938E 04	0.9500000E 02	0.9050000E 03	0.5330937E 01	0.2106767E 02
CUM.DRY HOLE FOOTAGE	CUM.GAS WELL FOOTAGE	CUM.FOOTAGE DRILLED	INC.DRY HOLE FOOTAGE	INC.GAS WELL FOOTAGE	INC.FOOTAGE DRILLED	INC.RESERVE PER FOOT	CUM.RESERVE PER FOOT
0.1752891E 08	0.1591374E 07	0.1912027E 08	0.1752891E 08	0.1591374E 07	0.1912027E 08	0.3317024E-02	0.3317024E-02
0.3507173E 08	0.3230672E 07	0.3830240E 08	0.1754282E 08	0.1639290E 07	0.1918211E 08	0.2610459E-02	0.2963171E-02
0.5245002E 08	0.5123619E 07	0.5757363E 08	0.1737829E 08	0.1892947E 07	0.1927123E 08	0.1939040E-02	0.2620370E-02
0.7028254E 08	0.6513128E 07	0.7680166E 08	0.1783853E 08	0.1389505E 07	0.1922803E 08	0.7908179E-03	0.2162324E-02
0.8779638E 08	0.8161362E 07	0.9595774E 08	0.1750784E 08	0.1648234E 07	0.1915606E 08	0.5863220E-03	0.1847707E-02
0.1053769E 09	0.9724220E 07	0.1151011E 09	0.1752050E 08	0.1562858E 07	0.1914334E 08	0.4102632E-03	0.1608634E-02
0.1226967E 09	0.1157819E 08	0.1342745E 09	0.1731981E 08	0.1853965E 07	0.1917376E 08	0.4031258E-03	0.1436494E-02
0.1404225E 09	0.1320967E 08	0.1536322E 09	0.1772886E 08	0.1631481E 07	0.1935733E 08	0.3424219E-03	0.1298643E-02
0.1581933E 09	0.1472694E 08	0.1729203E 09	0.1777080E 08	0.1517275E 07	0.1928806E 08	0.3023923E-03	0.1187518E-02
0.1759023E 09	0.1631661E 08	0.1922189E 09	0.1778893E 08	0.1589671E 07	0.1929859E 08	0.2762345E-03	0.1096026E-02

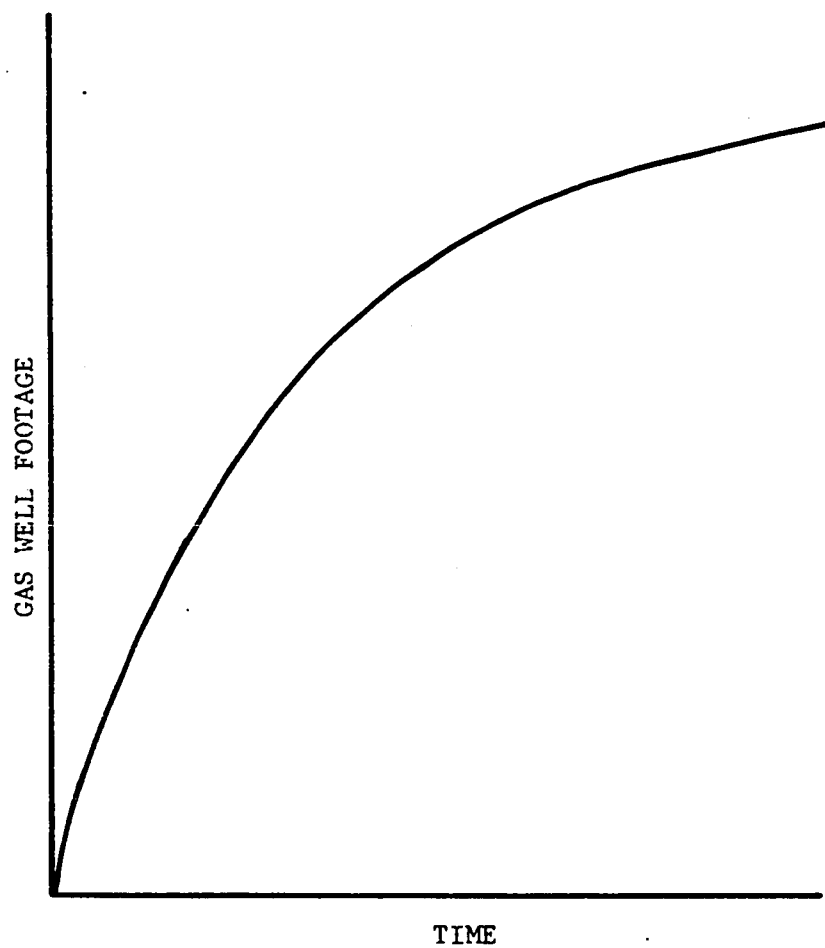


FIGURE VI-4. Hyperbolic representation of gas well footage vs. time.

footage, A and B are empirical constants, t_0 is calendar time at which drilling commences, and t is calendar year time.

The simulation of the exploratory results of the drilling activities in three regions is simulated. In this simulation, different parameters are used in the drilling rate equation for each of the regions. The values used for A, B and t_0 are shown in Table VI-4.

Table VI-4
Values of Empirical Constants and Time Zero for
Different Regions (k Regions)

Region	1	2	3
A	5×10^{-8}	5×10^{-8}	5×10^{-8}
B	2.5×10^{-9}	2.13×10^{-9}	2.3×10^{-9}
t_0	2 years	4 years	3 years

By coupling the primary phase results and the parameters shown in Table VI-4, the second phase results are obtained. These results constitute the prediction of the future reserves additions for the next 20 years. The calculations for the case of the hyperbolic drilling rate are as follows.

First, time was tested against t_0 . If

$$t \leq t_0 \quad (VI-48)$$

then the gas well footage and cumulative reserve are zero:

$$GF_{t,k} = 0 \quad (VI-49)$$

$$CR_{t,k} = 0 \quad (VI-50)$$

But for time greater than t_0 ; i.e., $t > t_0$, the gas well footage is equal to the value indicated by the hyperbolic equation which is as follows:

$$GF_{t,k} = \frac{t - t_0}{A_k + B_k(t - t_0)} \quad (VI-51)$$

In order to calculate the cumulative reserve for each year and each region, the sequence of steps below are followed:
If

$$GF_{t,k} \geq CGF_{JS,k} \quad (VI-52)$$

then set

$$CR_{t,k} = CRF_{JS,k} \quad (VI-53)$$

On the other hand, if

$$GF_{t,k} < CGF_{JS,k} \quad (VI-54)$$

then the gas well footage must be tested against the array of cumulative gas well footage values. The value for gas well footage is bracketed by two values for cumulative gas well footage. The value for cumulative reserves is found by interpolation between the tabulated cumulative reserves values corresponding to these two values of cumulative gas well footage. The interpolation procedure is as follows:

For

$$j = 1 \quad \text{and} \quad CGF_{1,k} = 0 \quad (VI-55)$$

then

$$CR_{t,k} = 0 \quad (VI-56)$$

If

$$j = 1 \quad \text{and} \quad CGF_{1,k} \neq 0 \quad (VI-57)$$

then

$$AI = \frac{GF_{t,k}}{CGF_{1,k}} \quad (VI-58)$$

$$CI = AI(CRF_{1,k}) \quad (VI-59)$$

$$CR_{t,k} = CI \quad (VI-60)$$

If

$$j \neq 1 \quad \text{and} \quad CGF_{j,k} = CGF_{j-1,k} \quad (VI-61)$$

then

$$CR_{t,k} = \frac{CRF_{j,k} + CRF_{j-1,k}}{2} \quad (VI-62)$$

If

$$j \neq 1 \quad \text{and} \quad CGF_{j,k} \neq CGF_{j-1,k} \quad (VI-63)$$

then

$$AI = \frac{GF_{t,k} - CGF_{j-1,k}}{CGF_{j,k} - CGF_{j-1,k}} \quad (VI-64)$$

$$CI = AI(CRF_{j,k} - CRF_{j-1,k}) \quad (VI-65)$$

$$CR_{t,k} = CRF_{j-1,k} + CI \quad (VI-66)$$

In calculating the increment of reserve, increment of footage, discovery rate (increment reserves per increment

of footage drilled), and cumulative discovery rate (cumulative reserve per cumulative footage drilled) for each region and each year, the following equations are used:

$$R_{t,k} = CR_{t,k} - CR_{t-1,k} \quad \text{for } t \geq 2; k = 1, NR \quad (VI-67)$$

$$R_{1,k} = CR_{1,k} \quad \text{for } t = 1; k = 1, NR \quad (VI-68)$$

$$IF_{t,k} = GF_{t,k} - GF_{t-1,k} \quad \text{for } t \geq 2; k = 1, NR \quad (VI-69)$$

$$IF_{1,k} = GF_{1,k} \quad \text{for } t = 1, k = 1, NR \quad (VI-70)$$

$$DR_{t,k} = \begin{cases} 0 & \text{if } IF_{t,k} = 0 \text{ for } t = 1, TL; k = 1, NR \\ \frac{R_{t,k}}{IF_{t,k}} & \text{if } IF_{t,k} \neq 0 \text{ for } t = 1, TL; k = 1, NR \end{cases} \quad (VI-71)$$

$$CDR_{t,k} = \begin{cases} 0 & \text{if } GF_{t,k} = 0 \text{ for } t = 1, TL; k = 1, NR \\ \frac{CR_{t,k}}{GF_{t,k}} & \text{if } GF_{t,k} \neq 0 \text{ for } t = 1, TL; k = 1, NR \end{cases} \quad (VI-72)$$

In calculating the cumulative discovery and total footage drilled for all three regions as a function of time equations VI-73 and VI-74 are used.

$$CD_t = \sum_{k=1}^{NR} CR_{t,k} \quad \text{for } t = 1, TL \quad (VI-73)$$

$$TF_t = \sum_{k=1}^{NR} GF_{t,k} \quad \text{for } t = 1, TL \quad (VI-74)$$

The calculations of increment reserves, increment footage, discovery rate, and cumulative discovery rate for all three regions as functions of time are shown in the

following equations:

$$R_t = CD_t - CD_{t-1} \quad \text{for } t = 2, TL \quad (VI-75)$$

$$R_1 = CD_1 \quad \text{for } t = 1 \quad (VI-76)$$

$$IF_t = TF_t - TF_{t-1} \quad \text{for } t = 2, TL \quad (VI-77)$$

$$IF_1 = TF_1 \quad \text{for } t = 1 \quad (VI-78)$$

$$DR_t = \begin{cases} 0 & \text{if } F_t = 0 \\ \frac{R_t}{F_t} & \text{if } F_t \neq 0 \end{cases} \quad \begin{matrix} \text{for } t = 1, TL \\ \text{for } t = 1, TL \end{matrix} \quad (VI-79)$$

$$CDR_t = \begin{cases} 0 & \text{if } TF_t = 0 \\ \frac{CD_t}{TF_t} & \text{if } TF_t \neq 0 \end{cases} \quad \begin{matrix} \text{for } t = 1, TL \\ \text{for } t = 1, TL \end{matrix} \quad (VI-80)$$

This completes the operations in phase two.

CHAPTER VII

ANALYSIS OF A MORE REALISTIC SYSTEM

In order to analyze a more realistic system, different cases in which the behavior of different provinces with different schedules of drilling activity were studied.

Case I. The number of fields in each class of the initial field size distribution of the original model was changed. This was done by reducing the number of fields in each class to 2/10 of its original number. Table VII-1 shows the values for the new distribution.

TABLE VII-1

Size Stratification of Population Fields

(All volumes in billions of cubic feet)

<u>Classes</u>	<u>No. of Fields</u>	<u>Population Strata Range</u>
1	376	$0 \leq \text{Field} \leq 1$
2	364	$1 < \text{Field} \leq 5$
3	144	$5 < \text{Field} \leq 10$
4	240	$10 < \text{Field} \leq 50$
5	102	$50 < \text{Field} \leq 200$
6	24	$200 < \text{Field} \leq 400$
7	22	$400 < \text{Field}$

Figure VII-1 is the histogram for the distribution, i.e. the number of fields versus field size of each class for this case (Case I).

This change would cause changes in the values of frequency and the products. Although the probabilities would be the same initially, they would be different during the run than those for the previous case (original model). Table VII-2 shows the initial field size distribution for this case. The other changes were the values of $A(K)$ and $B(K)$ for this case are ten times more than the values used previously (original model) as shown in Table VII-3.

TABLE VII-3

Values of Empirical Constants and Time Zero
for Different Regions (k regions)

Region	1	2	3
A	5×10^{-7}	5×10^{-7}	5×10^{-7}
B	2.5×10^{-8}	2.13×10^{-8}	2.3×10^{-8}
t_0	2 years	4 years	3 years

Case II. For this case the number of fields in each class in the distribution shown in Table VI-1 was changed for each of the three regions. Specifically, the number of fields was reduced from its original value to 1/10 for the first region ($k = 1$), to 2/10 for the second region ($k = 2$), and to 3/10 for the third region ($k = 3$). This is shown in Table

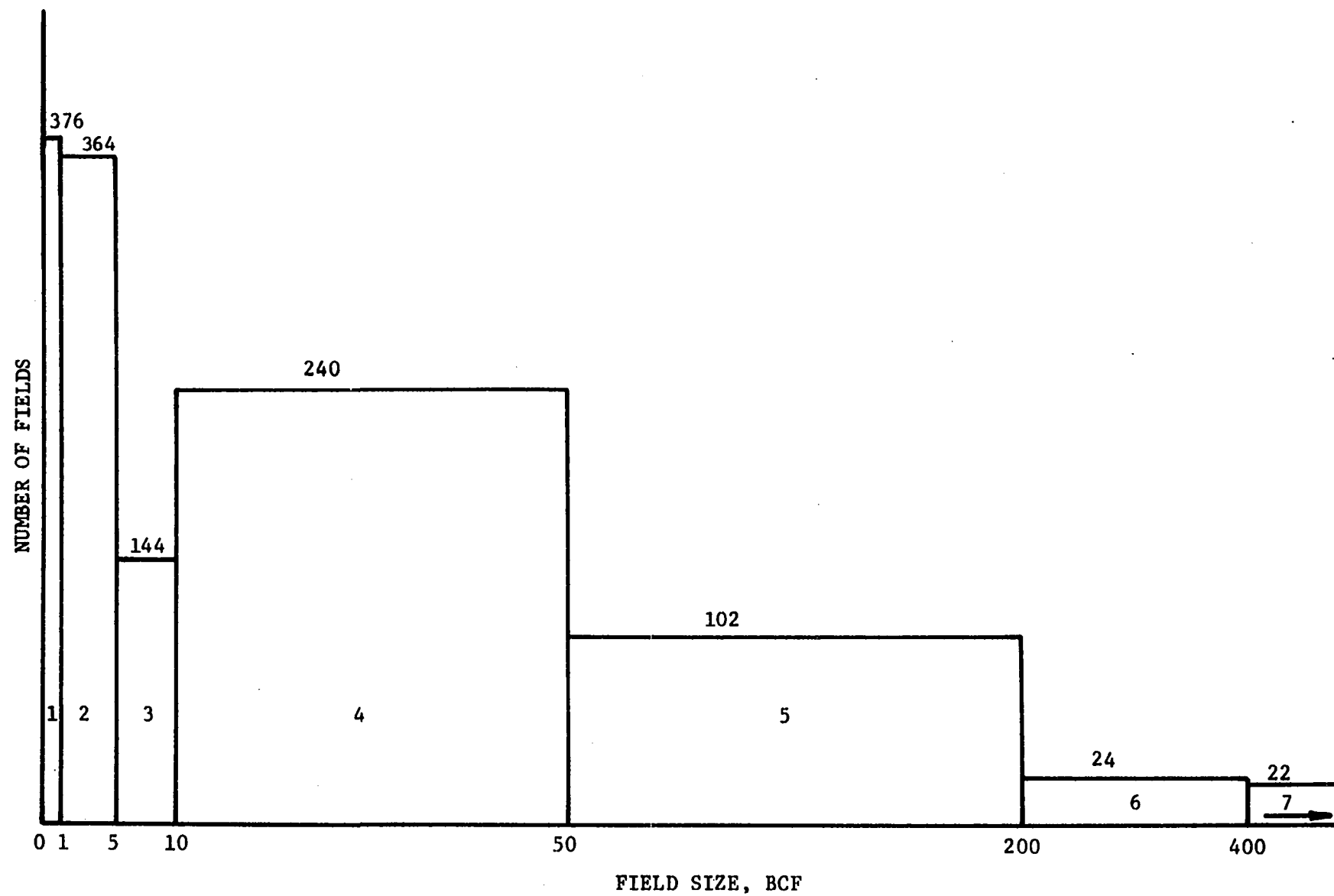


FIGURE VII-1. Histogram of number of fields and their size distributions for each class.

TABLE VII-2
INITIAL FIELD SIZE DISTRIBUTION

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD REMAINING
0.2955974E 00	0.3162279E 00	0.9347612E-01	0.2286699E-03	0.2286699E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2861635E 00	0.2236068E 01	0.6358210E 00	0.1561228E-02	0.1789292E-02	0.0000000E 00	0.0000000E 00	0.3640000E 03
0.1132075E 00	0.7071069E 01	0.8004980E 00	0.1953114E-02	0.3742412E-02	0.0000000E 00	0.0000000E 00	0.1440000E 03
0.1966792E 00	0.2236067E 02	0.4218993E 01	0.1025381E-01	0.1403622E-01	0.0000000E 00	0.0000000E 00	0.2400000E 03
0.8018863E-01	0.1000000E 03	0.2018863E 01	0.1956501E-01	0.3360123E-01	0.0000000E 00	0.0000000E 00	0.1020000E 03
0.1866792E-01	0.2828425E 03	0.5336650E 01	0.1302075E-01	0.4662192E-01	0.0000000E 00	0.0000000E 00	0.2400000E 02
0.1729560E-01	0.1264911E 04	0.2187738E 02	0.5337605E-01	0.1000000E 00	0.0000000E 00	0.0000000E 00	0.2200000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.0000000E 00	0.0000000E 00	0.0000000E 00

VII-4. The histograms for each class and for each region are plotted in Figures VII-2, VII-3, and VII-4.

This change would cause changes in the values of frequency and the products. As before, probabilities during the simulation would differ for each run. Tables VII-5, VII-6 and VII-7 show the initial field size distributions. Also the values of $A(K)$ and $B(K)$ were increased for this case (Case II) like Case I as shown in Table VII-3.

In order to extend our understanding of the resource base response to the future exploration activities, other mathematical functions were used for the future drilling rate. In addition to the hyperbolic curve used in Phase II of the study, curves with much different characteristics were also used in Phase II.

1. Straight Line Equation

The idealized straight line plot is shown in Figure VII-5. This function has an equation of

$$y = A(t - t_0) \quad (VII-1)$$

where for our purposes y would represent the gas well footage, t_0 is time zero, t is time, and A can be calculated by using

$$A = \frac{1}{B} \quad (VII-2)$$

Again, as in the original model, three runs were made for different sets of assumptions for values of B and t_0 as indicated in Table VII-8.

Table VII-4
Size Stratification of Population Fields
(All volumes in billions of cubic feet)

Classes	No. of Fields for k = 1	No. of Fields for k = 2	No. of Fields for k = 3	Population Strata Range
1	188	376	564	$0 \leq \text{Field} \leq 1$
2	182	364	546	$1 < \text{Field} \leq 5$
3	72	144	216	$5 < \text{Field} \leq 10$
4	120	240	360	$10 < \text{Field} \leq 50$
5	51	102	153	$50 < \text{Field} \leq 200$
6	12	24	36	$200 < \text{Field} \leq 400$
7	11	22	33	$400 < \text{Field}$

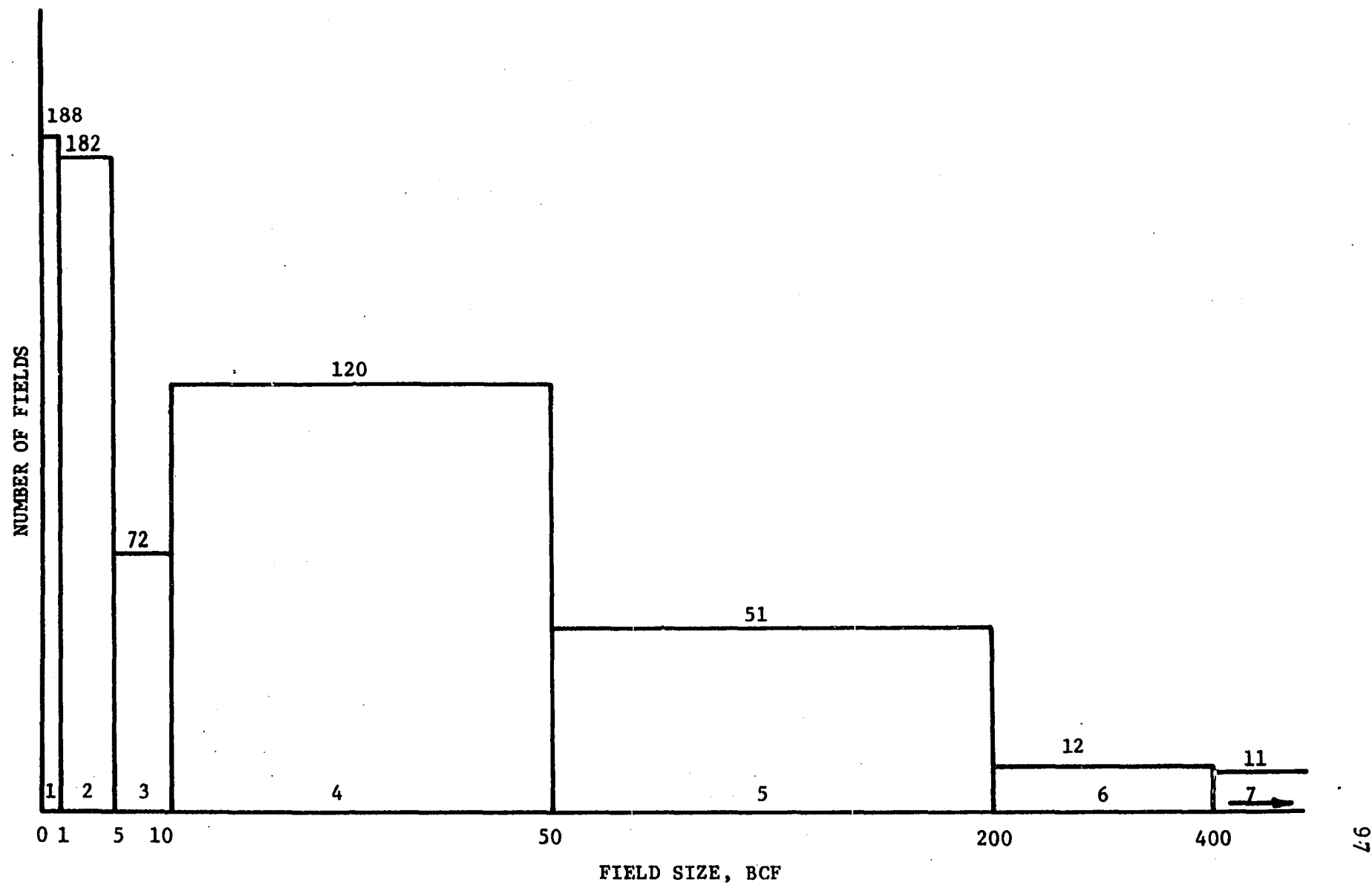


FIGURE VII-2. Histogram of number of fields and their size distributions for each class for first run ($k = 1$)

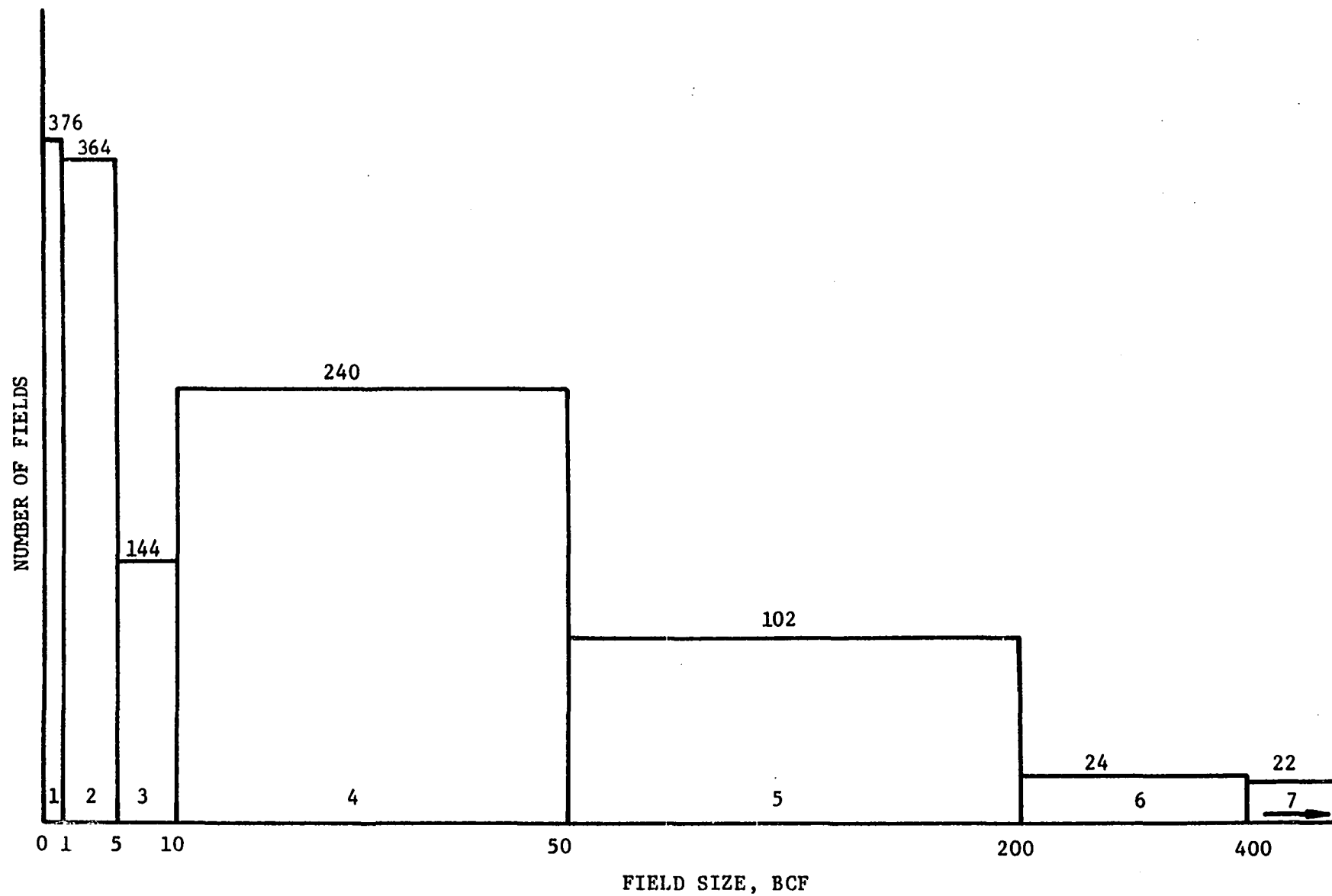


FIGURE VII-3. Histogram of number of fields and their size distributions for each class for second run ($k = 2$)

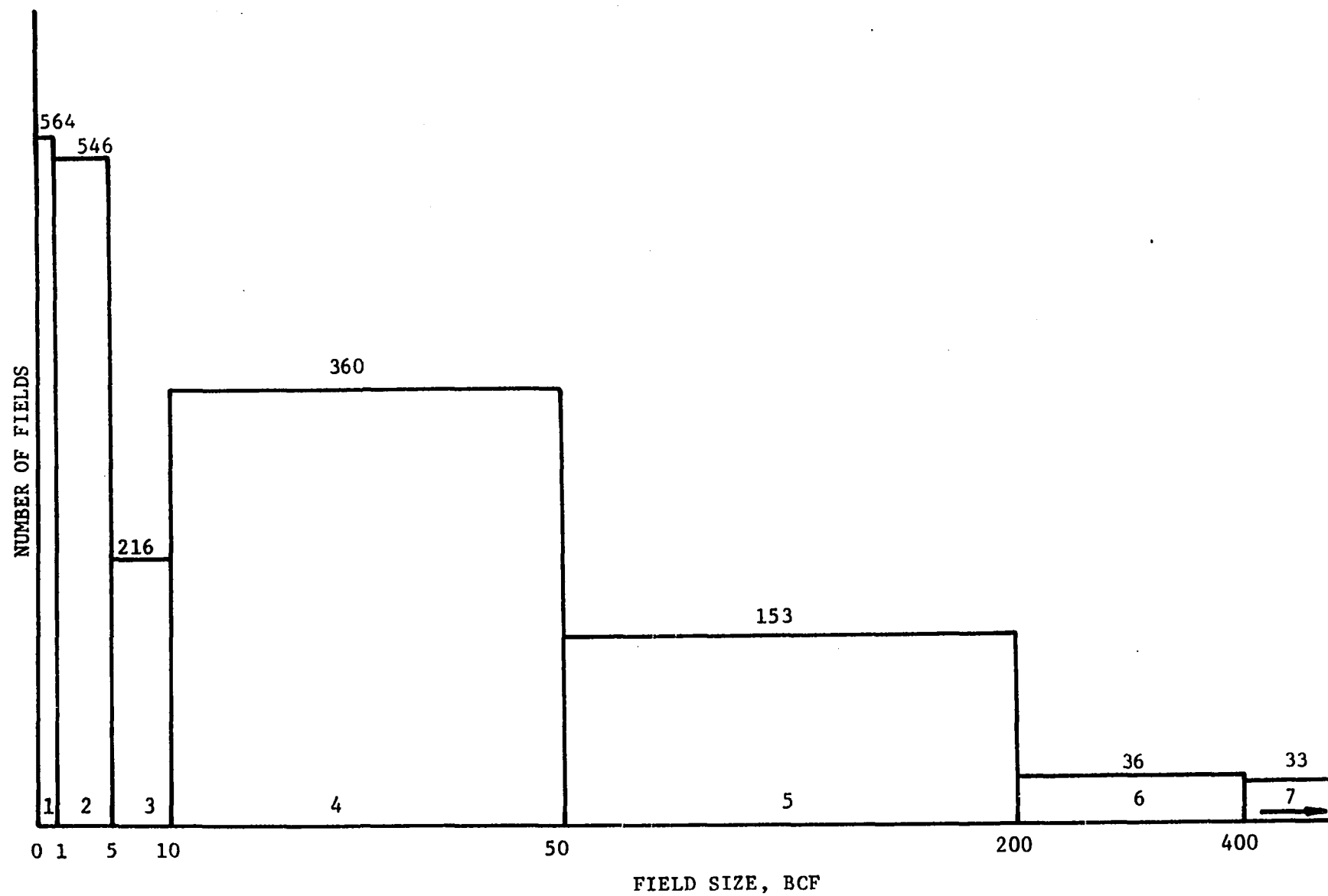


FIGURE VII-4. Histogram of number of fields and their size distributions for each class for second run ($k = 3$)

TABLE VII-5
INITIAL FIELD SIZE DISTRIBUTION

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD REMAINING
0.2955974E 00	0.3162278E 00	0.9347612E-01	0.2280699E-03	0.2280699E-03	0.0000000E 00	0.0000000E 00	0.1880000E 03
0.2861635E 00	0.2236068E 01	0.6398210E 00	0.1561228E-02	0.1789292E-02	0.0000000E 00	0.0000000E 00	0.1820000E 03
0.1132075E 00	0.7071068E 01	0.8004980E 00	0.1953114E-02	0.3742412E-02	0.0000000E 00	0.0000000E 00	0.7200000E 02
0.1886792E 00	0.2236067E 02	0.4218993E 01	0.1029381E-01	0.1403622E-01	0.0000000E 00	0.0000000E 00	0.1200000E 03
0.8018963E-01	0.1000000E 03	0.8018863E 01	0.1956501E-01	0.3360123E-01	0.0000000E 00	0.0000000E 00	0.5100000E 02
0.1886792E-01	0.2228425E 03	0.5336650E 01	0.1302075E-01	0.4662198E-01	0.0000000E 00	0.0000000E 00	0.1200000E 02
0.1729560E-01	0.1264911E 04	0.2187738E 02	0.5337805E-01	0.1000000E 00	0.0000000E 00	0.0000000E 00	0.1100000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.0000000E 00	0.0000000E 00	0.0000000E 00

TABLE VII-6
INITIAL FIELD SIZE DISTRIBUTION

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD REMAINING
0.2955974E 00	0.3162278E 00	0.9347612E-01	0.2280699E-03	0.2280699E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2861635E 00	0.2236068E 01	0.6398810E 00	0.1561228E-02	0.1789292E-02	0.0000000E 00	0.0000000E 00	0.3640000E 03
0.1132075E 00	0.7071068E 01	0.2004980E 00	0.1953114E-02	0.3742412E-02	0.0000000E 00	0.0000000E 00	0.1440000E 03
0.1826752E 00	0.2236067E 02	0.4218993E 01	0.1029381E-01	0.1403622E-01	0.0000000E 00	0.0000000E 00	0.2400000E 03
0.0018863E-01	0.1000000E 03	0.8018863E 01	0.1954501E-01	0.3360123E-01	0.0000000E 00	0.0000000E 00	0.1020000E 03
0.1826792E-01	0.2828425E 03	0.5336650E 01	0.1302075E-01	0.4662192E-01	0.0000000E 00	0.0000000E 00	0.2400000E 02
0.1729560E-01	0.1264911E 04	0.2187738E 02	0.5337805E-01	0.1000000E 00	0.0000000E 00	0.0000000E 00	0.2200000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.0000000E 00	0.0000000E 00	0.0000000E 00

TABLE VII-7

INITIAL FIELD SIZE DISTRIBUTION

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD REMAINING
0.2955974E 00	0.3162278E 00	0.9347612E-01	0.2280699E-03	0.2280699E-03	0.0000000E 00	0.0000000E 00	0.5640000F 03
0.2861635E 00	0.2236068E 01	0.6368810E 00	0.1561228E-02	0.1789298E-02	0.0000000E 00	0.0000000E 00	0.5460000E 03
0.1132075E 00	0.7071068E 01	0.8004980E 00	0.1953114E-02	0.3742412E-02	0.0000000E 00	0.0000000E 00	0.2160000E 03
0.1886752E 00	0.2236067E 02	0.4218593E 01	0.1025381E-01	0.1403622E-01	0.0000000E 00	0.0000000E 00	0.3600000E 03
0.8018863E-01	0.1000000E 03	0.8018863E 01	0.1956501E-01	0.3360123E-01	0.0000000E 00	0.0000000E 00	0.1530000E 03
0.1886752E-01	0.2828425E 03	0.5376650E 01	0.1302075E-01	0.4662198E-01	0.0000000E 00	0.0000000E 00	0.3600000E 02
0.1729560E-01	0.1264911E 04	0.2187738E 02	0.5337605E-01	0.1000000E 00	0.0000000E 00	0.0000000E 00	0.3300000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.0000000E 00	0.0000000E 00	0.0000000E 00

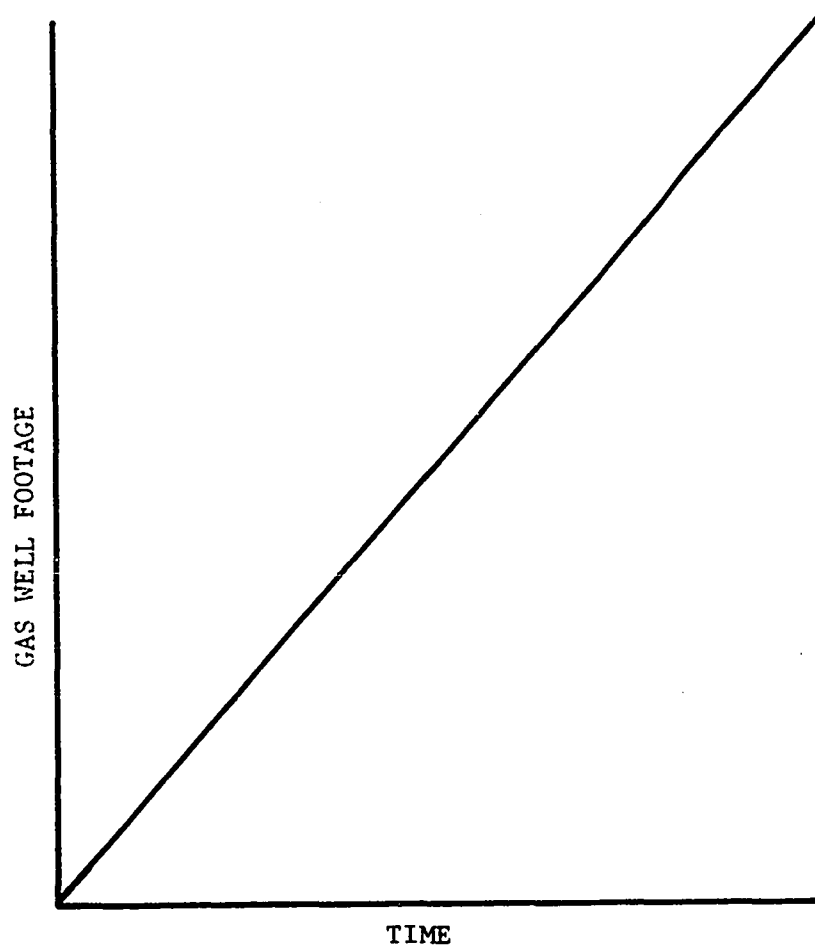


FIGURE VII-5. Straight line representation of gas well footage vs. time.

Table VII-8
Values of Empirical Constant B and Time Zero
for Different Regions (k regions)

Region	1	2	3
B	1×10^{-7}	$.88 \times 10^{-7}$	$.95 \times 10^{-7}$
t_0	2 years	4 years	3 years

The calculations are all the same as in the original model except equation VI-51 would be changed to

$$GF_{t,k} = A_k(t - t_0) \quad (VII-3)$$

where

$$A_k = \frac{1}{B_k} \quad (VII-4)$$

Also this straight line curve was used for applying Cases I and II. The only changes required to run these was in equation VII-4 which was changed to

$$A_k = \frac{1}{10 B_k} \quad (VII-5)$$

2. Logistic Curve

The idealized logistic curve is shown in Figure VII-6. This function has an equation of the form

$$y = \frac{C}{1 + De^{-A(t - t_0)}} \quad (VII-6)$$

where for our purposes y represents the gas well footage, t_0 is time zero, t is time in years, and the values of C and D

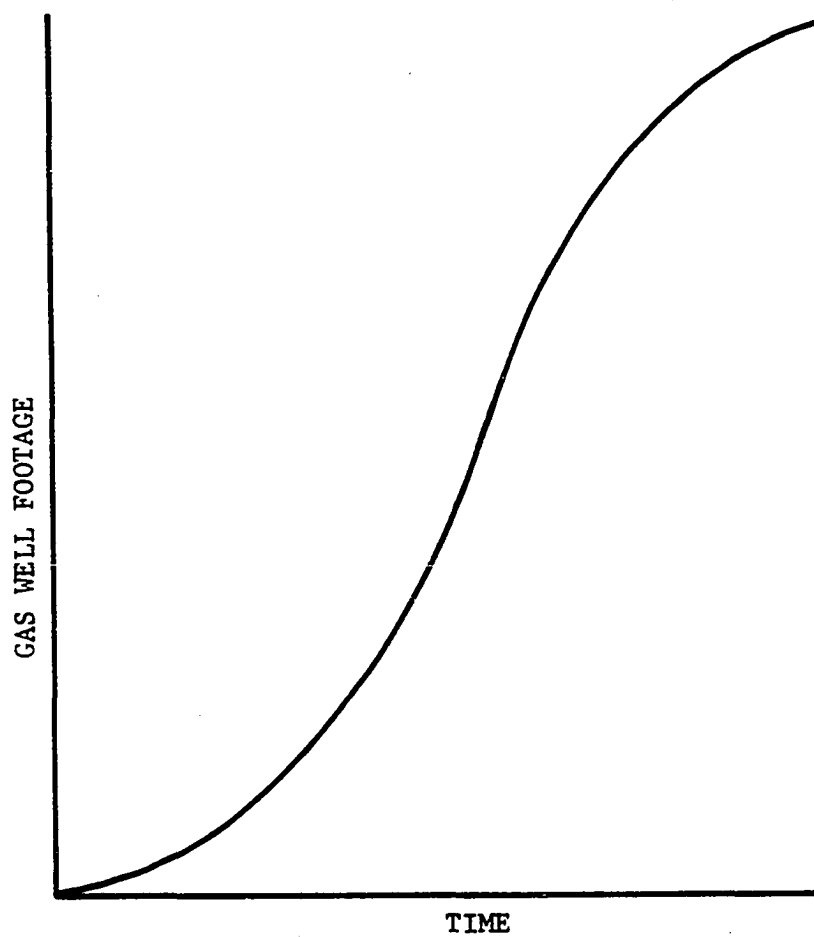


FIGURE VII-6. Logistic curve representation of gas well footage vs. time.

can be evaluated by using equations VII-7 and VII-8.

$$C = \frac{1}{B} \quad (\text{VII-7})$$

$$D = 99 e^A \quad (\text{VII-8})$$

As with the original model, three runs were made for different sets of assumptions for values of A, B, and t_0 as indicated in Table VII-9.

Table VII-9

Values of Empirical Constants A, B, and Time

Zero for Different Regions (k regions)

Region	1	2	3
A	.141	.132	.137
B	7.09×10^{-10}	3.57×10^{-10}	4.35×10^{-10}
t_0	2 years	4 years	3 years

The calculations are all the same as in the original model except that equation VI-51 was changed to:

$$GF_{t,k} = \frac{C_k}{1 + D_k e^{-A_k(t - t_0)}} \quad (\text{VII-9})$$

where

$$C_k = \frac{1}{B_k} \quad (\text{VII-10})$$

and

$$D_k = 99 e^{A_k} \quad (\text{VII-11})$$

This logistic function was also used for applying Cases I and II. The only change required to run these cases was that equation VII-10 was changed to:

$$C_k = \frac{1}{10 B_k} \quad (\text{VII-12})$$

3. Increasing Drilling Rate Function

The idealized increasing drilling rate curve is shown in Figure VII-7. This function has an equation of the form

$$y = \frac{A(t - t_0)}{t_L - (t - t_0)} \quad (\text{VII-13})$$

where for our purposes y would represent the gas well footage, t_0 is time zero, t_L is the total time in years, t is time, and A can be calculated by using

$$A = \frac{1}{B} \quad (\text{VII-14})$$

Again, as in the original model, three runs were made for different sets of values of B and t_0 as indicated in Table VII-10. The calculations are all the same as in the original model except equation VI-51 would be changed to:

$$GF_{t,k} = \frac{A(t - t_0)}{t_L - (t - t_0)} \quad (\text{VII-15})$$

where

$$A_k = \frac{1}{B_k} \quad (\text{VII-16})$$

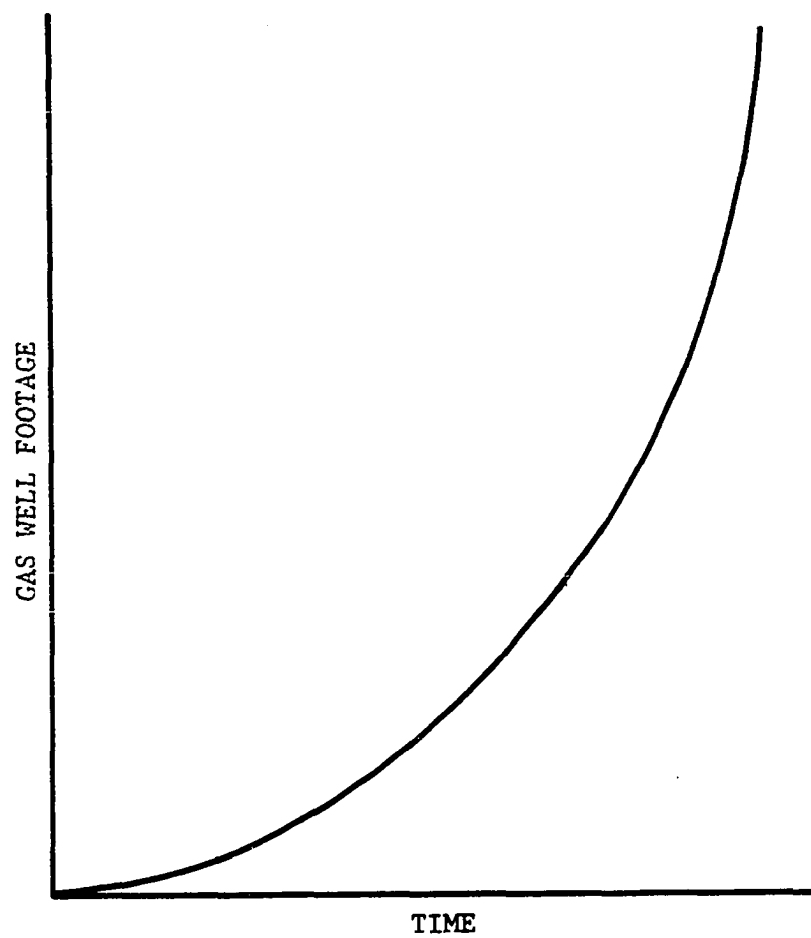


FIGURE VII-7. Increasing drilling rate curve representation of gas well footage vs. time.

Table VII-10
 Values of Empirical Constant B and Time Zero
 for Different Regions (k regions)

Region	1	2	3
B	5×10^{-8}	2.2×10^{-8}	3.2×10^{-8}
t_0	2 years	4 years	3 years

Also this increasing drilling rate function was used for applying Cases I and II. The only changes required to run these cases was in equation VII-16. It was changed to:

$$A_k = \frac{1}{10 B_k} \quad (\text{VII-17})$$

CHAPTER VIII

DISCUSSION OF RESULTS OF THE FIRST PHASE FOR THE ORIGINAL MODEL AND OTHER REALISTIC SYSTEMS

As mentioned before in the mathematical section, the model is designed to calculate the parameters of the frequency distribution of the undiscovered fields during the exploratory play. It computes for each class the class mark, the product of the class mark and the frequency, and the probability that a field the size of the class mark will be found in drilling the next well. After the drilling of W wells, it records the number of fields found, the reserves found, and the number of fields remaining. Tables VIII-1 to VIII-10 are results of these calculations for W ranging from 1000 to 10,000 wells with increments of 1000 wells. The results in Table VIII-1 shows that after 1000 wells were drilled, only 98 fields were found. The remaining 902 wells were unsuccessful. Most of the fields found were giant fields (60 fields with reserves greater than 400 Bcf), even though the class containing the giant fields had the fewest number of fields. The rest of the fields found were distributed among all other classes with the exception of the small fields which have reserves less than 1 Bcf. There were none found from

TABLE VIII-1

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 1000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3001597E 00	0.3162278E 00	0.9451879E-01	0.3042750E-03	0.3048750E-03	0.0000000E 00	0.0000000E 00	0.1879000E 04
0.2908946E 00	0.2236068E 01	0.6504599E 00	0.2089249E-02	0.2394123E-02	0.1000000E 01	0.2236062E 01	0.1821000E 04
0.1143770E 00	0.7071068E 01	0.8087672E 00	0.2597724E-02	0.4991844E-02	0.3000000E 01	0.2121320E 02	0.7160000E 03
0.1852971E 00	0.2236067E 02	0.4232809E 01	0.1355560E-01	0.1858744E-01	0.1500000E 02	0.3354097E 03	0.1185000E 04
0.7827473E-01	0.1000000E 03	0.7827473E 01	0.2514149E-01	0.4372893E-01	0.1900000E 02	0.1900000E 04	0.4900000E 03
0.1693290E-01	0.2828425E 03	0.4789345E 01	0.1532316E-01	0.5911209E-01	0.1500000E 02	0.4242637E 04	0.1060000E 03
0.1006385E-01	0.1264911E 04	0.1272993E 02	0.4082797E-01	0.1000000E 00	0.4500000E 02	0.5692096E 05	0.6300000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.9020000E 03	0.0000000E 00	0.9020000E 03

TABLE VIII-2

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 2000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3048240E 00	0.3162278E 00	0.9641278E-01	0.4102518E-03	0.4102918E-03	0.0000000E 00	0.0000000E 00	0.1879000E 04
0.2948235E 00	0.2236068E 01	0.6592463E 00	0.2805475E-02	0.3215767E-02	0.5000000E 01	0.1118034E 02	0.1817000E 04
0.1158527E 00	0.7071068E 01	0.8192019E 00	0.3486179E-02	0.6701943E-02	0.5000000E 01	0.3535532E 02	0.7140000E 03
0.1893558E 00	0.2236067E 02	0.4234122E 01	0.1801864E-01	0.2472058E-01	0.3300000E 02	0.7379004E 03	0.1167000E 04
0.7561245E-01	0.1000000E 03	0.7561248E 01	0.3217749E-01	0.5689807E-01	0.4300000E 02	0.4300000E 04	0.4660000E 03
0.1476553E-01	0.2828425E 03	0.4176321E 01	0.1777266E-01	0.7467073E-01	0.3000000E 02	0.8485234E 04	0.9100000E 02
0.4705500E-02	0.1264911E 04	0.5952038E 01	0.2532937E-01	0.1000001E 00	0.7900000E 02	0.9992694E 05	0.2900000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.1805000E 04	0.0000000E 00	0.1805000E 04

TABLE VIII-3

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 3000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3102992E 00	0.3162278E 00	0.9812522E-01	0.5523684E-03	0.5523684E-03	0.2000000E 01	0.6324556E 00	0.1877000E 04
0.2992230E 00	0.2236068E 01	0.6650829E 00	0.3766551E-02	0.4318938E-02	0.1200000E 02	0.2683275E 02	0.1810000E 04
0.1177054E 00	0.7071068E 01	0.8323029E 00	0.4685383E-02	0.9004321E-02	0.7000000E 01	0.4949744E 02	0.7120000E 03
0.1894528E 00	0.2236067E 02	0.4236291E 01	0.2384787E-01	0.3285220E-01	0.5400000E 02	0.1207473E 04	0.1146000E 04
0.7075542E-01	0.1000000E 03	0.7075548E 01	0.3983126E-01	0.7268345E-01	0.8100000E 02	0.8100000E 04	0.4200000E 03
0.1124153E-01	0.2828425E 03	0.3179581E 01	0.1789920E-01	0.9058261E-01	0.5300000E 02	0.1499055E 05	0.6800000E 02
0.1322533E-02	0.1264911E 04	0.1672885E 01	0.9417374E-02	0.9999906E-01	0.1000000E 03	0.1264893E 06	0.8000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.2691000E 04	0.0000000E 00	0.2691000E 04

TABLE VIII-4

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 4000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.314345E 00	0.3162279E 00	0.9942067E-01	0.6431011E-03	0.6431011E-03	0.3000000E 01	0.9486834E 00	0.1676000E 04
0.3028322E 00	0.2236060E 01	0.6771533E 00	0.4380155E-02	0.5023256E-02	0.1500000E 02	0.3354091E 02	0.1807000E 04
0.118455E 00	0.7071068E 01	0.8378153E 00	0.5419396E-02	0.1044265E-01	0.1200000E 02	0.8485274E 02	0.7070000E 03
0.1992073E 00	0.2236067E 02	0.4230801E 01	0.2736688E-01	0.3780953E-01	0.7100000E 02	0.1587603E 04	0.1129000E 04
0.6535947E-01	0.1000000E 03	0.6535947E 01	0.4227769E-01	0.8008712E-01	0.1190000E 03	0.1190000E 05	0.3900000E 03
0.9384945E-02	0.2828425E 03	0.2654462E 01	0.1717035E-01	0.9725749E-01	0.6500000E 02	0.1838463E 05	0.5600000E 02
0.3351767E-03	0.1264911E 04	0.4239626E 00	0.2742436E-02	0.9599990E-01	0.1060000E 03	0.1340786E 06	0.2000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.3609000E 04	0.0000000E 00	0.3609000E 04

TABLE VIII-5

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 5000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.319392E 00	0.3162278E 00	0.1009902E 00	0.7314782E-03	0.7314782E-03	0.5000000E 01	0.1581138E 01	0.1874000E 04
0.3072597E 00	0.2236069E 01	0.6870534E 00	0.4976369E-02	0.5707845E-02	0.1900000E 02	0.4249512E 02	0.1803000E 04
0.1191236E 00	0.7071069E 01	0.8423092E 00	0.6100900E-02	0.1180275E-01	0.2000000E 02	0.1414212E 03	0.6990000E 03
0.1871166E 00	0.2236067E 02	0.4184052E 01	0.3030535E-01	0.4211409E-01	0.1020000E 03	0.2280781E 04	0.1098000E 04
0.6015678E-01	0.1000000E 03	0.6015677E 01	0.4357193E-01	0.8568603E-01	0.1560000E 03	0.1560000E 05	0.3530000E 03
0.6987046E-02	0.2828425E 03	0.1976233E 01	0.1431398E-01	0.9999996E-01	0.8000000E 02	0.2262723E 05	0.4100000E 02
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.1080000E 03	0.1366083E 06	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.4510000E 04	0.0000000E 00	0.4510000E 04

TABLE VIII-6

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 6000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROCB.	FIFLD FIND	RESERVE FIND	FIELD
0.3245021E 00	0.3162278E 00	0.1026165E 00	0.8100020E-03	0.8100020E-03	0.5000000E 01	0.1561138E 01	0.1674000E 04
0.3113415E 00	0.2236068E 01	0.6961817E 00	0.5495299E-02	0.6305300E-02	0.2400000E 02	0.5366539E 02	0.1798000E 04
0.1205195E 00	0.7071068E 01	0.9522012E 00	0.6726631E-02	0.1303213E-01	0.2300000E 02	0.1626344E 03	0.6960000E 03
0.1837225E 00	0.2236067E 02	0.4108168E 01	0.3242776E-01	0.4545989E-01	0.1390000E 03	0.3108124E 04	0.1061000E 04
0.5489177E-01	0.1000000E 03	0.5489177E 01	0.4332874E-01	0.8878857E-01	0.1920000E 03	0.1920000E 05	0.3170000E 03
0.5021643E-02	0.2828425E 03	0.1420334E 01	0.1121138E-01	0.9999990E-01	0.9200000E 02	0.2602130E 05	0.2900000E 02
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999990E-01	0.1080000F 03	0.1366083E 06	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.5417000E 04	0.0000000E 00	0.5417000E 04

TABLE VIII-7

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 7000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3308032E 00	0.3162278E 00	0.1046091E 00	0.9056870E-03	0.9056870E-03	0.5000000E 01	0.1581138E 01	0.1874000E 04
0.3159752E 00	0.2236068E 01	0.7065420E 00	0.6117113E-02	0.7022798E-02	0.3200000E 02	0.7155382E 02	0.1790000E 04
0.1218005E 00	0.7071068E 01	0.8612595E 00	0.7456623E-02	0.1447942E-01	0.2900000E 02	0.2050608E 03	0.6900000E 03
0.1804060E 00	0.2236067E 02	0.4033598E 01	0.3492564E-01	0.4940506E-01	0.1780000E 03	0.3980187E 04	0.1022000E 04
0.4695495E-01	0.1000000E 03	0.4695498E 01	0.4065279E-01	0.9005785E-01	0.2430000E 03	0.2430000E 05	0.2660000E 03
0.4060015E-02	0.2828425E 03	0.1148344E 01	0.9942155E-02	0.9999996E-01	0.9800000E 02	0.2771834E 05	0.2300000E 02
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.1080000E 03	0.1366083E 06	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.6307000E 04	0.0000000E 00	0.6307000E 04

TABLE VIII-8

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 2000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3367475E 00	0.3162278E 00	0.1064885E 00	0.1007777E-02	0.1007777E-02	0.5000000E 01	0.1581138E 01	0.1874000E 04
0.3202156E 00	0.2236068E 01	0.7160237E 00	0.6776221E-02	0.7783998E-02	0.4000000E 02	0.2944225E 02	0.1782000E 04
0.1223715E 00	0.7071068E 01	0.8653001E 00	0.8188922E-02	0.1597292E-01	0.3800000E 02	0.2687002E 03	0.6810000E 03
0.1778976E 00	0.2236067E 02	0.3977909E 01	0.3764568E-01	0.5361860E-01	0.2100000E 03	0.4695691E 04	0.9900000E 03
0.3935310E-01	0.1000000E 03	0.3935309E 01	0.3724253E-01	0.9086108E-01	0.2900000E 03	0.2900000E 05	0.2190000E 03
0.3414156E-02	0.2828425E 03	0.9656797E 00	0.9138882E-02	0.9999996E-01	0.1020000E 03	0.2884970E 05	0.1900000E 02
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.1080000E 03	0.1366083E 06	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.7207000E 04	0.0000000E 00	0.7207000E 04

TABLE VIII-9

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 9000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3422254E 00	0.3162278E 00	0.1082212E 00	0.1118146E-02	0.1118146E-02	0.6000000E 01	0.1897365E 01	0.1873000E 04
0.3248675E 00	0.2236068E 01	0.7264257E 00	0.7505458E-02	0.8623600E-02	0.4400000E 02	0.9838646E 02	0.1778000E 04
0.1233327E 00	0.7071069E 01	0.8720937E 00	0.9010505E-02	0.1763410E-01	0.4400000F 02	0.3111265E 03	0.6750000E 03
0.1728495E 00	0.2236067E 02	0.3865008E 01	0.3993244E-01	0.5756754E-01	0.2540000E 03	0.5679504E 04	0.9460000E 03
0.3435045E-01	0.1000000E 03	0.3435044E 01	0.3549103E-01	0.9305853E-01	0.3210000E 03	0.3210000E 05	0.1880000E 03
0.2375297E-02	0.2828425E 03	0.6718349E 00	0.6941427E-02	0.9999990E-01	0.1080000E 03	0.3054674E 05	0.1300000E 02
0.0003000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999990E-01	0.1080000E 03	0.1366083E 06	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.8115000E 04	0.0000000E 00	0.8115000E 04

TABLE VIII-10

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS=10000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRC9.	FIELD FIND	RESERVE FIND	FIELD
0.3477125E 00	0.3162278E 00	0.1099564E 00	0.1241277E-02	0.1241277E-02	0.5000000E 01	0.2946045E 01	0.1870000E 04
0.3296764E 00	0.2236068E 01	0.7371789E 00	0.8321863E-02	0.9563137E-02	0.4900000E 02	0.1095667E 03	0.1773000E 04
0.1236515E 00	0.7071068E 01	0.8743507E 00	0.9870369E-02	0.1943351E-01	0.5400000E 02	0.3818369E 03	0.6650000E 03
0.1682782E 00	0.2735067E 02	0.3762813E 01	0.4247765E-01	0.6191111E-01	0.2950000E 03	0.6596238E 04	0.9050000E 03
0.2900706E-01	0.1000000E 03	0.2900705E 01	0.3274549E-01	0.9465665E-01	0.3530000E 03	0.3530000E 05	0.1560000E 03
0.1673494E-02	0.2828425E 03	0.4733325E 00	0.5343355E-02	0.9999996E-01	0.1120000E 03	0.3167810E 05	0.9000000E 01
0.0000000E 00	0.1264711E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.1080000E 03	0.1366083E 06	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.9020000E 04	0.0000000E 00	0.9020000E 04

the small fields even though this class contained the largest number of fields. As drilling activities continued, all the giant fields were found after 3000 wells were drilled. Additional fields were found from all other classes. The last column in Table VIII-10 shows the remaining number of fields after 10,000 wells were drilled. By looking at this column we can see there are more smaller fields remaining to be found than larger ones.

For Case I the same response to exploration activity can be observed. Tables VIII-11 to VIII-20 are results of the calculations for W ranging from 100 to 1000 wells with increments of 100 wells. Again more giant fields have been found after drilling 100 wells (Table VIII-11) and most of the remaining fields after termination of the drilling activity were from smaller size classes (last column in Table VIII-20).

For Case II, the behavior of three different regions was simulated, and the response of each region was determined. Tables VIII-21 to VIII-50 are results of the calculations for W ranging from 100 to 1000 wells with increments of 100 wells. Again the results for each region demonstrate the same characteristic behavior that was observed previously in the original model and Case I. Namely, the giant fields and larger fields are found sooner than the smaller fields. This is actually what is expected, because there are better chances or higher probabilities of finding the larger fields than the smaller ones. In fact, it is one of the main points

TABLE VIII-11

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 100

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROCB.	FIFD FIND	RESERVE FIND	FIELD
0.2981761E 00	0.3162278E 00	0.9429151E-01	0.2678544E-03	0.2678544E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2878668E 00	0.2236068E 01	0.6436856E 00	0.1828533E-02	0.2096387E-02	0.1000000E 01	0.2236068E 01	0.3630000E 03
0.1134020E 00	0.7071069E 01	0.8018733E 00	0.2277886E-02	0.4374273E-02	0.1000000E 01	0.7071068E 01	0.1430000E 03
0.1887391E 00	0.2236067E 02	0.4220332E 01	0.1198873E-01	0.1636300E-01	0.2000000E 01	0.4472134E 02	0.2380000E 03
0.8009511E-01	0.1000000E 03	0.8009511E 01	0.2275267E-01	0.3911567E-01	0.1000000E 01	0.1000000E 03	0.1010000E 03
0.1903251E-01	0.2828425E 03	0.5383204E 01	0.1529210E-01	0.5440776E-01	0.0000000E 00	0.0000000E 00	0.2400000E 02
0.1268834E-01	0.1264911E 04	0.1604962E 02	0.4555226E-01	0.1000000E 00	0.6000000E 01	0.7589461E 04	0.1600000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.8900000E 02	0.0000000E 00	0.8900000E 02

TABLE VIII-12

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 200

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROCB.	FIELD FIND	RESERVE FIND	FIELD
0.3005595E 00	0.3162278E 00	0.9504527E-01	0.3167479E-03	0.3167475E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2901678E 00	0.2236062E 01	0.6488349E 00	0.2162308E-02	0.2479056E-02	0.1000000E 01	0.2236068E 01	0.3630000E 03
0.1143025E 00	0.7071068E 01	0.8082834E 00	0.2693686E-02	0.5172741E-02	0.1000000E 01	0.7071068E 01	0.1430000E 03
0.1886491E 00	0.2236067E 02	0.4218319E 01	0.1405757E-01	0.1923071E-01	0.4000000E 01	0.8944269E 02	0.2360000E 03
0.7913667E-01	0.1000000E 03	0.7913667E 01	0.2637309E-01	0.4560380E-01	0.3000000E 01	0.3000000E 03	0.9900000E 02
0.1832525E-01	0.2228425E 03	0.5200142E 01	0.1733000E-01	0.6293380E-01	0.1000000E 01	0.2228425E 03	0.2300000E 02
0.8792963E-02	0.1264911E 04	0.1112231E 02	0.3706624E-01	0.1000000E 00	0.1100000E 02	0.1391401E 05	0.1100000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.1790000E 03	0.0000000E 00	0.1790000E 03

TABLE VIII-13

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 300

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3027375E 00	0.3162278E 00	0.9573400E-01	0.3617245E-03	0.3617245E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2922705E 00	0.2236062E 01	0.6535366E 00	0.2469345E-02	0.2631070E-02	0.1000000E 01	0.2236062E 01	0.3630000E 03
0.1143317E 00	0.7071068E 01	0.8084473E 00	0.3054666E-02	0.5685735E-02	0.2000000E 01	0.1414214E 02	0.1420000E 03
0.1900161E 00	0.2236067E 02	0.4248827E 01	0.1605414E-01	0.2193987E-01	0.4000000E 01	0.8944269E 02	0.2360000E 03
0.7729465E-01	0.1000000E 03	0.7729465E 01	0.2920528E-01	0.5114515E-01	0.6000000E 01	0.6000000E 03	0.9600000E 02
0.1690821E-01	0.2828425E 03	0.4782360E 01	0.1806584E-01	0.6921494E-01	0.3000000E 01	0.8485276E 03	0.2100000E 02
0.6441221E-02	0.1264911E 04	0.8147570E 01	0.3076506E-01	0.9999996E-01	0.1400000E 02	0.1770874E 05	0.8000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.2700000E 03	0.0000000E 00	0.2700000E 03

TABLE VIII-14

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 400

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3042071E 00	0.3162278E 00	0.9619868E-01	0.3685900E-03	0.3685900E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2936893E 00	0.2236068E 01	0.6567092E 00	0.2516215E-02	0.2884800E-02	0.1000000E 01	0.2236068E 01	0.3630000E 03
0.1140776E 00	0.7071068E 01	0.8066506E 00	0.3090723E-02	0.5975526E-02	0.3000000E 01	0.2121320E 02	0.1410000E 03
0.1901294E 00	0.2236067E 02	0.4251421E 01	0.1628954E-01	0.2226506E-01	0.5000000E 01	0.1118034E 03	0.2350000E 03
0.7524270E-01	0.1000000E 03	0.7524269E 01	0.2882962E-01	0.5109468E-01	0.9000000E 01	0.9000000E 03	0.9300000E 02
0.1618123E-01	0.2828425E 03	0.4576738E 01	0.1753600E-01	0.6863064E-01	0.4000000E 01	0.1131370E 04	0.2000000E 02
0.6472491E-02	0.1264911E 04	0.8187123E 01	0.3136938E-01	0.9599996E-01	0.1400000E 02	0.1770874E 05	0.8000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.3640000E 03	0.0000000E 00	0.3640000E 03

TABLE VIII-15

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 500

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROCR.	FIELD FIND	RESERVE FIND	FIFLD
0.306682E 00	0.3162278E 00	0.9698337E-01	0.4163873E-03	0.4163873E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2952591E 00	0.2236068E 01	0.6602418E 00	0.2834675E-02	0.3251062E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1150081E 00	0.7071068E 01	0.8132302E 00	0.3491513E-02	0.6742574E-02	0.3000000E 01	0.2121320E 02	0.1410000E 03
0.1908646E 00	0.2236067E 02	0.4267859E 01	0.1832358E-01	0.2506615E-01	0.6000000E 01	0.1341640E 03	0.2340000E 03
0.7340944E-01	0.1000000E 03	0.7340943E 01	0.3151752E-01	0.5658368E-01	0.1200000E 02	0.1200000E 04	0.9000000E 02
0.1386623E-01	0.2824425E 03	0.3921959E 01	0.1683649E-01	0.7342213E-01	0.7000000E 01	0.1979898E 04	0.1700000E 02
0.4353562E-02	0.1264911E 04	0.6190426E 01	0.2657790E-01	0.1000000E 00	0.1600000E 02	0.2023856E 05	0.6000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.4540000E 03	0.0000000E 00	0.4540000E 03

TABLE VIII-16

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 600

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3089564E 00	0.3162278E 00	0.9770060E-01	0.4495201E-03	0.4495201E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2974527E 00	0.2236068E 01	0.6651245E 00	0.3060236E-02	0.3505756E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1150370E 00	0.7071068E 01	0.8134341E 00	0.3742608E-02	0.7252362E-02	0.4000000E 01	0.2829426E 02	0.1400000E 03
0.1959110E 00	0.2236067E 02	0.4244301E 01	0.1952802E-01	0.2678038E-01	0.9000000E 01	0.2012460E 03	0.2310000E 03
0.7230490E-01	0.1000000E 03	0.7230889E 01	0.3326530E-01	0.6004966E-01	0.1400000E 02	0.1400000E 04	0.8800000E 02
0.1232535E-01	0.2822425E 03	0.3486143E 01	0.1603573E-01	0.7609938E-01	0.9000000E 01	0.2545583E 04	0.1500000E 02
0.4108462E-02	0.1264911E 04	0.5196838E 01	0.2391064E-01	0.9999996E-01	0.1700000E 02	0.2150347E 05	0.5000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.5450000E 03	0.0000000E 00	0.5450000E 03

TABLE VIII-17

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 700

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3112582E 00	0.3162278E 00	0.9842849E-01	0.5086425E-03	0.5086425E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2996682E 00	0.2236068E 01	0.6700798E 00	0.3462731E-02	0.3971372E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1158540E 00	0.7071068E 01	0.8194944E 00	0.4234850E-02	0.8206222E-02	0.4000000E 01	0.2828426E 02	0.1400000E 03
0.1895695E 00	0.2236067E 02	0.4238502E 01	0.2190512E-01	0.3011134E-01	0.1100000E 02	0.2459674E 03	0.2290000E 03
0.6870260E-01	0.1000000E 03	0.6870859E 01	0.3550613E-01	0.6561744E-01	0.1900000E 02	0.1900000E 04	0.8300000E 02
0.1241722E-01	0.2828425E 03	0.3512116E 01	0.1814535E-01	0.8376676E-01	0.9000000E 01	0.2545583E 04	0.1500000E 02
0.2483444E-02	0.1264911E 04	0.3141335E 01	0.1623328E-01	0.1000000E 00	0.1900000E 02	0.2403329E 05	0.3000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.6360000E 03	0.0000000E 00	0.6360000E 03

TABLE VIII-18

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 800

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3143212E 00	0.3162278E 00	0.9941608E-01	0.5984295E-03	0.5984295E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.3026755E 00	0.2236068E 01	0.6768030E 00	0.4073977E-02	0.4672404E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1170562E 00	0.7071068E 01	0.8277169E 00	0.4982397E-02	0.9654801E-02	0.4000000E 01	0.2828426E 02	0.1400000E 03
0.1872910E 00	0.2236067E 02	0.4187951E 01	0.2520915E-01	0.3486395E-01	0.1600000E 02	0.3577703E 03	0.2240000E 03
0.6628955E-01	0.1000000E 03	0.6688958E 01	0.4026383E-01	0.7512772E-01	0.2200000E 02	0.2200000E 04	0.8000000E 02
0.1086956E-01	0.2828425E 03	0.3074374E 01	0.1850603E-01	0.9363377E-01	0.1100000E 02	0.3111268E 04	0.1300000E 02
0.8361202E-03	0.1264911E 04	0.1057617E 01	0.6366264E-02	0.1000000E 00	0.2100000E 02	0.2656311E 05	0.1000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.7240000E 03	0.0000000E 00	0.7240000E 03

TABLE VIII-19

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 900

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3167650E 00	0.3162278E 00	0.1001698E 00	0.6432049E-03	0.6432049E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.3049705E 00	0.2236066E 01	0.6819347E 00	0.4378803E-02	0.5022008E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1171015E 00	0.7071068E 01	0.8280355E 00	0.5316935E-02	0.1033894E-01	0.5000000E 01	0.3535532E 02	0.1390000E 03
0.1870261E 00	0.2236067E 02	0.4182029E 01	0.2685342E-01	0.3719237E-01	0.1800000E 02	0.4024915E 03	0.2220000E 03
0.6571186E-01	0.1000000E 03	0.6571185E 01	0.4215455E-01	0.7938689E-01	0.2400000E 02	0.2400000E 04	0.7800000E 02
0.7582135E-02	0.2828425E 03	0.2144551E 01	0.1377048E-01	0.9315735E-01	0.1500000E 02	0.4242637E 04	0.9000000E 01
0.8424600E-03	0.1264911E 04	0.1065637E 01	0.6842606E-02	0.9999999E-01	0.2100000E 02	0.2656311E 05	0.1000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.8150000E 03	0.0000000E 00	0.8150000E 03

TABLE VIII-20

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 1000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.320272E 00	0.3162279E 00	0.1012791E 00	0.7362966E-03	0.7362966E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.3083475E 00	0.2236062E 01	0.6894959E 00	0.5012549E-02	0.5748846E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1183596E 00	0.7071068E 01	0.8372046E 00	0.6086461E-02	0.1183531E-01	0.5000000E 01	0.3535532E 02	0.1390000E 03
0.1856959E 00	0.2236067E 02	0.4152151E 01	0.3016606E-01	0.4202136E-01	0.2200000E 02	0.4919338E 03	0.2180000E 03
0.6047700E-01	0.1000000E 03	0.6047700E 01	0.4396667E-01	0.8598799E-01	0.3100000E 02	0.3100000E 04	0.7100000E 02
0.6814308E-02	0.2828425E 03	0.1927376E 01	0.1401198E-01	0.9999996E-01	0.1600000E 02	0.4525477E 04	0.8000000E 01
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.2200000E 02	0.2782802E 05	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.9020000E 03	0.0000000E 00	0.9020000E 03

TABLE VIII-21

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 100

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROCB.	FIELD FIND	RESERVE FIND	FIELD
0.300000E 00	0.3162278E 00	0.9512126E-01	0.3244523E-03	0.3244523E-03	0.0000000E 00	0.0000000E 00	0.1880000E 03
0.2056000E 00	0.2236068E 01	0.6475651E 00	0.2206801E-02	0.2533254E-02	0.1000000E 01	0.2236068E 01	0.1810000E 03
0.1136000E 00	0.7071069E 01	0.8032730E 00	0.2735511E-02	0.5273163E-02	0.1000000E 01	0.7071068E 01	0.7100000E 02
0.1888000E 00	0.2236067E 02	0.4221694E 01	0.1439592E-01	0.1967302E-01	0.2000000E 01	0.4472134E 02	0.1180000E 03
0.7999598E-01	0.1000000E 03	0.7999998E 01	0.2728746E-01	0.4696054E-01	0.1000000E 01	0.1000000E 03	0.5000000E 02
0.1920000E-01	0.2828425E 03	0.5430575E 01	0.1852333E-01	0.6548387E-01	0.0000000E 00	0.0000000E 00	0.1200000E 02
0.7999598E-02	0.1264911E 04	0.1011928E 02	0.3451620E-01	0.1000000E 00	0.6000000E 01	0.7589461E 04	0.5000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.8900000E 02	0.0000000E 00	0.8900000E 02

TABLE VIII-22

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 200

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.305691E 00	0.3162278E 00	0.9666795E-01	0.4773859E-03	0.4773859E-03	0.0000000E 00	0.0000000E 00	0.1880000E 03
0.294308E 00	0.2236068E 01	0.6580946E 00	0.3249943E-02	0.3727325E-02	0.1000000E 01	0.2236068E 01	0.1810000E 03
0.1154471E 00	0.7071068E 01	0.8163342E 00	0.4031294E-02	0.7758722E-02	0.1000000E 01	0.7071068E 01	0.7100000E 02
0.1886179E 00	0.2236067E 02	0.4217622E 01	0.2082836E-01	0.2858708E-01	0.4000000E 01	0.8944269E 02	0.1160000E 03
0.7804977E-01	0.1000000E 03	0.7804876E 01	0.3854371E-01	0.6713074E-01	0.3000000E 01	0.3000000E 03	0.4800000E 02
0.1626016E-01	0.2829425E 03	0.4599065E 01	0.2271208E-01	0.8984280E-01	0.2000000E 01	0.5656851E 03	0.1000000E 02
0.1626016E-02	0.1264911E 04	0.2056765E 01	0.1015715E-01	0.9999990E-01	0.1000000E 02	0.1264910E 05	0.1000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.1790000E 03	0.0000000E 00	0.1790000E 03

TABLE VIII-23

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 300

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3102310E 00	0.3162278E 00	0.9810364E-01	0.5686979E-03	0.5686979E-03	0.0000000E 00	0.0000000E 00	0.1880000E 03
0.2986798E 00	0.2236068E 01	0.6678683E 00	0.3871574E-02	0.4440270E-02	0.1000000E 01	0.2236068E 01	0.1810000E 03
0.1155115E 00	0.7071068E 01	0.8167899E 00	0.4734859E-02	0.9175125E-02	0.2000000E 01	0.1414214E 02	0.7000000E 02
0.1881188E 00	0.2236067E 02	0.4206461E 01	0.2438448E-01	0.3355961E-01	0.6000000E 01	0.1341640E 03	0.1140000E 03
0.7260722E-01	0.1000000E 03	0.7260721E 01	0.4206976E-01	0.7564932E-01	0.7000000E 01	0.7000000E 03	0.4400000E 02
0.1485148E-01	0.2228425E 03	0.4200631E 01	0.2438069E-01	0.9999996E-01	0.3000000E 01	0.8485276E 03	0.9000000E 01
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.1100000E 02	0.1391401E 05	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.2700000E 03	0.0000000E 00	0.2700000E 03

TABLE VIII-24

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 400

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.313333E 00	0.3162278E 00	0.9908468E-01	0.5837362E-03	0.5837362E-03	0.0000000E 00	0.0000000E 00	0.1880000E 03
0.3000000E 00	0.2236068E 01	0.6708202E 00	0.3951557E-02	0.4535731E-02	0.2000000E 01	0.4472136E 01	0.1800000E 03
0.1166666E 00	0.7071068E 01	0.8249575E 00	0.4860062E-02	0.9395793E-02	0.2000000E 01	0.1414214E 02	0.7000000E 02
0.1849999E 00	0.2236067E 02	0.4136723E 01	0.2437063E-01	0.3376643E-01	0.5000000E 01	0.2012460E 03	0.1110000E 03
0.6999999E-01	0.1000000E 03	0.6599999E 01	0.4123503E-01	0.7500541E-01	0.9000000E 01	0.9000000E 03	0.4200000E 02
0.1500000E-01	0.2826425E 03	0.4242637E 01	0.2499460E-01	0.9999996E-01	0.3000000E 01	0.8485276E 03	0.9000000E 01
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.1100000E 02	0.1391401E 05	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.3640000E 03	0.0000000E 00	0.3640000E 03

TABLE VIII-25

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 500

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.312644E 00	0.3162278E 00	0.1007641E 00	0.6553300E-03	0.6553300E-03	0.0000000E 00	0.0000000E 00	0.1880000E 03
0.303389E 00	0.2236068E 01	0.6784001E 00	0.4412048E-02	0.5067375E-02	0.3000000E 01	0.6708203E 01	0.1790000E 03
0.1186441E 00	0.7071068E 01	0.8389401E 00	0.5456135E-02	0.1052351E-01	0.2000000E 01	0.1414214E 02	0.7000000E 02
0.1847457E 00	0.2236067E 02	0.4131038E 01	0.2686665E-01	0.3739016E-01	0.1100000E 02	0.2459674E 03	0.1090000E 03
0.6271183E-01	0.1000000E 03	0.6271183E 01	0.407EE32E-01	0.7817543E-01	0.1400000E 02	0.1400000E 04	0.3700000E 02
0.1186441E-01	0.2828425E 03	0.3355758E 01	0.2182453E-01	0.9999990E-01	0.5000000E 01	0.1414213E 04	0.7000000E 01
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999990E-01	0.1100000E 02	0.1391401E 05	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999990E 00	0.4540000E 03	0.0000000E 00	0.4540000E 03

TABLE VIII-26

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 600

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROC.	FIELD FIND	RESERVE FIND	FIELD
0.3235000E 00	0.3162278E 00	0.1023250E 00	0.6920395E-03	0.6920395E-03	0.0000000E 00	0.0000000E 00	0.1880000E 03
0.3080000E 00	0.2736068E 01	0.6889089E 00	0.4659194E-02	0.5351231E-02	0.3000000E 01	0.6708203E 01	0.1790000E 03
0.1170396E 00	0.7071008E 01	0.8275946E 00	0.5597148E-02	0.1094838E-01	0.4000000E 01	0.2828426E 02	0.6800000E 02
0.1824440E 00	0.2236067E 02	0.4079571E 01	0.2759077E-01	0.3853915E-01	0.1400000E 02	0.3130491E 03	0.1060000E 03
0.5679862E-01	0.1000900E 03	0.5679862E 01	0.3841378E-01	0.7695287E-01	0.1800000E 02	0.1800000E 04	0.3300000E 02
0.1204819E-01	0.2828425E 03	0.3407741E 01	0.2304707E-01	0.9599990E-01	0.5000000E 01	0.1414213E 04	0.7000000E 01
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999990E-01	0.1100000E 02	0.1391401E 05	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.5450000E 03	0.0000000E 00	0.5450000E 03

TABLE VIII-27

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 700

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3226713E 00	0.3162278E 00	0.1039345E 00	0.7947688E-03	0.7947688E-03	0.0000000E 00	0.0000000E 00	0.188000CE 03
0.312937CE 0C	0.2236068E 01	0.6997483E 00	0.5350832E-02	0.6145600E-02	0.3000000F 01	0.67082C3E 01	0.1790000E 03
0.1188811E 00	0.7071068E 01	0.8406163E 00	0.6422014E-02	0.1257361E-01	0.4000000E 01	0.2828426E 02	0.6800000E 02
0.1818181E 00	0.2236067E 02	0.4065575E 01	0.3102E61E-01	0.4366223E-01	0.1600000E 02	0.3577703E 03	0.104000CE 03
0.4895105E-01	0.1000000E 03	0.4895104E 01	0.3743185E-01	0.8109403E-01	0.2300000E 02	0.2300000E 04	0.2800000E 02
0.8741256E-02	0.2828425E 03	0.2472399E 01	0.1890592E-01	0.999599CE-01	0.7000000E 01	0.1979898E 04	0.5000000E 01
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999990E-01	0.1100000E 02	0.1391401E 05	0.0000000E 00
0.000000CE 0C	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.6360000E 03	0.0000000E 00	0.6360000E 03

TABLE VIII-28

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 800

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3357143E 00	0.3162278E 00	0.1061621E 00	0.9409655E-03	0.9409655E-03	0.0000000E 00	0.0000000E 00	0.1880000E 03
0.3156428E 00	0.2236068E 01	0.7147430E 00	0.6335102E-02	0.7276064E-02	0.3000000E 01	0.6708203E 01	0.1790000E 03
0.1196425E 00	0.7071068E 01	0.8460027E 00	0.7498521E-02	0.1477455E-01	0.5000000E 01	0.3535532E 02	0.6700000E 02
0.1785714E 00	0.2236067E 02	0.3992976E 01	0.3535166E-01	0.5016625E-01	0.2000000E 02	0.4472126E 03	0.1000000E 03
0.4107143E-01	0.1000000E 03	0.4107142E 01	0.3640357E-01	0.8656979E-01	0.2800000E 02	0.2800000E 04	0.2300000E 02
0.5357143E-02	0.2828425E 03	0.1515227E 01	0.1343018E-01	0.9999996E-01	0.5000000E 01	0.2545563E 04	0.3000000E 01
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.1100000E 02	0.1391401E 05	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.7240000E 03	0.0000000E 00	0.7240000E 03

TABLE VIII-29

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 900

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.341157E 00	0.316227E 00	0.107896E 00	0.110440E-02	0.110440E-02	0.000000E 00	0.000000E 00	0.188000E 03
0.323048E 00	0.223606E 01	0.722359E 00	0.739353E-02	0.849833E-02	0.400000E 01	0.894427E 01	0.178000E 03
0.121597E 00	0.707106E 01	0.859821E 00	0.880096E-02	0.172993E-01	0.500000E 01	0.353553E 02	0.670000E 02
0.176043E 00	0.223606E 02	0.393645E 01	0.402528E-01	0.575521E-01	0.230000E 02	0.514294E 03	0.970000E 02
0.362976E-01	0.100000E 03	0.362976E 01	0.371536E-01	0.947457E-01	0.310000E 02	0.310000E 04	0.200000E 02
0.181488E-02	0.282842E 03	0.513325E 00	0.525430E-02	0.999999E-01	0.110000E 02	0.311126E 04	0.100000E 01
0.000000E 00	0.126491E 04	0.000000E 00	0.000000E 00	0.999999E-01	0.110000E 02	0.139140E 05	0.000000E 00
0.000000E 00	0.000000E 00	0.000000E 00	0.900000E 00	0.999999E 00	0.815000E 03	0.000000E 00	0.815000E 03

TABLE VIII-30

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 1000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3494424E 00	0.3162278E 00	0.1105034E 00	0.1267095E-02	0.1267095E-02	0.0000000E 00	0.0000000E 00	0.1880000E 03
0.3308550E 00	0.2236068E 01	0.7398142E 00	0.8483130E-02	0.9750225E-02	0.4000000E 01	0.8944271E 01	0.1780000E 03
0.1226166E 00	0.7071068E 01	0.8674542E 00	0.9946723E-02	0.1969695E-01	0.6000000E 01	0.4242638E 02	0.6600000E 02
0.1635687E 00	0.2236067E 02	0.3657506E 01	0.4193506E-01	0.6163601E-01	0.3200000E 02	0.7155398E 03	0.8800000E 02
0.3345725E-01	0.1000000E 03	0.3345724E 01	0.3836399E-01	0.9999996E-01	0.3300000E 02	0.3300000E 04	0.1800000E 02
0.0000000E 00	0.2828425E 03	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.1200000E 02	0.3394110E 04	0.0000000E 00
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.1100000E 02	0.1391401E 05	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.9020000E 03	0.0000000E 00	0.9020000E 03

TABLE VIII-31

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 100

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.2981761E 00	0.3162272E 00	0.9429151E-01	0.2678544E-03	0.2678544E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2678668E 00	0.2236068E 01	0.6436896E 00	0.1828533E-02	0.2096387E-02	0.1000000E 01	0.2236068E 01	0.3630000E 03
0.1134020E 00	0.7071068E 01	0.8018733E 00	0.2277886E-02	0.4374273E-02	0.1000000E 01	0.7071068E 01	0.1430000E 03
0.1887391E 00	0.2236067E 02	0.4220332E 01	0.1198873E-01	0.1636300E-01	0.2000000E 01	0.4472134E 02	0.2380000E 03
0.8009511E-01	0.1000000E 03	0.8009511E 01	0.2275267E-01	0.3911567E-01	0.1000000E 01	0.1000000E 03	0.1010000E 03
0.1903251E-01	0.2828425E 03	0.5383204E 01	0.1525210E-01	0.5440776E-01	0.0000000E 00	0.0000000E 00	0.2400000E 02
0.1268934E-01	0.1264911E 04	0.1604962E 02	0.4555226E-01	0.1000000E 00	0.6000000E 01	0.7589461E 04	0.1600000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.8900000E 02	0.0000000E 00	0.8900000E 02

TABLE VIII-32

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 200

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3005595E 00	0.3162278E 00	0.9504527E-01	0.3167479E-03	0.3167479E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2901672E CC	0.2236068E 01	0.6488349E 00	0.2162308E-02	0.2479056E-02	0.1000000E 01	0.2236068E 01	0.3630000E 03
0.1143025E CC	0.7071068E 01	0.8082834E 00	0.2693686E-02	0.5172741E-02	0.1000000E 01	0.7071068E 01	0.1430000E 03
0.1826451E 00	0.2236067E 02	0.4218319E C1	0.1405757E-01	0.1923071E-C1	0.4000000E 01	0.8944269E 02	0.2360000E 03
0.7913667E-C1	0.1000000E 03	0.7913667E 01	0.2637309E-01	0.4560380E-01	0.3000000E 01	0.3000000E 03	0.9900000E 02
0.1832525E-01	0.2228425E 03	0.5200142E 01	0.1733000E-01	0.6293380E-C1	0.1000000E 01	0.2228425E 03	0.2300000E 02
0.8792963E-02	0.1264911E 04	0.1112231E 02	0.3706624E-01	0.1000000E 00	0.1100000E 02	0.1391401E 05	0.1100000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.1790000E 03	0.0000000E 00	0.1790000E 03

TABLE VIII-33

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 300

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3027375E 00	0.3162278E 00	0.9573400E-01	0.3617245E-03	0.3617245E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2922705E 00	0.2236068E 01	0.6535366E 00	0.2469345E-02	0.2831070E-02	0.1000000E 01	0.2236068E 01	0.3630000E 03
0.1143317E 00	0.7071068E 01	0.8084473E 00	0.3054666E-02	0.5885735E-02	0.2000000E 01	0.1414214E 02	0.1420000E 03
0.1900161E 00	0.2236067E 02	0.4248887E 01	0.1605414E-01	0.2193907E-01	0.4000000E 01	0.8944269E 02	0.2360000E 03
0.7729465E-01	0.1000000E 03	0.7729465E 01	0.2920528E-01	0.5114515E-01	0.6000000E 01	0.6000000E 03	0.9600000E 02
0.1690821E-01	0.2828425E 03	0.4782360E 01	0.1606984E-01	0.6921494E-01	0.3000000E 01	0.8485276E 03	0.2100000E 02
0.6441221E-02	0.1264911E 04	0.8147570E 01	0.3078506E-01	0.9999994E-01	0.1400000E 02	0.1770874E 05	0.8000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.2700000E 03	0.0000000E 00	0.2700000E 03

TABLE VIII-34

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 400

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3042071E 00	0.3162278E 00	0.9619868E-01	0.3685900E-03	0.3685900E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2936893E 00	0.2236068E 01	0.6567092E 00	0.2516215E-02	0.2884805E-02	0.1000000E 01	0.2236068E 01	0.3630000E 03
0.1140776E 00	0.7071068E 01	0.8066506E 00	0.3090723E-02	0.5975526E-02	0.3000000E 01	0.2121320E 02	0.1410000E 03
0.1901254E 00	0.2236067E 02	0.4251421E 01	0.1628954E-01	0.2226506E-01	0.5000000E 01	0.1118034E 03	0.2350000E 03
0.7524270E-01	0.1000000E 03	0.7524269E 01	0.2882562E-01	0.5109468E-01	0.9000000E 01	0.9000000E 03	0.9300000E 02
0.1618123E-01	0.2828425E 03	0.4576738E 01	0.1753600E-01	0.6863064E-01	0.4000000E 01	0.1131370E 04	0.2000000E 02
0.6472491E-02	0.1264911E 04	0.8187123E 01	0.3136538E-01	0.9999996E-01	0.1400000E 02	0.1770874E 05	0.8000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.5000000E 00	0.9999995E 00	0.3640000E 03	0.0000000E 00	0.3640000E 03

TABLE VIII-35

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 500

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3066824E 00	0.3162278E 00	0.9698337E-01	0.4163873E-03	0.4163873E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2952691E 00	0.2236068E 01	0.6602418E 00	0.2834675E-02	0.3251062E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1157081E 00	0.7071068E 01	0.8132302E 00	0.3491513E-02	0.6742574E-02	0.3000000E 01	0.2121320E 02	0.1410000E 03
0.1908646E 00	0.2236067E 02	0.4267859E 01	0.1832358E-01	0.2506615E-01	0.6000000E 01	0.1341640E 03	0.2340000E 03
0.7340944E-01	0.1000000E 03	0.7340943E 01	0.3151752E-01	0.5658366E-01	0.1200000E 02	0.1200000E 04	0.9000000E 02
0.1366623E-01	0.2828425E 03	0.3921959E 01	0.1683849E-01	0.7342213E-01	0.7000000E 01	0.1979898E 04	0.1700000E 02
0.4893562E-02	0.1264911E 04	0.6190426E 01	0.2657790E-01	0.1000000E 00	0.1600000E 02	0.2023856E 05	0.6000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.4540000E 03	0.0000000E 00	0.4540000E 03

TABLE VIII-36

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 600

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3089564E 00	0.3162278E 00	0.9770060E-01	0.4495201E-03	0.4495201E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2974527E 00	0.2236068E 01	0.6651245E 00	0.3060236E-02	0.3509756E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1150370E 00	0.7071068E 01	0.8134341E 00	0.3742608E-02	0.7252362E-02	0.4000000E 01	0.2828426E 02	0.1400000E 03
0.1858110E 00	0.2236067E 02	0.4244301E 01	0.1952602E-01	0.2678038E-01	0.9000000E 01	0.2012460E 03	0.2310000E 03
0.7230890E-01	0.1000000E 03	0.7230889E 01	0.3326930E-01	0.6004968E-01	0.1400000E 02	0.1400000E 04	0.8800000E 02
0.1232539E-01	0.2828425E 03	0.3486143E 01	0.1603573E-01	0.7608938E-01	0.9000000E 01	0.2545583E 04	0.1500000E 02
0.4108462E-02	0.1264911E 04	0.5196838E 01	0.2391064E-01	0.9999996E-01	0.1700000E 02	0.2150347E 05	0.5000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.5450000E 03	0.0000000E 00	0.5450000E 03

TABLE VIII-37

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 700

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3112583E 00	0.3162278E 00	0.9842849E-C1	0.5086425E-03	0.5086425E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.2956682E 00	0.2236062E 01	0.6700798E 00	0.3462731E-02	0.3971372E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1158940E 00	0.7071069E 01	0.8194944E 00	0.4234250E-C2	0.8206222E-02	0.4000000E 01	0.2828426E 02	0.1400000E 03
0.1895655E 00	0.2236067E 02	0.4238502E 01	0.2190512E-C1	0.3011134E-01	0.1100000E 02	0.2459674E 03	0.2290000E 03
0.6870860E-01	0.1000000E 03	0.6870859E 01	0.3550613E-01	0.6561744E-01	0.1900000E 02	0.1900000E 04	0.8300000E 02
0.1241722E-01	0.2828425E 03	0.3512116E 01	0.1814535E-01	0.8376674E-01	0.9000000E 01	0.2545583E 04	0.1500000E 02
0.2483444E-02	0.1264511E 04	0.3141335E 01	0.1623328E-01	0.1000000E 00	0.1900000E 02	0.2403329E 05	0.3000000E 01
0.0900900E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.6360000E 03	0.0000000E 00	0.6360000E 03

TABLE VIII-38

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 800

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3143812E 00	0.3162278E 00	0.9941608E-01	0.5984295E-03	0.5984295E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.3026755E 00	0.2236062E 01	0.6768030E 00	0.4073577E-02	0.4672404E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1170562E 00	0.7071068E 01	0.8277169E 00	0.4982397E-02	0.9654801E-02	0.4000000E 01	0.2829426E 02	0.1400000E 03
0.1872510E 00	0.2236067E 02	0.4187551E 01	0.2520915E-01	0.3486395E-01	0.1600000E 02	0.3577703E 03	0.2240000E 03
0.6688958E-01	0.1000000E 03	0.6688958E 01	0.4026383E-01	0.7512778E-01	0.2200000E 02	0.2200000E 04	0.8000000E 02
0.1026556E-01	0.2228425E 03	0.3074374E 01	0.1850603E-01	0.9363377E-01	0.1100000E 02	0.3111268E 04	0.1300000E 02
0.6361202E-03	0.1264911E 04	0.1057617E 01	0.6366264E-02	0.1000000E 00	0.2100000E 02	0.2656311E 05	0.1000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.7240000E 03	0.0000000E 00	0.7240000E 03

TABLE VIII-39

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 900

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.316765E 00	0.3162278E 00	0.1001698E 00	0.6432049E-03	0.6432049E-03	0.0000000E 00	0.0000000E 00	0.3760000E 03
0.3049705E 00	0.2236065E 01	0.6819347E 00	0.4378803E-02	0.5022008E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1171015E 00	0.7071069E 01	0.8280355E 00	0.5316535E-02	0.1033894E-01	0.5000000E 01	0.3535532E 02	0.1390000E 03
0.1870261E 00	0.2236067E 02	0.4182029E 01	0.2685342E-01	0.3719237E-01	0.1800000E 02	0.4024515E 03	0.2220000E 03
0.6571186E-01	0.1000000E 03	0.6571185E 01	0.4215455E-01	0.7938685E-01	0.2400000E 02	0.2400000E 04	0.7800000E 02
0.7582139E-02	0.2828425E 03	0.2144551E 01	0.1377048E-01	0.9315735E-01	0.1500000E 02	0.4242637E 04	0.9000000E 01
0.8424600E-03	0.1264911E 04	0.1065637E 01	0.6842606E-02	0.9999990E-01	0.2100000E 02	0.2656311E 05	0.1000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.8150000E 03	0.0000000E 00	0.8150000E 03

TABLE VIII-40

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 1000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3202726E 00	0.3162278E 00	0.1012751E 00	0.7362566E-03	0.7362966E-03	0.0000000E 00	0.0001000E 00	0.3760000E 03
0.3083475E 00	0.2236062E 01	0.6894859E 00	0.5012549E-02	0.5748846E-02	0.2000000E 01	0.4472136E 01	0.3620000E 03
0.1183986E 00	0.7071069E 01	0.8372046E 00	0.6086461E-02	0.1183531E-01	0.5000000E 01	0.3535532E 02	0.1390000E 03
0.1256255E 00	0.2236067E 02	0.4152151E 01	0.3018606E-01	0.4202136E-01	0.2200000E 02	0.4919339E 03	0.2180000E 03
0.6047700E-01	0.1000000E 03	0.6047700E 01	0.4396667E-01	0.8598795E-01	0.3100000E 02	0.3100000E 04	0.7100000E 02
0.6814308E-02	0.2828425E 03	0.1927376E 01	0.1401198E-01	0.9999996E-01	0.1600000E 02	0.4525477E 04	0.8000000E 01
0.0000000E 00	0.1264911E 04	0.0000000E 00	0.0000000E 00	0.9999996E-01	0.2200000E 02	0.2782802E 05	0.0000000E 00
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.5020000E 03	0.0000000E 00	0.9020000E 03

TABLE VIII-41

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 100

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.2973115E 00	0.3162278E 00	0.9401816E-01	0.2531356E-03	0.2531356E-03	0.0000000E 00	0.0000000E 00	0.5640000E 03
0.2872957E 00	0.2236068E 01	0.6424126E 00	0.1725639E-02	0.1982775E-02	0.1000000E 01	0.2236068E 01	0.8450000E 03
0.1133366E 00	0.7071068E 01	0.8014122E 00	0.2157732E-02	0.4140504E-02	0.1000000E 01	0.7071068E 01	0.2150000E 03
0.1887190E 00	0.2236067E 02	0.4219883E 01	0.1136166E-01	0.1550216E-01	0.2000000E 01	0.4472134E 02	0.3580000E 03
0.8012646E-01	0.1000000E 03	0.8012646E 01	0.2157334E-01	0.3707550E-01	0.1000000E 01	0.1000000E 03	0.1520000E 03
0.1897733E-01	0.2828425E 03	0.5367596E 01	0.1445178E-01	0.5152728E-01	0.0000000E 00	0.0000000E 00	0.3600000E 02
0.1423300E-01	0.1264911E 04	0.1800346E 02	0.4847275E-01	0.1000000E 00	0.6000000E 01	0.7589461E 04	0.2700000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.8900000E 02	0.0000000E 00	0.8900000E 02

TABLE VIII-42

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 200

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROCB.	FIELD FIND	RESERVE FIND	FIELD
0.2922271E 00	0.3162278E 00	0.9451640E-01	0.2864758E-03	0.2864758E-03	0.0000000E 00	0.0000000E 00	0.5640000E 03
0.2288182E 00	0.2236068E 01	0.645817CE 00	0.1957449E-02	0.2243924E-02	0.1000000E 01	0.2236068E 01	0.5450000E 03
0.1139374E 00	0.7071063E 01	0.8056553E 00	0.2441925E-02	0.4685849E-02	0.1000000E 01	0.7071068E 01	0.2150000E 03
0.1226592E 00	0.2236067E 02	0.4218546E 01	0.1272226E-01	0.1747211E-01	0.4000000E 01	0.8944269E 02	0.3560000E 03
0.8055109E-01	0.1000000E 03	0.8055108E 01	0.2441474E-01	0.4188685E-01	0.1000000E 01	0.1000000E 03	0.1520000E 03
0.1801201E-01	0.2828425E 03	0.5096260E 01	0.1544658E-01	0.5733343E-01	0.2000000E 01	0.5656851E 03	0.3400000E 02
0.1112872E-01	0.1264911E 04	0.1407691E 02	0.4266662E-01	0.1000000E 00	0.1200000E 02	0.1517892E 05	0.2100000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.1790000E 03	0.0000000E 00	0.1790000E 03

TABLE VIII-43

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 300

FFQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3003174E 00	0.3162278E 00	0.9495933F-01	0.3151516E-03	0.3151516E-03	0.0000000E 00	0.0000000E 00	0.5640000E 03
0.2902123E 00	0.2236064E 01	0.6489120E 00	0.2153387E-02	0.2468538E-02	0.1000000E 01	0.2236068E 01	0.5450000E 03
0.1144935E 00	0.7071068E 01	0.9095204E 00	0.2686358E-02	0.5154897E-02	0.1000000E 01	0.7071068E 01	0.2150000E 03
0.1450306E 00	0.2236067E 02	0.4226856E 01	0.1402664E-01	0.1918153E-01	0.5000000E 01	0.1118034E 03	0.3550000E 03
0.7933968E-01	0.1000000E 03	0.7933968E 01	0.2632853E-01	0.4551006E-01	0.4000000E 01	0.4000000E 03	0.1490000E 03
0.1757188E-01	0.2828425E 03	0.4970075E 01	0.1649298E-01	0.6200304E-01	0.3000000E 01	0.8485276E 03	0.3300000E 02
0.9052180E-02	0.1264911E 04	0.1145020E 02	0.3799700E-01	0.1000000E 00	0.1600000E 02	0.2023856E 05	0.1700000E 02
0.6600000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.2700000E 03	0.0000000E 00	0.2700000E 03

TABLE VIII-44

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 400

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3012E2CE 00	0.3162278E 00	0.9527373E-01	0.3253E92E-03	0.3253692E-03	0.0000000E 00	0.0000000E 00	0.5640C00E 03
0.2911325E 0C	0.2236068E 01	0.6509919E 00	0.2223201E-02	0.254857CE-02	0.10C0000E 01	0.2236068E 01	0.5450C00E 03
0.1143162F 00	0.7071068E 01	0.8083377E 00	0.276C553E-02	0.530912CE-02	0.20C0000F 01	0.1414214E 02	0.2140000E 03
0.1991025E 00	0.2236067E 02	0.4228455E 01	0.1444060E-01	0.1974972E-01	0.6000000E 01	0.1341640E 03	0.35400CCE 03
0.7852560E-01	0.1000000E 03	0.7852560E 01	0.2681726E-01	0.4656699E-01	0.6000000E 01	0.6000000E 03	0.1470000E 03
0.1709402E-01	0.2828425E 03	0.4834914E 01	0.1651170E-01	0.6307864E-01	0.4000000F 01	0.1131370E 04	0.3200000E 02
0.8547C0CE-02	0.1264911E 04	0.1081120E 02	0.3692132E-01	0.9999990E-01	0.1700000E 02	0.2150347E 05	0.1600000E 02
0.000000CF 0C	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.3640000E 03	0.0000000E 00	0.3640000E 03

TABLE VIII-45

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 500

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROB.	FIELD FIND	RESERVE FIND	FIELD
0.3029001E 00	0.3162278E 00	0.9578538E-01	0.3557771E-03	0.3557771E-03	0.0000000E 00	0.0000000E 00	0.5640000E 03
0.2921590E 00	0.2236068E 01	0.6532872E 00	0.2426514E-02	0.2782291E-02	0.2000000E 01	0.4472136E 01	0.5440000E 03
0.1149352E 00	0.7071068E 01	0.8126789E 00	0.3012546E-02	0.5800836E-02	0.2000000E 01	0.1414214E 02	0.2140000E 03
0.1895810E 00	0.2236067E 02	0.4239159E 01	0.1574557E-01	0.2154640E-01	0.7000000E 01	0.1565247E 03	0.3530000E 03
0.7733615E-01	0.1000000E 03	0.7733619E 01	0.2872510E-01	0.5027150E-01	0.9000000E 01	0.9000000E 03	0.1440000E 03
0.1611171E-01	0.2828425E 03	0.4557076E 01	0.1692641E-01	0.6719786E-01	0.6000000E 01	0.1697055E 04	0.3000000E 02
0.6981738E-02	0.1264511E 04	0.8831276E 01	0.3280214E-01	0.9999996E-01	0.2000000E 02	0.2529820E 05	0.1300000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.4540000E 03	0.0000000E 00	0.4540000E 03

TABLE VIII-46

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 600

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3043712E 00	0.3162278E 00	0.9625059E-01	0.3798720E-03	0.3798720E-03	0.0000000E 00	0.0000000E 00	0.5640000E 03
0.2935780E 00	0.2236068E 01	0.6564602E 00	0.2590851E-02	0.2970723E-02	0.2000000E 01	0.4472136E 01	0.5440000E 03
0.1154884E 00	0.7071069E 01	0.8166260E 00	0.3222977E-02	0.6193697E-02	0.2000000E 01	0.1414214E 02	0.2140000E 03
0.1898925E 00	0.2236067E 02	0.4223548E 01	0.1666507E-01	0.2286277E-01	0.1000000E 02	0.2236067E 03	0.3500000E 03
0.7609278E-01	0.1000000E 03	0.7609278E 01	0.3003153E-01	0.5289430E-01	0.1200000E 02	0.1200000E 04	0.1410000E 03
0.1565025E-01	0.2828425E 03	0.4426568E 01	0.1747033E-01	0.7036455E-01	0.7000000E 01	0.1979898E 04	0.2900000E 02
0.5936317E-02	0.1264911E 04	0.7508912E 01	0.2963542E-01	0.9999999E-01	0.2200000E 02	0.2782802E 05	0.1100000E 02
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999999E 00	0.5450000E 03	0.0000000E 00	0.5450000E 03

TABLE VIII-47

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 700

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.305856E 00	0.3162278E 00	0.9672040E-01	0.4099074E-03	0.4099074E-03	0.0000000E 00	0.0000000E 00	0.5640000E 03
0.2950108E 00	0.2236068E 01	0.6596641E 00	0.2795702E-02	0.3205609E-02	0.2000000E 01	0.4472136E 01	0.5440000E 03
0.1160520E 00	0.7071068E 01	0.8206118E 00	0.3477809E-02	0.6683417E-02	0.2000000E 01	0.1414214E 02	0.2140000E 03
0.1887202E 00	0.2236067E 02	0.4219910E 01	0.1788426E-01	0.2456768E-01	0.1200000E 02	0.2683279E 03	0.3480000E 03
0.7483727E-01	0.1000000E 03	0.7483727E 01	0.3171654E-01	0.5628422E-01	0.1500000E 02	0.1500000E 04	0.1380000E 03
0.1464208E-01	0.2828425E 03	0.4141403E 01	0.1755155E-01	0.7383573E-01	0.9000000E 01	0.2545523E 04	0.2700000E 02
0.4880693E-02	0.1264911E 04	0.6173641E 01	0.2616431E-01	0.1000000E 00	0.2400000E 02	0.3035784E 05	0.9000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.6360000E 03	0.0000000E 00	0.6360000E 03

TABLE VIII-48

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 800

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PROCB.	FIELD FIND	RESERVE FIND	FIELD
0.30786C3E 00	0.3162278E 00	0.9735394E-01	0.4487685E-03	0.4487685E-03	0.0000000E 00	0.0000000E 00	0.5640000E 03
0.2967432F 00	0.2236068E 01	0.6639851E 00	0.3060748E-02	0.3509517E-02	0.2000000E 01	0.4472136E 01	0.5440000E 03
0.1168122E 00	0.7071068E 01	0.8259867E 00	0.3807522E-02	0.7317036E-02	0.2000000E 01	0.1414214E 02	0.2140000E 03
0.1877725E 00	0.2236067E 02	0.4198727E 01	0.1935472E-01	0.2667175E-01	0.1600000E 02	0.3577703E 03	0.3440000E 03
0.7368994E-01	0.1000000E 03	0.7368994E 01	0.3396659E-01	0.6064034E-01	0.1800000E 02	0.1800000E 04	0.1350000E 03
0.1310043E-01	0.2828425E 03	0.3705359E 01	0.1708046E-01	0.7772076E-01	0.1200000E 02	0.3394110E 04	0.2400000E 02
0.3820551E-02	0.1264911E 04	0.4833175E 01	0.2227931E-01	0.1000000E 00	0.2600000E 02	0.3288766E 05	0.7000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.7240000E 03	0.0000000E 00	0.7240000E 03

TABLE VIII-49

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 900

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3093201E 00	0.3162278E 00	0.5723459E-C1	0.5191676E-03	0.5191676E-03	0.0000000E 00	0.0000000E 00	0.5640000E 03
0.2924092E 00	0.2236062E 01	0.6672631E 00	0.3540291E-02	0.4060056E-02	0.2000000E 01	0.4472136E 01	0.5440000E 03
0.1168404E 00	0.7071068E 01	0.8261861E C0	0.4384227E-02	0.8444283E-02	0.3000000E 01	0.2121320E 02	0.2130000E 03
0.1891514E 00	0.2236067E C2	0.4207191E C1	0.2232583E-C1	0.3077011E-01	0.1700000E 02	0.3801309E 03	0.3430000E 03
0.7240202E-C1	0.1000000E 03	0.7240808E 01	0.3842399E-01	0.6919402E-01	0.2100000E 02	0.2100000E 04	0.1320000E 03
0.1316511E-01	0.2826425E 03	0.3723652E C1	0.1975589E-01	0.8895391E-01	0.1200000E 02	0.3394110E 04	0.2400000E 02
0.1645639E-02	0.1264911E 04	0.2081586E 01	0.1104612E-01	0.1000000E 00	0.3000000E 02	0.3794730E 05	0.3000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.1000000E 01	0.2150000E 03	0.0000000E 00	0.8150000E 03

TABLE VIII-50

FIELD SIZE DISTRIBUTION FOR NO.OF WELLS= 1000

FREQUENCY	CLASS MARK	PRODUCT	PROBABILITY	CUM.PRCB.	FIELD FIND	RESERVE FIND	FIELD
0.3116022E 00	0.3162278E 00	0.9853727E-C1	0.5597814E-C3	0.5597814E-03	0.0000000E 00	0.0000000E 00	0.5640000E 03
0.3005524E 00	0.2236066E 01	0.6720555E 00	0.3817891E-02	0.4377671E-02	0.2000000E 01	0.4472136E 01	0.5440000E 03
0.1176795E 00	0.7071069E 01	0.8321159E 00	0.4727203E-02	0.9104874E-02	0.3000000E 01	0.2121320E 02	0.2130000E 03
0.1883978E 00	0.2236067E 02	0.4212700E 01	0.2393159E-01	0.3303687E-C1	0.1900000E 02	0.4248521E 03	0.3410000E 03
0.6755575E-01	0.1000000E 03	0.6795579E 01	0.3860511E-01	0.7164192E-01	0.3000000E 02	0.3000000E 04	0.1230000E 03
0.1270718E-01	0.2828425E 03	0.3594131E 01	0.2041795E-01	0.9205985E-C1	0.1300000E 02	0.3676953E 04	0.2300000E 02
0.1104972E-02	0.1264911E 04	0.1397691E 01	0.7940162E-02	0.9999996E-01	0.3100000E 02	0.3921221E 05	0.2000000E 01
0.0000000E 00	0.0000000E 00	0.0000000E 00	0.9000000E 00	0.9999995E 00	0.9020000E 03	0.0000000E 00	0.9020000E 03

in the arguments introduced by the oil and natural gas experts who contend that it is highly probable that most of the larger fields in the explored regions of the U.S. have already been found.

The next set of results is shown in Table VIII-51. This table gives the values of cumulative reserves, cumulative fields found, cumulative dry fields (holes), reserves found, fields found, dry fields (holes) found, ratio of reserves per number of wells drilled, cumulative dry hole footage drilled, cumulative gas well footage drilled, footage drilled, ratio of reserves per foot drilled, and ratio of cumulative reserves per cumulative footage drilled for all the classes combined, and for each region. The results for the mentioned parameters (Table VIII-51) are shown after W wells are drilled where W ranges from 1000 to 10,000 wells with increments of 1000 wells. By plotting some of the results given in Table VIII-51, some interesting relations can be seen.

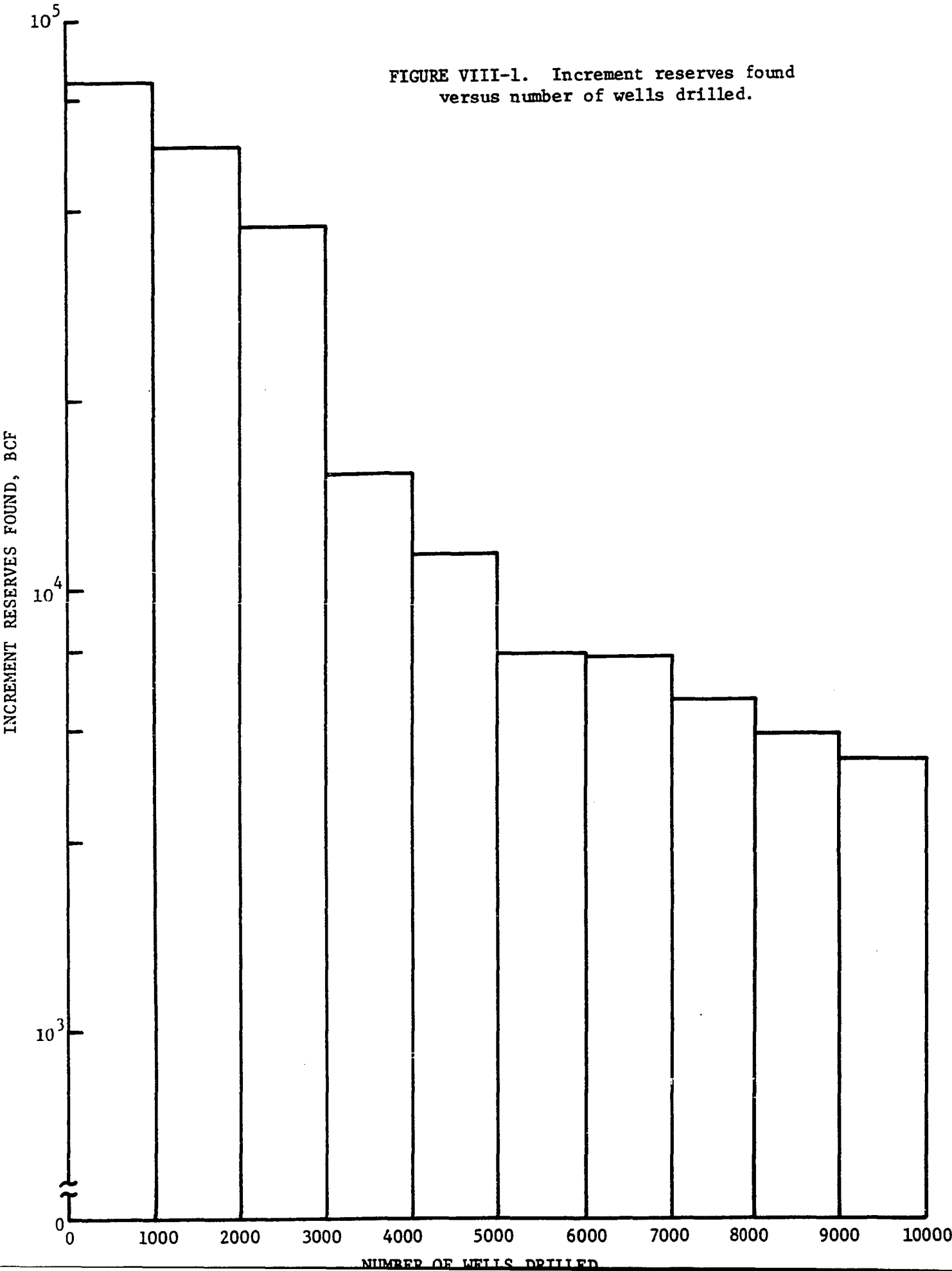
A general relationship can be obtained by plotting reserves found in Bcf of gas versus the number of wells drilled, Figure VIII-1. This figure shows that initially more reserves are found per given annual amount of drilling effort than later in the exploratory play. During the play, this factor drops steadily, with greater drops in the first half and lesser drops in the second half of the drilling program. This is a direct consequence of the fact that more giant and larger

TABLE VIII-51

Results of the Calculation in Phase I for Original Model

RESEERVE CUM.	FIELD CUM.	DRY HOLE CUM.	RESERVE INC.	FIELD INC.	DRY HOLE INC.	INC.RES/WELLS	CUM.RES/CUM.W
0.6342245E 05	0.9800000E 02	0.9020000E 03	0.6342245E 05	0.9800000E 02	0.9020000E 03	0.6342244E 02	0.6342244E 02
0.1134566E 06	0.1950000E 03	0.1805000E 04	0.5007411E 05	0.9700000E 02	0.9030000E 03	0.5007411E 02	0.5674828E 02
0.1508643E 06	0.3090000E 03	0.2691000E 04	0.3736769E 05	0.1140000E 03	0.8860000E 03	0.3736768E 02	0.5028807E 02
0.1660701E 06	0.3910000E 03	0.3609000E 04	0.1520588E 05	0.8200000E 02	0.9180000E 03	0.1520587E 02	0.4151752E 02
0.1773012E 06	0.4900000E 03	0.4510000E 04	0.1123163E 05	0.9900000E 02	0.9010000E 03	0.1123162E 02	0.3546034E 02
0.1851556E 06	0.5830000E 03	0.5417000E 04	0.7853813E 04	0.9300000E 02	0.9070000E 03	0.7853812E 01	0.3085925E 02
0.1928950E 06	0.6930000E 03	0.6307000E 04	0.7729438E 04	0.1100000E 03	0.8900000E 03	0.7729437E 01	0.2755499E 02
0.1995134E 06	0.7930000E 03	0.7207000E 04	0.6628375E 04	0.1000000E 03	0.9000000E 03	0.6628374E 01	0.2493916E 02
0.2053459E 06	0.8950000E 03	0.8115000E 04	0.5832563E 04	0.9200000E 02	0.9000000E 03	0.5832562E 01	0.2281621E 02
0.2106765E 06	0.9800000E 03	0.9020000E 04	0.5330938E 04	0.9500000E 02	0.9050000E 03	0.5330937E 01	0.2106767E 02
CUM.DRY HOLE FOOTAGE	CUM.GAS WELL FOOTAGE	CUM.FOOTAGE DRILLED	INC.DRY HOLE FOOTAGE	INC.GAS WELL FOOTAGE	INC.FOOTAGE DRILLED	INC.RESERVE PER FOOT	CUM.RESERVE PER FOOT
0.1752891E 08	0.1591374E 07	0.1912027E 08	0.1752891E 08	0.1591374E 07	0.1912027E 08	0.3317026E-02	0.3317026E-02
0.3507173E 08	0.3230672E 07	0.3830240E 08	0.1754282E 08	0.1639292E 07	0.1918211E 08	0.2610459E-02	0.2963171E-02
0.5245002E 08	0.5123619E 07	0.5757363E 08	0.1737829E 08	0.1892947E 07	0.1927123E 08	0.1939040E-02	0.2620370E-02
0.7028854E 08	0.6513128E 07	0.7680166E 08	0.1783853E 08	0.1389505E 07	0.1922803E 08	0.7908179E-03	0.2162324E-02
0.8779638E 08	0.8161362E 07	0.9595774E 08	0.1750784E 08	0.1648234E 07	0.1915606E 08	0.5863220E-03	0.1847707E-02
0.1053769E 09	0.9724220E 07	0.1151011E 09	0.1752050E 08	0.1562858E 07	0.1914334E 08	0.4102632E-03	0.1608634E-02
0.1226967E 09	0.1157819E 08	0.1342745E 09	0.1731981E 08	0.1853965E 07	0.1917376E 08	0.4031258E-03	0.1436494E-02
0.1404225E 09	0.1320967E 08	0.1536322E 09	0.1772586E 08	0.1631481E 07	0.1935733E 08	0.3424219E-03	0.1298643E-02
0.1581933E 09	0.1472694E 08	0.1729203E 09	0.1777080E 08	0.1517275E 07	0.1928806E 08	0.3023923E-03	0.1187518E-02
0.1759023E 09	0.1631661E 08	0.1922189E 09	0.1770893E 08	0.1589671E 07	0.1929859E 08	0.2762345E-03	0.1096026E-02

FIGURE VIII-1. Increment reserves found
versus number of wells drilled.



fields were found at the beginning of the play, and that fewer larger fields are found as drilling activities continue. As the smaller fields begin to dominate the mix of field sizes of the discovered fields, the quantity of reserves found decreases. By dividing the incremental reserves discovered or found by the number of wells drilled each time, the ratio of incremental reserves per well drilled is obtained. These values, which are shown in column 7 of Table VIII-51, are sometimes referred to as a reward rate as it indicates reward in terms of reserves expected to be found during a given unit of drilling activity. A plot of cumulative reserves found versus cumulative number of wells drilled, Figure VIII-2, is another important relationship. This curve is rising steeply at first. However, the rate of rise decreases and by the end of the simulated exploratory play, the curve is rising much more gradually. The slope of this curve represents the cumulative reserves found per cumulative number of wells drilled. The values of this slope for each W wells drilled (W ranging from 1000 to 10,000 wells with increments of 1000 wells) are shown in column 8 of Table VIII-51. Figure VIII-3 gives a relationship between reserves found versus number of fields found. Again we can see that even though approximately the same number of fields are found during later stages of the drilling activities, the reserves found initially during the drilling of the first 1000 or 2000 wells were markedly higher. Again this behavior reflects the fact that more giant and

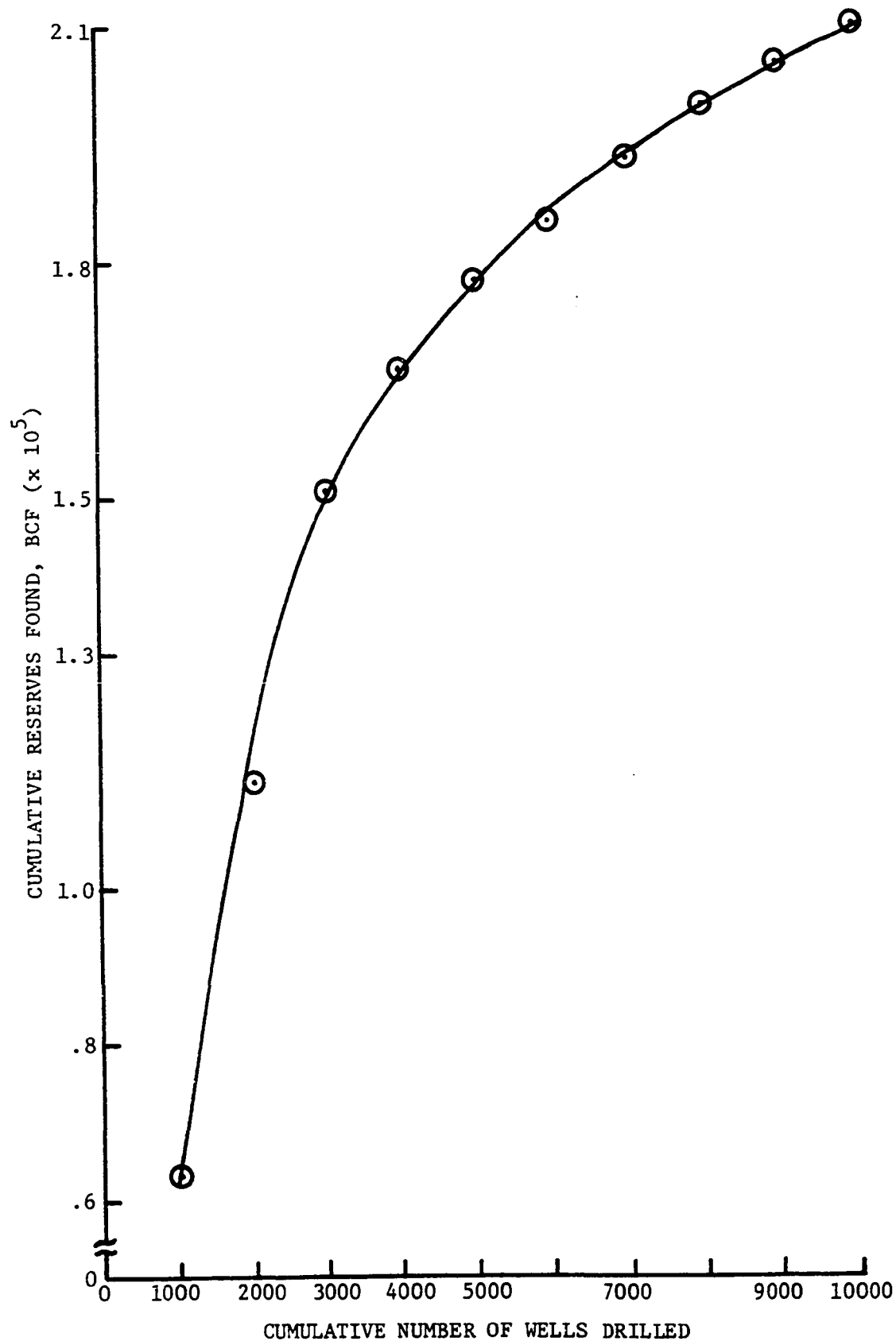
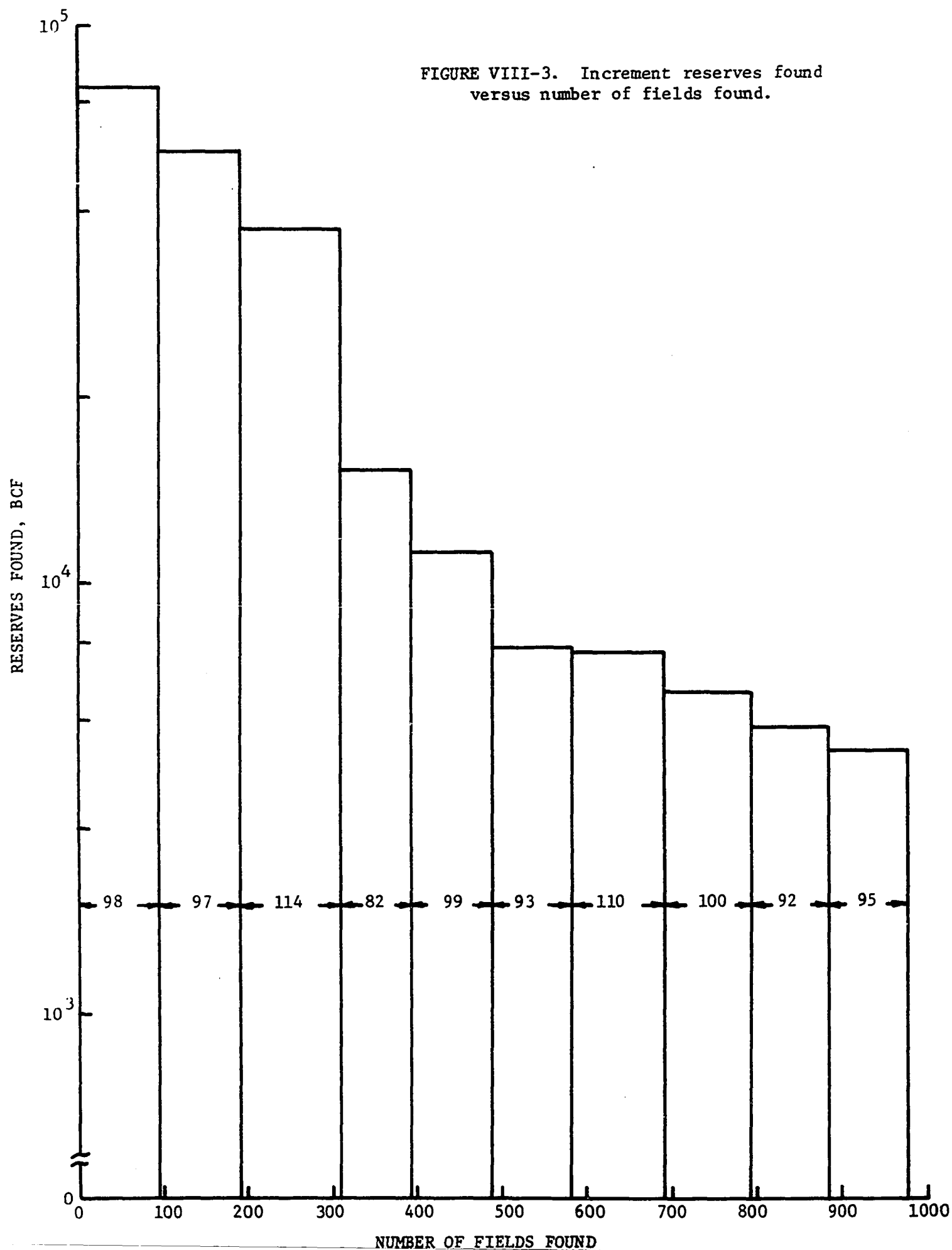


FIGURE VIII-2. Cumulative reserves found versus cumulative number of wells drilled.

FIGURE VIII-3. Increment reserves found
versus number of fields found.



larger fields were found at the beginning of the play. Figure VIII-4 is actually the same relationship as Figure VIII-3, but on a cumulative basis. This curve demonstrates a sharp increase at the beginning followed by more and more gradual increases later in the play. A total of 980 fields were found in drilling 10,000 wells. These fields contained a total of about 2.04×10^5 Bcf of gas. Another approach is shown in Figures VIII-5 and VIII-6 which gives plots of reserves found versus footage drilled and cumulative reserves found versus cumulative footage drilled (this includes both footage drilled for gas and dry wells). It should be mentioned that all the previous figures and these figures must go through the origin because no effort produces no results. Furthermore, the cumulative reserves discovered or found versus cumulative footage curve rises first sharply and then more gently. Also the slopes of the curves on Figures VIII-5 and VIII-6 represent the incremental reserves discovered per foot drilled and cumulative reserves discovered per cumulative footage drilled, respectively. The values for the slopes mentioned above are shown in columns 5 and 6 of the lower part of Table VIII-51. Also the values of the slope (incremental reserves per incremental footage drilled) are plotted versus the cumulative footage drilled, Figure VIII-7. This curve shows a very sharp decrease at the beginning and then a very gentle decrease during the later stages.

Most of the values in Table VIII-51 and the figures which were discussed (Figures VIII-1 to VIII-7) to this point

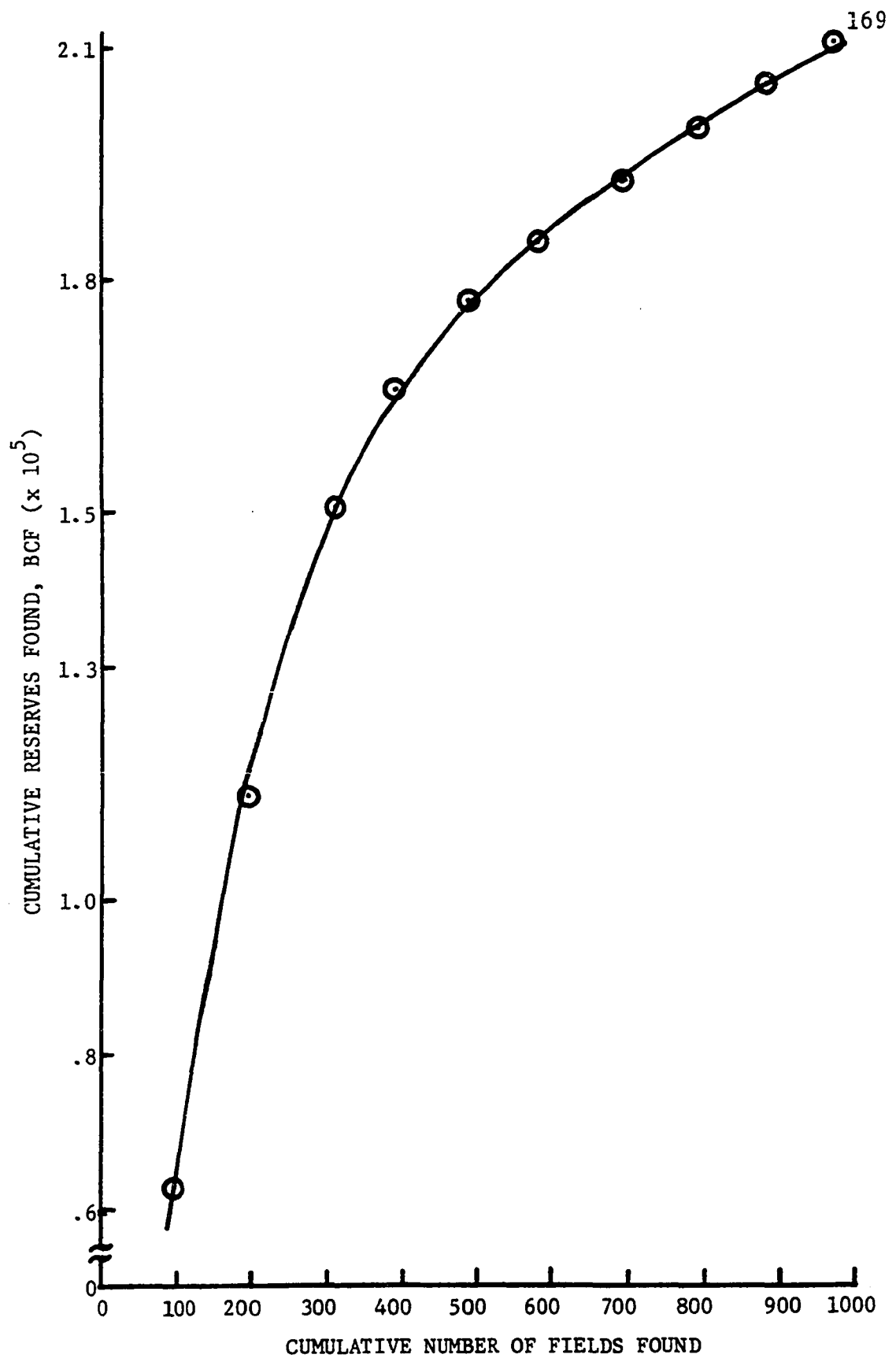
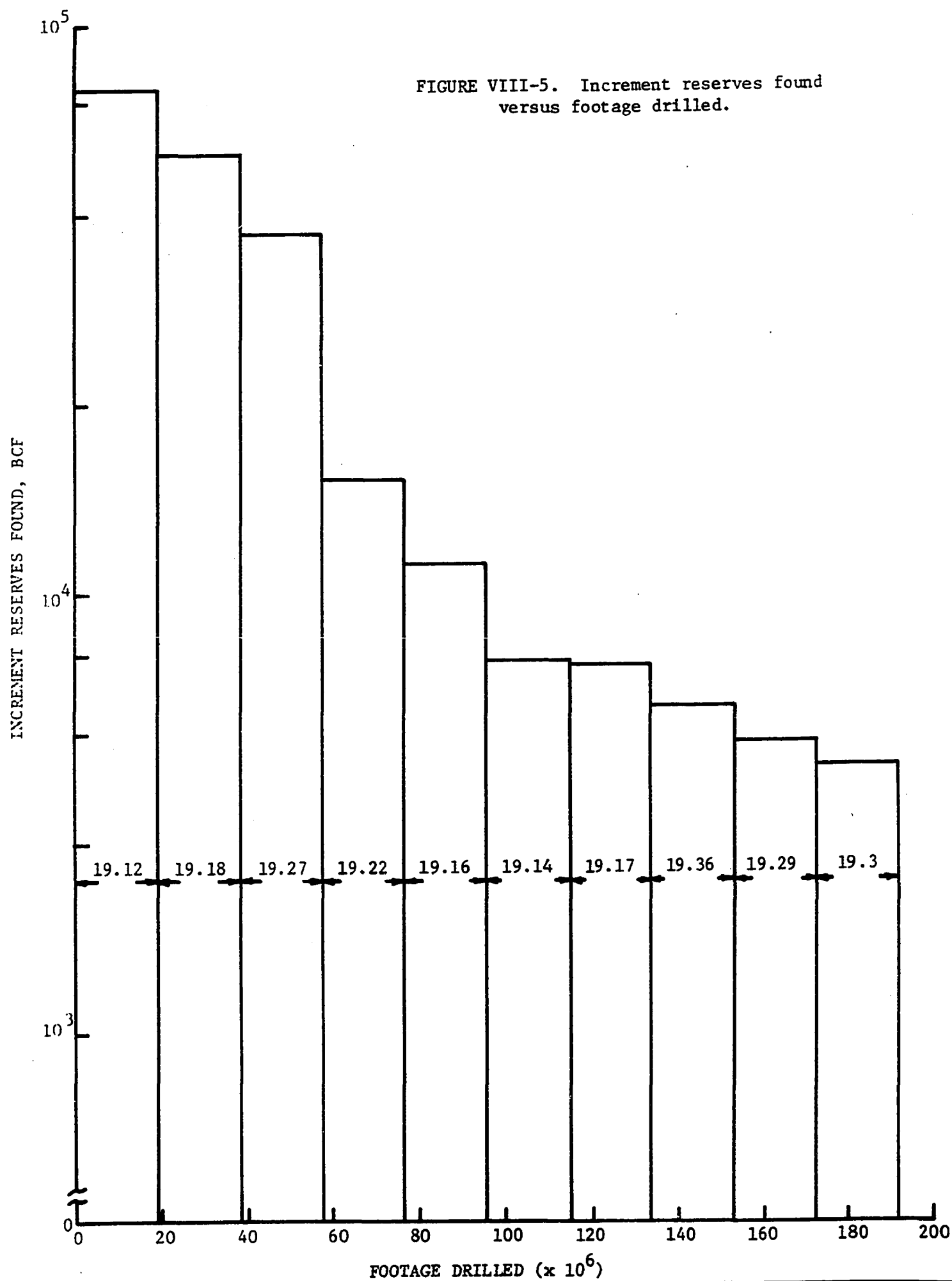


FIGURE VIII-4. Cumulative reserves found versus cumulative number of fields found.

FIGURE VIII-5. Increment reserves found
versus footage drilled.



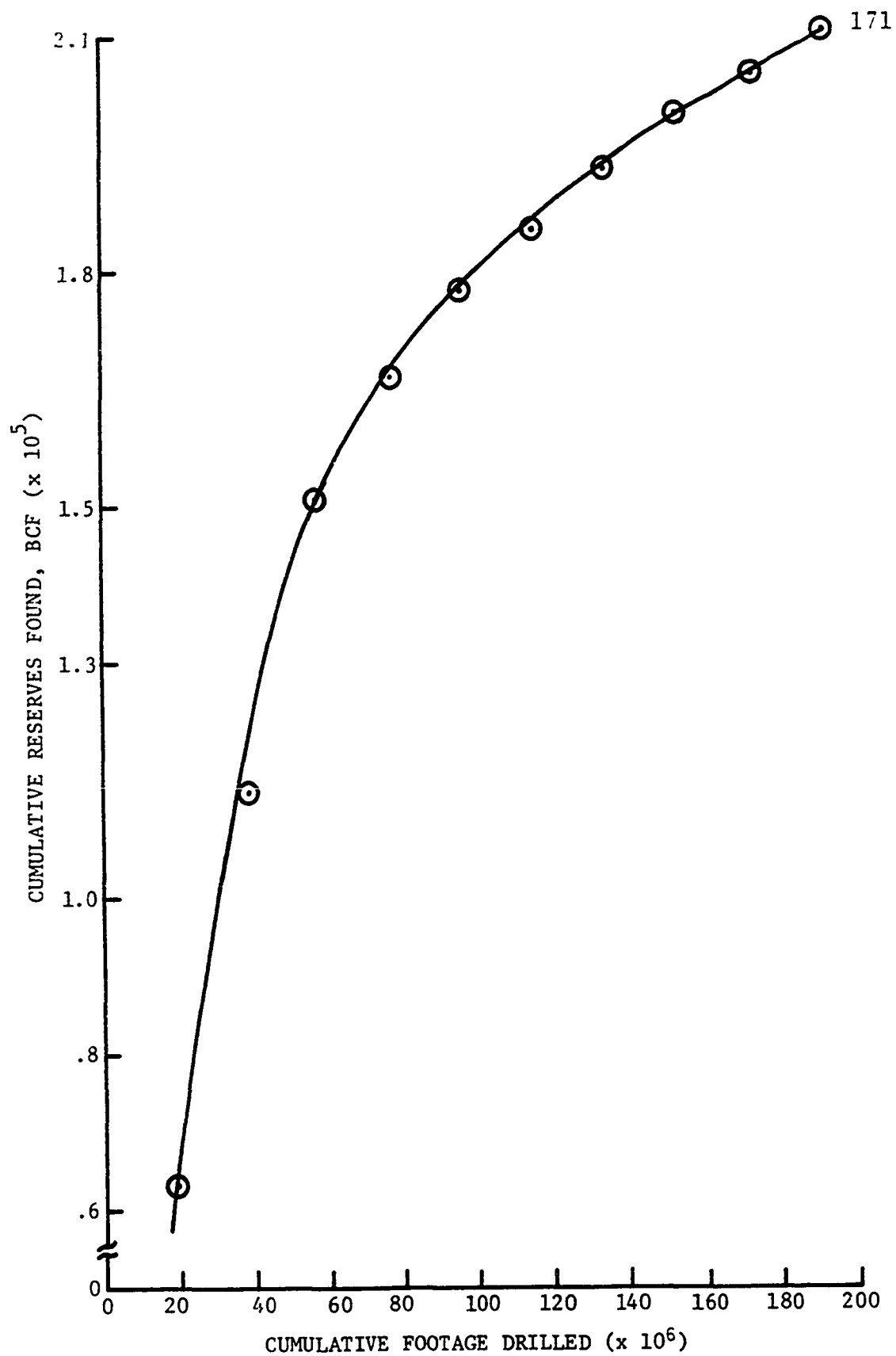


FIGURE VIII-6. Cumulative reserves found versus cumulative footage drilled.

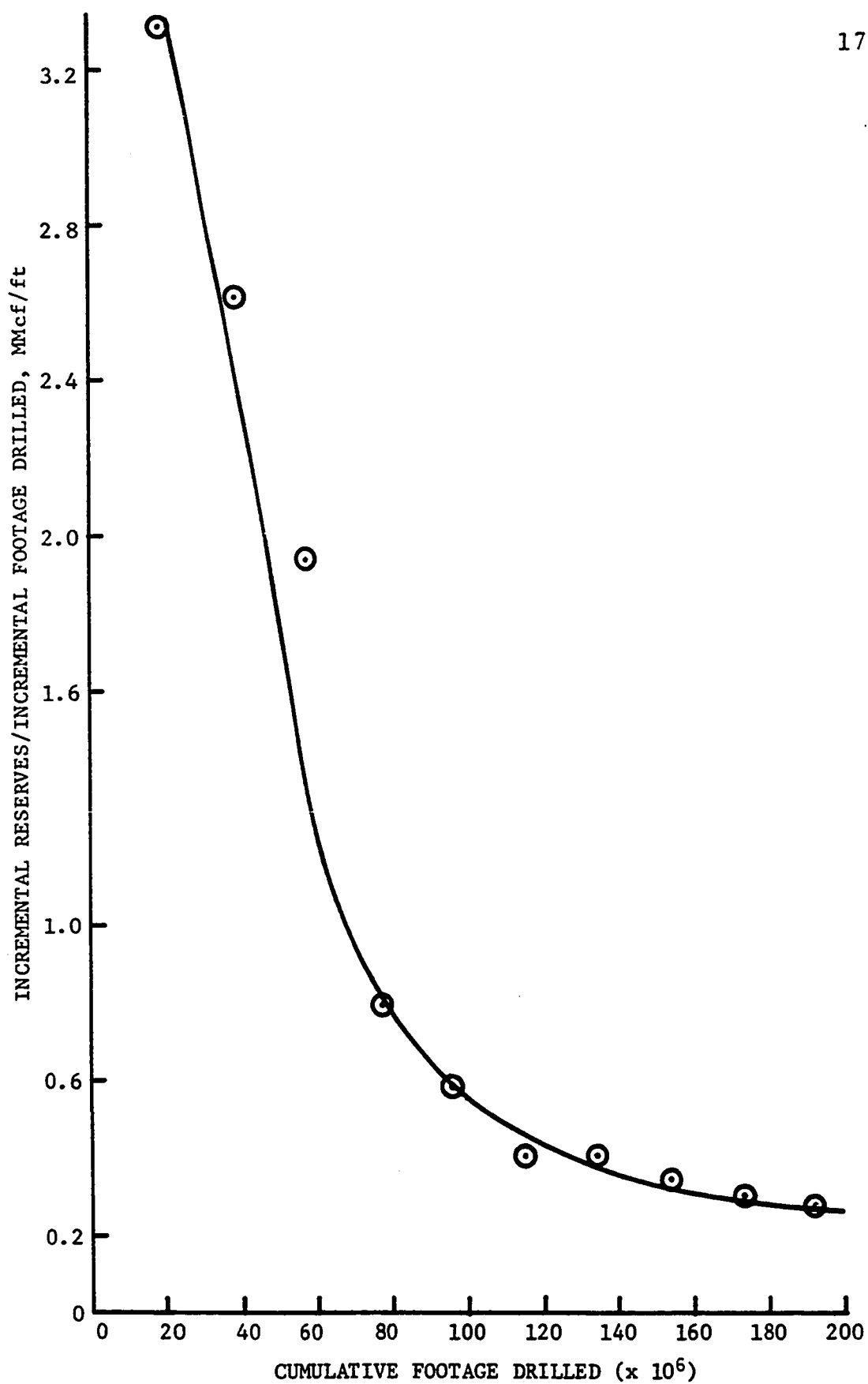


FIGURE VIII-7. Incremental reserves/incremental footage drilled versus cumulative footage drilled.

can be used to determine an economic limit. (Economic limit is usually understood to mean the point or stage in the exploratory activities when the rewards do not justify the expenditures for drilling and developing the play.) This is done by converting reserves found and footage drilled, or number of wells drilled, to their corresponding dollar values.

For Case I, Table VIII-52 is constructed. The same conclusions can be drawn from the results and plots (Figures VIII-8 to VIII-14) for this case, except that here everything is to a smaller scale with W ranging from 100 to 1000 wells with increments of 100 wells. The most notable changes for this case can be seen by looking at Figures VIII-8 to VIII-14. Again for this case more reserves were found in the initial stage of drilling (W ranges from 0 to 100 wells). But afterwards the reserves finding rate oscillated wildly for the rest of the drilling activities. This increased amount of dispersion in the results is due to the smaller drilling increment sample size (100 wells versus 1000 wells previously) which in turn caused the finding of the giant and larger fields to be spread more evenly throughout all the stages of drilling activities. To the extent that the number of larger fields in the sample tends to dominate the field size mix reserves attributable to the sample are greater.

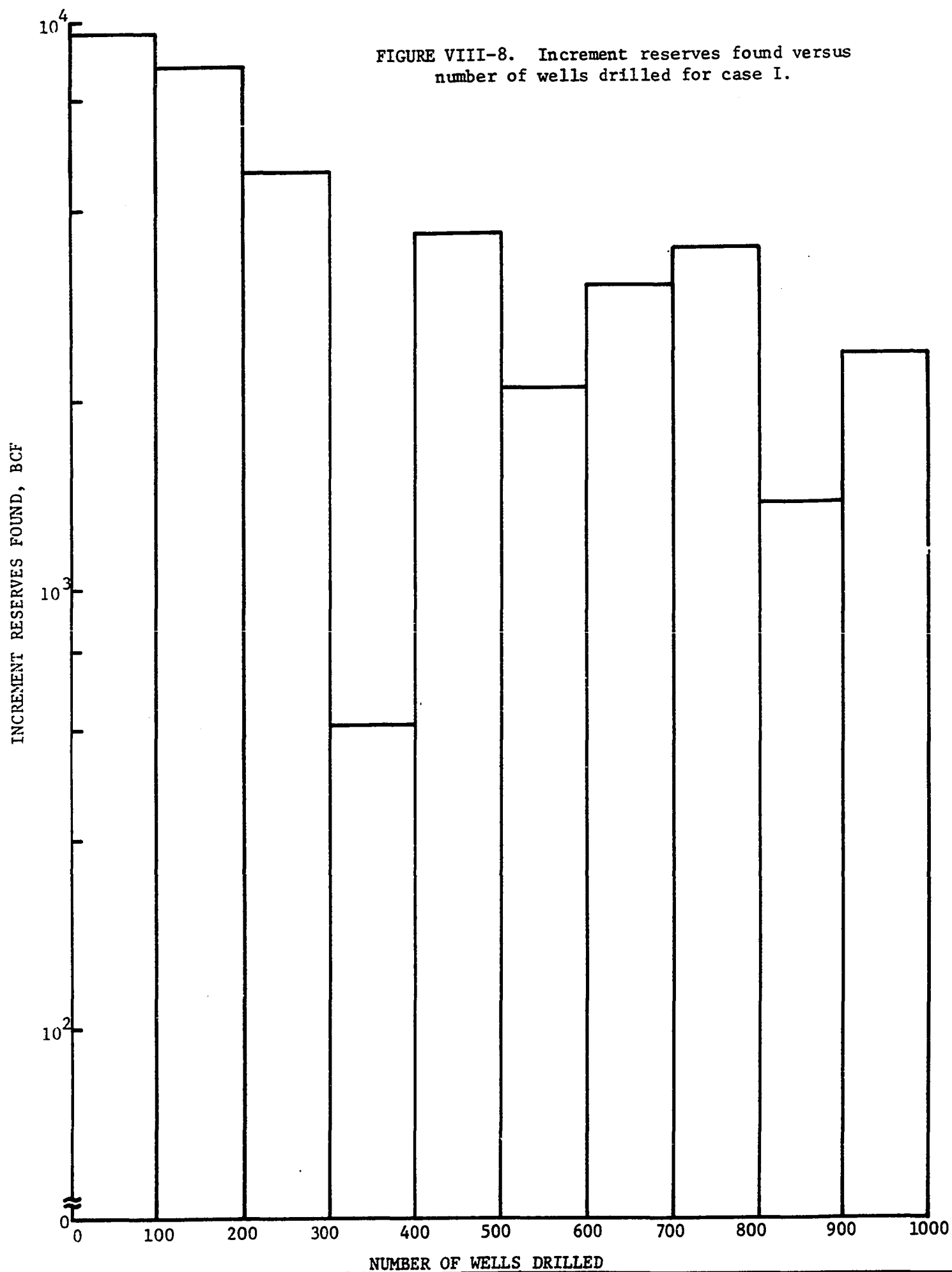
For Case II, in which there were three different regions, the results for each region are shown in Tables VIII-53 to VIII-55. The results from this case are plotted in Figures

Table VIII-52

Results of the Calculation in Phase I for Case I

RESERVE CUM.	FIELD CUM.	DRY HOLE CUM.	RESERVE INC.	FIELD INC.	DRY HOLE INC.	INC.RES/WELLS	CUM.RES/CUM.W
0.774348E C4	0.110000E 02	0.850000E 02	0.774348E C4	0.110000E 02	0.890000E 02	0.774348E C2	0.774348E 02
0.145956E 05	0.210000E 02	0.179000E 03	0.685211E 04	0.100000E 02	0.500000E 02	0.685211E 02	0.729780E 02
0.192630E 05	0.300000E 02	0.270000E 03	0.466748E 04	0.900000E C1	0.910000E 02	0.466748E 02	0.642103E 02
0.198753E 05	0.360000E 02	0.364000E 03	0.612273E 03	0.600000E 01	0.940000E 02	0.612273E 01	0.496884E 02
0.235763E 05	0.460000E 02	0.454000E 03	0.370294E 04	0.100000E 02	0.500000E 02	0.370294E 02	0.471566E 02
0.256830E 05	0.550000E 02	0.545000E 03	0.210474E 04	0.900000E 01	0.510000E 02	0.210474E 02	0.428050E 02
0.287576E 05	0.640000E 02	0.636000E 03	0.307454E 04	0.900000E 01	0.910000E 02	0.307454E 02	0.410822E 02
0.322649E 05	0.760000E 02	0.724000E 03	0.350730E 04	0.120000E 02	0.880000E 02	0.350730E 02	0.403311E 02
0.336480E 05	0.850000E 02	0.815000E 03	0.138316E 04	0.900000E 01	0.910000E 02	0.138316E 02	0.373867E 02
0.359852E 05	0.980000E 02	0.902000E 03	0.233719E 04	0.130000E 02	0.870000E 02	0.233719E 02	0.359852E 02
CUM.DRY HOLE FOOTAGE	CUM.GAS WELL FOOTAGE	CUM.FOOTAGE DRILLED	INC.DRY HOLE FOOTAGE	INC.GAS WELL FOOTAGE	INC.FOOTAGE DRILLED	INC.RESERVE PER FOOT	CUM.RESERVE PER FOOT
0.174397E 07	0.173160E 06	0.191713E 07	0.174397E 07	0.173160E 06	0.191713E 07	0.403908E-02	0.403908E-02
0.348381E 07	0.335794E 06	0.381961E 07	0.173984E 07	0.162634E 06	0.190247E 07	0.360166E-02	0.382122E-02
0.525167E 07	0.479641E 06	0.573131E 07	0.176785E 07	0.143847E 06	0.191170E 07	0.244153E-02	0.336102E-02
0.712717E 07	0.580417E 06	0.770758E 07	0.187549E 07	0.100775E 06	0.197627E 07	0.309811E-03	0.257867E-02
0.890068E 07	0.732956E 06	0.963363E 07	0.177351E 07	0.152538E 06	0.192605E 07	0.192255E-02	0.244749E-02
0.106426E 08	0.867541E 06	0.115101E 08	0.174156E 07	0.134585E 06	0.187655E 07	0.112160E-02	0.223133E-02
0.124116E 08	0.102854E 07	0.134402E 08	0.176503E 07	0.161006E 06	0.193004E 07	0.159299E-02	0.213966E-02
0.141218E 08	0.121760E 07	0.153394E 08	0.171011E 07	0.189056E 06	0.189917E 07	0.184675E-02	0.210339E-02
0.158811E 08	0.136826E 07	0.172494E 08	0.175935E 07	0.150661E 06	0.191001E 07	0.724162E-03	0.198047E-02
0.175289E 08	0.159137E 07	0.191202E 08	0.164775E 07	0.223108E 06	0.187086E 07	0.124925E-02	0.188204E-02

FIGURE VIII-8. Increment reserves found versus number of wells drilled for case I.



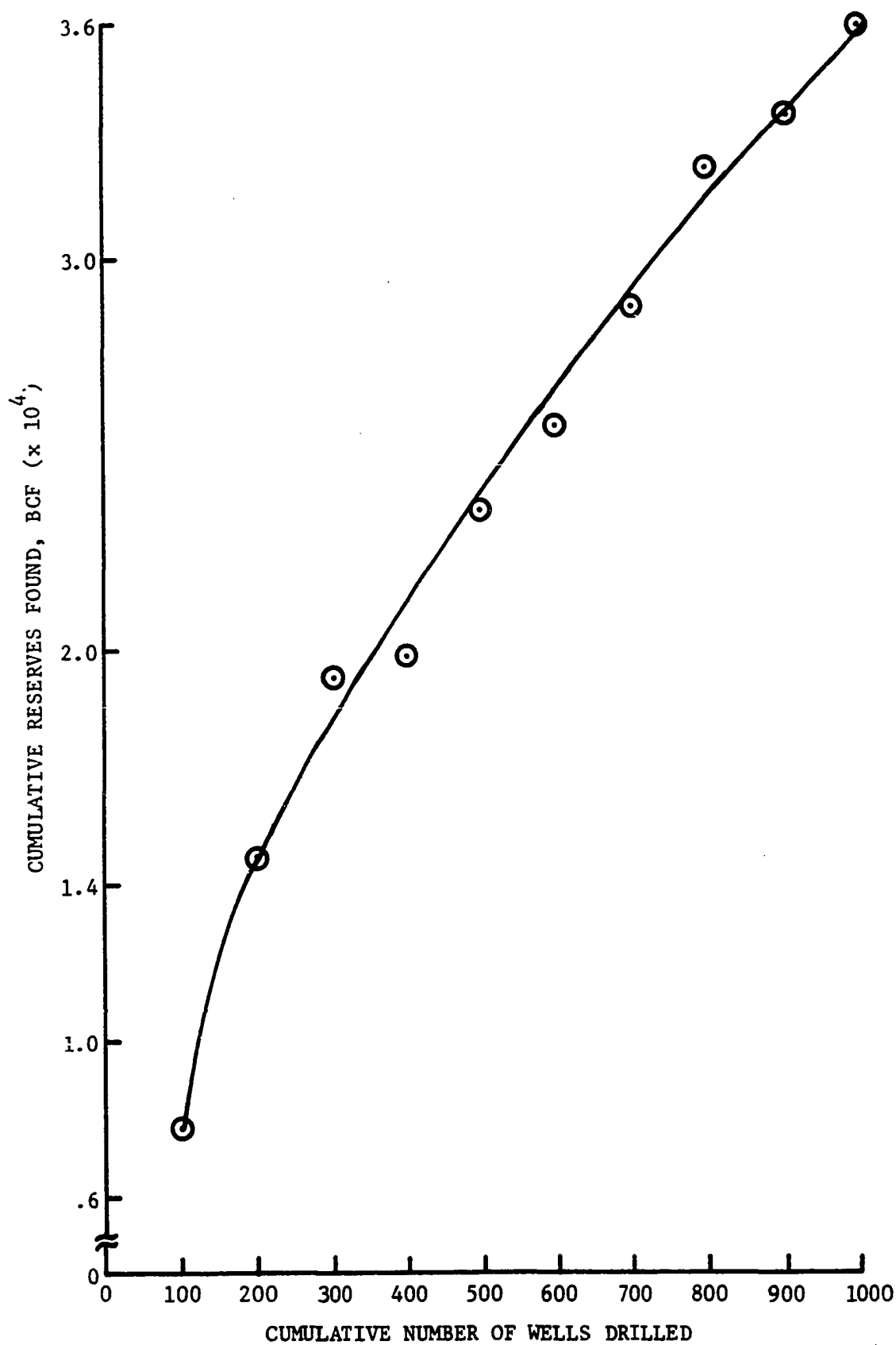
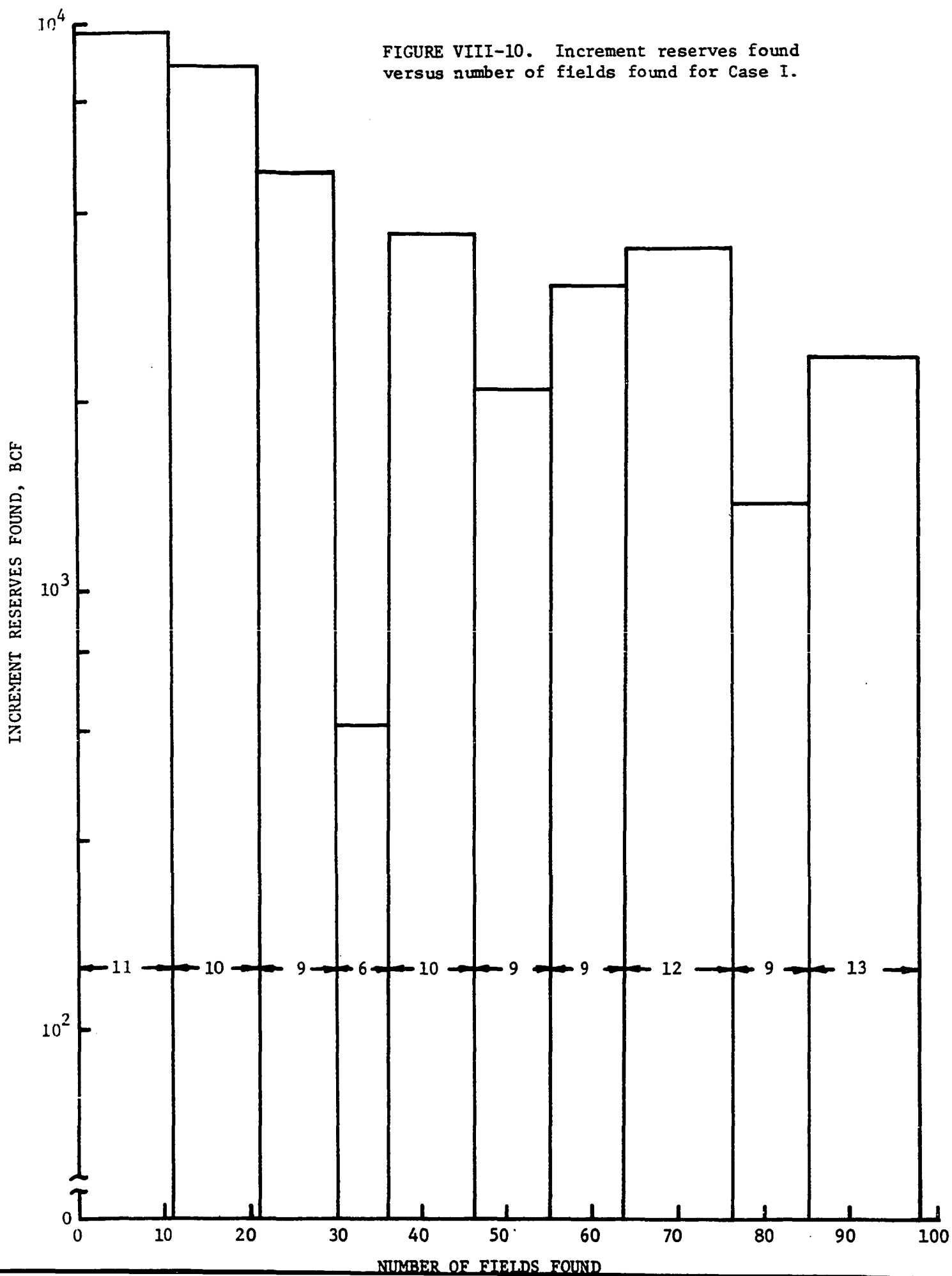


FIGURE VIII-9. Cumulative reserves found versus cumulative number of wells drilled for Case I.

FIGURE VIII-10. Increment reserves found versus number of fields found for Case I.



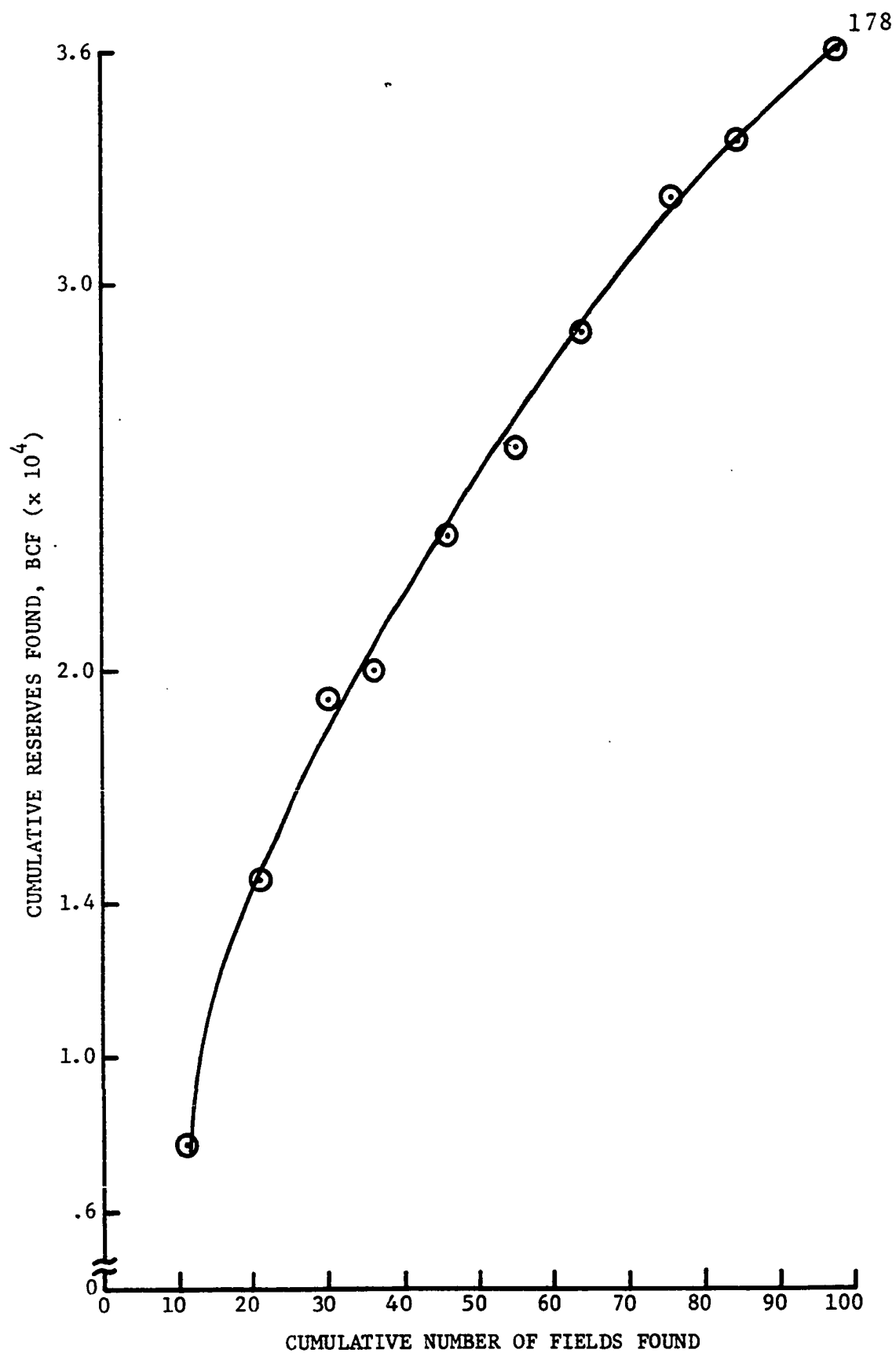
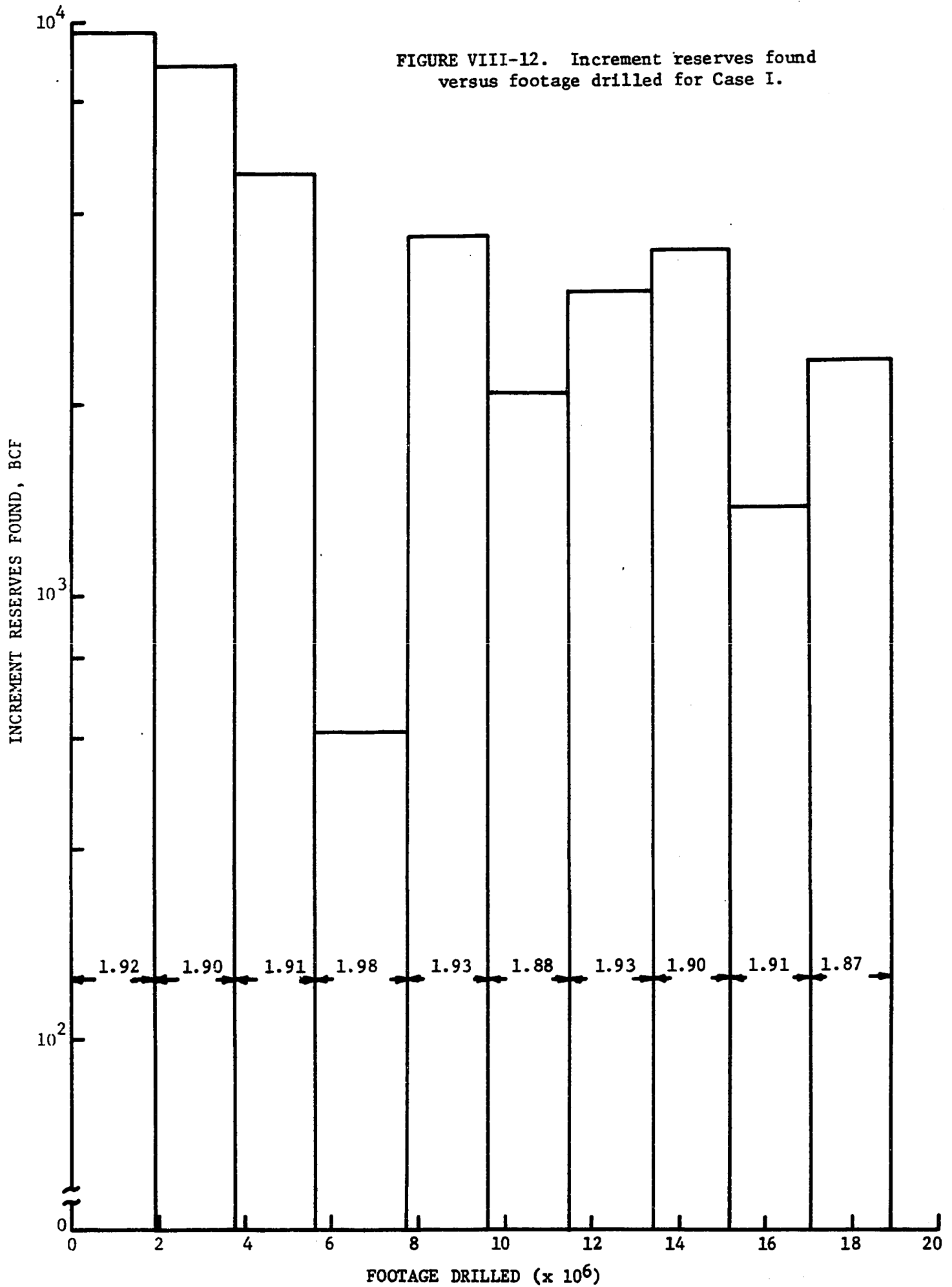


FIGURE VIII-11. Cumulative reserves found versus cumulative number of fields found for Case I.

FIGURE VIII-12. Increment reserves found
versus footage drilled for Case I.



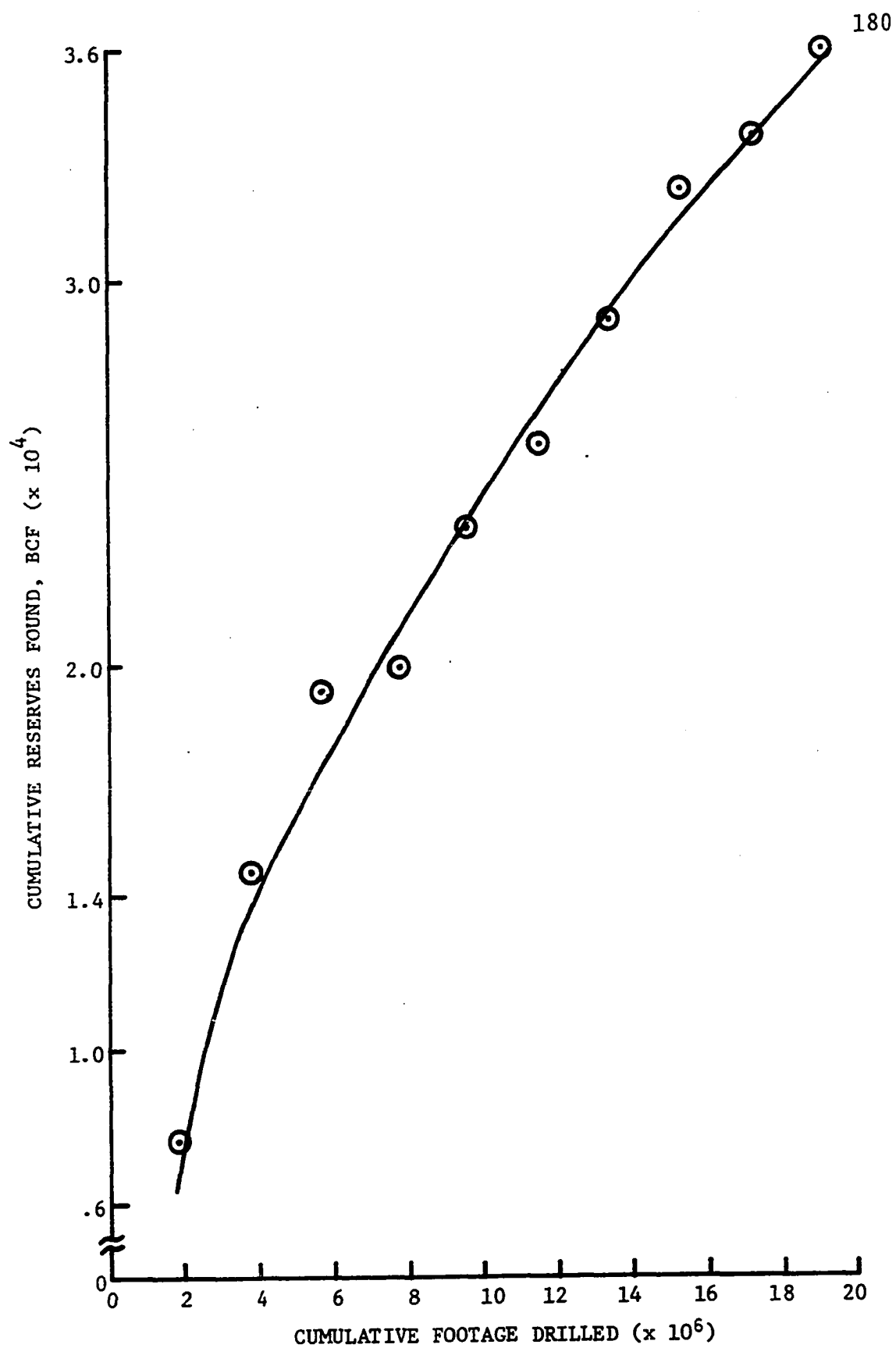


FIGURE VIII-13. Cumulative reserves found versus cumulative footage drilled for Case I.

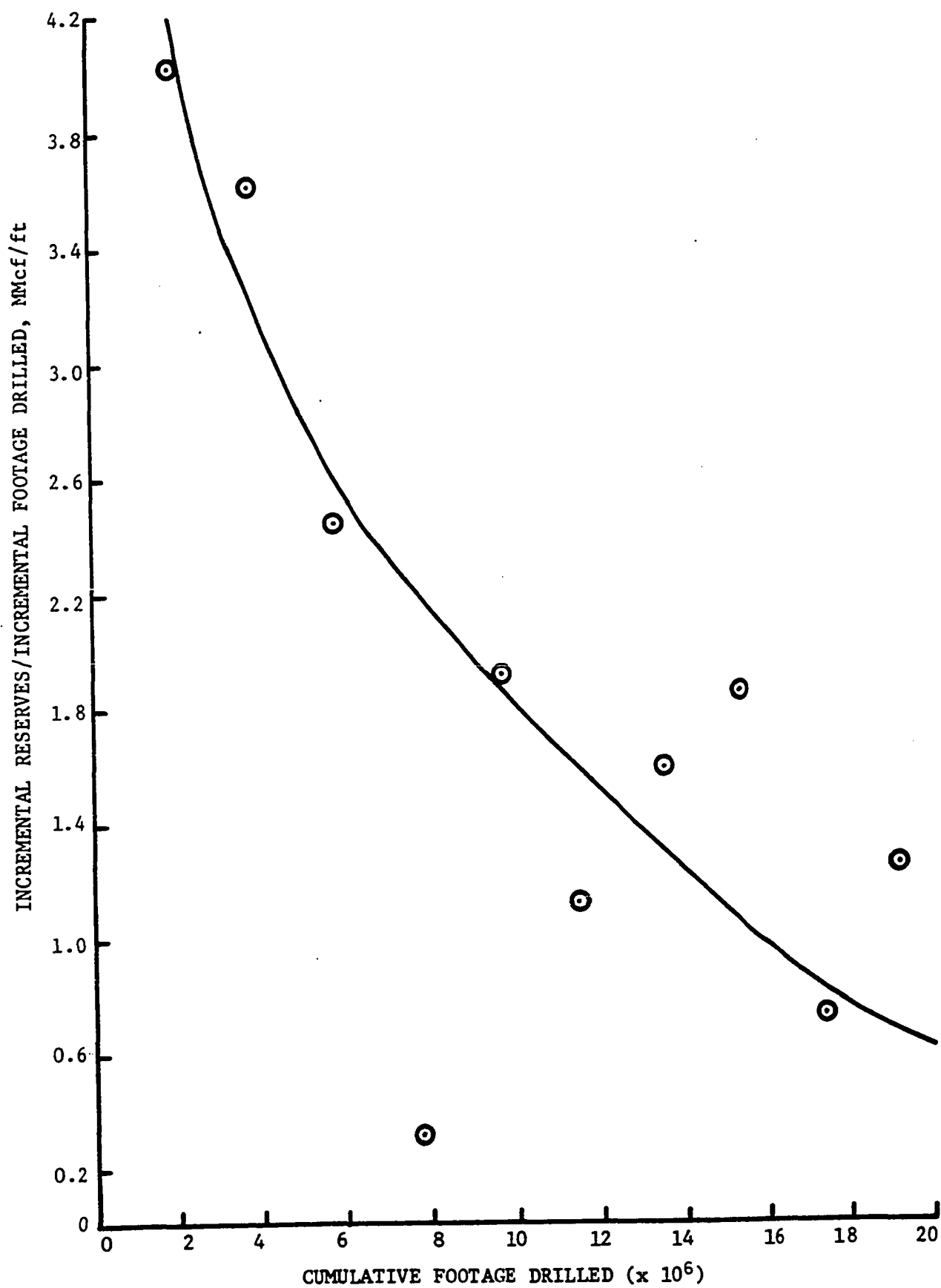


FIGURE VIII-14. Incremental reserves/incremental footage drilled vs. cumulative footage drilled for Case I.

Table VIII-53

Results of the Calculation in Phase I for Case II, Region 1

RESERVE CUM.	FIELD CUM.	DRY HOLE CUM.	RESERVE INC.	FIELD INC.	DRY HOLE INC.	INC.RES/WELLS	CUM.RES/CUM.W
0.7743488E 04	0.1100000E 02	0.8900000E 02	0.7743488E 04	0.1100000E 02	0.8900000E 02	0.7743488E 02	0.7743488E 02
0.1361354E 05	0.2100000E 02	0.1790000E 03	0.5870047E 04	0.1000000E 02	0.5000000E 02	0.5870045E 02	0.6806767E 02
0.1561308E 05	0.3000000E 02	0.2700000E 03	0.1995543E 04	0.9000000E 01	0.9100000E 02	0.1995542E 02	0.5204352E 02
0.1588740E 05	0.4600000E 02	0.3640000E 03	0.2693203E 03	0.6000000E 01	0.9400000E 02	0.2693203E 01	0.3970595E 02
0.1699504E 05	0.4600000E 02	0.4540000E 03	0.1112641E 04	0.1000000E 02	0.5000000E 02	0.1112641E 02	0.3399007E 02
0.1747627E 05	0.5500000E 02	0.5450000E 03	0.4812266E 03	0.9000000E 01	0.9100000E 02	0.4812265E 01	0.2912711E 02
0.1858667E 05	0.6400000E 02	0.6360000E 03	0.1110406E 04	0.9000000E 01	0.9100000E 02	0.1110406E 02	0.2655232E 02
0.1974887E 05	0.7600000E 02	0.7240000E 03	0.1162195E 04	0.1200000E 02	0.8800000E 02	0.1162195E 02	0.2468608E 02
0.2068387E 05	0.8500000E 02	0.8150000E 03	0.9350039E 03	0.9000000E 01	0.9100000E 02	0.9350039E 01	0.2298207E 02
0.2137503E 05	0.9800000E 02	0.9020000E 03	0.6911602E 03	0.1300000E 02	0.8700000E 02	0.6911601E 01	0.2137503E 02
CUM.DRY HOLE FOOTAGE	CUM.GAS WELL FOOTAGE	CUM.FOOTAGE DRILLED	INC.DRY HOLE FOOTAGE	INC.GAS WELL FOOTAGE	INC.FOOTAGE DRILLED	INC.RESERVE PER FOOT	CUM.RESERVE PER FOOT
0.1743977E 07	0.1731600E 06	0.1917137E 07	0.1743977E 07	0.1731600E 06	0.1917137E 07	0.4039086E-02	0.4039086E-02
0.3483617E 07	0.3357942E 06	0.3819611E 07	0.1739840E 07	0.1626342E 06	0.1902474E 07	0.3085481E-02	0.3564115E-02
0.5251671E 07	0.4796419E 06	0.5731312E 07	0.1767854E 07	0.1438477E 06	0.1911701E 07	0.1045950E-02	0.2724172E-02
0.7127170E 07	0.5804176E 06	0.7707587E 07	0.1875499E 07	0.1007752E 06	0.1976274E 07	0.1362768E-03	0.2060619E-02
0.8900692E 07	0.7329566E 06	0.9633638E 07	0.1773512E 07	0.1525389E 06	0.1926050E 07	0.5776798E-03	0.1764135E-02
0.1064265E 08	0.8675419E 06	0.1151019E 08	0.1741967E 07	0.1345854E 06	0.1876552E 07	0.2564418E-03	0.1518330E-02
0.1241165E 08	0.1028549E 07	0.1344024E 08	0.1769039E 07	0.1610065E 06	0.1930045E 07	0.5753264E-03	0.1382913E-02
0.1412181E 08	0.1217605E 07	0.1533941E 08	0.1710117E 07	0.1890562E 06	0.1899173E 07	0.6119481E-03	0.1287459E-02
0.1588116E 08	0.1368266E 07	0.1724941E 08	0.1759351E 07	0.1506610E 06	0.1910012E 07	0.4895276E-03	0.1199106E-02
0.1752891E 08	0.1591374E 07	0.1912027E 08	0.1647756E 07	0.2231080E 06	0.1870864E 07	0.3694335E-03	0.1117925E-02

Table VIII-54

Results of the Calculation in Phase I for Case II, Region 2

RESERVE CUM.	FIELD CUM.	DRY HOLE CUM.	RESERVE INC.	FIELD INC.	DRY HOLE INC.	INC.RES/WELLS	CUM.RES/CUM.W
0.774348EE C4	0.1100000E 02	0.8500000E 02	0.7743488E C4	0.1100000E 02	0.8900000E 02	0.7743488E C2	0.7743488E 02
0.145956CE 05	0.2170000E C2	0.1740000E 03	0.6852113E 04	0.1000000E 02	0.5000000E 02	0.6852112E 02	0.7297800E 02
0.1926309E 05	0.3000000E 02	0.2700000E 03	0.4667488E C4	0.9000000E C1	0.5100000E 02	0.4667488E 02	0.6421030E 02
0.198753CE 05	0.3600000E 02	0.3640000E 03	0.6122734E 03	0.6000000E 01	0.9400000E 02	0.6122734E 01	0.4968840E 02
0.2357631E 05	0.4600000E 02	0.4540000E 03	0.3702945E 04	0.1000000E 02	0.5000000E 02	0.3702945E 02	0.4715662E 02
0.256830EE 05	0.5500000E 02	0.5450000E 03	0.2104746E 04	0.9000000E 01	0.5100000E 02	0.2104745E 02	0.4280508E 02
0.2875760E 05	0.6400000E 02	0.6360000E 03	0.3074543E 04	0.9000000E 01	0.9100000E 02	0.3074542E 02	0.4108228E 02
0.3226491E 05	0.7600000E 02	0.7240000E 03	0.3507309E 04	0.1200000E 02	0.8800000E 02	0.3507307E 02	0.4033113E 02
0.3364807E 05	0.8500000E 02	0.8150000E 03	0.1383160E 04	0.9000000E 01	0.9100000E 02	0.1383160E 02	0.3738673E 02
0.3598526E 05	0.9800000E 02	0.9020000E 03	0.2337191E 04	0.1300000E 02	0.8700000E 02	0.2337190E 02	0.3598524E 02
CUM.DRY HOLE FOOTAGE	CUM.GAS WELL FOOTAGE	CUM.FOOTAGE DRILLED	INC.DRY HOLE FOOTAGE	INC.GAS WELL FOOTAGE	INC.FOOTAGE DRILLED	INC.RESERVE PER FOOT	CUM.RESERVE PER FOOT
0.1743977E 07	0.1731600E C6	0.1917137E 07	0.1743977E 07	0.1731600E 06	0.1917137E 07	0.4039086E-02	0.4039086E-02
0.3483817E 07	0.3357942E 06	0.3819611E 07	0.1739840E 07	0.1626342E 06	0.1902474E 07	0.3601686E-02	0.3821227E-02
0.5251671E 07	0.4796419E 06	0.5731312E C7	0.1767854E 07	0.1438477E C6	0.1911701E 07	0.2441537E-02	0.3361026E-02
0.7127170E 07	0.5804176E 06	0.7707587E 07	0.1875499E 07	0.1007758E 06	0.1976274E 07	0.3098119E-03	0.2578678E-02
0.8900682E 07	0.7329566E 06	0.9633638E 07	0.1773512E 07	0.1525385E 06	0.1926050E 07	0.1922559E-02	0.2447498E-02
0.1064265E 08	0.8675419E 06	0.1151019E 08	0.1741967E 07	0.1345854E 06	0.1876552E 07	0.1121603E-02	0.2231332E-02
0.1241165E 08	0.1028549E 07	0.1344024E 08	0.1769039E 07	0.1610069E 06	0.1930045E 07	0.1592990E-02	0.2139664E-02
0.1412181E 08	0.1217605E C7	0.1533941E 08	0.1710117E 07	0.1890562E 06	0.1899173E 07	0.1846756E-02	0.2103399E-02
0.1588116E 08	0.1368266E 07	0.1724941E 08	0.1759351E 07	0.1506610E 06	0.1910012E 07	0.7241629E-03	0.1950679E-02
0.1752891E 08	0.1591374E 07	0.1912027E 08	0.1647756E 07	0.2231080E C6	0.1870864E 07	0.1249258E-02	0.1882047E-02

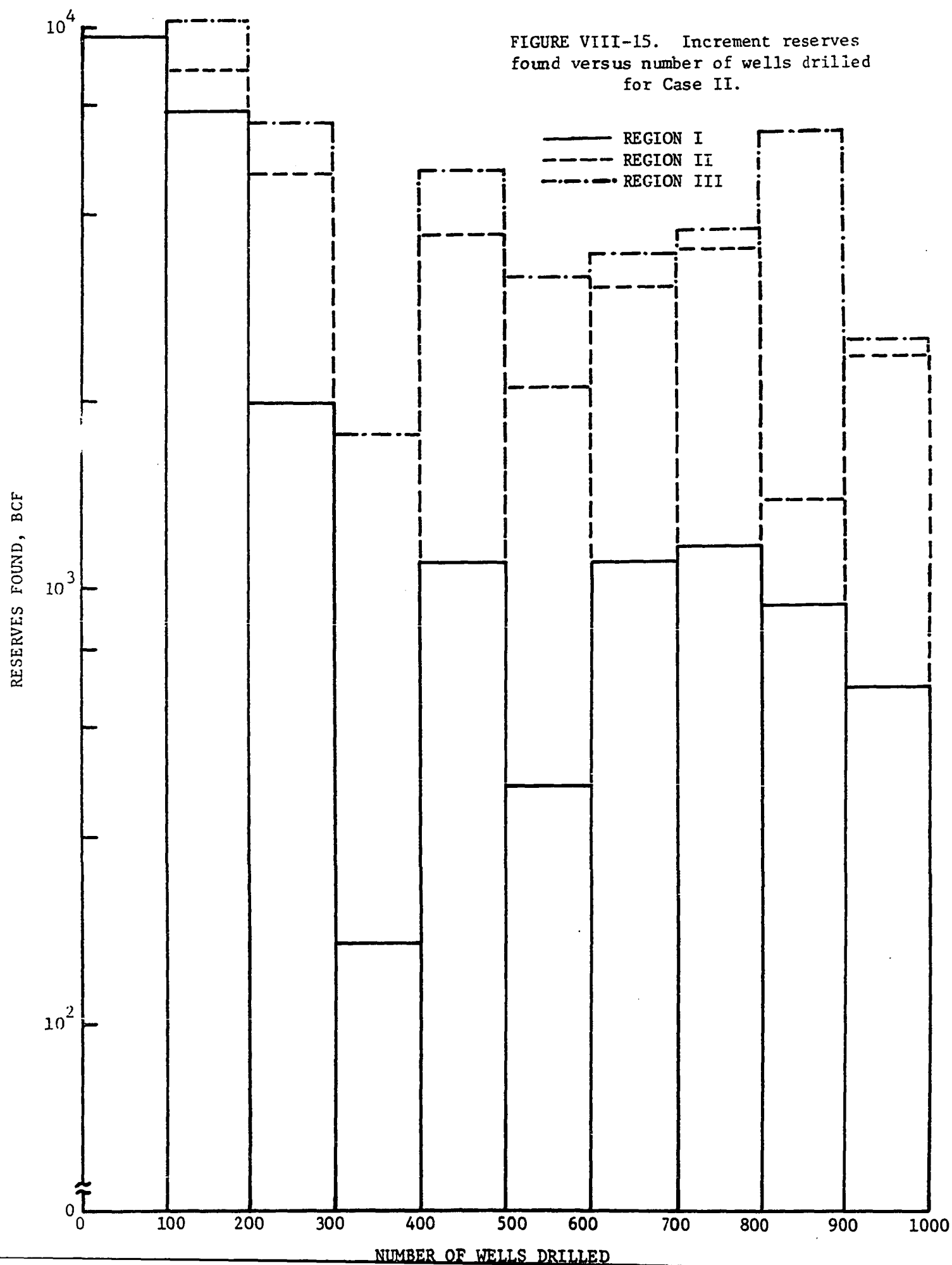
Table VIII-55

Results of the Calculation in Phase I for Case II, Region 3

RESERVE CUM.	FIELD CUM.	DRY HOLE CUM.	RESERVE INC.	FIELD INC.	DRY HOLE INC.	INC.RES/WELLS	CUM.RES/CUM.W
0.774348E C4	0.1100000E 02	0.8900000E 02	0.7743488E C4	0.1100000E 02	0.8900000E 02	0.7743488E C2	0.7743488E 02
0.1594336E 05	0.2100000E 02	0.1790000E C3	0.8195867E 04	0.1000000E 02	0.9000000E 02	0.8199866E 02	0.7971677E 02
0.2160220E 05	0.3000000E 02	0.2700000E C3	0.5664844E 04	0.9000000E 01	0.9100000E 02	0.5664844E 02	0.7202733E 02
0.233853E 05	0.3600000E 02	0.3640000E C3	0.1777184E C4	0.6000000E 01	0.5400000E 02	0.1777184E 02	0.5846346E 02
0.2807035E C5	0.4600000E 02	0.4540000E C3	0.4685012E 04	0.1000000E 02	0.9000000E 02	0.4685011E 02	0.5614078E 02
0.3125014E 05	0.5500000E 02	0.5450000E C3	0.3179746E 04	0.9000000E 01	0.9100000E 02	0.3179745E 02	0.5208356E 02
0.3469037E 05	0.6400000E 02	0.6360000E C3	0.3440227E 04	0.9000000E 01	0.9100000E 02	0.3440225E 02	0.4955766E 02
0.384581E 05	0.7600000E 02	0.7240000E C3	0.3767789E C4	0.1200000E 02	0.8800000E 02	0.3767789E 02	0.4807269E 02
0.4384723E C5	0.8500000E 02	0.8150000E C3	0.5389074E 04	0.9000000E 01	0.9100000E 02	0.5389073E 02	0.4871913E 02
0.463397E C5	0.9800000E 02	0.9020000E C3	0.2492473E C4	0.1300000E 02	0.8700000E 02	0.2492471E 02	0.4633969E 02
CUM.DRY HOLE FOOTAGE	CUM.GAS WELL FOOTAGE	CUM.FOOTAGE DRILLED	INC.DRY HOLE FOOTAGE	INC.GAS WELL FOOTAGE	INC.FOOTAGE DRILLED	INC.RESERVE PER FOOT	CUM.RESERVE PER FOOT
0.1743977E C7	0.1731600E 06	0.1917137E 07	0.1743977E 07	0.1731600E 06	0.1917137E 07	0.4039086E-02	0.4039086E-02
0.3483917E 07	0.3357942E 06	0.3819611E C7	0.1739840E C7	0.1626342E 06	0.1902474E 07	0.4310105E-02	0.4174076E-02
0.5251671E 07	0.4796419E 06	0.5731312E C7	0.1767854E 07	0.1438477E 06	0.1511701E 07	0.2963248E-02	0.3770201E-02
0.7127170E 07	0.5804176E 06	0.7707587E 07	0.1875499E 07	0.1007758E 06	0.1976274E C7	0.8992597E-03	0.3034073E-02
0.8900682E 07	0.7329566E 06	0.9633638E C7	0.1773512E C7	0.1525385E 06	0.1926050E 07	0.2432446E-02	0.2913790E-02
0.1064265E 08	0.8675419E 06	0.1151019E 08	0.1741567E 07	0.1345854E 06	0.1876552E 07	0.1694462E-02	0.2714992E-02
0.1241169E 08	0.1028549E 07	0.1344024E 08	0.1769039E 07	0.1610069E 06	0.1930045E 07	0.1782459E-02	0.2581083E-02
0.1412181E 08	0.1217605E 07	0.1533941E 08	0.1710117E 07	0.1890562E 06	0.1899173E 07	0.1983510E-02	0.2507147E-02
0.1588116E 08	0.1368266E 07	0.1724941E 08	0.1759351E 07	0.1506610E 06	0.1910012E 07	0.2821487E-02	0.2541956E-02
0.1752891E 08	0.1591374E 07	0.1912027E 08	0.1647756E 07	0.2231080E 06	0.1870864E 07	0.1332257E-02	0.2423890E-02

VIII-15 to VIII-21 with each figure representing the plotted parameters for all three regions. Again the characteristic behavior is observed for each of the regions. Figures VIII-15 and VIII-17 show that more reserves are found when more giant and larger fields are found. This occurs for each of the regions. Figures VIII-16 and VIII-18 show the smooth increase of cumulative reserve for Region I and sharper increases for Regions II and III. Figure VIII-19 shows the reserves found for the initial stage of drilling (i.e., the drilling of the first 100 wells or 1.92×10^6 feet) was the same for all three regions. But as drilling activities continued, more reserves were found in Region III than Regions I and II, and more reserves from Region II than Region I. This is what is really expected because we have more fields available in Region III than Regions I and II, and more fields in Region II than Region I. Figure VIII-20 shows a smooth increase in cumulative reserves curve for Region I and very sharp increase for the cumulative curves of Regions II and III. Figure VIII-21 shows a much sharper drop for the increment of reserves per increment of footage drilled curve for Region I than for Regions II and III.

These figures (VIII-8 to VIII-21) indicate that the results for Cases I and II almost follow the same path as the original path given in Figures VIII-1 to VIII-7. This tends to support the validity of the results of the model.



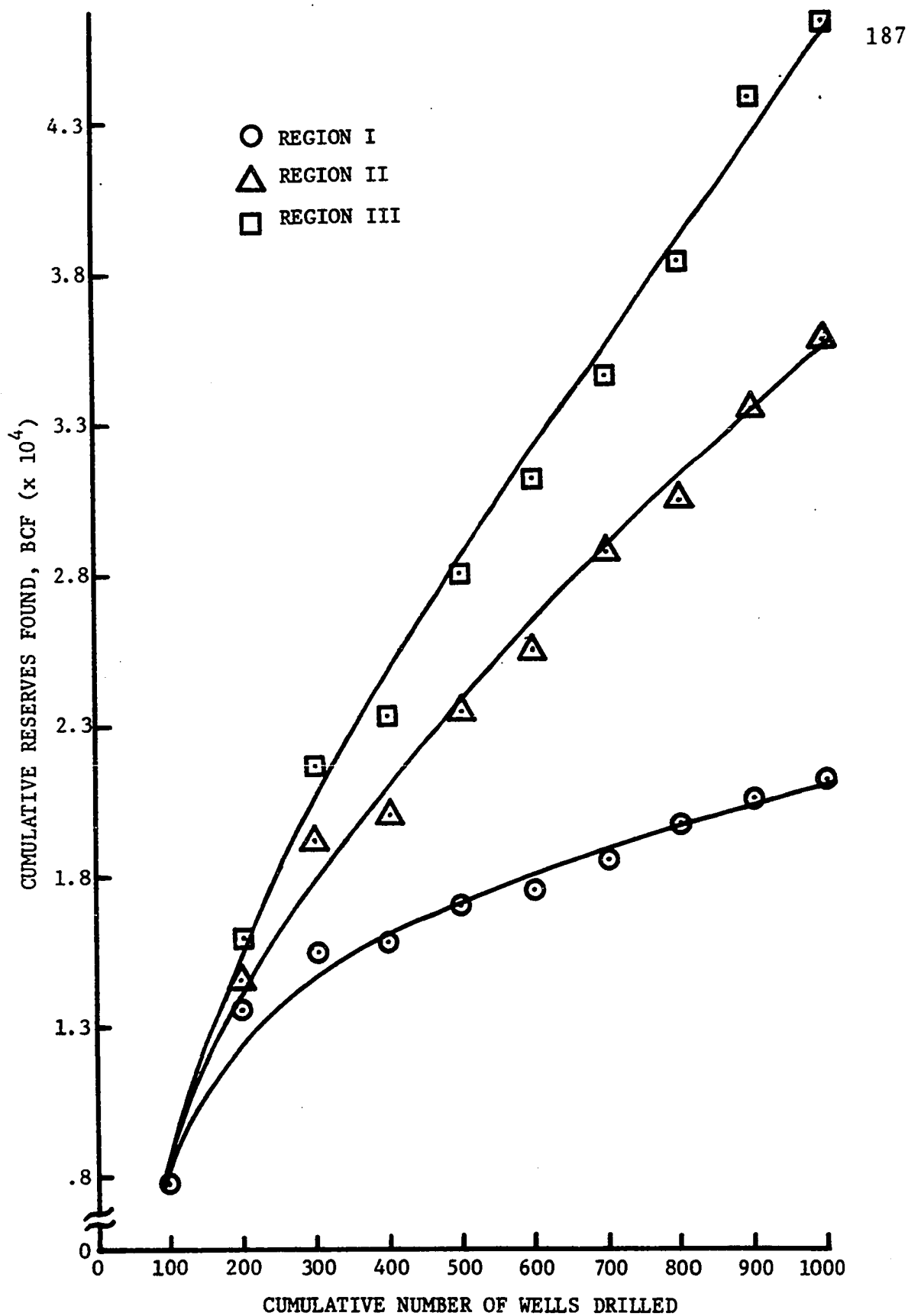
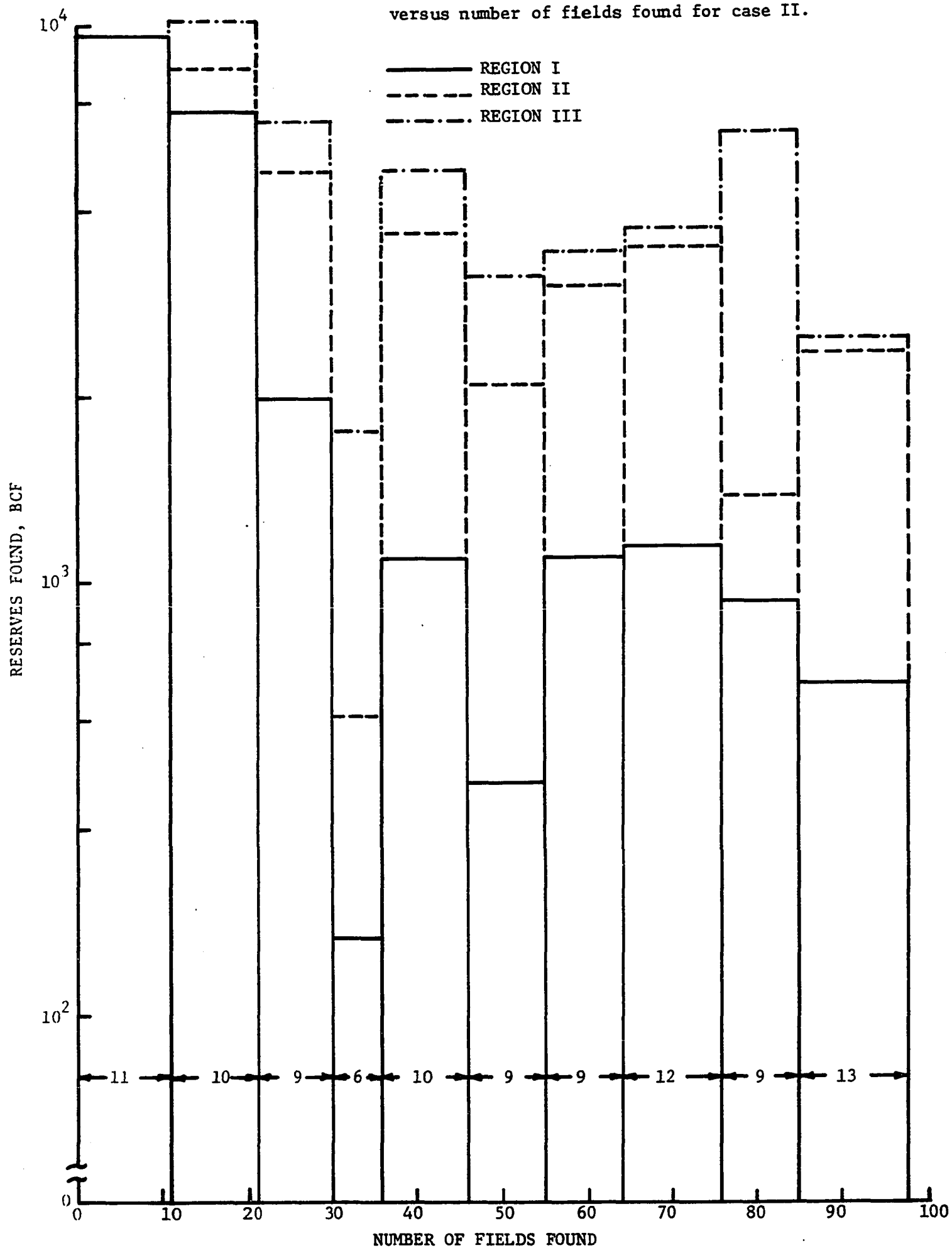


FIGURE VIII-16. Cumulative reserves found versus cumulative number of wells drilled for Case II.

FIGURE VIII-17. Incremental reserves found versus number of fields found for case II.



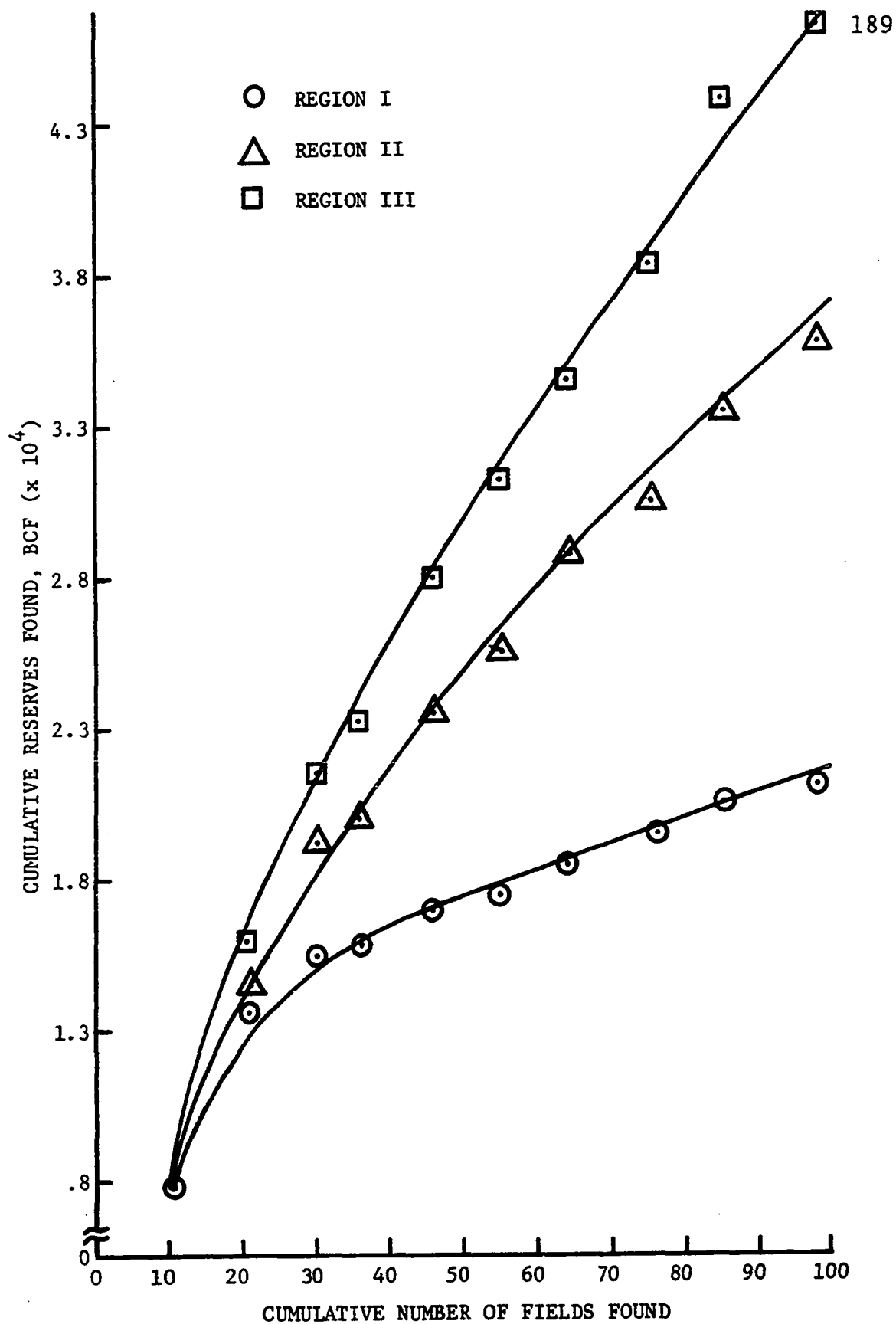
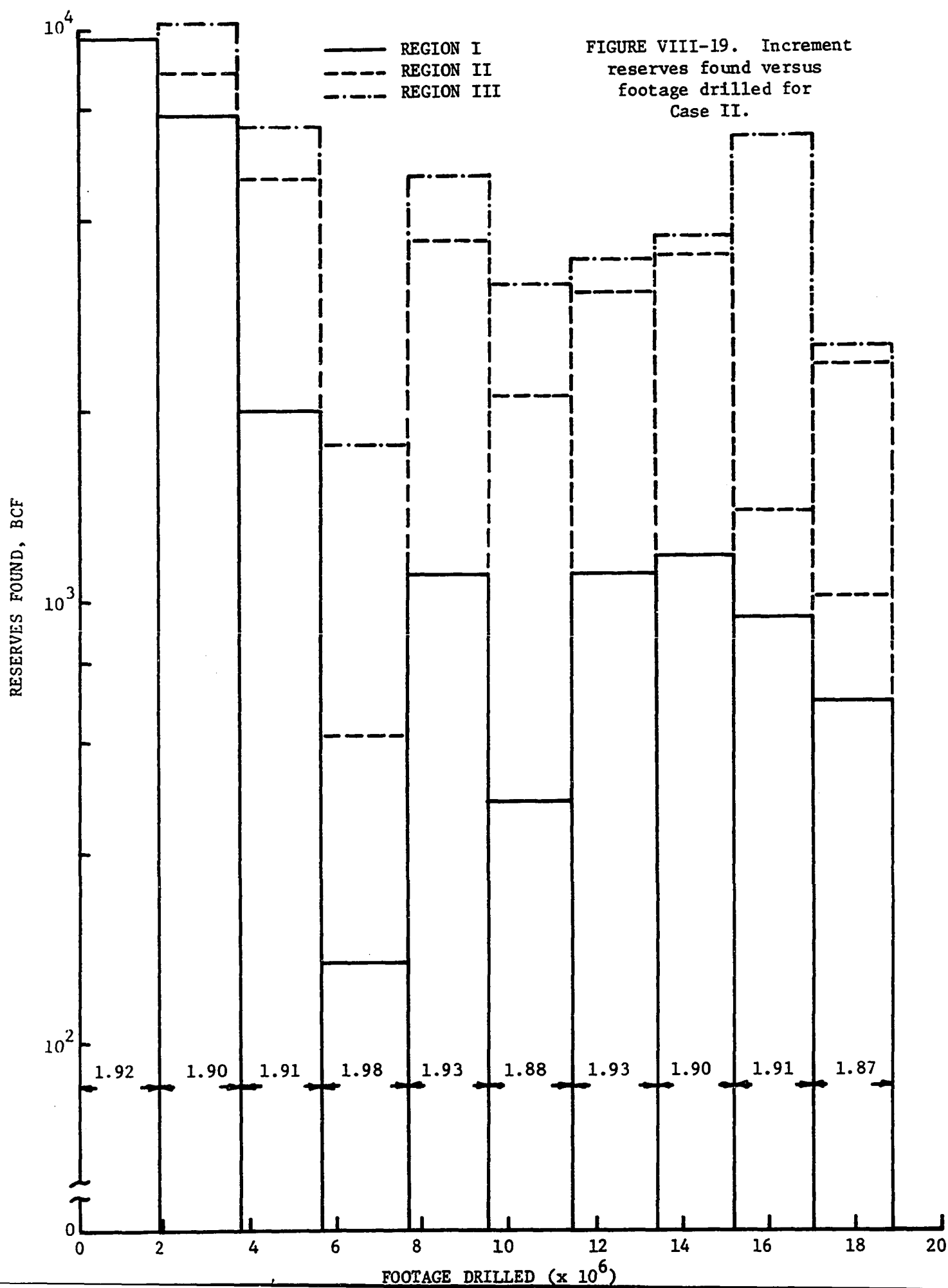


FIGURE VIII-18. Cumulative reserves found versus cumulative number of fields found for Case II.



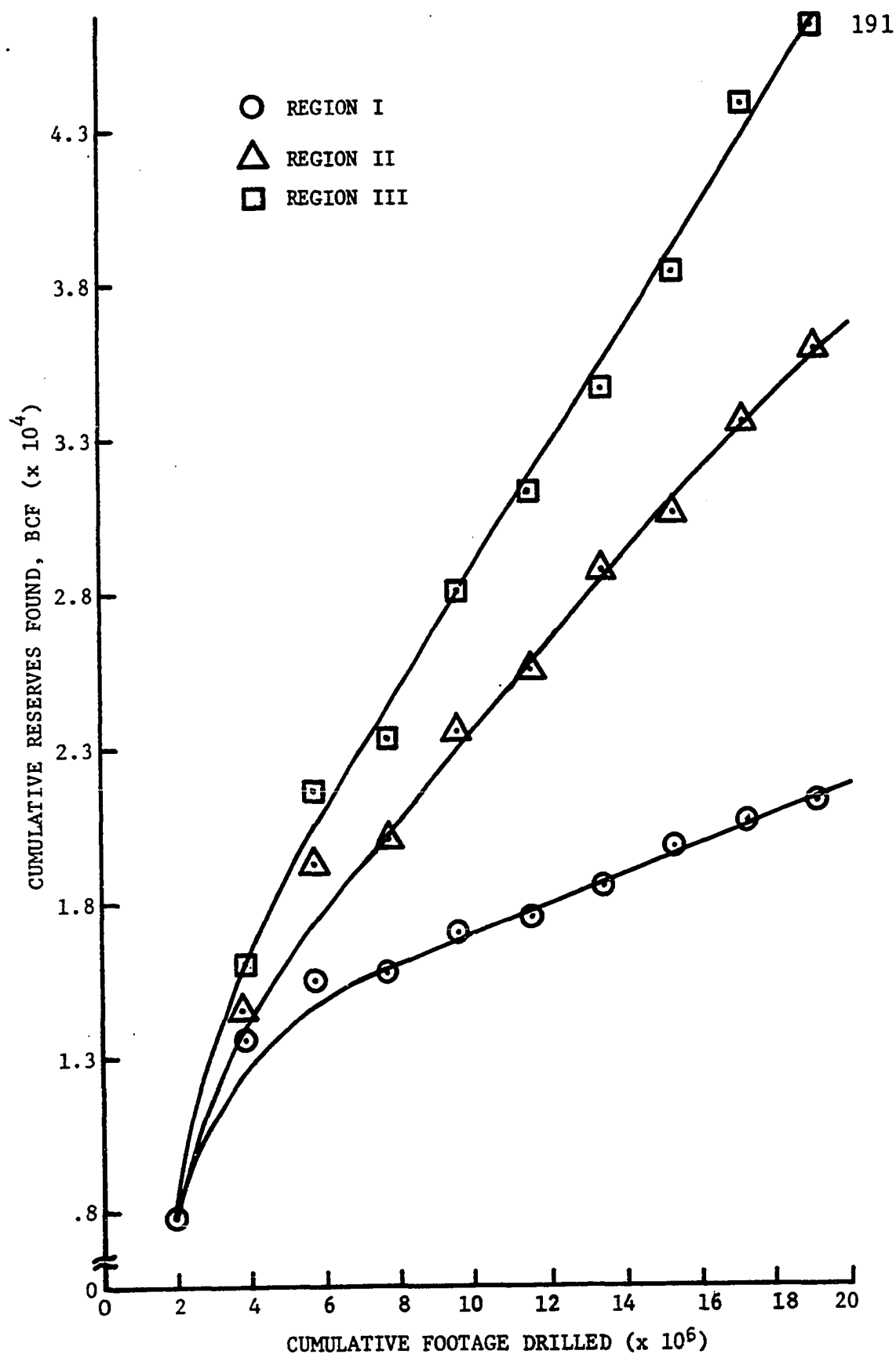


FIGURE VIII-20. Cumulative reserves found versus cumulative footage drilled for Case II.

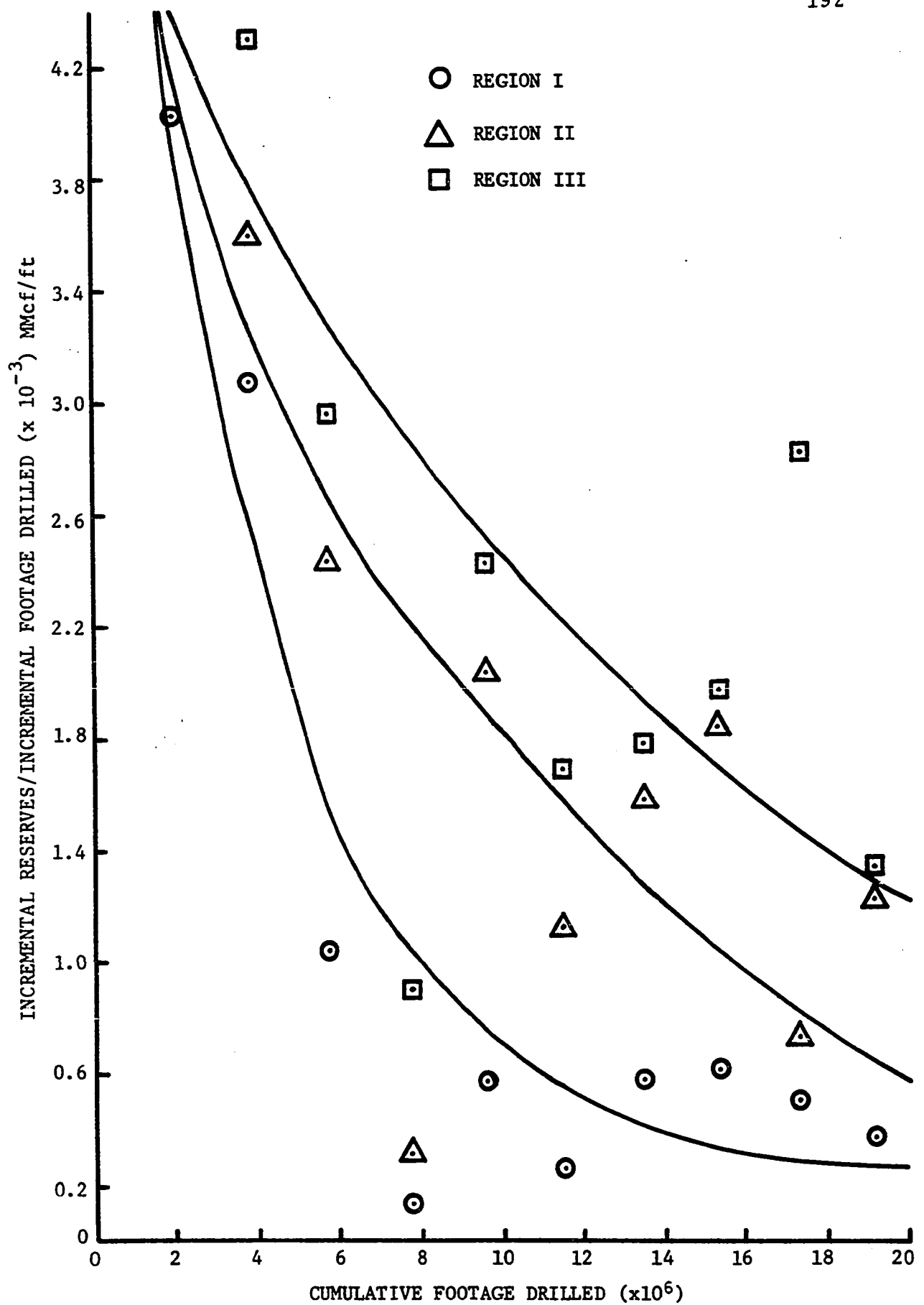


FIGURE VIII-21. Incremental reserves/incremental footage drilled versus cumulative footage drilled for Case II.

CHAPTER IX

DISCUSSION OF RESULTS OF THE SECOND PHASE FOR THE ORIGINAL MODEL AND OTHER REALISTIC SYSTEMS

The result of this phase of the study is actually a prediction and forecast of the future reserves discoveries. This is accomplished by using the results of phase one and assuming that the future drilling activities will follow a mathematical function, i.e., hyperbolic curve. Other runs were made based on the results of Case I and Case II using other mathematical functions to get a broader range of forecasts and predictions. The results of each of these runs will be discussed in detail in this chapter.

The results of this phase are expressed in terms of such parameters as future reserves, future cumulative reserves, future discovery rate (ratio of increment reserves per increment footage), and future cumulative discovery rate (ratio of cumulative reserves per cumulative footage) for each region, and also for all (three) regions combined as functions of time. The results are actually a prediction and forecast of these mentioned parameters for the next 20 years. And they are also plotted for each region and for all the regions

combined for all runs made in the study. However, it was not feasible to include all figures generated during the course of the study in the dissertation because of both the number of figures involved and the similarity of the results from various cases. In particular, plots for the individual regions were omitted after the third run.

First Run

The results obtained from the first run are shown in Tables IX-1 to IX-4 and Figures IX-1 to IX-24. This run is based on the results of the original model from Phase one using a hyperbolic curve for future drilling activities. Tables IX-1 to IX-3 are results for regions one to three, respectively. Table IX-4 contains the results for all regions (three) combined. As shown in these tables, some of the values in initial rows are zeros. This happened because of time of initiation of drilling, t_0 , was not equal to zero; i.e., it did not correspond to the time reference for the run. For example, Region 1 has the first 2 rows (years) zeros, or Region 2 has the first 4 rows (years) zeros, because t_0 was equal to 2 for Region 1 and equal to 4 for Region 2. By plotting the results versus either time or footage, or cumulative footage, for each region and all regions combined, some interesting relationships are obtained. It should be mentioned that for all plots the zero values for each of the rows were not included.

TABLE IX-1

Prediction of Future Discoveries for Region 1
(Hyperbolic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.1504762E 08	0.6318145E 05	0.1904762E 08	0.6318145E 05	0.3317026E-02	0.3317026E-02
4	0.1731602E 08	0.4525399E 05	0.3636363E 08	0.1084354E 06	0.2613418E-02	0.2991975E-02
5	0.1581027E 09	0.3195850E 05	0.5217390E 08	0.1403939E 06	0.2021376E-02	0.2690884E-02
6	0.1449277E 08	0.1766125E 05	0.6666667E 08	0.1580552E 06	0.1218625E-02	0.2370828E-02
7	0.1333336E 08	0.9890188E 04	0.8000003E 08	0.1679454E 06	0.7417626E-03	0.2099316E-02
8	0.1230766E 08	0.7216250E 04	0.9230770E 08	0.1751616E 06	0.5863216E-03	0.1847594E-02
9	0.1139605E 08	0.5318000E 04	0.1037037E 09	0.1804756E 06	0.4666529E-03	0.1740339E-02
10	0.1056157E 08	0.4341375E 04	0.1142857E 09	0.1848210E 06	0.4102616E-03	0.1617184E-02
11	0.9852256E 07	0.3977500E 04	0.1241380E 09	0.1887965E 06	0.4037146E-03	0.1520876E-02
12	0.9195456E 07	0.3706938E 04	0.1333334E 09	0.1925054E 06	0.4031269E-03	0.1443790E-02
13	0.8602096E 07	0.3002688E 04	0.1419355E 09	0.1955081E 06	0.3490646E-03	0.1377443E-02
14	0.8064560E 07	0.2761500E 04	0.1500001E 09	0.1982656E 06	0.3424240E-03	0.1321797E-02
15	0.7575712E 07	0.2436250E 04	0.1575750E 09	0.2007059E 06	0.3215868E-03	0.1273710E-02
16	0.7130176E 07	0.2156063E 04	0.1647060E 09	0.2028619E 06	0.3023855E-03	0.1231661E-02
17	0.6722624E 07	0.2032875E 04	0.1714286E 09	0.2048948E 06	0.3023930E-03	0.1195220E-02
18	0.6349264E 07	0.1792938E 04	0.1777779E 09	0.2066878E 06	0.2823849E-03	0.1162618E-02
19	0.6005936E 07	0.1659063E 04	0.1837838E 09	0.2083468E 06	0.2762370E-03	0.1133652E-02
20	0.5689968E 07	0.1571750E 04	0.1894738E 09	0.2099166E 06	0.2762317E-03	0.1107903E-02

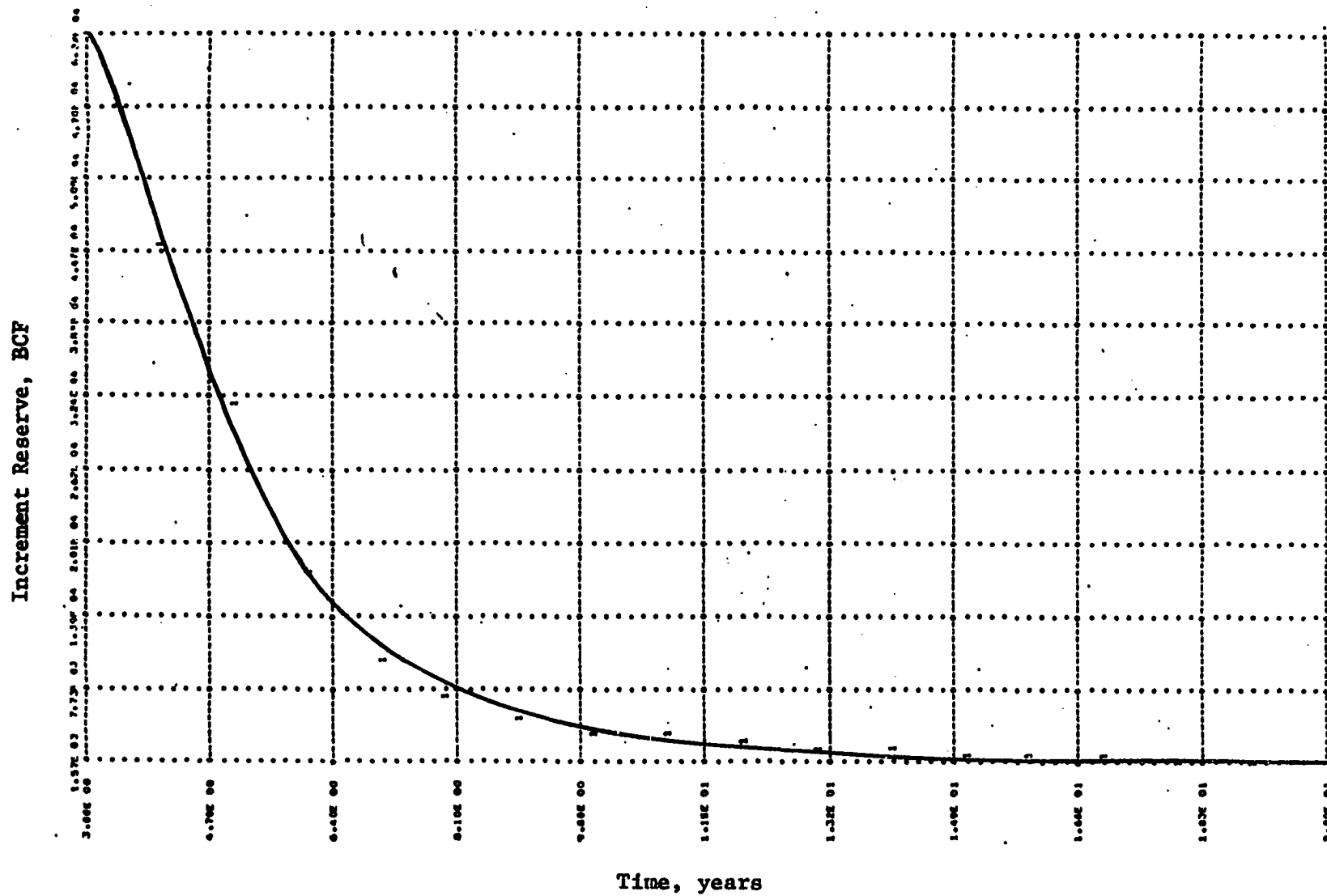


FIGURE IX-1. Plot of increment reserve vs. time for Region 1.
(Hyperbolic curve)

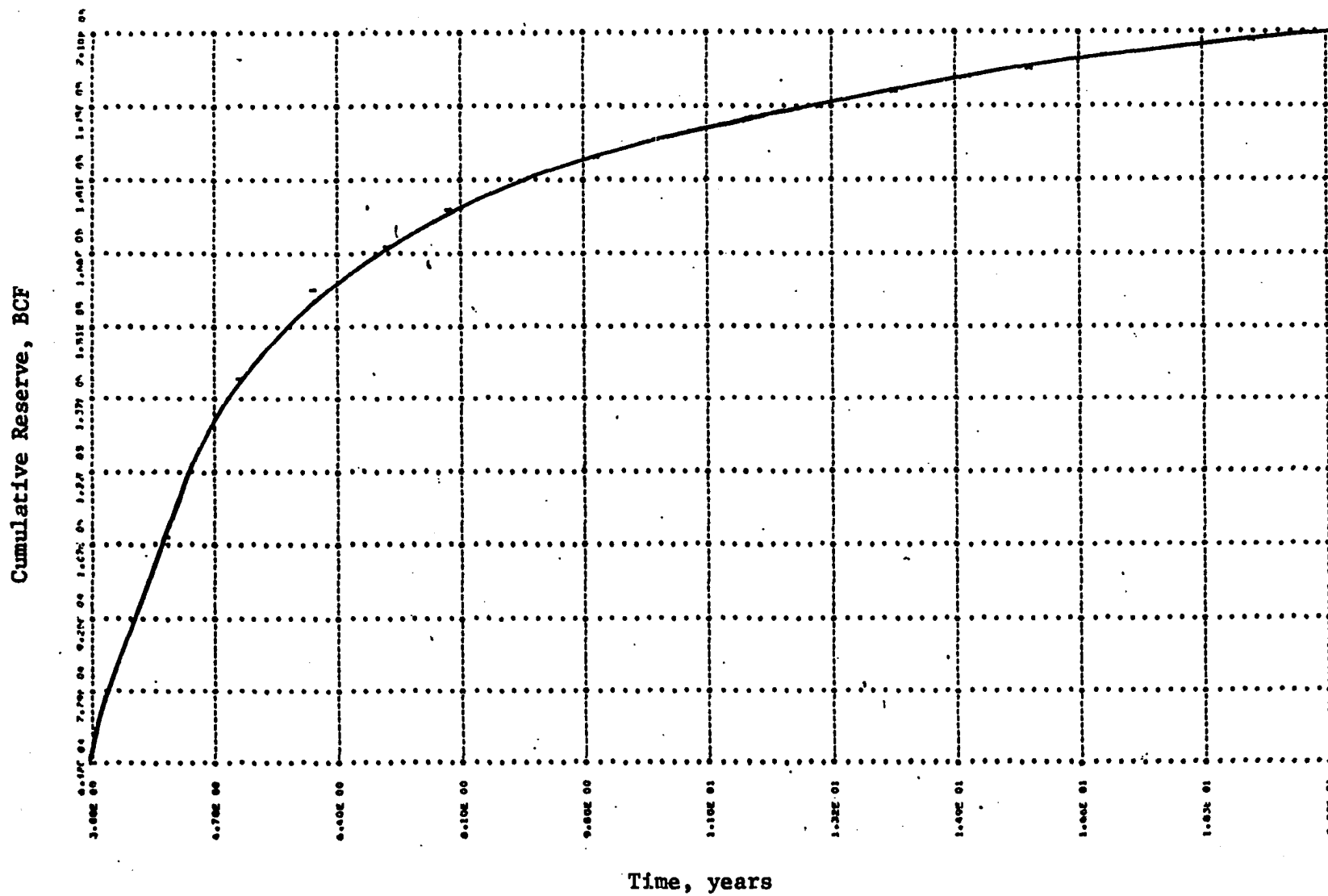


FIGURE IX-2. Plot of cumulative reserve vs. time for Region 1.
(Hyperbolic curve)

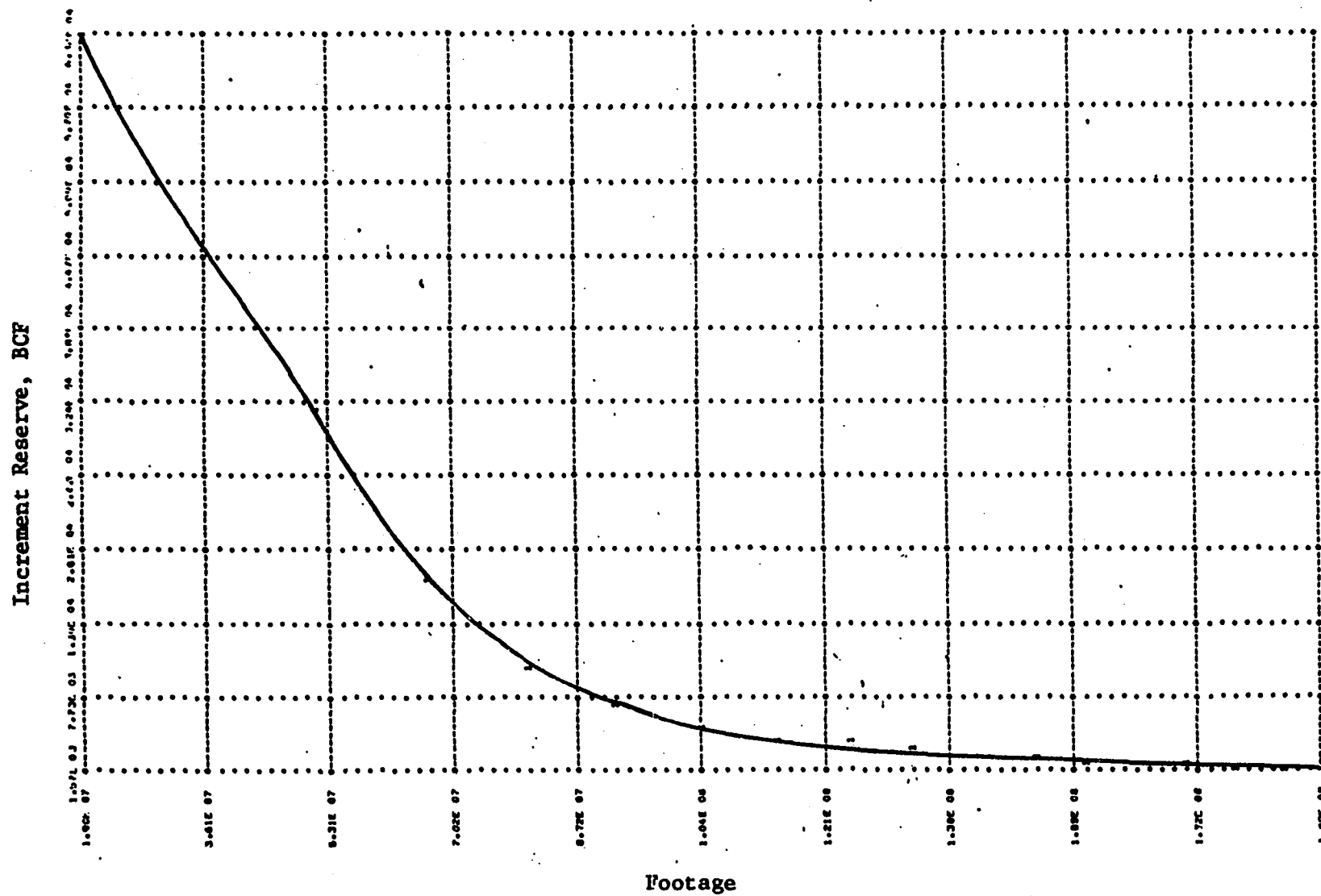


FIGURE IX-4. Plot of increment reserve vs. footage for Region 1.
(Hyperbolic curve)

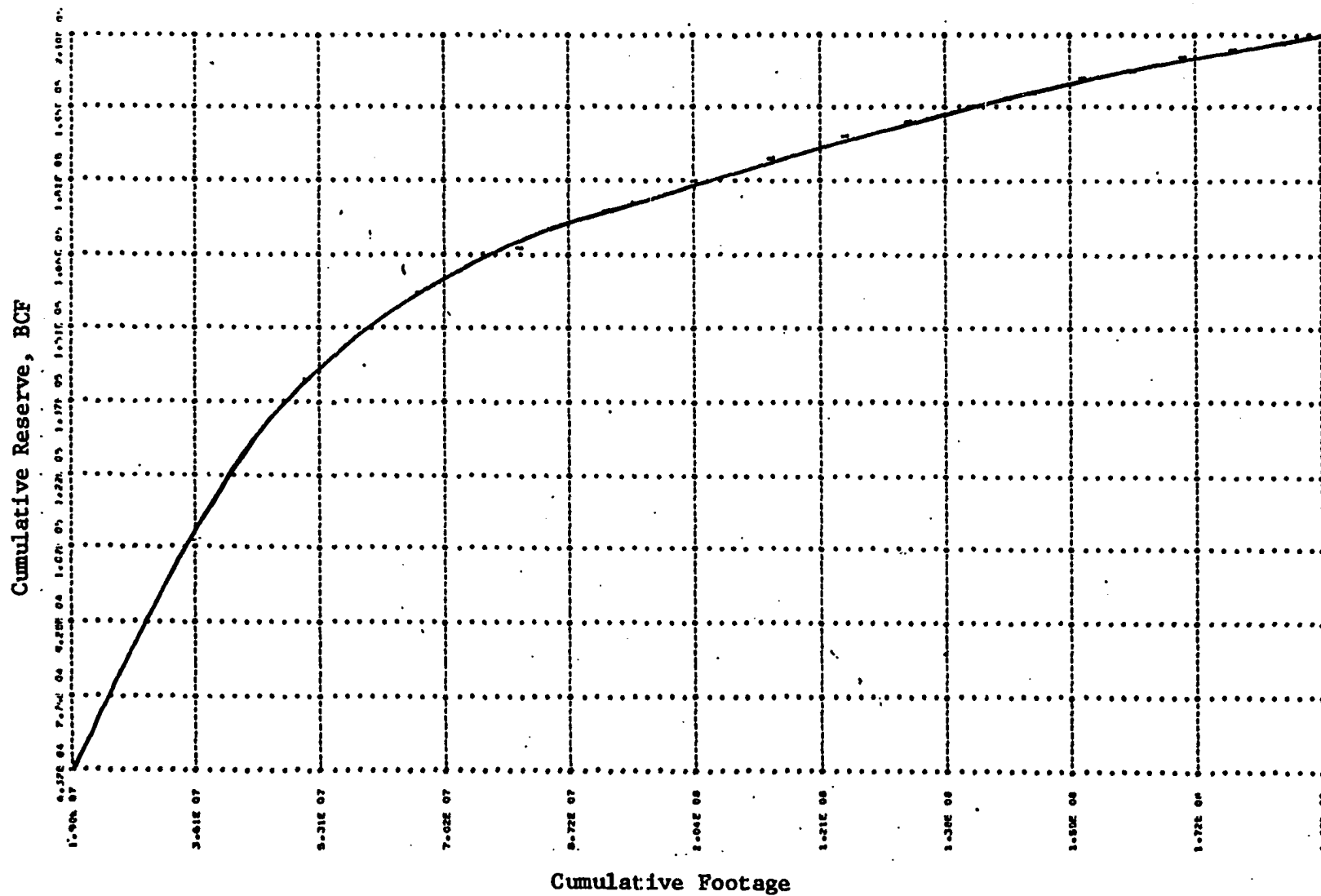


FIGURE IX-5. Plot of cumulative reserve vs. cumulative footage for Region 1.
(Hyperbolic curve)

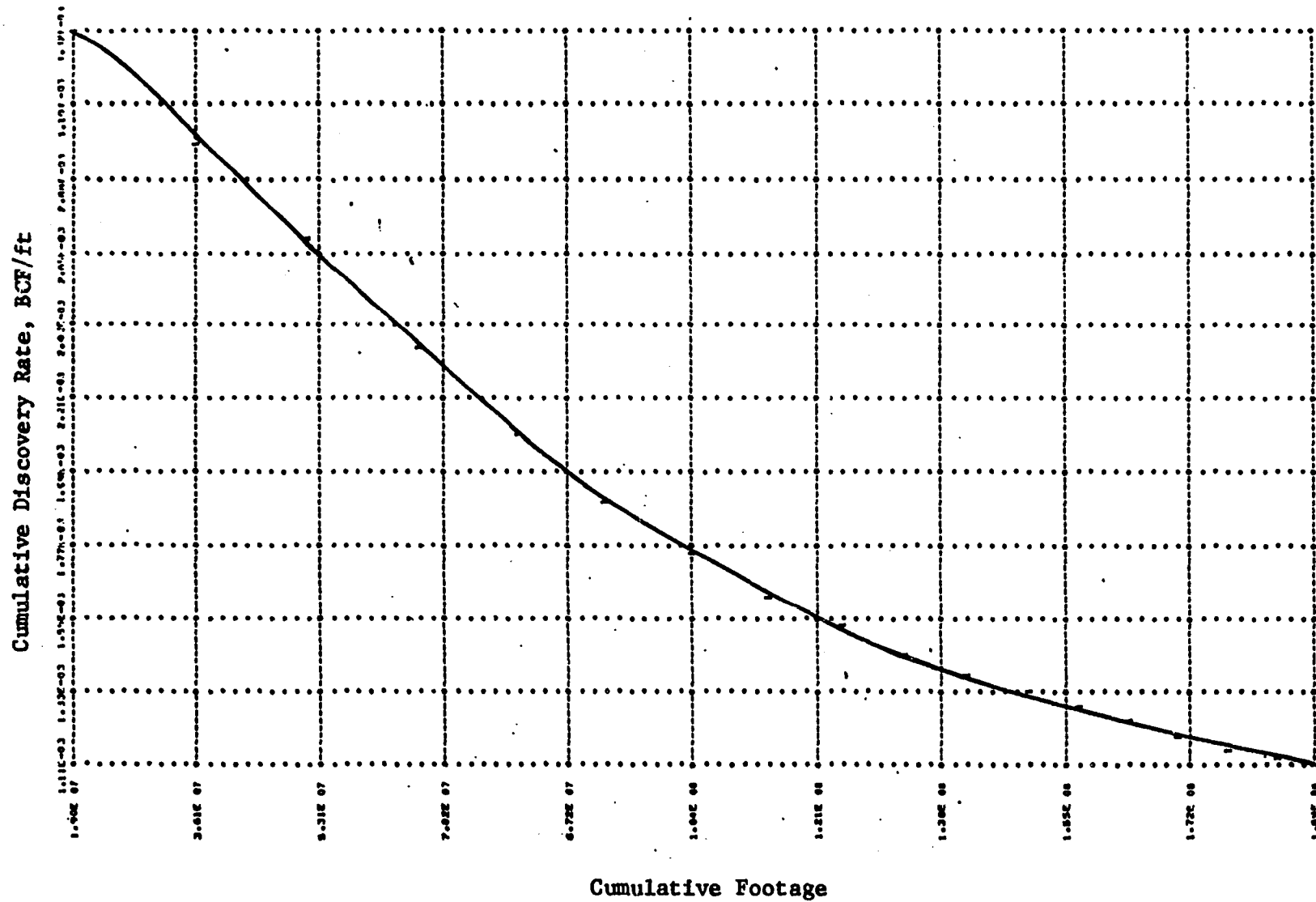


FIGURE IX-6. Plot of cumulative discovery rate vs. cumulative footage for Region 1. (Hyperbolic curve)

TABLE IX-2

Prediction of Future Discoveries for Region 2
(Hyperbolic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
4	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
5	0.1912280E 08	0.6358568E 05	0.1912280E 08	0.6358568E 05	0.3314723E-02	0.3314723E-02
6	0.1767675E 08	0.4614439E 05	0.3685955E 08	0.1097301E 06	0.2610456E-02	0.2976977E-02
7	0.1634136E 08	0.3265525E 05	0.5320091E 08	0.1423853E 06	0.1998319E-02	0.2676370E-02
8	0.1515178E 08	0.1700319E 05	0.6835269E 08	0.1593865E 06	0.1122191E-02	0.2331854E-02
9	0.1402754E 08	0.9987625E 04	0.8244022E 08	0.1693761E 06	0.7089688E-03	0.2054533E-02
10	0.1313165E 08	0.7699375E 04	0.9557187E 08	0.1770755E 06	0.5863220E-03	0.1852799E-02
11	0.1226982E 08	0.5101750E 04	0.1078417E 09	0.1821773E 06	0.4157964E-03	0.1689303E-02
12	0.1149005E 08	0.4683750E 04	0.1193317E 09	0.1868610E 06	0.4076352E-03	0.1565895E-02
13	0.1078251E 08	0.4346750E 04	0.1301143E 09	0.1912078E 06	0.4031295E-03	0.1469537E-02
14	0.1013229E 08	0.3724125E 04	0.1402525E 09	0.1949319E 06	0.3673327E-03	0.1389863E-02
15	0.9550000E 07	0.3270125E 04	0.1498025E 09	0.1992020E 06	0.3424212E-03	0.1323088E-02
16	0.9011712E 07	0.2878375E 04	0.1588143E 09	0.201804E 06	0.3194036E-03	0.1266135E-02
17	0.8517552E 07	0.2575625E 04	0.1673318E 09	0.2036560E 06	0.3023902E-03	0.1217079E-02
18	0.8062864E 07	0.2373438E 04	0.1753947E 09	0.2060254E 06	0.2943664E-03	0.1174662E-02
19	0.7643840E 07	0.2111500E 04	0.1830385E 09	0.2081409E 06	0.2762354E-03	0.1137143E-02
20	0.7256432E 07	0.2004438E 04	0.1902949E 09	0.2101454E 06	0.2762289E-03	0.1104314E-02

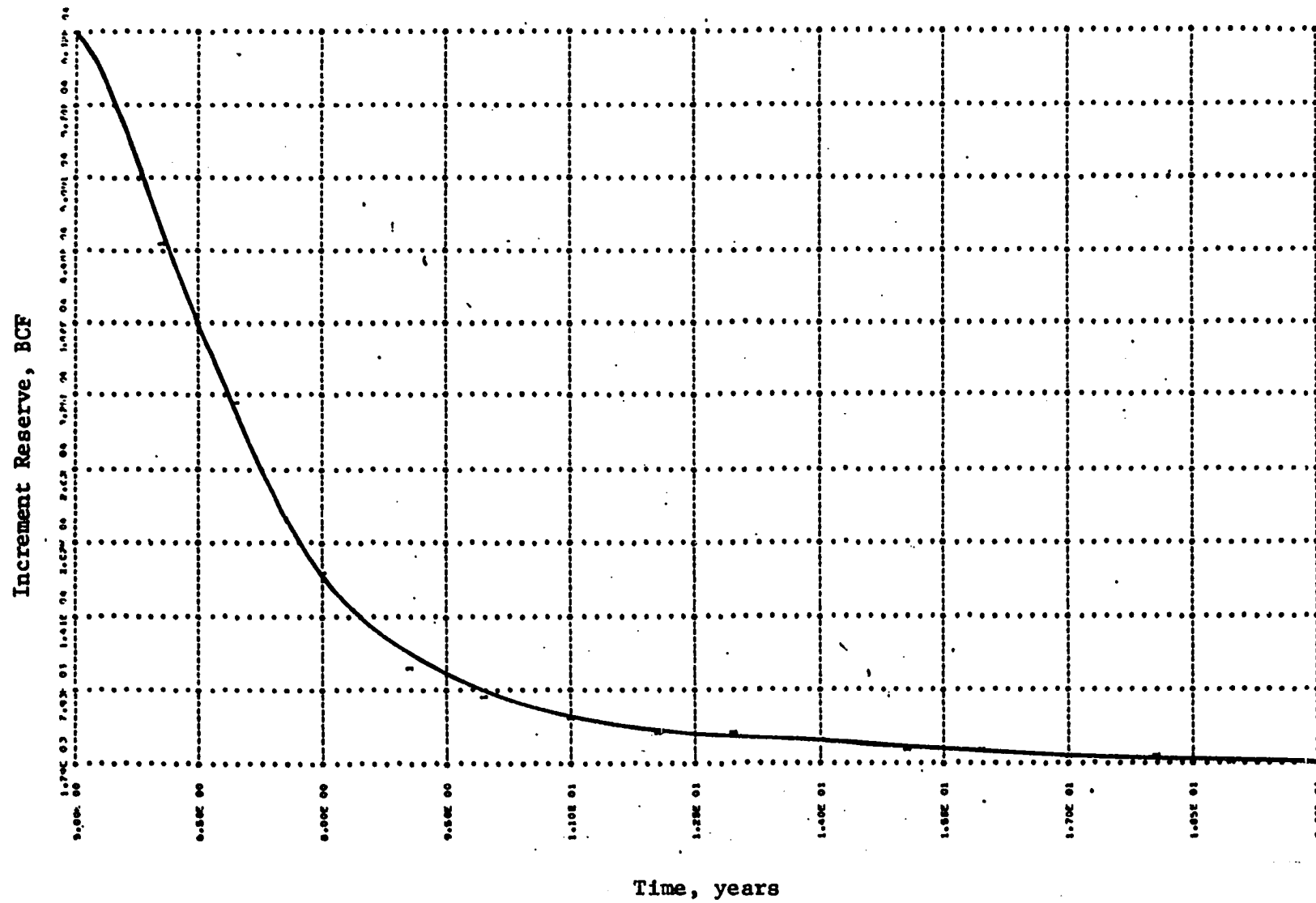


FIGURE IX-7. Plot of increment reserve vs. time for Region 2.
(Hyperbolic curve)

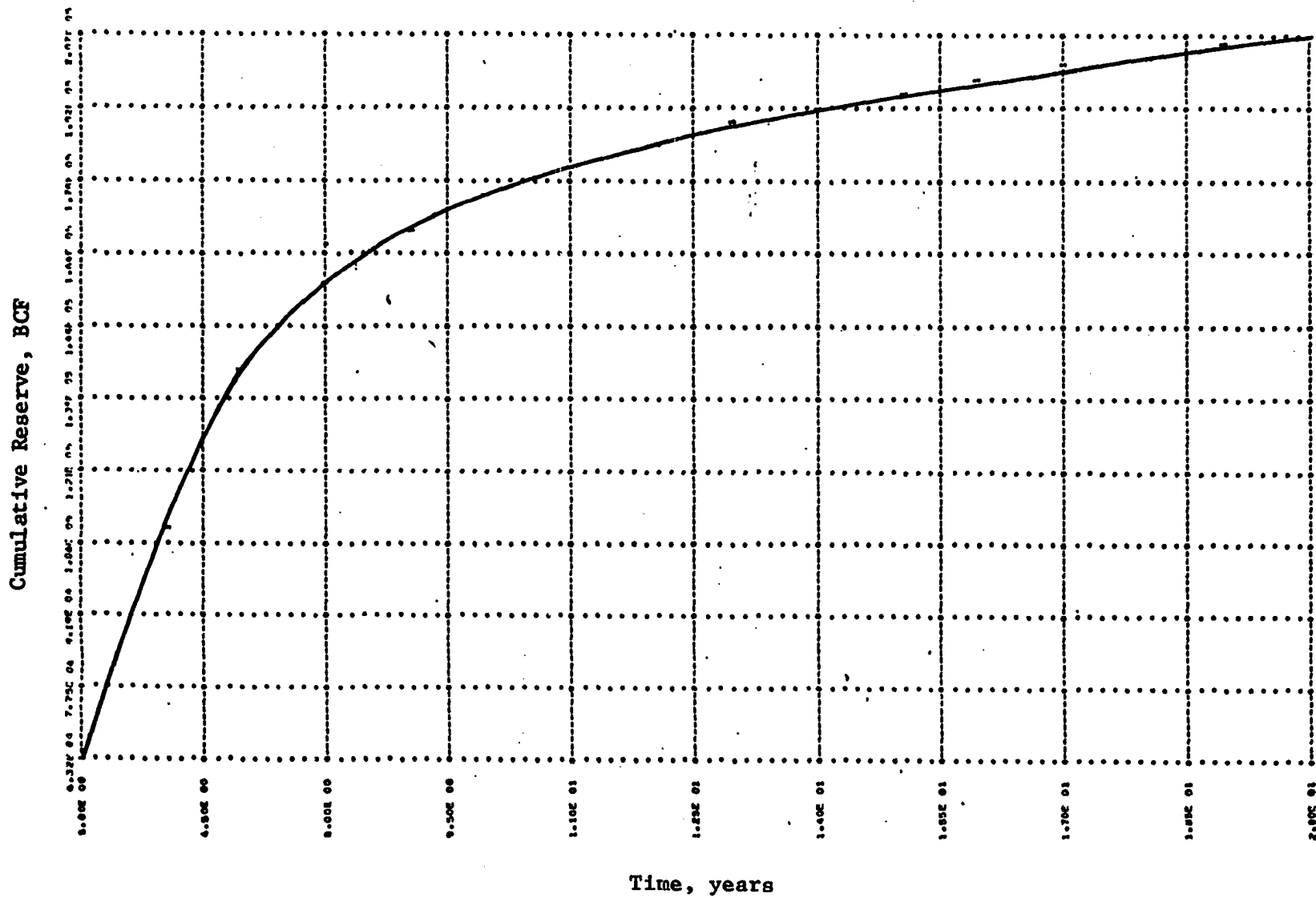


FIGURE IX-8. Plot of cumulative reserve vs. time for Region 2.
(Hyperbolic curve)

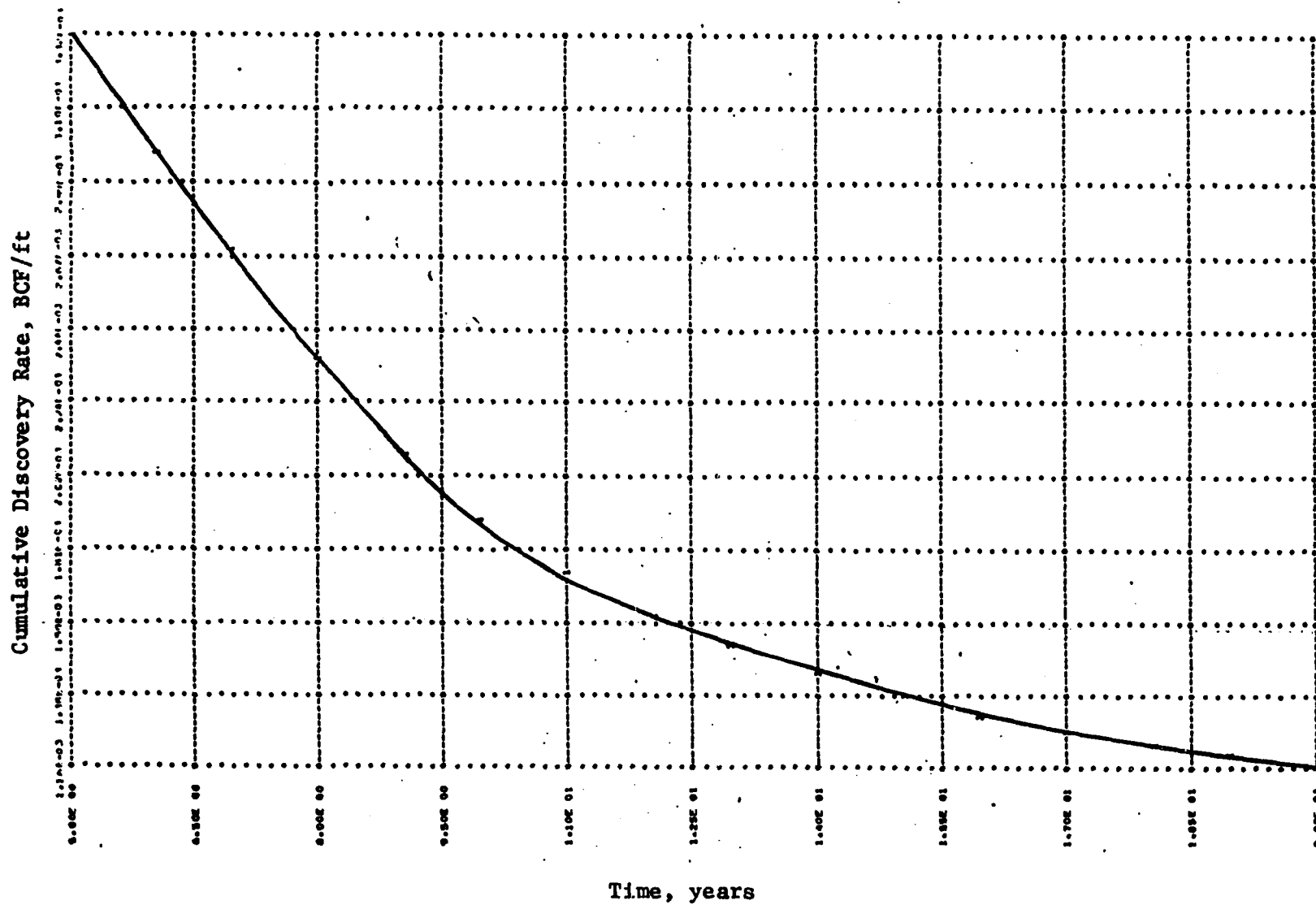


FIGURE IX-9. Plot of cumulative discovery rate vs. time for Region 2.
(Hyperbolic curve)

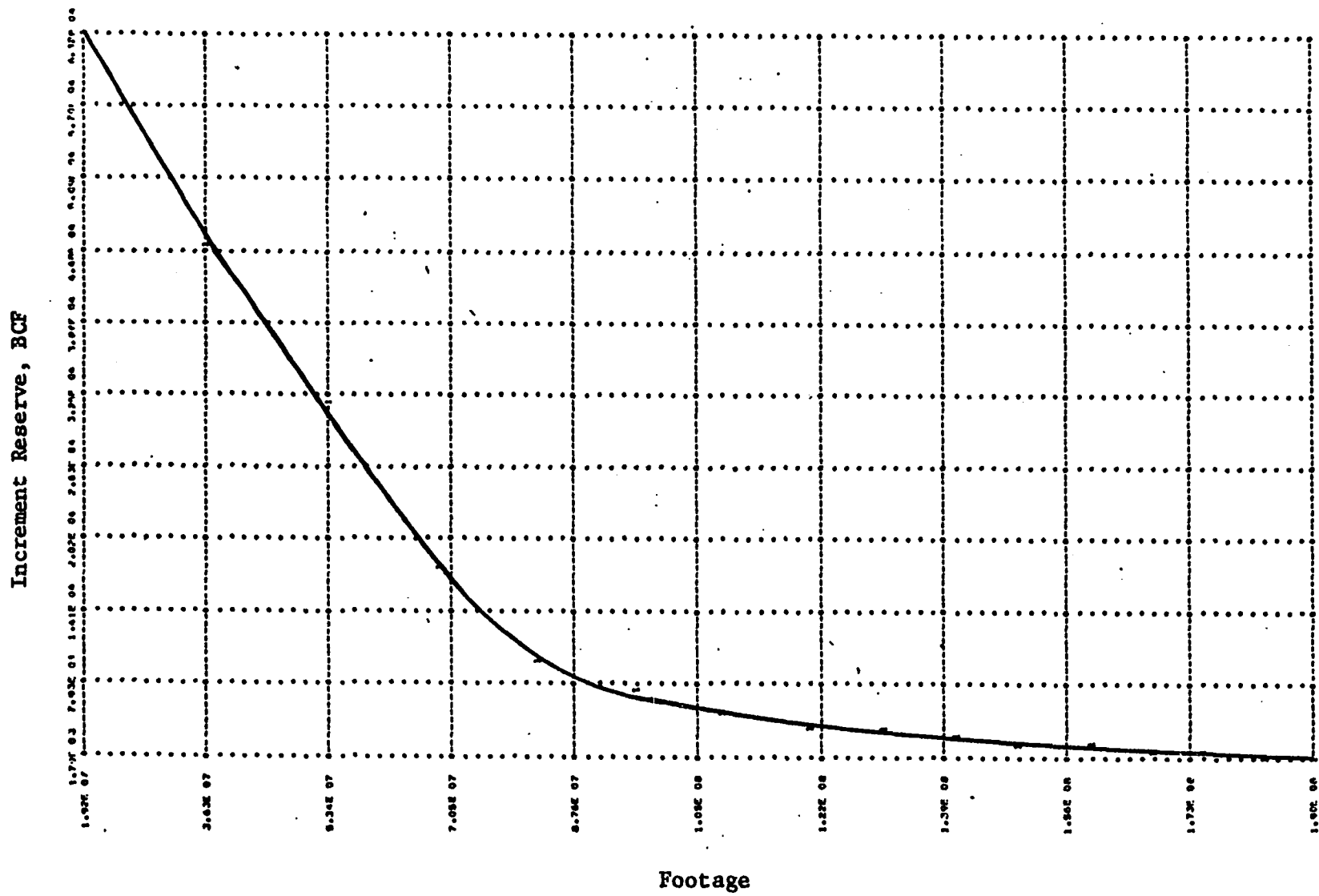


FIGURE IX-10. Plot of increment reserve vs. footage for Region 2.
(Hyperbolic curve)

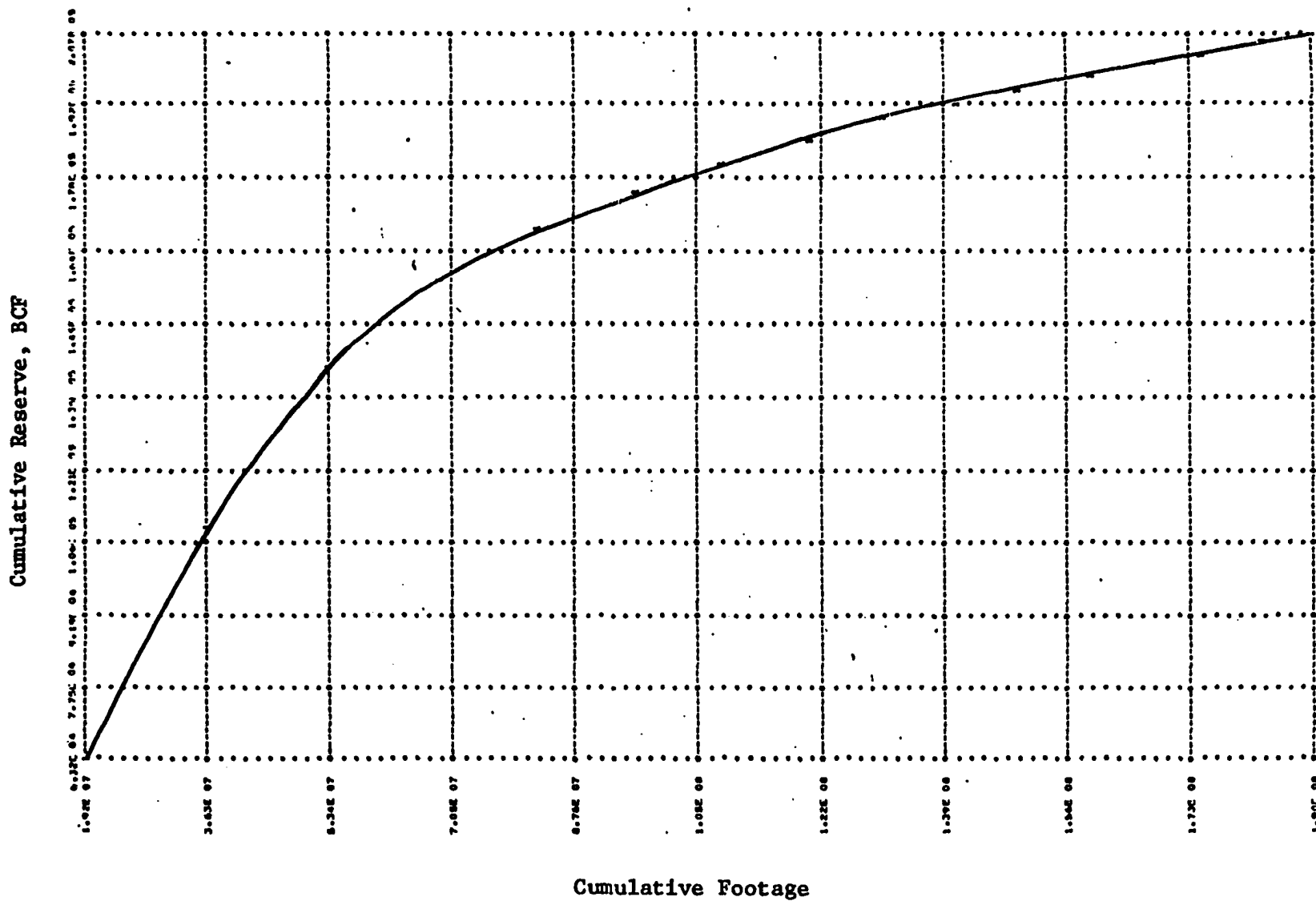


FIGURE IX-11. Plot of cumulative reserve vs. cumulative footage for Region 2.
(Hyperbolic curve)

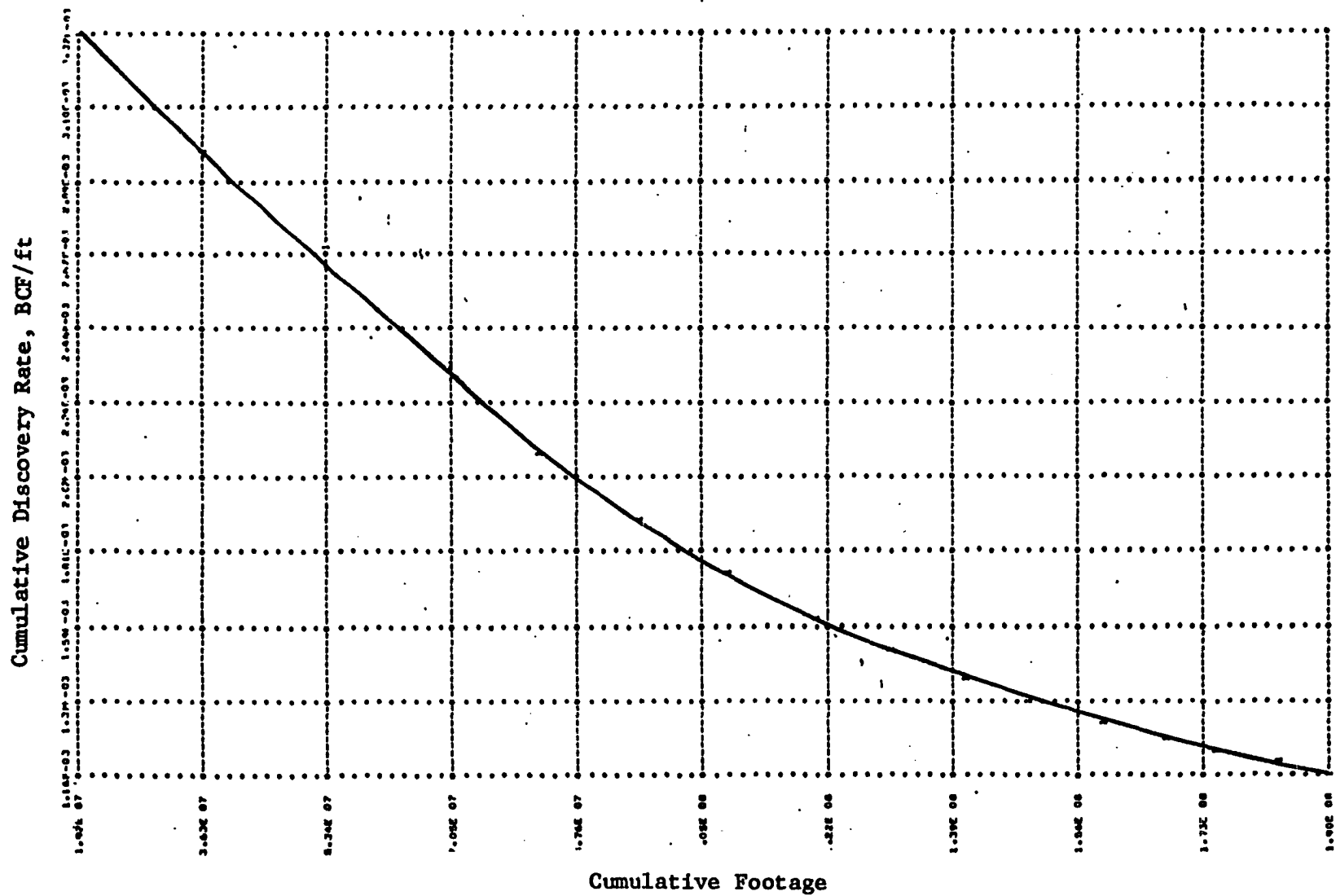


FIGURE IX-12. Plot of cumulative discovery rate vs. cumulative footage for Region 2.
(Hyperbolic curve)

TABLE IX-3

Prediction of Future Discoveries for Region 3
(Hyperbolic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
4	0.1912045E 08	0.6342291E 05	0.1912045E 08	0.6342291E 05	0.3317020E-02	0.3317020E-02
5	0.1750958E 08	0.4570797E 05	0.3663003E 08	0.1091309E 06	0.2610454E-02	0.2979273E-02
6	0.1609403E 08	0.3232981E 05	0.5272406E 08	0.1414607E 06	0.2008807E-02	0.2693039E-02
7	0.1484350E 08	0.1730694E 05	0.6756757E 08	0.1587676E 06	0.1165960E-02	0.2349761E-02
8	0.1373326E 08	0.9940438E 04	0.8130083E 08	0.1687081E 06	0.7238218E-03	0.2075109E-02
9	0.1274309E 08	0.7471563E 04	0.9404392E 08	0.1761796E 06	0.5863227E-03	0.1873376E-02
10	0.1185627E 08	0.5201125E 04	0.1059002E 09	0.1813808E 06	0.4386811E-03	0.1712752E-02
11	0.1108891E 08	0.4523813E 04	0.1169591E 09	0.1859046E 06	0.4090648E-03	0.1599493E-02
12	0.1033939E 08	0.4162063E 04	0.1272985E 09	0.1900726E 06	0.4031244E-03	0.1493125E-02
13	0.9687856E 07	0.3740813E 04	0.1369864E 09	0.1939134E 06	0.3861340E-03	0.1414838E-02
14	0.9096048E 07	0.3114688E 04	0.1460824E 09	0.1969281E 06	0.3424219E-03	0.1348062E-02
15	0.8556832E 07	0.2889750E 04	0.1546392E 09	0.1998179E 06	0.3377125E-03	0.1292155E-02
16	0.8064224E 07	0.2438563E 04	0.1627035E 09	0.2022564E 06	0.3023925E-03	0.1243098E-02
17	0.7612912E 07	0.2302063E 04	0.1703164E 09	0.2045585E 06	0.3023890E-03	0.1201050E-02
18	0.7198496E 07	0.2056563E 04	0.1775149E 09	0.2066151E 06	0.2856932E-03	0.1163931E-02
19	0.6817008E 07	0.1883125E 04	0.1843319E 09	0.2084922E 06	0.2762391E-03	0.1131102E-02
20	0.6465072E 07	0.1785875E 04	0.1907969E 09	0.2102841E 06	0.2762342E-03	0.1102135E-02

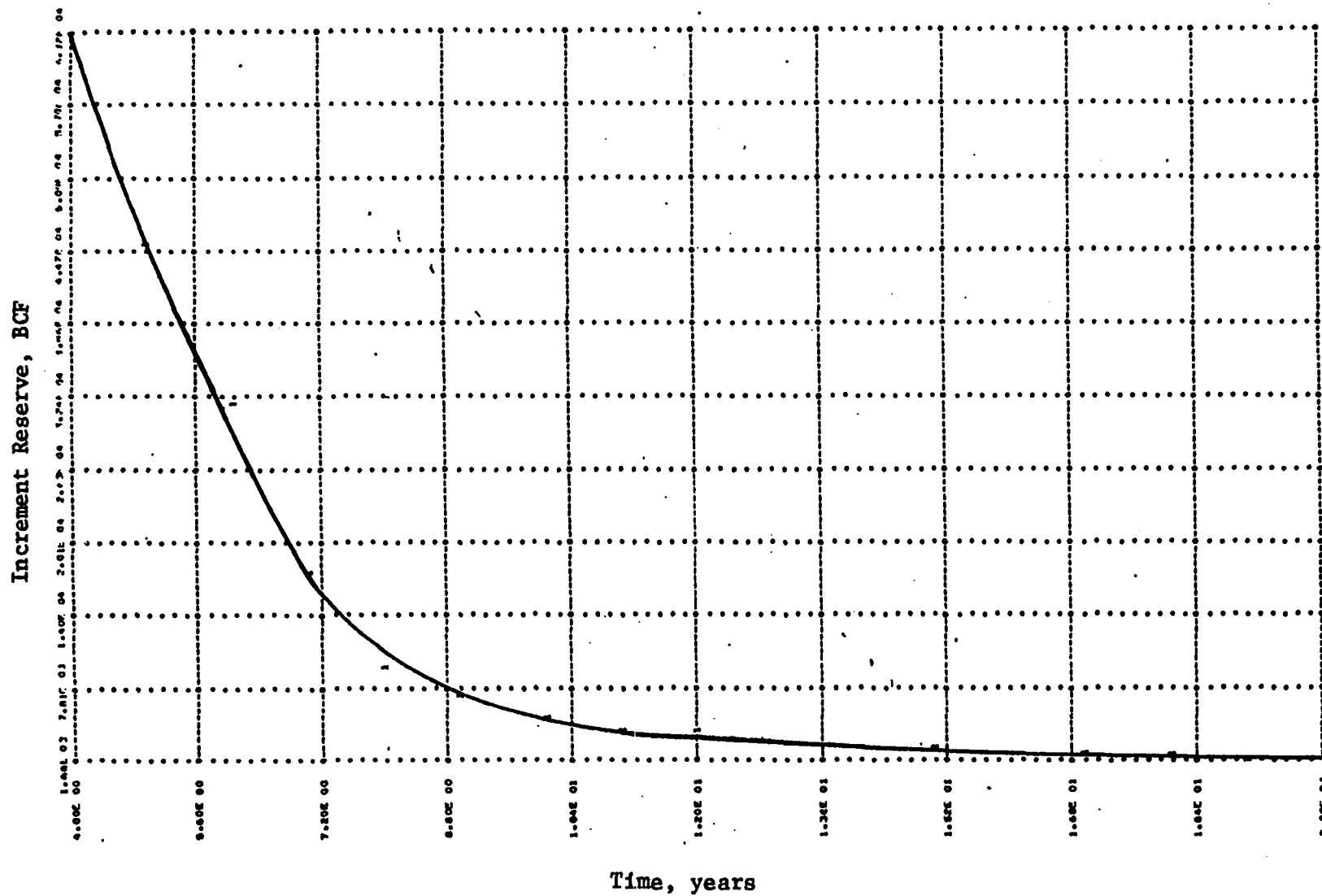


FIGURE IX-13. Plot of increment reserve vs. time for Region 3.
(Hyperbolic curve)

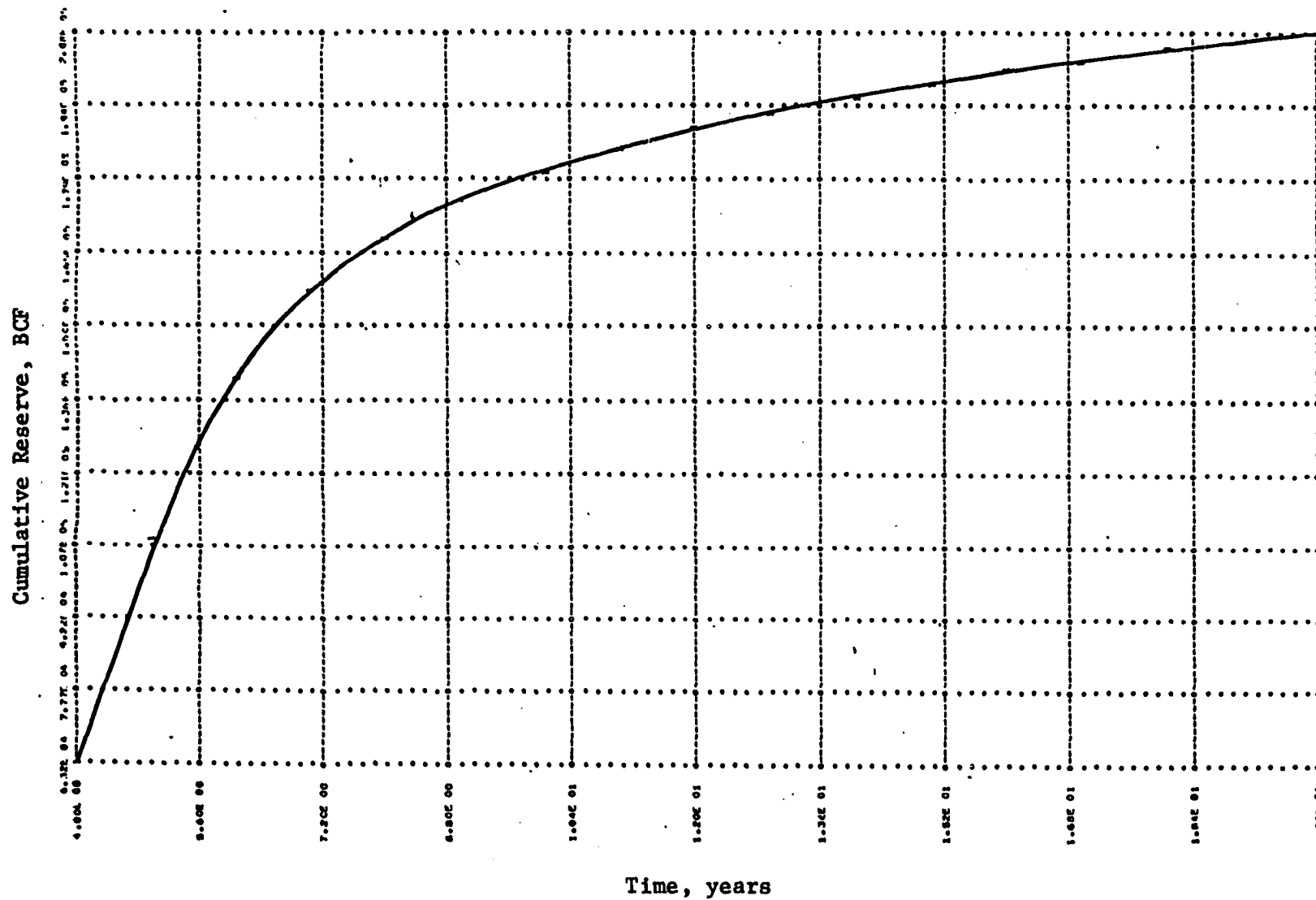


FIGURE IX-14. Plot of cumulative reserve vs. time for Region 3.
(Hyperbolic curve)

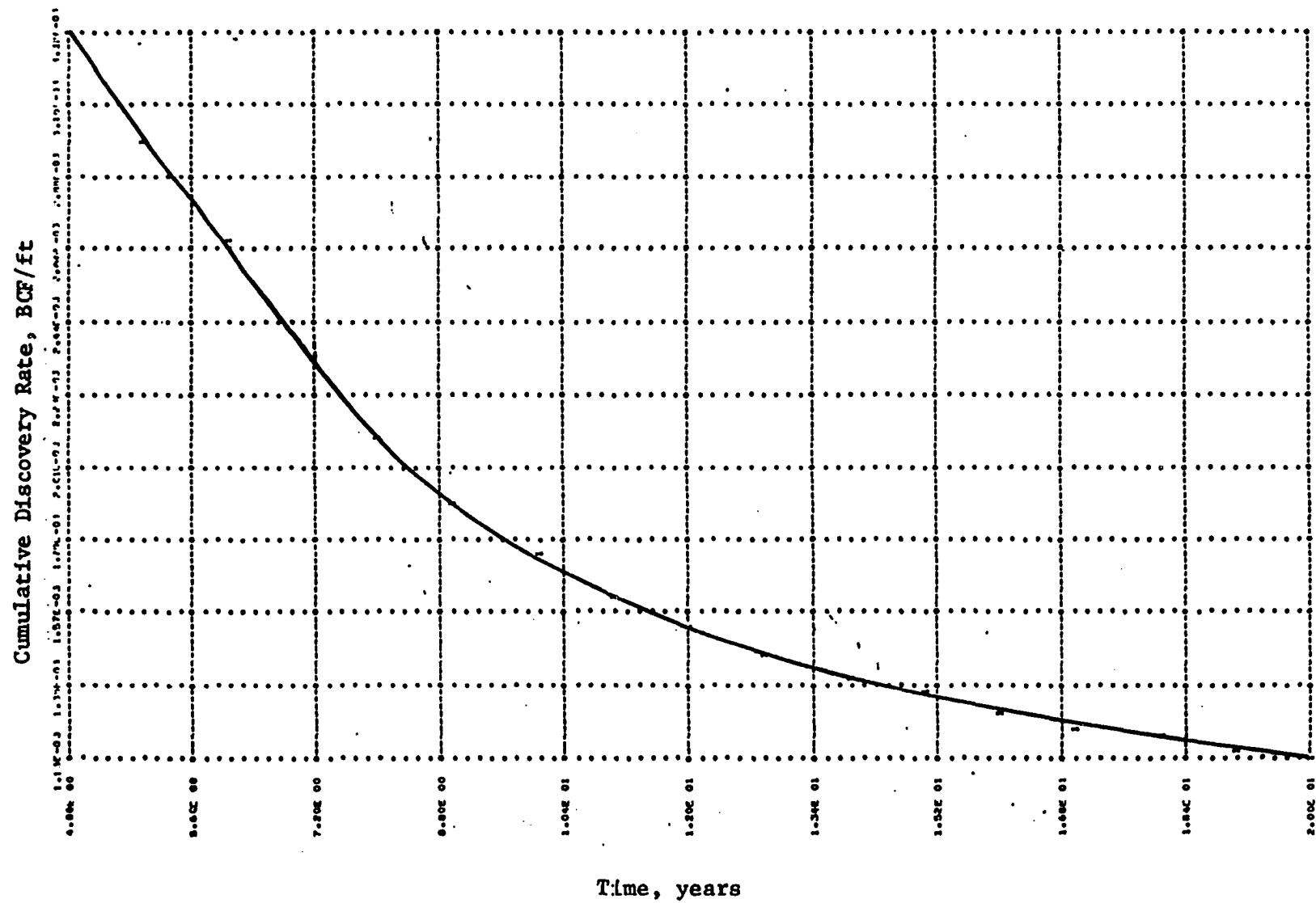


FIGURE IX-15. Plot of cumulative discovery rate vs. time for Region 3.
(Hyperbolic curve)

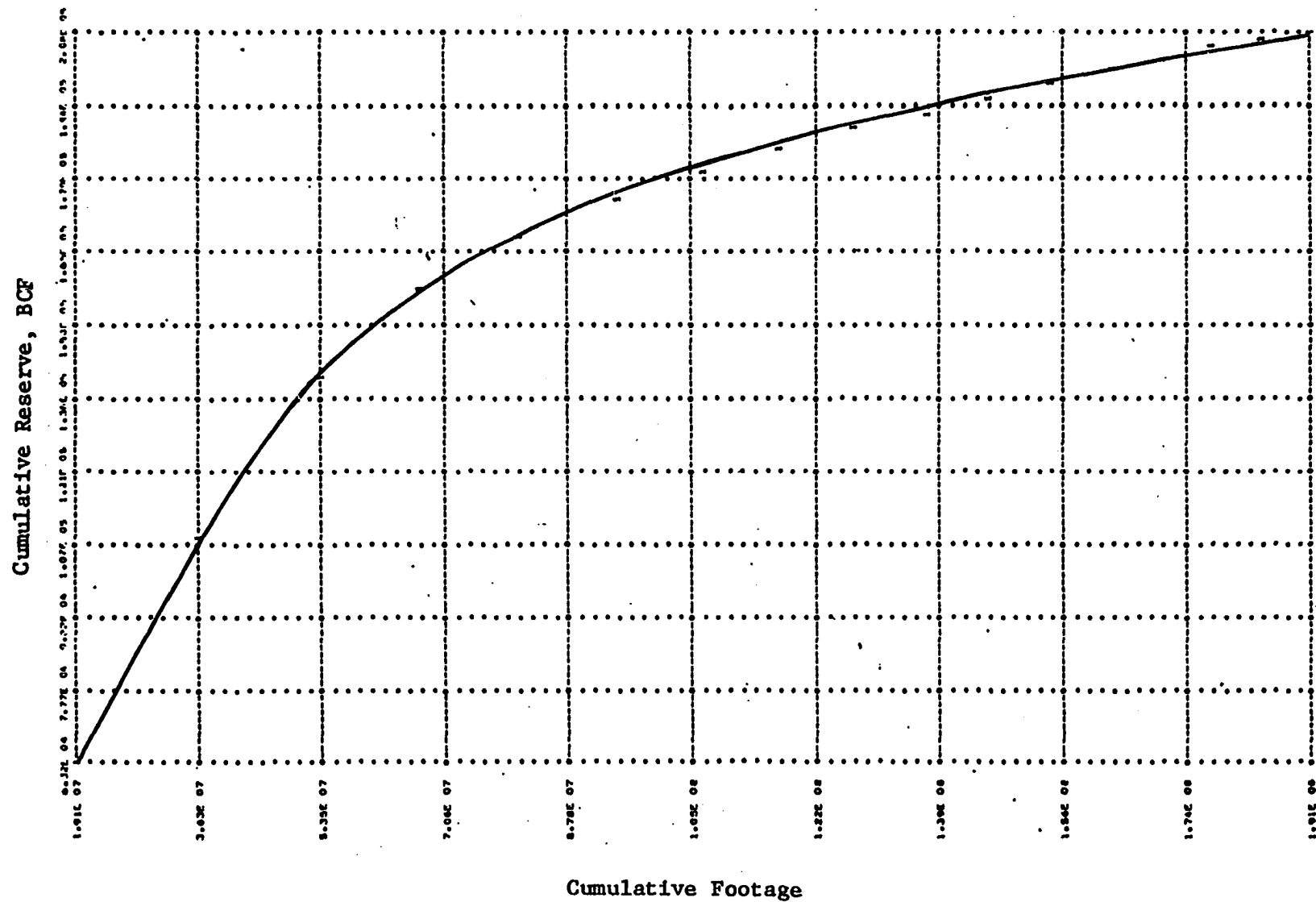


FIGURE IX-17. Plot of cumulative reserve vs. cumulative footage for Region 3.
(Hyperbolic curve)

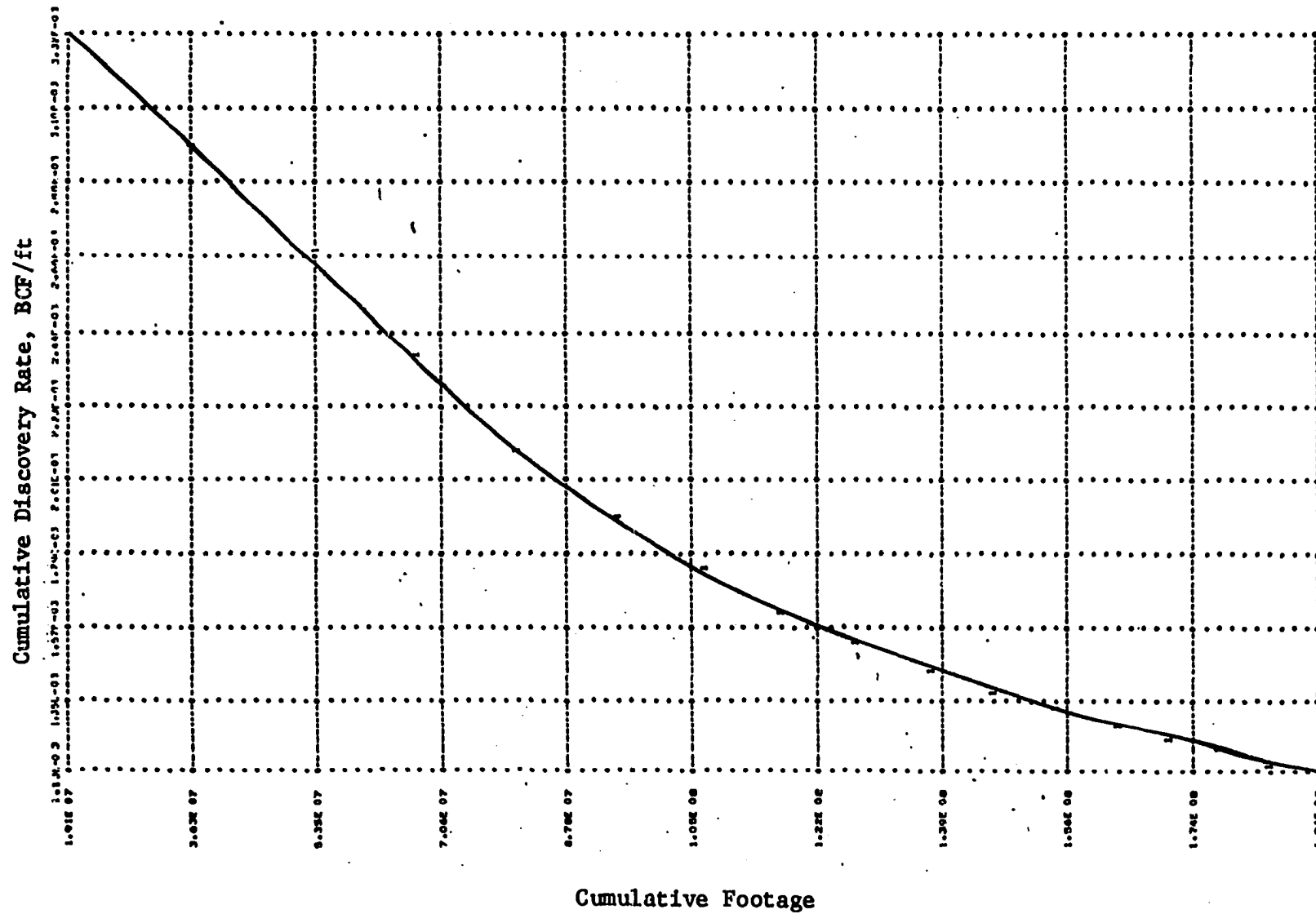


FIGURE IX-18. Plot of cumulative discovery rate vs. cumulative footage for Region 3.
(Hyperbolic curve)

TABLE IX -4

COMPOSITE PARAMETERS FOR ALL K BASINS

(Hyperbolic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.1904762E 08	0.6718145E 05	0.1904762E 08	0.6718145E 05	0.3317026E-02	0.3317026E-02
4	0.3643646E 08	0.1086768E 06	0.5548408E 08	0.1718523E 06	0.2982635E-02	0.3097435E-02
5	0.5250266E 08	0.1412521E 06	0.1079867E 09	0.3131104E 06	0.2690380E-02	0.2899527E-02
6	0.4826355E 08	0.9613550E 05	0.1562503E 09	0.4092459E 06	0.1991886E-02	0.2619169E-02
7	0.4451822E 08	0.5985232E 05	0.2007685E 09	0.4690923E 06	0.1344447E-02	0.2336513E-02
8	0.4119270E 08	0.3415982E 05	0.2419612E 09	0.5032582E 06	0.8292699E-03	0.2079912E-02
9	0.3822643E 08	0.2277719E 05	0.2801876E 09	0.5260354E 06	0.5958490E-03	0.1877439E-02
10	0.3556992E 08	0.1724122E 05	0.3157576E 09	0.5422773E 06	0.4847317E-03	0.1720552E-02
11	0.3318118E 08	0.1360306E 05	0.3489388E 09	0.5568803E 06	0.4099631E-03	0.1595926E-02
12	0.3102490E 08	0.1255875E 05	0.3799636E 09	0.5694391E 06	0.4047955E-03	0.1498667E-02
13	0.2907213E 08	0.1109025E 05	0.4090358E 09	0.5805293E 06	0.3814735E-03	0.1419263E-02
14	0.2729907E 08	0.9600313E 04	0.4363348E 09	0.5901296E 06	0.3516714E-03	0.1352469E-02
15	0.2562243E 08	0.8596125E 04	0.4620173E 09	0.5987258E 06	0.3347083E-03	0.1295895E-02
16	0.2420608E 08	0.7473000E 04	0.4862234E 09	0.6061922E 06	0.3087239E-03	0.1246749E-02
17	0.2285312E 08	0.6910563E 04	0.5050765E 09	0.6131053E 06	0.3023902E-03	0.1204356E-02
18	0.2161075E 08	0.6222938E 04	0.5306872E 09	0.6193323E 06	0.2879554E-03	0.1167038E-02
19	0.2046669E 08	0.5653688E 04	0.5511539E 09	0.6249859E 06	0.2762384E-03	0.1133959E-02
20	0.1941146E 08	0.5362063E 04	0.5705654E 09	0.6303480E 06	0.2762317E-03	0.1104778E-02

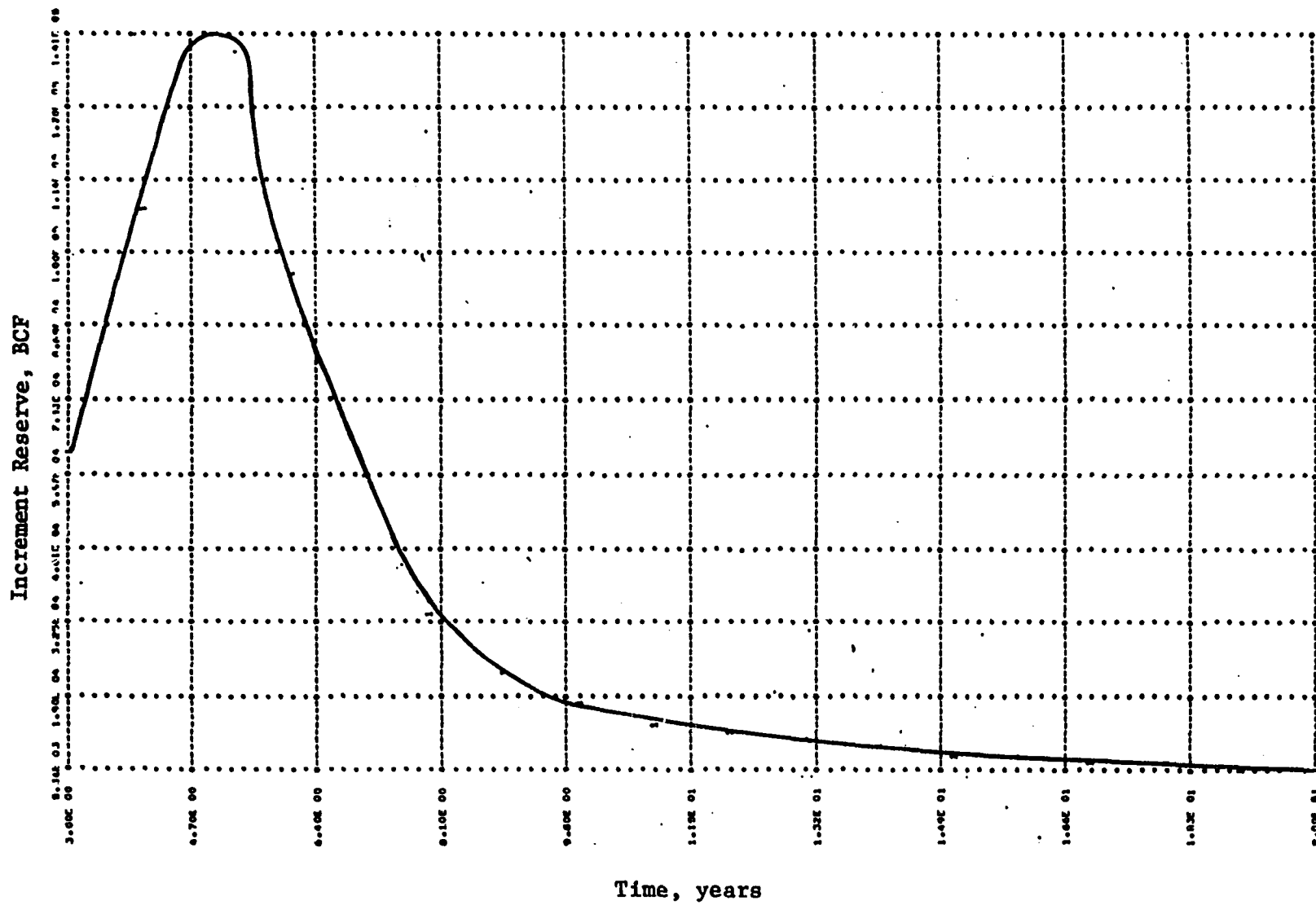


FIGURE IX-19. Composite plot of increment reserve vs. time for original model.
(Hyperbolic curve)

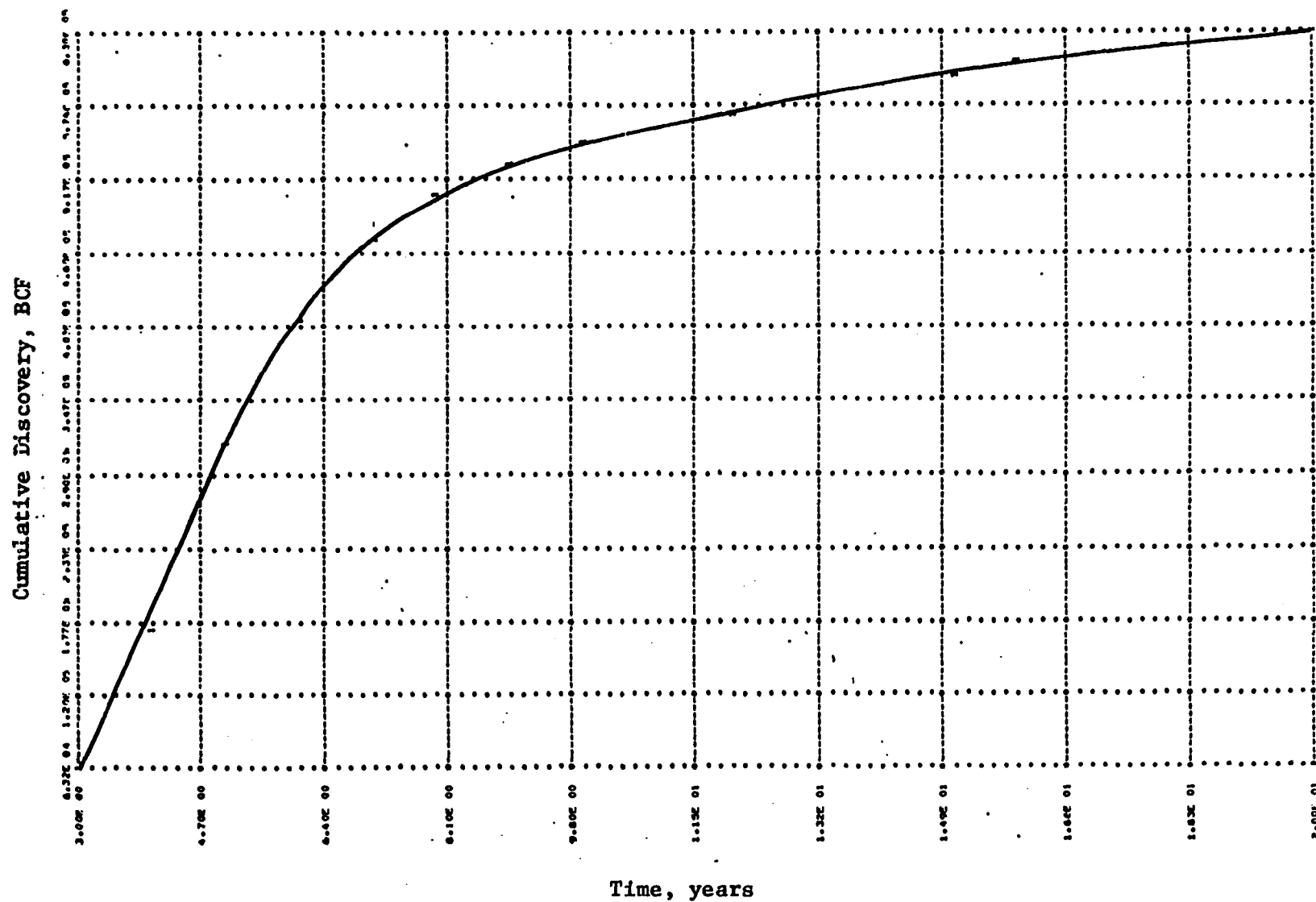


FIGURE IX-20. Composite plot of cumulative discovery vs. time for original model.
(Hyperbolic curve)

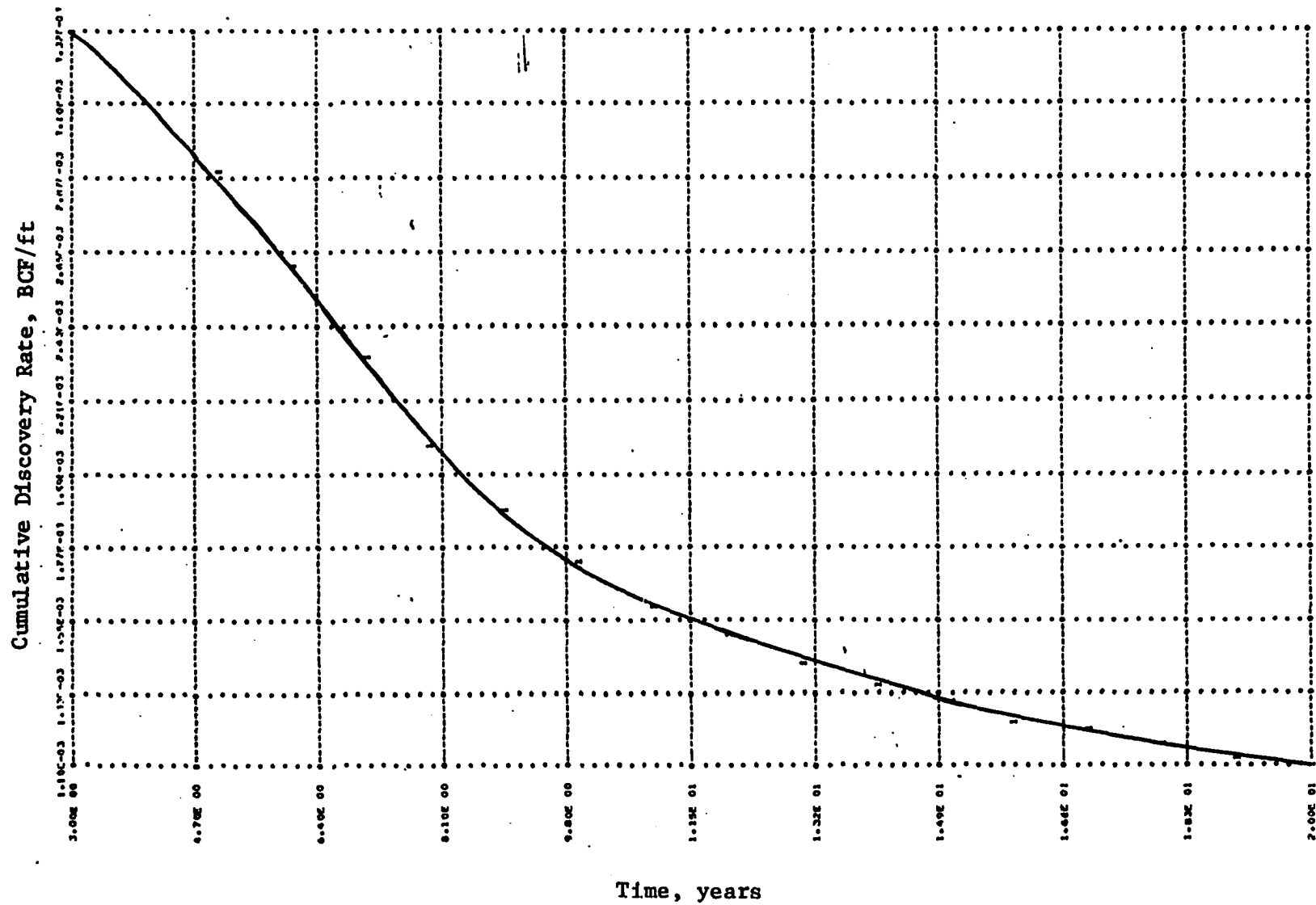


FIGURE IX-21. Composite plot of cumulative discovery rate vs. time for original model.
(Hyperbolic curve)

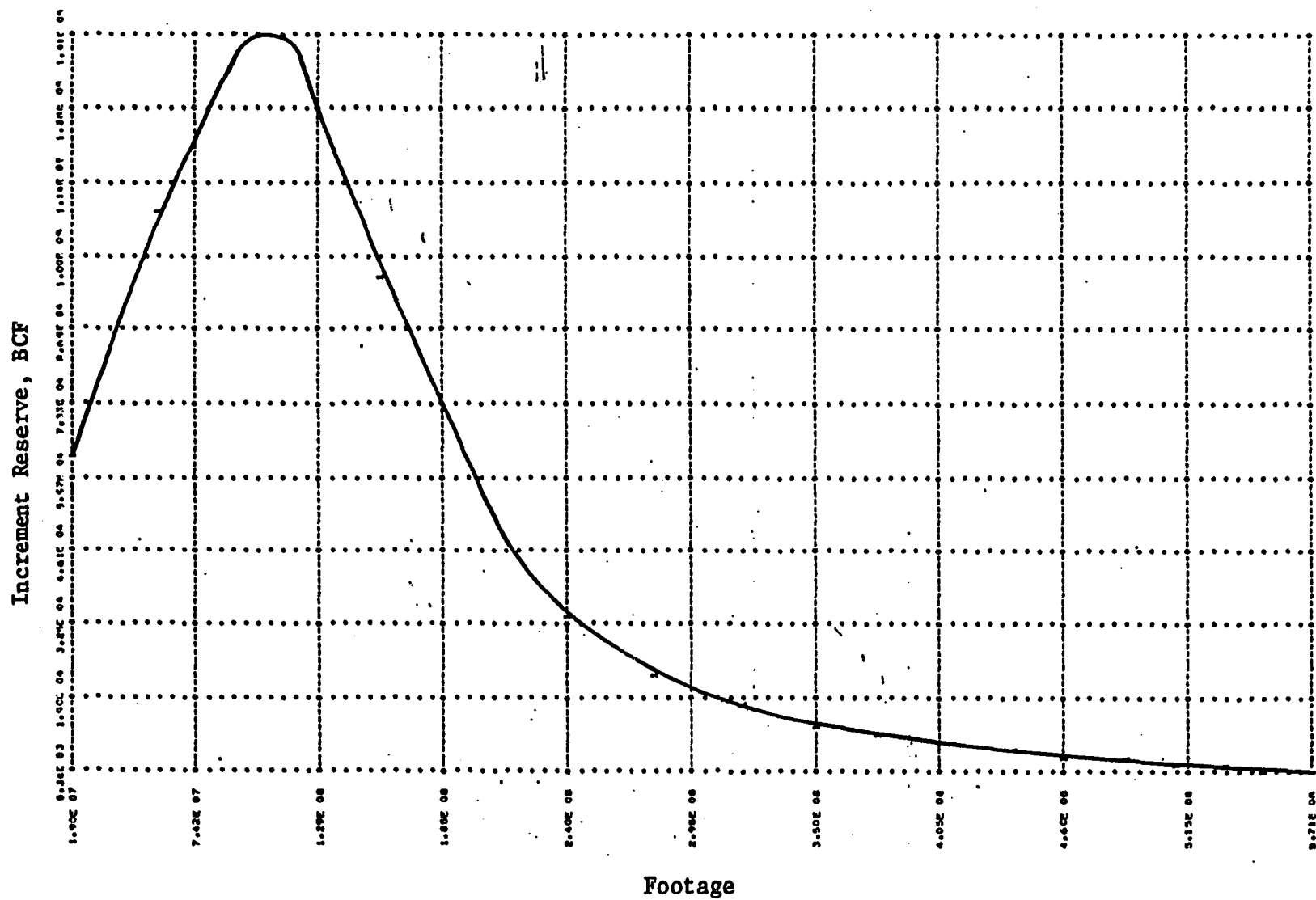


FIGURE IX-22. Composite plot of increment reserve vs. footage for original model.
(Hyperbolic curve)

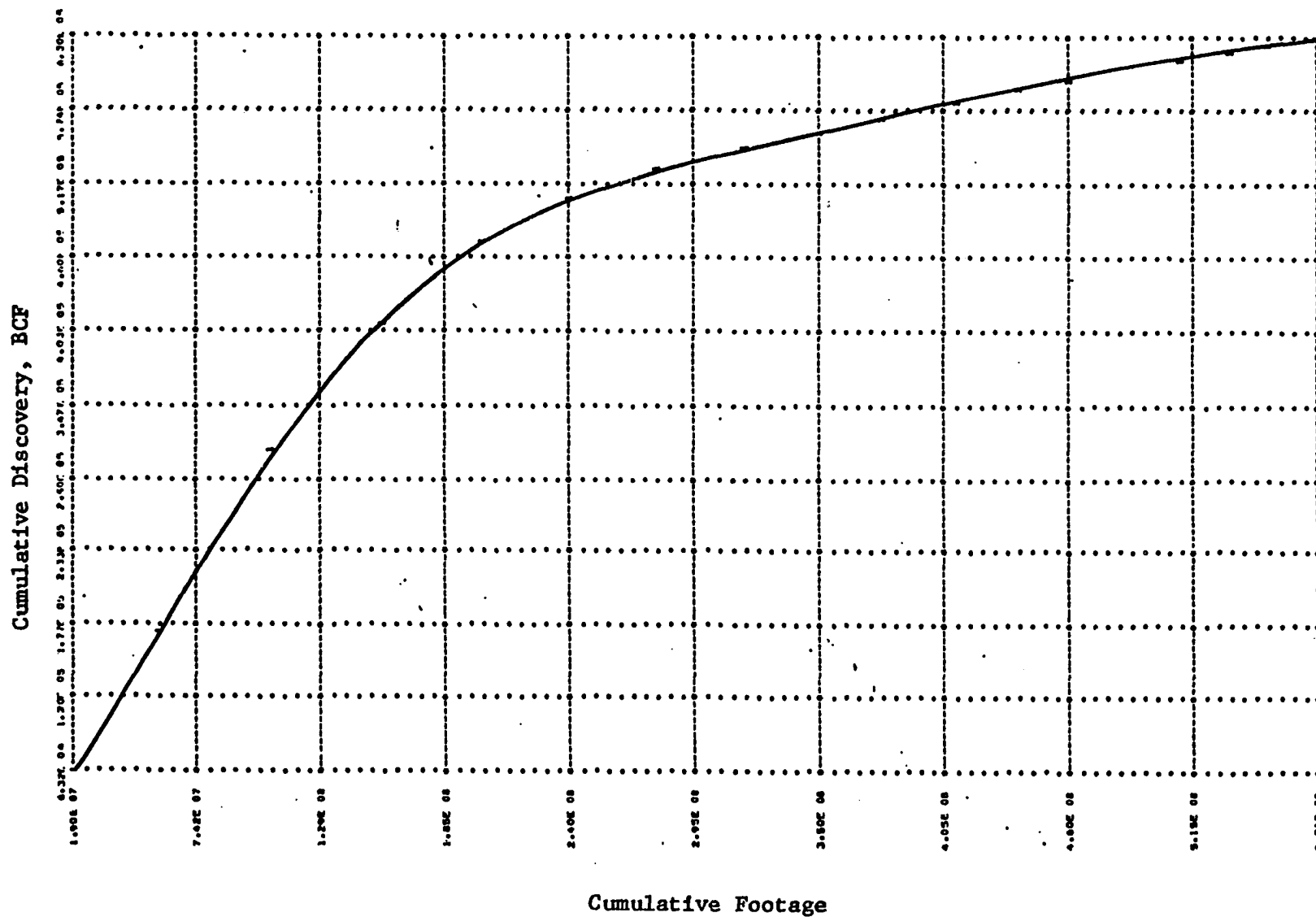


FIGURE IX-23. Composite plot of cumulative discovery vs. cumulative footage for original model. (Hyperbolic curve)

The plots of increment reserves in Bcf of gas vs. time in years would give the general relationships which are shown in Figures IX-1, IX-7, and IX-13 for Regions 1, 2, and 3 respectively. These figures show that more reserves were discovered or found in the first 10 years than the last 10 years. All three curves show a very sharp drop in reserve discovery for the first half, and a more gradual drop for the second half. Figures IX-2, IX-8, and IX-14 give the cumulative reserves vs. time for Regions 1, 2, and 3 respectively. For these curves the rate of increase is very steep for the first few years. However, the rate of increase decreases and is much more gradual over the remaining years. A plot of cumulative discovery rate which is a ratio of cumulative reserves discovered per foot drilled in Bcf/ft versus time in years is also another important relationship. These plots are shown in Figures IX-3, IX-9, and IX-15 for Regions 1, 2, and 3 respectively. These curves show that we have found more reserves per foot in the first half of the time period than the second half. These curves decrease steadily with greater decrease during the first ten years and lesser decrease during the latter periods. The slopes of these curves are not as great as those for the curves of increment reserves versus time.

Another approach is shown in Figures IX-4, IX-10, and IX-16 which give plots of increment reserves found versus footage for Region 1, 2, and 3 respectively. These curves

almost follow the same path as curves previously discussed for increment reserves vs. time. Again it can be seen that initially more reserves are found with less footage being drilled. The latter part of this time period, the slope of the curve decreases and the curve decreases more gradually. The plots of cumulative reserves found in Bcf of gas vs. footage are shown in Figures IX-5, IX-11, and IX-17 for Regions 1, 2, and 3 respectively. These curves rise more rapidly in the initial stages of drilling and the rate of increase goes much more gradually in the latter stages of drilling. The plots of cumulative discovery rate vs. cumulative footage are shown in Figures IX-6, IX-12, and IX-18 for Regions 1, 2, and 3 respectively. Initially the curve rises and we find more reserves per footage drilled, but after a while it starts decreasing almost at the same rate as it rose and continues to decrease all the way to the end of drilling activities.

The next sets of results and plots are from Table IX-4 which is the composite plot of all regions. Figure IX-19 shows the plot of increment reserves in Bcf of gas vs. time in years. This curve shows that when $t = 5$ years the maximum incremental reserves are found. This results from the values used for t_0 . It was equal to 2 years for Region 1, 4 years for Region 2 and 3 years for Region 3. Thus the value for incremental reserves of year 3 reflects only the initial contribution of Region 1; the increase in year 4 reflects the initial contribution from Region 3 which exceed

the decline in incremental reserves from Region 1; finally the increase in year 5 reflects the initial contribution from Region 2 which exceeds the combined declines from Regions 1 and 3. Exploration activities are not expanded into additional regions after year 4 and the decreases after year 5 reflect the combined declines from all three regions. For the period from $t = 5$ to $t = 20$ years the reserve discoveries decrease with sharper decreases from $t = 5$ to $t = 10$ years and more gradual decrease in reserve discoveries in the period from $t = 10$ to $t = 20$ years. Figure IX-20 is a composite plot of cumulative discoveries in Bcf of gas vs. time in years. This curve increases sharply from $t = 3$ to $t = 10$ years and then the rate of increase declines and the curve rises more gradually. The plot of cumulative discovery rate in Bcf of gas per foot drilled versus time is shown in Figure IX-21. This curve decreases steadily all the way through the whole period of investigation. A plot of increment reserve versus footage, Figure IX-22 shows almost the same response as the plot of increment reserve versus time, Figure IX-19. The plot of cumulative discovery versus cumulative footage, Figure IX-23, shows a very sharp increase in the initial stages of drilling, but it gets smoother as the drilling activities continue toward the later stages of exploration. The plot of cumulative discovery rate in Bcf of gas per foot drilled vs. cumulative footage, Figure IX-24, shows a steady drop almost through the whole course of the drilling activities.

Second Run

The results obtained from the second run are shown in Tables IX-5 to IX-8 and Figures IX-25 to IX-48. This run is based on the results of Case I of Phase one using the hyperbolic curve for future drilling activities. Tables IX-5, IX-6, and IX-7 are results for Regions 1, 2, and 3 respectively, and they are plotted in Figures IX-25 to IX-42. Table IX-8 and Figures IX-43 to IX-48 are results for all regions combined. For this run, all responses follow almost the same path as those for the first run and the results are in very close agreement with the results of that run. However, the response curves are to a smaller scale, the parameters such as increment footage, increment reserves, cumulative reserve, and cumulative footage are all almost 1/10 less than the same parameters for the first run. The most notable changes for this run can be seen by observing the plot of cumulative reserve vs. time, Figures IX-26, IX-32, and IX-38 for Regions 1, 2, and 3 respectively. For the second run, the rate of increase in cumulative reserves discoveries for the initial part is not as sharp as it was for the first run. Actually for this run the rate of increase is very steady all the way from $t = 3$ to $t = 20$ years. Another notable change for this run as compared to the first run is the plot of cumulative reserves vs. cumulative footage. The plot of cumulative reserves vs. footage for the second run is shown in Figures IX-29, IX-35, and IX-41 for

TABLE IX-5

Prediction of Future Discoveries for Region 1
(Case I)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.1904762E 07	0.7693504E C4	0.1904762E 07	0.7693504E C4	0.4039086E-02	0.4039086E-02
4	0.1731601E C7	0.6242094E 04	0.3636363E 07	0.1393560E 05	0.3604810E-02	0.3632290E-02
5	0.1581028E 07	0.4072734E C4	0.5217391E 07	0.1800833E 05	0.2576004E-02	0.3451597E-02
6	0.1449276E 07	0.1544539E 04	0.6666667E 07	0.1955267E 05	0.1068731E-02	0.2932930E-02
7	0.1233333E C7	0.8846719E 03	0.8000000E 07	0.2043754E 05	0.6635040E-03	0.2554693E-02
8	0.1230769E 07	0.2366223E C4	0.9230769E 07	0.2280377E C5	0.1922556E-02	0.2470408E-02
9	0.1139601E C7	0.1600863E 04	0.1037037E 08	0.2440463E 05	0.1404758E-02	0.2353303E-02
10	0.1058201E 07	0.1186879E C4	0.1142857E 08	0.2559151E C5	0.1121601E-02	0.2239257E-02
11	0.9852220E 06	0.1530977E 04	0.1241379E 08	0.2712248E 05	0.1553941E-02	0.2184867E-02
12	0.9195400E 06	0.1464816E C4	0.1233333E 08	0.2858730E 05	0.1592988E-02	0.2144048E-02
13	0.8602160E 06	0.1561480E 04	0.1419355E 08	0.3014877E C5	0.1815219E-02	0.2124118E-02
14	0.8064510E 06	0.1489316E C4	0.1500000E 08	0.3163810E 05	0.1846754E-02	0.2109206E-02
15	0.7575760E 06	0.9296289E 03	0.1575758E 08	0.3256773E C5	0.1227110E-02	0.2066798E-02
16	0.7130130E 06	0.8163392E C3	0.1647059E 08	0.3308407E 05	0.7241659E-03	0.2008675E-02
17	0.6722590E 06	0.4868320E C3	0.1714285E 08	0.3357050E C5	0.7241732E-03	0.1958303E-02
18	0.6349280E C6	0.7372344E 03	0.1777778E 08	0.3430813E 05	0.1161131E-02	0.1929833E-02
19	0.6005920E 06	0.7502930E C3	0.1837837E 08	0.3505843E 05	0.1249256E-02	0.1907592E-02
20	0.5689920E 06	0.7108203E 03	0.1894736E 08	0.3576925E 05	0.1249262E-02	0.1887822E-02

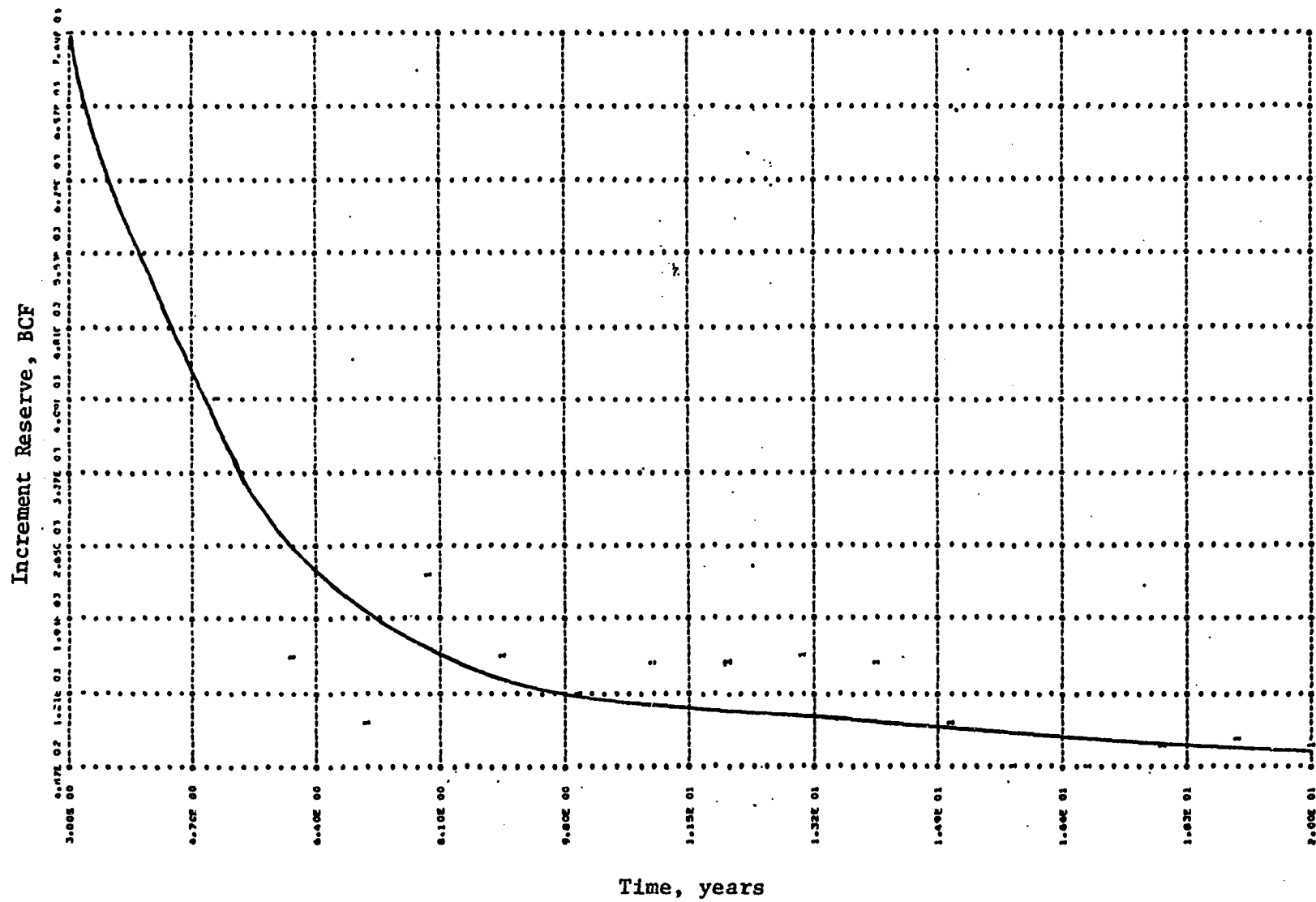


FIGURE IX-25. Plot of increment reserve vs. time for Region 1.
(Case I)

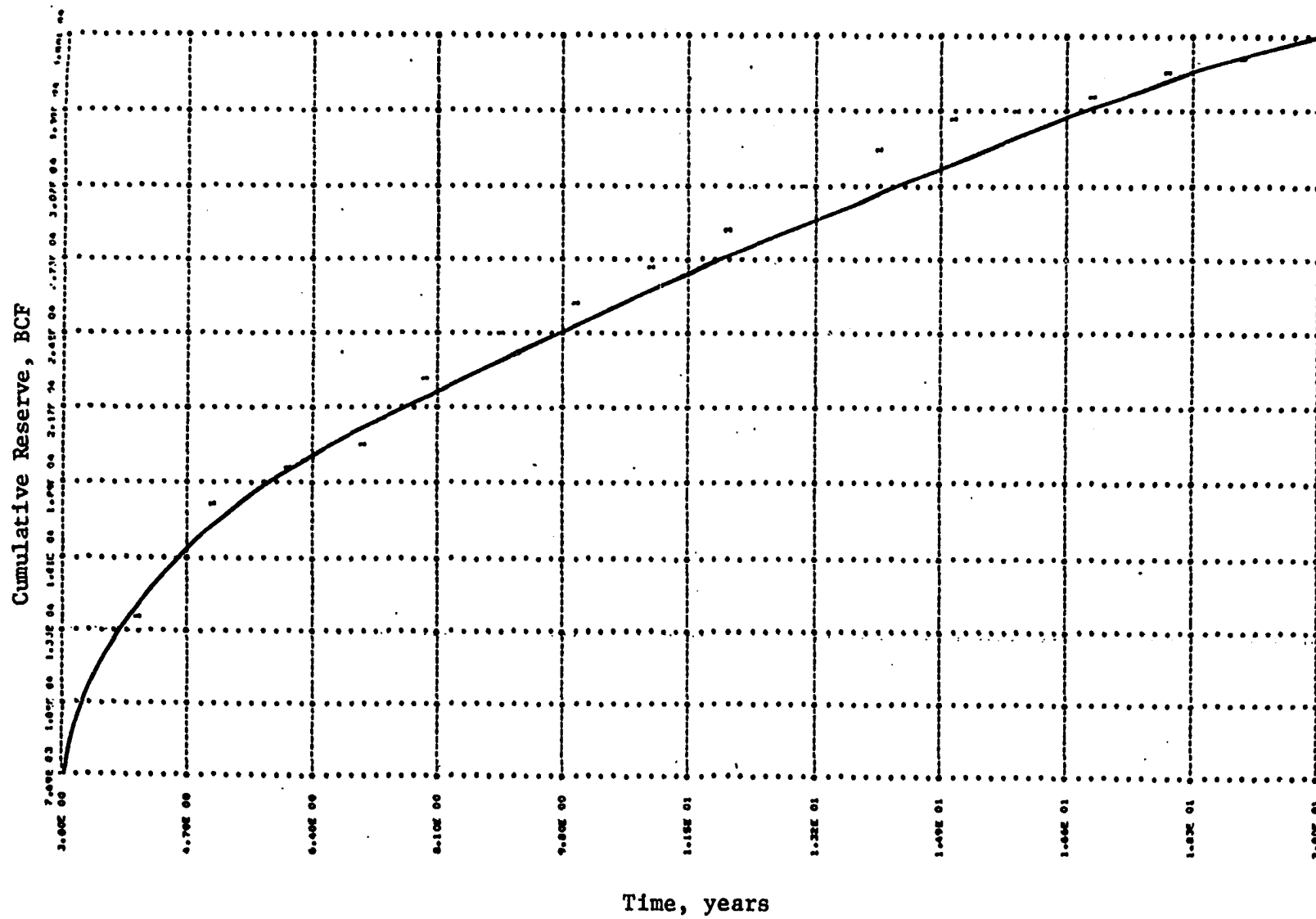


FIGURE IX-26. Plot of cumulative reserve vs. time for Region 1.
(Case I)

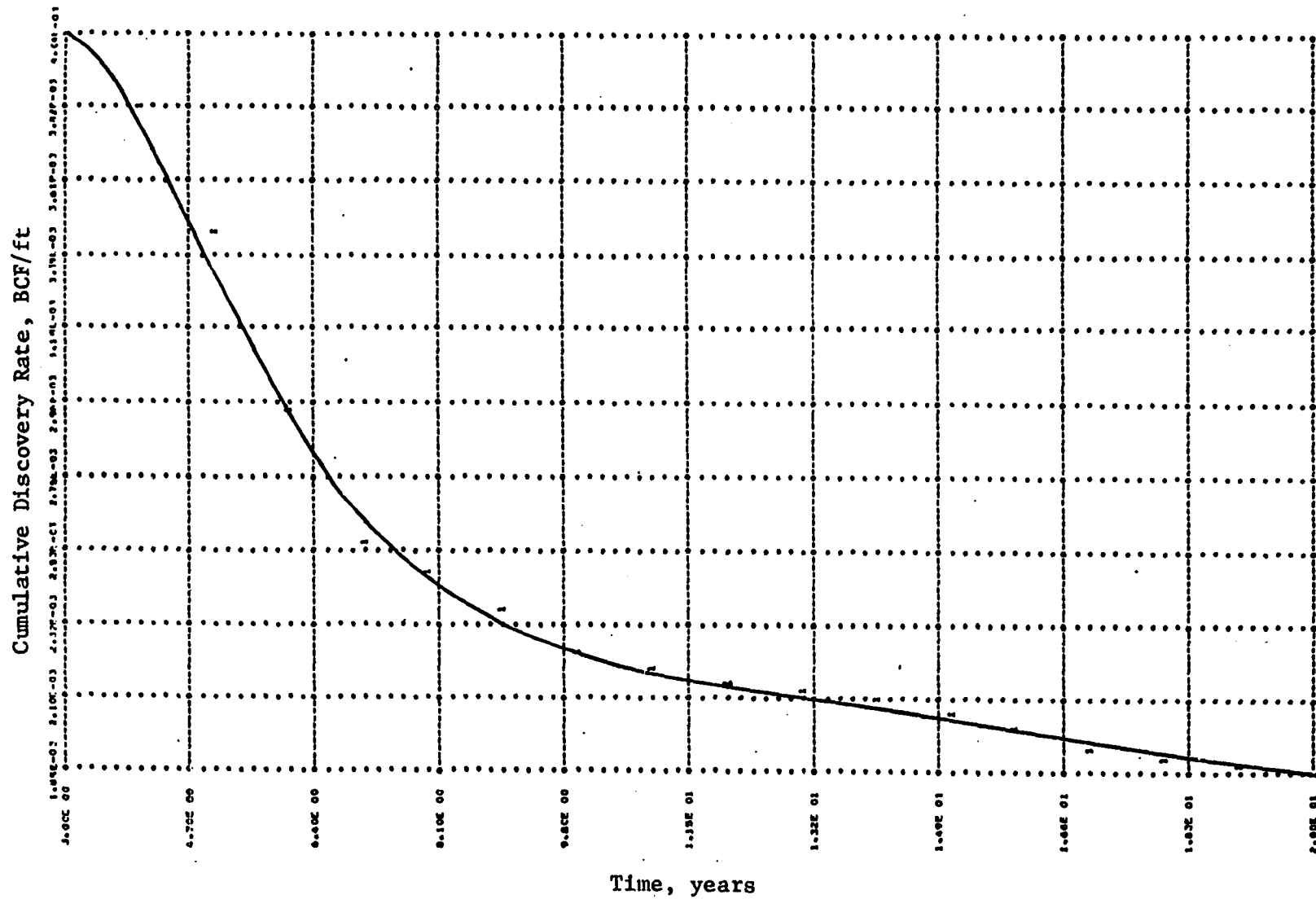


FIGURE IX-27. Plot of cumulative discovery rate vs. time for Region 1.
(Case I)

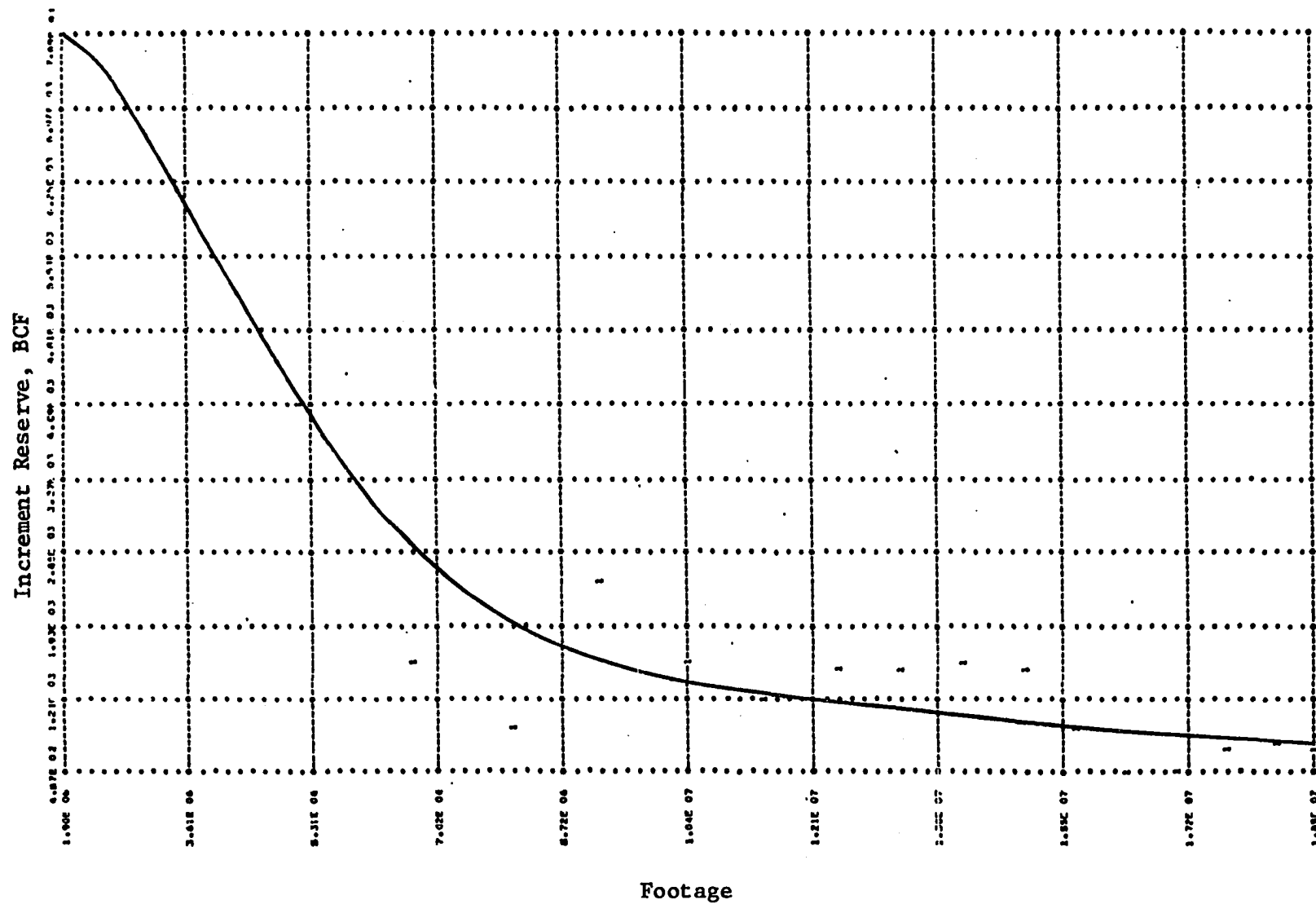


FIGURE IX-28. Plot of increment reserve vs. footage for Region 1.
(Case I)

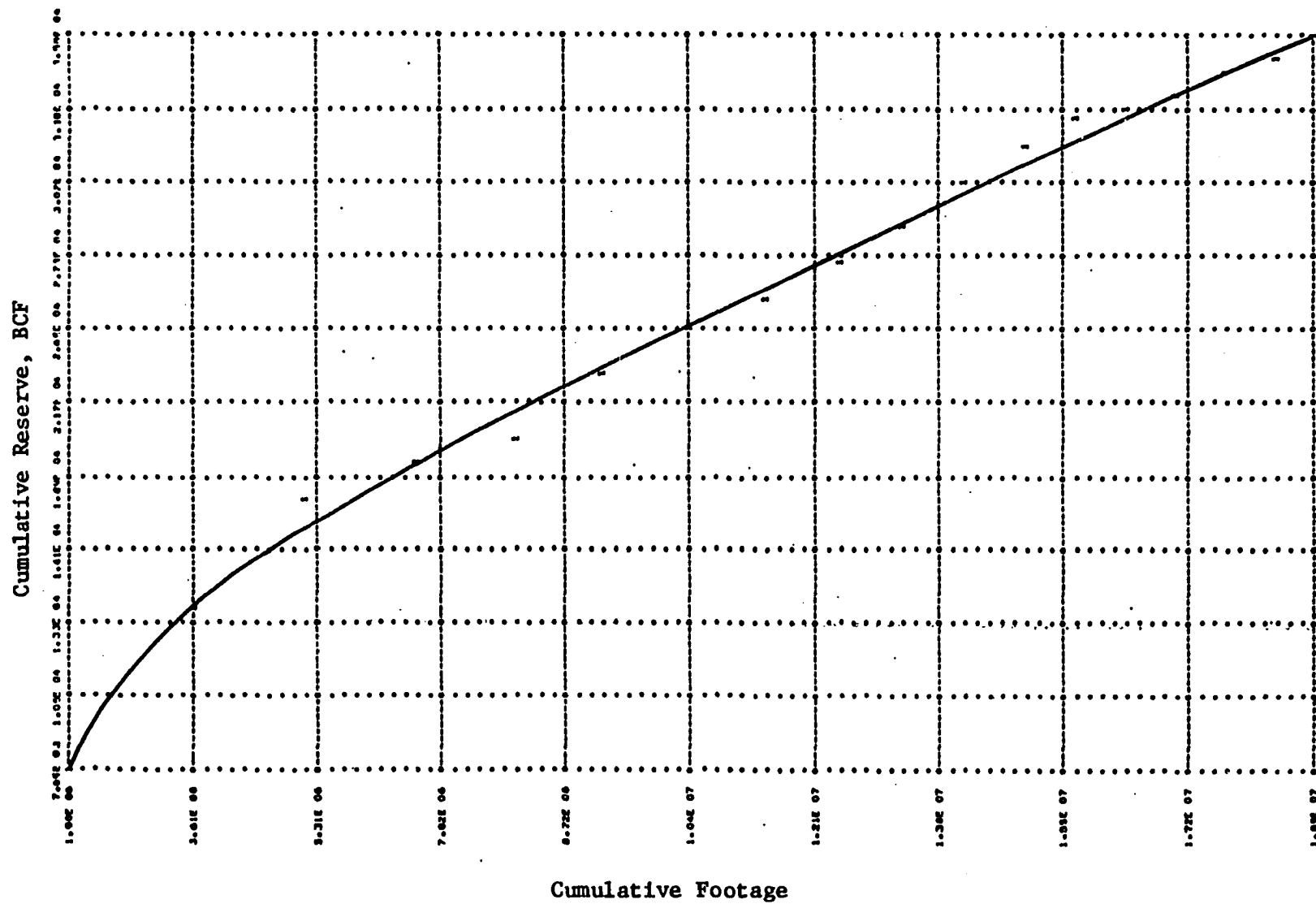


FIGURE IX-29. Plot of cumulative reserve vs. cumulative footage for Region 1.
(Case I)

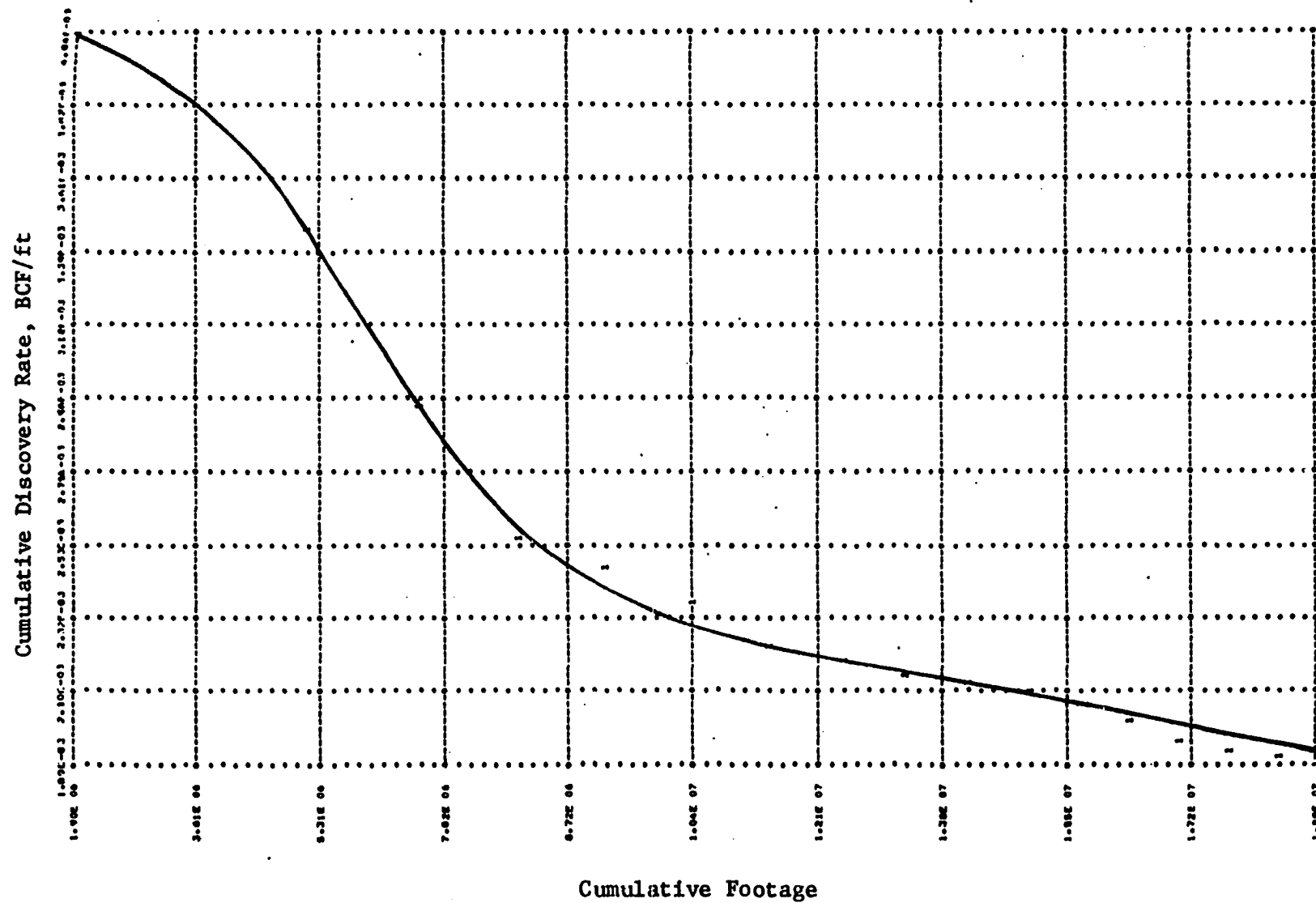


FIGURE IX-30. Plot of cumulative discovery rate vs. cumulative footage for Region 1.
(Case I)

TABLE IX-6

Prediction of Future Discoveries for Region 2
(Case 1)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
4	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
5	0.1918281E 07	0.7747605E 04	0.1918281E 07	0.7747605E 04	0.4038826E-02	0.4038826E-02
6	0.1767675E 07	0.6366605E 04	0.3685956E 07	0.1411421E 05	0.3601625E-02	0.3825187E-02
7	0.1634136E 07	0.4144863E 04	0.5320092E 07	0.1825502E 05	0.2536425E-02	0.3432098E-02
8	0.1515172E 07	0.1346027E 04	0.6835270E 07	0.1560511E 05	0.8883623E-03	0.2868227E-02
9	0.1402753E 07	0.1301566E 04	0.8244023E 07	0.2090669E 05	0.9239276E-03	0.2535982E-02
10	0.1313161E 07	0.2524629E 04	0.9557184E 07	0.2343132E 05	0.1922555E-02	0.2451697E-02
11	0.1224975E 07	0.1437418E 04	0.1078416E 08	0.2486874E 05	0.1171510E-02	0.2306042E-02
12	0.1149011E 07	0.1488125E 04	0.1193317E 08	0.2635686E 05	0.1295135E-02	0.2208705E-02
13	0.1078247E 07	0.1717633E 04	0.1301142E 08	0.2807450E 05	0.1592986E-02	0.2157681E-02
14	0.1013825E 07	0.1763465E 04	0.1402525E 08	0.2583756E 05	0.1739421E-02	0.2127447E-02
15	0.9550070E 06	0.1763664E 04	0.1498025E 08	0.3160163E 05	0.1846755E-02	0.2109552E-02
16	0.9011660E 06	0.1055781E 04	0.1588142E 08	0.3265741E 05	0.1171572E-02	0.2056328E-02
17	0.8517510E 06	0.6168125E 03	0.1673317E 08	0.3327422E 05	0.7241699E-03	0.1988519E-02
18	0.8062860E 06	0.7361875E 03	0.1753946E 08	0.3401041E 05	0.9130598E-03	0.1939080E-02
19	0.7643840E 06	0.9549102E 03	0.1830384E 08	0.3496532E 05	0.1249254E-02	0.1910272E-02
20	0.7256480E 06	0.9065234E 03	0.1902949E 08	0.3587164E 05	0.1249261E-02	0.1885066E-02

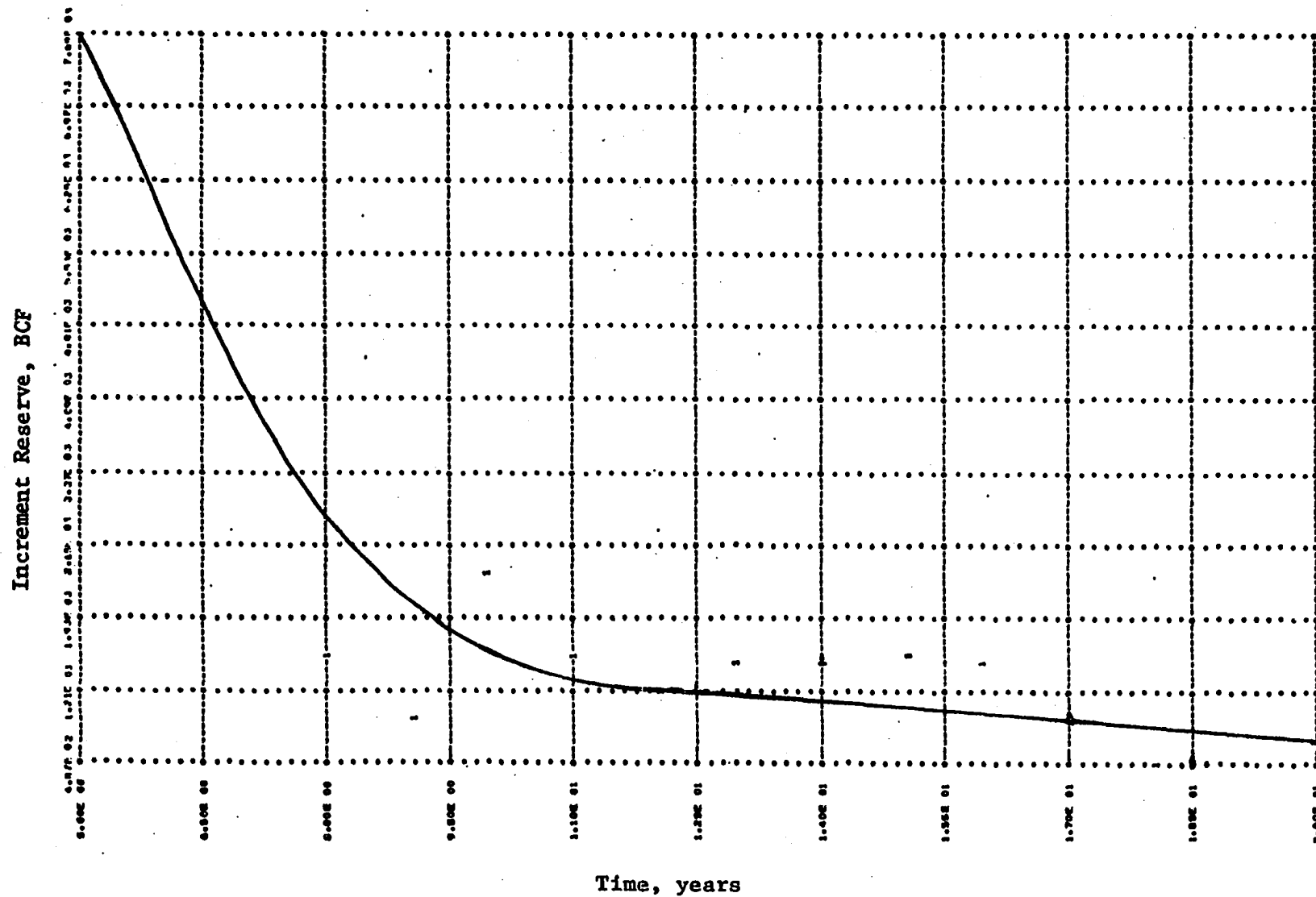


FIGURE IX-31. Plot of increment reserve vs. time for Region 2.
(Case I)

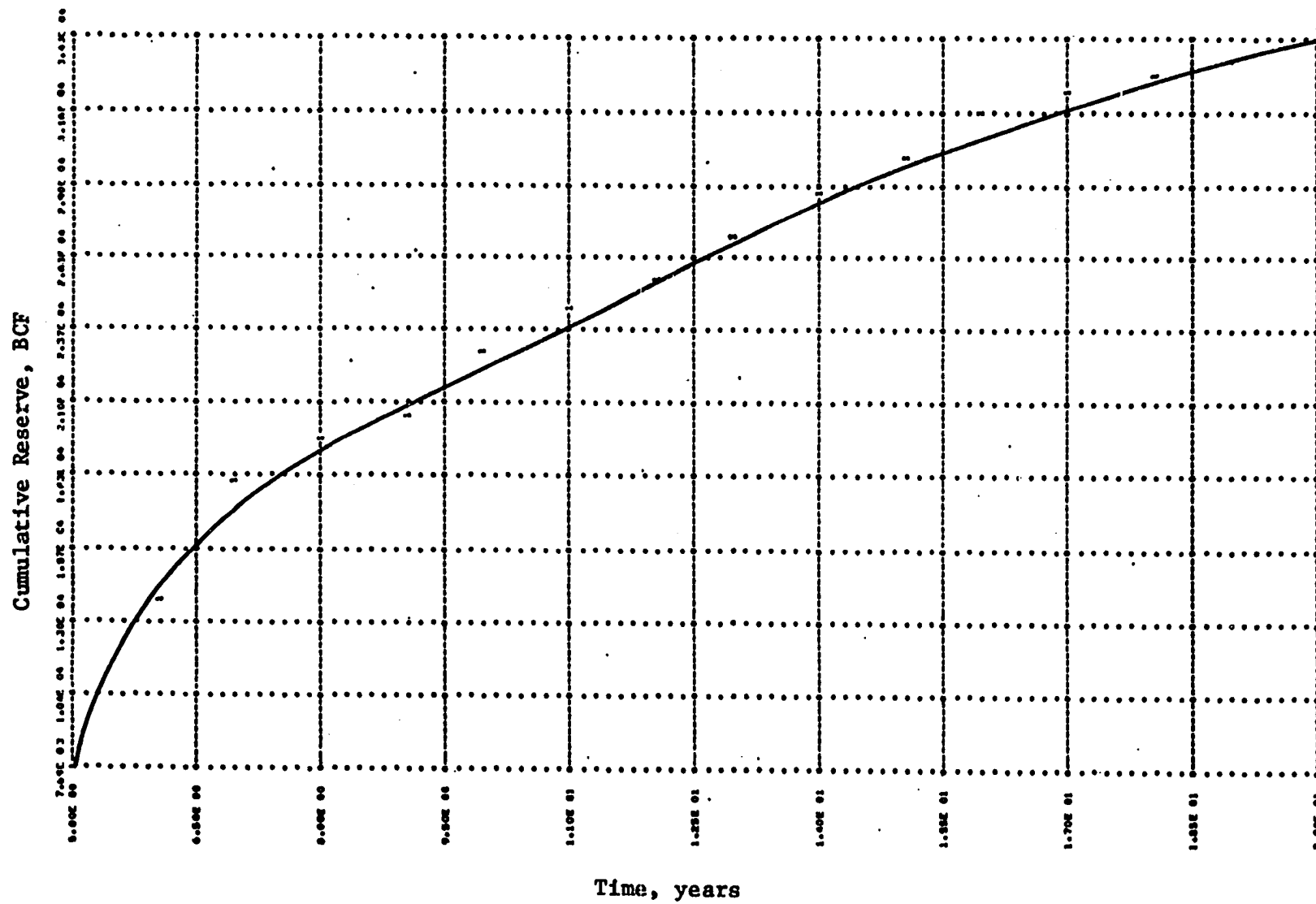


FIGURE IX-32. Plot of cumulative reserve vs. time for Region 2.
(Case I)

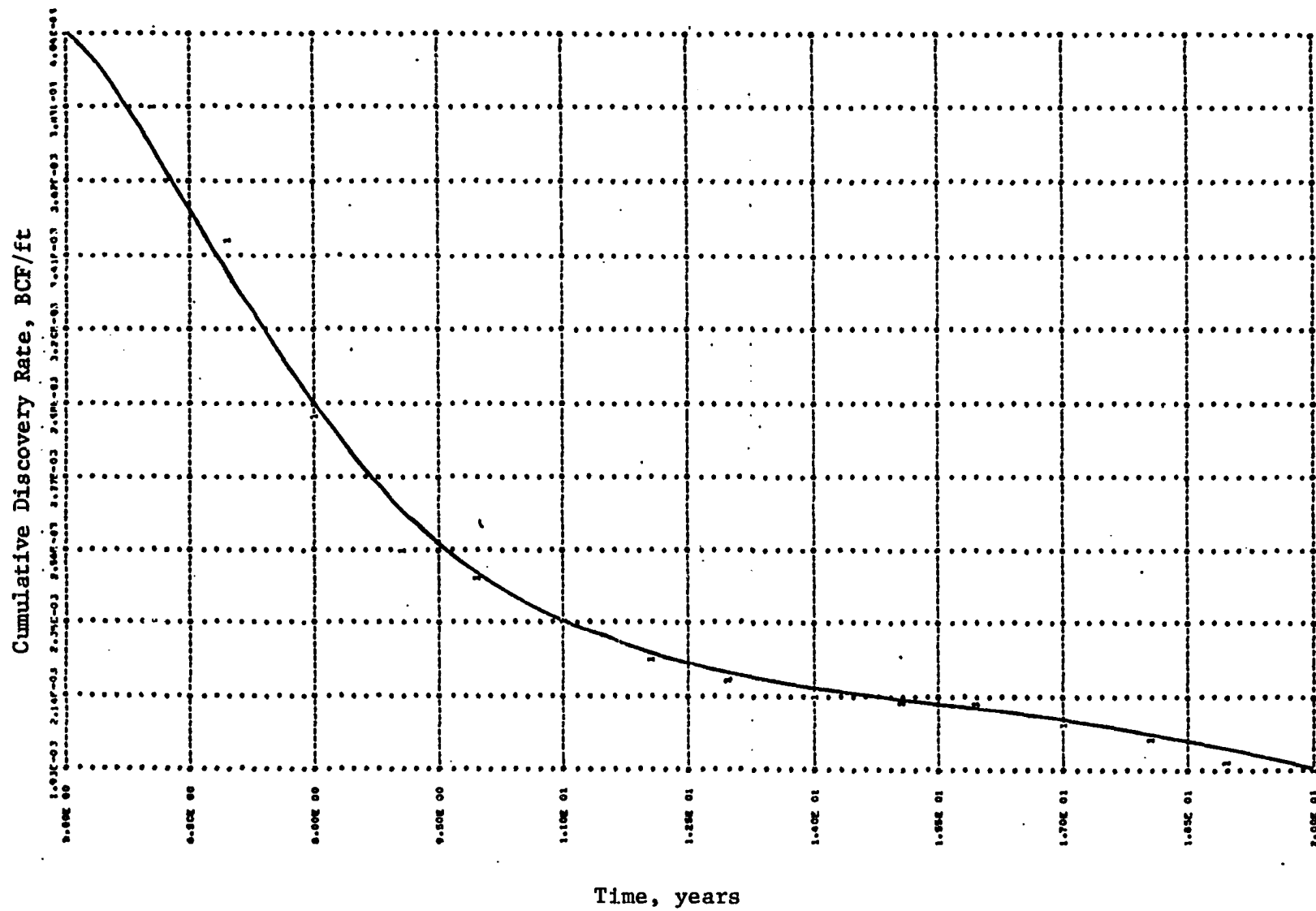


FIGURE IX-33. Plot of cumulative discovery rate vs. time for Region 2.
(Case I)

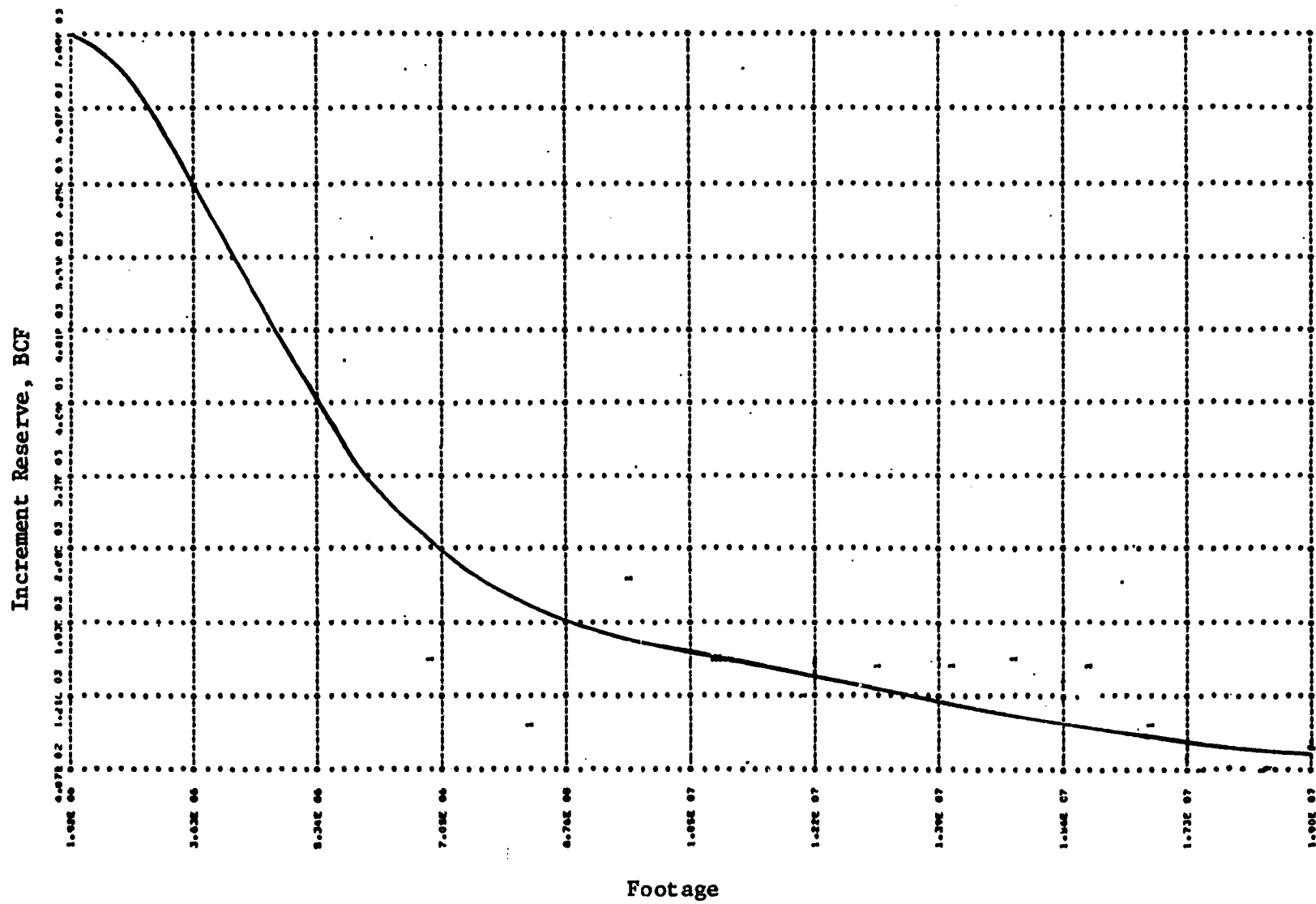


FIGURE IX-34. Plot of increment reserve vs. footage for Region 2.
(Case I)

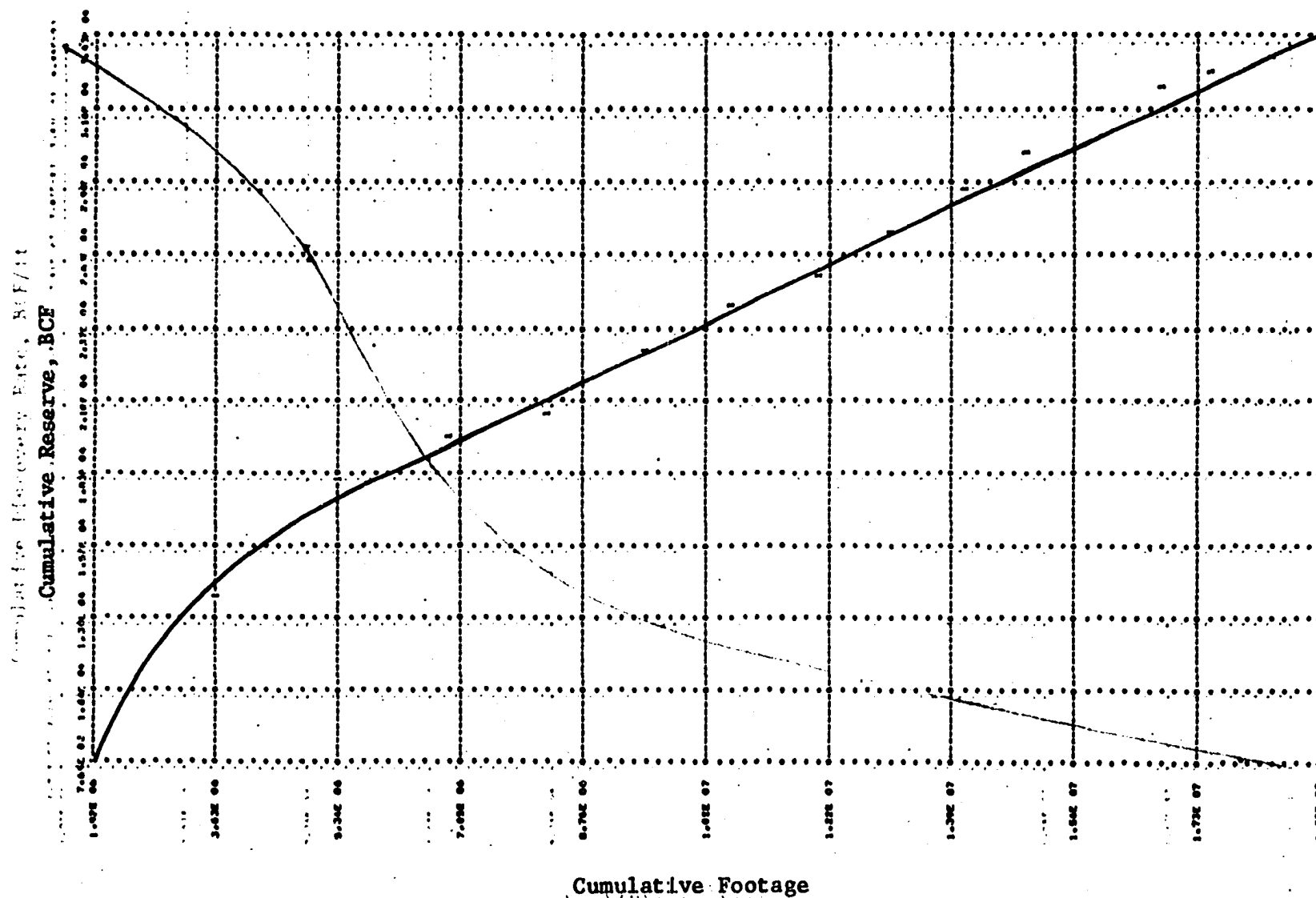


FIGURE IX-35. Plot of cumulative reserve vs. cumulative footage for Region 2.
(Case I)

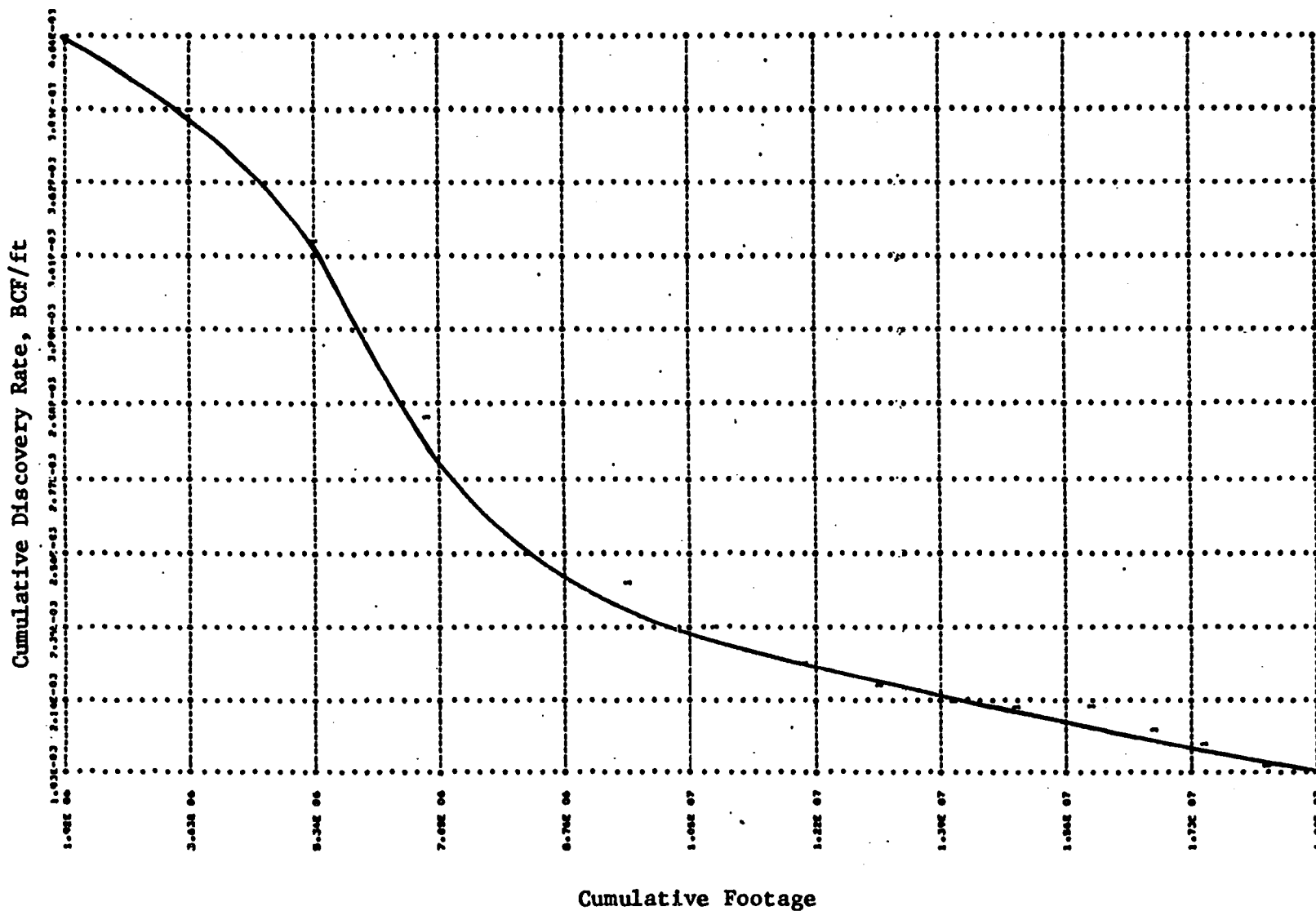


FIGURE IX-36. Plot of cumulative discovery rate vs. cumulative footage for Region 2.
(Case I)

TABLE IX-7

Prediction of Future Discoveries for Region 3
(Case I)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.191204E 07	0.772291E 04	0.191204E 07	0.772291E 04	0.403909E-02	0.403909E-02
5	0.175095E 07	0.630862E 04	0.366300E 07	0.140315E 05	0.360295E-02	0.383061E-02
6	0.160540E 07	0.411110E 04	0.527240E 07	0.181426E 05	0.255442E-02	0.344105E-02
7	0.148434E 07	0.143812E 04	0.675675E 07	0.155807E 05	0.968259E-03	0.289795E-02
8	0.137332E 07	0.110684E 04	0.813008E 07	0.206876E 05	0.805961E-03	0.284457E-02
9	0.127430E 07	0.244993E 04	0.940438E 07	0.231375E 05	0.192256E-02	0.246029E-02
10	0.118562E 07	0.151342E 04	0.105900E 08	0.246505E 05	0.127447E-02	0.232775E-02
11	0.110589E 07	0.132791E 04	0.116959E 08	0.259788E 05	0.120076E-02	0.222119E-02
12	0.103393E 07	0.164705E 04	0.127298E 08	0.276255E 05	0.159299E-02	0.217017E-02
13	0.965787E 06	0.160884E 04	0.136986E 08	0.292347E 05	0.166067E-02	0.213413E-02
14	0.909803E 06	0.167981E 04	0.146082E 08	0.309146E 05	0.184675E-02	0.211624E-02
15	0.855623E 06	0.144046E 04	0.154639E 08	0.323550E 05	0.148340E-02	0.209229E-02
16	0.806421E 06	0.583988E 03	0.162703E 08	0.329395E 05	0.724172E-03	0.202449E-02
17	0.761278E 06	0.551293E 03	0.170316E 08	0.334903E 05	0.724167E-03	0.196636E-02
18	0.719856E 06	0.784928E 03	0.177514E 08	0.342752E 05	0.109039E-02	0.193084E-02
19	0.681696E 06	0.851613E 03	0.184331E 08	0.351266E 05	0.124925E-02	0.190563E-02
20	0.646512E 06	0.807660E 03	0.190796E 08	0.359345E 05	0.124925E-02	0.188339E-02

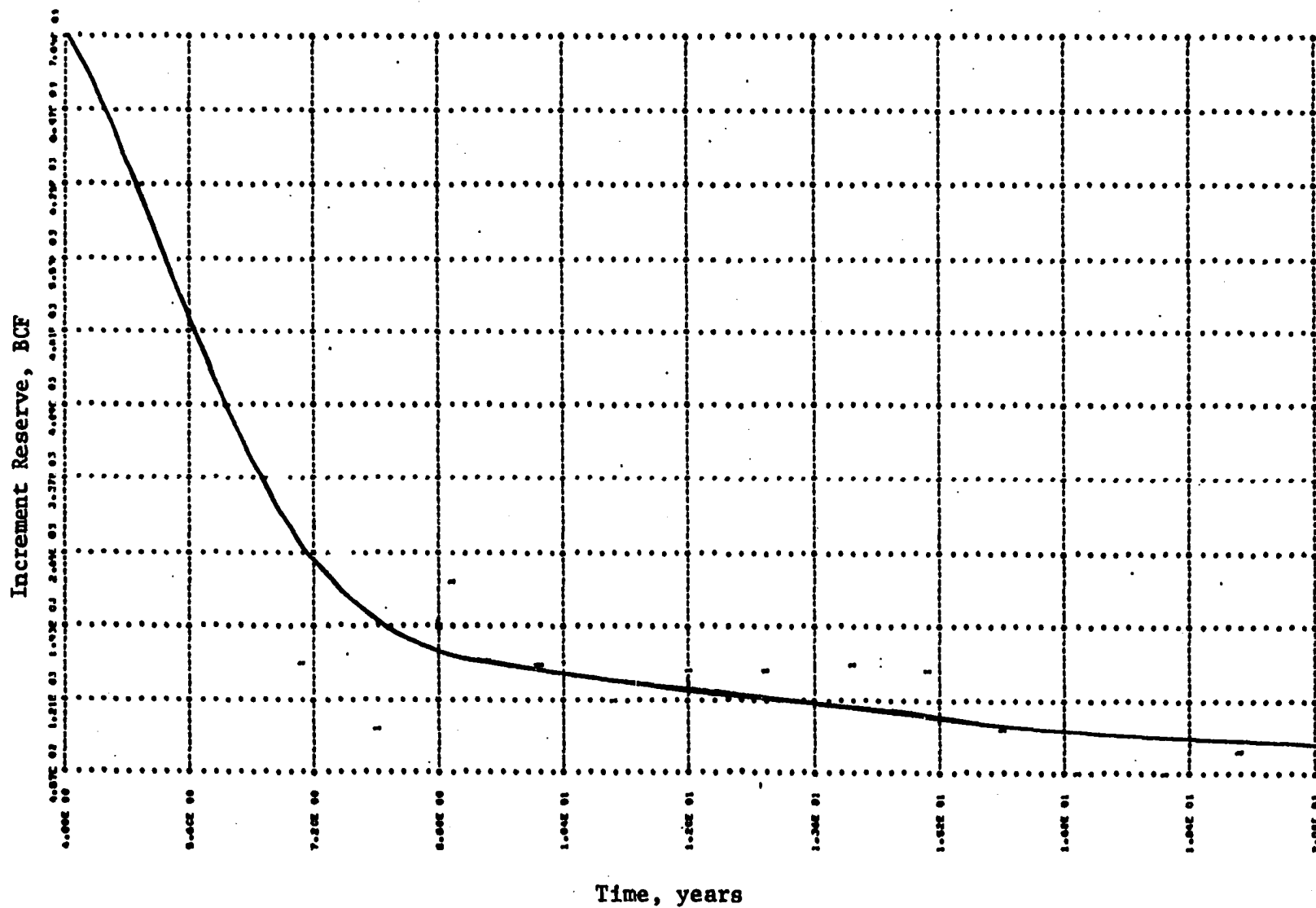


FIGURE IX-37'. Plot of increment reserve vs. time for Region 3.
(Case I)

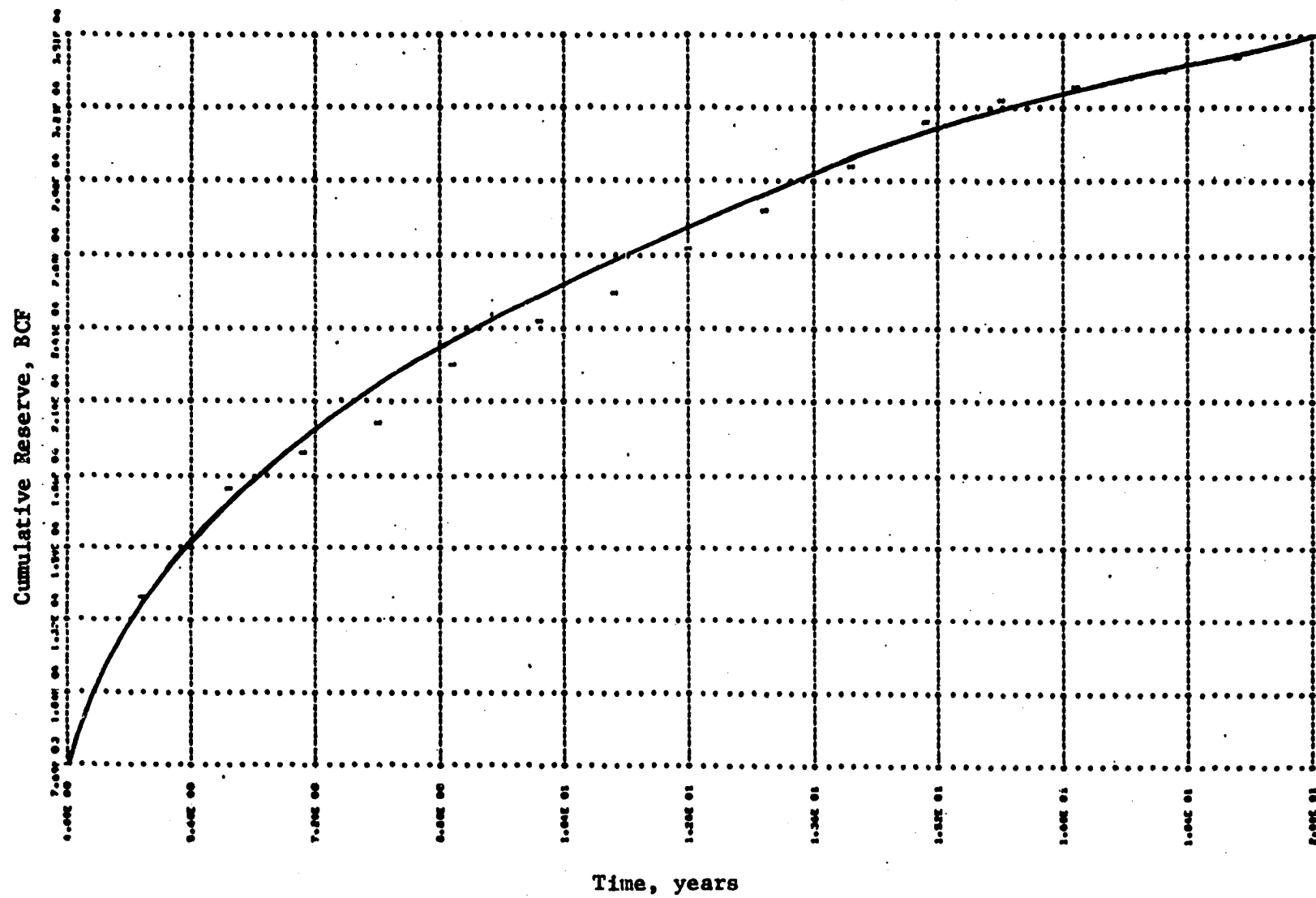


FIGURE IX-38. Plot of cumulative reserve vs. time for Region 3.
(Case I)

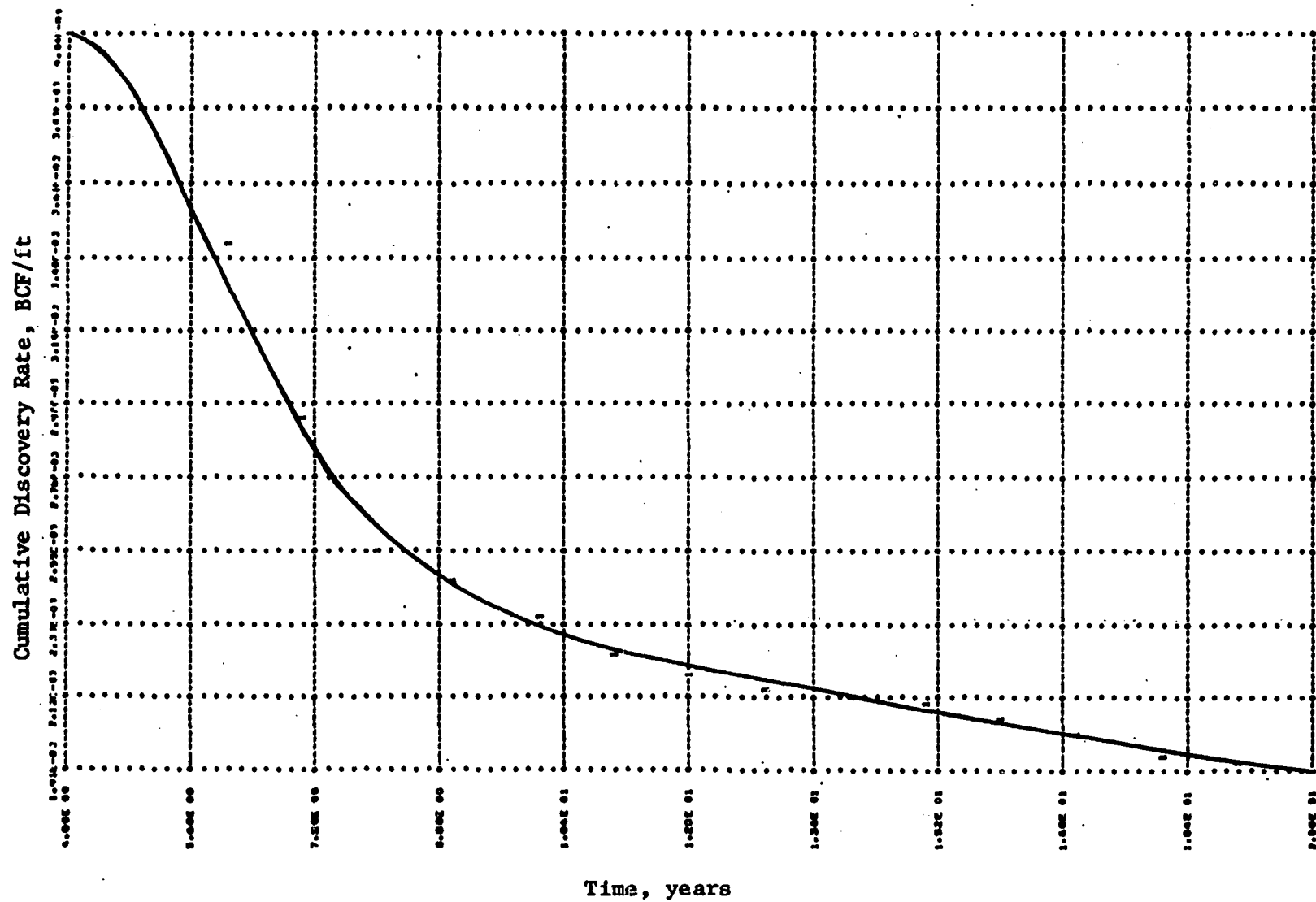


FIGURE IX-39. Plot of cumulative discovery rate vs. time for Region 3.
(Case I)

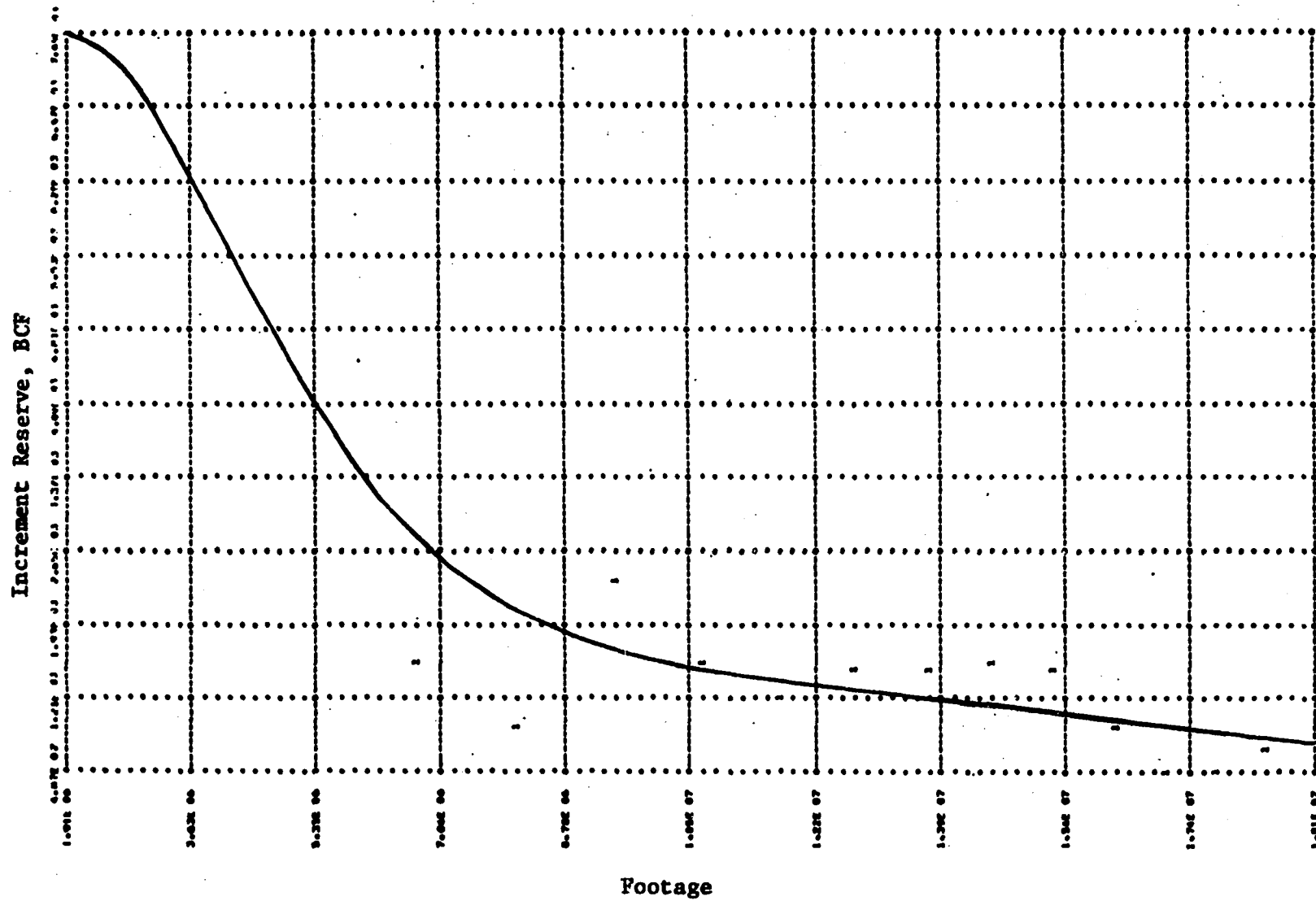


FIGURE IX-40. Plot of increment reserve vs. footage for Region 3.
(Case I)

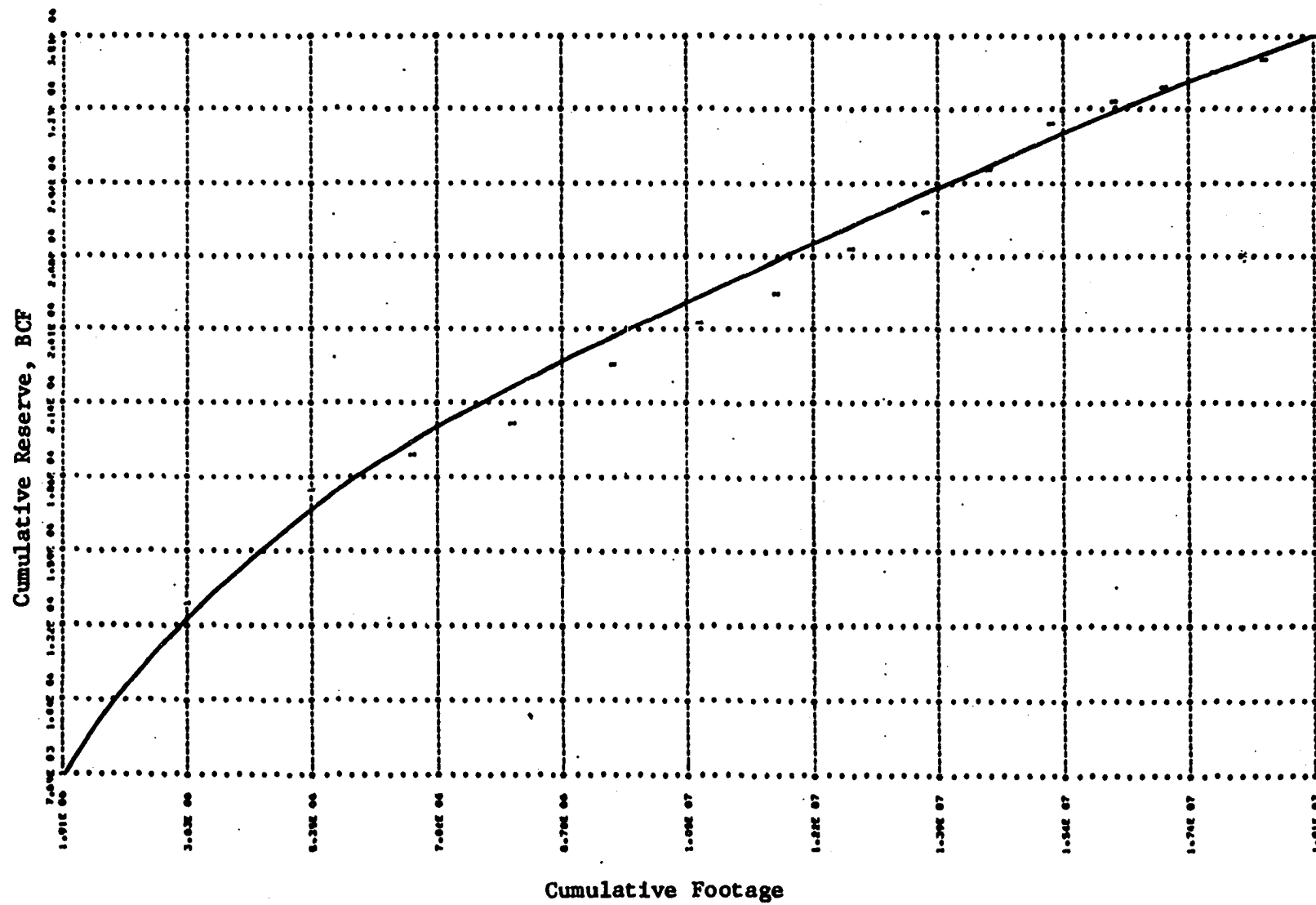


FIGURE IX-41. Plot of cumulative reserve vs. cumulative footage for Region 3.
(Case I)

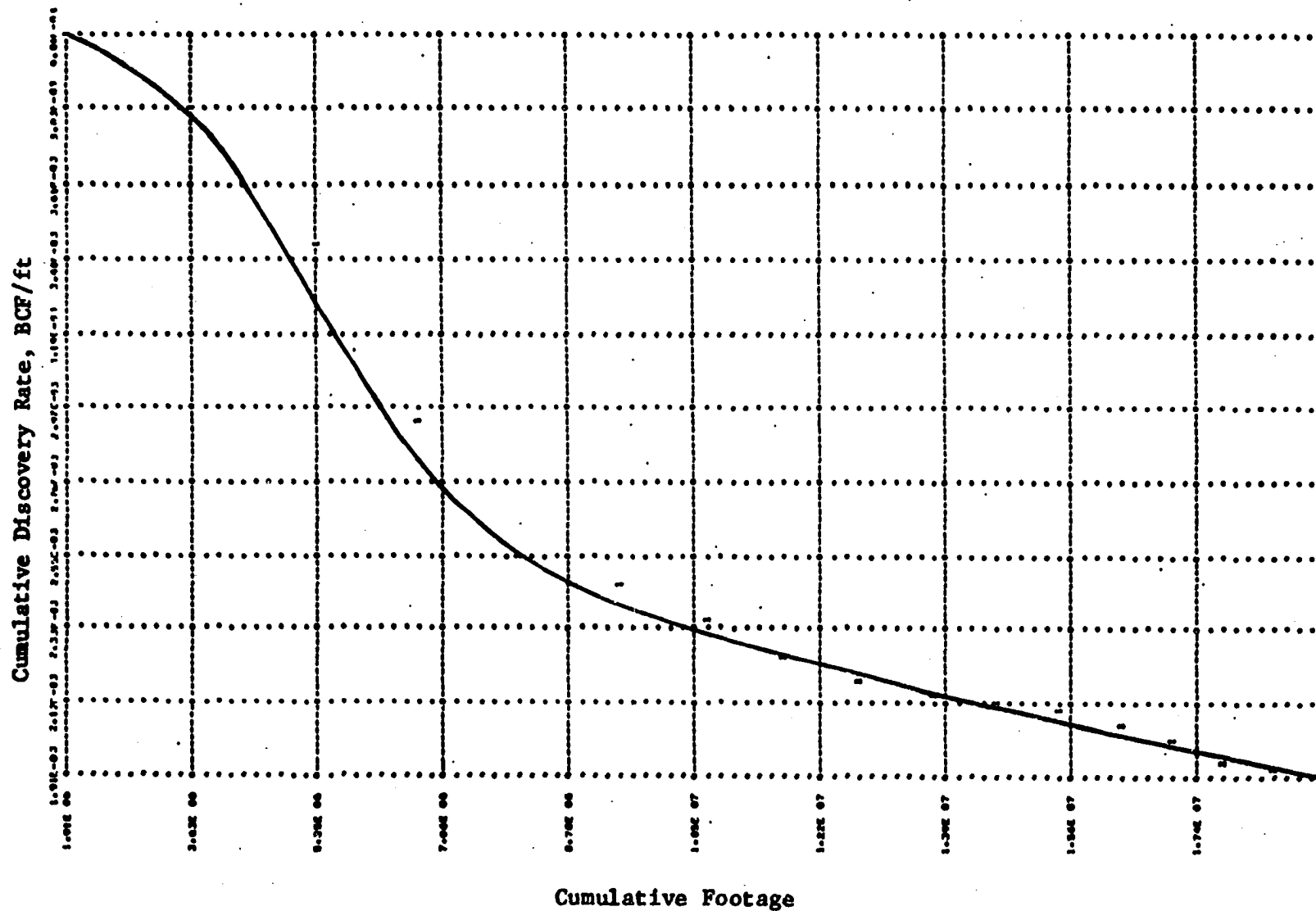


FIGURE IX-42. Plot of cumulative discovery rate vs. cumulative footage for Region 3.
(Case I)

TABLE IX-8

Composite Parameters for all k Basins
(Case I, Hyperbolic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.1904762E 07	0.7693504E 04	0.1904762E 07	0.7693504E 04	0.4039086E-02	0.4039086E-02
4	0.3643646E 07	0.1396501E 05	0.5548408E 07	0.2165852E 05	0.3932703E-02	0.3903555E-02
5	0.5250267E 07	0.1812897E 05	0.1079868E 08	0.3972748E 05	0.3452961E-02	0.3644478E-02
6	0.4626356E 07	0.1202226E 05	0.1562503E 08	0.5180974E 05	0.2490960E-02	0.3315217E-02
7	0.4451817E 07	0.6467660E 04	0.2007685E 08	0.5627740E 05	0.1452813E-02	0.2902717E-02
8	0.4119264E 07	0.4819098E 04	0.2419611E 08	0.6309650E 05	0.1169893E-02	0.2607712E-02
9	0.3822656E 07	0.5352375E 04	0.2801977E 08	0.6844888E 05	0.1400172E-02	0.2442965E-02
10	0.3556992E 07	0.5224938E 04	0.3127576E 08	0.7367381E 05	0.1468920E-02	0.233239E-02
11	0.3318096E 07	0.4296250E 04	0.3469386E 08	0.7797006E 05	0.1294794E-02	0.2214492E-02
12	0.3102480E 07	0.4600000E 04	0.3799634E 08	0.8257006E 05	0.1482685E-02	0.2173106E-02
13	0.2907248E 07	0.4888000E 04	0.4090358E 08	0.8745806E 05	0.1681315E-02	0.2138152E-02
14	0.2729872E 07	0.4932563E 04	0.4363346E 08	0.9239083E 05	0.1806884E-02	0.2117426E-02
15	0.2568272E 07	0.4133750E 04	0.4620173E 08	0.9652438E 05	0.1609548E-02	0.2099194E-02
16	0.2420608E 07	0.2156063E 04	0.4862234E 08	0.9868044E 05	0.8907111E-03	0.2029529E-02
17	0.2285296E 07	0.1654938E 04	0.5090763E 08	0.1003354E 06	0.7241674E-03	0.1970930E-02
18	0.2161072E 07	0.2288375E 04	0.5306870E 08	0.1025938E 06	0.1045025E-02	0.1933225E-02
19	0.2046672E 07	0.2556813E 04	0.5511538E 08	0.1051506E 06	0.1249254E-02	0.1907826E-02
20	0.1941152E 07	0.2420000E 04	0.5705653E 08	0.1075786E 06	0.1249258E-02	0.1885421E-02

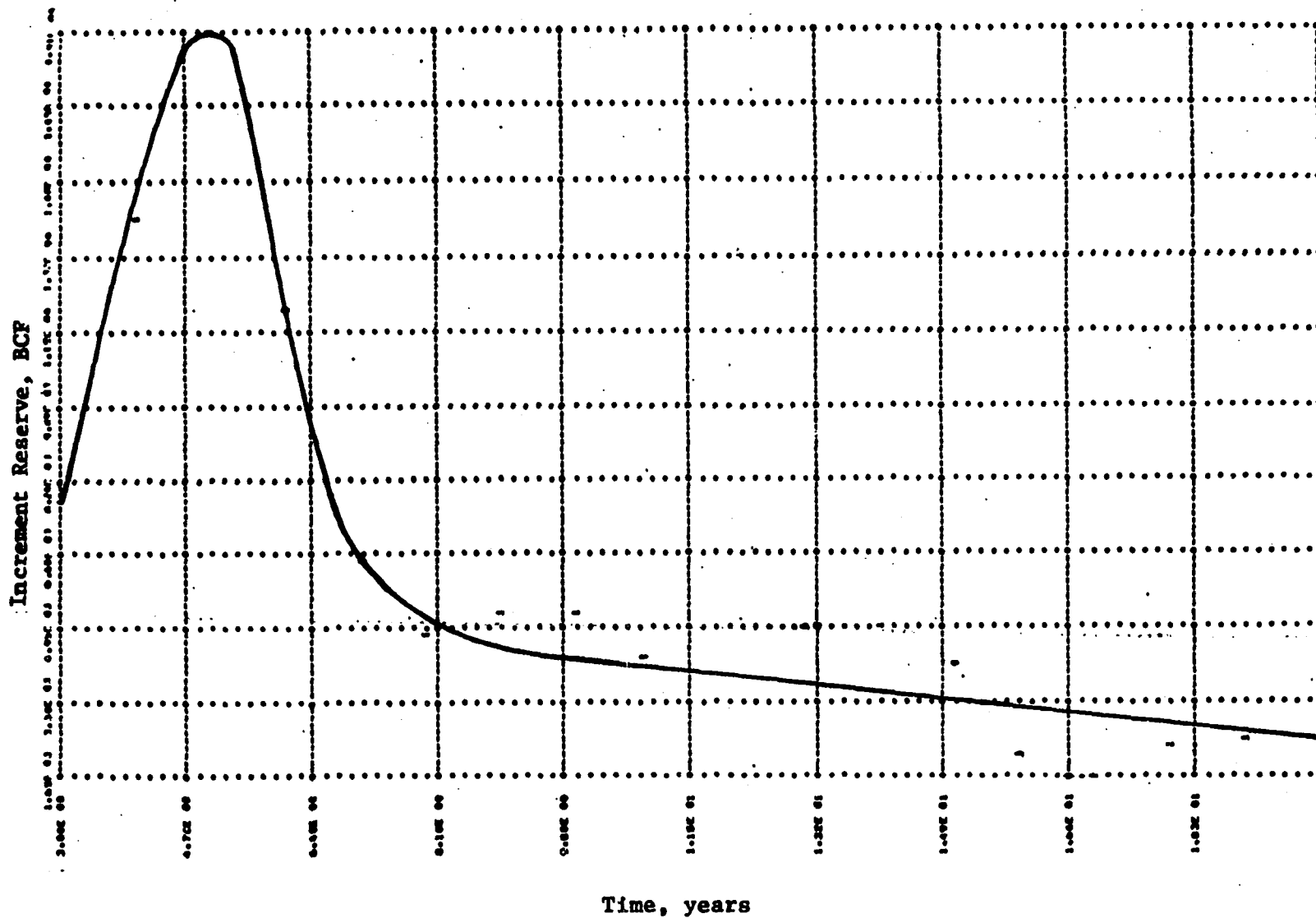


FIGURE IX-43. Composite plot of increment reserve vs. time.
(Case I, Hyperbolic Curve)

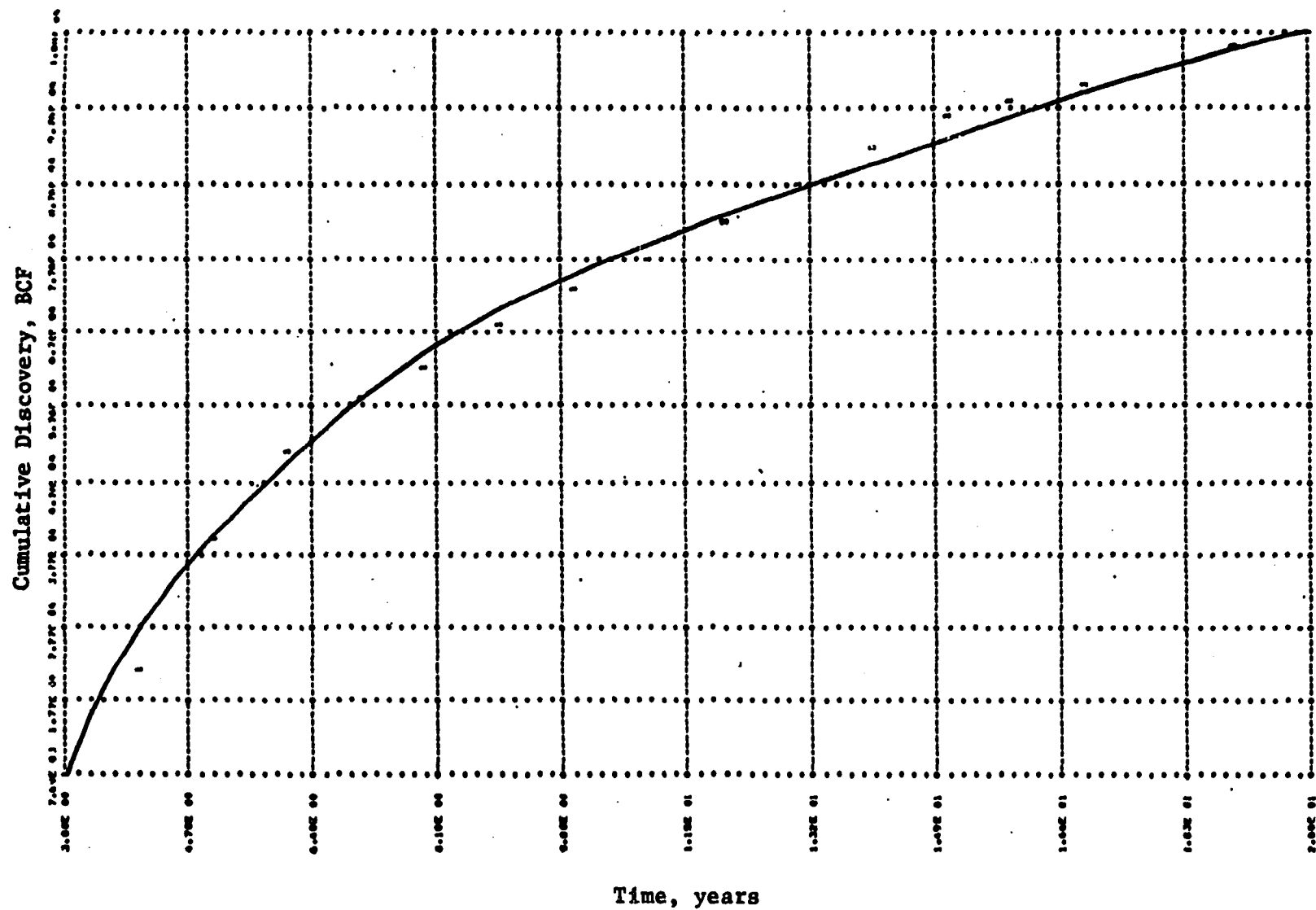


FIGURE IX-44. Composite plot of cumulative discovery vs. time.
(Case I, Hyperbolic Curve)

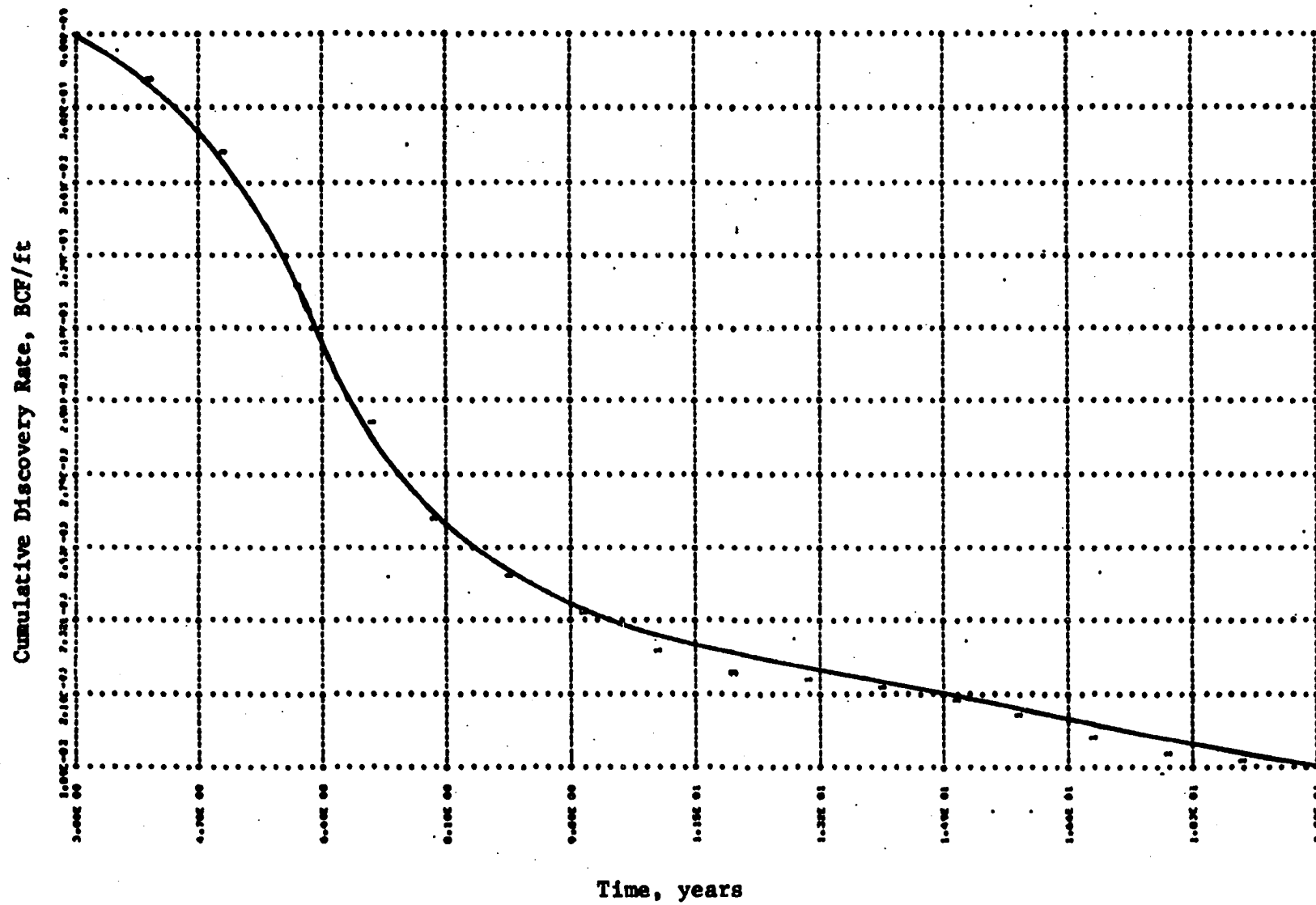


FIGURE IX-45. Composite plot of cumulative discovery rate vs. time.
(Case I, Hyperbolic Curve)

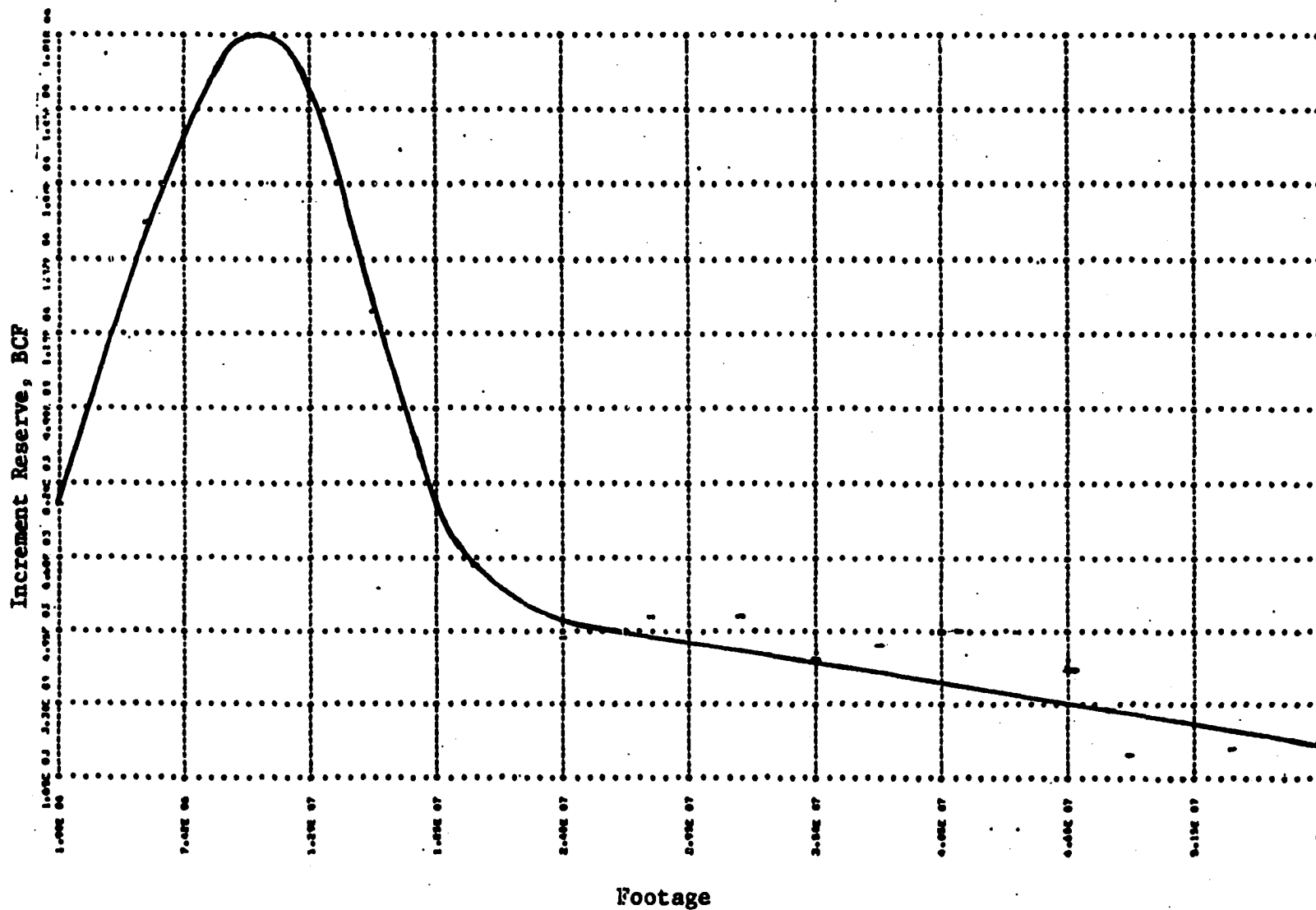


FIGURE IX-46. Composite plot of increment reserve vs. footage.
(Case I, Hyperbolic Curve)

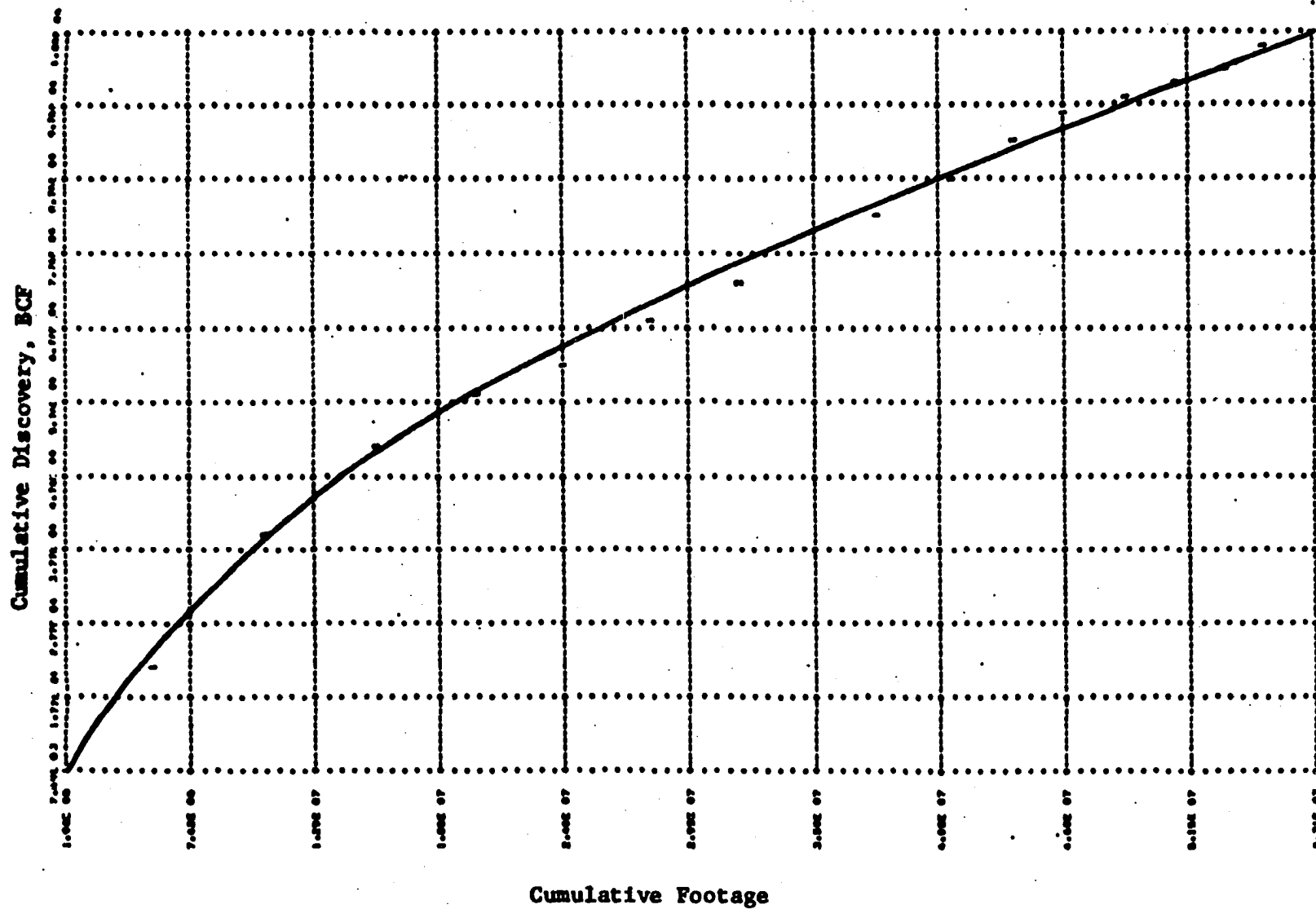


FIGURE IX-47. Composite plot of cumulative discovery vs. cumulative footage.
(Case I, Hyperbolic Curve)

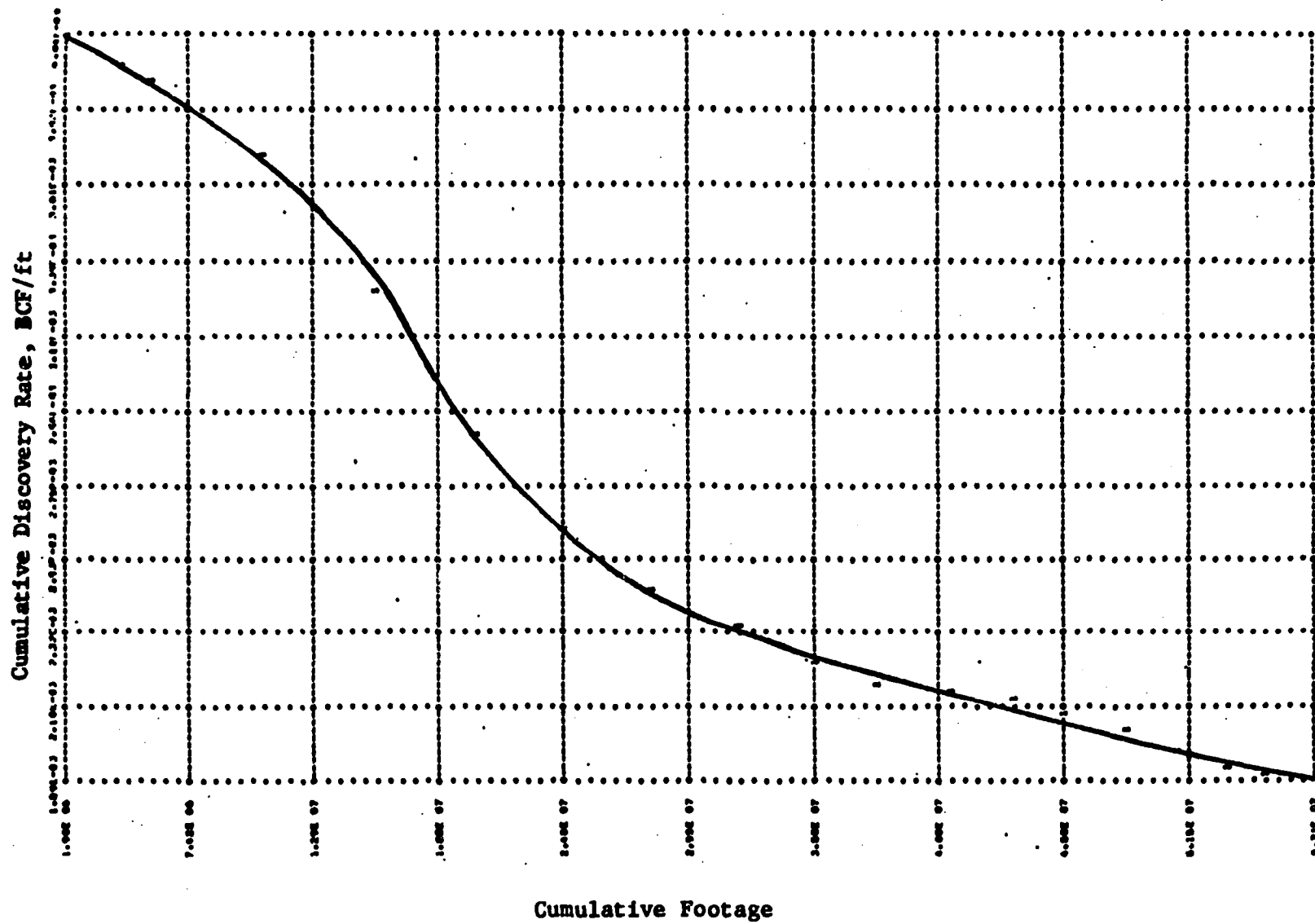


FIGURE IX-48. Composite plot of cumulative discovery rate vs. cumulative footage.
(Case I, Hyperbolic Curve)

Regions 1, 2, and 3 respectively. Here again the rate of increase in the initial or first half of drilling activities is not as great as that on the first run. The rate of increase for the second run is steady through the whole course of drilling activities. Another notable change for this run as compared to the first run is shown on the plot of cumulative discovery rate vs. cumulative footage. The plots of cumulative discovery rate vs. cumulative footage for the second run are shown in Figures IX-30, IX-36, and IX-42 for Regions 1, 2, and 3 respectively. The curves for this run initially are not dropping as rapidly as the curves for the first run. Comparison of the results of composite parameters for this run to those for the first run indicates that the most notable changes occur in plots of cumulative discovery vs. either time or cumulative footage and also the plot of cumulative discovery rate vs. cumulative footage. The plots of cumulative discovery vs. time or vs. footage for this run are shown in Figures IX-44 and IX-47 respectively. These curves do not increase as fast or as sharply as the corresponding curves in the first run and the rate of increase for these curves is steady all the way through the whole period of drilling activities. The plot of cumulative discovery rate vs. cumulative footage for this run is shown in Figure IX-48. This curve is not dropping or decreasing as smoothly as the corresponding curve for the first run.

Third Run

The results obtained from the third run are shown in Tables IX-9 to IX-12 and Figures IX-49 to IX-72. This run is based on the results of Case II of Phase one using the hyperbolic curve for future drilling activities. Tables IX-9, IX-10, and IX-11 are results for Regions 1, 2, and 3 respectively, and they are plotted in Figures IX-49 to IX-66. Table IX-12 and Figures IX-67 to IX-72 are results for all (three) regions combined. For this run we can observe almost the same response as that from the last two runs with the exception of few plots. But as a whole almost the same conclusions can be drawn for this run as for the last two runs except for minor differences and changes. One of the most notable changes in this run as compared with the last two runs lies in the plots of cumulative reserves versus either time or cumulative footage. The plots of cumulative reserves vs. time are shown in Figures IX-50, IX-56, and IX-62 and vs. cumulative footage are shown in Figures IX-53, IX-59, IX-65 for Regions 1, 2, and 3 respectively. The changes on these curves for this run compared to the curves for the previous run are reflected primarily in the rate of increase of the curve in the initial stages or first half. For this run the rate of increase of these curves is not as sharp as that of the curves for the first run, but they are sharper than the curves for the second run. Thus, the rate of increase for the curves of this run lies between those for the

TABLE IX-9

Prediction of Future Discoveries for Region 1
(Case II)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.1004742E 07	0.7693804E 04	0.1004742E 07	0.7693804E 04	0.4039086E-02	0.4039086E-02
4	0.1731601E 07	0.5356621E 04	0.3636343E 07	0.1304813E 05	0.3092295E-02	0.3598235E-02
5	0.1591020E 07	0.2027614E 04	0.5217391E 07	0.1507554E 05	0.1262339E-02	0.2899474E-02
6	0.1649276E 07	0.6650039E 03	0.6866467E 07	0.1274054E 05	0.4555524E-03	0.2341081E-02
7	0.1333333E 07	0.3107734E 03	0.8000000E 07	0.1605132E 05	0.2330801E-03	0.2006414E-02
8	0.1230769E 07	0.7109922E 03	0.9230769E 07	0.1672231E 05	0.5774812E-03	0.1815917E-02
9	0.1134601E 07	0.4216543E 03	0.1037037E 08	0.1718356E 05	0.3700033E-03	0.1657025E-02
10	0.1058201E 07	0.2713672E 03	0.1142057E 08	0.1745533E 05	0.2544420E-03	0.1527342E-02
11	0.4052220E 06	0.5407969E 03	0.1241379E 08	0.1799613E 05	0.5489089E-03	0.1449688E-02
12	0.519260E 06	0.5290382E 03	0.1333333E 08	0.1852516E 05	0.5753257E-03	0.1399327E-02
13	0.6602160E 06	0.5224922E 03	0.1419355E 08	0.1904726E 05	0.6073945E-03	0.1341994E-02
14	0.8066510E 06	0.4935070E 03	0.1500000E 08	0.1954116E 05	0.6119499E-03	0.1302744E-02
15	0.7575760E 06	0.4124003E 03	0.1275750E 08	0.1995327E 05	0.5443760E-03	0.1266294E-02
16	0.7130130E 06	0.3490430E 03	0.1647059E 08	0.2030261E 05	0.4895322E-03	0.1232659E-02
17	0.6722590E 06	0.320090E 03	0.1714285E 08	0.2063170E 05	0.4895283E-03	0.1203516E-02
18	0.6349280E 06	0.2473633E 03	0.1777778E 08	0.2087907E 05	0.3295925E-03	0.1174449E-02
19	0.6088920E 06	0.2210780E 03	0.1837037E 08	0.2110095E 05	0.3494335E-03	0.1148140E-02
20	0.5809920E 06	0.2102031E 03	0.1894736E 08	0.2131112E 05	0.3694305E-03	0.1124755E-02

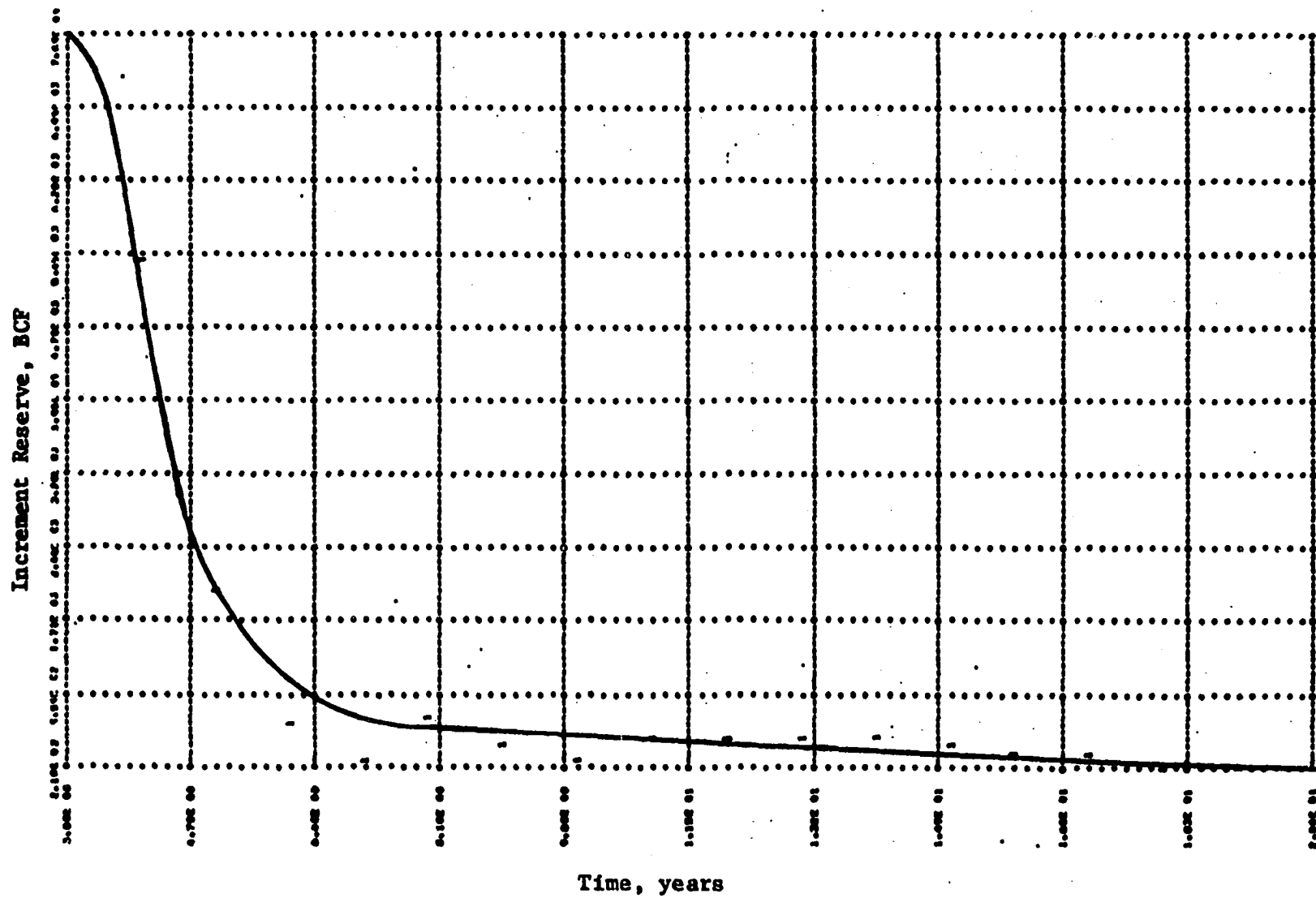


FIGURE IX-49. Plot of increment reserve vs. time for Region 1.
(Case II)

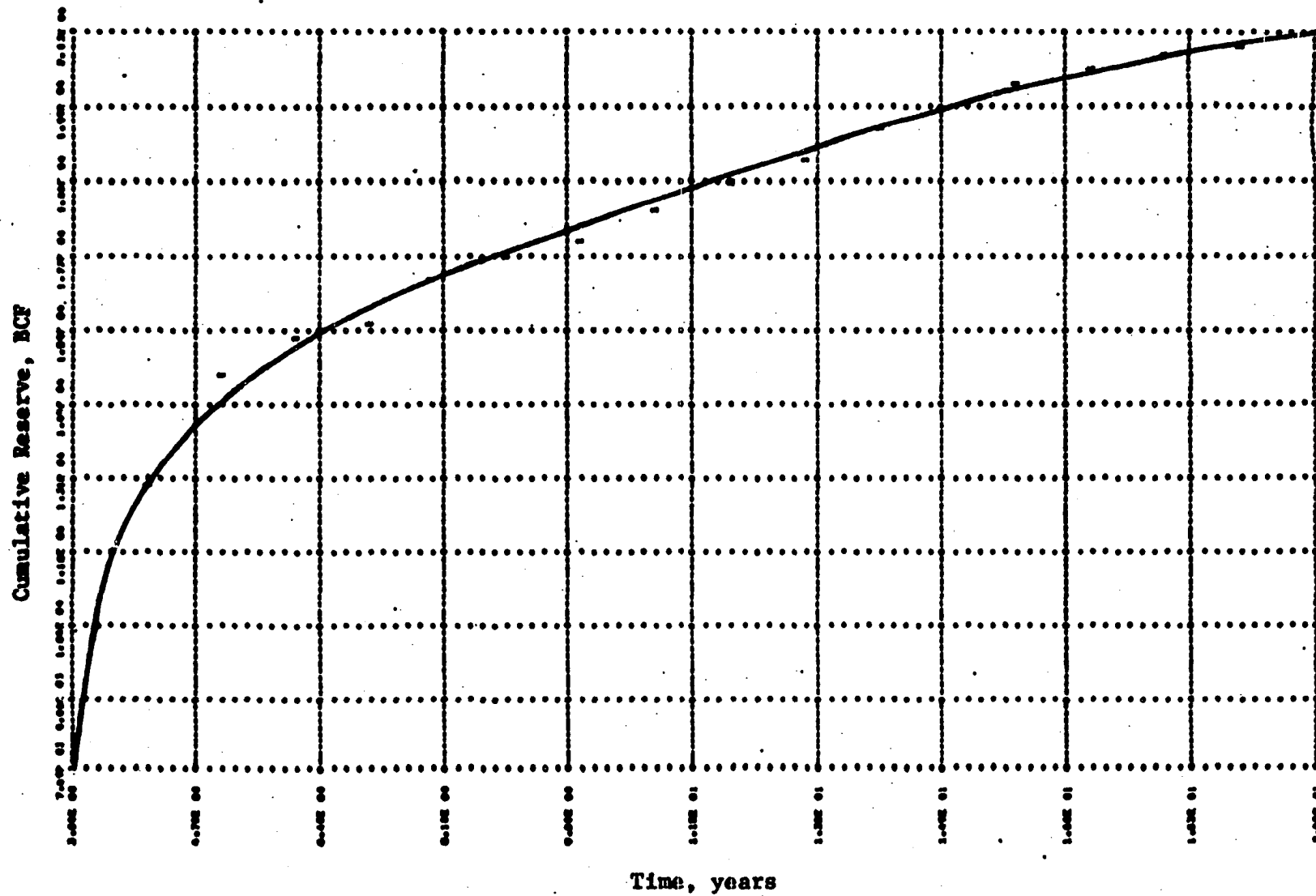


FIGURE IX-50. Plot of cumulative reserve vs. time for Region 1.
(Case II)

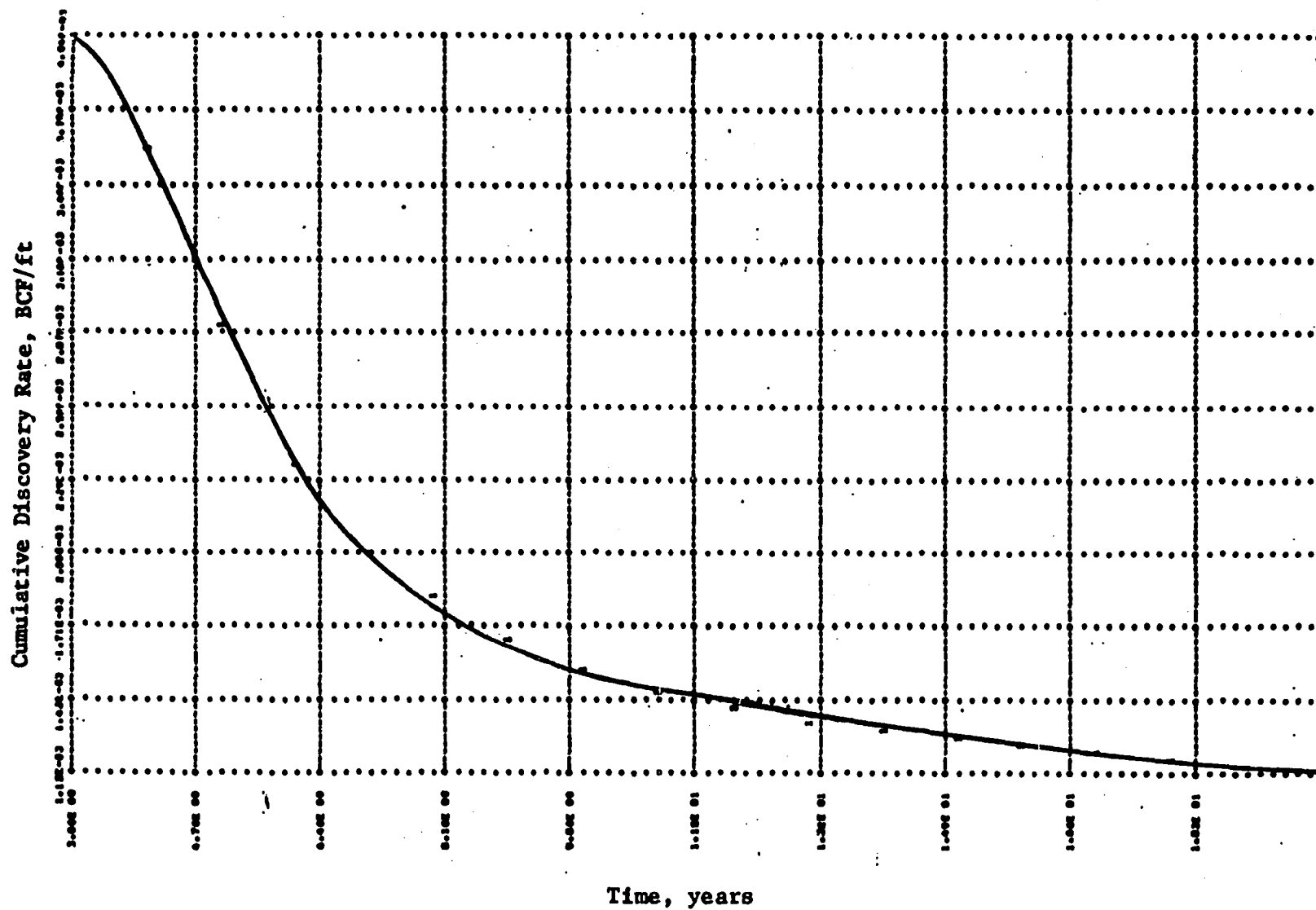


FIGURE IX-51. Plot of cumulative discovery rate vs. time for Region 1.
(Case II)

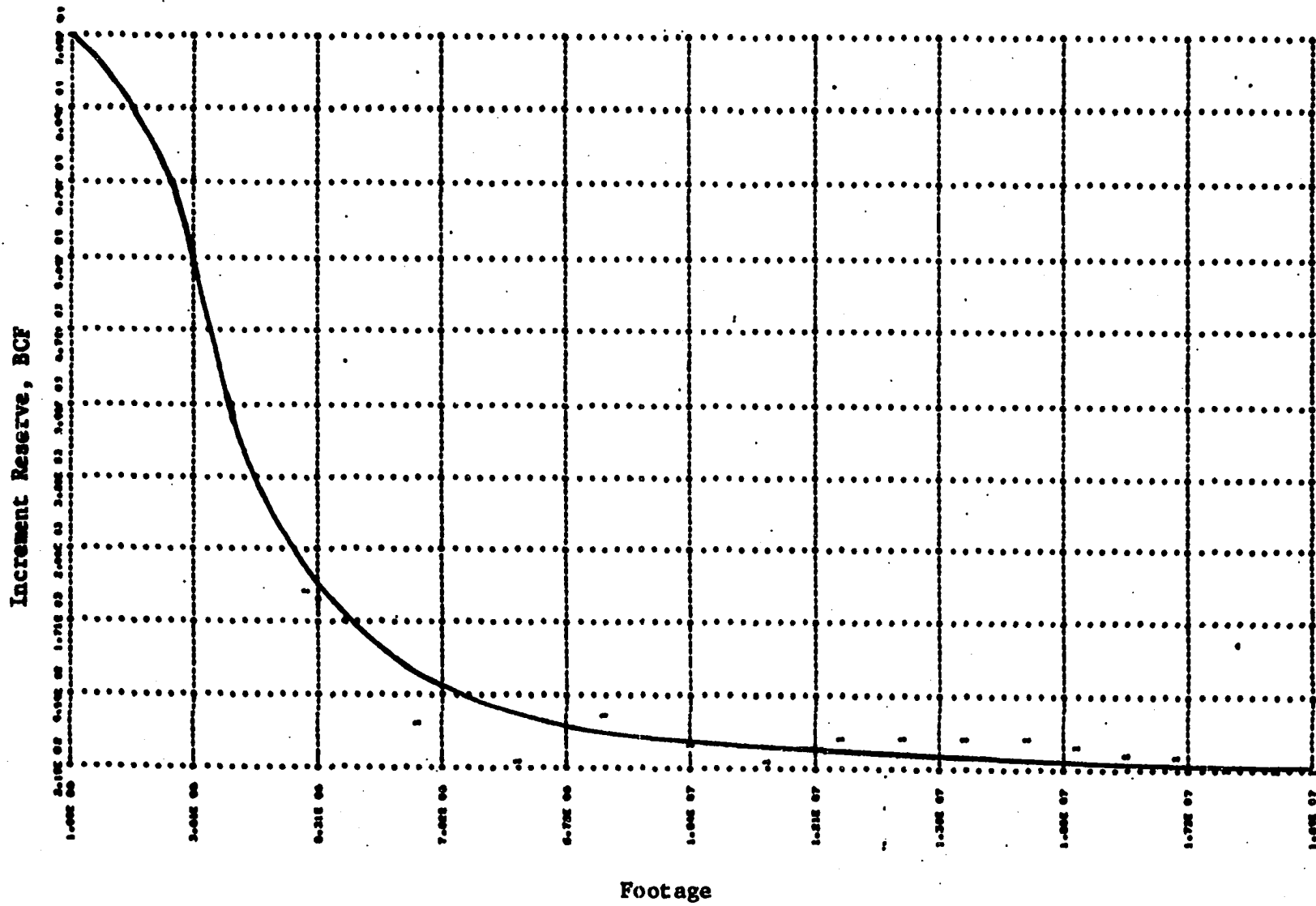


FIGURE IX-52. Plot of increment reserve vs. footage for Region 1.
(Case II)

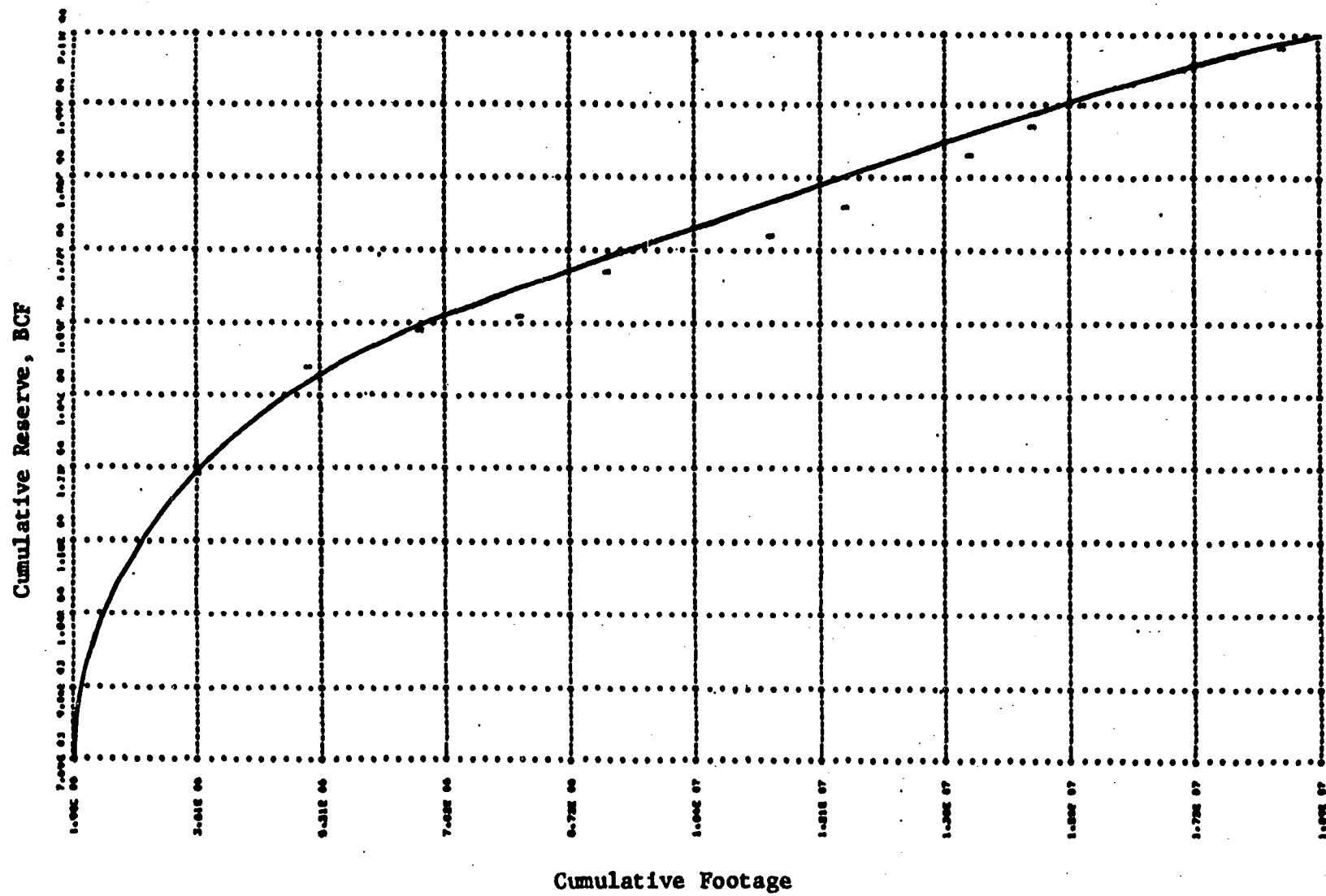


FIGURE IX-53. Plot of cumulative reserve vs. cumulative footage for Region 1.
(Case II)

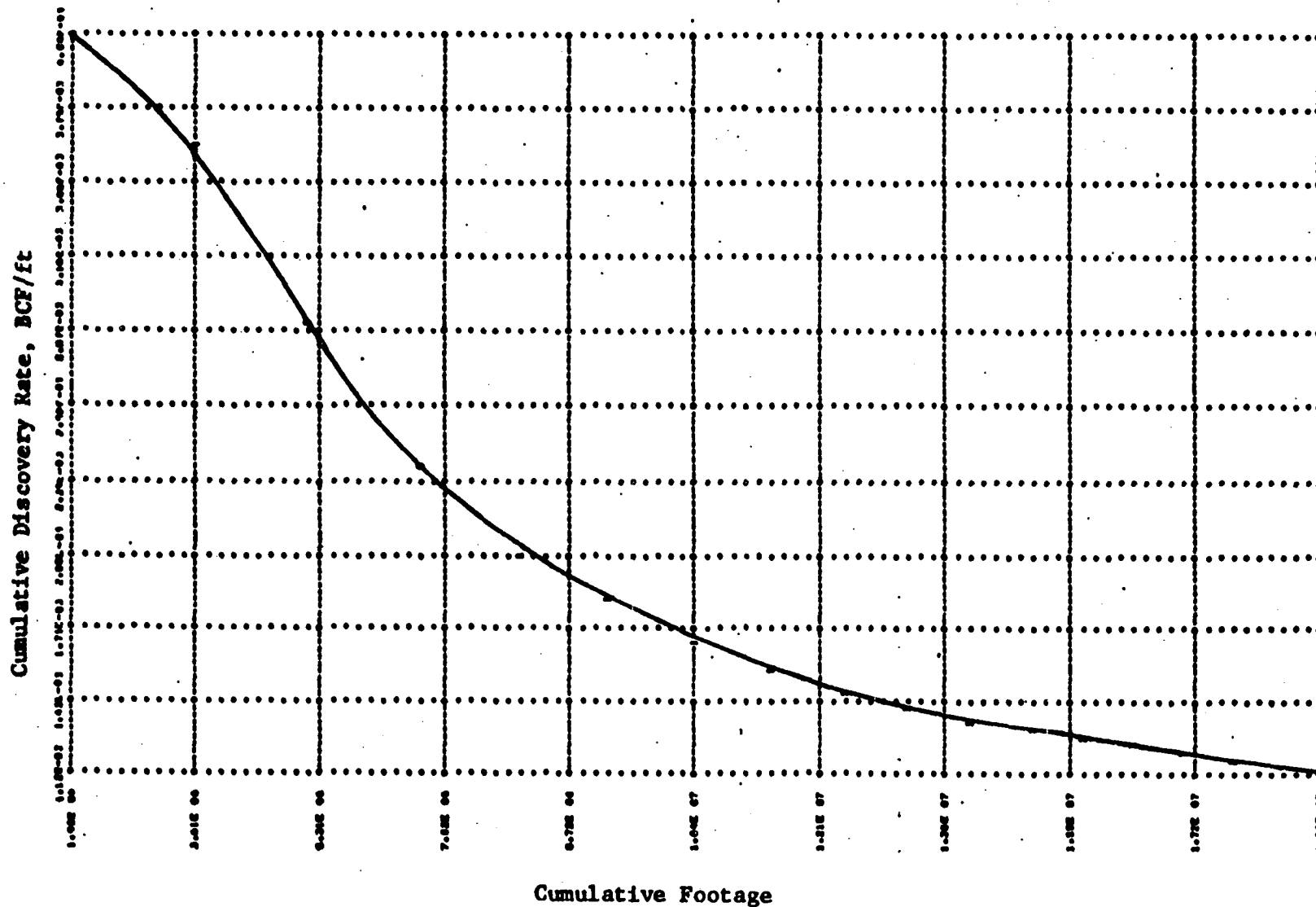


FIGURE IX-54. Plot of cumulative discovery rate vs. cumulative footage for Region 1.
(Case II)

TABLE IX-10

Prediction of Future Discoveries for Region 2
(Case II)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RFS/INC.FT)	CUM.DISCOVERY RATE (CUM.RFS/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
4	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
5	0.1918281E 07	0.7747605E 04	0.1918281E 07	0.7747605E 04	0.4038826E-02	0.4038826E-02
6	0.1767679E 07	0.6366609E 04	0.3685960E 07	0.1411421E 05	0.3601685E-02	0.3829187E-02
7	0.1634136E 07	0.4144863E 04	0.5320092E 07	0.1825908E 05	0.2536425E-02	0.3432098E-02
8	0.1515178E 07	0.1346027E 04	0.6835270E 07	0.1560511E 05	0.8883623E-03	0.2869227E-02
9	0.1408753E 07	0.1301586E 04	0.8244023E 07	0.2090649E 05	0.9239276E-03	0.2535962E-02
10	0.1313161E 07	0.2524626E 04	0.9557184E 07	0.2343132E 05	0.1922559E-02	0.2451697E-02
11	0.1226979E 07	0.1437418E 04	0.1078416E 08	0.2496974E 05	0.1171510E-02	0.2396042E-02
12	0.1149011E 07	0.1488125E 04	0.1193317E 08	0.2635686E 05	0.1295135E-02	0.2208705E-02
13	0.1078247E 07	0.1717633E 04	0.1301142E 08	0.2207450E 05	0.1592986E-02	0.2157691E-02
14	0.1013825E 07	0.1763469E 04	0.1402525E 08	0.2983766E 05	0.1739421E-02	0.2127447E-02
15	0.9550070E 06	0.1763664E 04	0.1498028E 08	0.3160163E 05	0.1846755E-02	0.2109552E-02
16	0.9011660E 06	0.1055781E 04	0.1588142E 08	0.3265741E 05	0.1171572E-02	0.2056328E-02
17	0.8517510E 06	0.6168125E 03	0.1673317E 08	0.3327422E 05	0.7241699E-03	0.1988519E-02
18	0.8062860E 06	0.7361875E 03	0.1753946E 08	0.3401041E 05	0.9130598E-03	0.1939080E-02
19	0.7643840E 06	0.9549102E 03	0.1830384E 08	0.3496532E 05	0.1249254E-02	0.1910272E-02
20	0.7256480E 06	0.9065234E 03	0.1902949E 08	0.3587144E 05	0.1249261E-02	0.1885066E-02

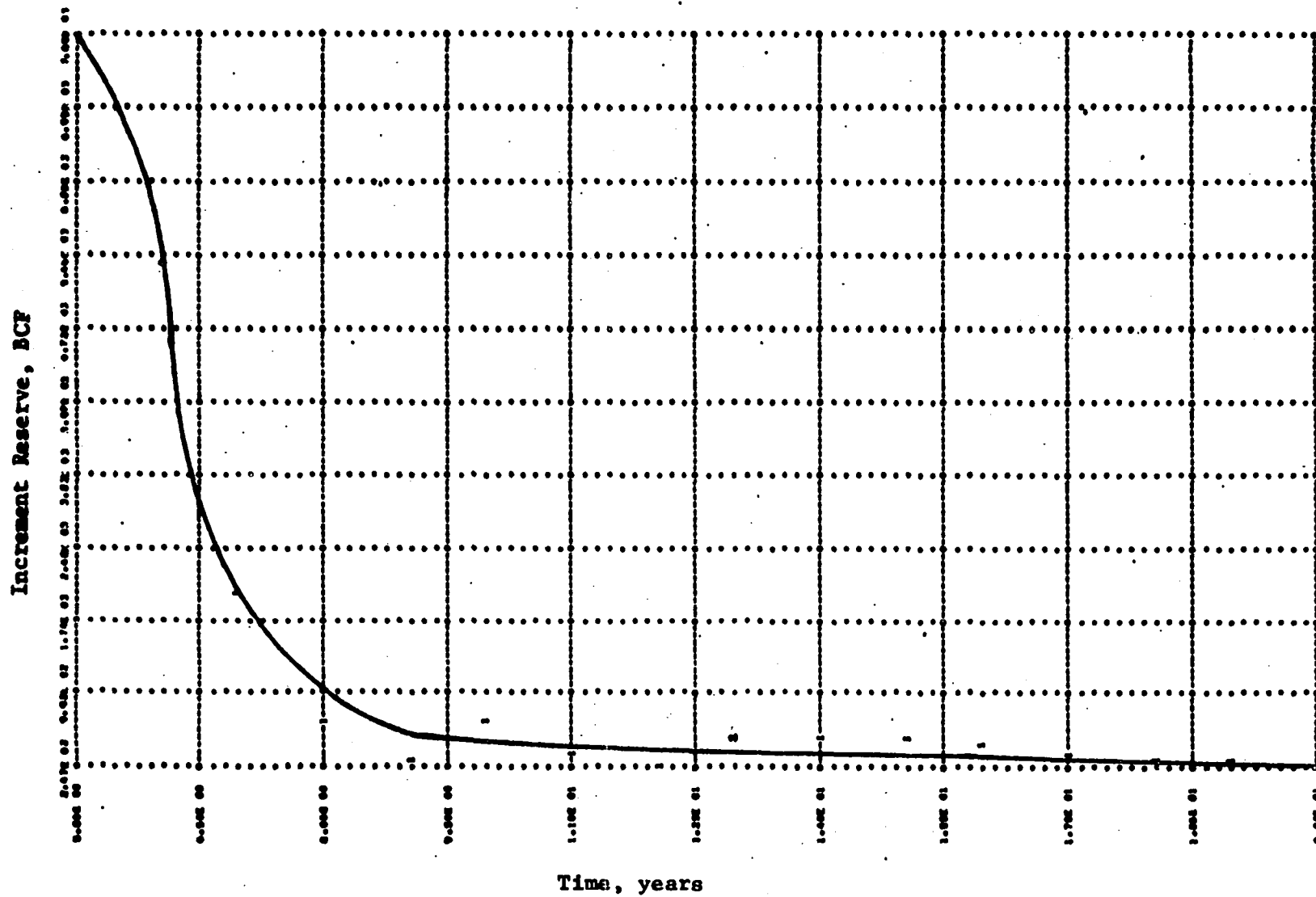


FIGURE IX-55. Plot of increment reserves vs. time for Region 2.
(Case II)

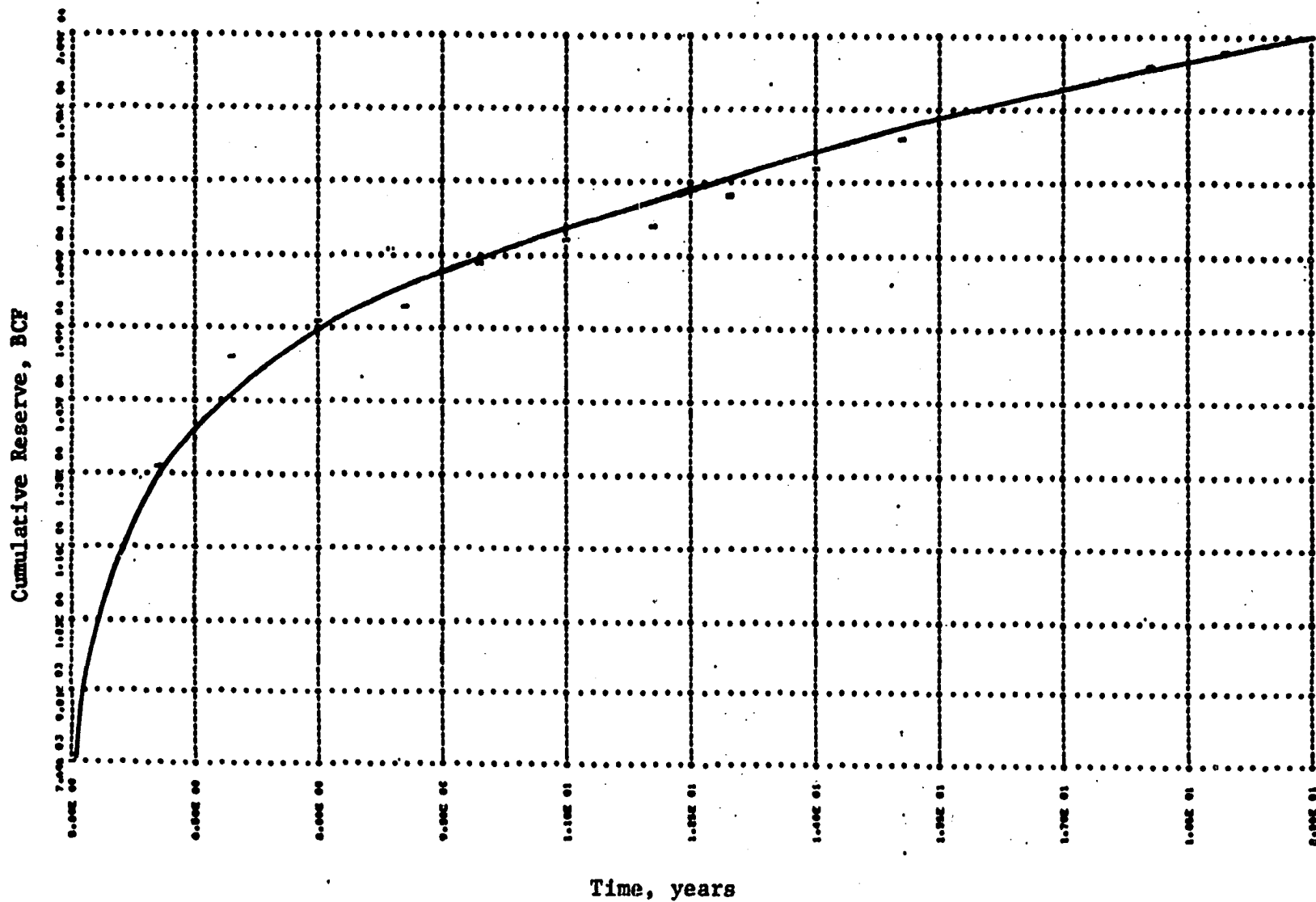


FIGURE IX-56. Plot of cumulative reserve vs. time for Region 2.
(Case II)

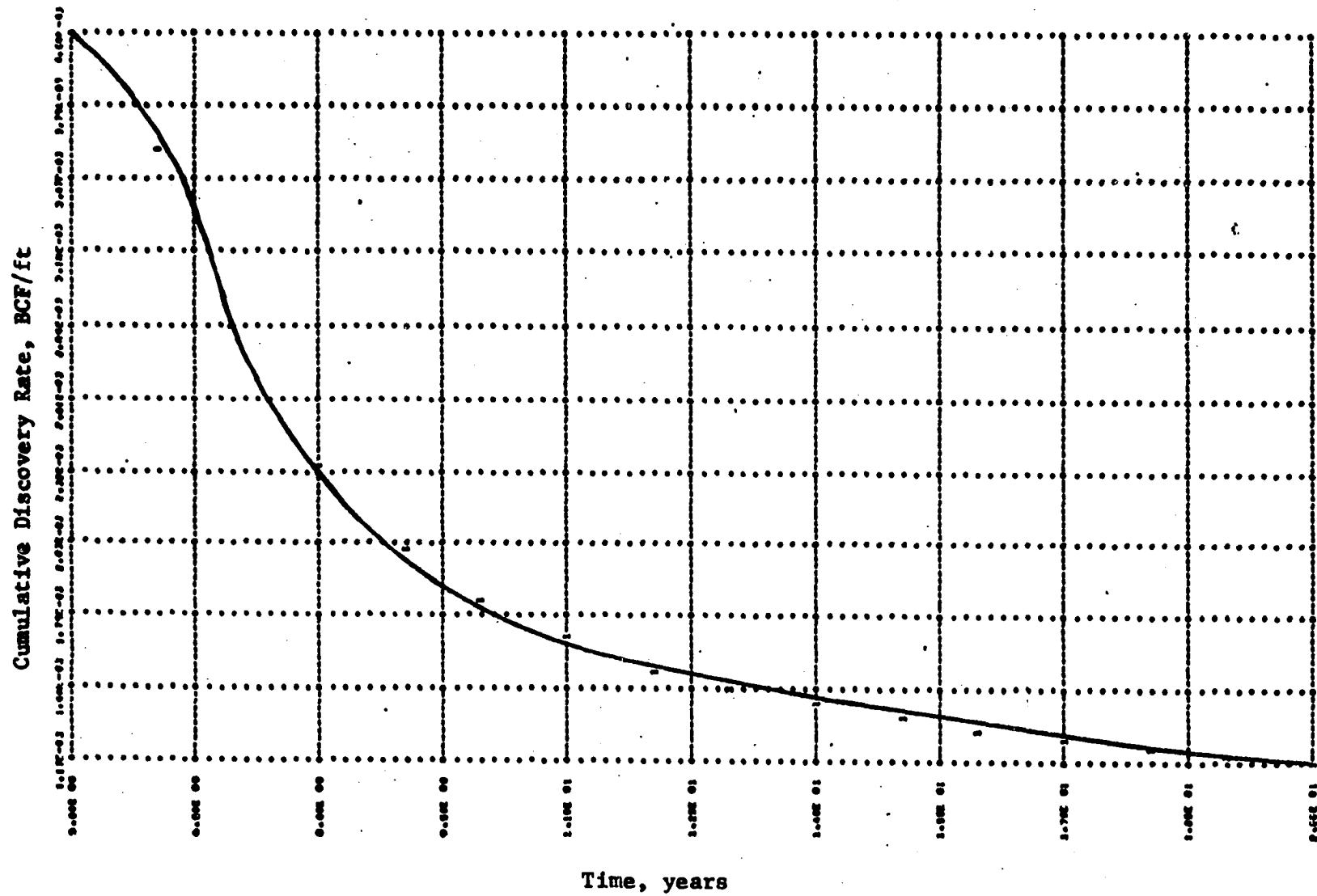


FIGURE IX-57. Plot of cumulative discovery rate vs. time for Region 2.
(Case II)

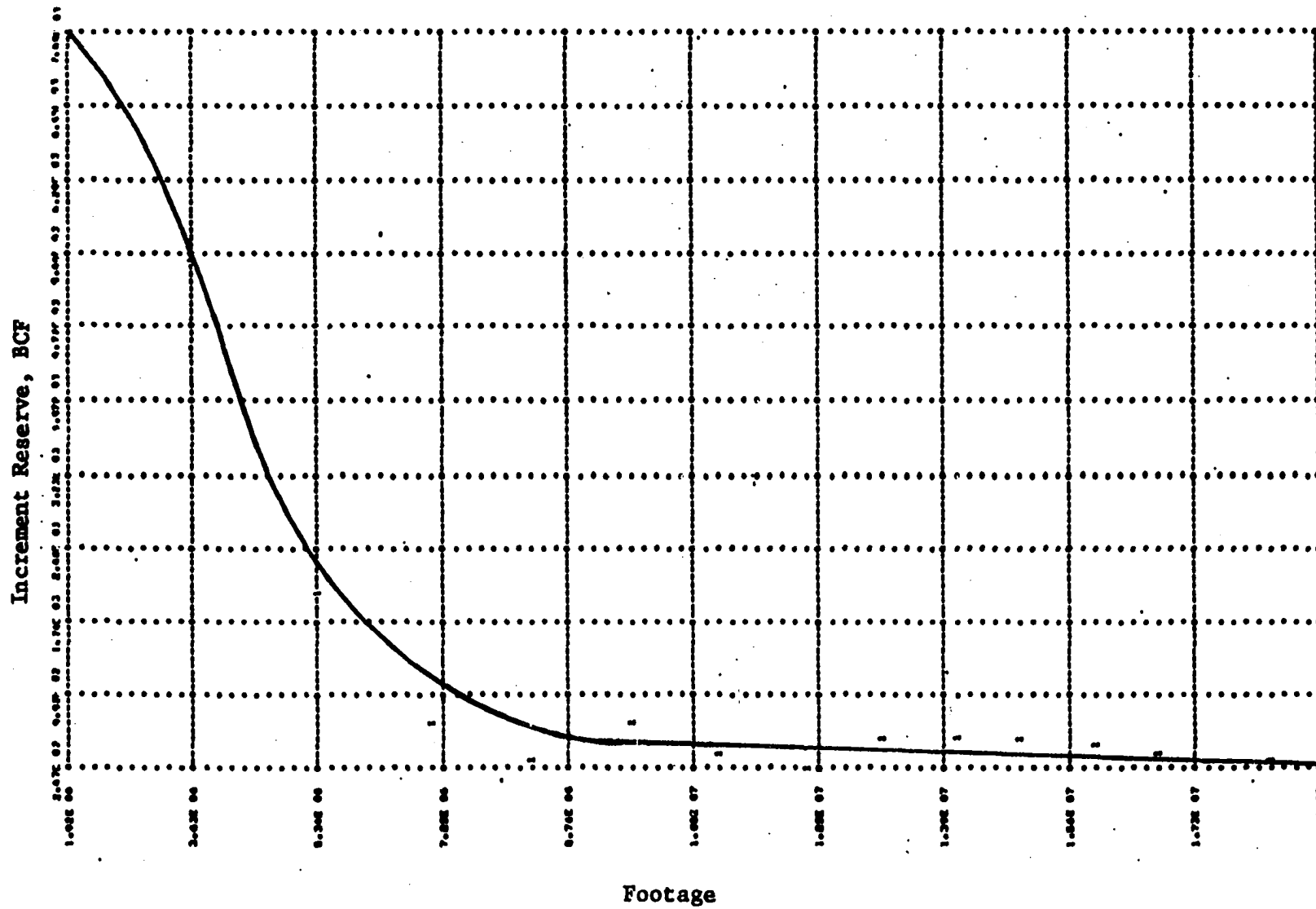


FIGURE IX-58. Plot of increment reserve vs. footage for Region 2.
(Case II)

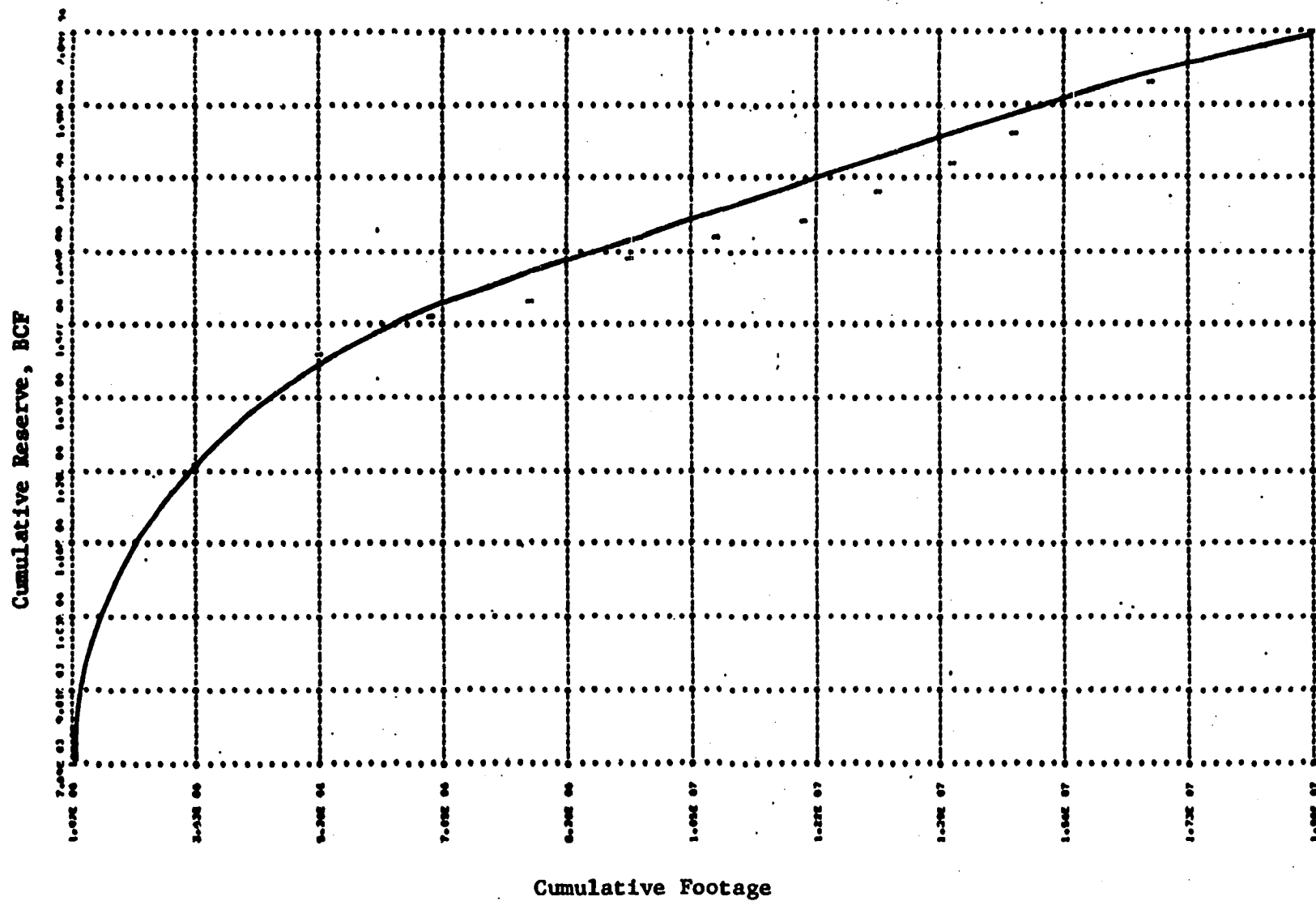


FIGURE IX-59. Plot of cumulative reserve vs. cumulative footage for Region 2.
(Case II)

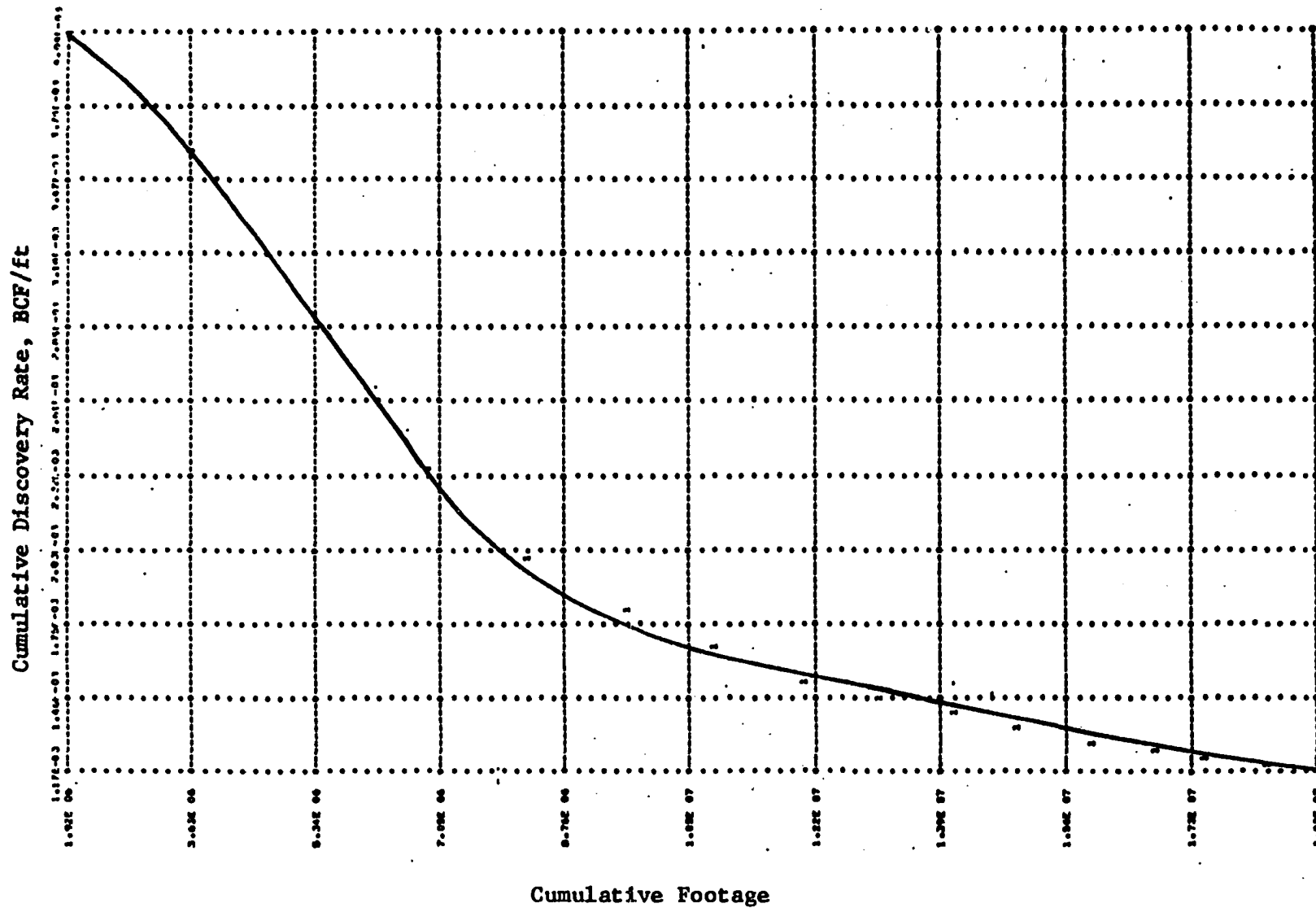


FIGURE IX-60. Plot of cumulative discovery rate vs. cumulative footage for Region 2.
(Case II)

TABLE IX-11

Prediction of Future Discoveries for Region 3
(Case II)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
4	0.1912045E 07	0.7722918E 04	0.1912045E 07	0.7722918E 04	0.4039086E-02	0.4039086E-02
5	0.1750958E 07	0.7545438E 04	0.3663003E 07	0.1526836E 05	0.4309319E-02	0.4168261E-02
6	0.1609405E 07	0.4979996E 04	0.5272408E 07	0.2024832E 05	0.3094305E-02	0.3840437E-02
7	0.1484342E 07	0.2281984E 04	0.6756756E 07	0.2253034E 05	0.1537365E-02	0.3334450E-02
8	0.1373325E 07	0.1482738E 04	0.8130081E 07	0.2441307E 05	0.1370934E-02	0.3002808E-02
9	0.1274308E 07	0.3095624E 04	0.9404389E 07	0.2751276E 05	0.2432444E-02	0.2925523E-02
10	0.1185627E 07	0.2178180E 04	0.1059002E 08	0.2569054E 05	0.1837154E-02	0.2807673E-02
11	0.1105890E 07	0.1890230E 04	0.1169591E 08	0.3158117E 05	0.1709239E-02	0.2700190E-02
12	0.1033938E 07	0.1842953E 04	0.1272984E 08	0.3342412E 05	0.1782460E-02	0.2625650E-02
13	0.9687870E 06	0.1778875E 04	0.1369863E 08	0.3520300E 05	0.1836182E-02	0.2569818E-02
14	0.9096030E 06	0.1804570E 04	0.1460823E 08	0.3700757E 05	0.1983910E-02	0.2533336E-02
15	0.8556830E 06	0.1801887E 04	0.1546392E 08	0.3880945E 05	0.2105788E-02	0.2509678E-02
16	0.8064210E 06	0.2275320E 04	0.1627034E 08	0.4108477E 05	0.2821504E-02	0.2525133E-02
17	0.7612780E 06	0.2147953E 04	0.1703162E 08	0.4323273E 05	0.2821509E-02	0.2538381E-02
18	0.7198560E 06	0.1283379E 04	0.1775147E 08	0.4451611E 05	0.1782827E-02	0.2507742E-02
19	0.6816960E 06	0.9081953E 03	0.1843317E 08	0.4542430E 05	0.1332258E-02	0.2464270E-02
20	0.6468120E 06	0.8613203E 03	0.1907968E 08	0.4622562E 05	0.1332257E-02	0.2425912E-02

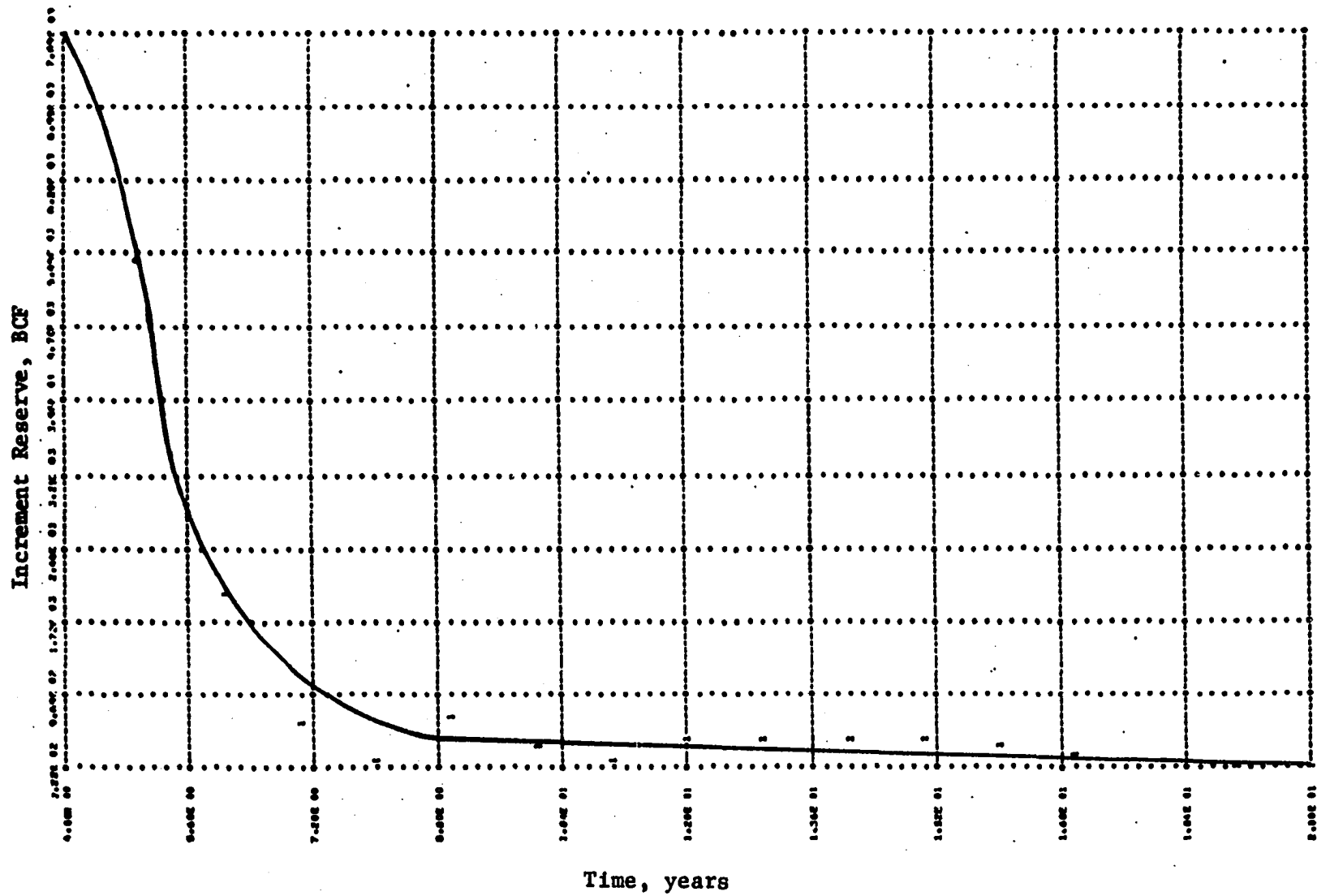


FIGURE IX-61. Plot of increment reserve vs. time for Region 3.
(Case II)

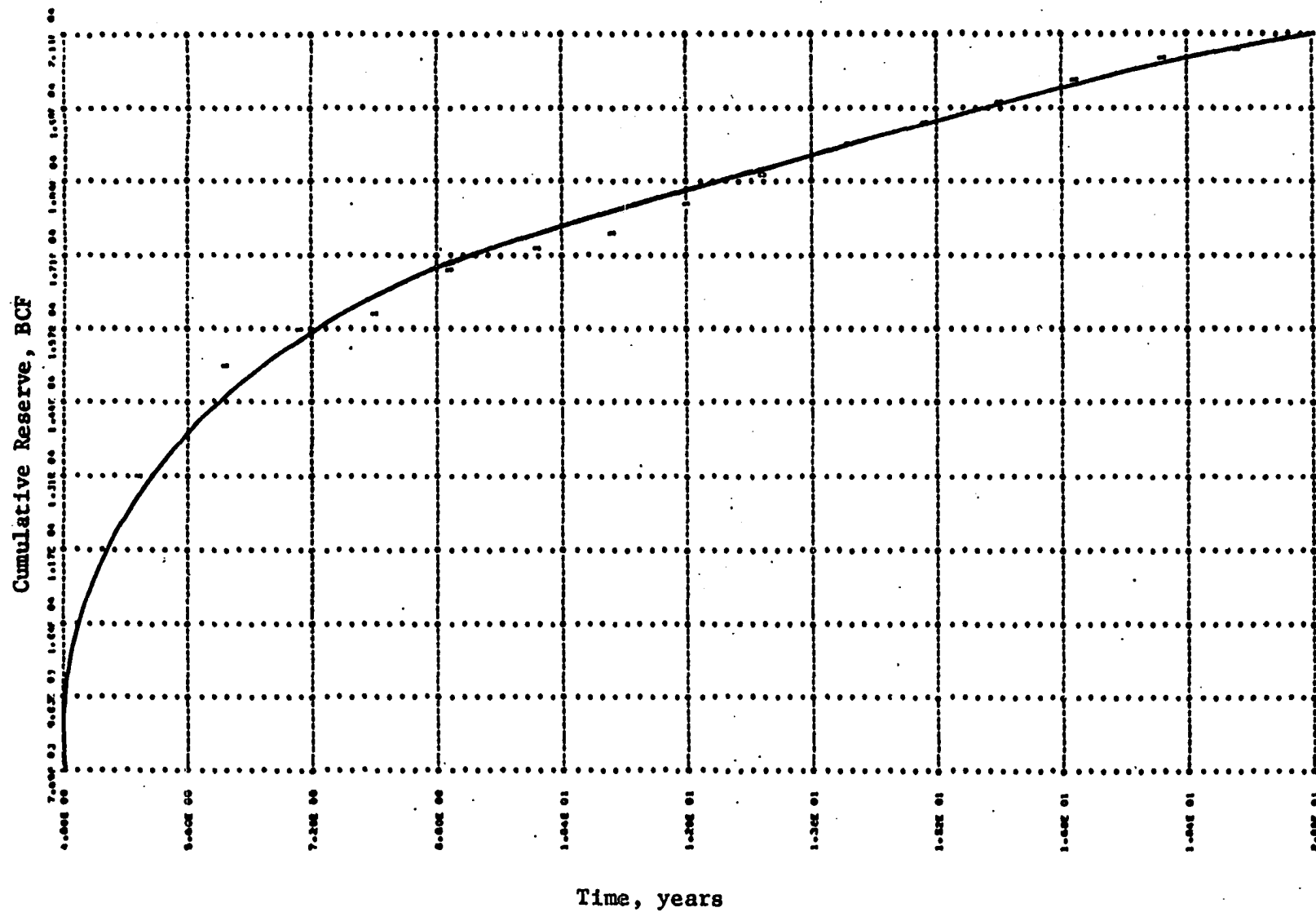


FIGURE IX-62. Plot of cumulative reserve vs. time for Region 3.
(Case II)

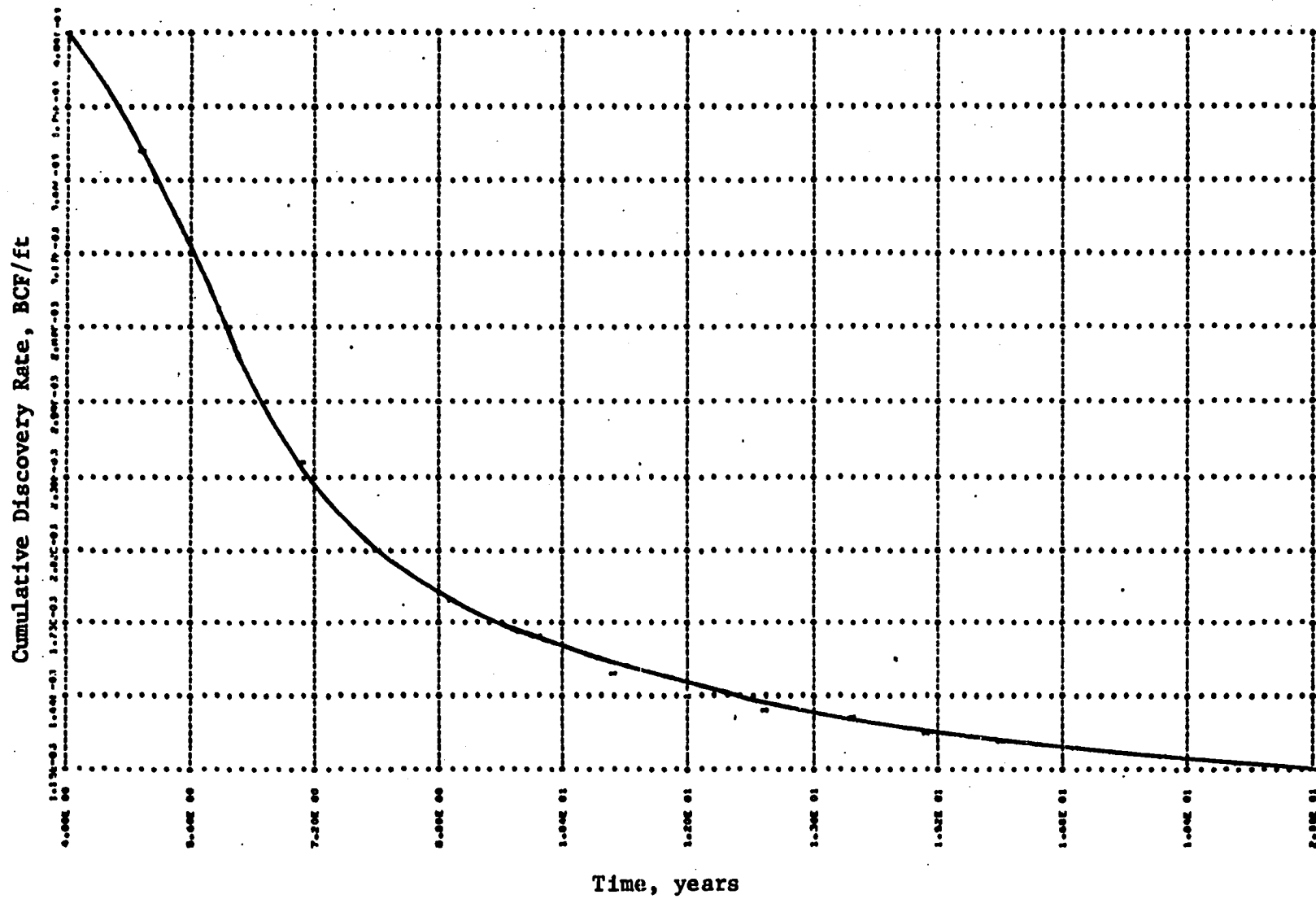


FIGURE IX-63. Plot of cumulative discovery rate vs. time for Region 3.

(Case II)

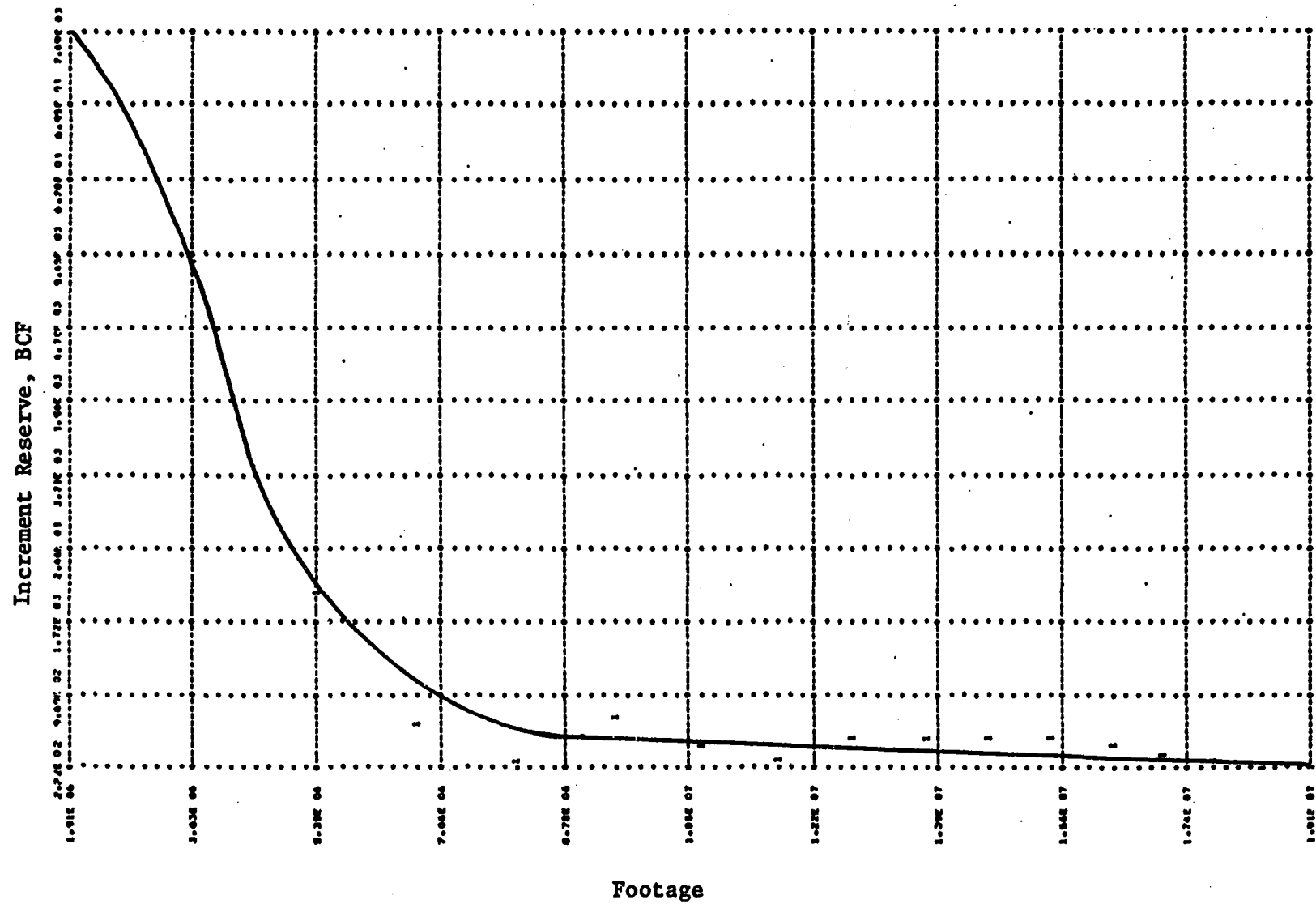


FIGURE IX-64. Plot of increment reserve vs. footage for Region 3.
(Case II)

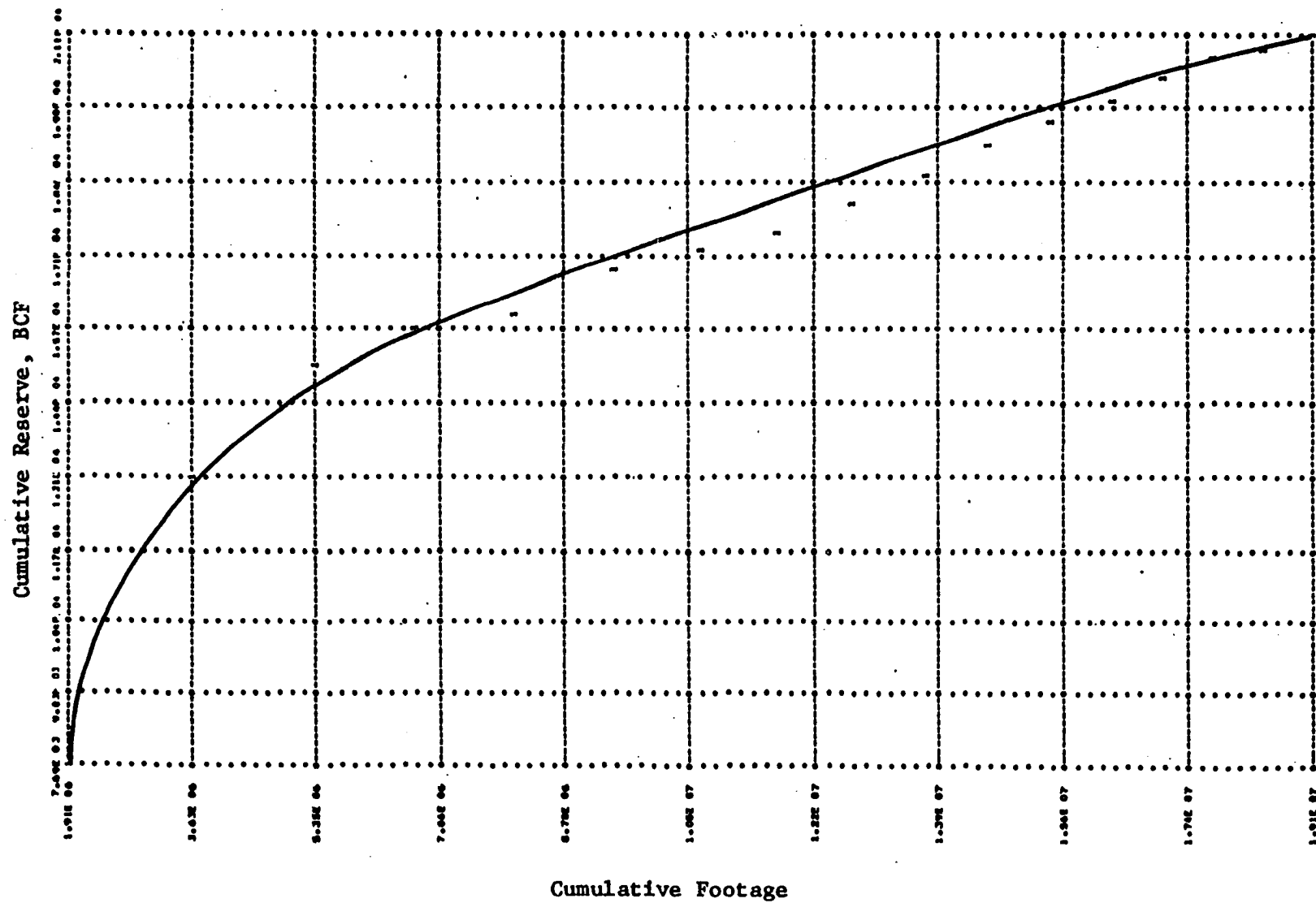


FIGURE IX-65. Plot of cumulative reserve vs. cumulative footage for Region 3.
(Case II)

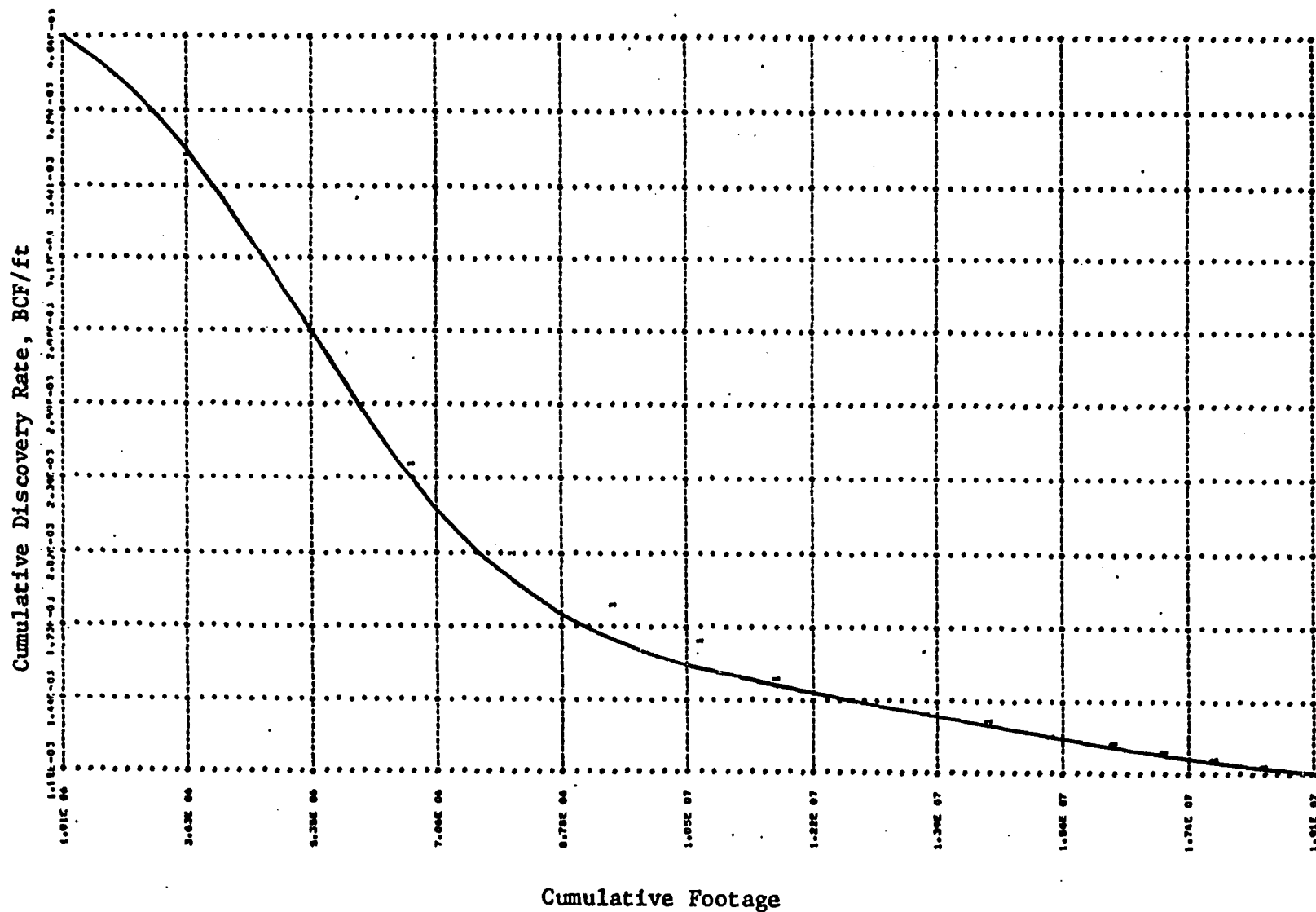


FIGURE IX-66. Plot of cumulative discovery rate vs. cumulative footage for Region 3.
(Case II)

TABLE IX-12

Composite Parameters for All k Basins
(Case II, Hyperbolic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.1904762E 07	0.7693504E 04	0.1904762E 07	0.7693504E 04	0.4039086E-02	0.4039086E-02
4	0.3643646E 07	0.1307754E 05	0.5548408E 07	0.2077104E 05	0.3589135E-02	0.3743604E-02
5	0.5250267E 07	0.1732046E 05	0.1079868E 08	0.3609150E 05	0.3298967E-02	0.3527423E-02
6	0.4826356E 07	0.1201161E 05	0.1562503E 08	0.5010311E 05	0.2488753E-02	0.3206593E-02
7	0.4451817E 07	0.6737621E 04	0.2000768E 08	0.5684073E 05	0.1513454E-02	0.2831158E-02
8	0.4119264E 07	0.3939758E 04	0.2419611E 08	0.6078049E 05	0.9564226E-03	0.2511994E-02
9	0.3822656E 07	0.4822887E 04	0.2801877E 08	0.6560338E 05	0.1261659E-02	0.2341408E-02
10	0.3556992E 07	0.4974188E 04	0.3187576E 08	0.7057756E 05	0.1398425E-02	0.2235182E-02
11	0.3318096E 07	0.5266432E 04	0.3489386E 08	0.7444600E 05	0.1165861E-02	0.2133499E-02
12	0.3102480E 07	0.3860125E 04	0.3799634E 08	0.7830613E 05	0.1244206E-02	0.2060886E-02
13	0.2907248E 07	0.4019000E 04	0.4090358E 08	0.8232513E 05	0.1382407E-02	0.2012663E-02
14	0.2729872E 07	0.4061563E 04	0.4363346E 08	0.8638669E 05	0.1487822E-02	0.1979827E-02
15	0.2568272E 07	0.3977938E 04	0.4620173E 08	0.9036463E 05	0.1548877E-02	0.1955871E-02
16	0.2420600E 07	0.3680128E 04	0.4862234E 08	0.9404475E 05	0.1520331E-02	0.1934122E-02
17	0.2285296E 07	0.3093875E 04	0.5050763E 08	0.9713863E 05	0.1353818E-02	0.1908135E-02
18	0.2161072E 07	0.2266932E 04	0.5306870E 08	0.9940566E 05	0.1048987E-02	0.1873148E-02
19	0.2046672E 07	0.2085000E 04	0.5511538E 08	0.1014900E 06	0.1018727E-02	0.1841420E-02
20	0.1941152E 07	0.1978000E 04	0.5705653E 08	0.1034686E 06	0.1018982E-02	0.1813439E-02

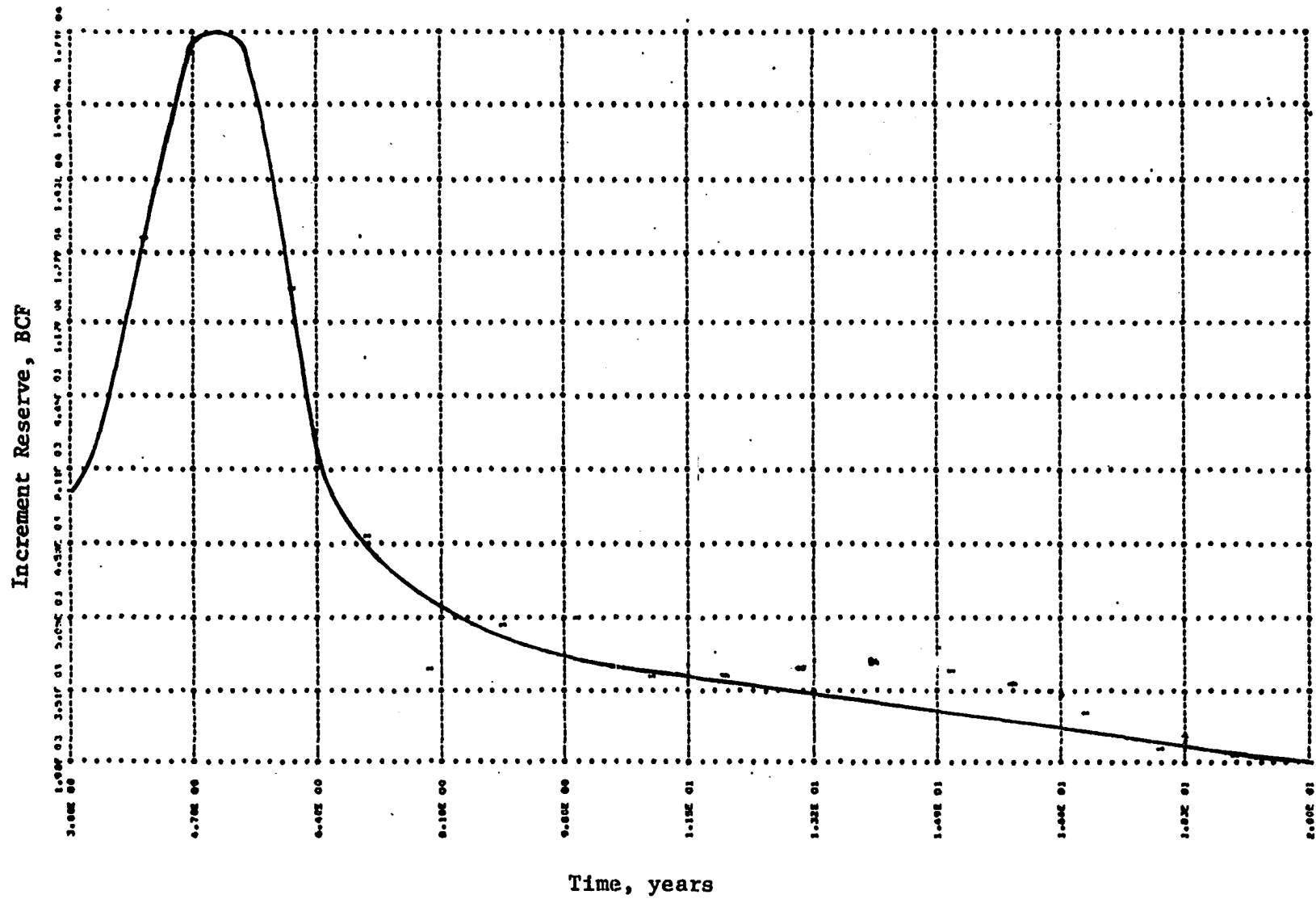


FIGURE IX-67. Composite plot of increment reserve vs. time.
(Case II, Hyperbolic Curve)

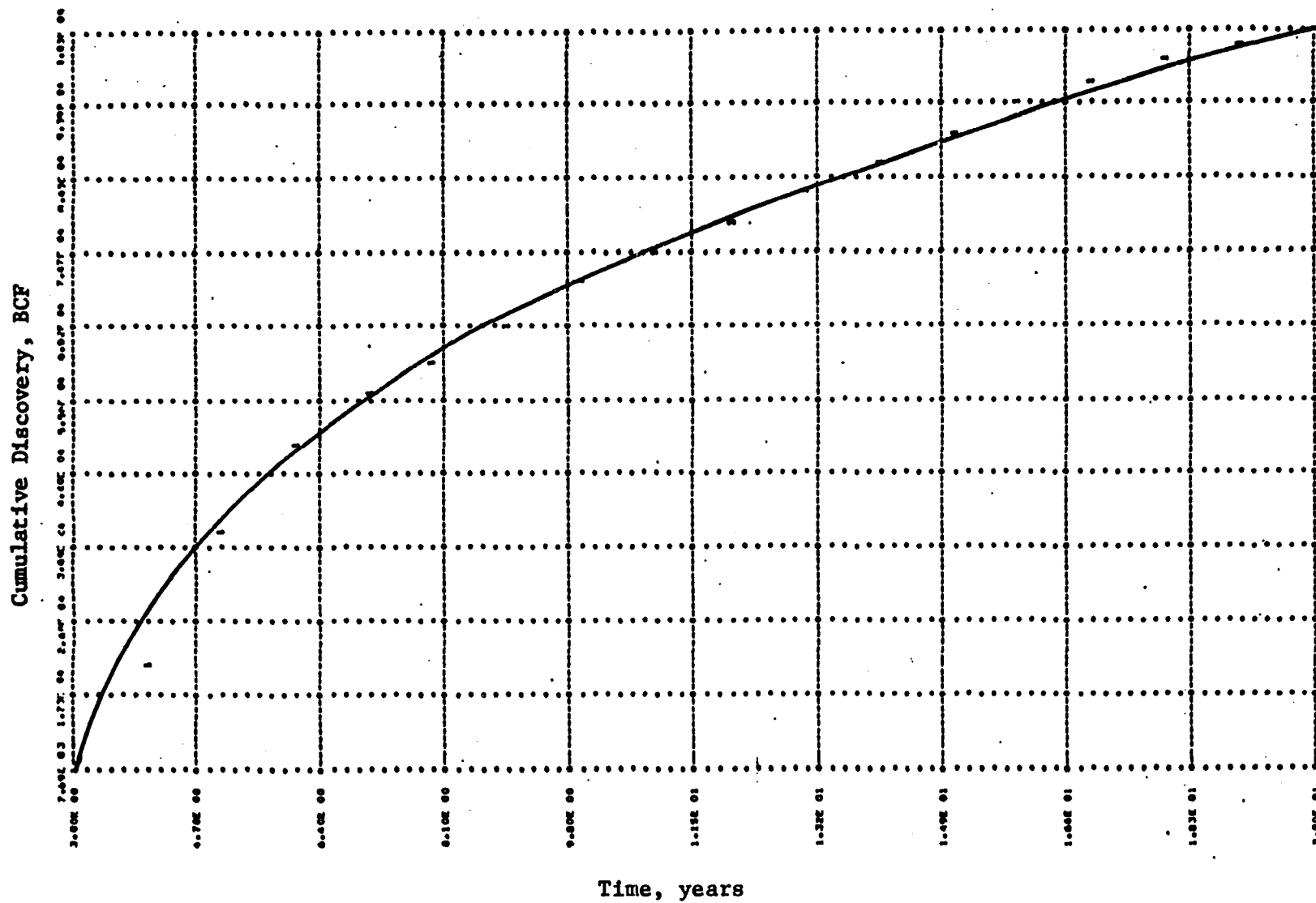


FIGURE IX-68. Composite plot of cumulative discovery vs. time.
(Case II, Hyperbolic Curve)

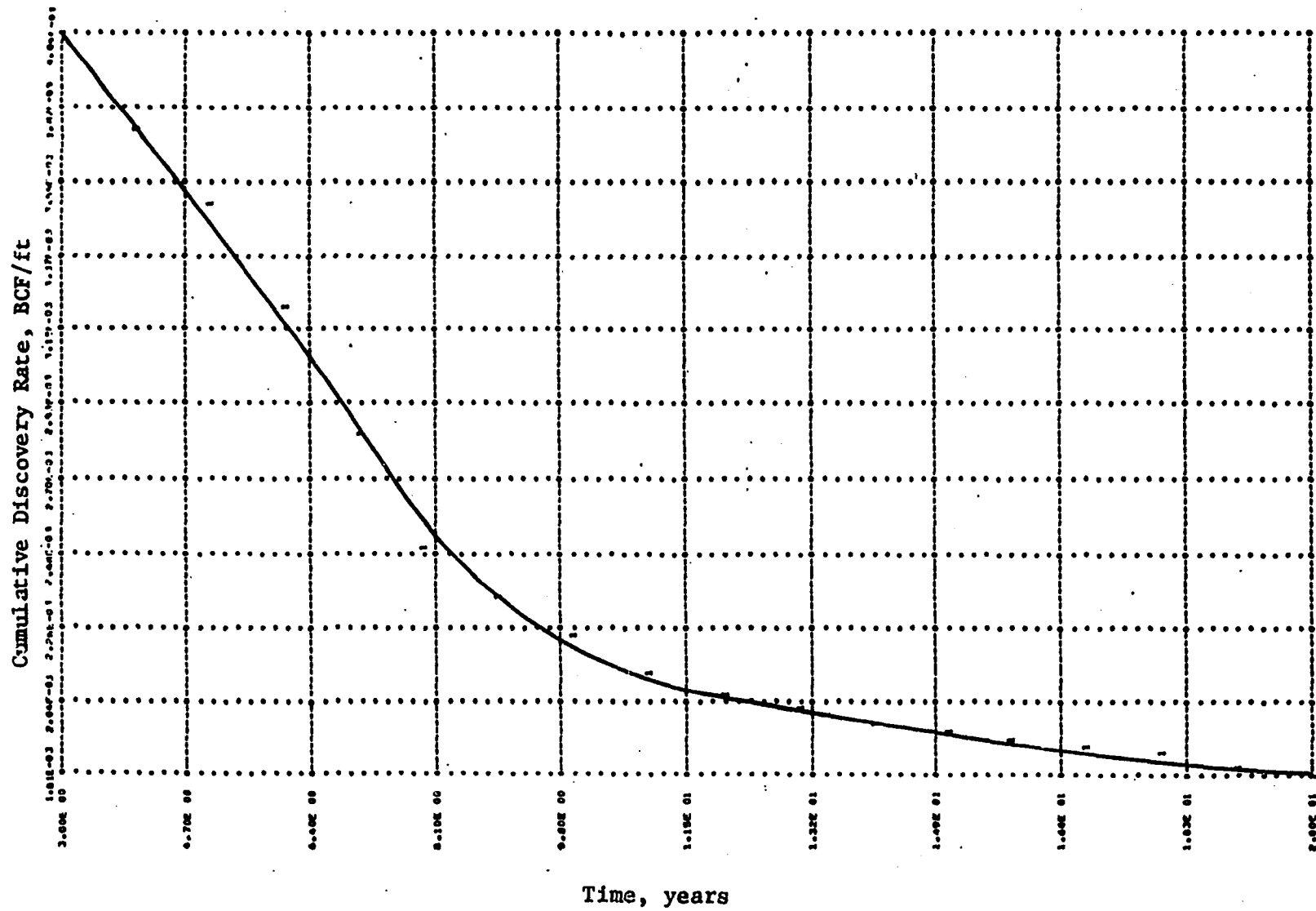


FIGURE IX-69. Composite plot of cumulative discovery rate vs. time.
(Case II, Hyperbolic Curve)

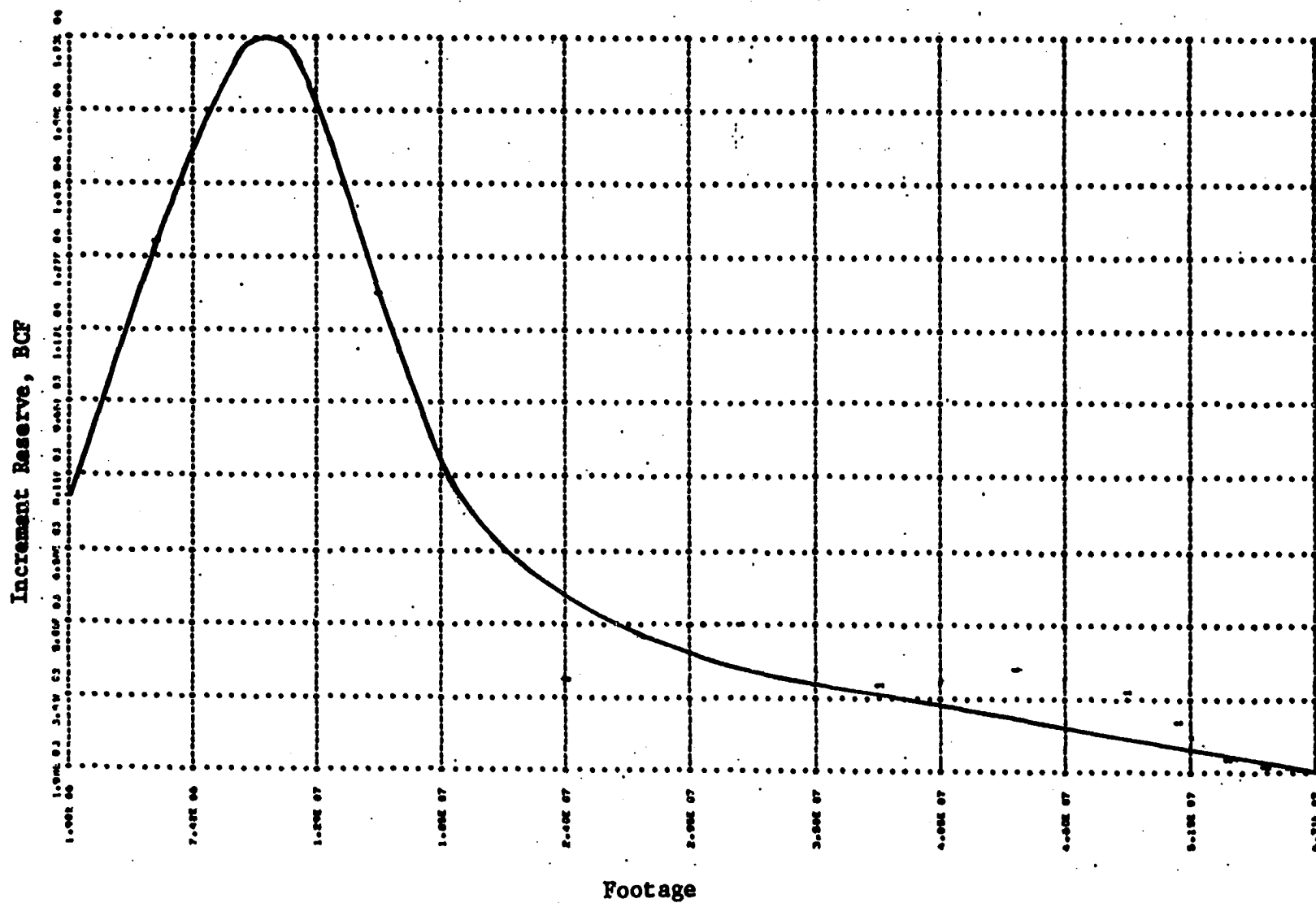


FIGURE IX-70. Composite plot of increment reserve vs. footage.
(Case II, Hyperbolic Curve)

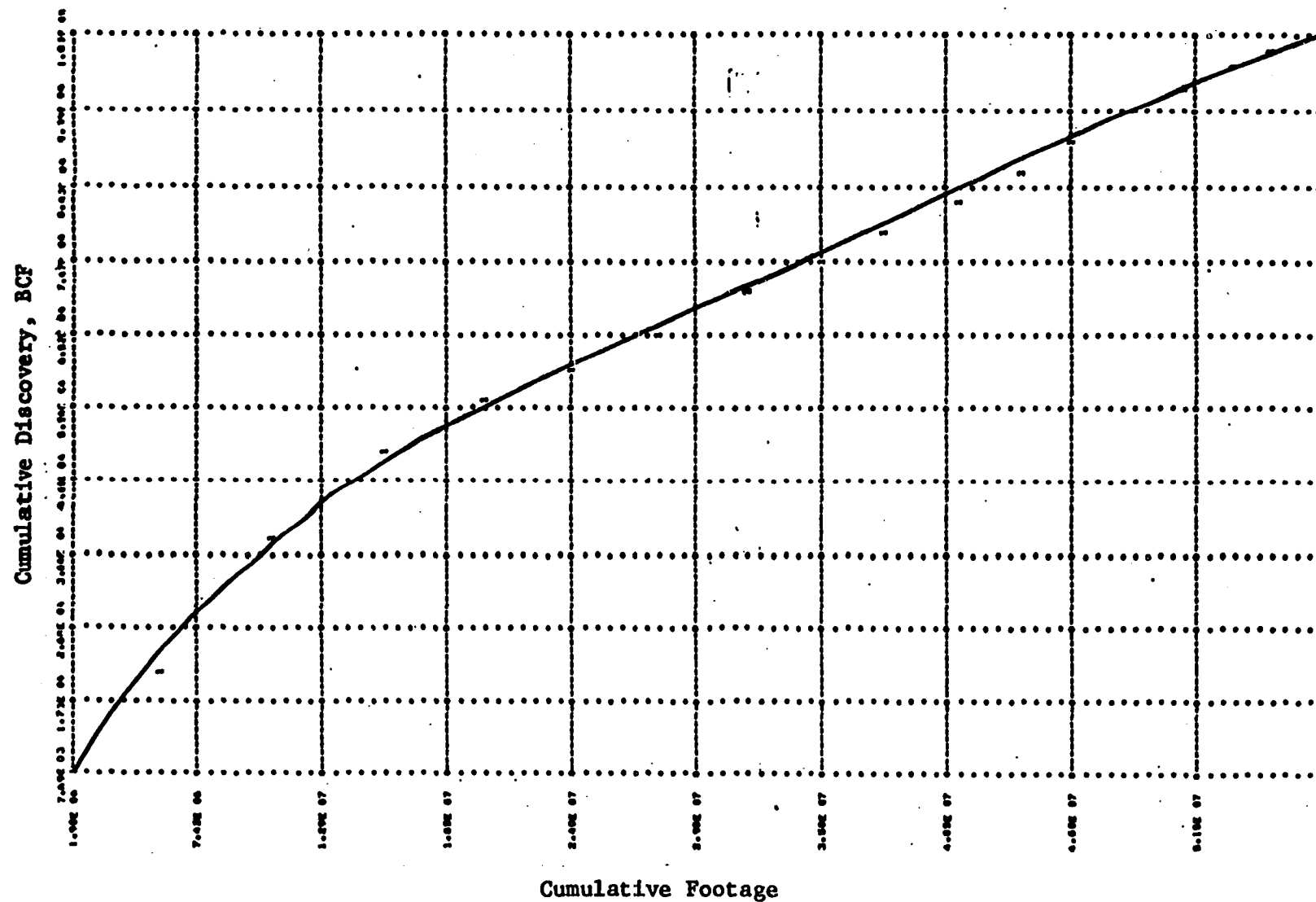


FIGURE IX-71. Composite plot of cumulative discovery vs. cumulative footage.
(Case II, Hyperbolic Curve)

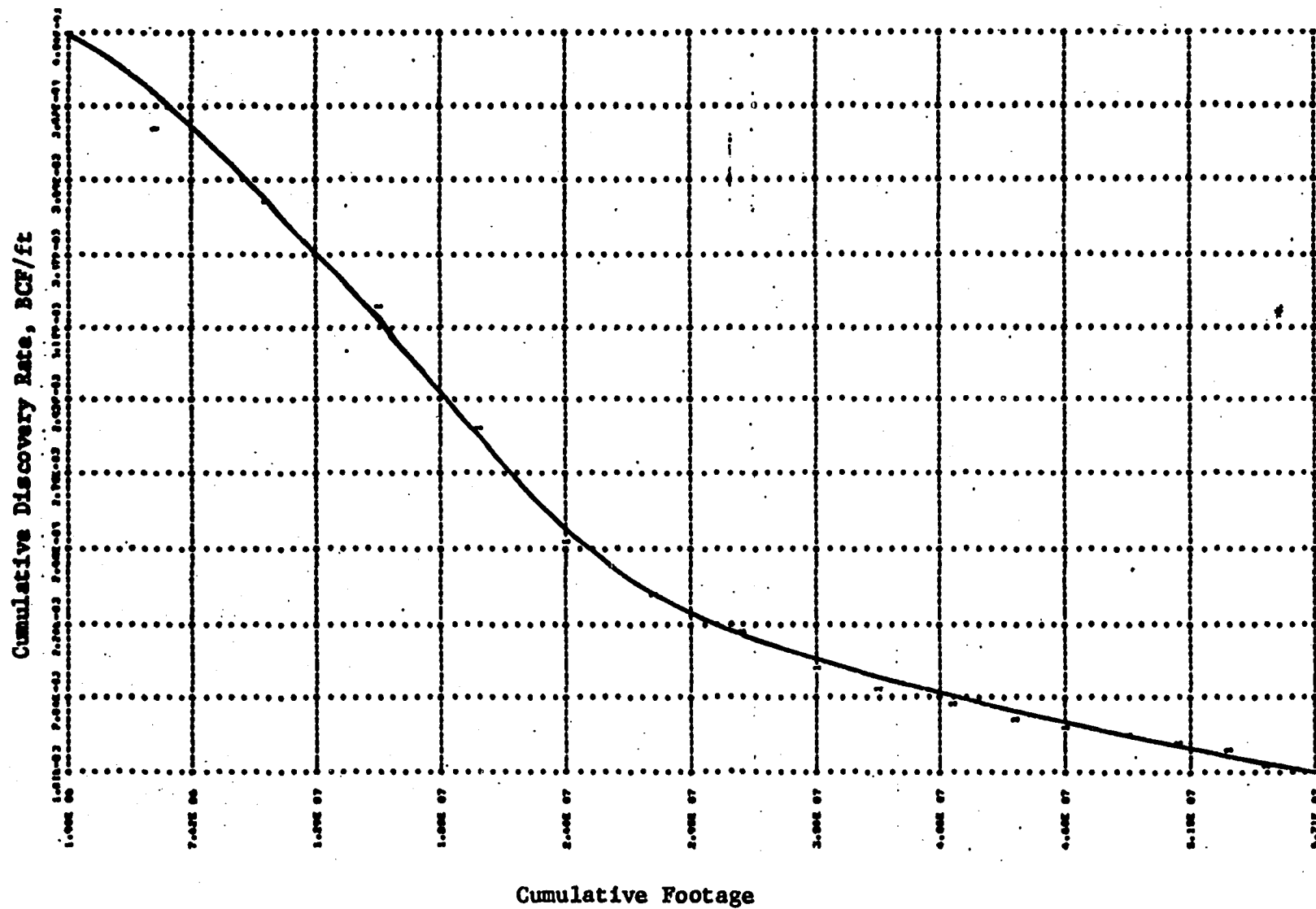


FIGURE IX-72 . Composite plot of cumulative discovery rate vs. cumulative footage.
(Case II, Hyperbolic Curve)

two previous runs. Comparison of the results or plots of composite parameters for this run with those for the last two indicates notable changes in only the plots of cumulative discovery vs. either time or cumulative and cumulative discovery rate vs. cumulative footage. The plot of cumulative reserves vs. either time, Figure IX-68, or cumulative footage, Figure IX-71, and cumulative discovery rate vs. cumulative footage, Figure IX-72, for this run are very similar to the corresponding plots for the second run and have corresponding differences with the first run.

Fourth Run

The results obtained from the fourth run are shown in Tables IX-13 to IX-16 and Figures IX-73 to IX-78. This run is based on the results of the original model from Phase one using the straight line extrapolation for future drilling activities. Tables IX-13 to IX-15 are results for Regions 1, 2, and 3, respectively. Table IX-16 and Figures IX-73 to IX-78 are results for all (three) regions combined. From the figures for this run as compared to the figures IX-19 to IX-24 for the first run, the same type of response can be observed for all the curves, so the same conclusions can be drawn for the plots for this run.

Fifth Run

The results obtained from the fifth run are shown in Tables IX-17 to IX-20 and Figures IX-79 to IX-84. This run

TABLE IX-13

Prediction of Future Discoveries for Region 1
(Straight Line)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.5999997E 07	0.3317025E 08	0.5999997E 07	0.3317025E 08	0.3317026E-02	0.3317026E-02
4	0.5999997E 07	0.3254862E 08	0.1999998E 08	0.6271822E 05	0.3254866E-02	0.3285546E-02
5	0.1000000E 08	0.2610456E 08	0.2999998E 08	0.9182344E 05	0.2610456E-02	0.3040783E-02
6	0.1000000E 08	0.2496475E 08	0.3999998E 08	0.1167822E 06	0.2496475E-02	0.2919706E-02
7	0.1000000E 08	0.1939044E 08	0.4999998E 08	0.1361726E 06	0.1939044E-02	0.2723573E-02
8	0.5999994E 07	0.1660430E 08	0.5999997E 08	0.1227830E 06	0.1660440E-02	0.2546384E-02
9	0.1000000E 08	0.7908186E 04	0.6999997E 08	0.1808912E 06	0.7908186E-03	0.2295585E-02
10	0.1000000E 08	0.7254125E 04	0.7999997E 08	0.1679423E 06	0.7254123E-03	0.2099317E-02
11	0.1000000E 08	0.5863250E 04	0.8999997E 08	0.1738022E 06	0.5863248E-03	0.1931207E-02
12	0.1000000E 08	0.5151563E 04	0.9999997E 08	0.1789601E 06	0.5151562E-03	0.1789602E-02
13	0.5999984E 07	0.4102625E 04	0.1100000E 09	0.1830622E 06	0.4102630E-03	0.1664207E-02
14	0.1000000E 08	0.4067625E 04	0.1200000E 09	0.1871304E 06	0.4067624E-03	0.1559420E-02
15	0.1000000E 08	0.4031250E 04	0.1300000E 09	0.1911612E 06	0.4031248E-03	0.1470475E-02
16	0.1000000E 08	0.3683750E 04	0.1400000E 09	0.1948444E 06	0.3683749E-03	0.1391753E-02
17	0.1000000E 08	0.3424188E 04	0.1500000E 09	0.1982666E 06	0.3424187E-03	0.1321797E-02
18	0.1000000E 08	0.3169313E 04	0.1600000E 09	0.2014389E 06	0.3169312E-03	0.1258993E-02
19	0.5999984E 07	0.3023930E 04	0.1699999E 09	0.2044628E 06	0.3023942E-03	0.1202723E-02
20	0.1000000E 08	0.2838750E 04	0.1799999E 09	0.2073016E 06	0.2838742E-03	0.1151676E-02

TABLE IX-14

Prediction of Future Discoveries
(Straight Line)

REGION 2

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
5	0.113636E 08	0.376934E 08	0.113636E 08	0.376934E 08	0.331702E-02	0.331702E-02
6	0.113636E 08	0.351448E 08	0.227272E 08	0.728381E 08	0.309274E-02	0.329488E-02
7	0.113636E 08	0.296643E 08	0.340909E 08	0.102502E 08	0.261045E-02	0.300674E-02
8	0.113636E 08	0.240621E 08	0.454545E 08	0.127364E 08	0.218787E-02	0.289202E-02
9	0.113636E 08	0.220345E 08	0.568181E 08	0.149394E 08	0.193903E-02	0.262942E-02
10	0.113636E 08	0.985400E 04	0.681818E 08	0.159253E 08	0.867152E-03	0.233571E-02
11	0.113636E 08	0.842550E 04	0.795454E 08	0.167674E 08	0.741443E-03	0.210796E-02
12	0.113636E 08	0.666262E 04	0.909091E 08	0.174341E 08	0.586316E-03	0.191775E-02
13	0.113636E 08	0.555093E 04	0.102272E 09	0.179892E 08	0.488482E-03	0.175894E-02
14	0.113636E 08	0.466212E 04	0.113636E 09	0.184554E 08	0.410266E-03	0.162408E-02
15	0.113636E 08	0.459143E 04	0.125000E 09	0.189146E 08	0.404046E-03	0.151316E-02
16	0.113636E 08	0.445418E 04	0.136363E 09	0.193600E 08	0.391900E-03	0.141973E-02
17	0.113636E 08	0.389112E 04	0.147727E 09	0.197491E 08	0.342418E-03	0.133684E-02
18	0.113636E 08	0.367262E 04	0.160909E 09	0.201164E 08	0.323190E-03	0.126445E-02
19	0.113636E 08	0.343631E 04	0.170454E 09	0.204600E 08	0.302395E-03	0.120032E-02
20	0.113636E 08	0.320350E 04	0.181818E 09	0.207803E 08	0.281907E-03	0.114292E-02

TABLE IX-15

Prediction of Future Discoveries
(Straight Line)

REGION 3

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.1052631E 08	0.349160E 05	0.1052631E 08	0.349160E 05	0.331702E-02	0.331702E-02
5	0.1052631E 08	0.335507E 05	0.2105262E 08	0.684667E 05	0.318731E-02	0.325217E-02
6	0.1052630E 08	0.274784E 05	0.3157893E 08	0.959451E 05	0.261045E-02	0.303826E-02
7	0.1052632E 08	0.249251E 05	0.4210525E 08	0.120870E 06	0.236789E-02	0.287067E-02
8	0.1052630E 08	0.204105E 05	0.5263155E 08	0.141281E 06	0.193904E-02	0.269434E-02
9	0.1052632E 08	0.139990E 05	0.6318787E 08	0.155280E 06	0.132990E-02	0.245860E-02
10	0.1052630E 08	0.832443E 04	0.7368418E 08	0.163604E 06	0.790222E-03	0.222038E-02
11	0.1052632E 08	0.680931E 04	0.8421050E 08	0.170414E 06	0.646884E-03	0.202368E-02
12	0.1052632E 08	0.617181E 04	0.9473682E 08	0.176585E 06	0.586321E-03	0.186396E-02
13	0.1052630E 08	0.453350E 04	0.1052631E 09	0.181119E 06	0.430682E-03	0.172063E-02
14	0.1052632E 08	0.431362E 04	0.1157894E 09	0.185433E 06	0.409794E-03	0.160146E-02
15	0.1052630E 08	0.424343E 04	0.1263157E 09	0.189674E 06	0.403126E-03	0.150160E-02
16	0.1052632E 08	0.408762E 04	0.1368421E 09	0.193764E 06	0.388324E-03	0.141596E-02
17	0.1052630E 08	0.360443E 04	0.1473684E 09	0.197365E 06	0.342421E-03	0.133927E-02
18	0.1052632E 08	0.343381E 04	0.1578947E 09	0.200802E 06	0.326212E-03	0.127174E-02
19	0.1052632E 08	0.316306E 04	0.1684210E 09	0.203985E 06	0.302390E-03	0.121116E-02
20	0.1052630E 08	0.302543E 04	0.1789473E 09	0.207010E 06	0.287416E-03	0.115682E-02

TABLE IX-16

COMPOSITE PARAMETERS FOR ALL K BASINS
(Straight Line)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.999997E 07	0.3317025E 05	0.999997E 07	0.3317025E 05	0.331702E-02	0.331702E-02
4	0.2052629E 08	0.6746456E 05	0.3052629E 08	0.106349E 06	0.3286739E-02	0.329663E-02
5	0.3188995E 08	0.9734875E 05	0.6241624E 08	0.1579836E 06	0.3052646E-02	0.3171989E-02
6	0.3188994E 08	0.8758806E 05	0.9430618E 08	0.2555717E 06	0.2746574E-02	0.3028133E-02
7	0.3188997E 08	0.7397994E 05	0.1261961E 09	0.3595816E 06	0.2319850E-02	0.2849149E-02
8	0.3188992E 08	0.6187750E 05	0.1580861E 09	0.4214291E 06	0.1940347E-02	0.2665821E-02
9	0.3188997E 08	0.4394175E 05	0.1859760E 09	0.4653709E 06	0.1377918E-02	0.2449629E-02
10	0.3188994E 08	0.2543256E 05	0.2218660E 09	0.4908034E 06	0.7975106E-03	0.2212162E-02
11	0.3188997E 08	0.2109806E 05	0.2537559E 09	0.5119015E 06	0.6615892E-03	0.2017298E-02
12	0.3188989E 08	0.1798606E 05	0.2856458E 09	0.5298876E 06	0.5640050E-03	0.1855051E-02
13	0.3188992E 08	0.1418706E 05	0.3175357E 09	0.5440746E 06	0.4448760E-03	0.1713428E-02
14	0.3188992E 08	0.1304338E 05	0.3494257E 09	0.5571180E 06	0.4090124E-03	0.1594382E-02
15	0.3188992E 08	0.1286613E 05	0.3813156E 09	0.5699841E 06	0.4034541E-03	0.1494783E-02
16	0.3188992E 08	0.1222556E 05	0.4132055E 09	0.5822057E 06	0.3833675E-03	0.1409007E-02
17	0.3188992E 08	0.1091975E 05	0.4450954E 09	0.5931254E 06	0.3424201E-03	0.1332569E-02
18	0.3188992E 08	0.1027575E 05	0.4769853E 09	0.6034052E 06	0.3222255E-03	0.1265039E-02
19	0.3188992E 08	0.9643313E 04	0.5088753E 09	0.6130488E 06	0.3023937E-03	0.1204713E-02
20	0.3188992E 08	0.9067688E 04	0.5407652E 09	0.6221162E 06	0.2843433E-03	0.1150437E-02

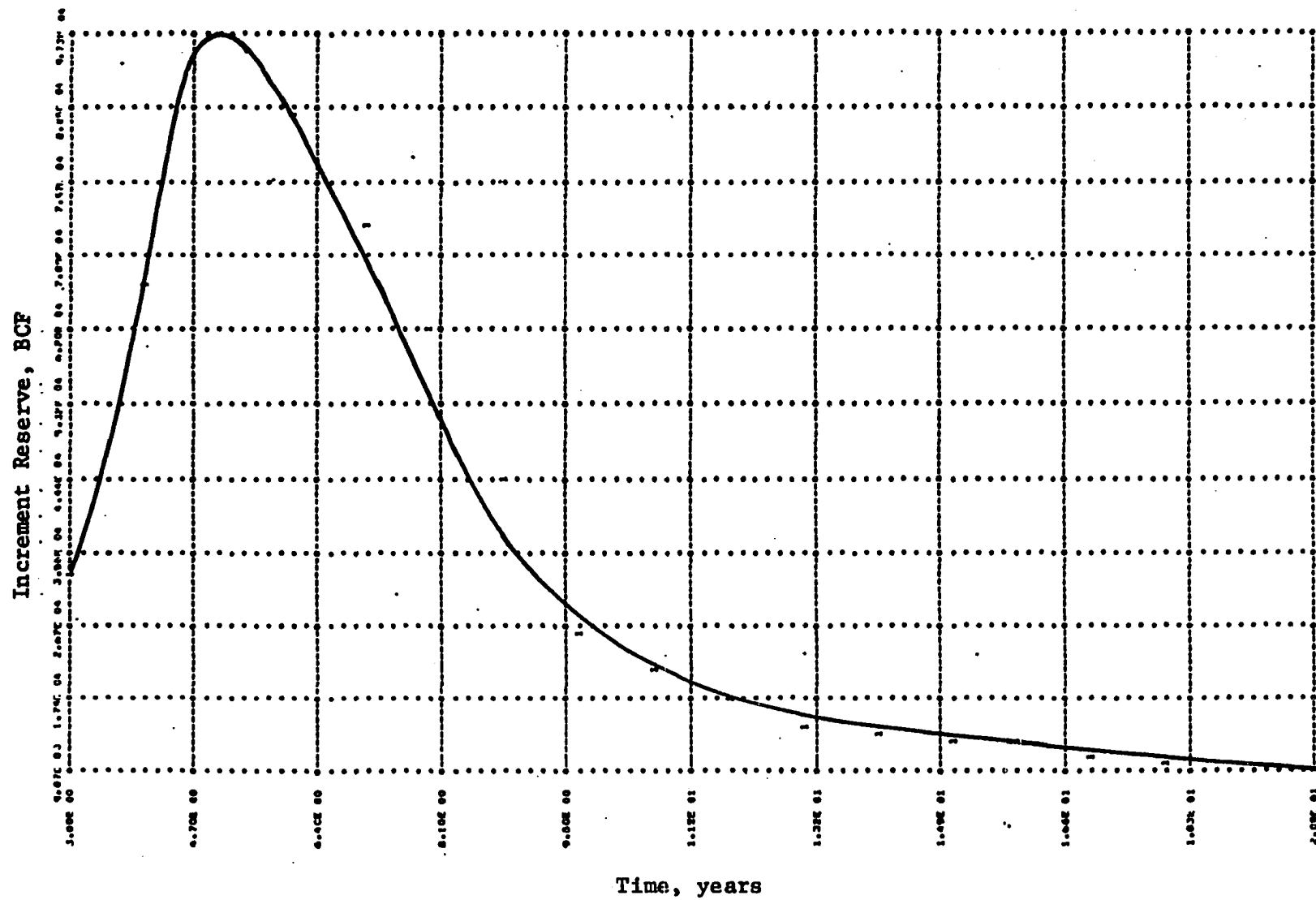


FIGURE IX-73. Composite plot of increment reserve vs. time.
(Straight line)

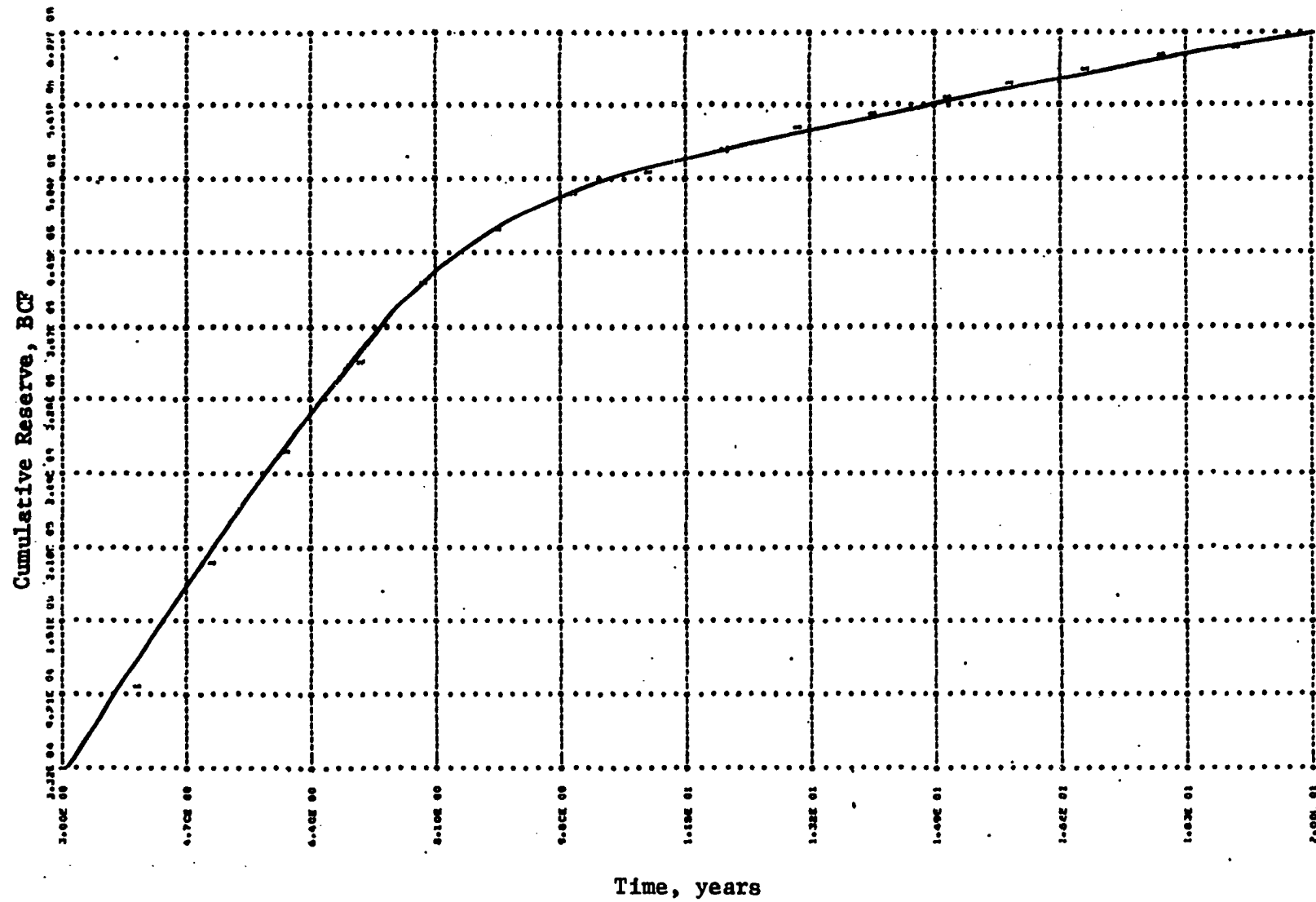


FIGURE IX-74. Composite plot of cumulative discovery vs. time.
(Straight line)

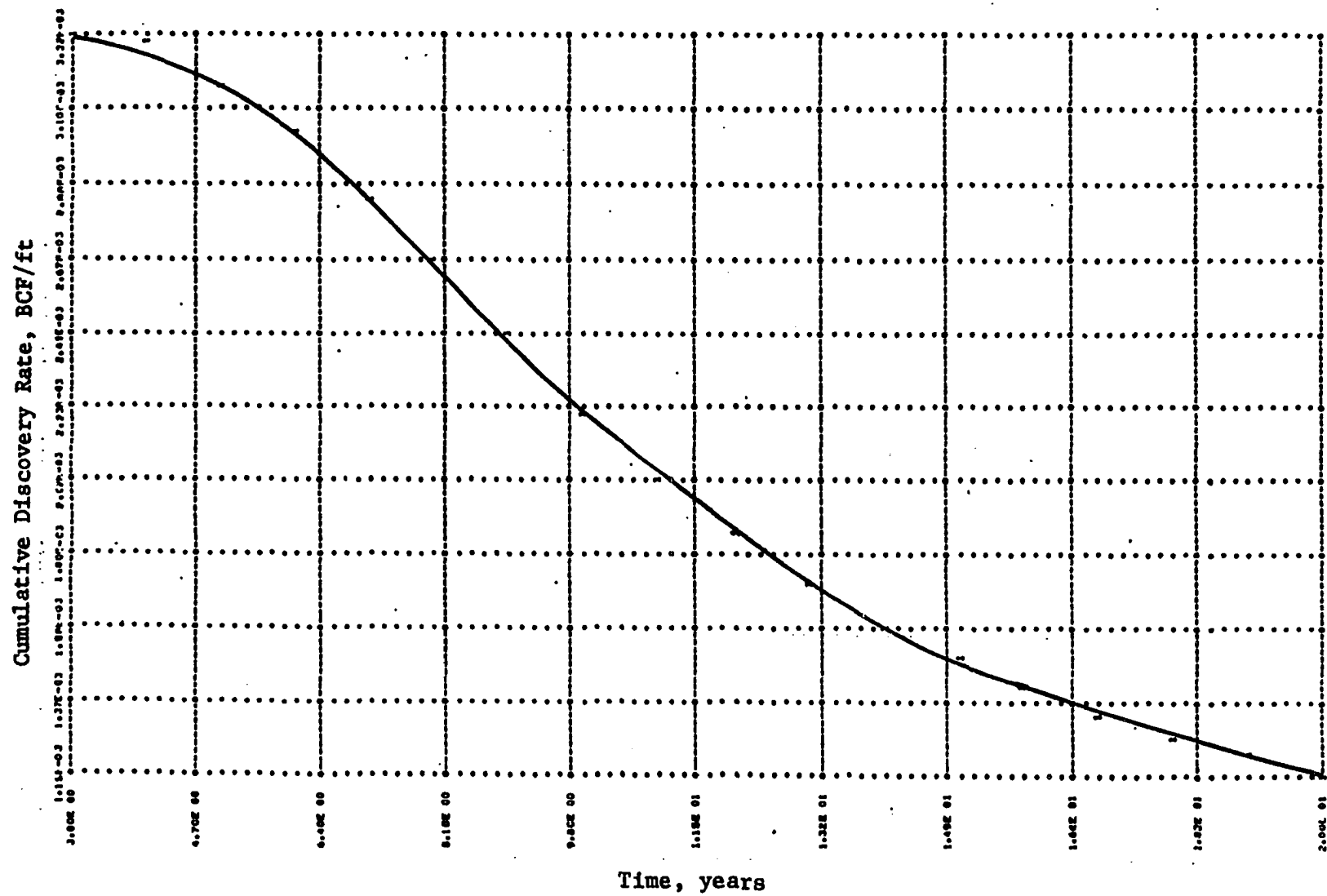


FIGURE IX-75. Composite plot of cumulative discovery rate vs. time.
(straight line)

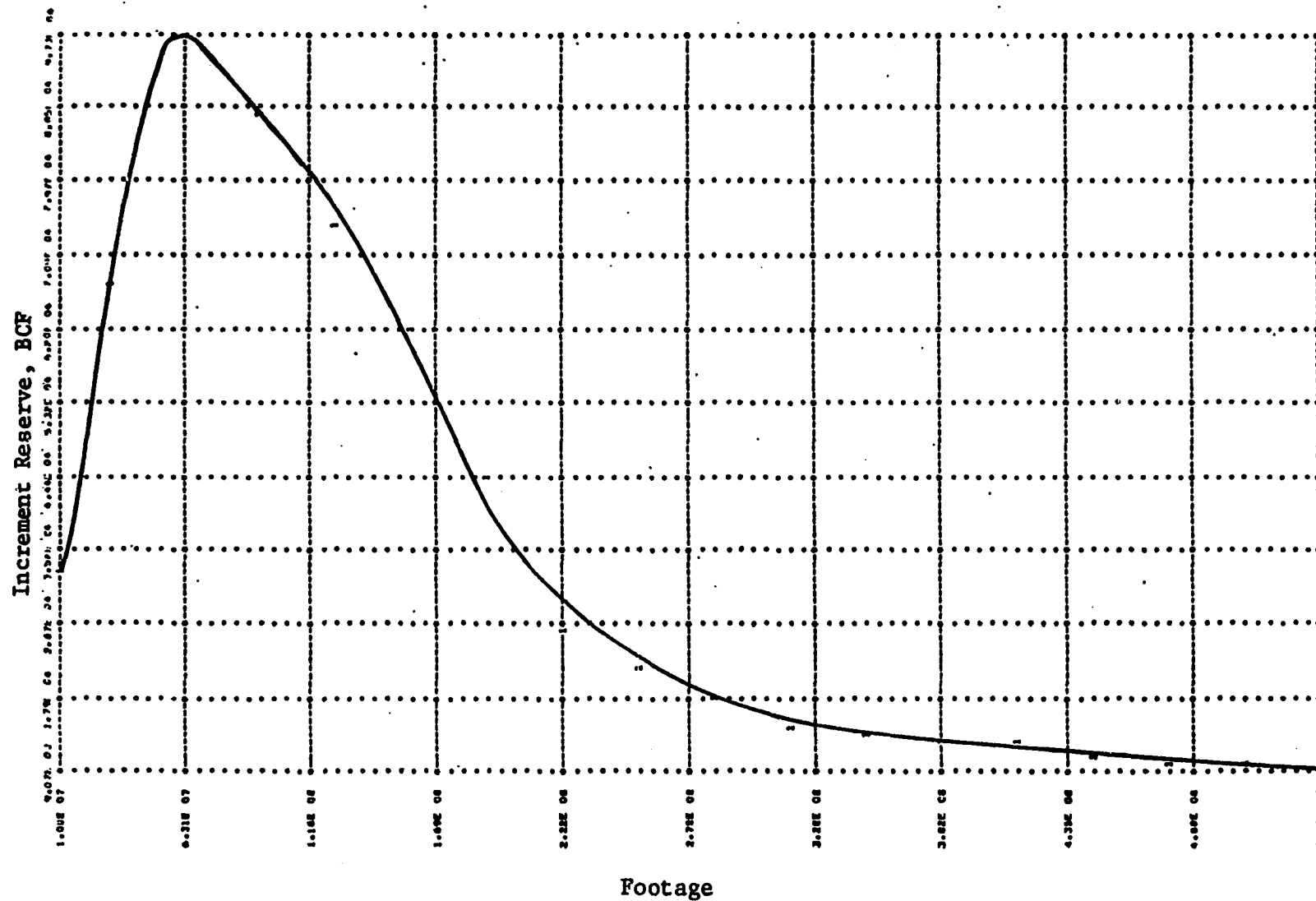


FIGURE IX-76. Composite plot of increment reserve vs. footage.
(Straight line)

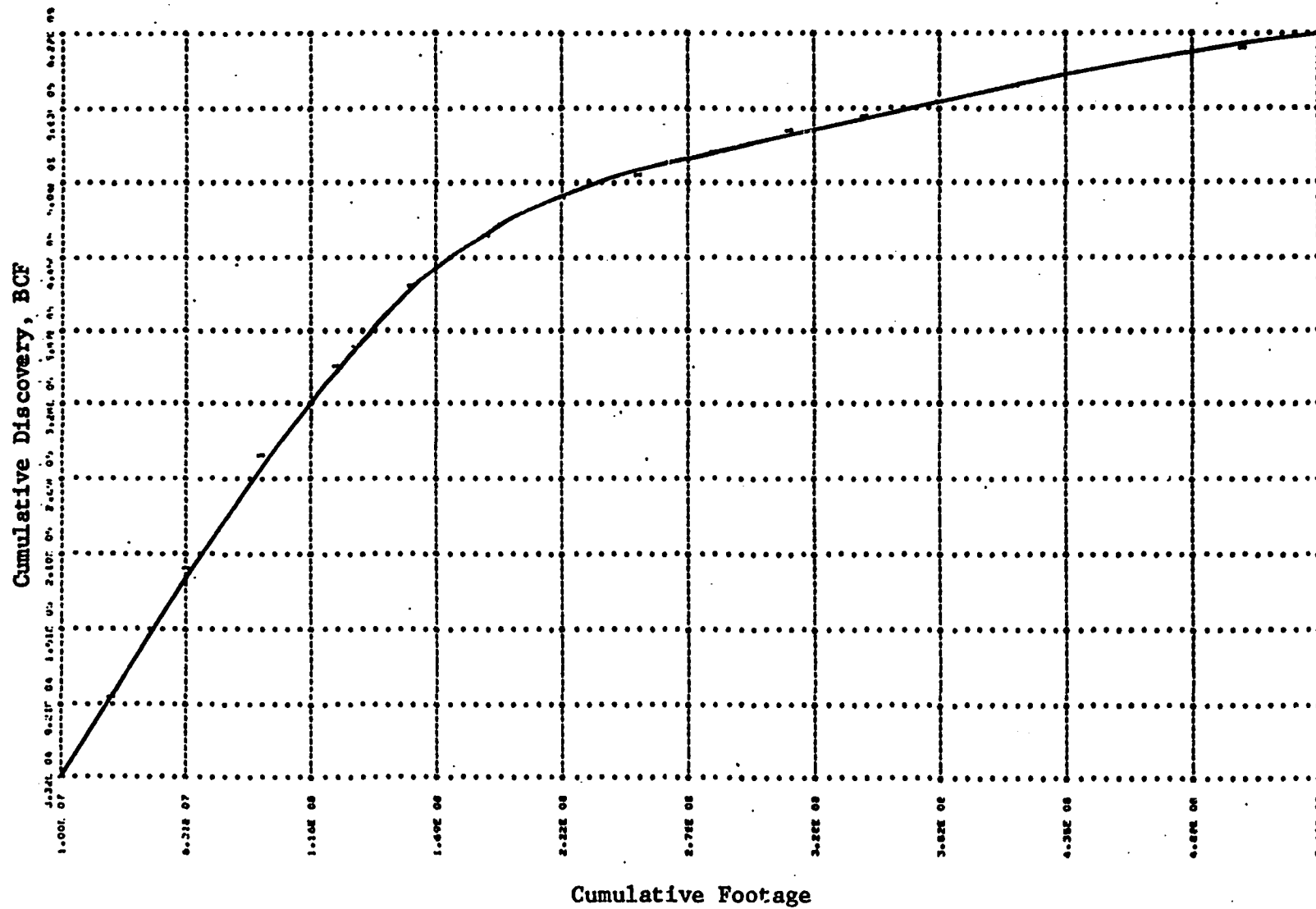


FIGURE IX-77. Composite plot of cumulative discovery vs. cumulative footage.
(Straight line)

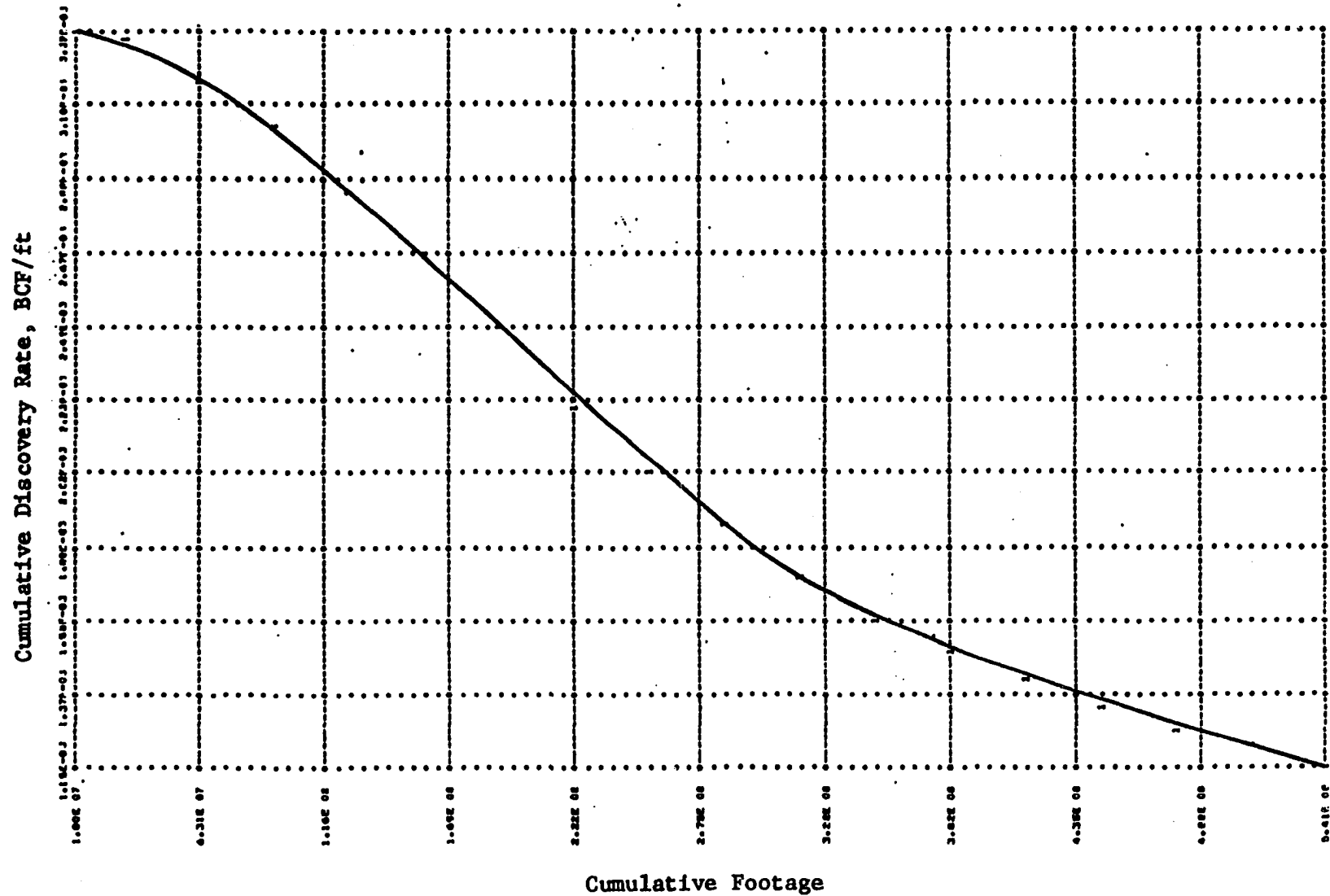


FIGURE IX-78. Composite plot of cumulative discovery rate vs. cumulative footage.
(Straight line)

TABLE IX-17

Prediction of Future Discoveries
(Case I, Straight Line)

REGION 1

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.999996E 06	0.403908E C4	0.999996E 06	0.403908E 04	0.403908E-02	0.403908E-02
4	0.999994E 06	0.400284E 04	0.199999E 07	0.804193E C4	0.400284E-02	0.402096E-02
5	0.999990E 06	0.360168E C4	0.299998E 07	0.116436E 05	0.360168E-02	0.388120E-02
6	0.100000E 07	0.339241E 04	0.399998E 07	0.150362E 05	0.339241E-02	0.375900E-02
7	0.100000E 07	0.244153E C4	0.499998E 07	0.174775E 05	0.244153E-02	0.349551E-02
8	0.999990E 06	0.186877E 04	0.599997E 07	0.193463E 05	0.186877E-02	0.322439E-02
9	0.100000E 07	0.309812E 03	0.699997E 07	0.196561E 05	0.309812E-03	0.280802E-02
10	0.100000E 07	0.781394E C3	0.799997E 07	0.204375E 05	0.781394E-03	0.255469E-02
11	0.999990E 06	0.192255E 04	0.899996E 07	0.223600E 05	0.192255E-02	0.248445E-02
12	0.100000E 07	0.162912E C4	0.999996E 07	0.239892E 05	0.162912E-02	0.239892E-02
13	0.999990E 06	0.112160E 04	0.110000E 08	0.251102E 05	0.112160E-02	0.224280E-02
14	0.100000E 07	0.135249E 04	0.120000E 08	0.264633E 05	0.135249E-02	0.220527E-02
15	0.100000E 07	0.159298E 04	0.130000E 08	0.280563E 05	0.159298E-02	0.215817E-02
16	0.999990E 06	0.173503E C4	0.139999E 08	0.297913E 05	0.173503E-02	0.212795E-02
17	0.100000E 07	0.184675E 04	0.149999E 08	0.316325E 05	0.184675E-02	0.210920E-02
18	0.100000E 07	0.110519E 04	0.159999E 08	0.327432E 05	0.110519E-02	0.204645E-02
19	0.999990E 06	0.724160E C3	0.169998E 08	0.334674E 05	0.724167E-03	0.196867E-02
20	0.100000E 07	0.111828E 04	0.179998E 08	0.345657E 05	0.111828E-02	0.192143E-02

TABLE IX-18

Prediction of Future Discoveries
(Case I, Straight Line)

REGION 2

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
5	0.113636E 07	0.458987E 04	0.113636E 07	0.458987E 04	0.403902E-02	0.403902E-02
6	0.113636E 07	0.443433E 04	0.227272E 07	0.902420E 04	0.390221E-02	0.357065E-02
7	0.113636E 07	0.409282E 04	0.340909E 07	0.121170E 05	0.360168E-02	0.384766E-02
8	0.113636E 07	0.325073E 04	0.454545E 07	0.163677E 05	0.286065E-02	0.360091E-02
9	0.113636E 07	0.277447E 04	0.568181E 07	0.151422E 05	0.244153E-02	0.336903E-02
10	0.113636E 07	0.457574E 03	0.681818E 07	0.195992E 05	0.402665E-03	0.287464E-02
11	0.113636E 07	0.750332E 03	0.754545E 07	0.203501E 05	0.660292E-03	0.255830E-02
12	0.113636E 07	0.218472E 04	0.909090E 07	0.225347E 05	0.192255E-02	0.247883E-02
13	0.113636E 07	0.170925E 04	0.102272E 08	0.242441E 05	0.150414E-02	0.237053E-02
14	0.113636E 07	0.127455E 04	0.113636E 08	0.255186E 05	0.112160E-02	0.224564E-02
15	0.113636E 07	0.174112E 04	0.124999E 08	0.272592E 05	0.153219E-02	0.218078E-02
16	0.113636E 07	0.185998E 04	0.136363E 08	0.251197E 05	0.163678E-02	0.213545E-02
17	0.113636E 07	0.209858E 04	0.147727E 08	0.312183E 05	0.184675E-02	0.211324E-02
18	0.113636E 07	0.145907E 04	0.159090E 08	0.326774E 05	0.128398E-02	0.205401E-02
19	0.113635E 07	0.822914E 03	0.170454E 08	0.335003E 05	0.724167E-03	0.196535E-02
20	0.113636E 07	0.131251E 04	0.181818E 08	0.348126E 05	0.115500E-02	0.191470E-02

TABLE IX-19

Prediction of Future Discoveries
(Case I, Straight Line)

REGION 3

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.1052631E 07	0.425166E 04	0.1052631E 07	0.425166E 04	0.4039086E-02	0.4039086E-02
5	0.1052631E 07	0.4169387E 04	0.2105262E 07	0.842105E 04	0.3960919E-02	0.4000001E-02
6	0.1052631E 07	0.379124E 04	0.3157893E 07	0.1221230E 05	0.3601686E-02	0.3667231E-02
7	0.1052631E 07	0.3337727E 04	0.4210524E 07	0.155503E 05	0.3170842E-02	0.3693133E-02
8	0.1052631E 07	0.257003E 04	0.526315E 07	0.1812007E 05	0.2441538E-02	0.3442814E-02
9	0.1052631E 07	0.1324098E 04	0.6315786E 07	0.1544416E 05	0.1257893E-02	0.3078661E-02
10	0.1052631E 07	0.3261172E 03	0.7368417E 07	0.1977028E 05	0.3098114E-03	0.2683111E-02
11	0.1052631E 07	0.1476750E 04	0.8421048E 07	0.2124703E 05	0.1402913E-02	0.2523086E-02
12	0.1052631E 07	0.2023746E 04	0.9473679E 07	0.232707E 05	0.1922560E-02	0.2456361E-02
13	0.1052631E 07	0.1308754E 04	0.1052631E 08	0.2457953E 05	0.1243317E-02	0.2335057E-02
14	0.1052631E 07	0.1213043E 04	0.1157894E 08	0.2579257E 05	0.1152391E-02	0.2227542E-02
15	0.1052631E 07	0.1676828E 04	0.1263157E 08	0.2746940E 05	0.1592987E-02	0.2174662E-02
16	0.1052631E 07	0.1738742E 04	0.1368420E 08	0.2920814E 05	0.1651806E-02	0.2134442E-02
17	0.1052631E 07	0.1943949E 04	0.1473683E 08	0.3115209E 05	0.1846753E-02	0.2113893E-02
18	0.1052631E 07	0.1438727E 04	0.1578947E 08	0.3259082E 05	0.1366791E-02	0.2064086E-02
19	0.1052631E 07	0.7622813E 03	0.1684210E 08	0.3335310E 05	0.7241676E-03	0.1980341E-02
20	0.1052624E 07	0.1101125E 04	0.1789472E 08	0.3445423E 05	0.1046076E-02	0.1925385E-02

TABLE IX-20

COMPOSITE PARAMETERS FOR ALL K BASINS
(Case I, Straight Line)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.599999E 06	0.403908E 04	0.999999E 06	0.403908E 04	0.403908E-02	0.403908E-02
4	0.205263E 07	0.625450E 04	0.305263E 07	0.122936E 05	0.402142E-02	0.402721E-02
5	0.318899E 07	0.123609E 05	0.624162E 07	0.246545E 05	0.387612E-02	0.395001E-02
6	0.318899E 07	0.116179E 05	0.943061E 07	0.362725E 05	0.364315E-02	0.384625E-02
7	0.318899E 07	0.987208E 04	0.126196E 08	0.461446E 05	0.309567E-02	0.365658E-02
8	0.318899E 07	0.768954E 04	0.158086E 08	0.538341E 05	0.241127E-02	0.340537E-02
9	0.318898E 07	0.440838E 04	0.185975E 08	0.582425E 05	0.138238E-02	0.306578E-02
10	0.318898E 07	0.156508E 04	0.221865E 08	0.598076E 05	0.490775E-03	0.269566E-02
11	0.318897E 07	0.414964E 04	0.253755E 08	0.639572E 05	0.130124E-02	0.252042E-02
12	0.318899E 07	0.583754E 04	0.286645E 08	0.657942E 05	0.123052E-02	0.244340E-02
13	0.318895E 07	0.413562E 04	0.317535E 08	0.739344E 05	0.129809E-02	0.232832E-02
14	0.318899E 07	0.384006E 04	0.345425E 08	0.777745E 05	0.120416E-02	0.222578E-02
15	0.318900E 07	0.501093E 04	0.381315E 08	0.827854E 05	0.167131E-02	0.217104E-02
16	0.318897E 07	0.233381E 04	0.413205E 08	0.861192E 05	0.167257E-02	0.213257E-02
17	0.318900E 07	0.588925E 04	0.445095E 08	0.940085E 05	0.184673E-02	0.211209E-02
18	0.318899E 07	0.400300E 04	0.476985E 08	0.980115E 05	0.125525E-02	0.205481E-02
19	0.318899E 07	0.230931E 04	0.508875E 08	0.100320E 06	0.724151E-03	0.197142E-02
20	0.318899E 07	0.353193E 04	0.540765E 08	0.103852E 06	0.110754E-02	0.192047E-02

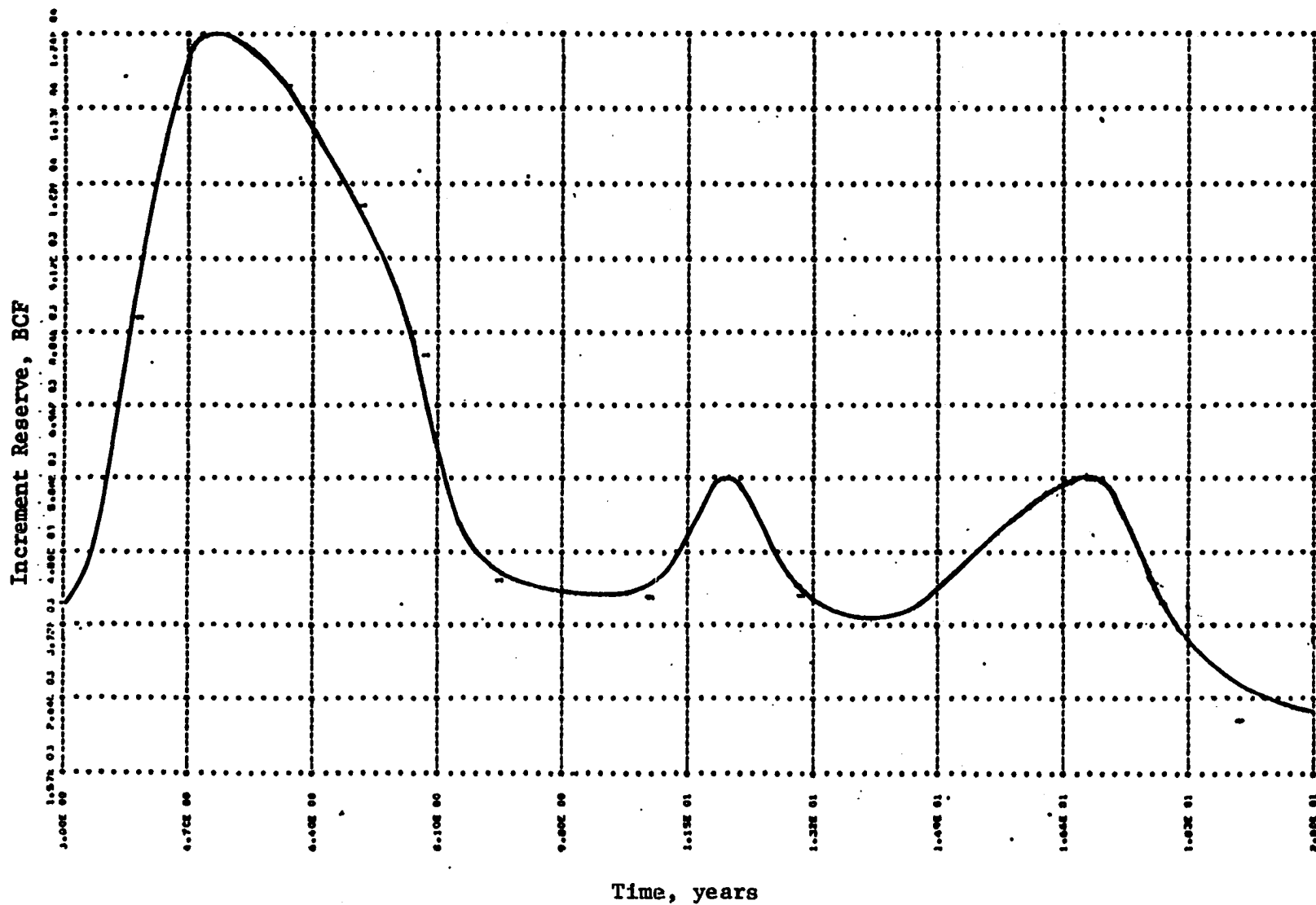


FIGURE IX-79. Composite plot of increment reserve vs. time.
(Case I, Straight line)

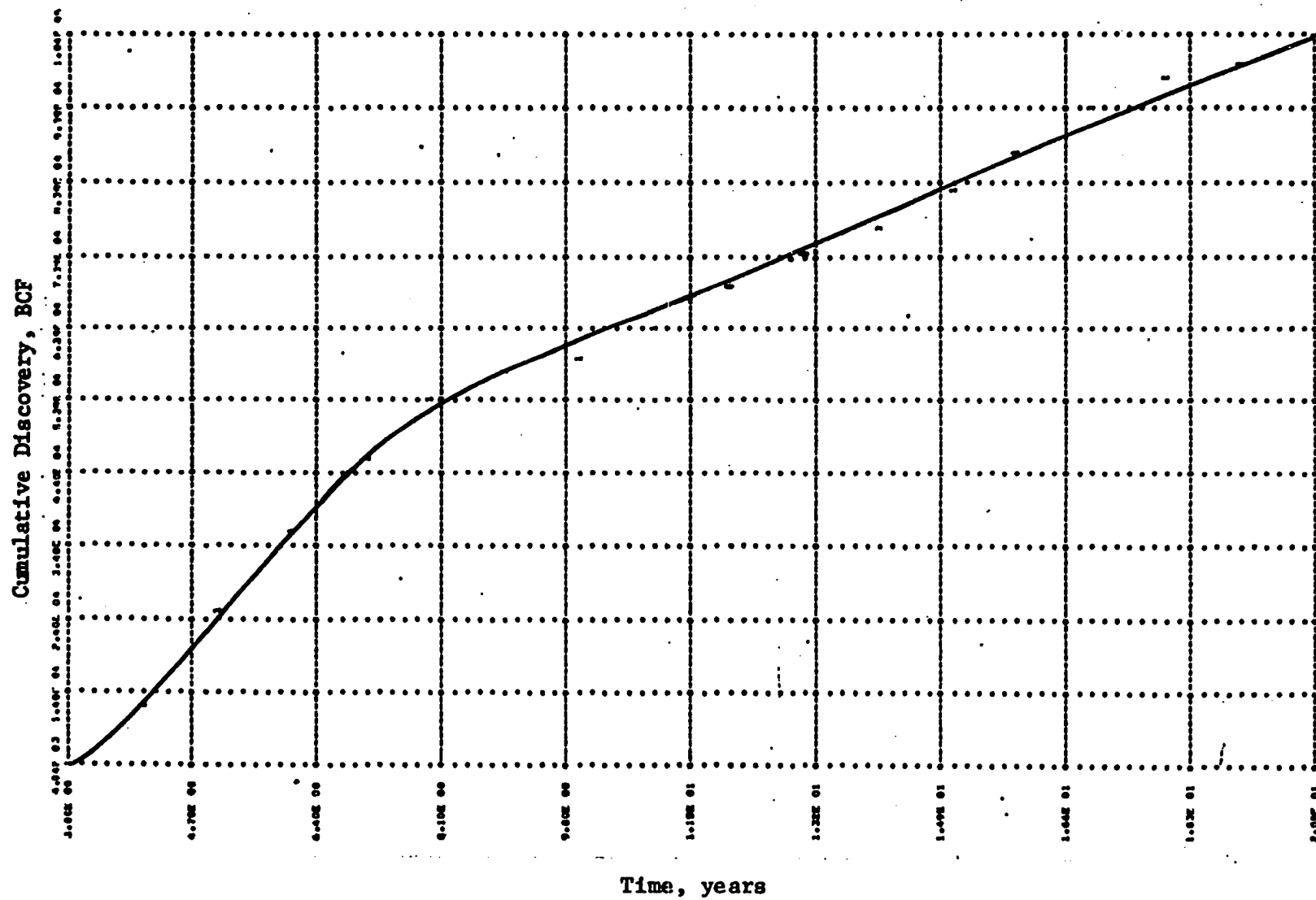


FIGURE IX-80. Composite plot of cumulative discovery vs. time.
(Case I, Straight line)

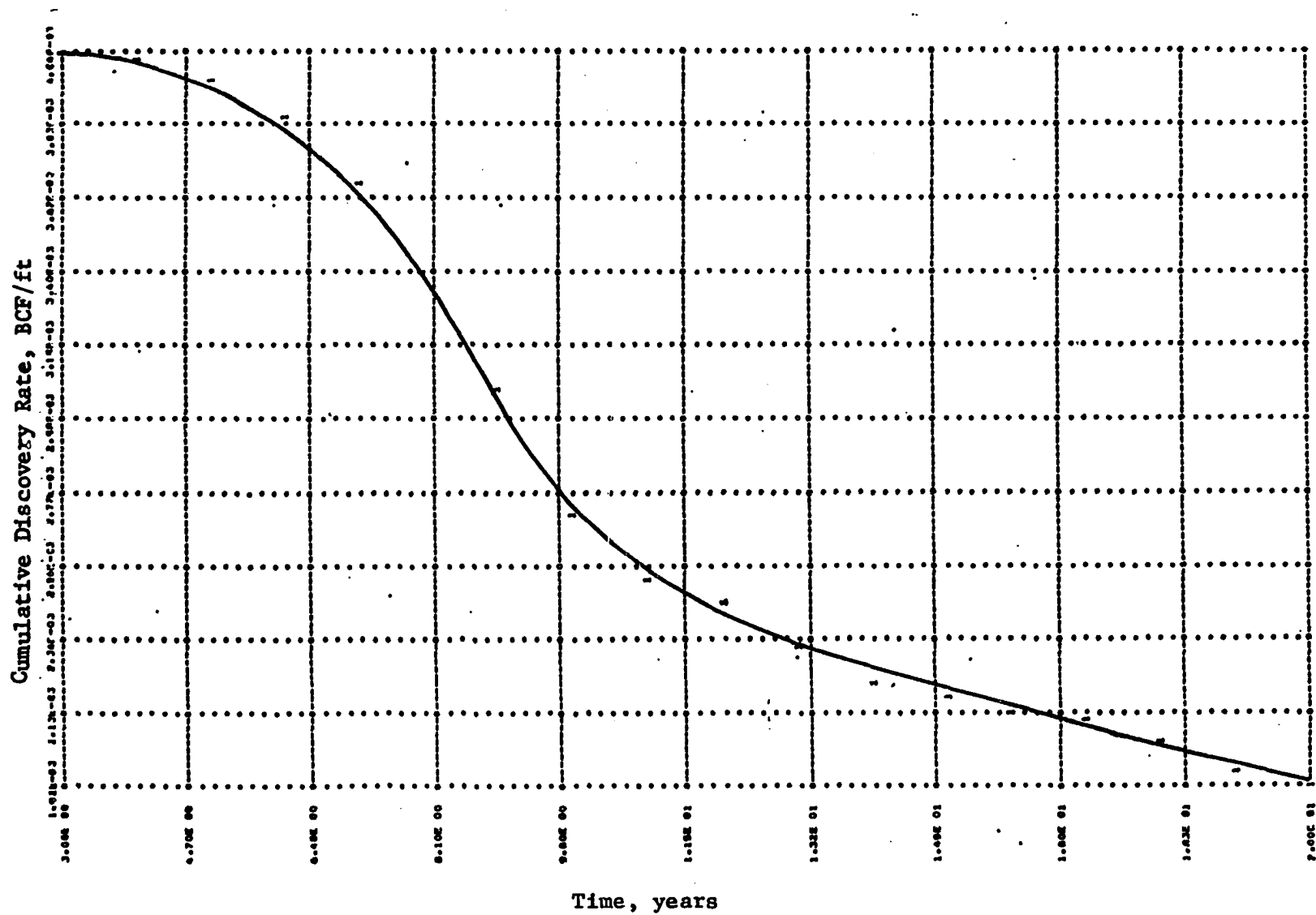


FIGURE IX-81. Composite plot of cumulative discovery rate vs. time.
(Case I, Straight line)

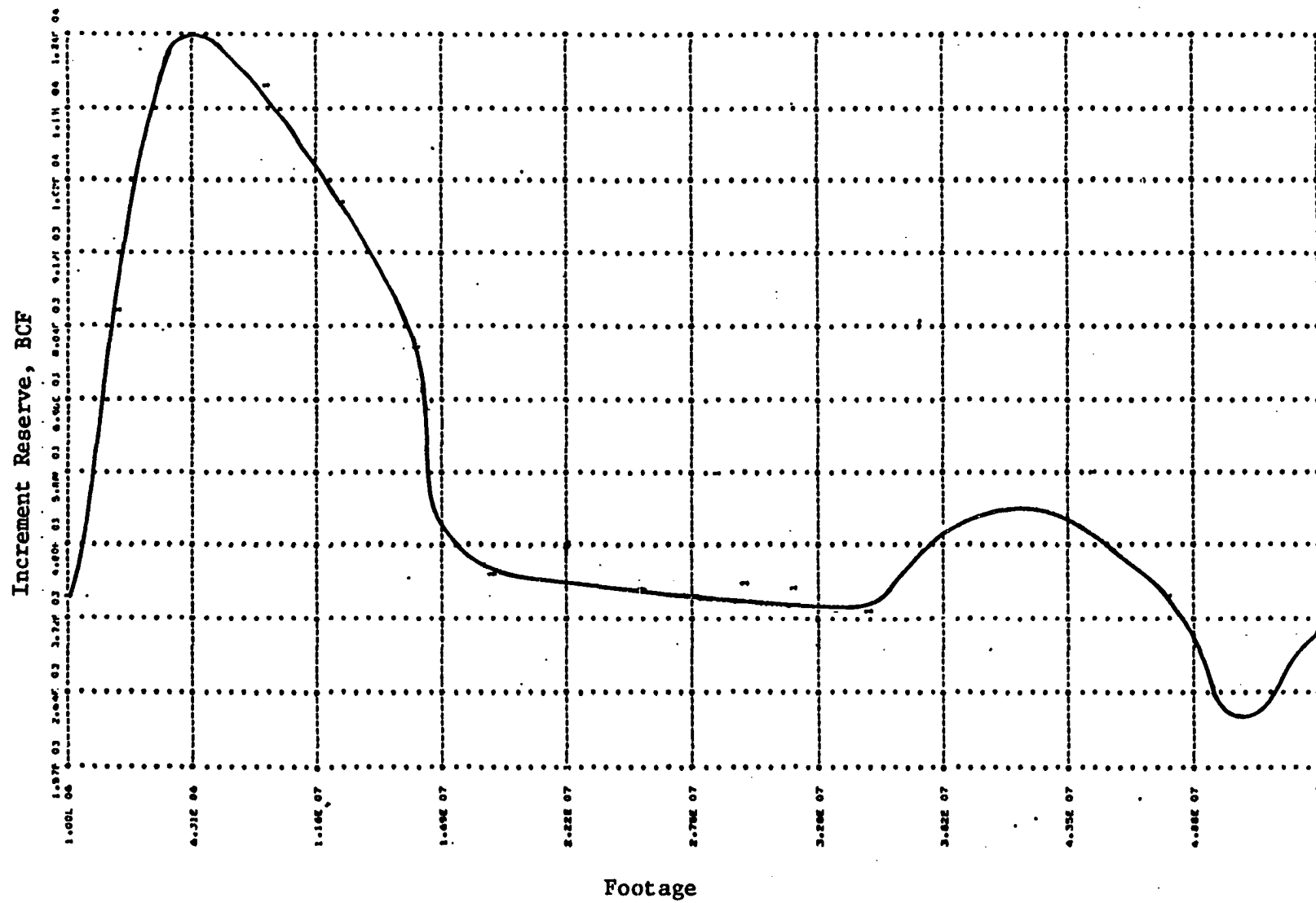


FIGURE IX-82. Composite plot of increment reserve vs. footage.
(Case I, straight line)

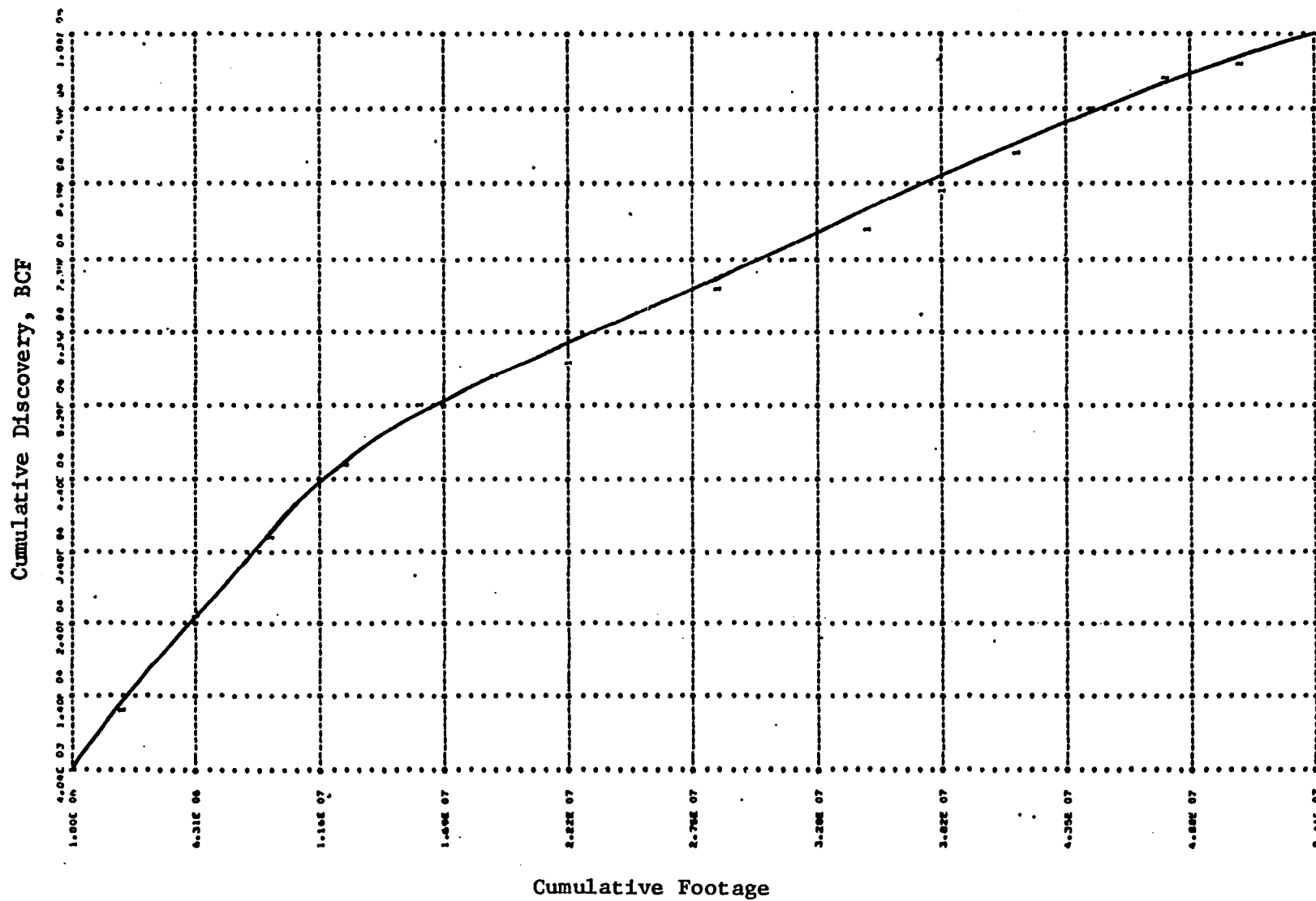


FIGURE IX-83. Composite plot of cumulative discovery vs. cumulative footage.
(Case I, straight line)

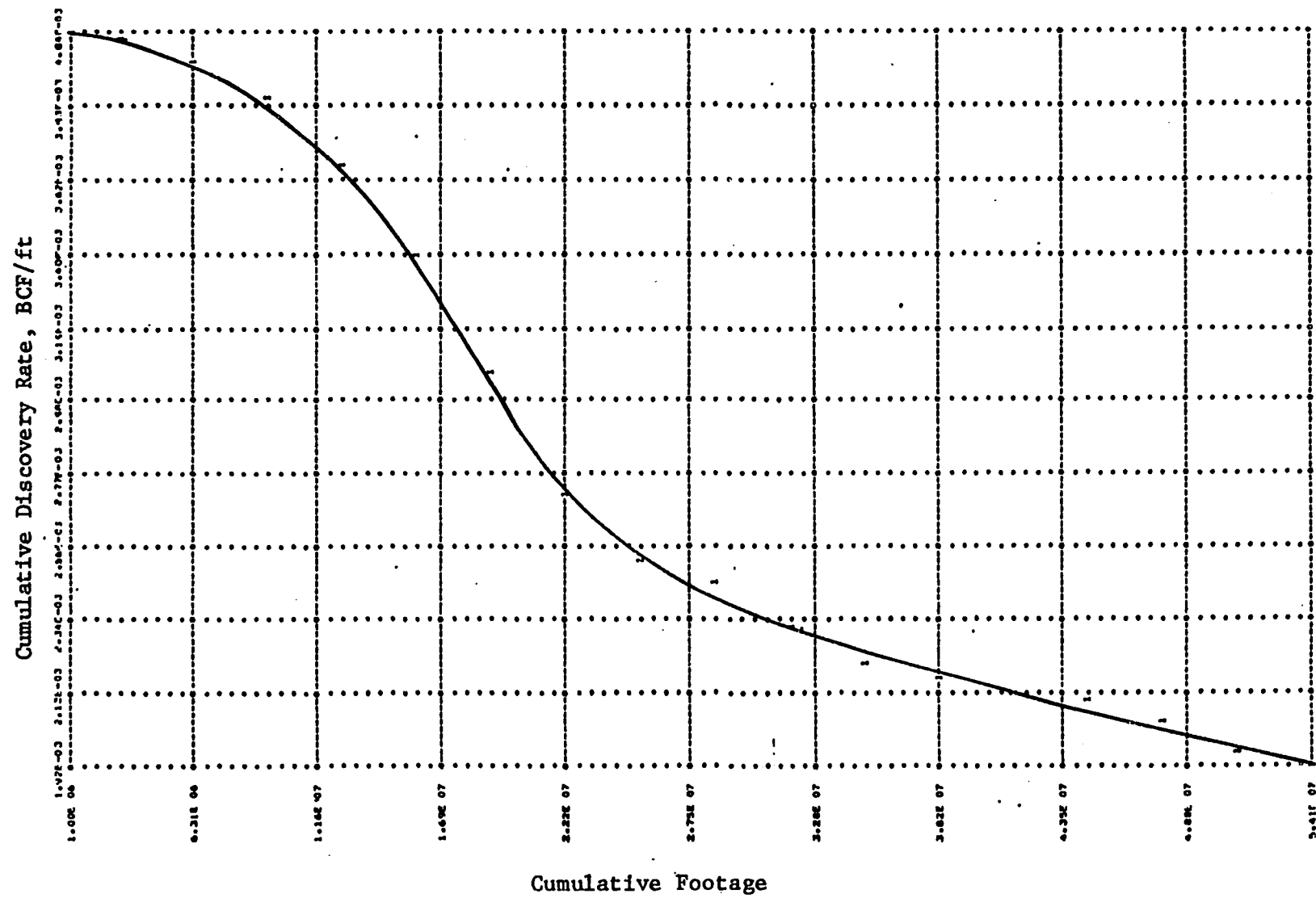


FIGURE IX-84. Composite plot of cumulative discovery rate vs. cumulative footage.
(Case I, straight line)

is based on the results of Case I of Phase one using a straight line extrapolation for future drilling activities. Tables IX-17, IX-18 and IX-19 are results for each of the individual regions (1, 2, and 3). Table IX-20 and Figures IX-79 to IX-84 are the results for all (three) regions combined. By observing these figures and comparing the plots for this run with the corresponding plots for the second run, almost the same response can be observed in most of the plots, except for the plot of increment reserve vs. either time or footage. The plots of increment footage vs. either time or footage for this run are shown in Figures IX-79 and IX-82 respectively. The plot of increment reserve vs. time, Figure IX-79, indicates that more reserves have been found when $t = 5$ years, then the curve drops sharply in the period of $t = 5$ to 10 years. From $t = 11$ to $t = 20$ years, the values of increment reserves oscillate. The plot of increment reserve vs. footage, Figure IX-82, shows nearly the same features as Figure IX-79. It shows that we have found more reserves in the first part of drilling activities, then the curve drops sharply for a while, and afterwards the rate of decrease in the curve becomes more gradual. Again the values of increment reserves oscillate in the latter portion of the drilling activities.

Sixth Run

The results obtained from the sixth run are shown in Tables IX-21 to IX-24 and Figures IX-85 to IX-90. This run

TABLE IX-21

Prediction of Future Discoveries for Region 1
(Case II, Straight Line)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.559999E 06	0.403908E 04	0.559999E 06	0.403908E 04	0.403908E-02	0.403908E-02
4	0.559999E 06	0.396006E 04	0.155999E 07	0.799915E 04	0.396006E-02	0.359952E-02
5	0.999999E 06	0.308547E 04	0.255999E 07	0.110846E 05	0.308548E-02	0.369488E-02
6	0.100000E 07	0.271757E 04	0.355999E 07	0.138022E 05	0.271757E-02	0.345053E-02
7	0.100000E 07	0.104595E 04	0.455999E 07	0.148481E 05	0.104595E-02	0.296963E-02
8	0.559999E 06	0.801531E 03	0.559999E 07	0.156496E 05	0.801531E-03	0.260828E-02
9	0.100000E 07	0.136277E 03	0.655999E 07	0.157859E 05	0.136277E-03	0.225513E-02
10	0.100000E 07	0.265347E 03	0.759999E 07	0.160513E 05	0.265347E-03	0.200641E-02
11	0.559999E 06	0.577675E 03	0.855999E 07	0.166290E 05	0.577680E-03	0.184766E-02
12	0.100000E 07	0.459992E 03	0.955999E 07	0.170885E 05	0.459992E-03	0.170889E-02
13	0.559999E 06	0.256441E 03	0.110000E 08	0.173454E 05	0.256441E-03	0.157685E-02
14	0.100000E 07	0.412632E 03	0.120000E 08	0.177580E 05	0.412632E-03	0.147963E-02
15	0.100000E 07	0.575324E 03	0.130000E 08	0.183333E 05	0.575324E-03	0.141026E-02
16	0.559999E 06	0.555824E 03	0.135999E 08	0.189292E 05	0.555824E-03	0.135207E-02
17	0.100000E 07	0.611949E 03	0.149999E 08	0.195411E 05	0.611949E-03	0.130274E-02
18	0.100000E 07	0.531082E 03	0.155999E 08	0.200722E 05	0.531081E-03	0.125451E-02
19	0.559999E 06	0.489527E 03	0.165999E 08	0.205617E 05	0.489532E-03	0.120951E-02
20	0.100000E 07	0.399386E 03	0.179999E 08	0.209611E 05	0.399386E-03	0.116451E-02

TABLE IX-22

Prediction of Future Discoveries for Region 2
(Case II, Straight Line)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
5	0.113636E 07	0.458987E 04	0.113636E 07	0.458987E 04	0.403908E-02	0.403908E-02
6	0.113636E 07	0.443433E 04	0.227272E 07	0.902420E 04	0.390221E-02	0.397065E-02
7	0.113636E 07	0.409282E 04	0.340909E 07	0.131170E 05	0.360168E-02	0.384766E-02
8	0.113636E 07	0.325073E 04	0.454545E 07	0.163677E 05	0.286065E-02	0.360091E-02
9	0.113636E 07	0.277447E 04	0.568181E 07	0.191422E 05	0.244153E-02	0.336903E-02
10	0.113636E 07	0.457574E 03	0.681818E 07	0.155991E 05	0.402665E-03	0.287464E-02
11	0.113636E 07	0.750332E 03	0.795454E 07	0.203501E 05	0.660292E-03	0.255830E-02
12	0.113636E 07	0.218472E 04	0.909090E 07	0.225348E 05	0.192255E-02	0.247883E-02
13	0.113636E 07	0.170925E 04	0.102272E 08	0.242441E 05	0.150414E-02	0.237053E-02
14	0.113636E 07	0.127455E 04	0.113636E 08	0.255186E 05	0.112160E-02	0.224564E-02
15	0.113636E 07	0.174112E 04	0.124999E 08	0.272596E 05	0.153219E-02	0.218078E-02
16	0.113636E 07	0.185998E 04	0.136363E 08	0.291197E 05	0.163678E-02	0.213545E-02
17	0.113636E 07	0.209858E 04	0.147727E 08	0.312183E 05	0.184675E-02	0.211324E-02
18	0.113636E 07	0.145907E 04	0.159090E 08	0.326774E 05	0.128398E-02	0.205401E-02
19	0.113636E 07	0.822914E 03	0.170454E 08	0.325003E 05	0.724167E-03	0.196535E-02
20	0.113636E 07	0.131251E 04	0.181818E 08	0.348128E 05	0.115500E-02	0.191470E-02

TABLE IX-23

Prediction of Future Discoveries for Region 3
(Case II, Straight Line)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.1052631E 07	0.4251668E 04	0.1052631E 07	0.4251668E 04	0.4035086E-02	0.4039056E-02
5	0.1052631E 07	0.4302656E 04	0.2105262E 07	0.8554324E 04	0.4087523E-02	0.4063305E-02
6	0.1052631E 07	0.4536953E 04	0.3157893E 07	0.1309128E 05	0.4310105E-02	0.4145570E-02
7	0.1052631E 07	0.4010445E 04	0.4210524E 07	0.1710173E 05	0.3809929E-02	0.4061662E-02
8	0.1052631E 07	0.3119207E 04	0.5263155E 07	0.2022053E 05	0.2963248E-02	0.3841979E-02
9	0.1052631E 07	0.1912855E 04	0.6315786E 07	0.2213379E 05	0.1817214E-02	0.3504518E-02
10	0.1052631E 07	0.9465858E 03	0.7368417E 07	0.2308038E 05	0.8992606E-03	0.3132339E-02
11	0.1052631E 07	0.2040457E 04	0.8421048E 07	0.2512064E 05	0.1938435E-02	0.2983101E-02
12	0.1052631E 07	0.2560465E 04	0.9473679E 07	0.2768130E 05	0.2432443E-02	0.2921917E-02
13	0.1052631E 07	0.1901691E 04	0.1052631E 08	0.2558259E 05	0.1806608E-02	0.2810386E-02
14	0.1052631E 07	0.1785651E 04	0.1157894E 08	0.3137268E 05	0.1700208E-02	0.2709460E-02
15	0.1052631E 07	0.1876273E 04	0.1263157E 08	0.3324856E 05	0.1782461E-02	0.2632210E-02
16	0.1052631E 07	0.1925418E 04	0.1368420E 08	0.3517438E 05	0.1829148E-02	0.2570436E-02
17	0.1052631E 07	0.2088324E 04	0.1473683E 08	0.3726270E 05	0.1983909E-02	0.2528541E-02
18	0.1052631E 07	0.2465289E 04	0.1578947E 08	0.3572759E 05	0.2342026E-02	0.2516107E-02
19	0.1052631E 07	0.2970008E 04	0.1684210E 08	0.4269800E 05	0.2821509E-02	0.2535195E-02
20	0.1052624E 07	0.2008953E 04	0.1789472E 08	0.4470655E 05	0.1908519E-02	0.2498332E-02

TABLE IX-24

Composite Parameters for All k Basins
(Case II, Straight Line)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.999999E 06	0.403908E 04	0.999999E 06	0.403908E 04	0.403908E-02	0.403908E-02
4	0.205263E 07	0.821173E 04	0.305263E 07	0.122506E 05	0.400058E-02	0.401320E-02
5	0.318899E 07	0.119780E 05	0.624162E 07	0.242288E 05	0.375604E-02	0.389191E-02
6	0.318899E 07	0.116888E 05	0.943061E 07	0.359176E 05	0.366537E-02	0.380862E-02
7	0.318899E 07	0.914922E 04	0.126196E 08	0.450669E 05	0.286899E-02	0.357118E-02
8	0.318899E 07	0.717147E 04	0.158086E 08	0.522383E 05	0.224882E-02	0.330442E-02
9	0.318899E 07	0.482360E 04	0.189975E 08	0.570620E 05	0.151258E-02	0.300364E-02
10	0.318900E 07	0.166951E 04	0.221865E 08	0.587315E 05	0.523520E-03	0.264716E-02
11	0.318897E 07	0.336846E 04	0.253755E 08	0.620998E 05	0.105628E-02	0.244723E-02
12	0.318899E 07	0.520514E 04	0.285645E 08	0.673051E 05	0.163222E-02	0.235624E-02
13	0.318899E 07	0.386737E 04	0.317535E 08	0.711725E 05	0.121272E-02	0.224140E-02
14	0.318899E 07	0.347687E 04	0.349425E 08	0.746493E 05	0.109027E-02	0.213634E-02
15	0.318900E 07	0.419275E 04	0.381315E 08	0.788421E 05	0.131475E-02	0.206763E-02
16	0.318897E 07	0.438118E 04	0.413205E 08	0.832233E 05	0.137385E-02	0.201409E-02
17	0.318900E 07	0.479875E 04	0.445095E 08	0.880221E 05	0.150481E-02	0.197760E-02
18	0.318899E 07	0.445543E 04	0.476985E 08	0.924776E 05	0.139713E-02	0.193879E-02
19	0.318899E 07	0.428243E 04	0.508875E 08	0.967600E 05	0.134288E-02	0.190145E-02
20	0.318899E 07	0.372087E 04	0.540765E 08	0.100480E 06	0.116678E-02	0.185812E-02

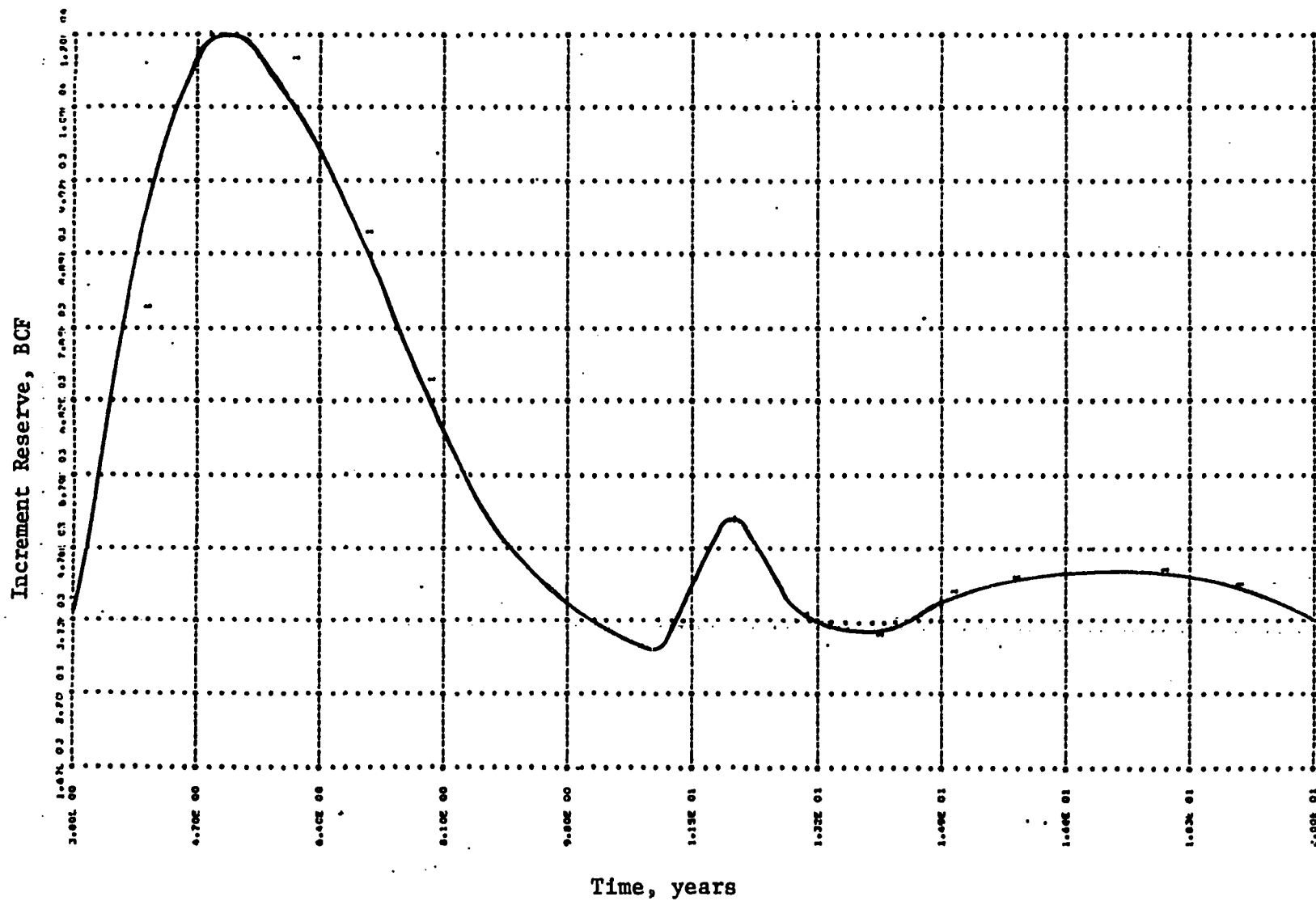


FIGURE IX-85. Composite plot of increment reserve vs. time.
(Case II, straight line)

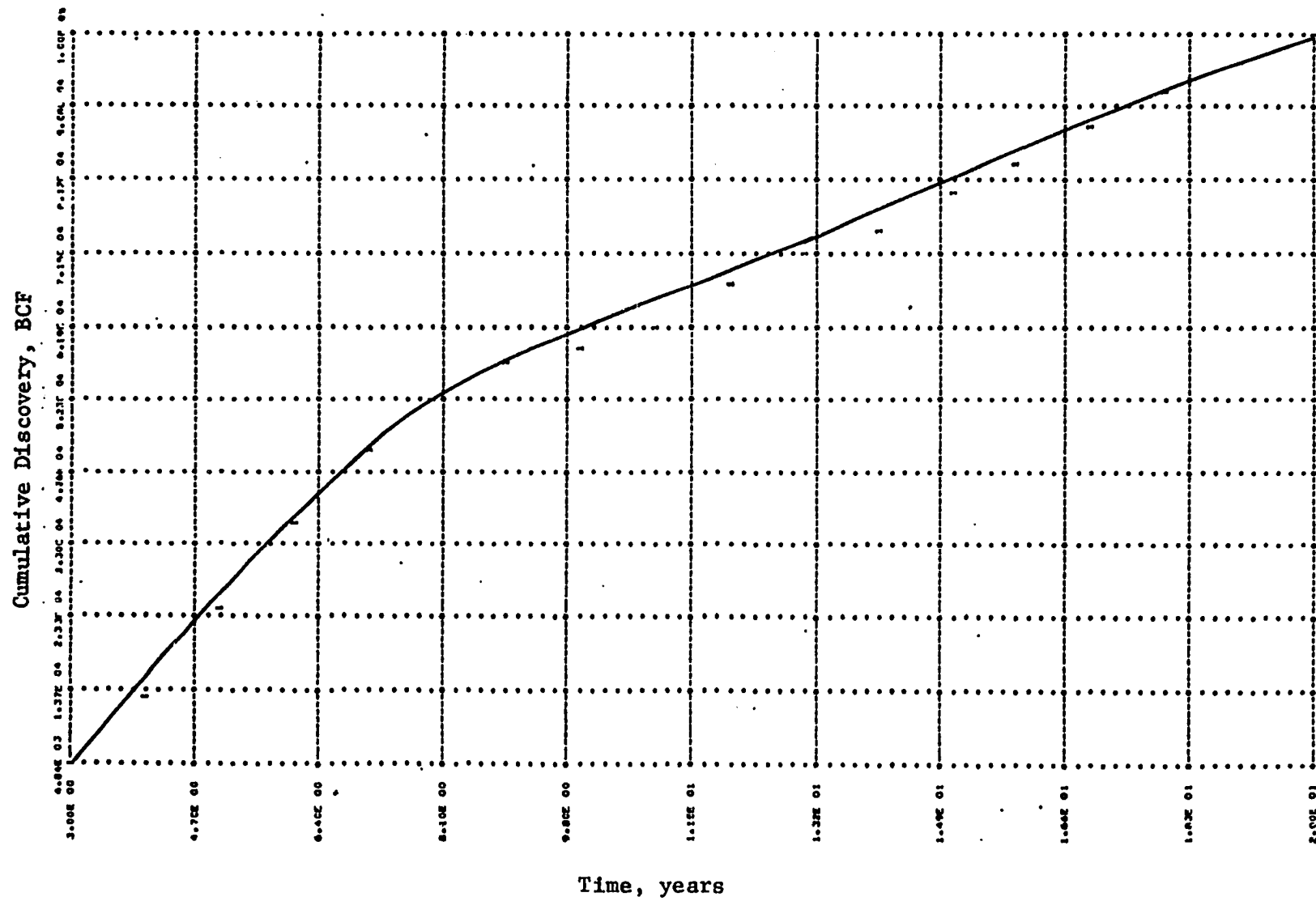


FIGURE IX-86. Composite plot of cumulative discovery vs. time.
(Case II, straight line)

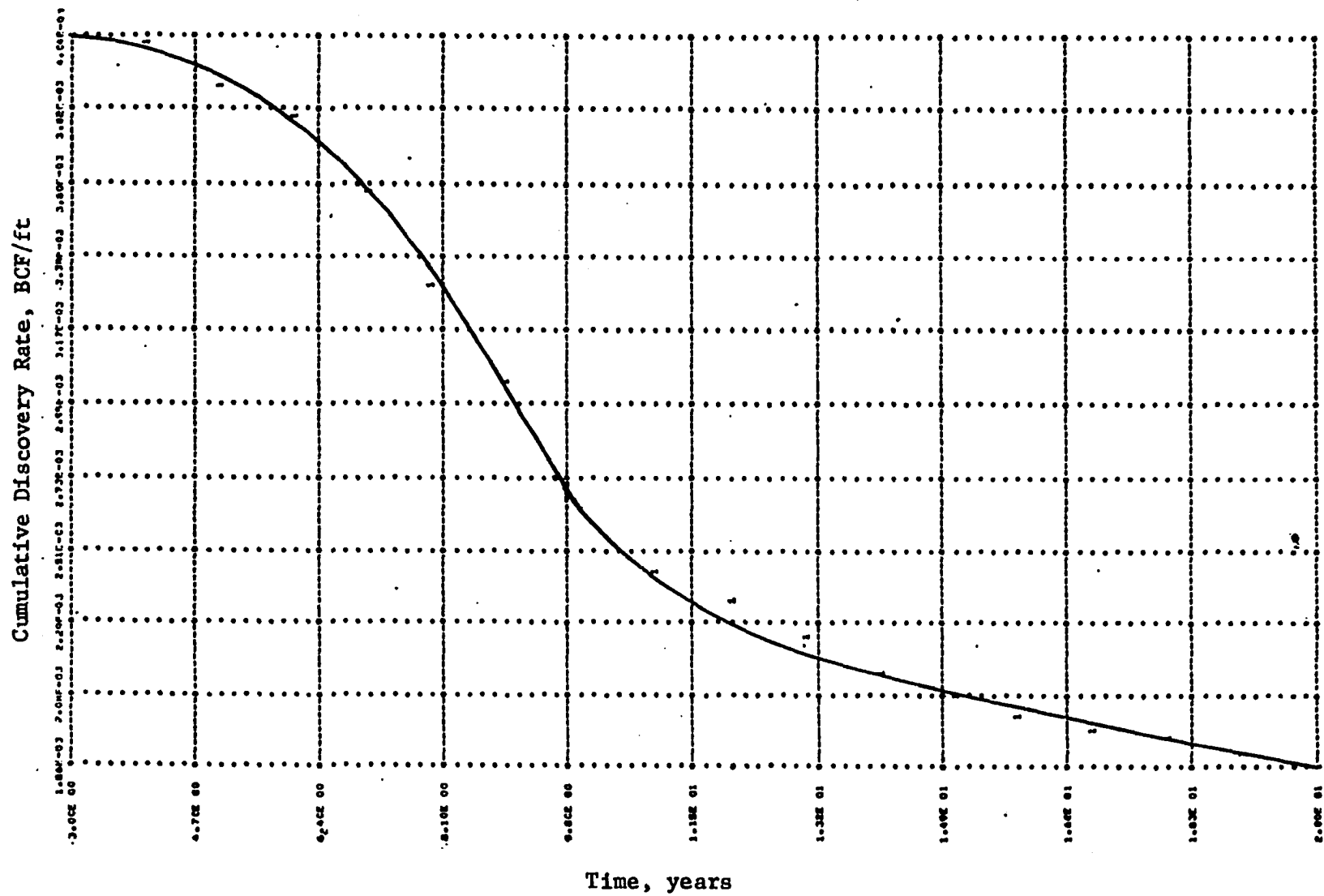


FIGURE IX-87. Composite plot of cumulative discovery rate vs. time.
(Case II, straight line)

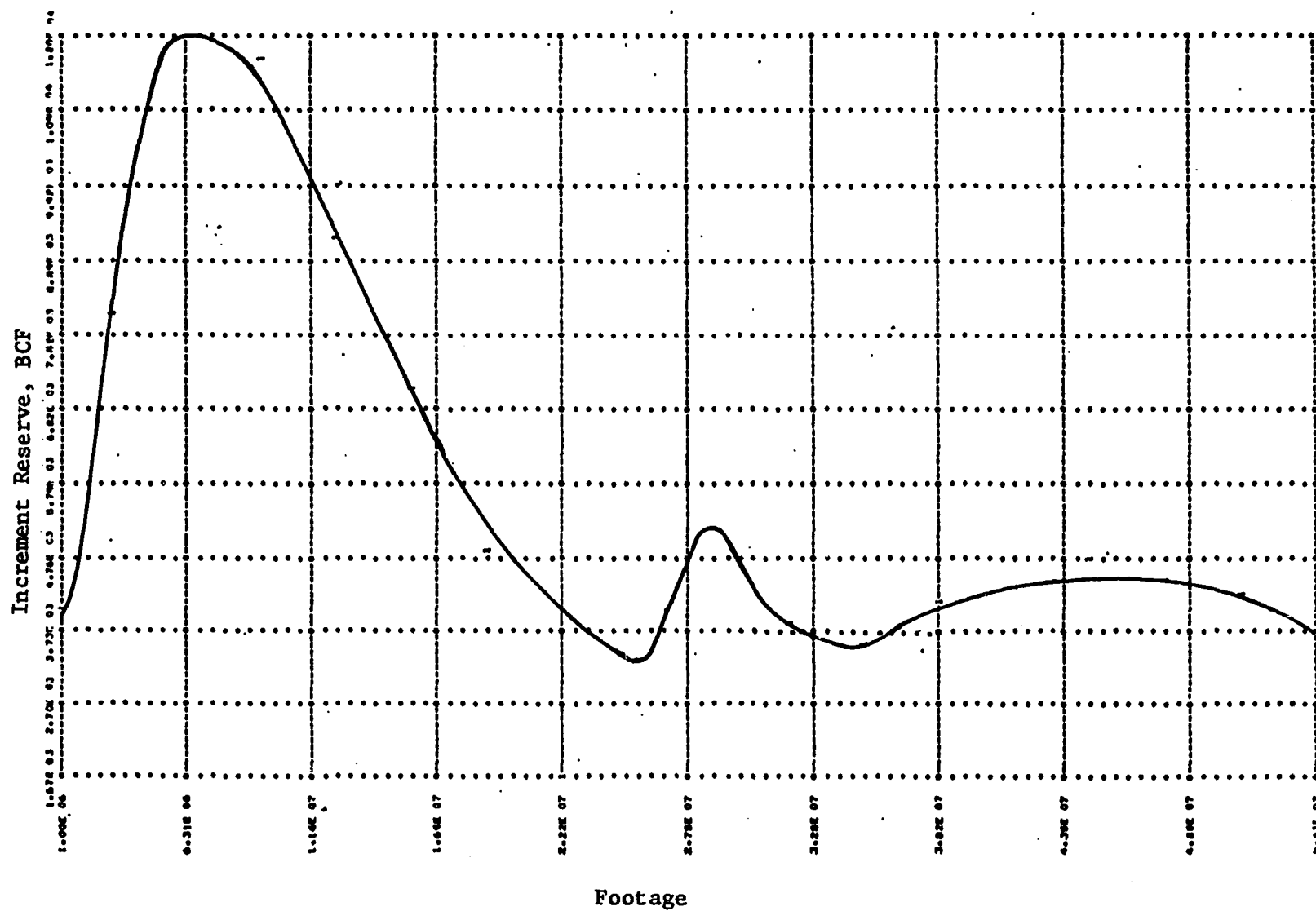


FIGURE IX-88. Composite plot of increment reserve vs. footage.
(Case II, straight line)

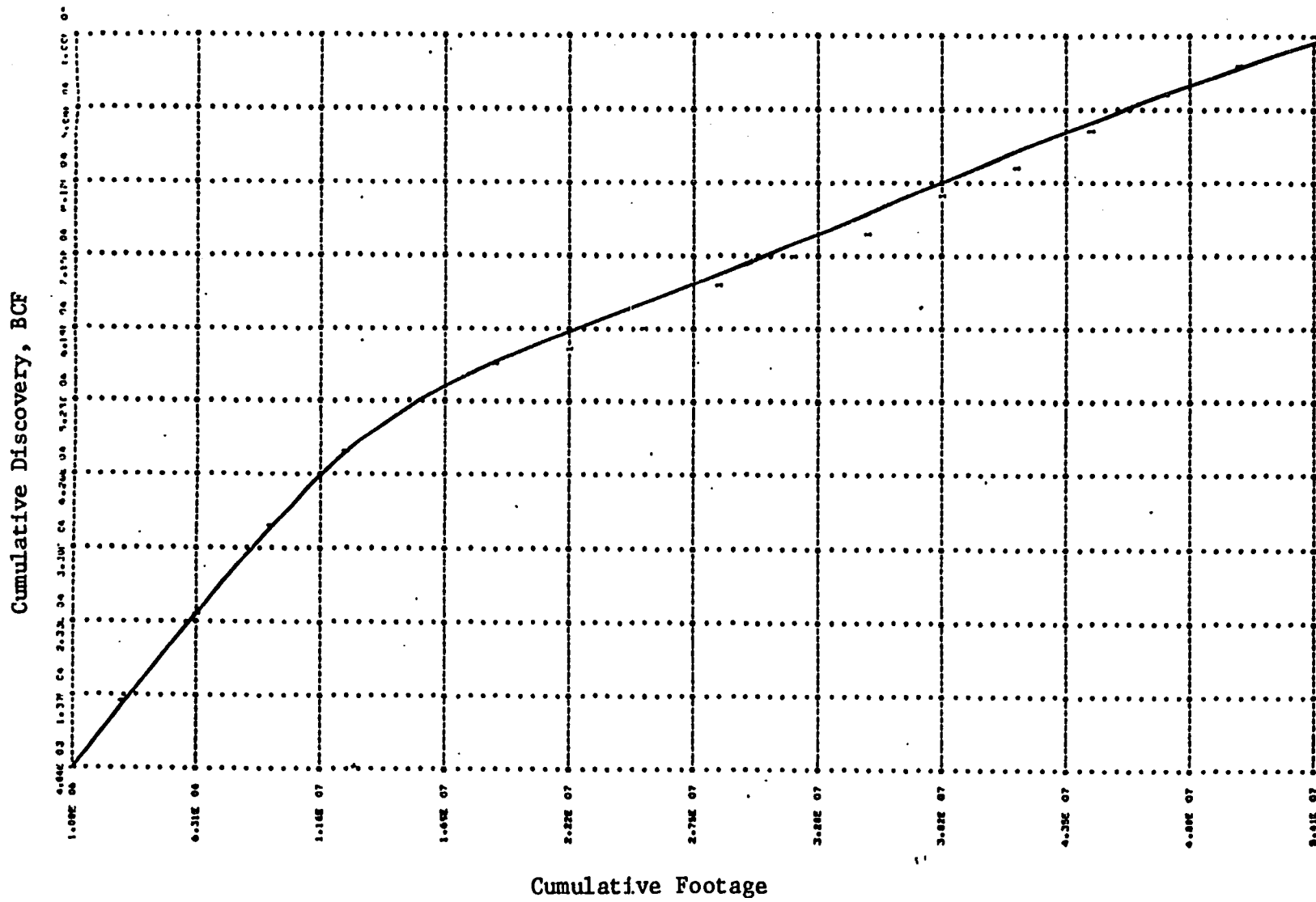


FIGURE IX-89. Composite plot of cumulative discovery vs. cumulative footage.
(Case II, straight line)

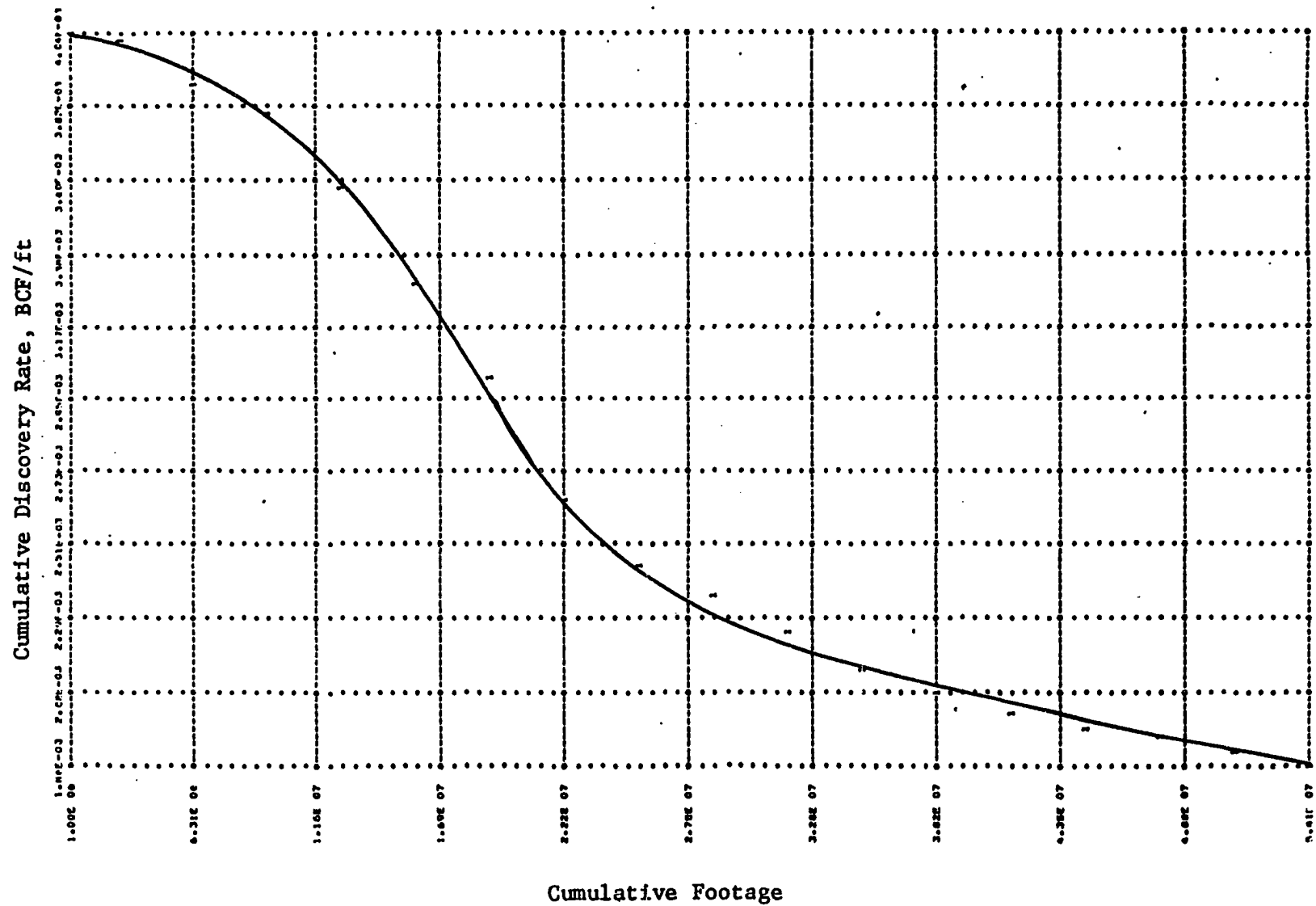


FIGURE IX-90. Composite plot of cumulative discovery rate vs. cumulative footage.
(Case II, straight line)

is based on the results of Case II of Phase one using the straight line extrapolation for future drilling activities. Tables IX-21, IX-22, and IX-23 show the results for each of the individual regions (1, 2, and 3). Table IX-24 and Figures IX-85 to IX-90 are results for all (three) regions combined. By comparing the plots for this run with the corresponding plots for the third run, Figures IX-67 to IX-72, almost identical response is observed for all the plots except in those of increment reserves vs. either time or footage. The plots of increment reserves vs. either time or footage for this run are shown in Figures IX-85 and IX-88. These two plots look very similar to Figures IX-79 and IX-82 for the fifth run. The curves on these plots increase very sharply for a while, then decrease almost at the same rate. Afterwards the curve oscillates during the latter stages of drilling.

Seventh Run

The results obtained from the seventh run are shown in Tables IX-25 to IX-28 and Figures IX-91 to IX-96. This run is based on the results of the original model from Phase one using a logistic curve extrapolation for future drilling activities. Tables IX-25, IX-26, and IX-27 are the results for Regions 1, 2, and 3, respectively. Table IX-28 and Figures IX-91 to IX-96 are the results for all three regions combined. The figures for this run as compared to Figures IX-19 to IX-24 for the first run and Figures IX-73 to IX-78 for the fourth run demonstrate the same response and would

TABLE IX-25

Prediction of Future Discoveries for Region 1
(Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.141043E 08	0.467845E 05	0.141043E 08	0.467845E 05	0.331702E-02	0.331702E-02
4	0.211115E 07	0.700288E 04	0.162155E 08	0.537874E 05	0.331702E-02	0.331702E-02
5	0.242299E 07	0.803712E 04	0.186385E 08	0.618245E 05	0.331702E-02	0.331702E-02
6	0.277947E 07	0.759603E 04	0.214180E 08	0.654206E 05	0.273290E-02	0.324122E-02
7	0.318664E 07	0.831856E 04	0.246046E 08	0.777391E 05	0.261044E-02	0.315952E-02
8	0.365112E 07	0.953112E 04	0.282557E 08	0.872703E 05	0.261046E-02	0.308958E-02
9	0.418022E 07	0.109122E 05	0.324360E 08	0.981824E 05	0.261044E-02	0.302676E-02
10	0.478200E 07	0.124832E 05	0.372180E 08	0.110665E 06	0.261046E-02	0.297344E-02
11	0.546516E 07	0.113252E 05	0.426831E 08	0.121591E 06	0.207226E-02	0.285805E-02
12	0.623907E 07	0.120578E 05	0.489222E 08	0.134088E 06	0.193904E-02	0.274085E-02
13	0.711377E 07	0.137538E 05	0.560360E 08	0.147882E 06	0.193903E-02	0.263906E-02
14	0.809937E 07	0.817062E 04	0.641354E 08	0.156053E 06	0.100879E-02	0.243318E-02
15	0.920672E 07	0.728087E 04	0.733421E 08	0.163334E 06	0.790821E-03	0.222701E-02
16	0.104460E 08	0.683218E 04	0.837881E 08	0.170164E 06	0.654081E-03	0.203091E-02
17	0.118274E 08	0.693462E 04	0.956155E 08	0.177101E 06	0.586317E-03	0.185222E-02
18	0.133699E 08	0.554137E 04	0.108975E 09	0.182642E 06	0.414774E-03	0.167599E-02
19	0.150505E 08	0.611100E 04	0.124026E 09	0.188753E 06	0.406032E-03	0.152188E-02
20	0.169040E 08	0.641043E 04	0.140930E 09	0.195163E 06	0.379224E-03	0.138492E-02

TABLE IX-26

Prediction of Future Discoveries for Region 2
(Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
5	0.2801122E 08	0.8663181E 05	0.2801122E 08	0.8663181E 05	0.3092754E-02	0.3092754E-02
6	0.3907584E 07	0.1020063E 05	0.3151880E 08	0.9683244E 05	0.2610468E-02	0.3033712E-02
7	0.4445552E 07	0.1160488E 05	0.3636435E 08	0.1084373E 06	0.2610446E-02	0.2981967E-02
8	0.5055424E 07	0.1110394E 05	0.4141978E 08	0.1195413E 06	0.2196440E-02	0.2886091E-02
9	0.5746272E 07	0.1114225E 05	0.4716605E 08	0.1306835E 06	0.1939040E-02	0.2770711E-02
10	0.6527936E 07	0.1265754E 05	0.5369398E 08	0.1433414E 06	0.1939041E-02	0.2669595E-02
11	0.7411408E 07	0.1031575E 05	0.6110539E 08	0.1536572E 06	0.1391874E-02	0.2514626E-02
12	0.8402464E 07	0.6649563E 04	0.6951386E 08	0.1603068E 06	0.7408177E-03	0.2306112E-02
13	0.9532176E 07	0.7079250E 04	0.7904603E 08	0.1673860E 06	0.7426688E-03	0.2117576E-02
14	0.1079630E 08	0.6330125E 04	0.8984234E 08	0.1737161E 06	0.5863232E-03	0.1933566E-02
15	0.1221563E 08	0.6088313E 04	0.1020580E 09	0.1798044E 06	0.4984033E-03	0.1761787E-02
16	0.1380552E 08	0.5658438E 04	0.1158635E 09	0.1854629E 06	0.4092676E-03	0.1600702E-02
17	0.1556216E 08	0.6281563E 04	0.1314456E 09	0.1917444E 06	0.4031251E-03	0.1458735E-02
18	0.1756134E 08	0.6185125E 04	0.1450070E 09	0.1979256E 06	0.3522011E-03	0.1328324E-02
19	0.1975934E 08	0.6160250E 04	0.1627663E 09	0.2040892E 06	0.3117637E-03	0.1209304E-02
20	0.2219094E 08	0.6238563E 04	0.1909573E 09	0.2103264E 06	0.2811309E-03	0.1101442E-02

TABLE IX-27

Prediction of Future Discoveries for Region 3
(Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.2298851E 08	0.7352031E 05	0.2298851E 08	0.7352031E 05	0.3198133E-02	0.3198133E-02
5	0.3336704E 07	0.8710313E 04	0.2632522E 08	0.8223063E 05	0.2610454E-02	0.3123645E-02
6	0.3814608E 07	0.9957875E 04	0.3013982E 08	0.9218850E 05	0.2610458E-02	0.3058654E-02
7	0.4352960E 07	0.1137888E 05	0.3449878E 08	0.1035674E 06	0.2610456E-02	0.3007058E-02
8	0.4972432E 07	0.1220719E 05	0.3947722E 08	0.1157746E 06	0.2452014E-02	0.2932693E-02
9	0.5682496E 07	0.1101856E 05	0.4515971E 08	0.1267931E 06	0.1939035E-02	0.2807660E-02
10	0.6481760E 07	0.1256838E 05	0.5164147E 08	0.1393615E 06	0.1939037E-02	0.2698635E-02
11	0.7387696E 07	0.1265381E 05	0.5902917E 08	0.1520153E 06	0.1712822E-02	0.2575258E-02
12	0.8412880E 07	0.6653000E 04	0.6744205E 08	0.1586683E 06	0.7908111E-03	0.2352661E-02
13	0.9570672E 07	0.7525500E 04	0.7701272E 08	0.1661938E 06	0.7863082E-03	0.2158005E-02
14	0.1087533E 08	0.6376438E 04	0.8788805E 08	0.1725703E 06	0.5863213E-03	0.1963523E-02
15	0.1234184E 08	0.6484188E 04	0.1002299E 09	0.1790544E 06	0.5253223E-03	0.1786437E-02
16	0.1398544E 08	0.5737688E 04	0.1142153E 09	0.1847921E 06	0.4102613E-03	0.1617927E-02
17	0.1582141E 08	0.6384375E 04	0.1300367E 09	0.1911765E 06	0.4035274E-03	0.1470173E-02
18	0.1786461E 08	0.6374500E 04	0.1479013E 09	0.1975510E 06	0.3568227E-03	0.1335694E-02
19	0.2012878E 08	0.6316188E 04	0.1680301E 09	0.2038672E 06	0.3137887E-03	0.1213277E-02
20	0.2262533E 08	0.6377813E 04	0.1906555E 09	0.2102450E 06	0.2818881E-03	0.1102748E-02

TABLE IX-28

Composite Parameters for All k Basins
(Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES./INC.FT)	CUM.DISCOVERY RATE (CUM.RES./TOTAL FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.141043E 08	0.467845E 05	0.141043E 08	0.467845E 05	0.331702E-02	0.331702E-02
4	0.2905970E 08	0.805231E 05	0.352040E 08	0.127307E 06	0.320813E-02	0.324730E-02
5	0.3377091E 08	0.103379E 06	0.729749E 08	0.230687E 06	0.306119E-02	0.316117E-02
6	0.105016E 08	0.277545E 05	0.834766E 08	0.258441E 06	0.264287E-02	0.309557E-02
7	0.119911E 08	0.313023E 05	0.954678E 08	0.289743E 06	0.261045E-02	0.303499E-02
8	0.136649E 08	0.328422E 05	0.109152E 09	0.322881E 06	0.239987E-02	0.295536E-02
9	0.156085E 08	0.330730E 05	0.124761E 09	0.355659E 06	0.211884E-02	0.285070E-02
10	0.177917E 08	0.377095E 05	0.142553E 09	0.393368E 06	0.211950E-02	0.275944E-02
11	0.202642E 08	0.342948E 05	0.162817E 09	0.427663E 06	0.169237E-02	0.262664E-02
12	0.230694E 08	0.254003E 05	0.185878E 09	0.453063E 06	0.110147E-02	0.243742E-02
13	0.262166E 08	0.283986E 05	0.212094E 09	0.481462E 06	0.108323E-02	0.227003E-02
14	0.297710E 08	0.208771E 05	0.241865E 09	0.502339E 06	0.701258E-03	0.207693E-02
15	0.337640E 08	0.198533E 05	0.275629E 09	0.522193E 06	0.588003E-03	0.189454E-02
16	0.382369E 08	0.182283E 05	0.313866E 09	0.540421E 06	0.476720E-03	0.172181E-02
17	0.432309E 08	0.196005E 05	0.357097E 09	0.560022E 06	0.453391E-03	0.156826E-02
18	0.487259E 08	0.181010E 05	0.405883E 09	0.578123E 06	0.371029E-03	0.142435E-02
19	0.549386E 08	0.185274E 05	0.460822E 09	0.556714E 06	0.338330E-03	0.129482E-02
20	0.617203E 08	0.190268E 05	0.522542E 09	0.615737E 06	0.308274E-03	0.117834E-02

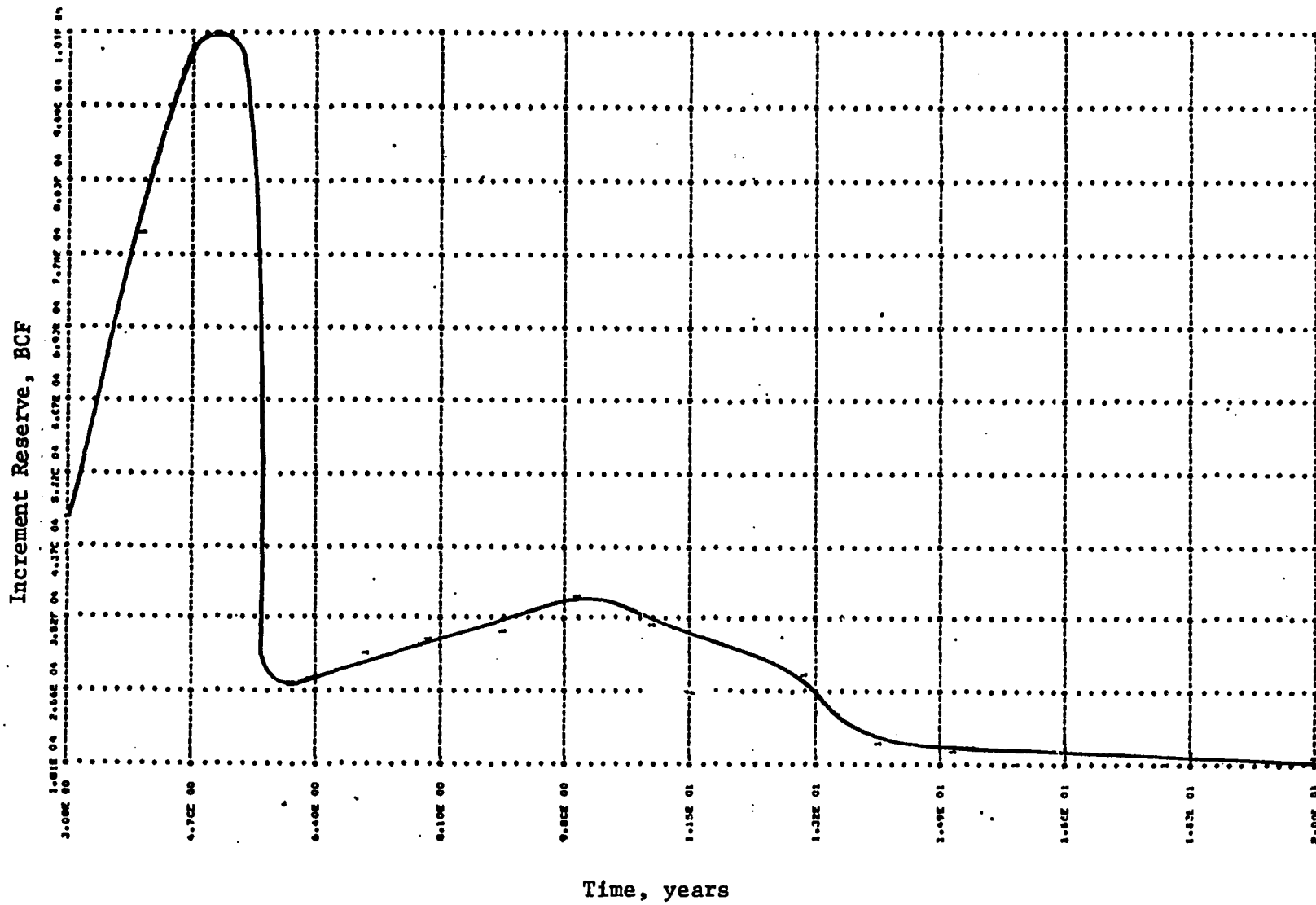


FIGURE IX-91. Composite plot of increment reserve vs. time.
(Logistic curve)

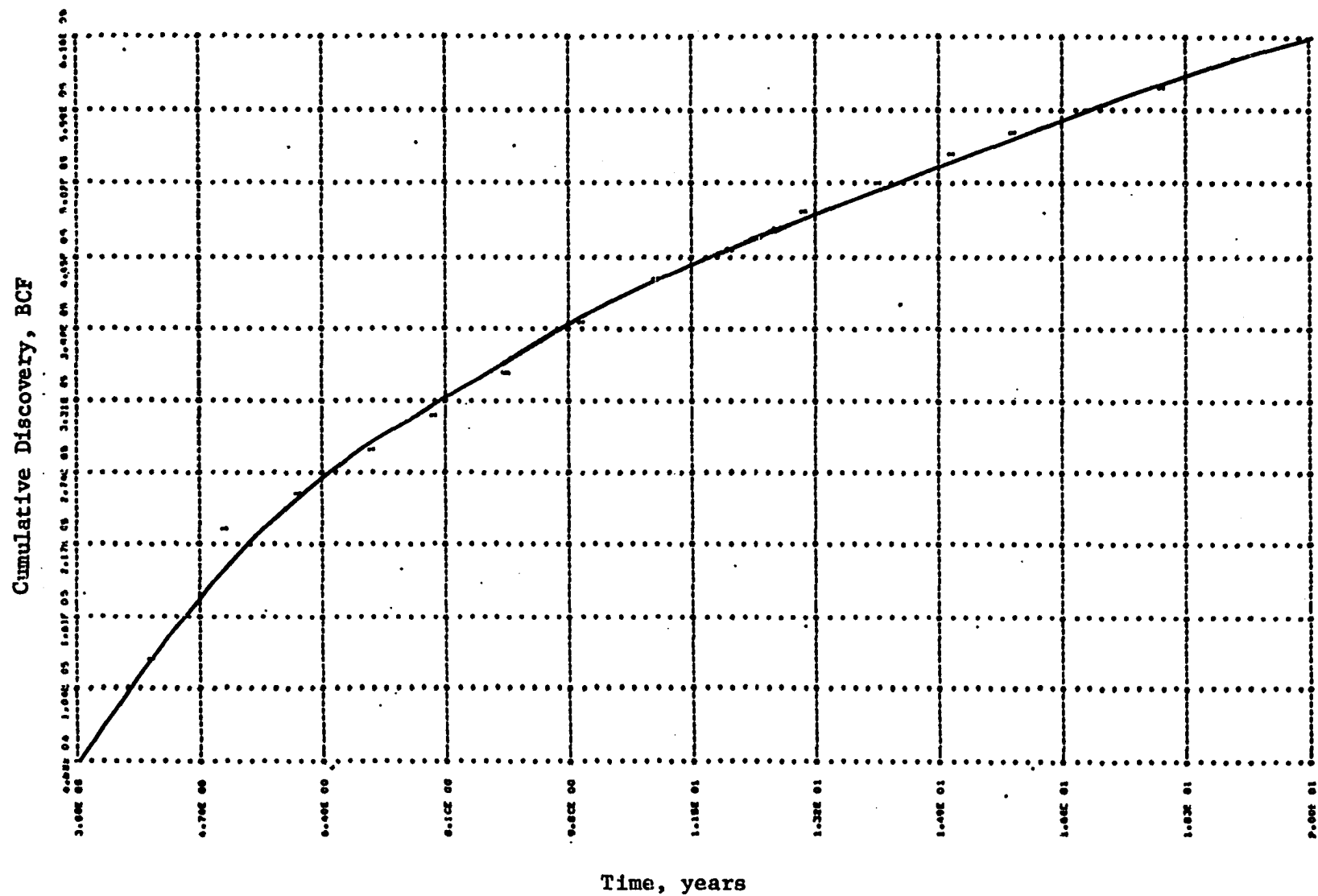


FIGURE IX-92. Composite plot of cumulative discovery vs. time.
(Logistic curve)

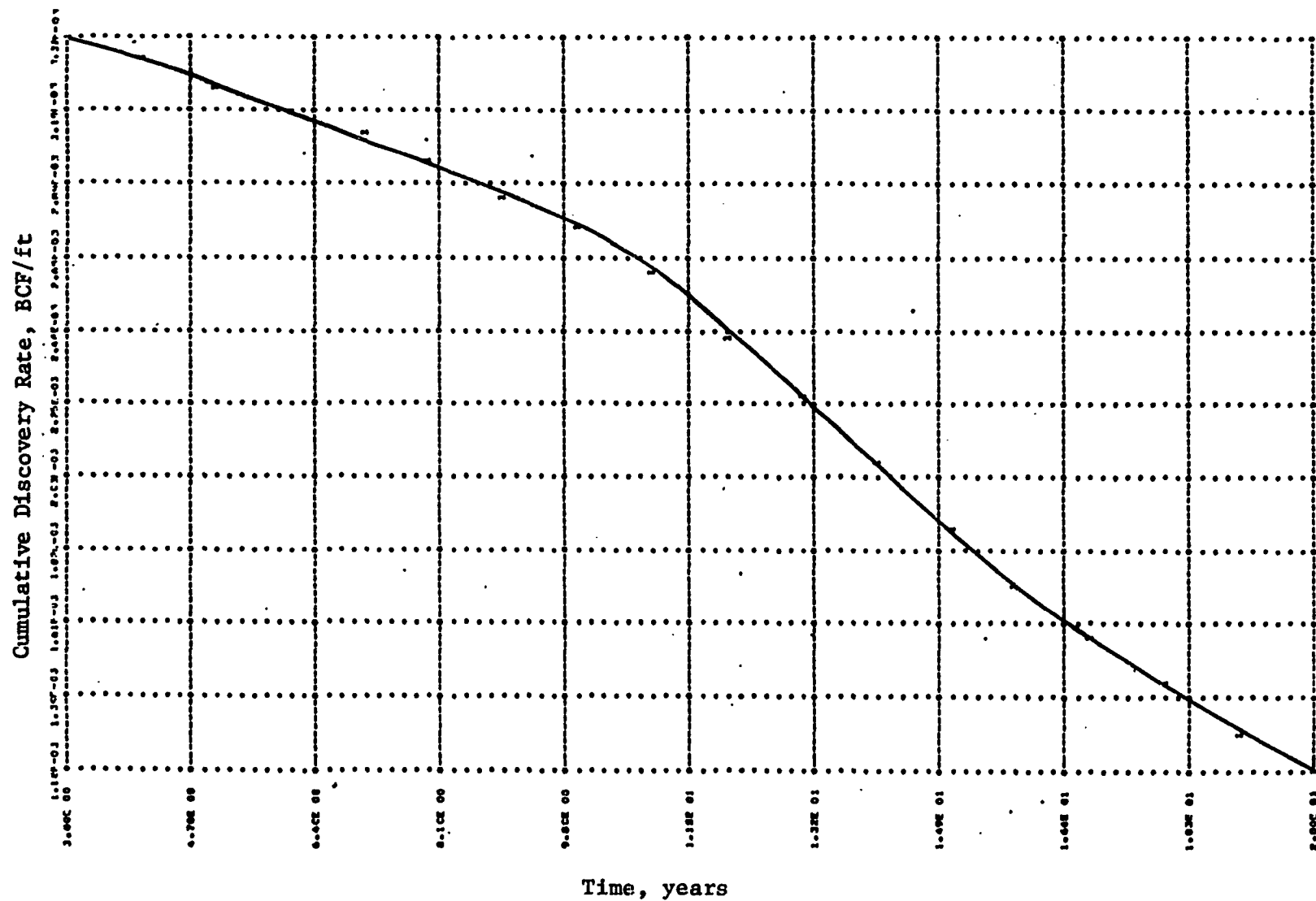


FIGURE IX-93. Composite plot of cumulative discovery rate vs. time.
(Logistic curve)

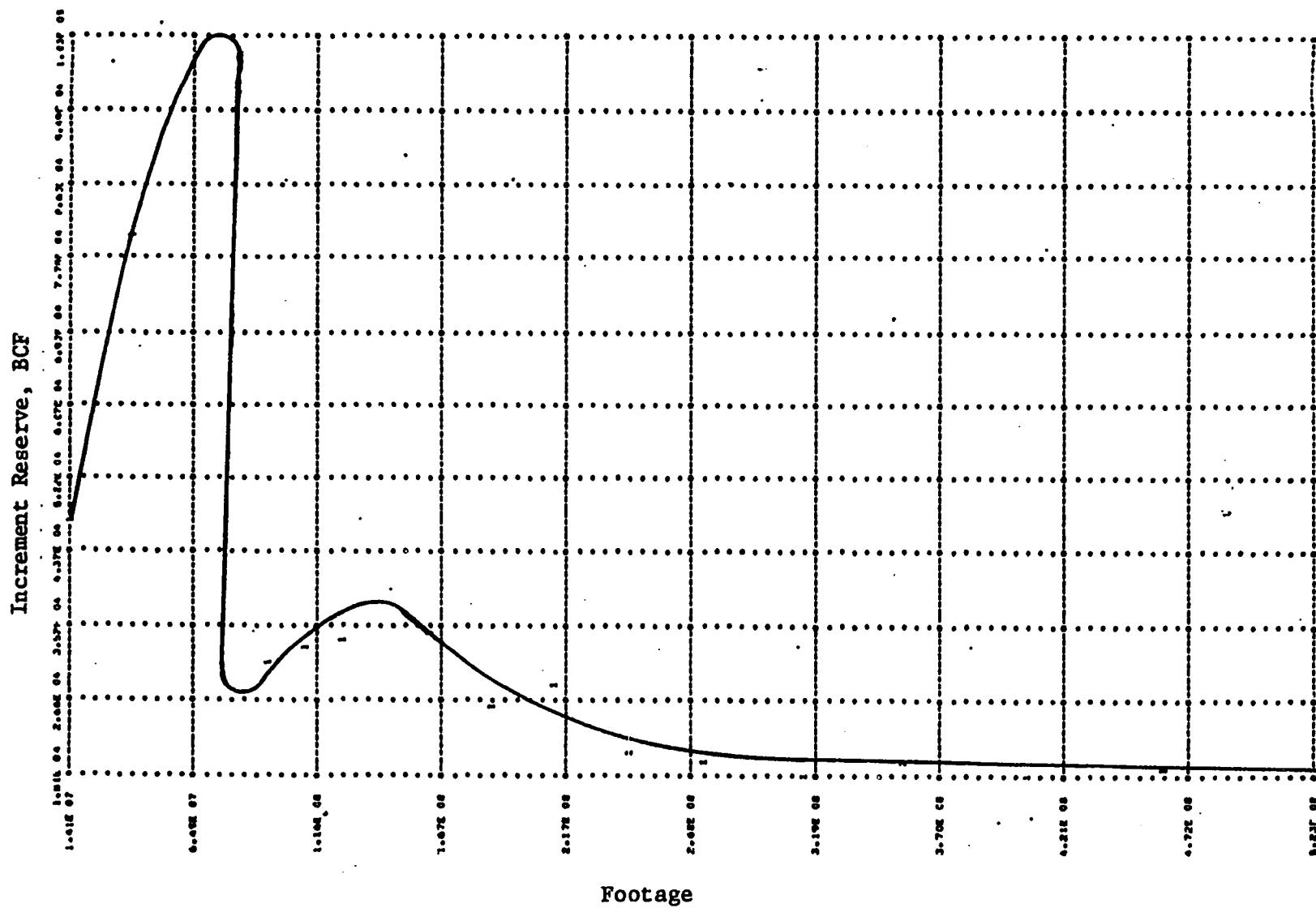


FIGURE IX-94. Composite plot of increment reserve vs. footage.
(Logistic curve)

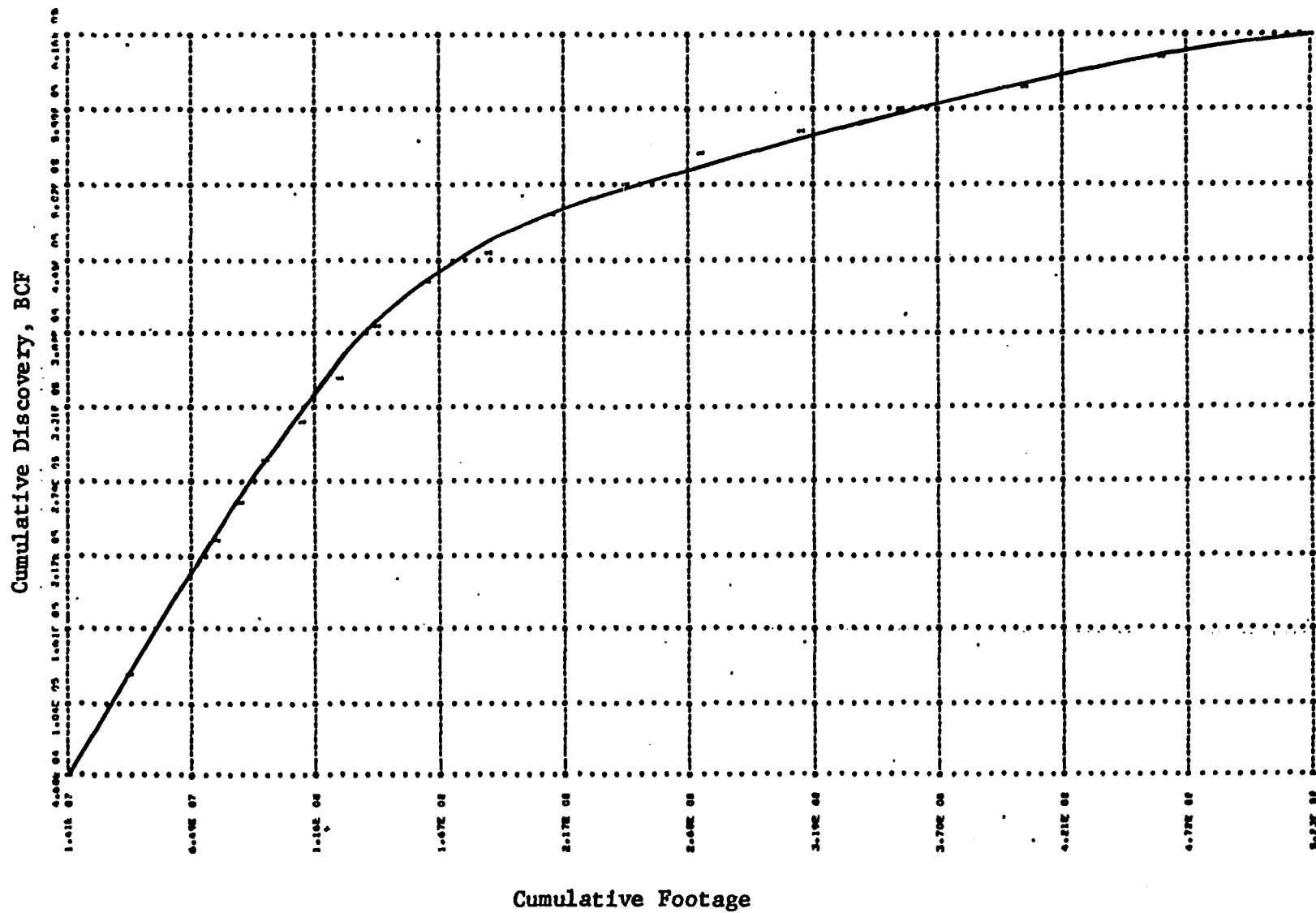


FIGURE IX-95. Composite plot of cumulative discovery vs. cumulative footage.
(Logistic curve)

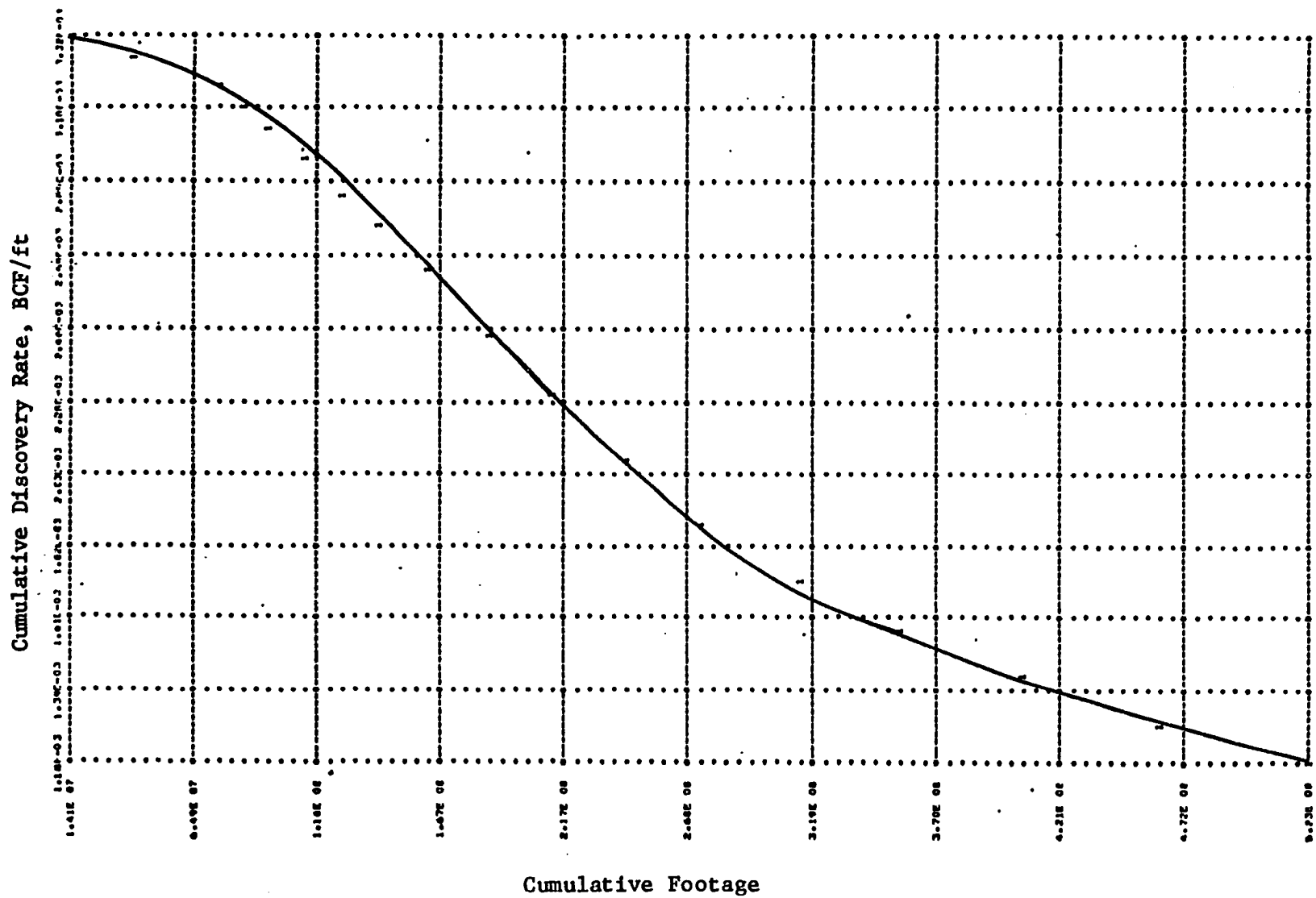


FIGURE IX-96. Composite plot of cumulative discovery rate vs. cumulative footage.
(Logistic curve)

lead to the same conclusions for this run, except there are slight differences in the plot of increment reserves vs. either time or footage. The plots of increment footage vs. either time or footage for this run are shown in Figures IX-91 and IX-94. For these two plots the rate of increase is very sharp initially and decreases almost as sharply. Afterwards, with the exception of one oscillation, it exhibits a generally declining trend.

Eighth Run

The results obtained from the eighth run are shown in Tables IX-29 to IX-32 and Figures IX-97 to IX-102. This run is based on the results of Case I of Phase one using a logistic curve extrapolation for future drilling activities. Tables IX-29, IX-30, and IX-31 are results for Regions 1, 2, and 3, respectively. Table IX-32 and Figures IX-97 to IX-102 are the results for all three regions combined. The same response can be observed and the same conclusions can be drawn for these figures when they are compared with the corresponding figures for the second and fifth runs, except for the plot of increment reserve vs. either time or footage which is considerably different. The plot of increment reserves vs. either time or footage for this run are shown in Figures IX-97 and IX-100. These plots show that in the initial stages the curve for reserve discovery increases rapidly and sharply and soon decreases with the same rapid and sharp rate. Afterwards it starts increasing smoothly and gradually through the

TABLE IX-29

Prediction of Future Discoveries for Region 1
(Case I, Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.1410437E 07	0.5696879E 04	0.1410437E 07	0.5696879E 04	0.4039086E-02	0.4039086E-02
4	0.2111190E 06	0.8527305E 03	0.1621556E 07	0.6549605E 04	0.4039098E-02	0.4039086E-02
5	0.2422990E 06	0.9786641E 03	0.1863855E 07	0.7528273E 04	0.4039075E-02	0.4039086E-02
6	0.2779480E 06	0.1024391E 04	0.2141803E 07	0.8552604E 04	0.3685548E-02	0.3993206E-02
7	0.3186640E 06	0.1147727E 04	0.2460467E 07	0.9700351E 04	0.3601682E-02	0.3942497E-02
8	0.3651120E 06	0.1315020E 04	0.2825579E 07	0.1101547E 05	0.3601688E-02	0.3898461E-02
9	0.4180230E 06	0.1505586E 04	0.3243602E 07	0.1252100E 05	0.3601682E-02	0.3860213E-02
10	0.4781980E 06	0.1722320E 04	0.3721800E 07	0.1424332E 05	0.3601688E-02	0.3826997E-02
11	0.5465170E 06	0.1447816E 04	0.4268317E 07	0.1669113E 05	0.2649170E-02	0.3676187E-02
12	0.6239080E 06	0.1923293E 04	0.4892225E 07	0.1721443E 05	0.2441535E-02	0.3518731E-02
13	0.7113770E 06	0.1736852E 04	0.5603602E 07	0.1895122E 05	0.2441535E-02	0.3381981E-02
14	0.8095380E 06	0.5231719E 03	0.6413540E 07	0.1947445E 05	0.6459404E-03	0.3036459E-02
15	0.9206710E 06	0.2852344E 03	0.7334211E 07	0.1975968E 05	0.3094112E-03	0.2694180E-02
16	0.1044601E 07	0.1406148E 04	0.8378812E 07	0.2116583E 05	0.1346110E-02	0.2526114E-02
17	0.1182741E 07	0.2273887E 04	0.9561553E 07	0.2343972E 05	0.1922557E-02	0.2451455E-02
18	0.1335997E 07	0.1556195E 04	0.1089755E 08	0.2499551E 05	0.1164819E-02	0.2293719E-02
19	0.1505052E 07	0.2108742E 04	0.1240260E 08	0.2710466E 05	0.1401109E-02	0.2185401E-02
20	0.1690405E 07	0.2888449E 04	0.1409301E 08	0.2996311E 05	0.1690985E-02	0.2126097E-02

TABLE IX-30

Prediction of Future Discoveries for Region 2
(Case I, Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
5	0.2801121E 07	0.1092732E 05	0.2801121E 07	0.1092732E 05	0.3901053E-02	0.3901053E-02
6	0.3907570E 06	0.1407383E 04	0.3191878E 07	0.1233470E 05	0.3601683E-02	0.3864403E-02
7	0.4445540E 06	0.1601145E 04	0.3636432E 07	0.1393565E 05	0.3601687E-02	0.3832286E-02
8	0.5055440E 06	0.1446816E 04	0.4141976E 07	0.1538266E 05	0.2861900E-02	0.3713847E-02
9	0.5746260E 06	0.1402973E 04	0.4716602E 07	0.1678564E 05	0.2441540E-02	0.3558841E-02
10	0.6527930E 06	0.1593816E 04	0.5369395E 07	0.1837945E 05	0.2441534E-02	0.3423003E-02
11	0.7411400E 06	0.1001121E 04	0.6110535E 07	0.1938057E 05	0.1350785E-02	0.3171666E-02
12	0.8408470E 06	0.2605039E 03	0.6961382E 07	0.1964108E 05	0.3098112E-03	0.2825493E-02
13	0.9532170E 06	0.6130502E 03	0.7504599E 07	0.2025413E 05	0.6431385E-03	0.2562322E-02
14	0.1079629E 07	0.2075648E 04	0.8584228E 07	0.2232978E 05	0.1922557E-02	0.2485442E-02
15	0.1221563E 07	0.1890258E 04	0.1020579E 08	0.2422004E 05	0.1F47409E-02	0.2373166E-02
16	0.1380550E 07	0.1584324E 04	0.1188634E 08	0.2580436E 05	0.1147604E-02	0.2227136E-02
17	0.1554215E 07	0.2402223E 04	0.1314456E 08	0.2828658E 05	0.1592991E-02	0.2151962E-02
18	0.1756133E 07	0.3168113E 04	0.1450069E 08	0.3145470E 05	0.1804028E-02	0.2110956E-02
19	0.1975919E 07	0.1923398E 04	0.1687661E 08	0.3337809E 05	0.9734195E-03	0.1977772E-02
20	0.2219104E 07	0.2576480E 04	0.1909571E 08	0.3595457E 05	0.1161045E-02	0.1892861E-02

TABLE IX-31

Prediction of Future Discoveries for Region 3
(Case I, Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.2298852E C7	0.9118305E C4	0.2298852E 07	0.9118305E 04	0.3966458E-02	0.3966458E-C2
5	0.3336710E 06	0.1201777E 04	0.2632523E 07	0.1032000E C5	0.3601683E-02	0.3920224E-02
6	0.3814600E C6	0.1373898E 04	0.3013983E 07	0.1169398E 05	0.3601624E-02	0.3879909E-02
7	0.4358970E 06	0.1569965E 04	0.3446880E 07	0.1326355E C5	0.3601687E-02	0.3844755E-02
8	0.4972420E 06	0.1644441E 04	0.3947722E 07	0.1490839E 05	0.3303139E-02	0.3776453E-02
9	0.5682500E 06	0.1387402E C4	0.4415972E 07	0.1629579E 05	0.2441535E-02	0.3608479E-02
10	0.6481760E 06	0.1582547E 04	0.5164148E 07	0.1787834E C5	0.2441535E-02	0.3462011E-02
11	0.7387700E 06	0.1437918E 04	0.5902918E 07	0.1931625E 05	0.1946368E-02	0.3272323E-C2
12	0.8412880E 06	0.2606406E 03	0.6744206E 07	0.1957629E C5	0.3098112E-03	0.2902772E-02
13	0.9570670E 06	0.2965117E 03	0.7701273E 07	0.1987341E 05	0.3098128E-03	0.2580535E-02
14	0.1087534E 07	0.2080664E 04	0.8788807E 07	0.2195407E 05	0.1913194E-02	0.2497958E-02
15	0.1234183E C7	0.2060934E 04	0.1002299E 08	0.2401500E 05	0.1669877E-02	0.2395992E-02
16	0.1398545E 07	0.1568613E 04	0.1142154E 08	0.2558362E 05	0.1121604E-02	0.2239946E-02
17	0.1582141E 07	0.2478543E 04	0.1300368E 08	0.2806216E 05	0.1566575E-02	0.2158017E-C2
18	0.1786462E 07	0.3188375E 04	0.1479014E 08	0.3125054E 05	0.1784743E-02	0.2112930E-02
19	0.2012870E 07	0.2074262E 04	0.1680301E 08	0.3332400E C5	0.1030500E-02	0.1983264E-02
20	0.2262520E 07	0.2592078E 04	0.1906554E 08	0.3591628E 05	0.1145656E-02	0.1883864E-02

TABLE IX-32

Composite Parameters for All k Basins
(Case I, Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.FTS/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.1410437E 07	0.5696879E 04	0.1410437E 07	0.5696879E 04	0.4039086E-02	0.4039086E-02
4	0.2505971E 07	0.9571035E 04	0.3620408E 07	0.1566791E 05	0.3972568E-02	0.3956459E-02
5	0.3377091E 07	0.1310776E 05	0.7257499E 07	0.2677562E 05	0.3661376E-02	0.3943224E-02
6	0.1050165E 07	0.3805672E 04	0.8347664E 07	0.3258135E 05	0.3623880E-02	0.3903050E-02
7	0.1199115E 07	0.4318836E 04	0.9546779E 07	0.3690018E 05	0.3601686E-02	0.3865197E-02
8	0.1362490E 07	0.4406277E 04	0.1091528E 08	0.4130646E 05	0.3219791E-02	0.3754280E-02
9	0.1560255E 07	0.4295961E 04	0.1247618E 08	0.4560242E 05	0.2752235E-02	0.3655160E-02
10	0.1775167E 07	0.4898604E 04	0.1425534E 08	0.5050111E 05	0.2753352E-02	0.3547609E-02
11	0.2026427E 07	0.3886855E 04	0.1628177E 08	0.5438796E 05	0.1918083E-02	0.3340421E-02
12	0.2306038E 07	0.2044432E 04	0.1858781E 08	0.5643240E 05	0.8665583E-03	0.3035990E-02
13	0.2621664E 07	0.2646414E 04	0.2120947E 08	0.5907981E 05	0.1009441E-02	0.2785492E-02
14	0.2977088E 07	0.4679484E 04	0.2418656E 08	0.6375830E 05	0.1571833E-02	0.2636104E-02
15	0.3376416E 07	0.4236391E 04	0.2756298E 08	0.6799469E 05	0.1254700E-02	0.2466885E-02
16	0.3823696E 07	0.4559063E 04	0.3138667E 08	0.7255375E 05	0.1192318E-02	0.2311610E-02
17	0.4323088E 07	0.7234688E 04	0.3570976E 08	0.7578844E 05	0.1673500E-02	0.2234359E-02
18	0.4872592E 07	0.7912688E 04	0.4058835E 08	0.8770113E 05	0.1621920E-02	0.2160746E-02
19	0.5493856E 07	0.6106375E 04	0.4608221E 08	0.9380750E 05	0.1111492E-02	0.2035655E-02
20	0.6172032E 07	0.8027000E 04	0.5225424E 08	0.1018345E 06	0.1300544E-02	0.1948827E-02

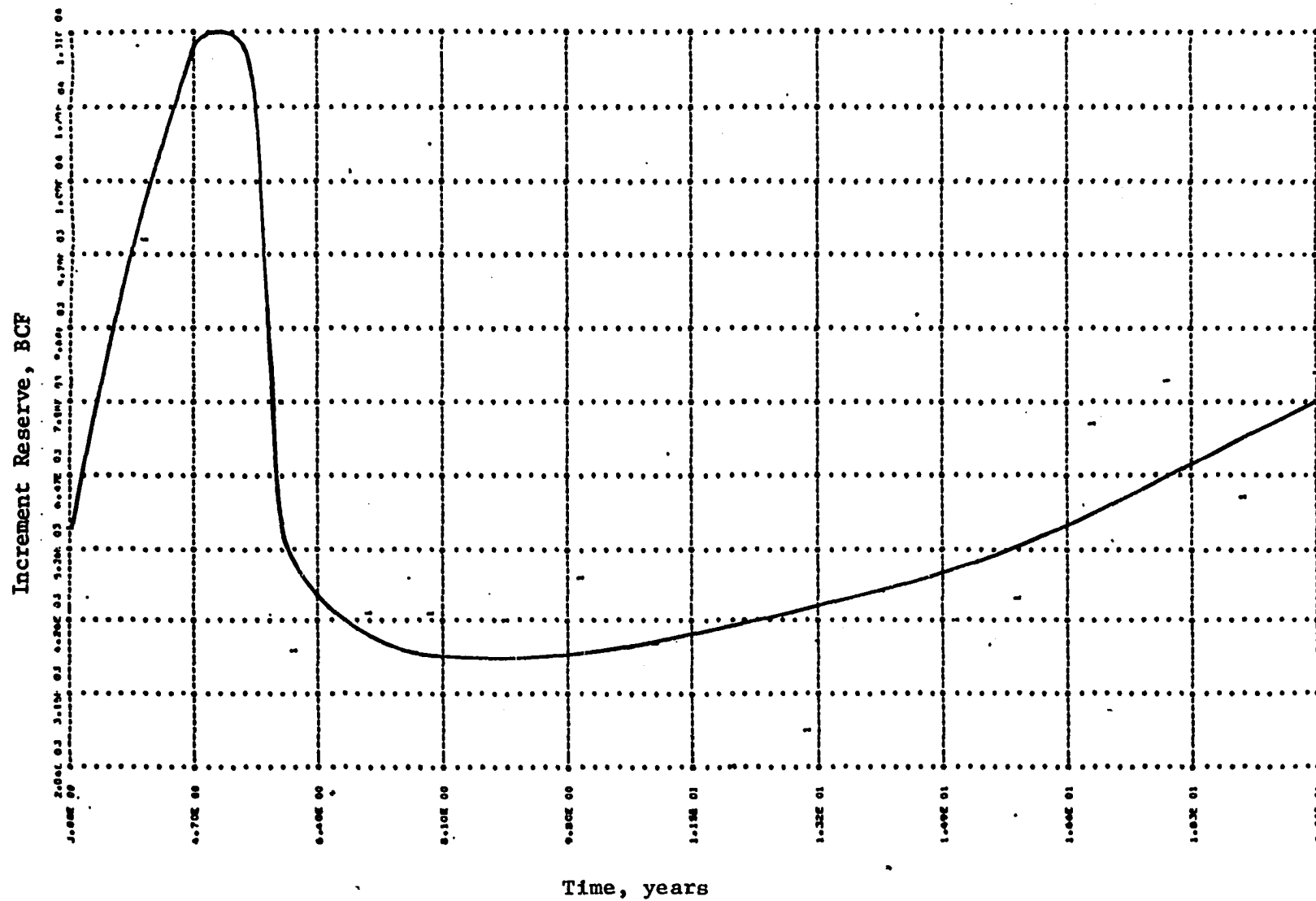


FIGURE IX-97. Composite plot of increment reserve vs. time.
(Case I, Logistic curve)

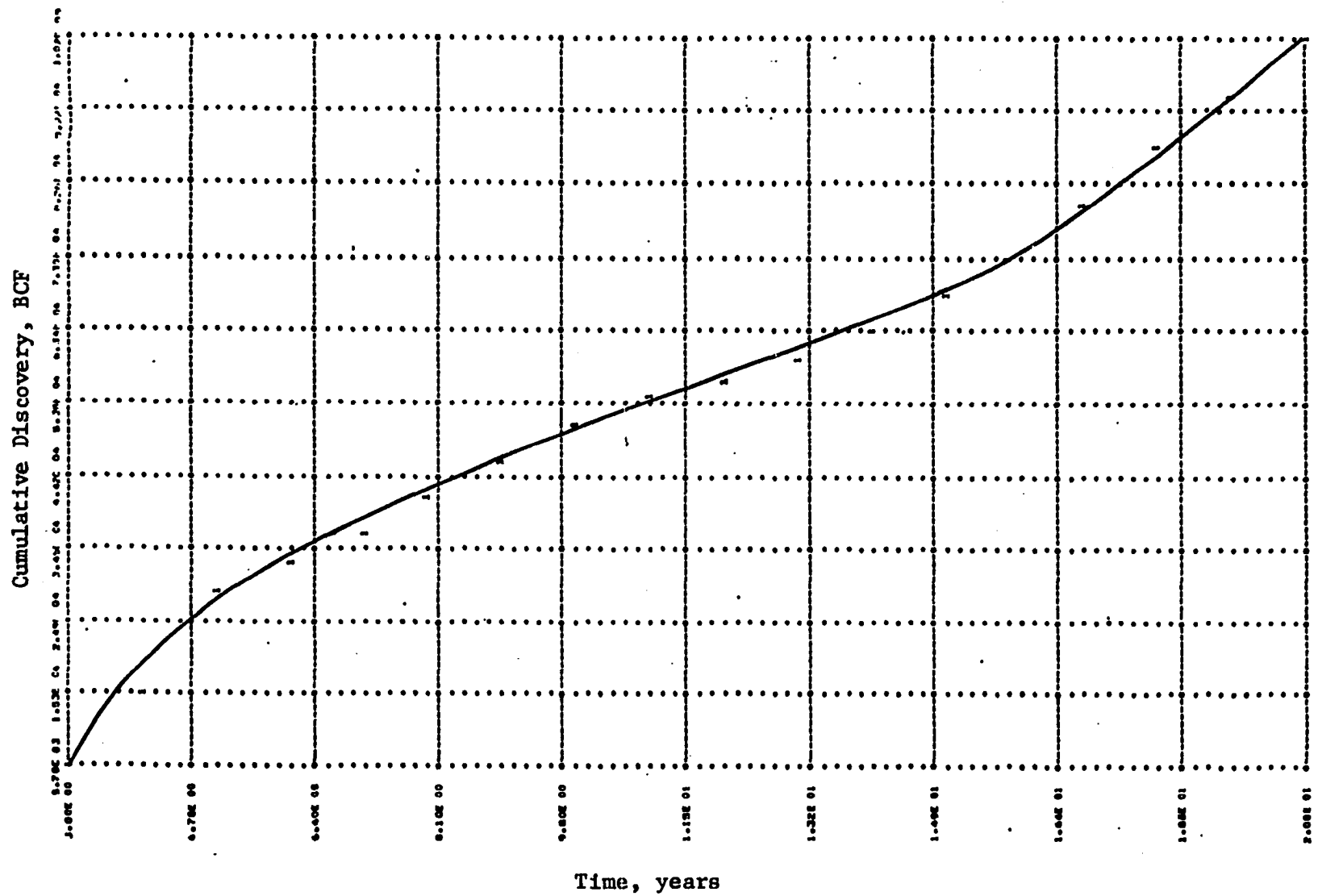


FIGURE IX-98. Composite plot of cumulative discovery vs. time.
(Case I, Logistic curve)

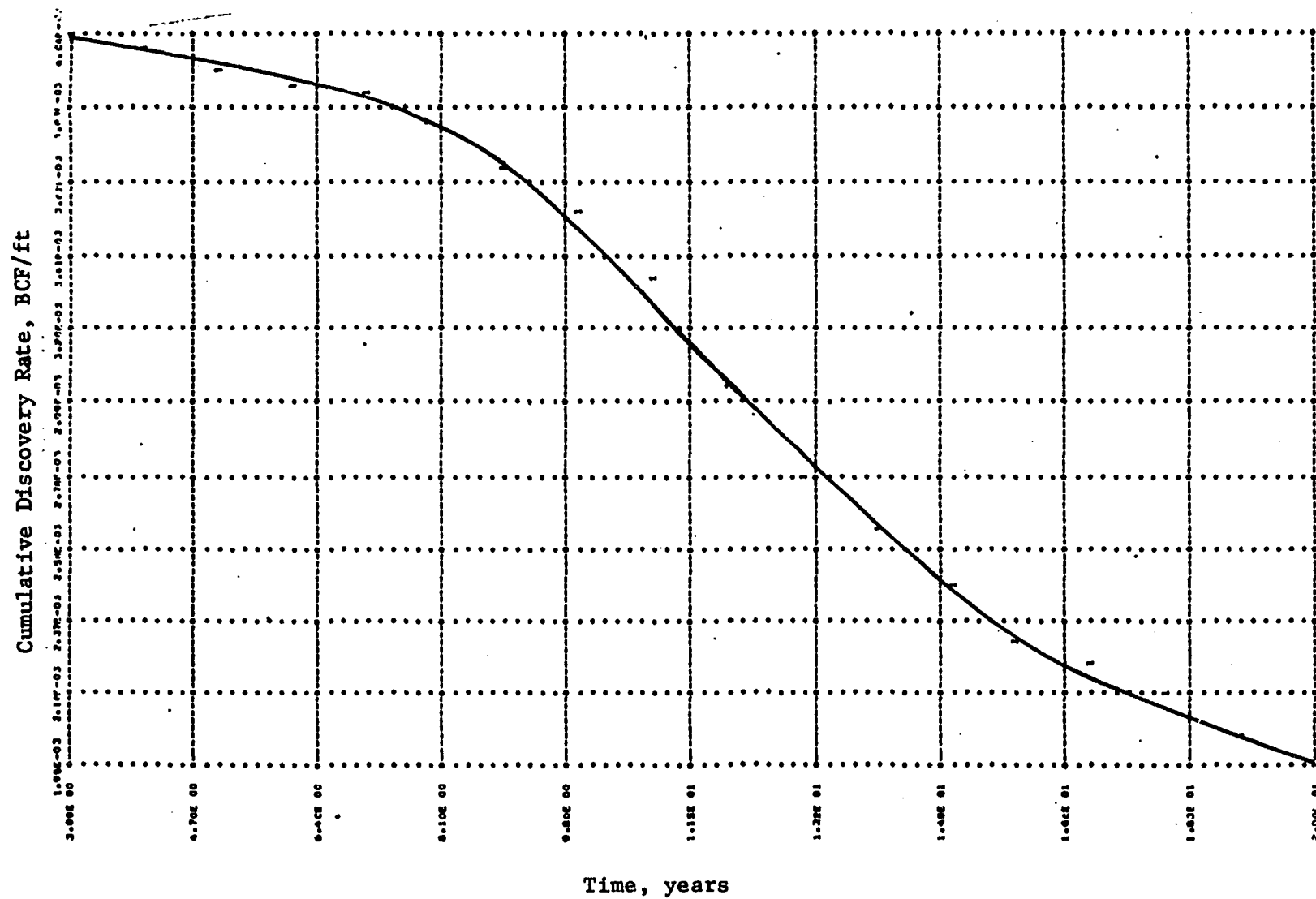


FIGURE IX-99. Composite plot of cumulative discovery rate vs. time.
(Case I, Logistic curve)

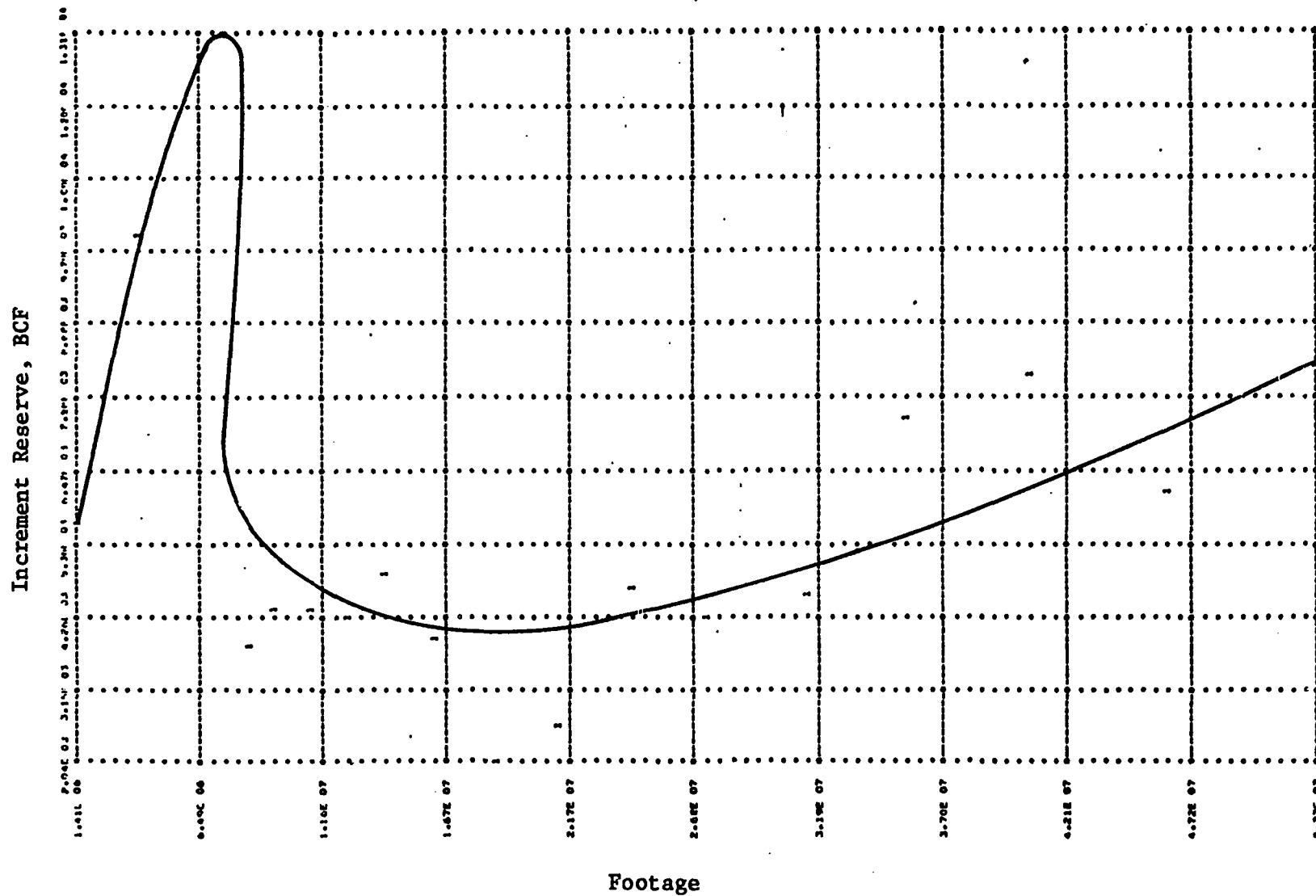


FIGURE IX-100. Composite plot of increment reserve vs. footage.
(Case I, Logistic curve)

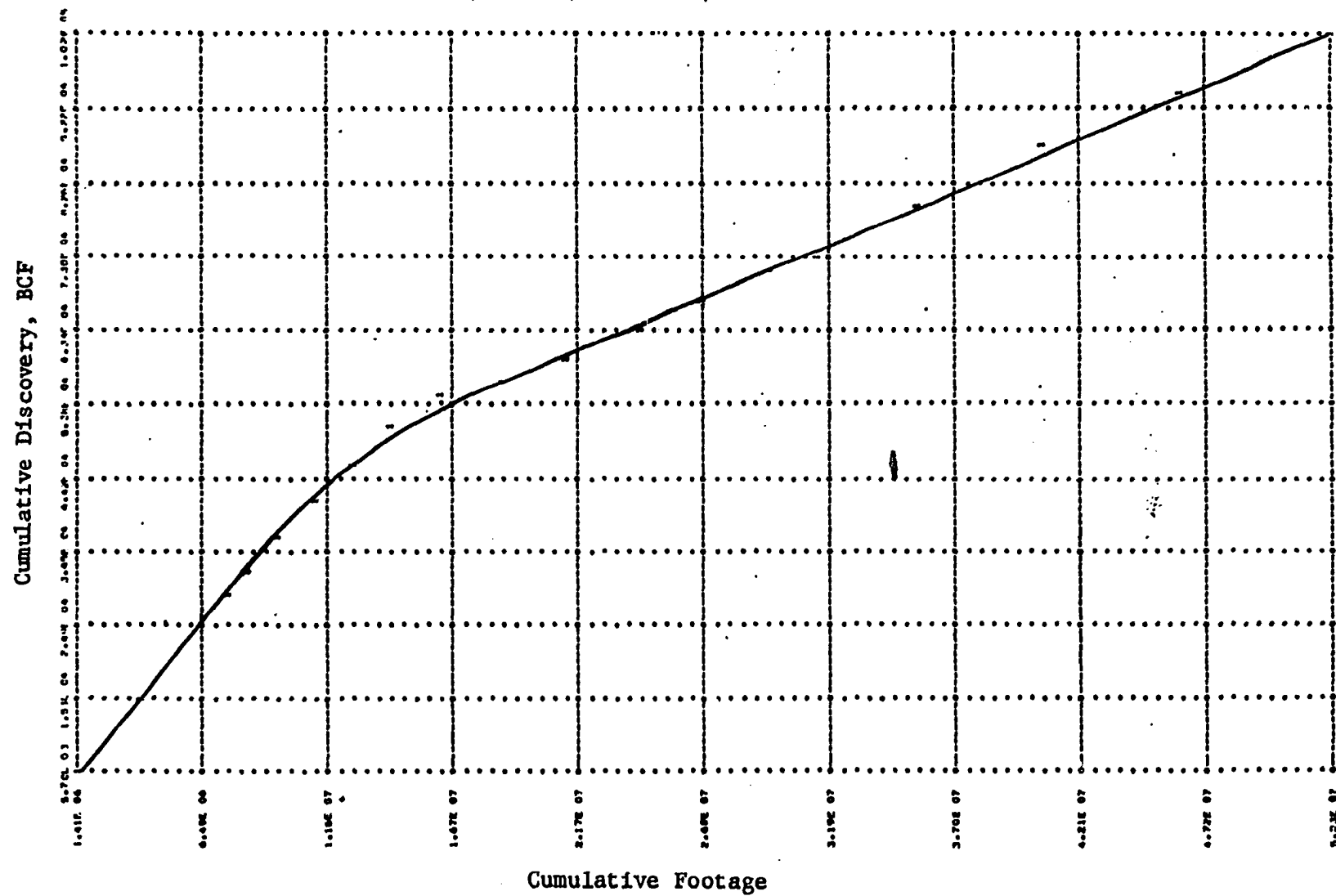


FIGURE IX-101. Composite plot of cumulative discovery vs. cumulative footage.
(Case I, Logistic curve)

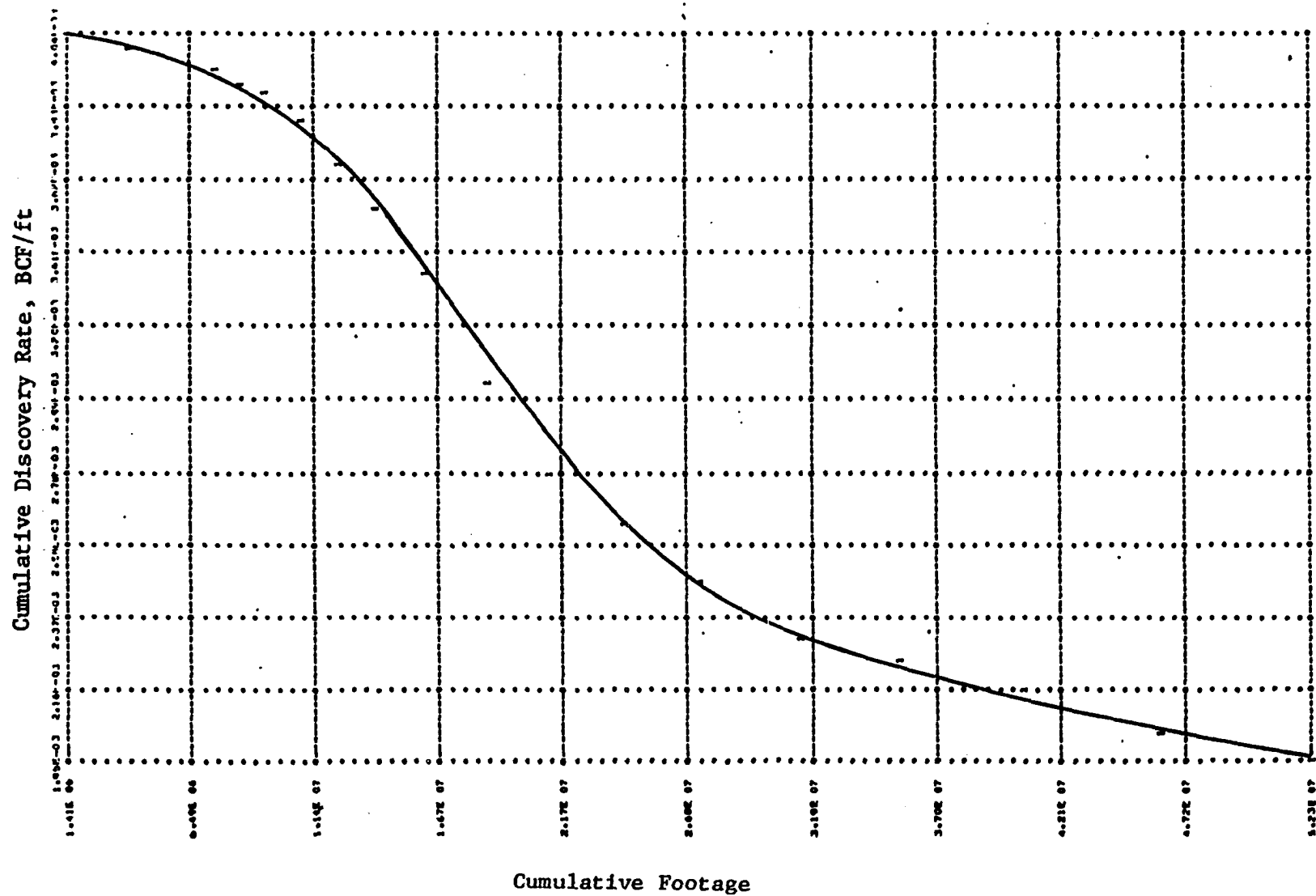


FIGURE IX-102. Composite plot of cumulative discovery rate vs. cumulative footage.
(Case I, Logistic curve)

whole course of drilling activities. This reflects the fact that the values for total footage drilled are less than the value at which rapid decreases in drilling activity are indicated in the particular logistic relationships used to describe the drilling activity.

Ninth Run

The results obtained from the ninth run are shown in Tables IX-33 to IX-36 and Figures IX-103 to IX-108. This run is based on the results of Case II of Phase one and uses a logistic curve extrapolation for future drilling activities. Tables IX-33, IX-34, and IX-35 are results for Regions 1, 2, and 3, respectively. Table IX-36 and Figures IX-103 to IX-108 are results for all three regions combined. By observing these plots for this run and comparing them with the corresponding plots of the third and sixth run, it can be seen that essentially the same response is indicated in all the plots, except those plots for increment reserves vs. either time or footage. The plots of increment reserves vs. either time or footage for this run are shown in Figures IX-103 and IX-106. The curves for these two plots are very much like Figures IX-97 and IX-100 for the eighth run. These curves increase sharply in the initial stages of drilling. They decrease with the same rate and sharpness, then they increase smoothly and gradually through the remaining course of drilling activities.

TABLE IX-33

Prediction of Future Discoveries for Region 1
(Case II, Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.1410437E 07	0.5696879E 04	0.1410437E 07	0.5696879E 04	0.4039086E-02	0.4039086E-02
4	0.2111190E 06	0.8527305E 03	0.1621556E 07	0.6549609E 04	0.4039098E-02	0.4039098E-02
5	0.2422990E 06	0.9786641E 03	0.1863855E 07	0.7528273E 04	0.4039075E-02	0.4039084E-02
6	0.2775480E 06	0.9024141E 03	0.2141803E 07	0.8436688E 04	0.3268288E-02	0.3939055E-02
7	0.3186640E 06	0.9832344E 03	0.2460467E 07	0.9419922E 04	0.3085489E-02	0.3828510E-02
8	0.3651120E 06	0.1126543E 04	0.2825579E 07	0.1054646E 05	0.3085472E-02	0.3732497E-02
9	0.4180230E 06	0.1289805E 04	0.3243602E 07	0.1183627E 05	0.3085487E-02	0.3647113E-02
10	0.4781980E 06	0.1475469E 04	0.3721800E 07	0.1331174E 05	0.3085477E-02	0.3576694E-02
11	0.5465170E 06	0.7711172E 03	0.4268317E 07	0.1402266E 05	0.1410967E-02	0.3299393E-02
12	0.6239080E 06	0.6525781E 03	0.4892225E 07	0.1473543E 05	0.1045952E-02	0.3012011E-02
13	0.7113770E 06	0.7440625E 03	0.5603602E 07	0.1547950E 05	0.1045947E-02	0.2762419E-02
14	0.8099380E 06	0.2265508E 03	0.6413540E 07	0.1570605E 05	0.2797137E-03	0.2448889E-02
15	0.9206710E 06	0.1254688E 03	0.7334211E 07	0.1583152E 05	0.1362797E-03	0.2158585E-02
16	0.1044601E 07	0.4386328E 03	0.8378812E 07	0.1627015E 05	0.4190045E-03	0.1941820E-02
17	0.1182741E 07	0.6832461E 03	0.9561553E 07	0.1695339E 05	0.5776801E-03	0.1773079E-02
18	0.1335997E 07	0.3657617E 03	0.1069755E 08	0.1731916E 05	0.2737741E-03	0.1589271E-02
19	0.1505052E 07	0.6705352E 03	0.1240260E 08	0.1798945E 05	0.4455228E-03	0.1450477E-02
20	0.1690405E 07	0.9964414E 03	0.1409301E 08	0.1898613E 05	0.5894690E-03	0.1347202E-02

TABLE IX-34

Prediction of Future Discoveries for Region 2
(Case II, Logistic Curve)

TIME	INC. FOOTAGE	INC. RESERVE	CUM. FOOTAGE	CUM. RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM. DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
4	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
5	0.2801121E 07	0.1092732E 05	0.2801121E 07	0.1092732E 05	0.3901053E-02	0.3901053E-02
6	0.3507570E 06	0.1407383E 04	0.3151878E 07	0.1233470E 05	0.3601683E-02	0.3864403E-02
7	0.4445540E 06	0.1601145E 04	0.3636432E 07	0.1393565E 05	0.3601687E-02	0.3832286E-02
8	0.5055440E 06	0.1446816E 04	0.4141976E 07	0.1538246E 05	0.2861900E-02	0.3713247E-02
9	0.5746260E 06	0.1402973E 04	0.4716602E 07	0.1678564E 05	0.2441540E-02	0.3552841E-02
10	0.6527930E 06	0.1593816E 04	0.5369395E 07	0.1837945E 05	0.2441534E-02	0.3423003E-02
11	0.7411400E 06	0.1001121E 04	0.6110535E 07	0.1938067E 05	0.1350785E-02	0.3171666E-02
12	0.8402470E 06	0.2605039E 03	0.6951382E 07	0.1964108E 05	0.3098112E-03	0.2825493E-02
13	0.9532170E 06	0.6130502E 03	0.7504599E 07	0.2025413E 05	0.6431385E-03	0.2562322E-02
14	0.1075629E 07	0.2075648E 04	0.8984228E 07	0.223297E 05	0.1922557E-02	0.2485442E-02
15	0.1221563E 07	0.1290258E 04	0.1020579E 08	0.2422004E 05	0.1547409E-02	0.2373166E-02
16	0.1380550E 07	0.1584324E 04	0.1158634E 08	0.2580436E 05	0.1147604E-02	0.2227136E-02
17	0.1552215E 07	0.2482223E 04	0.1314456E 08	0.2828652E 05	0.1592991E-02	0.2151962E-02
18	0.1756133E 07	0.3168113E 04	0.1450069E 08	0.3145470E 05	0.1204028E-02	0.2110956E-02
19	0.1975919E 07	0.1923398E 04	0.1687661E 08	0.3337809E 05	0.9734195E-03	0.1977772E-02
20	0.2219104E 07	0.2576480E 04	0.1909571E 08	0.3595457E 05	0.1161045E-02	0.1882861E-02

TABLE IX-35

Prediction of Future Discoveries for Region 3
(Case II, Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.2292852E 07	0.9388719E 04	0.2292852E 07	0.9388719E 04	0.4084088E-02	0.4084088E-02
5	0.3336710E 06	0.1432156E 04	0.2632523E 07	0.1082688E 05	0.4310101E-02	0.4112735E-02
6	0.3814600E 06	0.1644137E 04	0.3013983E 07	0.1247101E 05	0.4310112E-02	0.4137717E-02
7	0.4352970E 06	0.1878762E 04	0.3449880E 07	0.1434977E 05	0.4310101E-02	0.4159499E-02
8	0.4978420E 06	0.1973203E 04	0.3947722E 07	0.1632298E 05	0.3963511E-02	0.4134782E-02
9	0.5682500E 06	0.1683867E 04	0.4515972E 07	0.1800684E 05	0.2963251E-02	0.3997368E-02
10	0.6481760E 06	0.1520707E 04	0.5164140E 07	0.1592755E 05	0.2963249E-02	0.3858826E-02
11	0.7387700E 06	0.1834965E 04	0.5902918E 07	0.2176222E 05	0.2483811E-02	0.3686738E-02
12	0.8412880E 06	0.7565352E 03	0.6744206E 07	0.2251905E 05	0.8992581E-03	0.3339022E-02
13	0.9570670E 06	0.8606523E 03	0.7701273E 07	0.2337970E 05	0.8992602E-03	0.3035823E-02
14	0.1087534E 07	0.2635684E 04	0.8788807E 07	0.2601539E 05	0.2423541E-02	0.2560059E-02
15	0.1234183E 07	0.2714744E 04	0.1002299E 08	0.2873013E 05	0.2199630E-02	0.2866423E-02
16	0.1392545E 07	0.2369785E 04	0.1142154E 08	0.3109952E 05	0.1694465E-02	0.2722919E-02
17	0.1582141E 07	0.2212297E 04	0.1300368E 08	0.3391221E 05	0.1777526E-02	0.2607894E-02
18	0.1786462E 07	0.3456234E 04	0.1479014E 08	0.3736845E 05	0.1934681E-02	0.2526579E-02
19	0.2012870E 07	0.5219258E 04	0.1680301E 08	0.4252771E 05	0.2592943E-02	0.2574529E-02
20	0.2262528E 07	0.3679070E 04	0.1906554E 08	0.4626678E 05	0.1626088E-02	0.2426723E-02

TABLE IX-36

Composite Parameters for All k Basins
(Case II, Logistic Curve)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.1410437E 07	0.5696879E 04	0.1410437E 07	0.5696879E 04	0.4039086E-02	0.4039086E-02
4	0.2509971E 07	0.1024145E 05	0.3920408E 07	0.1593833E 05	0.4080303E-02	0.4065476E-02
5	0.3377091E 07	0.1334414E 05	0.7297499E 07	0.2928247E 05	0.3951371E-02	0.4012670E-02
6	0.1050165E 07	0.3959934E 04	0.8347664E 07	0.3324240E 05	0.3770773E-02	0.3982238E-02
7	0.1199115E 07	0.4463141E 04	0.9546779E 07	0.3770554E 05	0.3722029E-02	0.3949553E-02
8	0.1366498E 07	0.4546563E 04	0.1091528E 08	0.4225211E 05	0.3322301E-02	0.3870914E-02
9	0.1560899E 07	0.4376645E 04	0.1247618E 08	0.4662875E 05	0.2803925E-02	0.3737423E-02
10	0.1779167E 07	0.4989992E 04	0.1425534E 08	0.5161874E 05	0.2804679E-02	0.3621010E-02
11	0.2026427E 07	0.3607203E 04	0.1628177E 08	0.5522555E 05	0.1780080E-02	0.3391888E-02
12	0.2306030E 07	0.1669617E 04	0.1858781E 08	0.5689556E 05	0.7240197E-03	0.3060907E-02
13	0.2621664E 07	0.2217766E 04	0.2120947E 08	0.5511333E 05	0.8459380E-03	0.2787119E-02
14	0.2977082E 07	0.4937883E 04	0.2418656E 08	0.6405121E 05	0.1658628E-02	0.2648215E-02
15	0.3376410E 07	0.4730414E 04	0.2756298E 08	0.6878163E 05	0.1401016E-02	0.2495435E-02
16	0.3823696E 07	0.4392750E 04	0.3138667E 08	0.7317438E 05	0.1148823E-02	0.2331384E-02
17	0.4323080E 07	0.5977813E 04	0.3570976E 08	0.7915219E 05	0.1382764E-02	0.2216542E-02
18	0.4878592E 07	0.6990063E 04	0.4058835E 08	0.8614225E 05	0.1432803E-02	0.2122339E-02
19	0.5493856E 07	0.7813188E 04	0.4608221E 08	0.9395544E 05	0.1422168E-02	0.2038866E-02
20	0.6172032E 07	0.7252000E 04	0.5225424E 08	0.1012074E 06	0.1174978E-02	0.1936827E-02

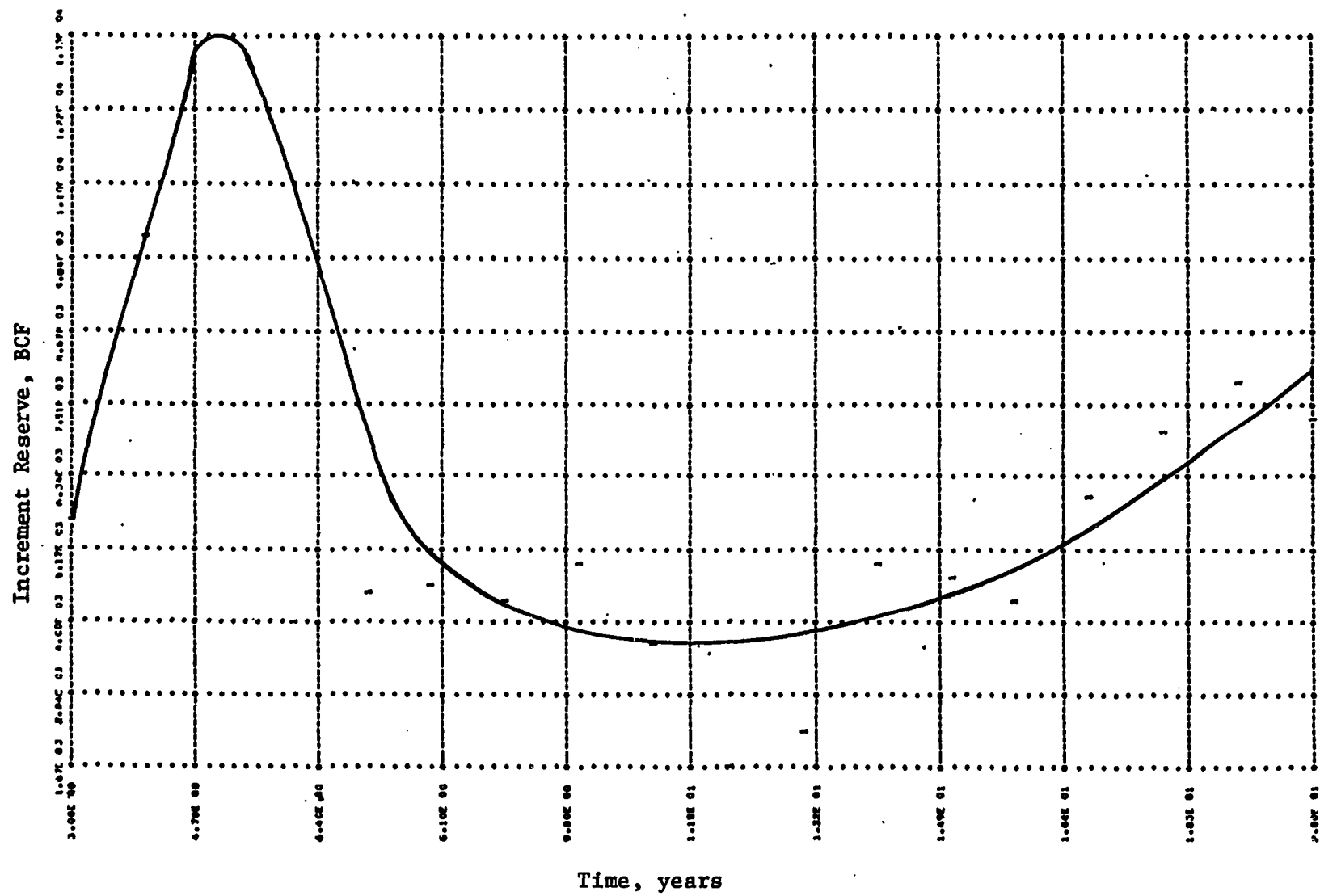


FIGURE IX-103. Composite plot of increment reserve vs. time.
(Case II, Logistic curve)

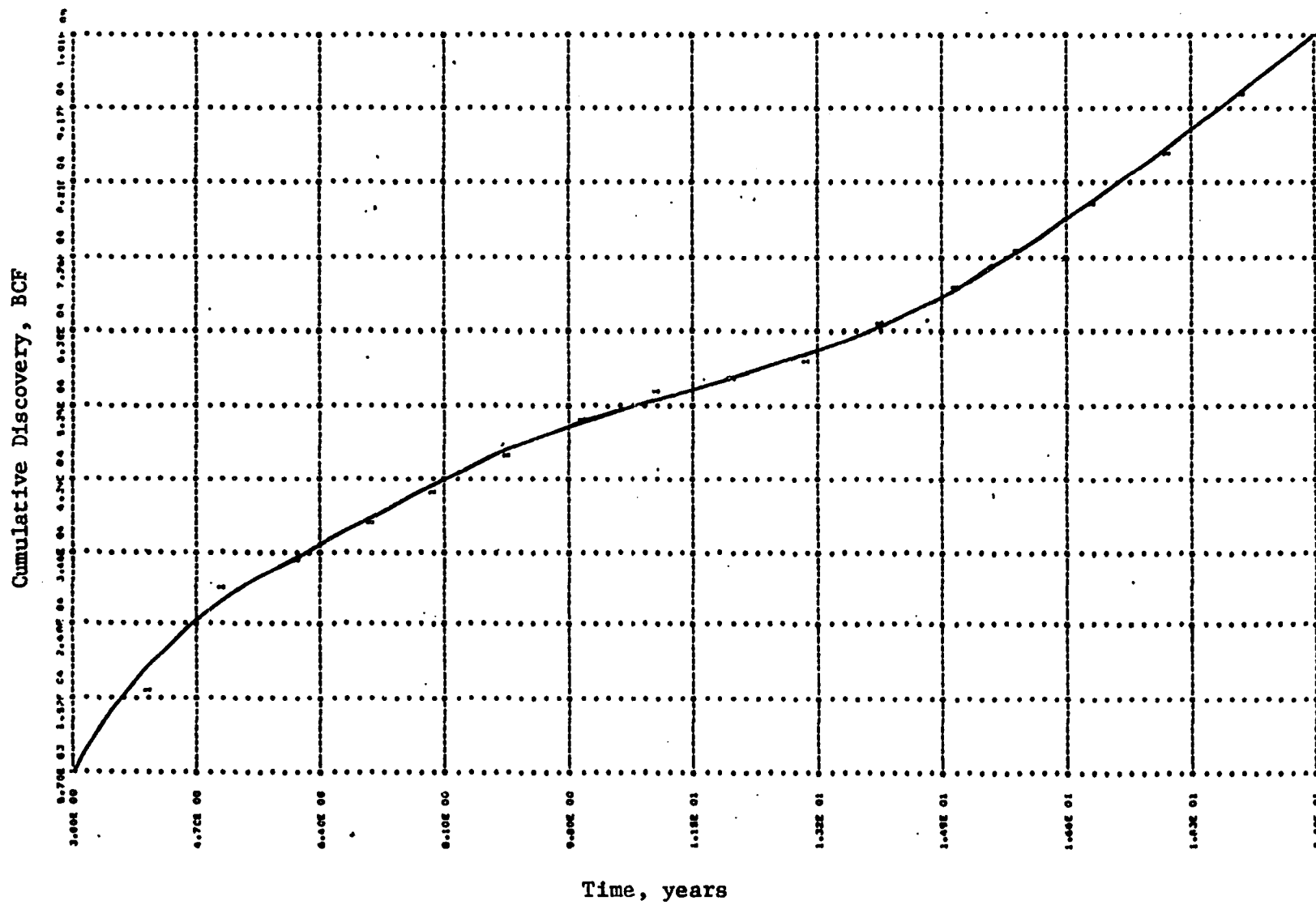


FIGURE IX-104. Composite plot of cumulative discovery vs. time.
(Case II, Logistic curve)

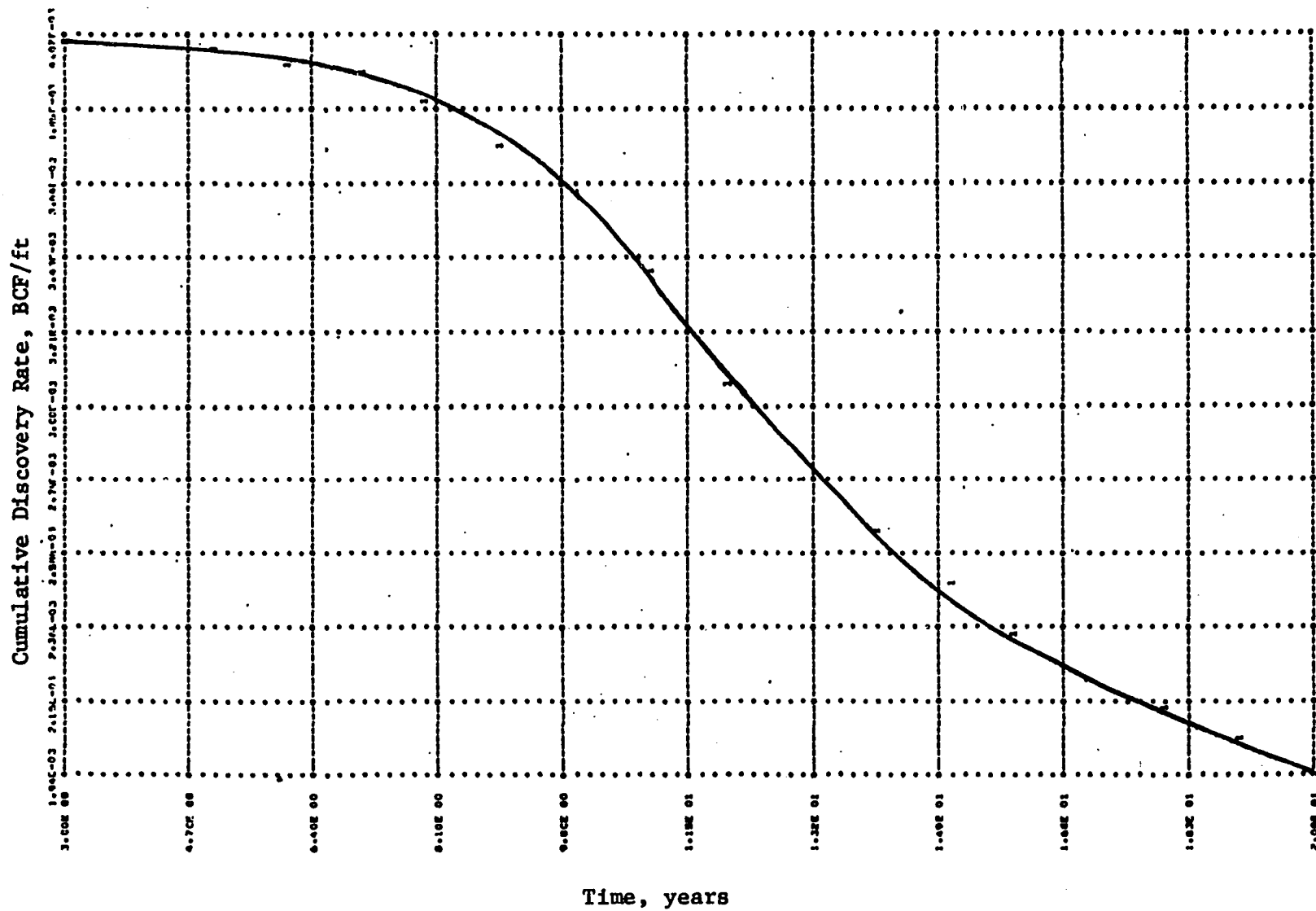


FIGURE IX-105. Composite plot of cumulative discovery rate vs. time.
(Case II, Logistic curve)

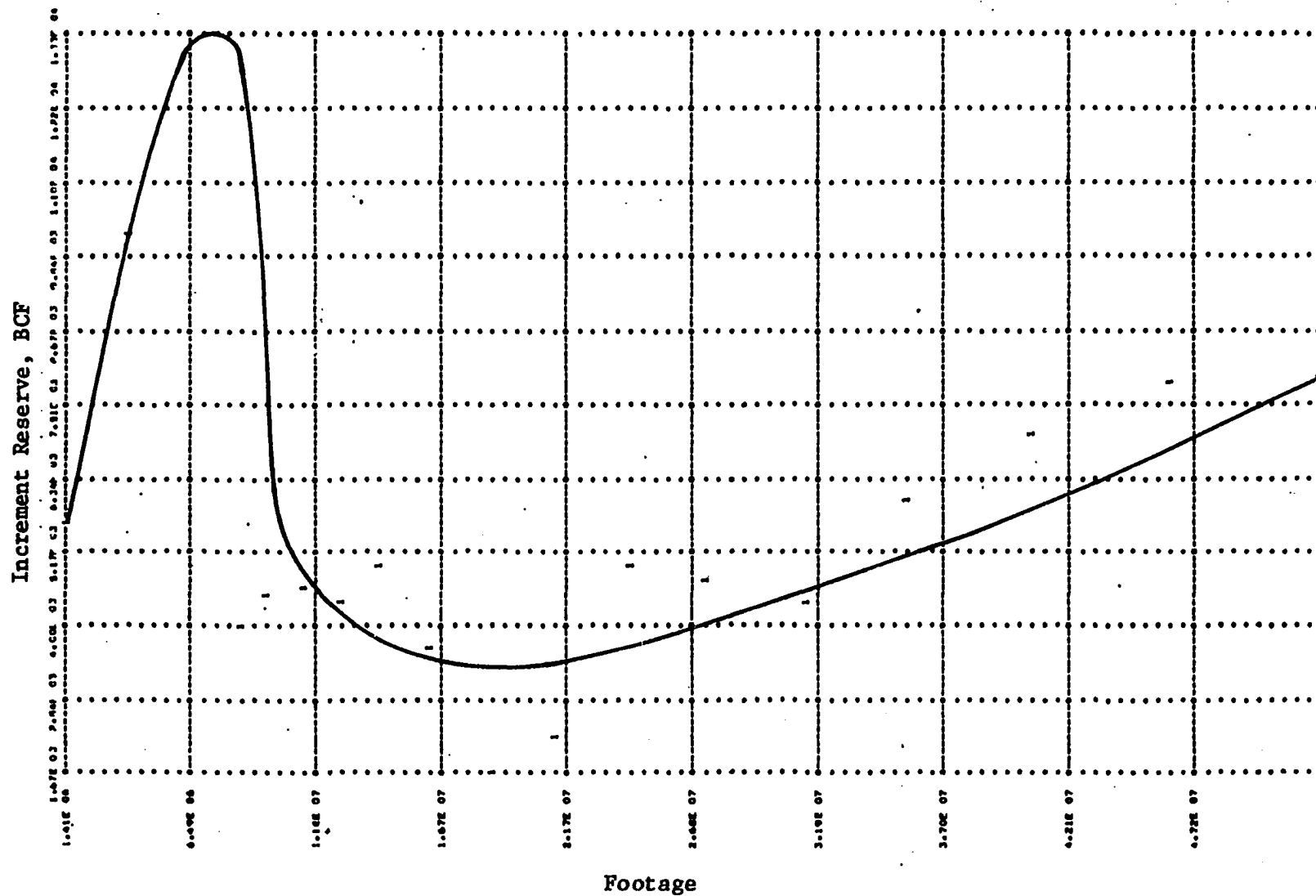


FIGURE IX-106. Composite plot of increment reserve vs. footage.
(Case II, Logistic curve)

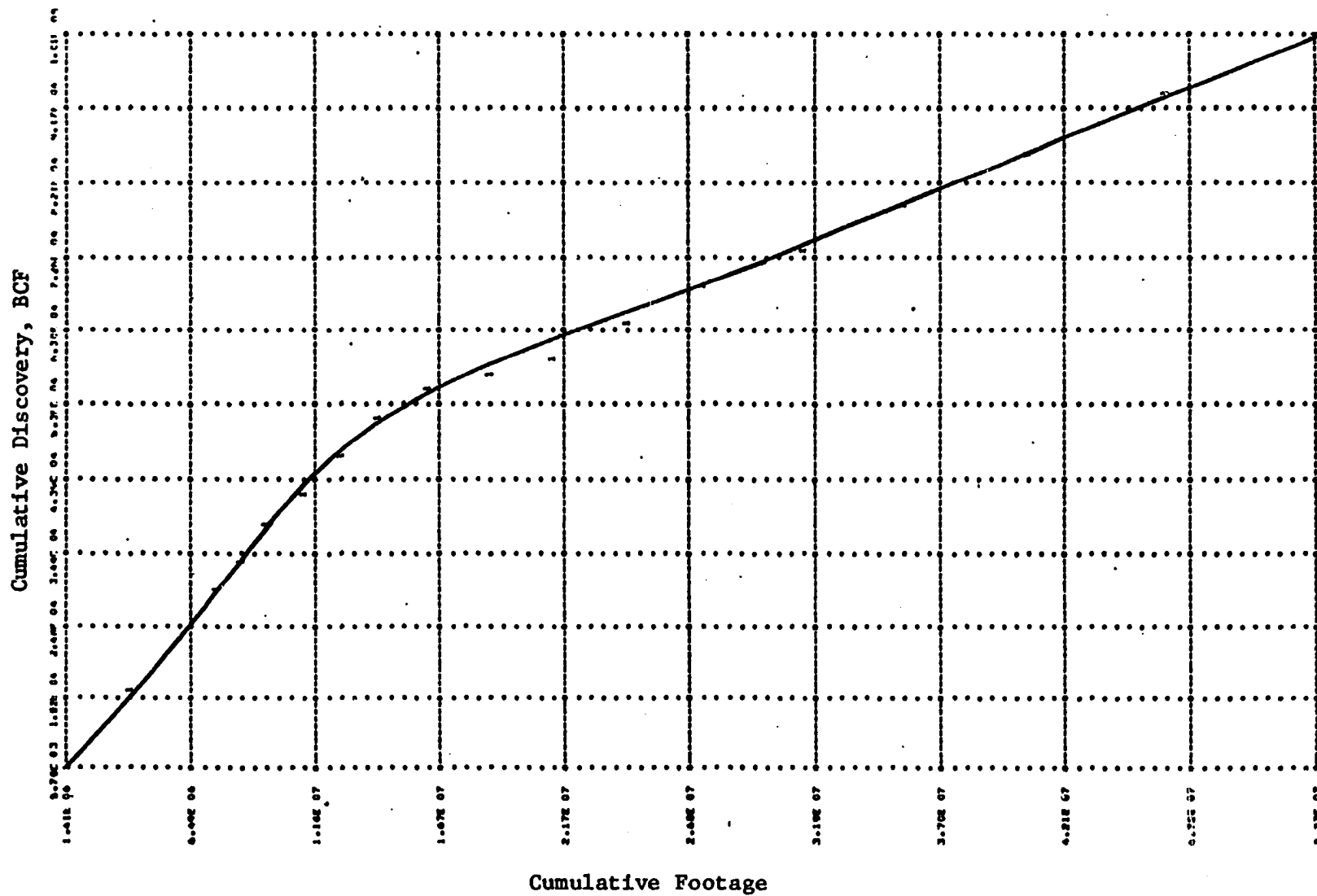


FIGURE IX-107. Composite plot of cumulative discovery vs. cumulative footage.
(Case II, Logistic curve)

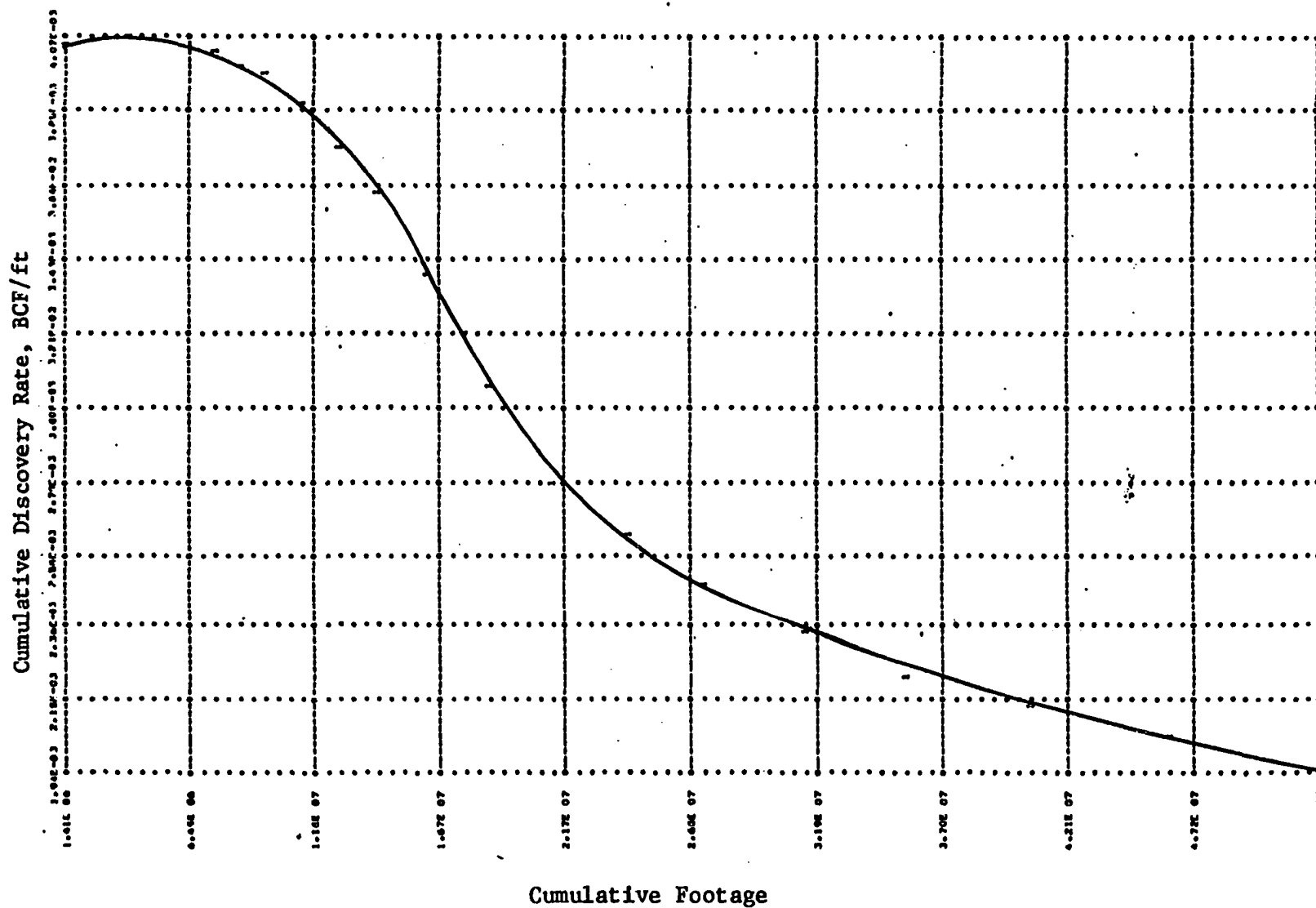


FIGURE IX-108. Composite plot of cumulative discovery rate vs. cumulative footage.
(Case II, Logistic curve)

Tenth Run

The results obtained from the tenth run are shown in Tables IX-37 to IX-40 and Figures IX-109 to IX-114. This run is based on the results of the original model of Phase one using an increasing drilling rate function for future drilling activities. Tables IX-37, IX-38 and IX-39 are the results for Regions 1, 2, and 3, respectively. Table IX-40 and Figures IX-109 to IX-114 are results for all three regions combined. By observing these plots for this run and comparing them with the corresponding plots for the first, fourth and seventh runs, it can be seen that different results are indicated in some of the plots. However, most of them look quite similar to the previous curves. The plot of increment reserves vs. time, Figure IX-109, increases all the way to the point where $t = 15$ years. Then it decreases for the next three years ($t = 18$). From this point it again increases with the same rate as it decreased for the rest of the period ($t = 20$ years). The plot of cumulative discovery rate vs time, Figure IX-111, shows a gradual decrease all the way to the point where $t = 10$ years. From this point on the rate of decrease is very steep through the rest of the remaining years. The plot of increment reserves vs. footage, Figure IX-112, shows an increase for the initial stages of drilling. Then it starts decreasing for a while and eventually it increases again for the rest of the drilling activities.

TABLE IX-37

Prediction of Future Discoveries for Region 1
(Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.1052630E 07	0.3491601E 04	0.1052630E 07	0.3491601E 04	0.3317026E-02	0.3317026E-02
4	0.1165550E 07	0.3879555E 04	0.2222220E 07	0.7371160E 04	0.3317025E-02	0.3317025E-02
5	0.1307188E 07	0.4335977E 04	0.3529408E 07	0.1170714E 05	0.3317026E-02	0.3317025E-02
6	0.1470588E 07	0.4877980E 04	0.4999996E 07	0.1658512E 05	0.3317027E-02	0.3317026E-02
7	0.1666665E 07	0.5528371E 04	0.6666661E 07	0.2211345E 05	0.3317026E-02	0.3317026E-02
8	0.1904760E 07	0.6318141E 04	0.8571421E 07	0.2843163E 05	0.3317027E-02	0.3317026E-02
9	0.2197801E 07	0.7290160E 04	0.1076922E 08	0.3572179E 05	0.3317025E-02	0.3317026E-02
10	0.2564100E 07	0.8505191E 04	0.1333332E 08	0.4422658E 05	0.3317028E-02	0.3317026E-02
11	0.3030301E 07	0.1005156E 05	0.1636362E 08	0.5427857E 05	0.3317027E-02	0.3317026E-02
12	0.3636361E 07	0.1144030E 05	0.1999998E 08	0.6571288E 05	0.3146086E-02	0.3285946E-02
13	0.4444432E 07	0.1160200E 05	0.2444442E 08	0.7732088E 05	0.2610457E-02	0.3163130E-02
14	0.5555552E 07	0.1450250E 05	0.2999997E 08	0.9182338E 05	0.2610452E-02	0.3060782E-02
15	0.7142848E 07	0.1864613E 05	0.3714282E 08	0.1104655E 06	0.2610461E-02	0.2974182E-02
16	0.9523808E 07	0.1924563E 05	0.4666662E 08	0.1297151E 06	0.2020791E-02	0.2779612E-02
17	0.1333331E 08	0.2306788E 05	0.5999994E 08	0.1527830E 06	0.1730093E-02	0.2546386E-02
18	0.2000000E 08	0.1516231E 05	0.7999994E 08	0.1679453E 06	0.7581154E-03	0.2099318E-02
19	0.3333322E 08	0.1648488E 05	0.1123332E 09	0.1844302E 06	0.4945479E-03	0.1627328E-02
20	0.6666659E 08	0.2287131E 05	0.1799997E 09	0.2073015E 06	0.3430699E-03	0.1151677E-02

TABLE IX-38

Prediction of Future Discoveries for Region 2
(Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
5	0.2392344E 07	0.7935465E 04	0.2392344E 07	0.7935465E 04	0.3317025E-02	0.3317025E-02
6	0.2658160E 07	0.8817184E 04	0.5050504E 07	0.1675265E 05	0.3317025E-02	0.3317025E-02
7	0.2970286E 07	0.9854512E 04	0.8021390E 07	0.2660716E 05	0.3317026E-02	0.3317026E-02
8	0.3342246E 07	0.1108632E 05	0.1136364E 08	0.3769346E 05	0.3317026E-02	0.3317026E-02
9	0.3787278E 07	0.1256449E 05	0.1515151E 08	0.5025757E 05	0.3317026E-02	0.3317026E-02
10	0.4326922E 07	0.1410463E 05	0.1948050E 08	0.6436280E 05	0.3258232E-02	0.3303961E-02
11	0.4995008E 07	0.1303920E 05	0.2447550E 08	0.7740200E 05	0.2610447E-02	0.3162427E-02
12	0.5627504E 07	0.1521244E 05	0.3030301E 08	0.9261444E 05	0.2610455E-02	0.3056279E-02
13	0.6287056E 07	0.1797838E 05	0.3719006E 08	0.1105922E 06	0.2610459E-02	0.2973719E-02
14	0.6264464E 07	0.1677200E 05	0.4545453E 08	0.127364E 06	0.2029411E-02	0.2802027E-02
15	0.1010099E 08	0.1958619E 05	0.5555552E 08	0.1469510E 06	0.1939036E-02	0.2645120E-02
16	0.1262627E 08	0.1230231E 05	0.6818179E 08	0.1592533E 06	0.9743422E-03	0.2335716E-02
17	0.1623376E 08	0.1128094E 05	0.8441555E 08	0.1705343E 06	0.6949059E-03	0.2020176E-02
18	0.2164502E 08	0.1091231E 05	0.1060606E 09	0.1814466E 06	0.5041487E-03	0.1710782E-02
19	0.3030304E 08	0.1215363E 05	0.1363636E 09	0.1936002E 06	0.4010694E-03	0.1419735E-02
20	0.4845456E 08	0.1420363E 05	0.1818182E 09	0.207003E 06	0.3124794E-03	0.1142921E-02

TABLE IX-39

Prediction of Future Discoveries for Region 3
(Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.1644736E 07	0.5455629E 04	0.1644736E 07	0.5455629E 04	0.3317024E-02	0.3317024E-02
5	0.1827466E 07	0.6061820E 04	0.3472222E 07	0.1151745E 05	0.3317027E-02	0.3317025E-02
6	0.2042483E 07	0.6774969E 04	0.5514705E 07	0.1829242E 05	0.3317026E-02	0.3317025E-02
7	0.2297795E 07	0.7621848E 04	0.7812500E 07	0.2591427E 05	0.3317027E-02	0.3317026E-02
8	0.2604166E 07	0.8638090E 04	0.1041667E 08	0.3455236E 05	0.3317027E-02	0.3317026E-02
9	0.2976191E 07	0.9872102E 04	0.1339286E 08	0.4442446E 05	0.3317025E-02	0.3317026E-02
10	0.3434055E 07	0.1139085E 05	0.1682691E 08	0.5581531E 05	0.3317026E-02	0.3317026E-02
11	0.4006416E 07	0.1207894E 05	0.2083333E 08	0.6789425E 05	0.3014899E-02	0.3258925E-02
12	0.4734832E 07	0.1236013E 05	0.2556816E 08	0.8025432E 05	0.2610467E-02	0.3138840E-02
13	0.5681824E 07	0.1483213E 05	0.3124998E 08	0.9508650E 05	0.2610451E-02	0.3042769E-02
14	0.6944442E 07	0.1812819E 05	0.3819443E 08	0.1132147E 06	0.2610458E-02	0.2964167E-02
15	0.8680544E 07	0.1690444E 05	0.4667490E 08	0.1301151E 06	0.1947394E-02	0.2775876E-02
16	0.1116074E 08	0.2111050E 05	0.5803571E 08	0.1512296E 06	0.1891497E-02	0.2605803E-02
17	0.1488093E 08	0.1176813E 05	0.7251664E 08	0.1629978E 06	0.7908193E-03	0.2235398E-02
18	0.2083331E 08	0.1300950E 05	0.9374995E 08	0.1760073E 06	0.6244564E-03	0.1877412E-02
19	0.3120005E 08	0.1313881E 05	0.1250000E 09	0.1291461E 06	0.4204412E-03	0.1513168E-02
20	0.5208330E 08	0.1734981E 05	0.1770833E 09	0.2064959E 06	0.3331166E-03	0.1166095E-02

TABLE IX-40

Composite Parameters for All k Basins
(Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.1052630E 07	0.3491601E 04	0.1052630E 07	0.3491601E 04	0.3317026E-02	0.3317026E-02
4	0.2814326E 07	0.9335188E 04	0.3866956E 07	0.1282679E 05	0.3317024E-02	0.3317025E-02
5	0.5827016E 07	0.1833326E 05	0.9393974E 07	0.3116005E 05	0.3317026E-02	0.3317025E-02
6	0.6171231E 07	0.2047013E 05	0.1556521E 08	0.5163018E 05	0.3317026E-02	0.3317025E-02
7	0.6935335E 07	0.2300469E 05	0.2250054E 08	0.7463482E 05	0.3317025E-02	0.3317025E-02
8	0.7851162E 07	0.2604250E 05	0.3035171E 08	0.1006774E 06	0.3317022E-02	0.3317025E-02
9	0.8961872E 07	0.2972681E 05	0.3931358E 08	0.1304042E 06	0.3317032E-02	0.3317026E-02
10	0.1032714E 08	0.3400081E 05	0.4964072E 08	0.1644050E 06	0.3292376E-02	0.3311898E-02
11	0.1203173E 08	0.3516981E 05	0.6167245E 08	0.1995748E 06	0.2923089E-02	0.3236045E-02
12	0.1419870E 08	0.3901288E 05	0.7587115E 08	0.2385877E 06	0.2747636E-02	0.3144643E-02
13	0.1701331E 08	0.4441250E 05	0.9288446E 08	0.2830002E 06	0.2610456E-02	0.3046798E-02
14	0.2076446E 08	0.4940269E 05	0.1136489E 09	0.3324029E 06	0.2379194E-02	0.2924822E-02
15	0.2592438E 08	0.5513675E 05	0.1395733E 09	0.3875356E 06	0.2126830E-02	0.2776603E-02
16	0.3331082E 08	0.5265844E 05	0.1728841E 09	0.4401921E 06	0.1580821E-02	0.2546203E-02
17	0.4444800E 08	0.4611694E 05	0.2173321E 09	0.4863150E 06	0.1037548E-02	0.2237658E-02
18	0.6247818E 08	0.3908413E 05	0.2798103E 09	0.5253951E 06	0.6255643E-03	0.1877697E-02
19	0.5488640E 08	0.4177731E 05	0.3746967E 09	0.5671764E 06	0.4402876E-03	0.1513695E-02
20	0.1642043E 09	0.5442475E 05	0.5329010E 09	0.6216012E 06	0.3314451E-03	0.1153461E-02

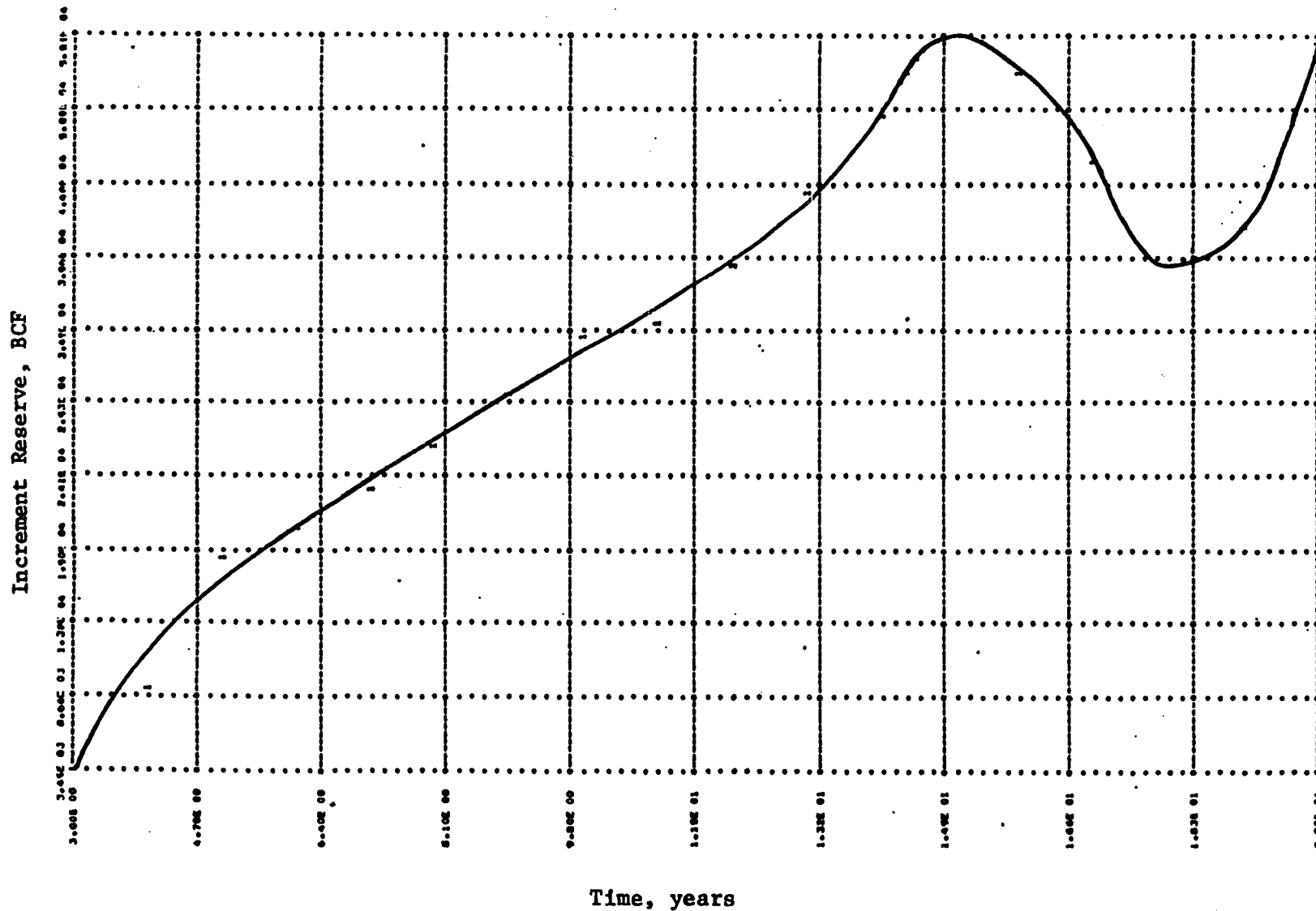


FIGURE IX-109. Composite plot of increment reserve vs. time.
(Increasing drilling rate function)

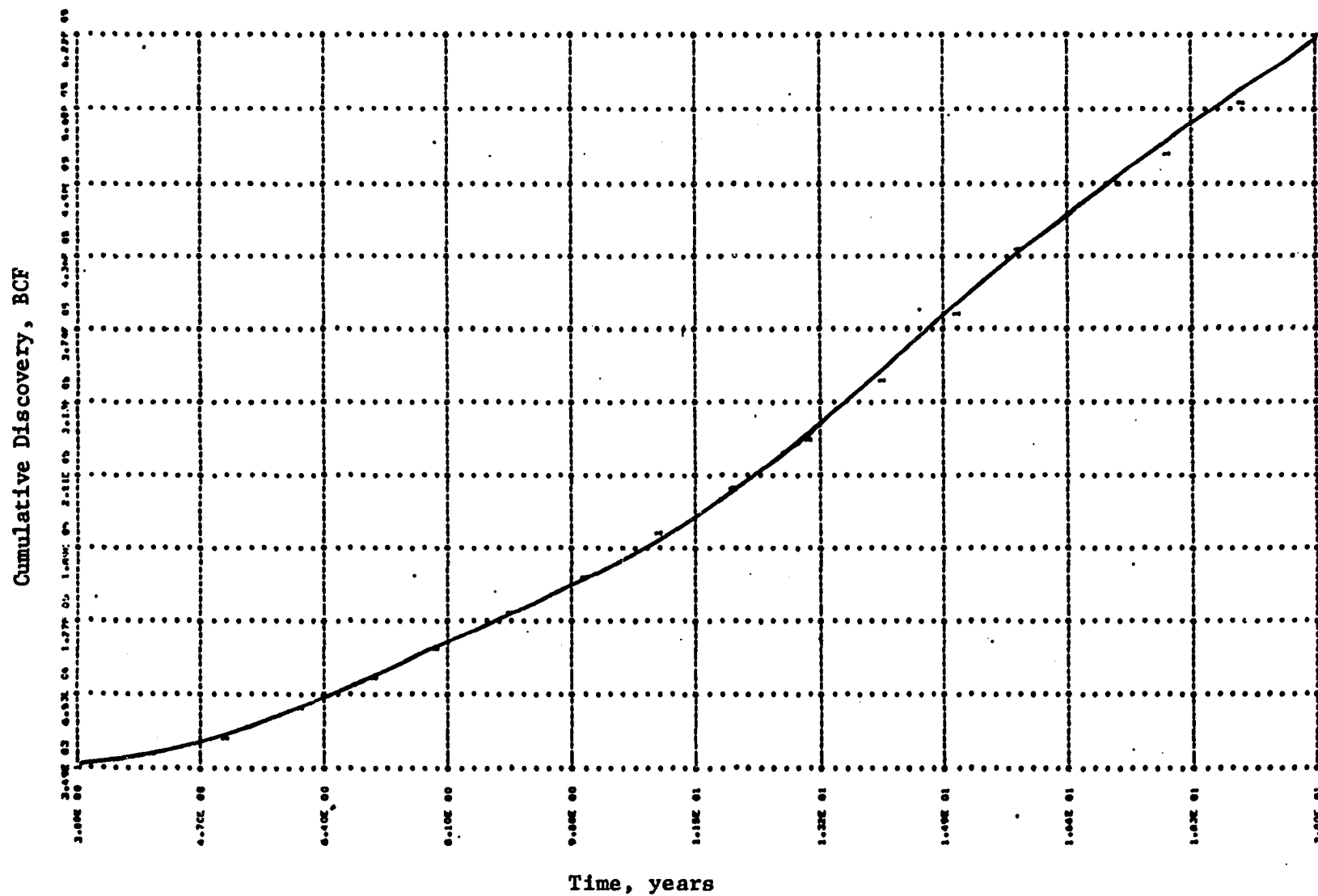


FIGURE IX-110. Composite plot of cumulative discovery vs. time.
(Increasing drilling rate function)

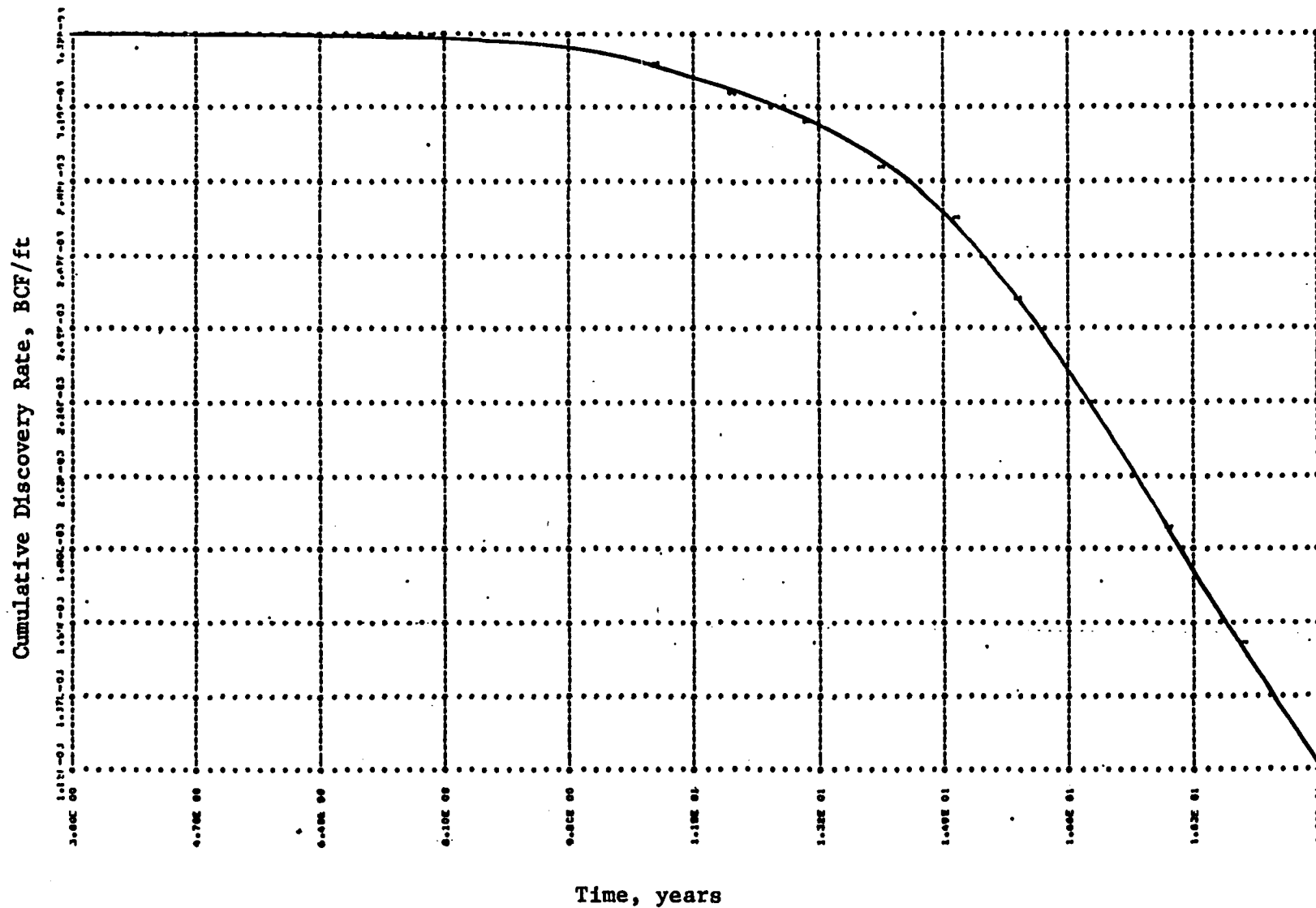


FIGURE IX-111.. Composite plot of cumulative discovery rate vs. time.
(Increasing drilling rate function)

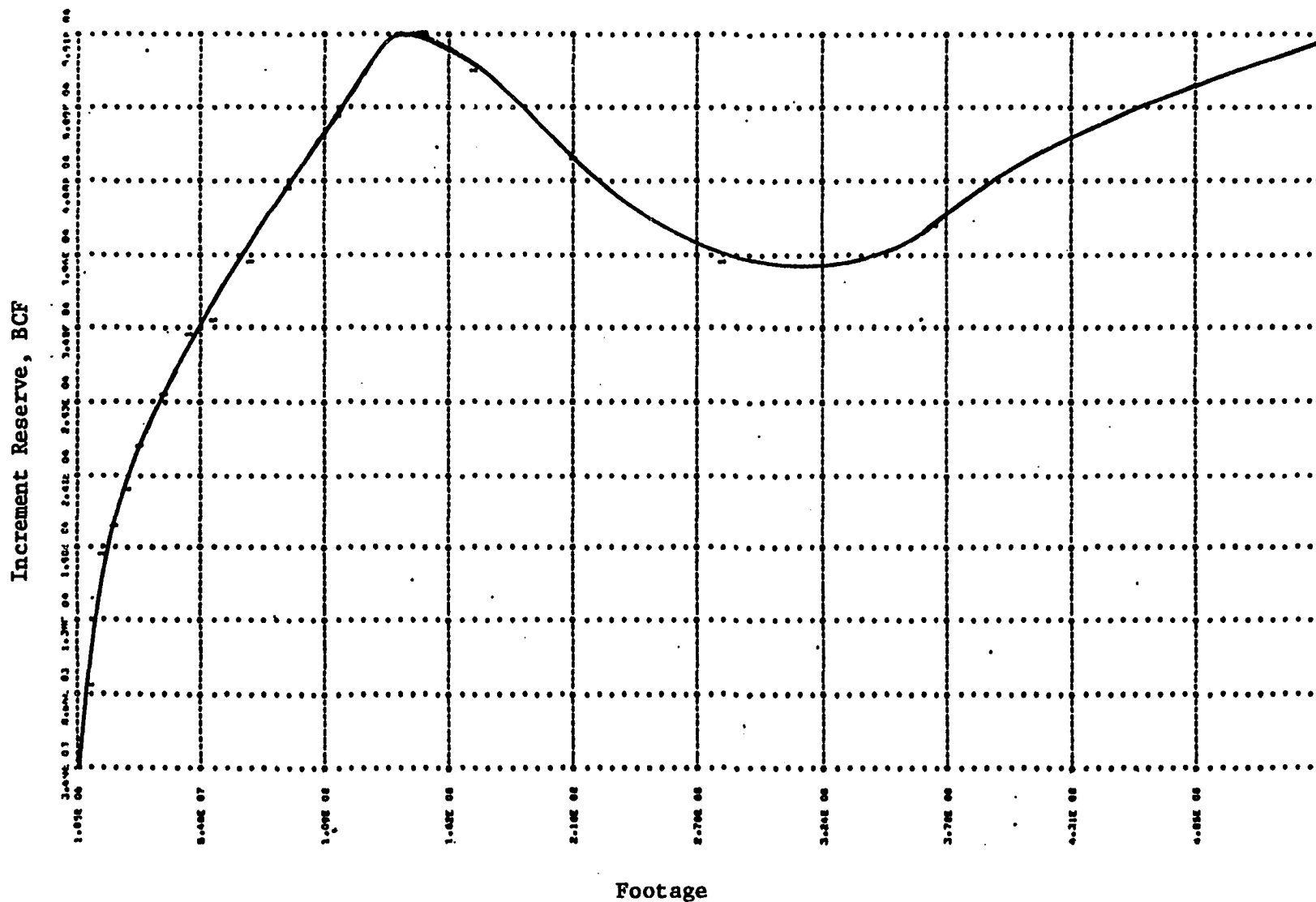


FIGURE IX-112. Composite plot of increment reserve vs. footage.
(Increasing drilling rate function)

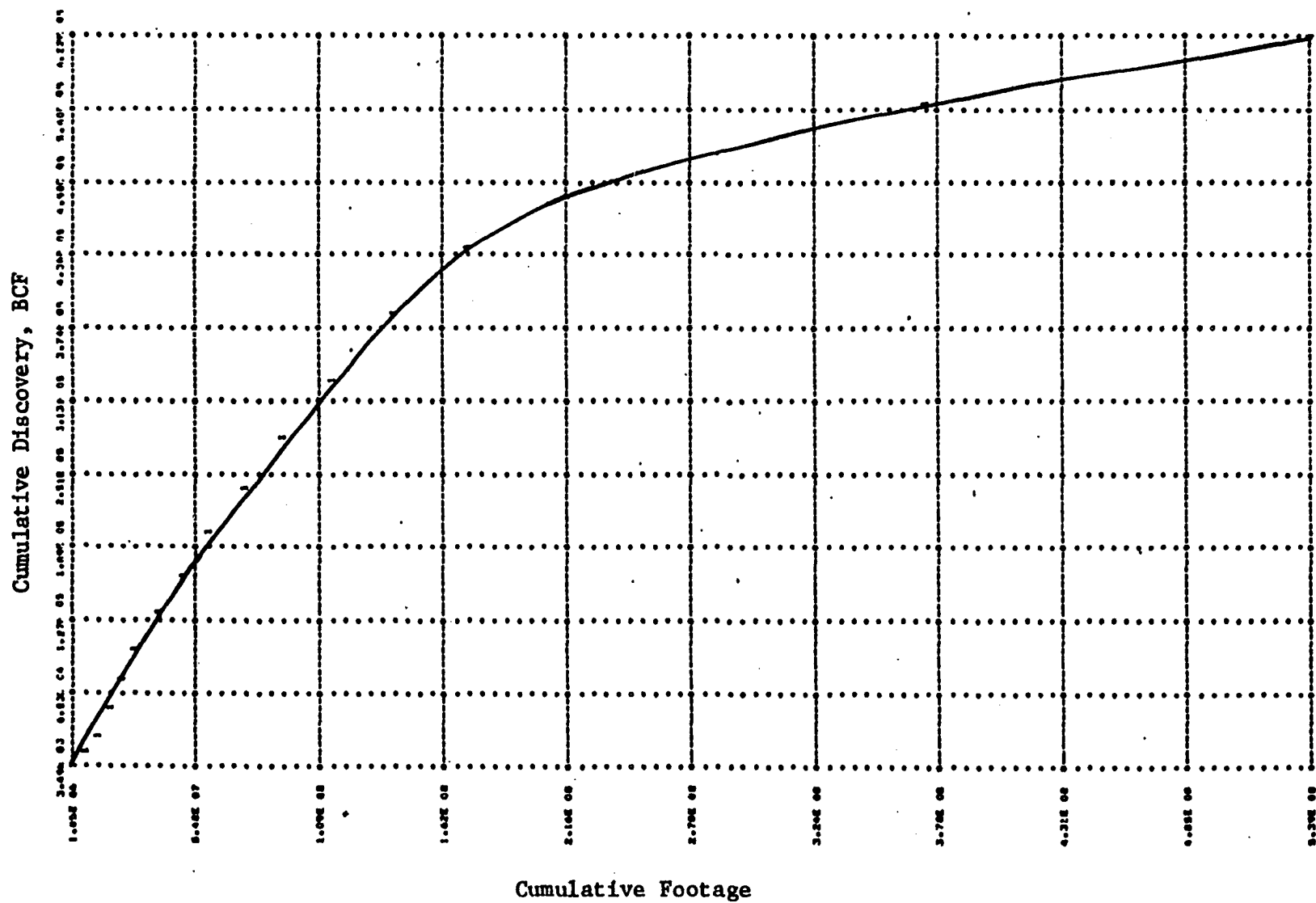


FIGURE IX-113. Composite plot of cumulative discovery vs. cumulative footage.
(Increasing drilling rate function)

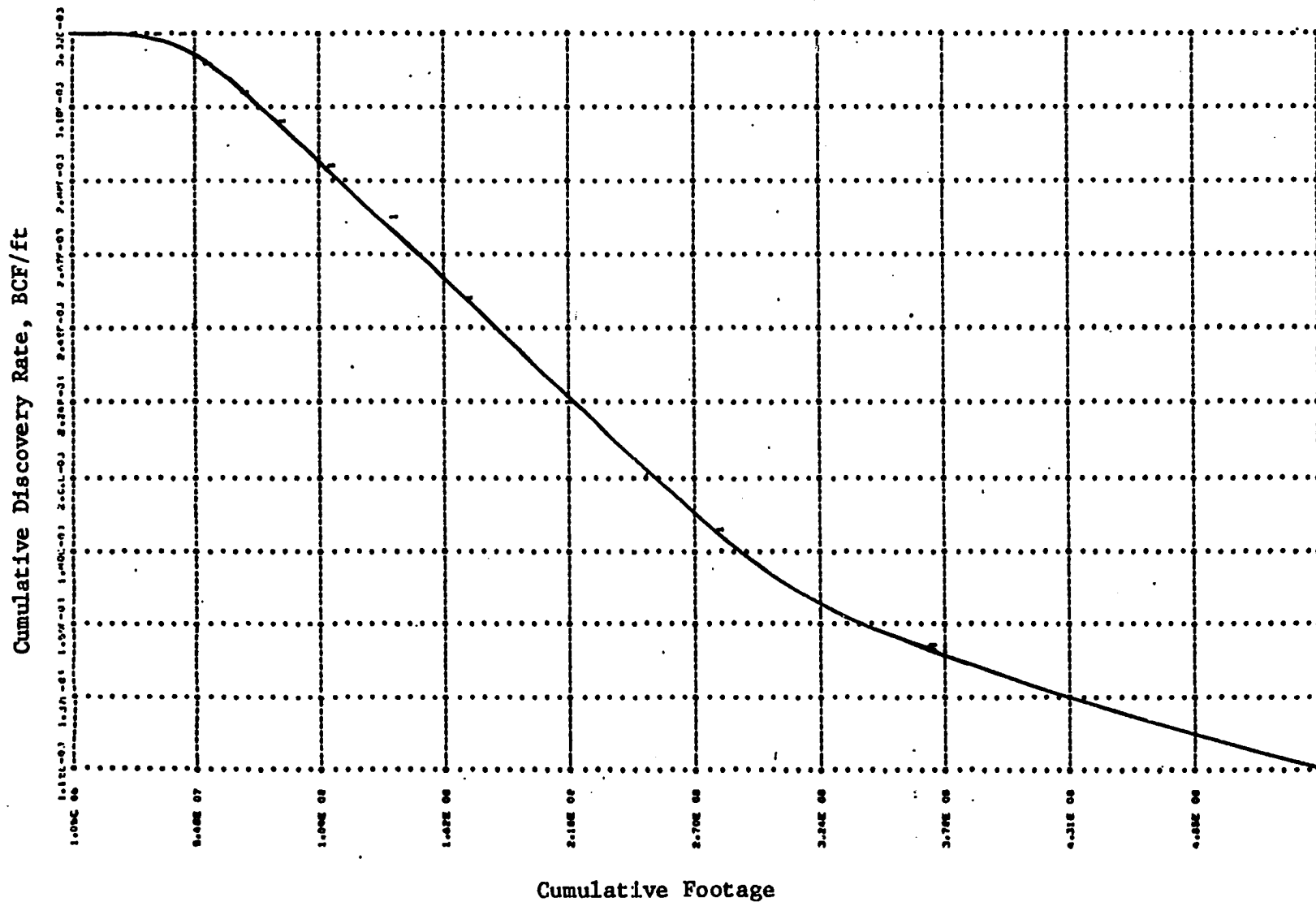


FIGURE IX-114. Composite plot of cumulative discovery rate vs. cumulative footage.
(Increasing drilling rate function)

Eleventh Run

The results obtained from the eleventh run are shown in Tables IX-41 to IX-44 and Figures IX-115 to IX-120. This run is based on the results of Case I of Phase one using an increasing drilling rate function for future drilling activities. Tables IX-41, IX-42, and IX-43 are results for Regions 1, 2, and 3, respectively. Table IX-44 and Figures IX-115 to IX-120 are the results for all three regions combined. By observing these plots for this run and comparing them with the corresponding plots of the second, fifth and eighth runs it can be seen that most of the figures follow the same trend except for the plots of increment reserves vs. either time or footage and cumulative discovery rate vs. time. The plot of increment reserve vs. time, Figure IX-115, increases gradually all the way up to the point where $t = 15$ years, then it decreases for a couple of years ($t = 17$). After this point it increases very sharply for the rest of the remaining period ($t = 20$). The plot of cumulative discovery rate vs. time, Figure IX-117, shows a gradual decrease all the way up to the point where $t = 12$ years. Then it decreases very sharply for the remaining eight years. The plot of increment reserves vs. footage, Figure IX-118, increases sharply in the initial stages of drilling, then it decreases for a short time interval, and afterwards it increases sharply for the rest of the drilling activities.

TABLE IX-41

Prediction of Future Discoveries for Region 1
(Case I, Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.1052631E 06	0.425167E 03	0.1052631E 06	0.425167E 03	0.403908E-02	0.403908E-02
4	0.1169591E 06	0.472407E 03	0.222222E 06	0.897574E 03	0.403908E-02	0.403908E-02
5	0.1307189E 06	0.527985E 03	0.352941E 06	0.142551E 04	0.403909E-02	0.403908E-02
6	0.147058E 06	0.593584E 03	0.500000E 06	0.201954E 04	0.403909E-02	0.403908E-02
7	0.166666E 06	0.673181E 03	0.666666E 06	0.269272E 04	0.403908E-02	0.403908E-02
8	0.190476E 06	0.769350E 03	0.857142E 06	0.346207E 04	0.403908E-02	0.403908E-02
9	0.219780E 06	0.887708E 03	0.107692E 07	0.434975E 04	0.403907E-02	0.403908E-02
10	0.256410E 06	0.103566E 04	0.133333E 07	0.538544E 04	0.403904E-02	0.403908E-02
11	0.303030E 06	0.122396E 04	0.163636E 07	0.660941E 04	0.403908E-02	0.403908E-02
12	0.363637E 06	0.143252E 04	0.200000E 07	0.804193E 04	0.393942E-02	0.402056E-02
13	0.444444E 06	0.160074E 04	0.244444E 07	0.964262E 04	0.360168E-02	0.394473E-02
14	0.555556E 06	0.200093E 04	0.300000E 07	0.116434E 05	0.360168E-02	0.389120E-02
15	0.714285E 06	0.257263E 04	0.371428E 07	0.142162E 05	0.360168E-02	0.382745E-02
16	0.952381E 06	0.244746E 04	0.466666E 07	0.166637E 05	0.256983E-02	0.357079E-02
17	0.133333E 07	0.268261E 04	0.600000E 07	0.193463E 05	0.201196E-02	0.322438E-02
18	0.200000E 07	0.109121E 04	0.800000E 07	0.204374E 05	0.545605E-03	0.255469E-02
19	0.333333E 07	0.504714E 04	0.113333E 08	0.254846E 05	0.151414E-02	0.224864E-02
20	0.666667E 07	0.910105E 04	0.180000E 08	0.345857E 05	0.136515E-02	0.192143E-02

TABLE IX-42

Prediction of Future Discoveries for Region 2
(Case I, Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
4	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
5	0.2392344E 06	0.9662886E 03	0.2392344E 06	0.9662886E 03	0.4039086E-02	0.4039086E-02
6	0.2658161E 06	0.1073655E 04	0.5050504E 06	0.2039944E 04	0.4039086E-02	0.4039086E-02
7	0.2970885E 06	0.1195967E 04	0.8021389E 06	0.3239911E 04	0.4039086E-02	0.4039086E-02
8	0.3342241E 06	0.1349960E 04	0.1126363E 07	0.4589871E 04	0.4039086E-02	0.4039086E-02
9	0.3787870E 06	0.1529953E 04	0.1515150E 07	0.6119824E 04	0.4039086E-02	0.4039086E-02
10	0.4329010E 06	0.1735004E 04	0.1848051E 07	0.7854828E 04	0.4007854E-02	0.4032146E-02
11	0.4995010E 06	0.1799047E 04	0.2447552E 07	0.9653875E 04	0.3601688E-02	0.3944296E-02
12	0.5827500E 06	0.2098883E 04	0.3030302E 07	0.1175276E 05	0.3601688E-02	0.3878411E-02
13	0.6887040E 06	0.2480492E 04	0.3719006E 07	0.1423325E 05	0.3601688E-02	0.3827165E-02
14	0.8264460E 06	0.2134516E 04	0.4545452E 07	0.1636777E 05	0.2582765E-02	0.3600910E-02
15	0.1010101E 07	0.2466195E 04	0.5555553E 07	0.1883356E 05	0.2441537E-02	0.3390115E-02
16	0.1262627E 07	0.7654477E 03	0.6818180E 07	0.1959921E 05	0.6065508E-03	0.2874640E-02
17	0.1623376E 07	0.1686648E 04	0.8441556E 07	0.2128646E 05	0.1038976E-02	0.2521628E-02
18	0.2164502E 07	0.3382516E 04	0.1060606E 08	0.2466898E 05	0.1562722E-02	0.2325932E-02
19	0.3030303E 07	0.4450813E 04	0.1363636E 08	0.2911975E 05	0.1468768E-02	0.2135451E-02
20	0.4545447E 07	0.5693082E 04	0.1818181E 08	0.3481287E 05	0.1252480E-02	0.1914709E-02

TABLE IX-43

Prediction of Future Discoveries for Region 3
(Case I, Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
4	0.1644736E C6	0.6643232E 03	0.1644736E 06	0.6643232E 03	0.4039086E-02	0.4039086E-02
5	0.1827484E C6	0.7381375E C3	0.3472221E 06	0.1402461E 04	0.4039090E-02	0.4039086E-02
6	0.2042483E C6	0.8249771E C3	0.5514704E 06	0.2227432E 04	0.4039086E-02	0.4039086E-02
7	0.2297794E C6	0.9280959E C3	0.7812498E 06	0.3155538E 04	0.4039090E-02	0.4039086E-02
8	0.2604166E C6	0.1051845E 04	0.1041666E 07	0.4207323E 04	0.4039086E-02	0.4039086E-02
9	0.2976177E C6	0.1202102E 04	0.1339284E 07	0.5409484E 04	0.4039079E-02	0.4039086E-02
10	0.3434070E C6	0.1387055E C4	0.1682691E 07	0.6796539E 04	0.4039098E-02	0.4039086E-02
11	0.4006410E C6	0.1545527E 04	0.2083332E 07	0.8342066E 04	0.3857636E-02	0.4004192E-02
12	0.4734840E C6	0.1705344E C4	0.2556816E 07	0.1004741E 05	0.3601692E-02	0.3929656E-02
13	0.5681820E C6	0.2046410E 04	0.3124998E 07	0.1209382E 05	0.3601681E-02	0.3870025E-02
14	0.6944430E C6	0.2501168E 04	0.3819441E 07	0.1459459E 05	0.3601689E-02	0.3821237E-02
15	0.8680570E C6	0.2119590E 04	0.4687498E 07	0.1671458E 05	0.2441763E-02	0.3565778E-02
16	0.1116070E C7	0.2570895E C4	0.5803568E 07	0.1928547E 05	0.2303524E-02	0.3323037E-02
17	0.1488056E 07	0.4610313E C3	0.7251664E 07	0.1974650E 05	0.3098128E-03	0.2708093E-02
18	0.2083331E 07	0.3334547E 04	0.9374995E 07	0.2308105E 05	0.1600584E-02	0.2461980E-02
19	0.3125001E 07	0.4178754E C4	0.1250000E 08	0.2725980E 05	0.1337201E-02	0.2180785E-02
20	0.5208324E 07	0.6961559E 04	0.1770832E 08	0.3422136E 05	0.1336622E-02	0.1932507E-02

TABLE IX-44

Composite Parameters for All k Basins
(Case I, Increasing Drilling Rate Function)

TIME	INC.FCCTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.1052631E 06	0.4251670E 03	0.1052631E 06	0.4251670E 03	0.4039086E-02	0.4039086E-02
4	0.2814327E 06	0.1136731E 04	0.3866958E 06	0.1561898E 04	0.4039086E-02	0.4039086E-02
5	0.5927018E 06	0.2232412E 04	0.9393976E 06	0.3794310E 04	0.4039086E-02	0.4039086E-02
6	0.6171224E 06	0.2492616E 04	0.1556520E 07	0.6286926E 04	0.4039094E-02	0.4039090E-02
7	0.6935340E 06	0.2801246E 04	0.2250054E 07	0.9088172E 04	0.4039086E-02	0.4039090E-02
8	0.7851170E 06	0.3171156E 04	0.3035171E 07	0.1225933E 05	0.4039086E-02	0.4039086E-02
9	0.8961860E 06	0.3619766E 04	0.3931357E 07	0.1587909E 05	0.4039075E-02	0.4039086E-02
10	0.1032718E 07	0.4157723E 04	0.4964075E 07	0.2003682E 05	0.4025999E-02	0.4036363E-02
11	0.1203172E 07	0.4568539E 04	0.6167247E 07	0.2460536E 05	0.3797079E-02	0.3989682E-02
12	0.1419871E 07	0.5236746E 04	0.7587118E 07	0.2984210E 05	0.3688184E-02	0.3933258E-02
13	0.1701330E 07	0.6127648E 04	0.9288448E 07	0.3596975E 05	0.3601681E-02	0.3872525E-02
14	0.2076445E 07	0.6636621E 04	0.1136489E 08	0.4260637E 05	0.3196146E-02	0.3748946E-02
15	0.2592443E 07	0.7158422E 04	0.1395734E 08	0.4576479E 05	0.2761265E-02	0.3565494E-02
16	0.3331064E 07	0.5784207E 04	0.1728840E 08	0.5554900E 05	0.1736444E-02	0.3213079E-02
17	0.4444816E 07	0.4830297E 04	0.2173322E 08	0.6037930E 05	0.1086726E-02	0.2778203E-02
18	0.6247824E 07	0.7808266E 04	0.2798104E 08	0.6818756E 05	0.1249758E-02	0.2436920E-02
19	0.9488624E 07	0.1367669E 05	0.3746966E 08	0.8186425E 05	0.1441377E-02	0.2184814E-02
20	0.1642046E 08	0.2175563E 05	0.5389013E 08	0.1036159E 06	0.1324909E-02	0.1922799E-02

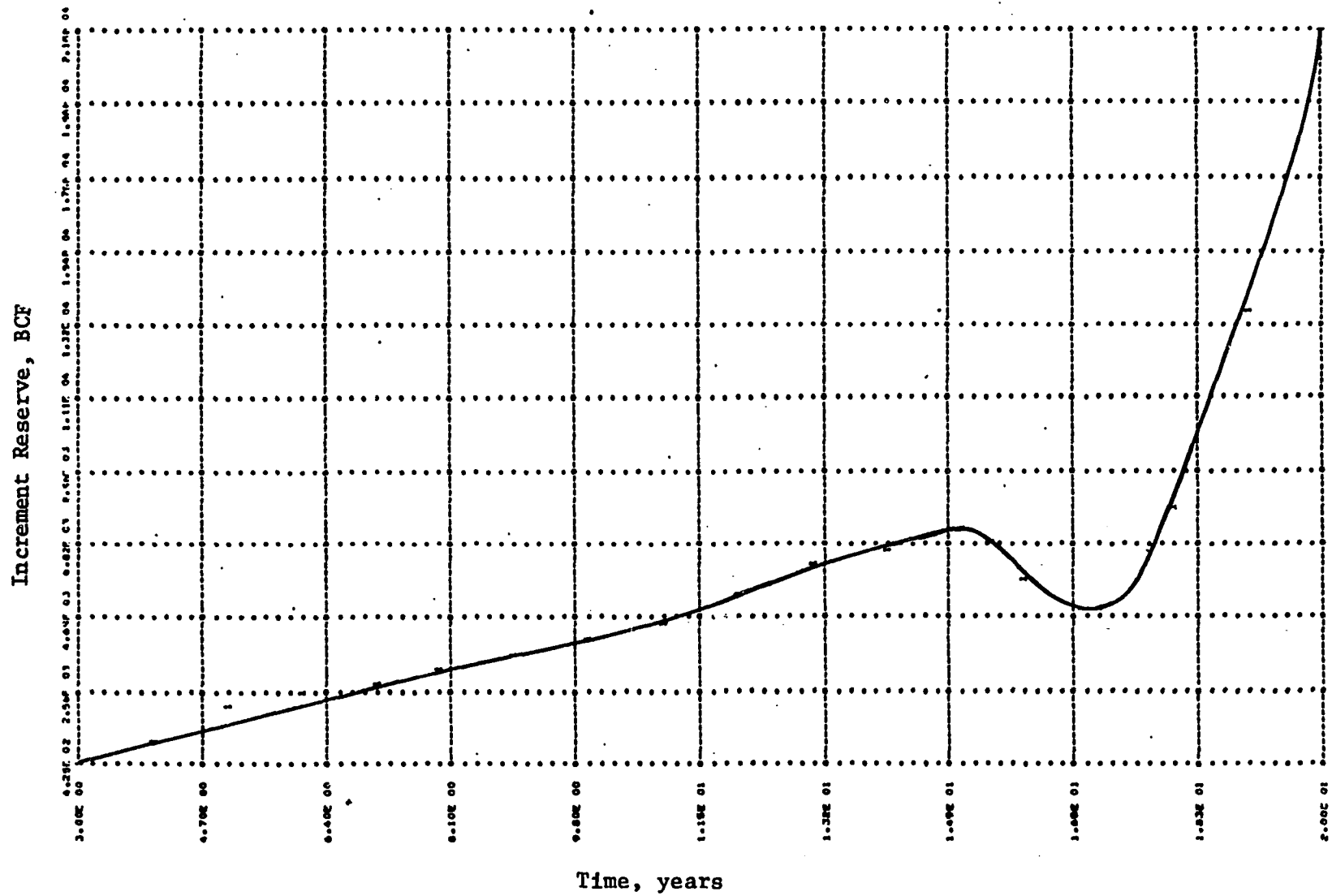


FIGURE IX-115. Composite plot of increment reserve vs. time.
(Case I, increasing drilling rate function)

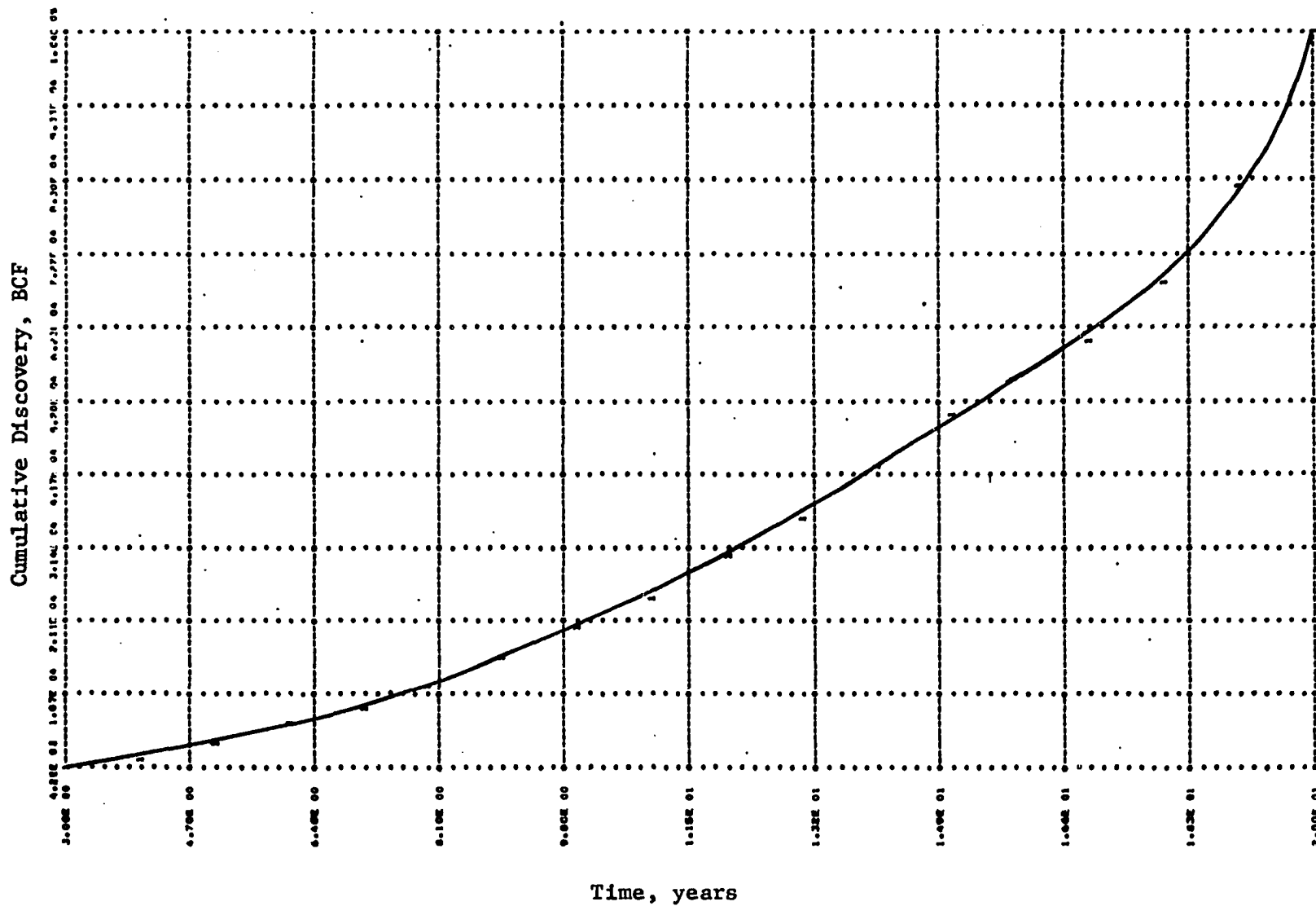


FIGURE IX-116. Composite plot of cumulative discovery vs. time.
(Case I, increasing drilling rate function)

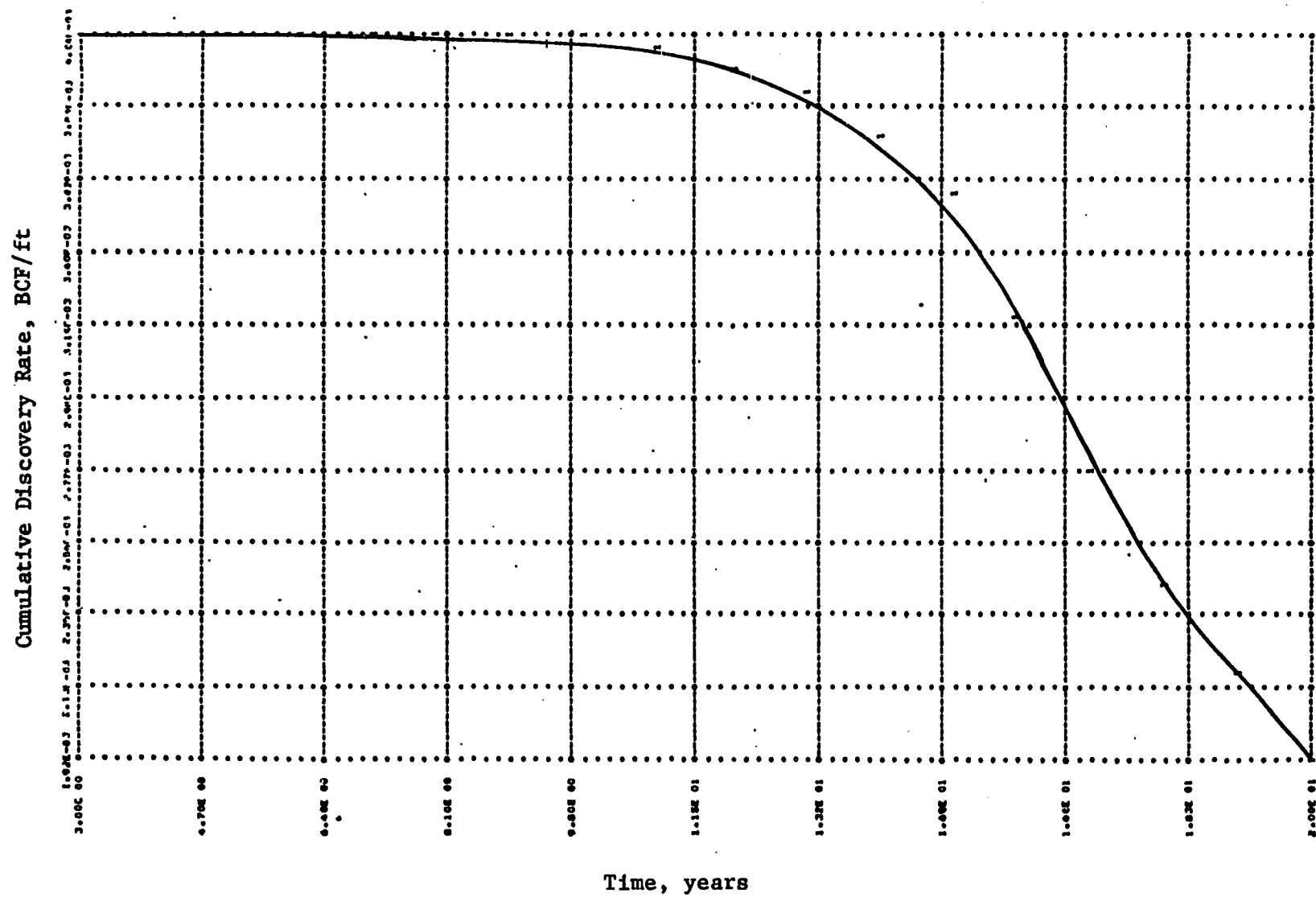


FIGURE IX-117. Composite plot of cumulative discovery rate vs. time.
(Case I, increasing drilling rate function)

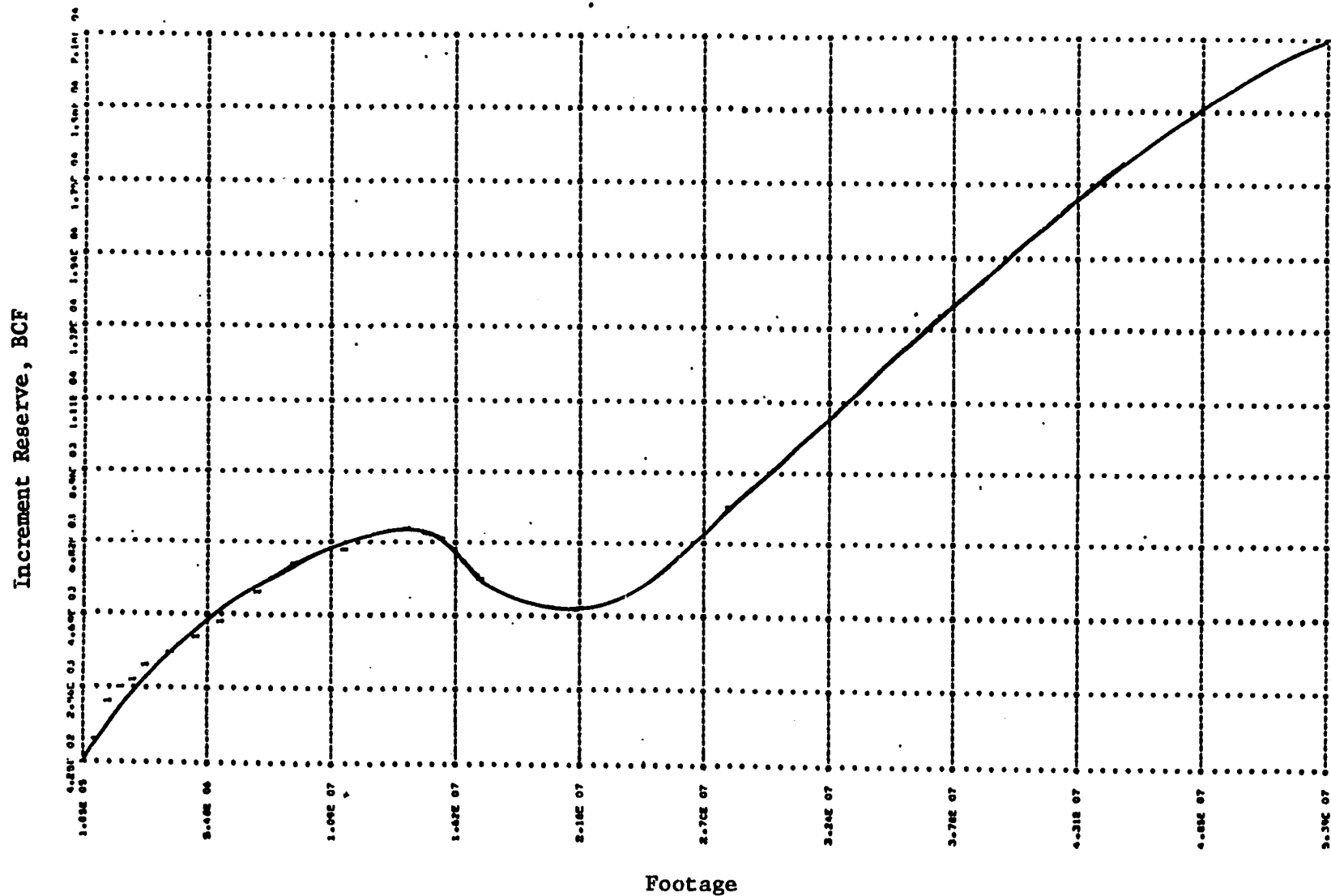


FIGURE IX-118. Composite plot of increment reserve vs. footage.
(Case I, Increasing drilling rate function)

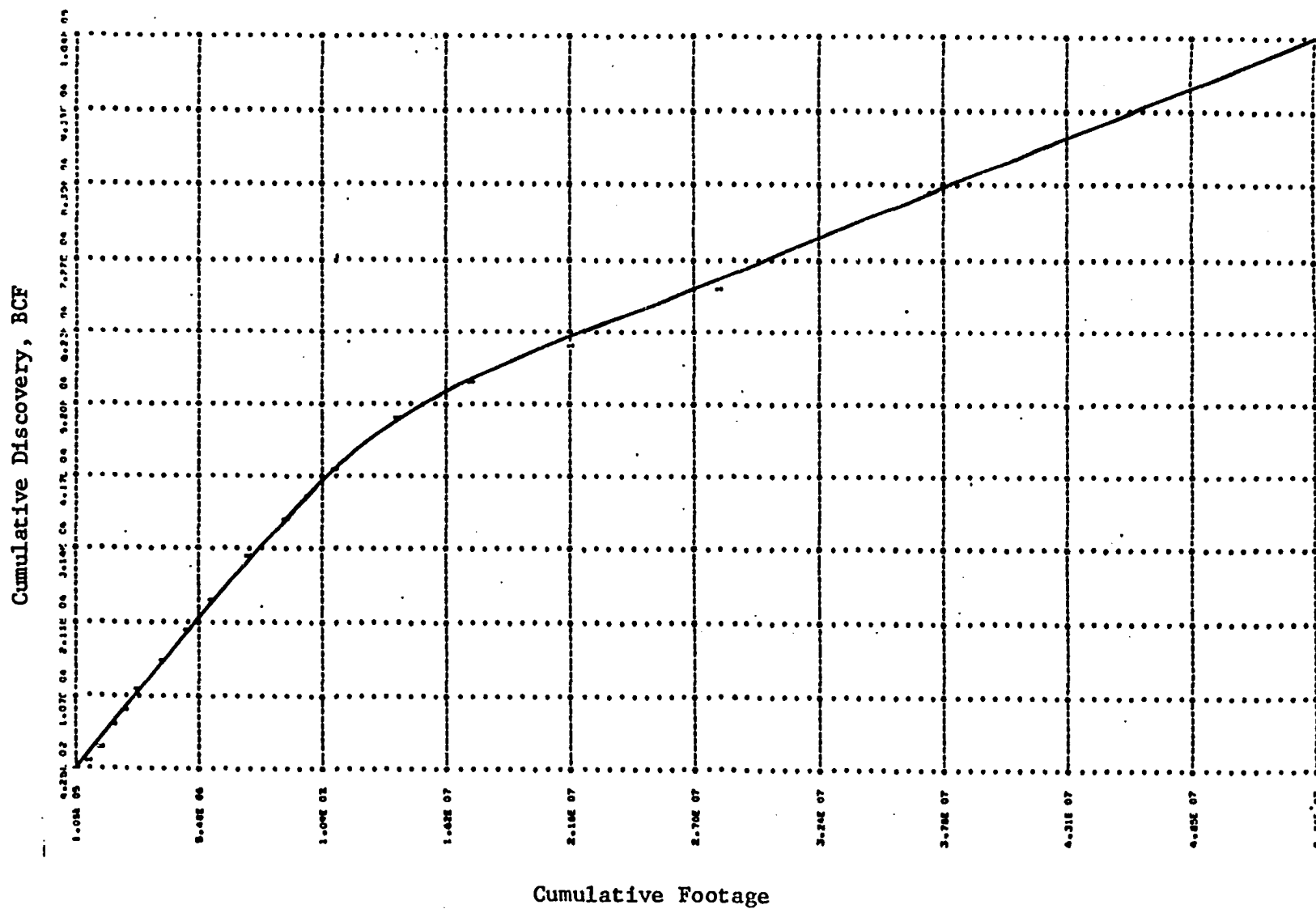


FIGURE IX-119. Composite plot of cumulative discovery vs. cumulative footage.
(Case I, Increasing drilling rate function)

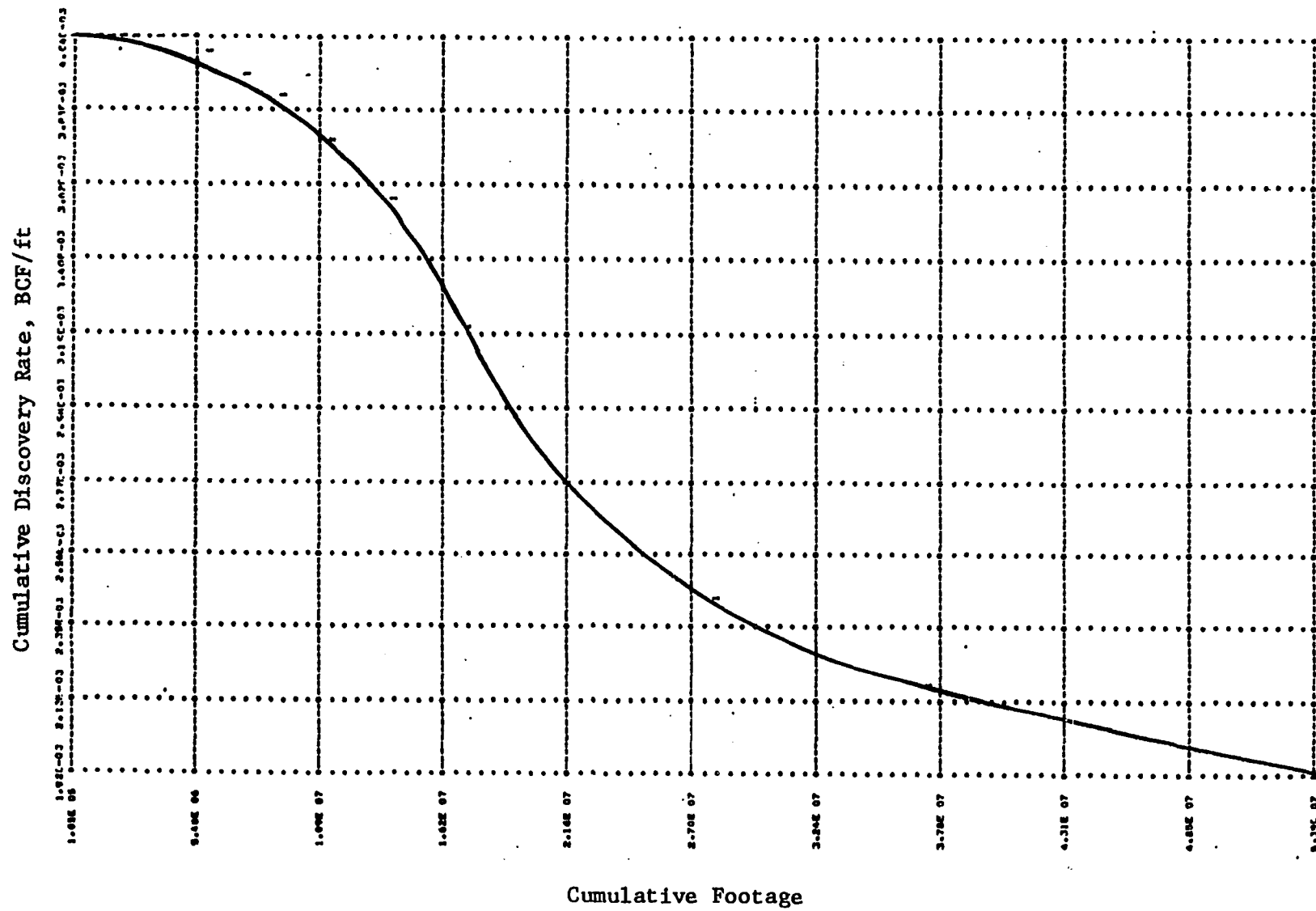


FIGURE IX-120. Composite plot of cumulative discovery rate vs.
cumulative footage
(Case I, Increasing drilling rate function)

Twelfth Run

The results obtained from the twelfth run are shown in Tables IX-45 to IX-48 and Figures IX-121 to IX-126. This run is based on the results of Case II of Phase one using an increasing drilling rate function for future drilling activities. Tables IX-45, IX-46, and IX-47 are results for Regions 1, 2, and 3, respectively. Table IX-48 and Figures IX-121 to IX-126 are the results for all three regions combined. By observing the plots for this run and comparing them with the corresponding plots for the third, fifth and eighth runs, it can be seen that most of the figures follow the same trend, except for the plots of increment reserves vs. either time or footage and cumulative discovery rate vs. time. The plot of increment reserves vs. time, Figure IX-121, increases gradually all the way up to the point where $t = 15$ years, then it decreases for a couple of years ($t = 17$). After this point it increases very sharply for the rest of the remaining period. Actually this figure is much like Figure IX-115. The plot of cumulative discovery rate vs. time, Figure IX-123, shows constant rate for a while and a very smooth decrease until $t = 12$ years. After this point it decreases very sharply for the rest of the period. The plot of increment reserves vs. footage, Figure IX-124, increases sharply in the initial stages of drilling activities. Then it decreases for a short while. Afterwards it increases for the rest of the drilling activities.

TABLE IX-45

Prediction of Future Discoveries for Region 1
(Case II, Increasing Drilling Rate Function)

TIME	INC. FOOTAGE	INC. RESERVE	CUM. FOOTAGE	CUM. RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM. DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.1052631E 06	0.4251670E 03	0.1052631E 06	0.4251670E 03	0.4039086E-02	0.4039086E-02
4	0.1165591E 06	0.4724077E 03	0.2222222E 06	0.8975747E 03	0.4039086E-02	0.4039086E-02
5	0.1307189E 06	0.5279858E 03	0.3529411E 06	0.1425561E 04	0.4039090E-02	0.4039086E-02
6	0.1470589E 06	0.5935841E 03	0.5000000E 06	0.2019545E 04	0.4039090E-02	0.4039086E-02
7	0.1666666E 06	0.6731814E 03	0.6666666E 06	0.2692726E 04	0.4035026E-02	0.4039086E-02
8	0.1904762E 06	0.7693503E 03	0.8571428E 06	0.3462076E 04	0.4039086E-02	0.4039086E-02
9	0.2197802E 06	0.8877087E 03	0.1076923E 07	0.4249765E 04	0.4039075E-02	0.4039086E-02
10	0.2564100E 06	0.1035664E 04	0.1333333E 07	0.5385449E 04	0.4039094E-02	0.4039086E-02
11	0.3030300E 06	0.1223965E 04	0.1636363E 07	0.6609414E 04	0.4039086E-02	0.4039086E-02
12	0.3636370E 06	0.1389746E 04	0.2000000E 07	0.7999160E 04	0.3821795E-02	0.3999520E-02
13	0.4444440E 06	0.1371320E 04	0.2444444E 07	0.9370480E 04	0.3085474E-02	0.2833379E-02
14	0.5555560E 06	0.1714160E 04	0.3000000E 07	0.1108464E 05	0.3085426E-02	0.3694880E-02
15	0.7142850E 06	0.2203910E 04	0.3714285E 07	0.1328855E 05	0.3085477E-02	0.3577687E-02
16	0.9523810E 06	0.1210961E 04	0.4666666E 07	0.1449951E 05	0.1271509E-02	0.3107039E-02
17	0.1333334E 07	0.1150180E 04	0.6000000E 07	0.1564969E 05	0.8626343E-03	0.2608222E-02
18	0.2000000E 07	0.4016280E 03	0.8000000E 07	0.1605132E 05	0.2008125E-03	0.2006414E-02
19	0.3333333E 07	0.1379594E 04	0.1133333E 08	0.1743091E 05	0.4138781E-03	0.1538021E-02
20	0.6666667E 07	0.3530284E 04	0.1800000E 08	0.2096116E 05	0.5295379E-03	0.1164509E-02

TABLE IX-46

Prediction of Future Discoveries for Region 2
(Case II, Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
2	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
3	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
4	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00	0.0000000E 00
5	0.2392344E 06	0.9662886E 03	0.2392344E 06	0.9662886E 03	0.4039086E-02	0.4039086E-02
6	0.2658161E 06	0.1073655E 04	0.5050504E 06	0.2039944E 04	0.4039086E-02	0.4039086E-02
7	0.2970885E 06	0.1199967E 04	0.8021389E 06	0.3239911E 04	0.4039090E-02	0.4039086E-02
8	0.3342241E 06	0.1349960E 04	0.1136363E 07	0.4589871E 04	0.4039086E-02	0.4039086E-02
9	0.3787870E 06	0.1529953E 04	0.1515150E 07	0.6119824E 04	0.4039083E-02	0.4039086E-02
10	0.4329010E 06	0.1735004E 04	0.1948051E 07	0.7854822E 04	0.4007854E-02	0.4032146E-02
11	0.4995010E 06	0.1799047E 04	0.2447552E 07	0.9653875E 04	0.3601688E-02	0.3944296E-02
12	0.5827500E 06	0.2098883E 04	0.3030302E 07	0.1175276E 05	0.3601686E-02	0.3878411E-02
13	0.6887040E 06	0.2480492E 04	0.3719006E 07	0.1423325E 05	0.3601681E-02	0.3827165E-02
14	0.8264460E 06	0.2134516E 04	0.4545452E 07	0.1636777E 05	0.2582765E-02	0.3600910E-02
15	0.1010101E 07	0.2466199E 04	0.5555553E 07	0.1883356E 05	0.2441537E-02	0.3390115E-02
16	0.1262627E 07	0.2652477E 04	0.6818180E 07	0.1959981E 05	0.6065508E-03	0.2874640E-02
17	0.1623376E 07	0.1686648E 04	0.8441556E 07	0.2128646E 05	0.1038976E-02	0.2521628E-02
18	0.2164502E 07	0.3382516E 04	0.1060606E 08	0.2466898E 05	0.1562722E-02	0.2325932E-02
19	0.3030303E 07	0.4450813E 04	0.1363636E 08	0.2611975E 05	0.1466768E-02	0.2135451E-02
20	0.4845447E 07	0.5693082E 04	0.1818181E 08	0.3481227E 05	0.1252480E-02	0.1914709E-02

TABLE IX-47

Prediction of Future Discoveries For Region 3
(Case II, Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	CUM.FOOTAGE	CUM.RESERVE	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/CUM.FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
4	0.1644736E C6	0.6643232E 03	0.1644736E 06	0.6643232E 03	0.4039086E-02	0.4039086E-02
5	0.1227484E C6	0.7381378E 03	0.3472221E 06	0.1402461E 04	0.4039090E-02	0.4039086E-02
6	0.2042483E 06	0.8249771E 03	0.5514704E 06	0.2227438E 04	0.4039086E-02	0.4039086E-02
7	0.2297794E C6	0.6280999E 03	0.7812498E 06	0.3155538E 04	0.4039090E-02	0.4039086E-02
8	0.2604166E 06	0.1051849E 04	0.1041666E 07	0.4207383E 04	0.4039086E-02	0.4039086E-02
9	0.2576177E 06	0.1202102E 04	0.1339284E 07	0.5409484E 04	0.4039079E-02	0.4039086E-02
10	0.3434070E C6	0.1387055E 04	0.1682691E 07	0.6796539E 04	0.4039098E-02	0.4039086E-02
11	0.4006410E 06	0.1663266E 04	0.2083332E 07	0.8459805E 04	0.4151502E-02	0.4060702E-02
12	0.4734840E 06	0.2040766E 04	0.2556816E 07	0.1050057E 05	0.4310101E-02	0.4106890E-02
13	0.5681620E 06	0.2448926E 04	0.3124998E 07	0.1294950E 05	0.4310105E-02	0.4143838E-02
14	0.6944430E C6	0.2993125E 04	0.3819441E 07	0.1594262E 05	0.4310109E-02	0.4174069E-02
15	0.8680570E 06	0.2572496E 04	0.4627498E 07	0.1851512E 05	0.2963510E-02	0.3949892E-02
16	0.1116070E C7	0.3158059E 04	0.5803568E 07	0.2167312E 05	0.2829624E-02	0.3734457E-02
17	0.1488096E 07	0.1338184E 04	0.7251664E 07	0.2301136E 05	0.8992588E-03	0.3155845E-02
18	0.2083331E 07	0.4429898E 04	0.9374995E 07	0.2744126E 05	0.2126354E-02	0.2927069E-02
19	0.3126001E 07	0.5573168E 04	0.1250000E 08	0.3301443E 05	0.1783413E-02	0.2641155E-02
20	0.5208324E 07	0.1144419E 05	0.1770832E 08	0.4445862E 05	0.2197289E-02	0.2510606E-02

TABLE IX-48

Composite Parameters for All k Basins
(Case II, Increasing Drilling Rate Function)

TIME	INC.FOOTAGE	INC.RESERVE	TOTAL FOOTAGE DRILLED	CUM.DISCOVERY	DISCOVERY RATE (INC.RES/INC.FT)	CUM.DISCOVERY RATE (CUM.RES/TOTAL FT)
1	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
2	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00	0.000000E 00
3	0.1052631E 06	0.425167E 03	0.1052631E 06	0.425167E 03	0.4039086E-02	0.4039086E-02
4	0.2814327E 06	0.1136731E 04	0.3866958E 06	0.126185E 04	0.4039086E-02	0.4039086E-02
5	0.5527016E 06	0.2232412E 04	0.9393976E 06	0.3794310E 04	0.4039086E-02	0.4039086E-02
6	0.6171224E 06	0.2492616E 04	0.1556520E 07	0.6286926E 04	0.4039094E-02	0.4039090E-02
7	0.6935340E 06	0.2801246E 04	0.2250054E 07	0.9088172E 04	0.4039026E-02	0.4039090E-02
8	0.7851170E 06	0.3171156E 04	0.3035171E 07	0.1225933E 05	0.4039086E-02	0.4039086E-02
9	0.8961860E 06	0.3619766E 04	0.3931357E 07	0.1587909E 05	0.4039075E-02	0.4039086E-02
10	0.1032718E 07	0.4157723E 04	0.4964075E 07	0.2003622E 05	0.4025999E-02	0.4036363E-02
11	0.1203172E 07	0.4686277E 04	0.6167247E 07	0.2472309E 05	0.3894935E-02	0.4008770E-02
12	0.1419871E 07	0.5525355E 04	0.7887118E 07	0.3025249E 05	0.3894293E-02	0.3987346E-02
13	0.1701330E 07	0.6300738E 04	0.9228448E 07	0.3655323E 05	0.3703419E-02	0.3935341E-02
14	0.2076445E 07	0.6841801E 04	0.1136489E 08	0.4339503E 05	0.3294955E-02	0.3818340E-02
15	0.2592443E 07	0.7242605E 04	0.1355734E 08	0.5063763E 05	0.2793737E-02	0.3628030E-02
16	0.3331064E 07	0.5134867E 04	0.1728840E 08	0.5577220E 05	0.1541510E-02	0.3226007E-02
17	0.4444816E 07	0.4175012E 04	0.2173322E 08	0.5594751E 05	0.9392989E-03	0.2752336E-02
18	0.6247824E 07	0.8213988E 04	0.2758104E 08	0.6616150E 05	0.1314696E-02	0.2435989E-02
19	0.9486624E 07	0.1140363E 05	0.3746966E 08	0.7956513E 05	0.1201821E-02	0.2123454E-02
20	0.1642046E 08	0.2066750E 05	0.5389013E 08	0.1002326E 06	0.1258643E-02	0.1859944E-02

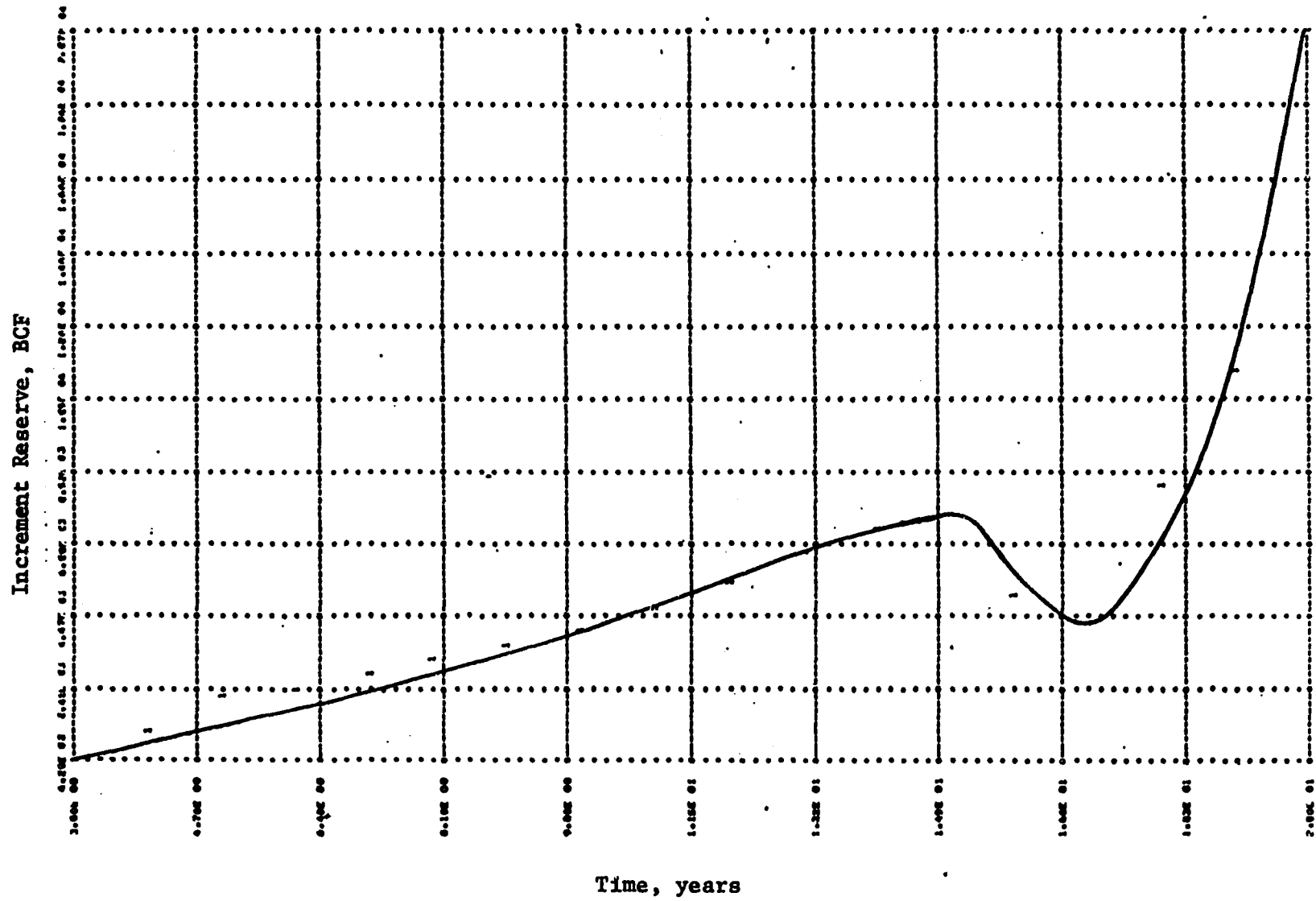


FIGURE IX-121. Composite plot of increment reserve vs. time.
(Case II, Increasing drilling rate function)

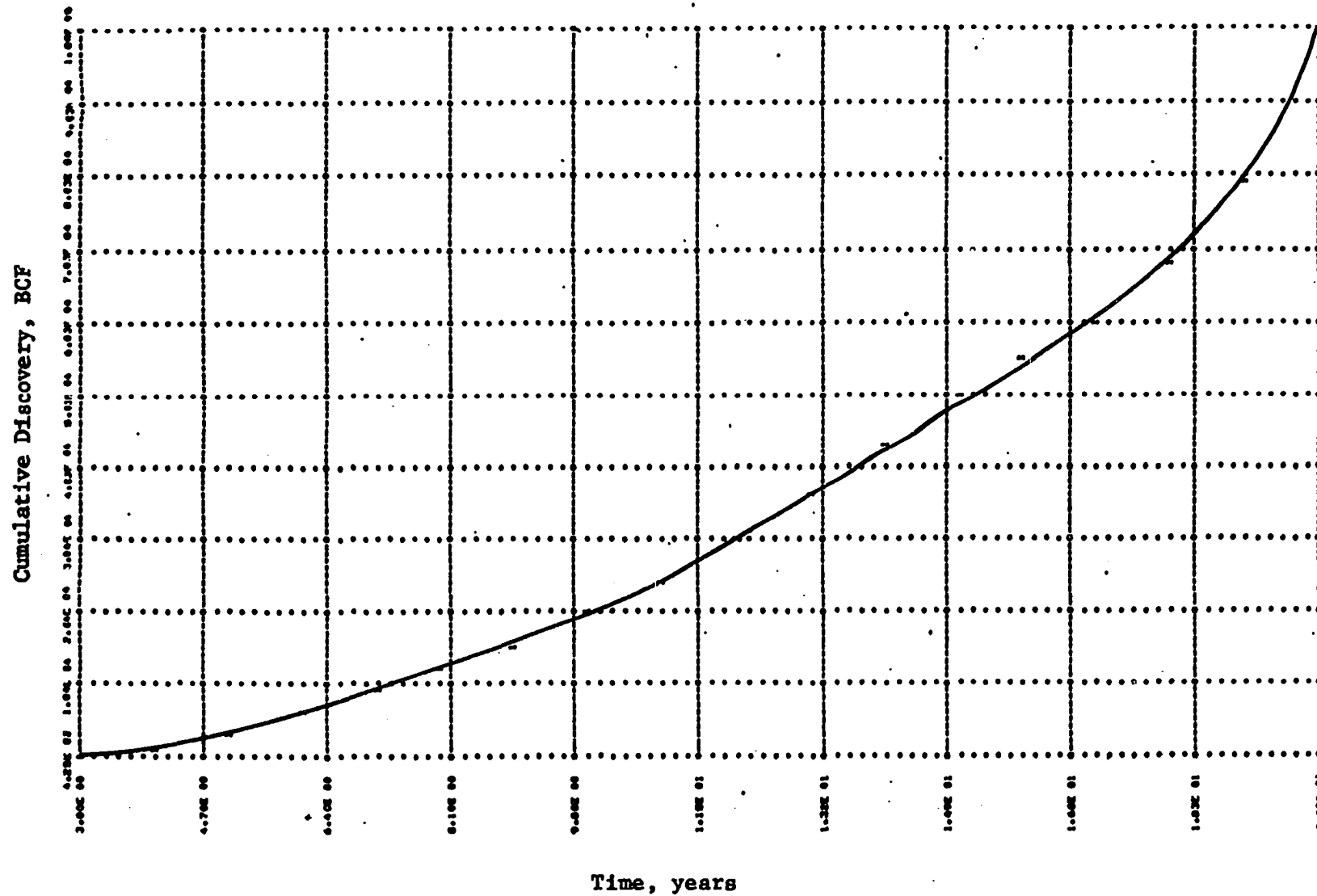


FIGURE IX-122. Composite plot of cumulative discovery vs. time.
(Case II, Increasing drilling rate function)

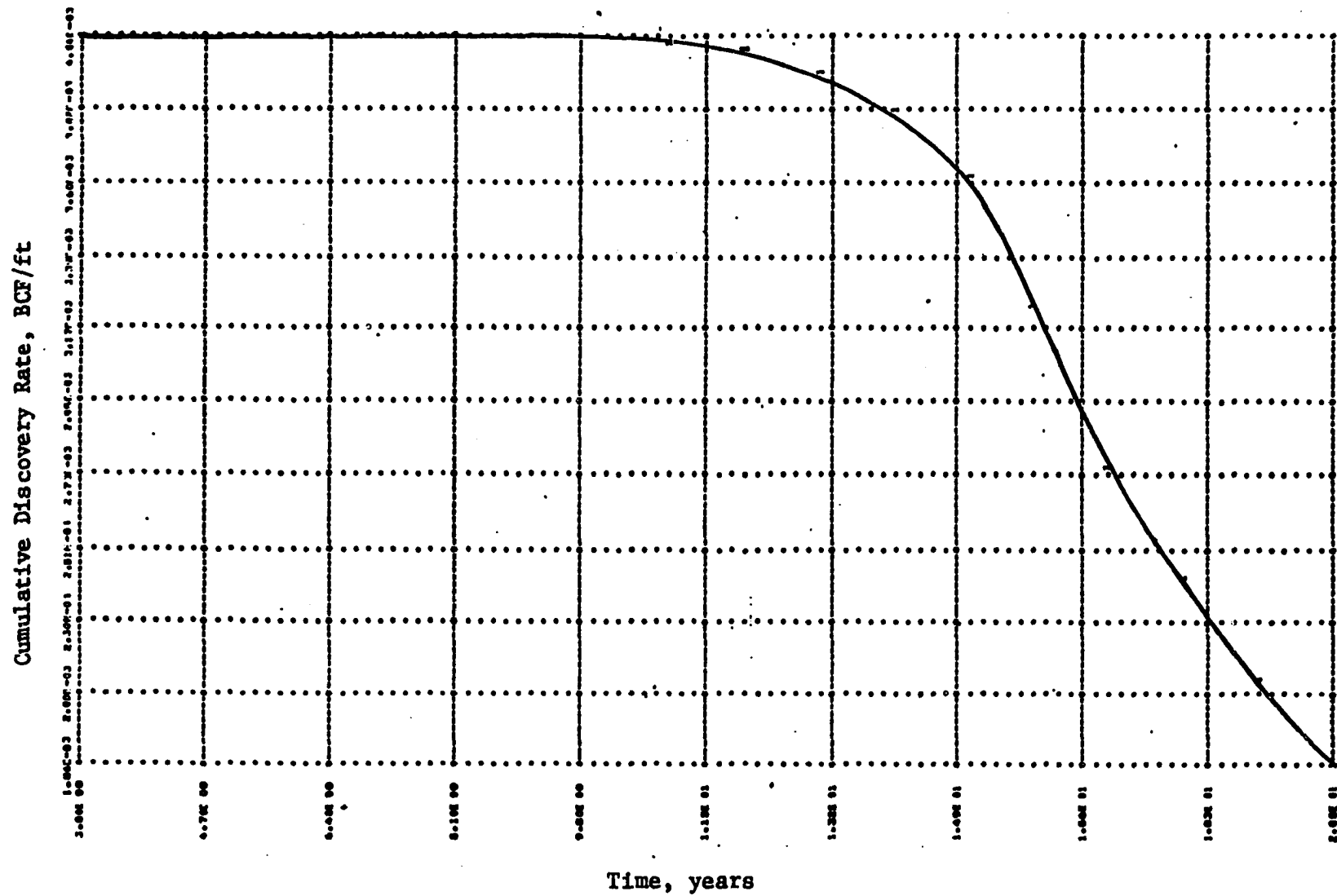


FIGURE IX-123. Composite plot of cumulative discovery rate vs. time.
(Case II, Increasing drilling rate function)

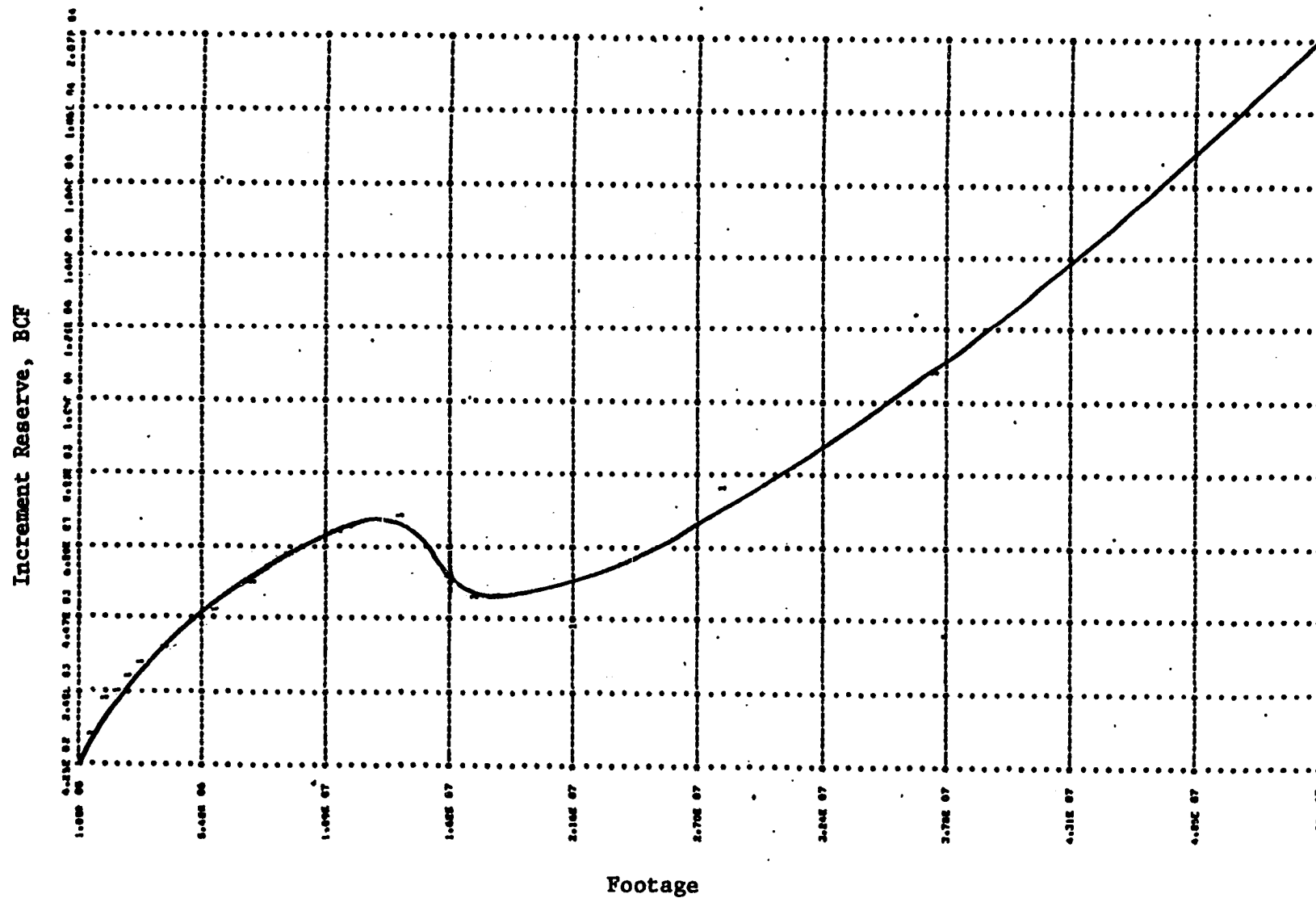


FIGURE IX-124.. Composite plot of increment reserve vs. footage.
(Case II, Increasing drilling rate function)

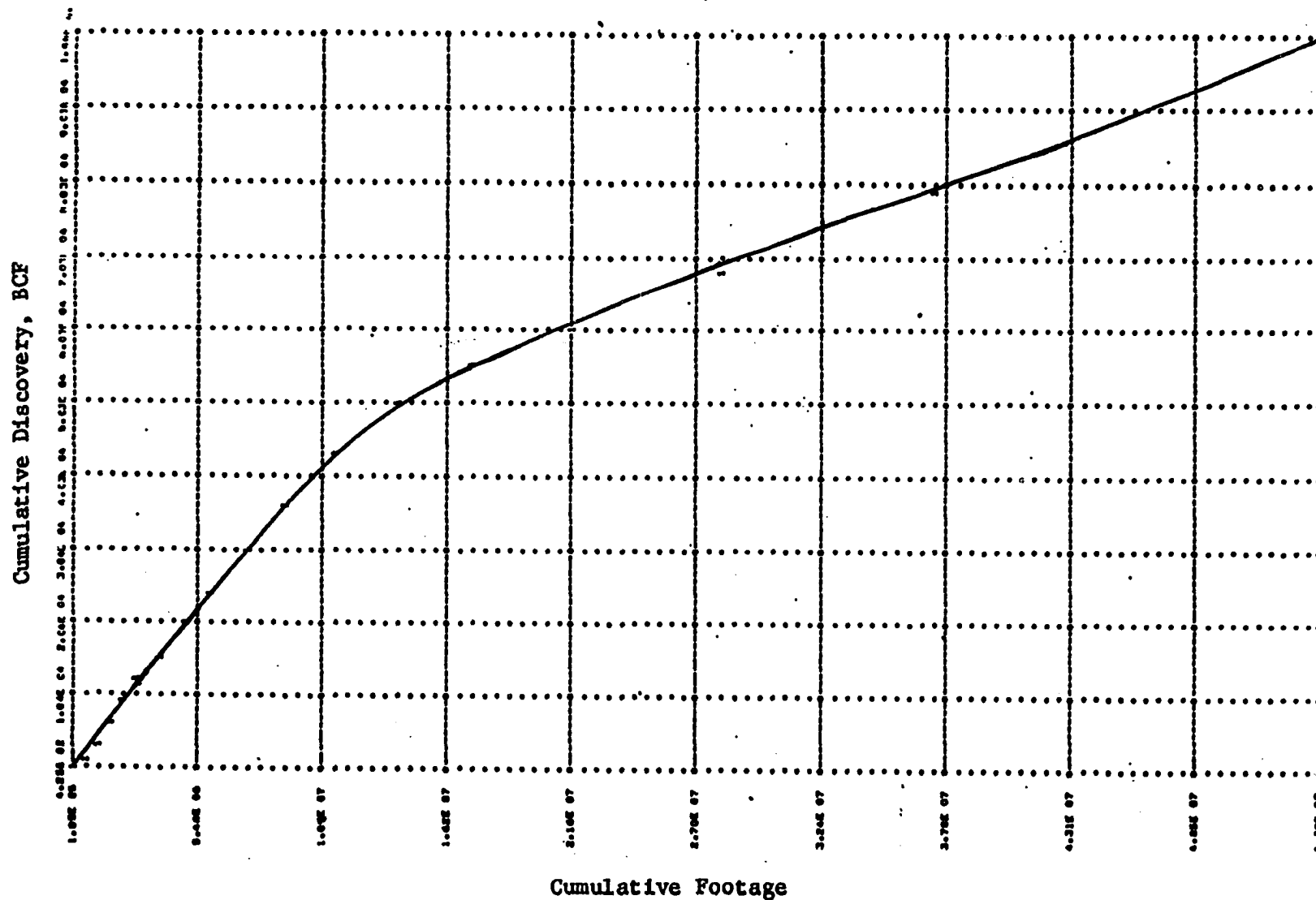


FIGURE IX-125. Composite plot of cumulative discovery vs. cumulative footage.
(Case II, Increasing drilling rate function)

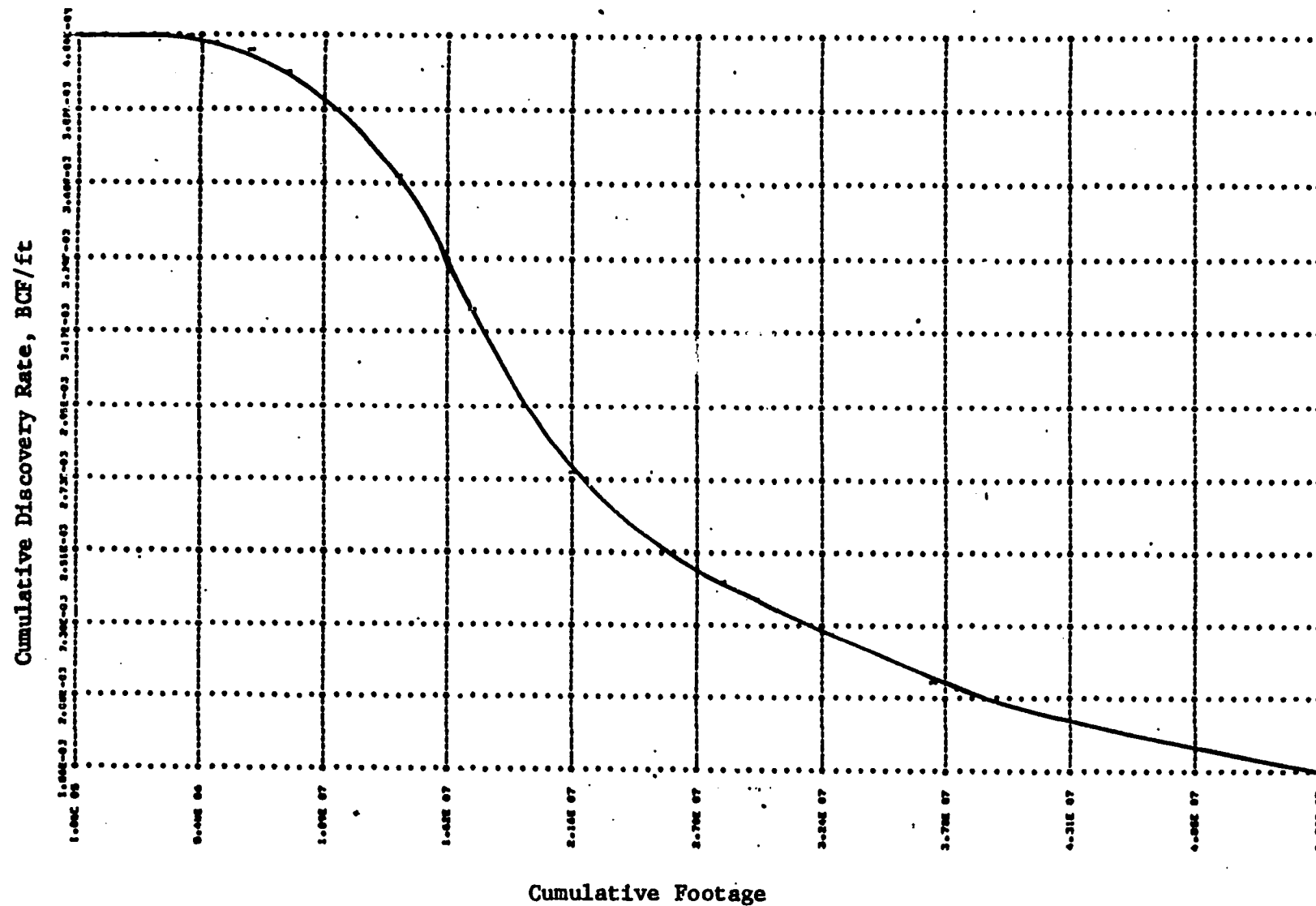


FIGURE IX-126. Composite plot of cumulative discovery rate vs. cumulative footage.
(Case II, Increasing drilling rate function)

This completes the discussion of results for the second phase of the model. By looking at these figures, it can be seen that no matter what case of Phase I was chosen or what type of future drilling curve was assumed to apply, all the cumulative reserves discoveries versus either time or footage for the cases covered in this study follow almost the same path and the curves are very similar to one another. On the other hand, the curves for incremental reserves versus either footage or time exhibit considerably different features even over the cases considered in this study.

CHAPTER X

SUMMARY AND CONCLUSIONS

Accurate information about energy resource bases and their response to exploratory and developmental activities is essential to the formulation of sound national energy policies. Adequate and effective future plans cannot be developed without a good data base and carefully structured analytical tools. The design of national energy strategies and energy planning require that all the available data and information be used. The resulting forecasts will be reliable to the extent that knowledge of the nature and characteristics of the energy resource base is available. One of the most important aspects of planning natural gas policy for a country or a company is to be able to predict the ultimate quantity of reserves that will be found. The reliability of the forecasts depends to a great extent on the reliability of the description of the resource base, i.e., the amount and distribution of gas in place by geographic areas.

In this dissertation, the possible sources of gas for consumption in the U.S. have been identified and their potential contribution to the composite energy supply has

been evaluated. The study covered all options and alternative supplies from both U.S. and foreign sources and presented projections of the future availability of natural gas for U.S. use over the next 20 years. It is obvious that solutions to the U.S. gas supply problem are not simple or swift, and cannot be solved easily.

It is projected by E. F. Hardy [42] that the natural gas importation could result in capital expenditures totaling well over 20 billion dollars and annual gas purchases of about 6 billion dollars by 1985 excluding costs for manufacture of synthetic natural gas (SNG). The volume of gas thus provided would total 5 trillion cubic feet per year, equivalent to 22% of the U.S. production in 1974.

Even when all possible contributions are considered, the availability of gas from all U.S. sources still is expected to fall increasingly behind demand, placing an increasingly heavy future reliance on imports and other supplemental gas supplies. The most likely alternative fuels are coal and oil. Increased use of the former may raise environmental, societal, and legal questions, while increased use of the latter may simply increase oil imports.

In this study the future prospects for future domestic reserve additions, pipeline of Alaskan gas, and synthetic gas from coal and domestic sources were presented as well as gas that may be available from foreign sources. Also in this work different estimates of domestic U.S. natural

gas resources, using various methodologies have been discussed and various techniques for future natural gas reserve discoveries were analyzed. The primary focus of this study involved the development and use of a model for predicting the response of an undrilled geological region or a group of regions to drilling activity. The resource base characteristics used in the model were patterned after those of the resource base of all natural gas fields for the U.S. The method for forecasting future discoveries used the probabilities of finding fields of various sizes remaining to be found. The assumption is that the reserve discovery by each additional unit of drilling is a function of the field size distribution of the remaining fields and the dry hole probability. As fields are discovered, the probabilities change and the likelihood of finding giant fields decreases and of finding small fields increases. The technique is most applicable to geological provinces in which little or no drilling has occurred. When a long history of exploration activity is available, other methods may also be used.

The features of the model may be stated as follows:

1. It provides a forecast of future reserve discovery trends.
 2. It serves as a means of evaluating the relative effectiveness of exploration drilling in different geological basins or areas.
-

3. It does not discover natural gas nor find any locations for future drilling, but forecasts on a statistical basis.

4. It serves as a prediction or evaluation tool for the company decision making or governmental policy making.

5. It can be used for geological areas, states, or countries simply by applying the appropriate resource base description and other available data.

6. It can be used for many different regions with different specifications, and it is capable of predicting the future discoveries for each individual region or for the combined regions.

7. It can be applied to formations within any depth range, simply by applying the proper depth or thicknesses data.

8. It can be used for other resources, i.e., oil, coal, uranium, etc.

At the end I should mention in order to alleviate the shortage of gas, sufficient data must be collected and analyzed to provide a data base to be used with a model of the type developed in this study. Thus, a forecast of future natural gas availability from all regions of the U.S., particularly those with little or no past drilling activity, can be made. This should serve as a sound basis for allocation of available supplies or plans for increasing supplies by using alternative sources of gas.

The conclusions drawn from this research based on the probability model developed and the assumed data may be stated as follows:

1. As drilling activity continues the size of reserve discoveries per unit of drilling decreases. This is actually shown in the first phase since large fields play a significantly larger role in the reserve discoveries than the small fields in the initial stages of drilling and smaller fields dominate the latter stages. This also can be seen in the results of the second phase because all the runs show that the incremental reserves values decrease as time or drilling activity progresses.

2. The values of the empirical constants (A, B, and t) do not affect the results significantly for the cases considered in this study. This is indicated by the fact that the response of all three regions to drilling activity was quite similar and the behavior curves followed nearly the same paths. It should be mentioned here that this is true as long as these values do not change considerably, and should not be interpreted as a general observation of the response of a resource base to drilling activity.

3. Proportionate changes or reductions in the frequencies of all classes of fields had an effect on some of the results. Comparing the results of the first three runs shows that the effect was most marked in the curves of cumulative reserves vs. either time or cumulative footage and

cumulative discovery rate vs. cumulative footage. For each region the changes between these runs show that the larger the frequencies of the classes of fields, the sharper were the increases in reserves additions that were obtained during the initial stages of drilling. In regard to the changes in the composite values for the three regions, it can be concluded that the rate of increases for cumulative discoveries versus either time or cumulative footage and cumulative discovery rate versus cumulative footage are in many respects similar to those for single regions. Irregularities may occur primarily because of differences in the timing of the exploratory programs in the individual regions; however, the basic trend of discovery of a mixture of fields in the early stages of exploration that was made up predominantly of large fields and a mixture later that was made up predominantly of small fields.

4. For the composite reserves discovered in the three regions, the different drilling rate prediction curves, i.e., hyperbolic, straight line, etc., had an effect on the responses and plots of incremental reserves vs. either time or footage. These responses differ considerably based on the selection of the type of curve used to represent drilling activity and the values of the empirical constants. This is in contrast to the behavior of a single region in which incremental reserves may vary with time depending on the timing of the exploration program but are invariant within

random fluctuations, with cumulative footage drilled.

5. As a whole, the responses for cumulative reserve discoveries versus either time or cumulative footage drilled for all the cases and runs covered in this study follow almost the same path and are very similar to one another. This is a consequence of the fact that these curves are essentially integral curves and variations in incremental reserves discoveries due to differences in exploratory timing or random fluctuations tend to be smoothed.

NOMENCLATURE

U	upper limit of reserves in billions of cubic feet
C	class mark
n	total number of classes
f	frequency
F	number of fields remaining to be found
p	product
PD	probability of a dry field (dry hole)
P	probability of finding a gas field (gas well)
CP	cumulative probability of finding a gas field (gas well)
RN	random number
FF	number of fields found
RF	reserve found in billions of cubic feet
D	depth
DMAX	maximum depth
DMIN	minimum depth
DF	dry hole footage
CDF	cumulative dry hole footage
H	thickness of sedimentary interval
GF	gas well footage, or footage
CGF	cumulative gas well footage
HMIN	minimum thickness of sedimentary interval for gas well

HMAX	maximum thickness of sedimentary interval for gas well
CRF	cumulative reserve found in billions of cubic feet
CFF	cumulative number of gas fields found
CDFI	cumulative number of dry fields found
DFI	increment number of dry fields found
TI	total interval
RPFI	increment reserve found/increment number of fields found
CRPFC	cumulative reserves found/cumulative number of fields found
RPF	increment reserves found/increment footage drilled
CRPF	cumulative reserves found/cumulative footage drilled
JS, JSAVE	total number of drilling programs
AI	A interval
BI	B interval
R	reserves in billions of cubic feet
CR	cumulative reserves in billions of cubic feet
IF	increment footage
T	time
T_0	time zero
TL	time limit
CD	cumulative discovery
NR	number of regions or number of runs
TF	total footage
DR	discovery rate
CDR	cumulative discovery rate
I	different classes

- J different drilling programs
- K number of regions
- W number of wells drilled in a drilling program
- I_c the number of the class indicated by the RN to be the outcome of the trial

BIBLIOGRAPHY

1. American Gas Association: "Gas Rate Fundamentals", Revised Edition, sponsored by the A.G.A. Rate Committee, 1969.
2. American Gas Association, 1971. Annual Report on Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada, 1970, V. 25, 256 p.
3. American Gas Association, 1972. A.G.A. News, Press Release on March 29.
4. American Gas Association, American Petroleum Institute, and Canadian Petroleum Association (1974). Reserves of Crude Oil, Natural Gas Liquids and Natural Gas in the United States and Canada and United States Productive Capacity, as of December 31, 1973. Washington: A.G.A.
5. American Gas Association. "Natural Gas Proved Reserves Down for Fifth Time in Last Six Years," A.G.A. News, March 29, 1974.
6. American Petroleum Institute, Department of Statistics (1969). Standard Definitions for Petroleum Statistics, Technical Report No. 1, first edition, July 1, 1969. Washington: API.

7. Anderson, Larry L. (1972). Energy Potential From Organic Wastes: A Review of Quantities and Sources, Bureau of Mines Information Circular 8549. Washington: Government Printing Office.
8. Arps, J. J., and T. G. Roberts. "Economics of Drilling for Cretaceous Oil on East Flank of Denver-Julesburg Basin." Bulleting of the AAPG, Vol. 42, No. 11 (Nov. 1958), pp. 2549-2566.
9. Arps, J. J., M. Mortada, and A. E. Smith. "Relationship Between Proved Reserves and Exploratory Effort." Journal of Petroleum Technology, June 1971, pp. 671-675.
10. Arrington, J. R. "Predicting the Size of Discoveries-- Key to Evaluating Exploration Programs." Oil and Gas Journal, 1960, Vol. 58, No. 9.
11. Arrington, J. R. "Estimation of Future Reserve Revision in Current Fields." Transactions of the West Texas Geological Society's Symposium, Economics and Petroleum Geologist, October, 1966.
12. Atkinson, C. H. Nuclear Fracturing Prospects for Low-Permeability Hydrocarbon Reservoirs in the United States. A report presented at the Pre-Shot Gasbuggy Symposium, Farmington, New Mexico, Sept. 18, 1967.
13. Averitt, Paul (1974). "Administrative Report--Pipeline Gas from Coal in the United States," National Gas Survey, Vol. V. Washington: FPC.

14. Bullard, Fredda Jean. "Mexico's Natural Gas--The Beginning of an Industry," Bureau of Business Research, University of Texas at Austin, 1968.
15. Cram, Ira H., Ed., 1971. Future Petroleum Provinces of the United States--Their Geology and Potential. Summary, Petroleum Geologists, Mem. 15, V. 1, Preface, viii; p. 1-34.
16. Craft, B. C. and Hawkins, M. F. Applied Petroleum Reservoir Engineering. Englewood Cliffs, N.J.: Prentice-Hall, Inc.
17. Department of the Interior (1968). United States Petroleum Through 1980. Washington, D. C.: Office of Oil and Gas, 92 p.
18. Department of the Interior (1972a). United States Energy Through the Year 2000, by Walter G. Dupree, Jr. and James A. West. Washington: Government Printing Office.
19. Department of the Interior (1972b). Statement, Questions and Policy Issues Related to Over-sight Hearings on the Administration of the Outer Continental Shelf Lands Act, Held by the Senate Committee on Interior and Insular Affairs, Pursuant to S. Res. 45, March 23, 1972.
20. Department of the Interior (1974a). "U.S. Energy Use Up Nearly Five Percent in 1973." News Release, U.S. Bureau of Mines, March 13, 1974.
21. Department of Interior (1974b). "USGS Releases Revised U.S. Oil and Gas Resource Estimates," News Release, March 26, 1974.

22. Duel, M., et al. Degasification of Coalbeds: A Commercial Source of Pipeline Gas. A Report presented at the IGT Clean Fuels from Gas Symposium, Chicago, Sept. 10-14, 1973.
23. Elliott, M. A., and Linden, H. R., 1968. "A New Analysis of U.S. Natural Gas Supplies," Jour. Petroleum Technology, Vol. 20, p. 135-141.
24. Federal Energy Administration (1974). Geological Estimates of Undiscovered Recoverable Oil and Gas Resources in the United States, Geological Survey Circular 725.
25. Federal Energy Administration (1974). Project Independence Blueprint, First Task Force Report: Natural Gas, under Direction of Federal Power Commission. Washington: Government Printing Office.
26. Federal Energy Office [now The Federal Energy Administration] (1974). "Petroleum Allocation and Price Regulations." Jan. 14, 1974.
27. Federal Power Commission, Bureau of Natural Gas (1972). Natural Gas Supply and Demand, Staff Report No. 2, Washington: FPC.
28. Federal Power Commission (1973a). National Gas Reserves Study. Washington: FPC.
29. Federal Power Commission (1973b). National Gas Survey, Vol. II, Supply Technical Advisory Task Force Report: Liquefied Natural Gas. Washington: Government Printing Office.

30. Federal Power Commission (1973c). "Order Adopting and Amending Proposed Section 2.77 of General Rules of Practice and Procedure." Order No. 482, Docket No. R-459. Issued April 12, 1973.
31. Federal Power Commission (1973d). National Gas Survey, Vol. II, Supply Technical Advisory Task Force Report: Natural Gas Technology. Washington: Government Printing Office.
32. Federal Power Commission (1973e). National Gas Survey, Vol. II, Supply Technical Advisory Task Force Report: Synthetic Gas-Coal. Washington: Government Printing Office.
33. Federal Power Commission (1974a). National Gas Survey, Vol. I, Chapter 2: The Resource and the Industry. Preliminary draft issued in advance of commission approval.
34. Federal Power Commission (1974b). National Gas Survey, Vol. I, Chapter 9: Future Domestic Natural Gas Supplies, Preliminary draft issued in advance of Commission approval.
35. Federal Power Commission (1974c). National Gas Survey, Vol. I, Chapter 10: Future Gas Supplies from Alternate Sources. Preliminary draft issued in advance of Commission approval.
36. Federal Power Commission (1974d). "Natural Gas Companies Annual Report of Proved Domestic Gas Reserves FPC Form 40." Docket No. RM74-16. Notice of Proposed Rule-making, Issued April 15, 1974.

37. Federal Power Commission (1974e). National Gas Survey, Vol. I, Chapter 5: The Current Gas Shortage, Preliminary draft issued in advance of Commission approval.
 38. Federal Power Commission (1974f). "Liquefied Natural Gas Applications Filed with the FPC," July 18, 1974. Washington: FPC.
 39. Ford Foundation (1973). Energy Study Draft Report.
 40. Future Requirements Committee (1971). Future Gas Requirements of the United States, Vol. 4, October 1971. Denver, Colorado: University of Denver Research Institute.
 41. Future Requirements Committee (1973). Future Gas Consumption of the United States, Vol. 5, November 1973. Denver, Colorado: University of Denver Research Institute.
 42. Hardy, E. F. (1974). "The Emergence of U.S. Gas Utilities as a Factor in World Petroleum Economics." Paper presented at the Annual Meeting of the AIChE, Tulsa, OK, March 10-13, 1974.
 43. Hendricks, T. A., 1965. "Resources of Oil, Gas, and Natural Gas Liquid in the United States and the World," U. S. Geol. Survey Cir. 522, 20 p.
 44. Gillette, R. (1974). "Oil and Gas Resources: Did USGS Gush Too High?" Science, V. 185, No. 4146 (July 12, 1974), p. 127-130.
-

45. Gregory, D. P. (1972). "The Hydrogen Economy," American Gas Association Monthly, Vol. 54, No. 6 (1972), 4-9.
46. Hubert, M. K. (1969). "Energy Resources," pp. 157-242 in Resources and Man, by the National Academy of Science, National Research Council, Commission on Resources and Man. Washington: NAS.
47. Hubbert, M. K. (1974). U.S. Energy Resources, A Review as of 1972. Printed for the use of the Committee on Interior and Insular Affairs, U.S. Government Printing Office, Washington: 1974.
48. Landes, Kenneth K. "The Estimation of Undiscovered Natural Gas Supplies," National Gas Survey, Vol. V. Federal Power Commission, 1974.
49. Linden, H. R. (1972). "An Analysis of Potential Production of Gas in the United States." Chicago: Institute of Gas Technology.
50. Linden, H. R. (1973). "The Role of SNG in the U.S. Energy Balance," Special Report for the Gas Supply Committee of the American Gas Association, May 15, 1973.
51. Martinez, A. R. "Estimation of Petroleum Resources," American Association of Petroleum Geologists Bulletin (September, 1966), pp. 2001-2007.
52. McCray, A. W. (1971). "Advanced Evaluation of Petroleum and Natural Gas Properties," Class Notes, School of Petroleum and Geological Engineering, University of Oklahoma.

53. McCray, A. W. "Petroleum Evaluations and Economic Decisions," Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1975.
54. Miller, J. N. "Is There Really a Shortage of Natural Gas," Reader's Digest, August, 1975.
55. Miller, O. N. and others (1970). Future Petroleum Provinces of the United States. Washington, D.C.: National Petroleum Council, 138 p.
56. Moody, John D., and Emmerich, Harry H. (1972). "Giant Oil Fields of the World;" International Geol. Cong. 24th Session, Sec. 5, p. 161-167.
57. Moore, C. L. "Method for Evaluating U. S. Crude Oil Resources and Projecting Domestic Crude Oil Availability." Washington, D.C.: Office of Oil and Gas, U. S. Department of Interior, May 1962.
58. Moore, C. L. (1966). Projections of U. S. Petroleum Supply to 1980. Washington, D.C.: U.S. Department of Interior, Office of Oil and Gas, 42 p.
59. National Petroleum Council (1970). Future Petroleum Provinces of the United States--A Summary. Washington, D.C.: National Petroleum Council, 138 p.
60. National Petroleum Council, Committee on U.S. Energy Outlook (1972). U.S. Energy Outlook. Washington: NPC.
61. National Science Foundation, Resource Appraisal Panel (1972). Conference on Geothermal Energy held in September 1972.

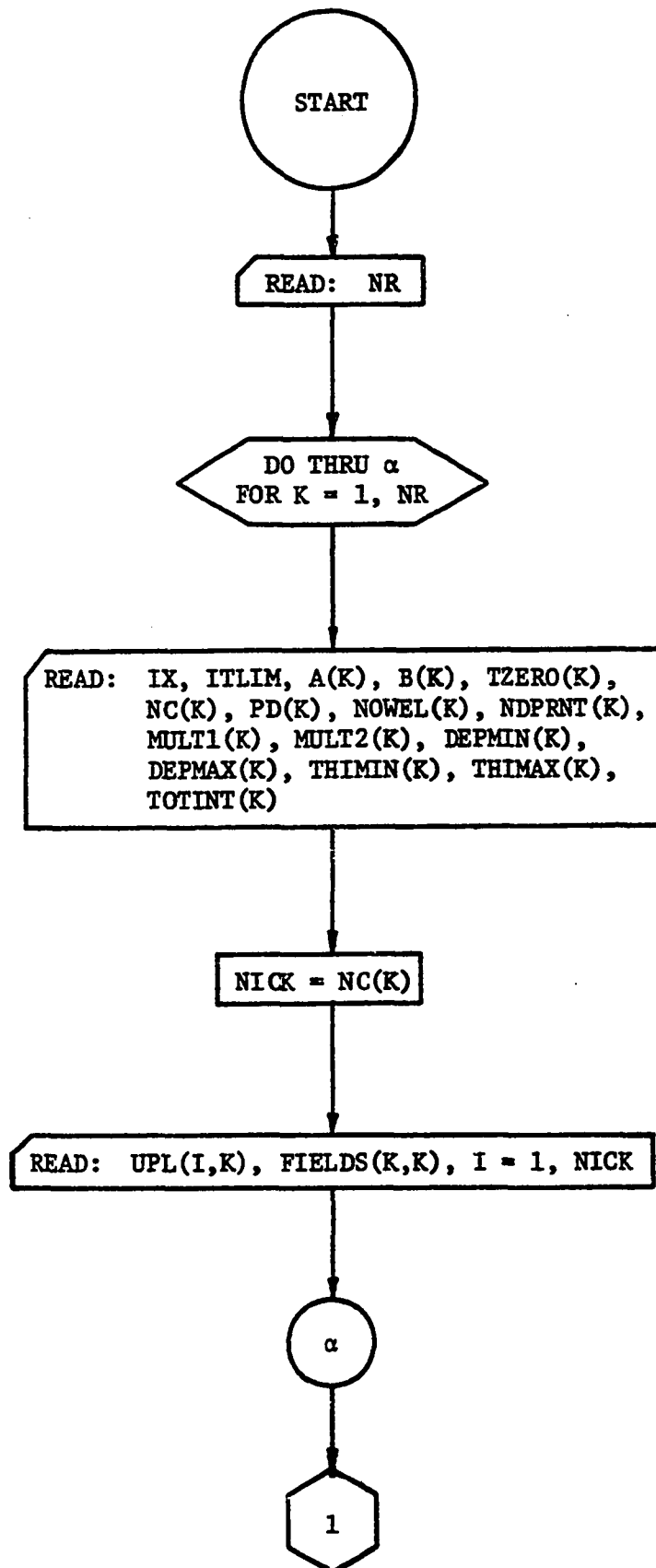
62. Nelson, T. W. and Burk, C. A. (1966). Petroleum Resources of the Continental Margins of the United States, MTS Conf. and Exhibit, 2nd Ann., 1966, Trans.: Washington, D.C.: Marine Technology Soc., P. 116-133.
63. North, F. K. "A Sane Look at United States Gas Reserves," National Gas Survey, Vol. V. Federal Power Commission, 1974.
64. Potential Gas Committee (1971). Potential Supply of Natural Gas in the United States (as of December 31, 1970), 41 p.
65. Potential Gas Committee (1973). Potential Supply of Natural Gas in the United States as of December 31, 1972. Golden, Colorado: Colorado School of Mines, Potential Gas Agency.
66. Rios, N. G. "An Exploratory Model for Prediction of Future Recoverable Reserves in the Seminole Region of Oklahoma." MSc. Thesis, University of Oklahoma, 1972.
67. Root, P. J. (1974). "Oil-Field Management and Evaluation," Class Notes. School of Petroleum and Geological Engineering, University of Oklahoma.
68. Root, P. J. "Natural Gas Availability," American Chemical Society.
69. Root, P. J. "Procedures and Results in the National Gas Reserves Study," University of Oklahoma.
70. Ryan, J. M. (1965). "Limitations of Logistic Projections," Bull. American Association of Petroleum Geologists 49, No. 10.

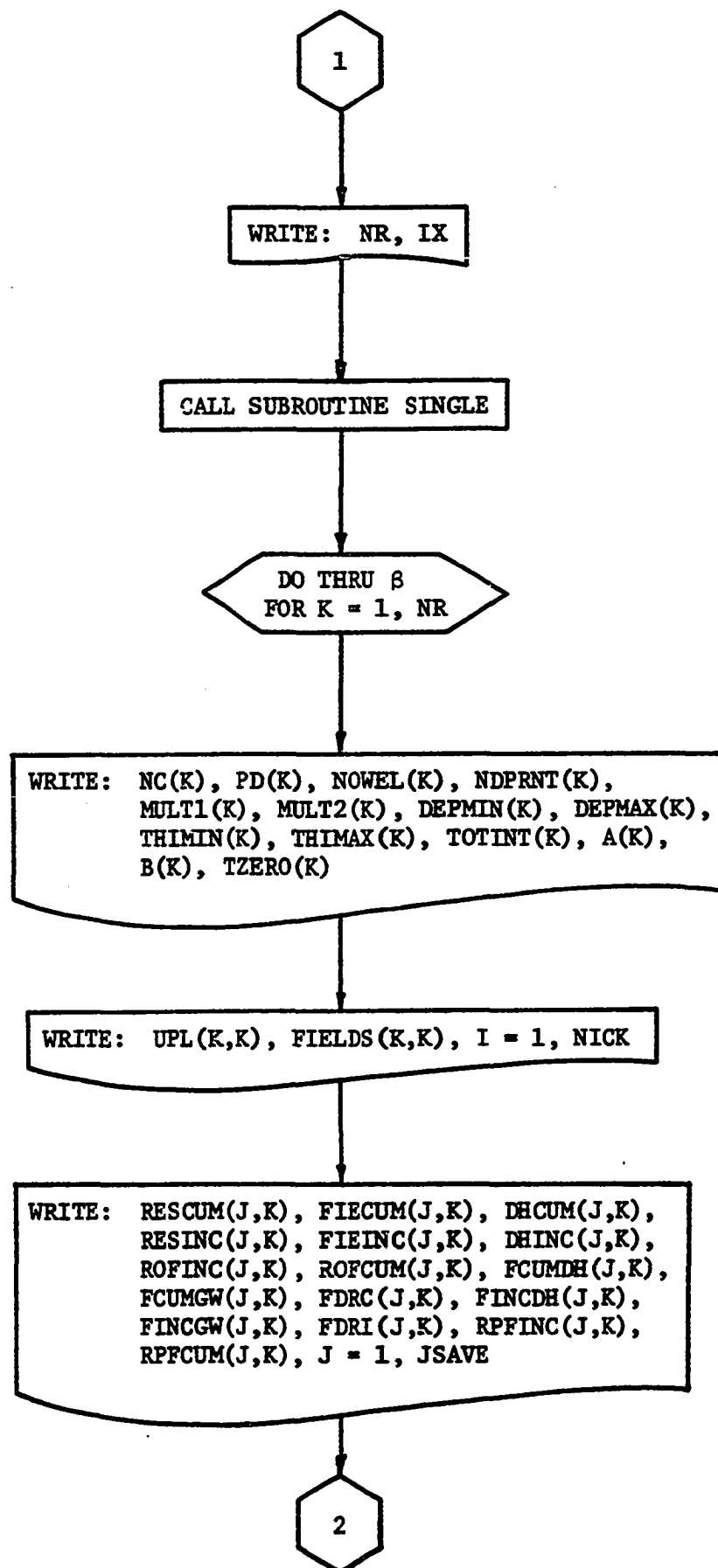
71. Ryan, J. M. "Limitation of Statistical Methods for Predicting Petroleum and Natural Gas Reserves and Availability." Journal of Petroleum Technology, March 1966, pp. 281-287.
72. Theobald, P. K., S. P. Schweinfurth, and D. C. Duncan (1972). Energy Resources of the United States. USGS Circular 650. Washington: Government Printing Office.
73. Weeks, L. G. (1958). "Fuel Reserves of the Future," Am. Assoc. Petroleum Geologists Bull., V. 42, No. 2, p. 431-441.
74. Zapp, A. D. (1962). "Future Petroleum Producing Capacity of the United States," U.S. Geol. Survey Bull., 1142-H, 36p.
75. Zareski, G. K. (1973). "The Gas Supplies of the United States--Present and Future," in Pollution Control and Energy Needs, Advances in Chemistry Series No. 127. New York: American Chemical Society.

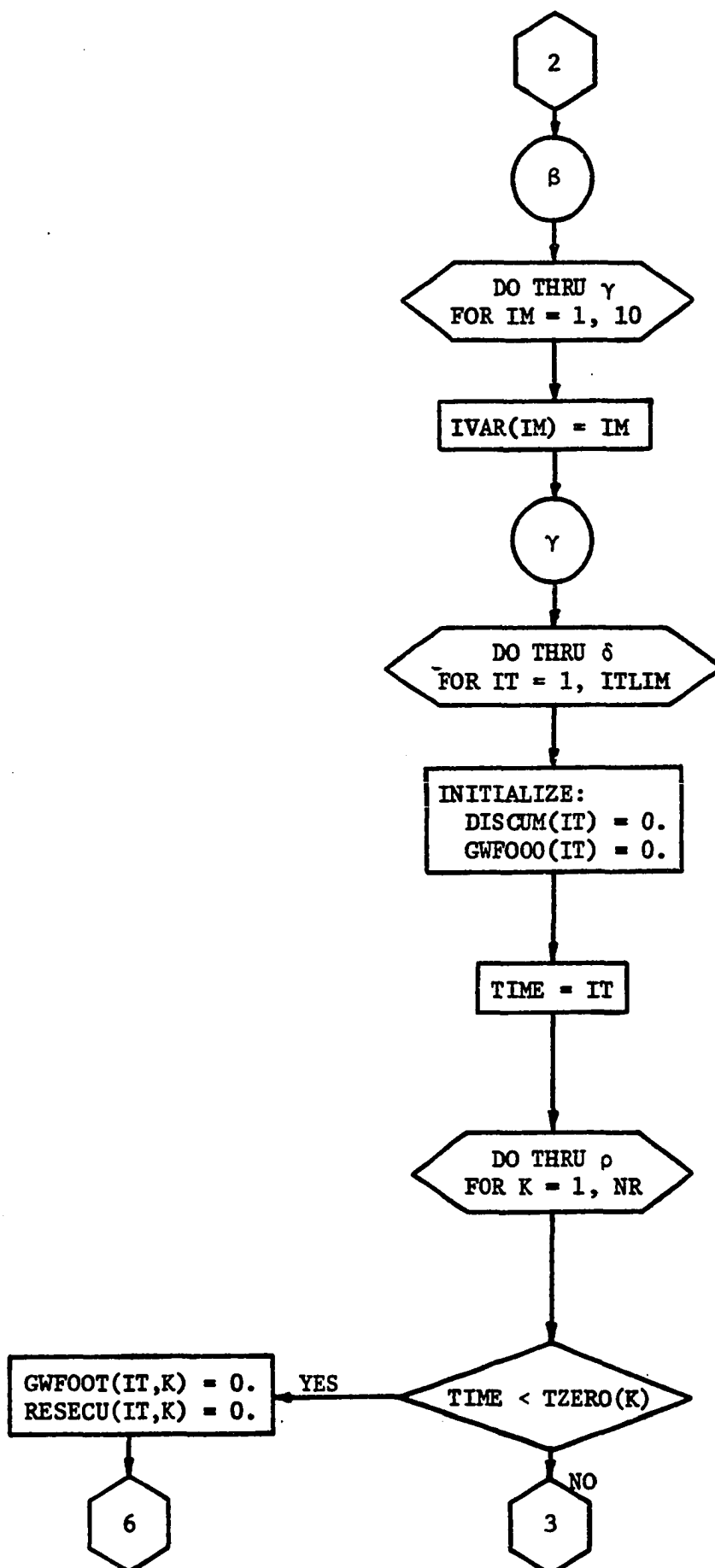
APPENDIX A

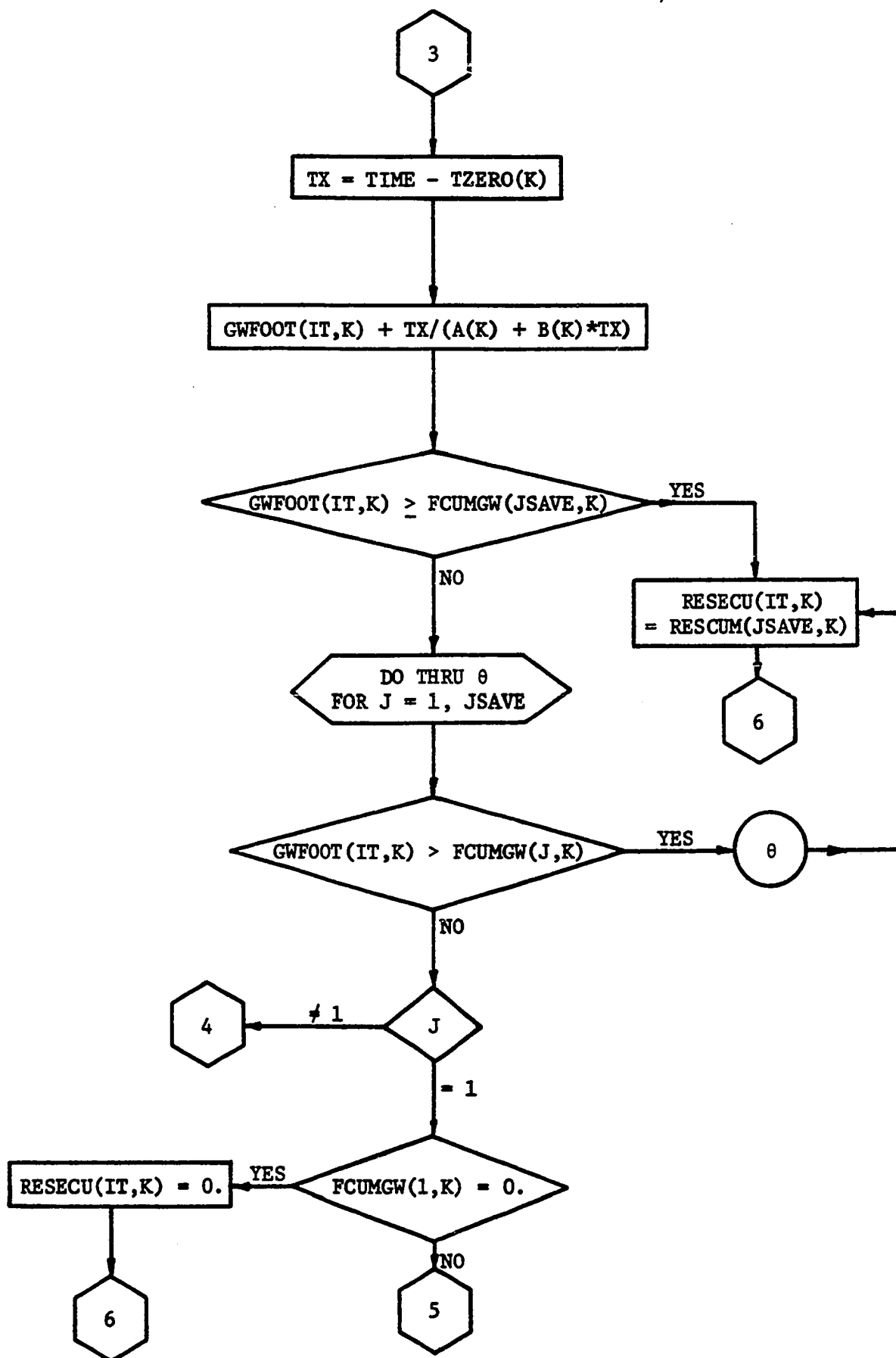
FLOW CHARTS AND COMPUTER PROGRAMS

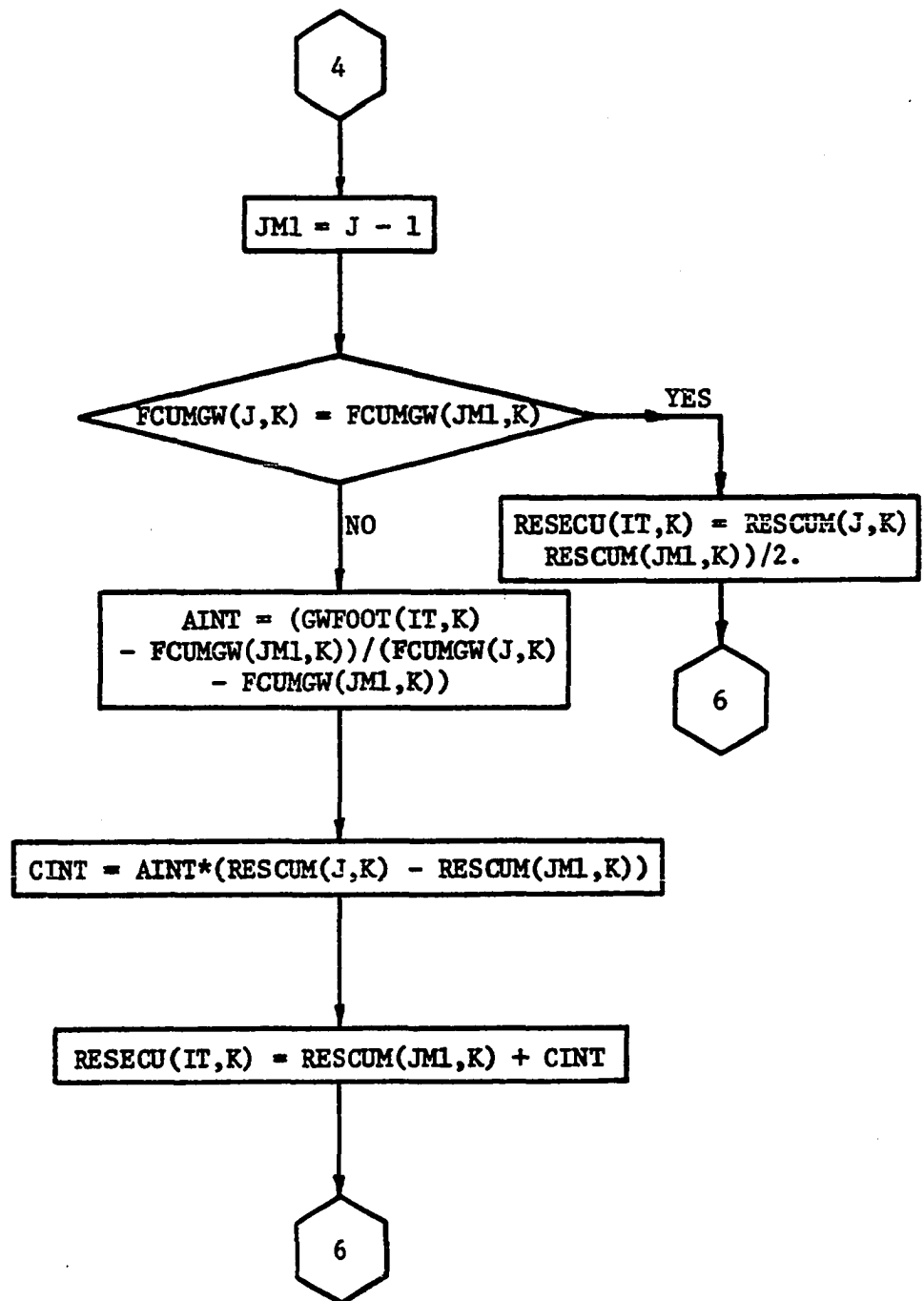
FLOW CHART FOR MAIN PROGRAM

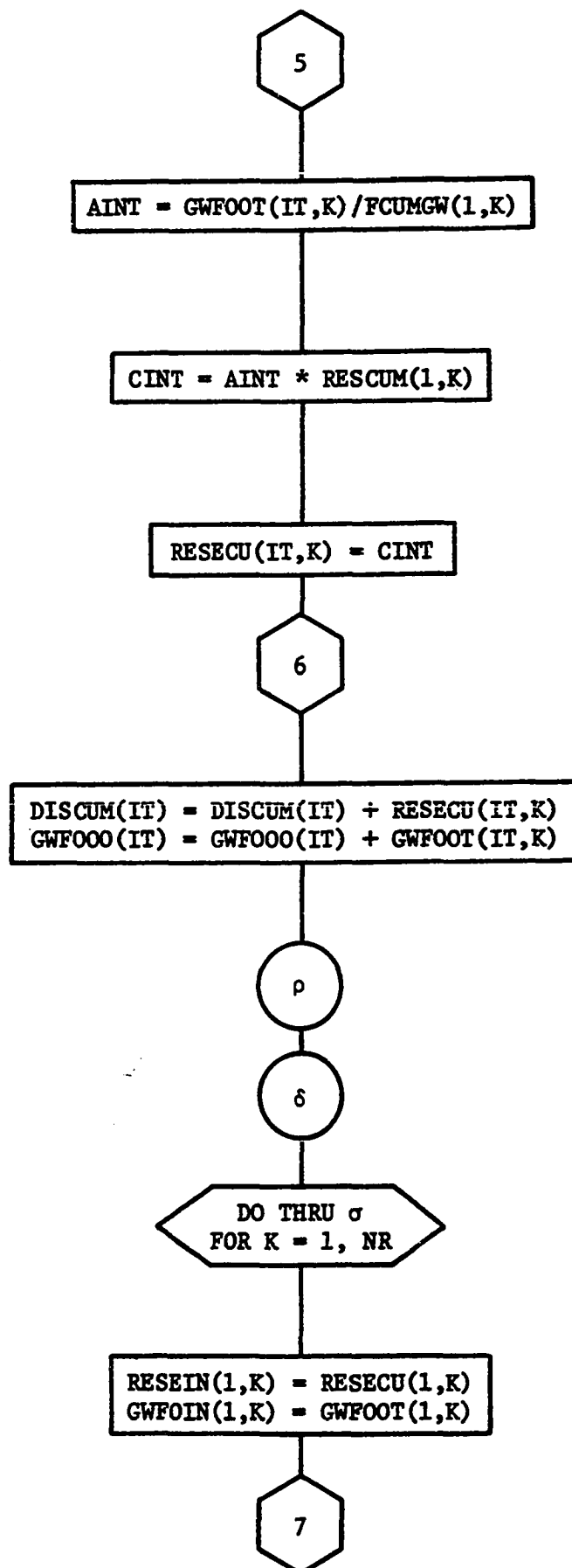


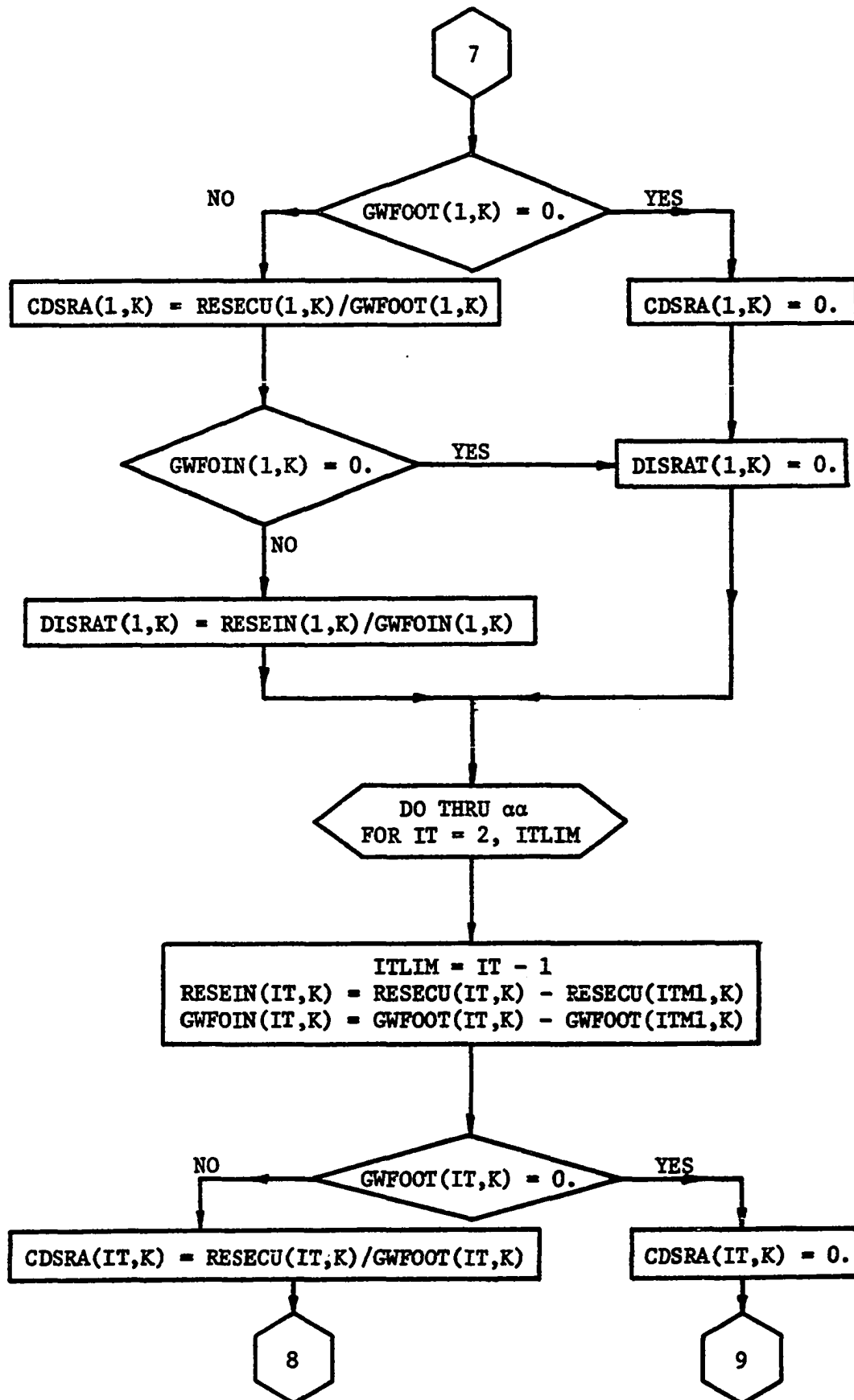


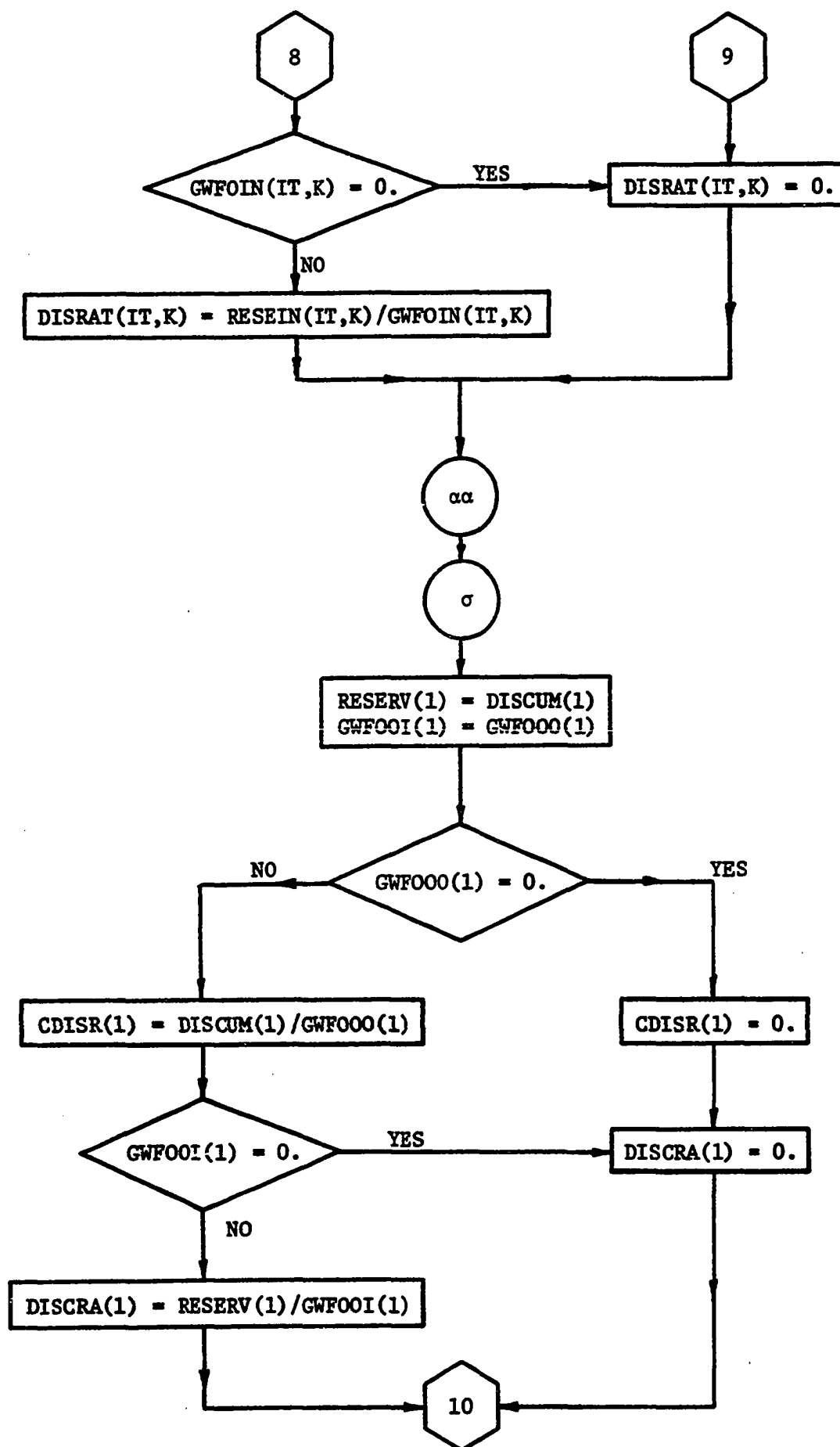


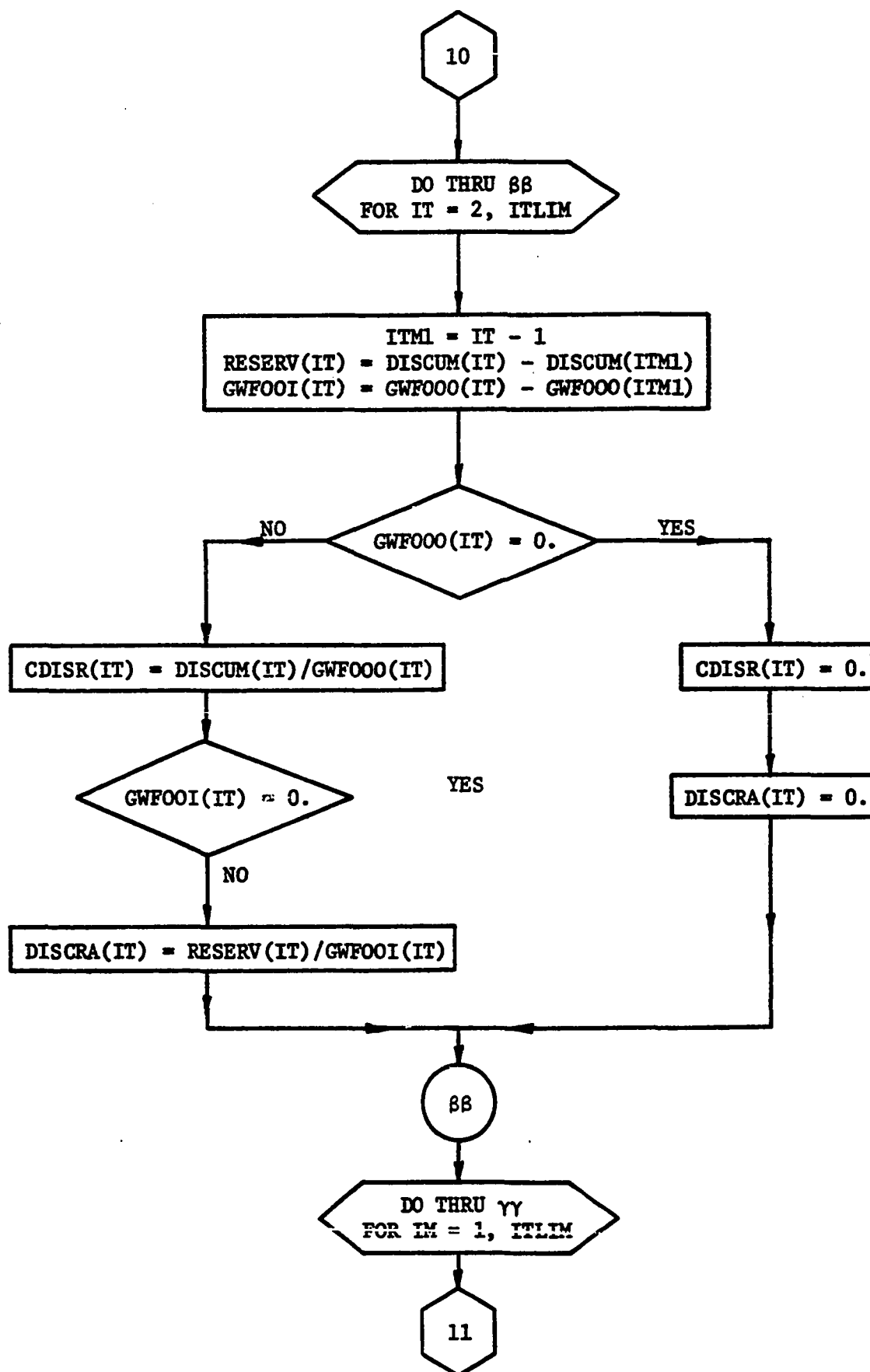


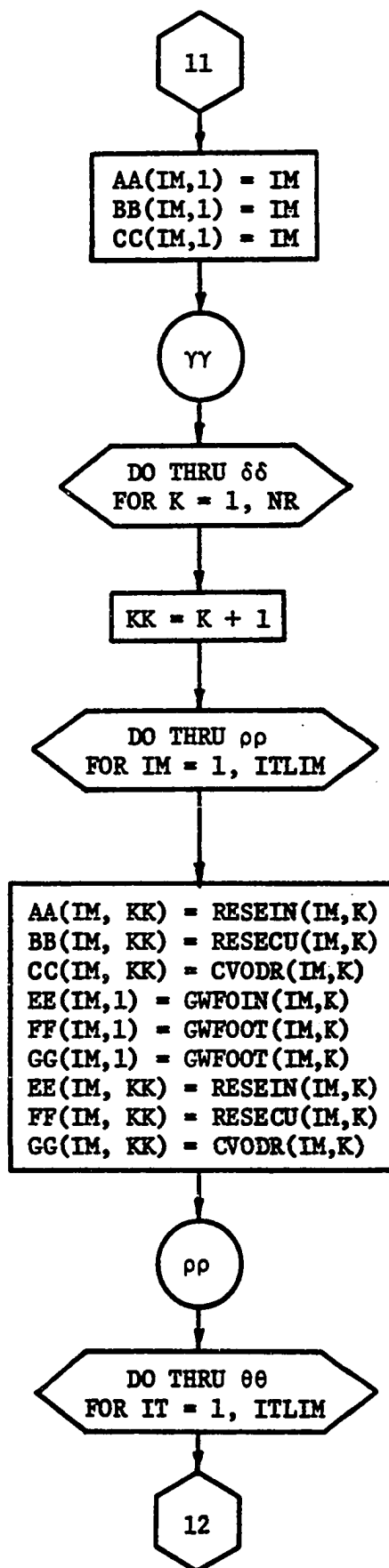


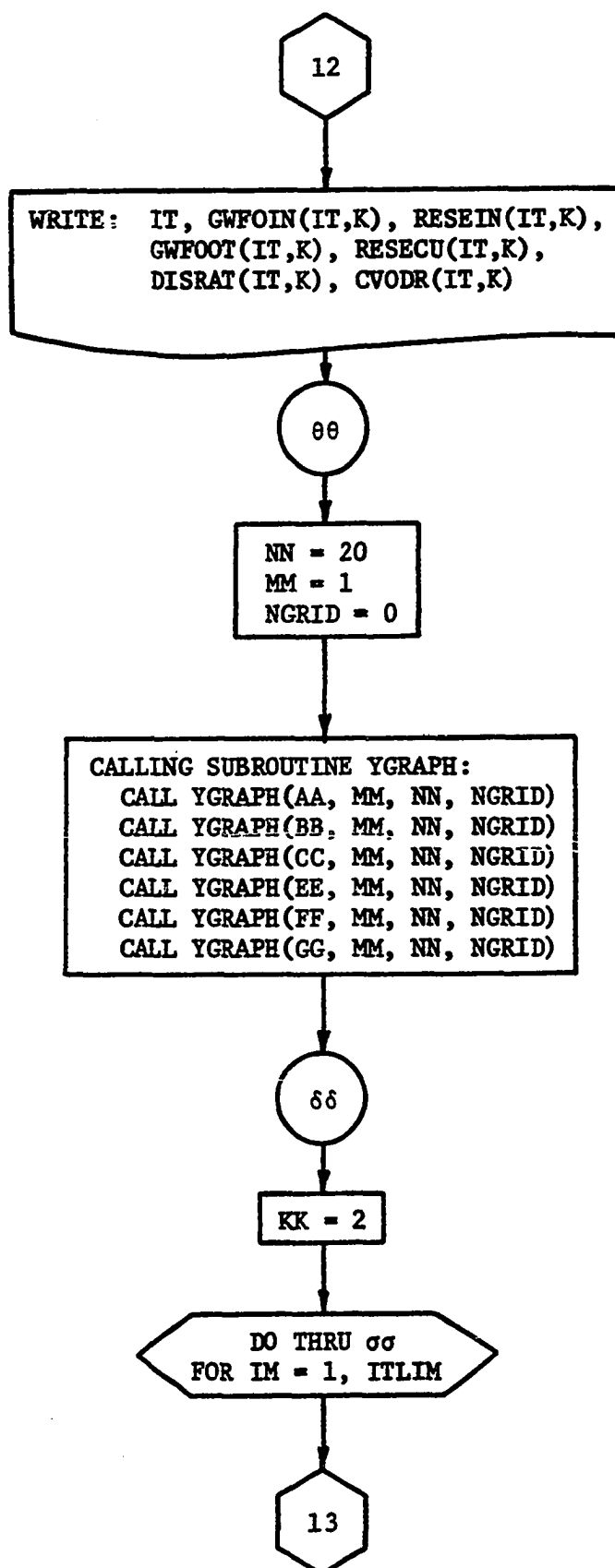


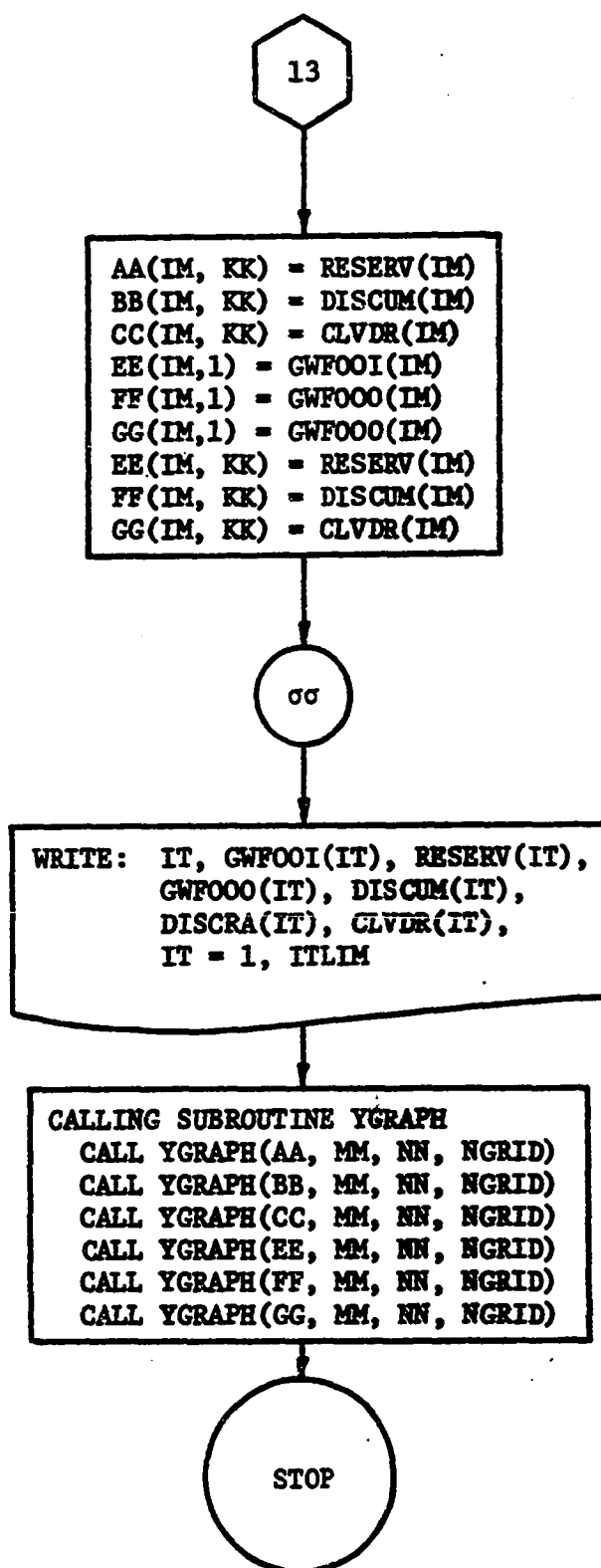




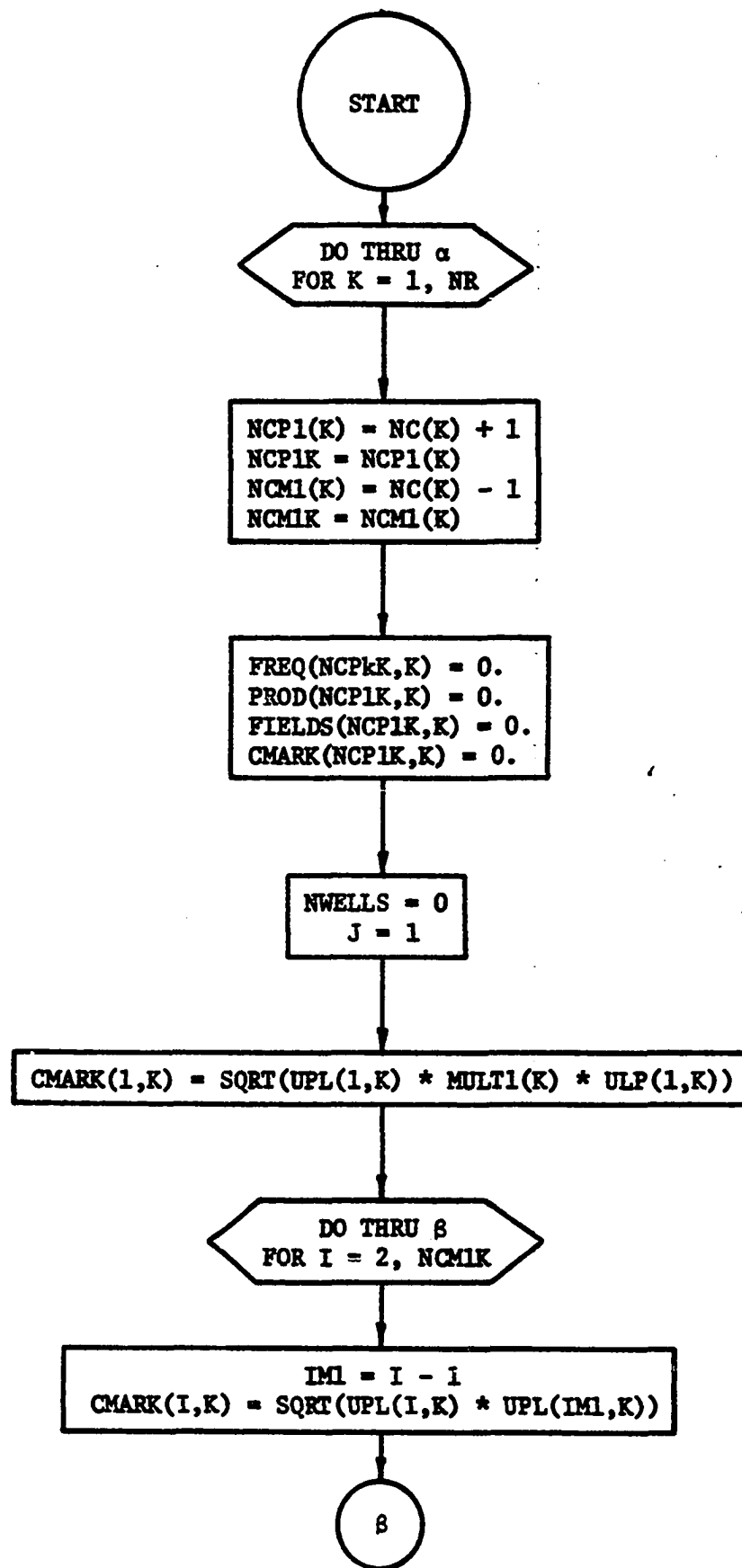


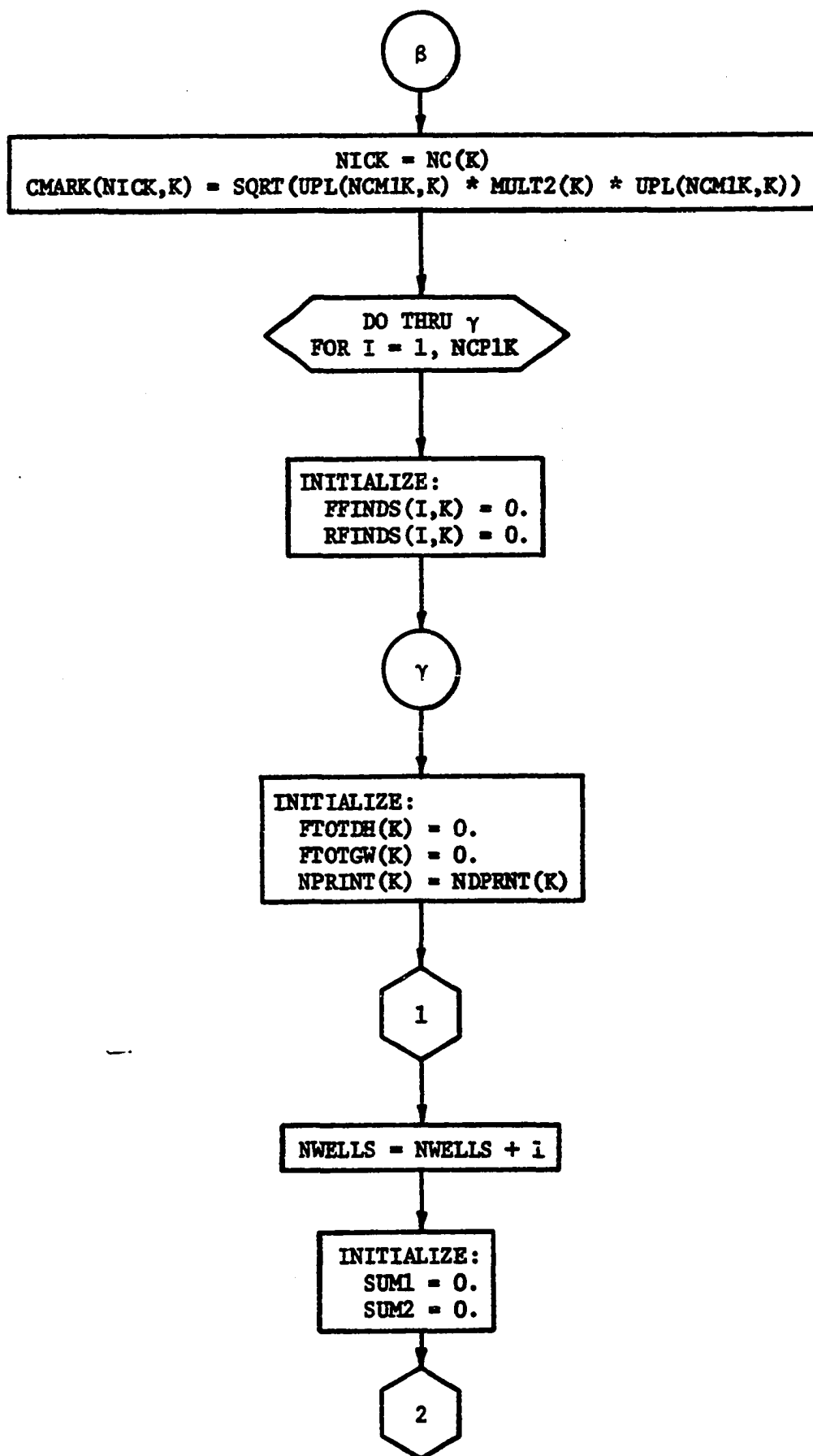


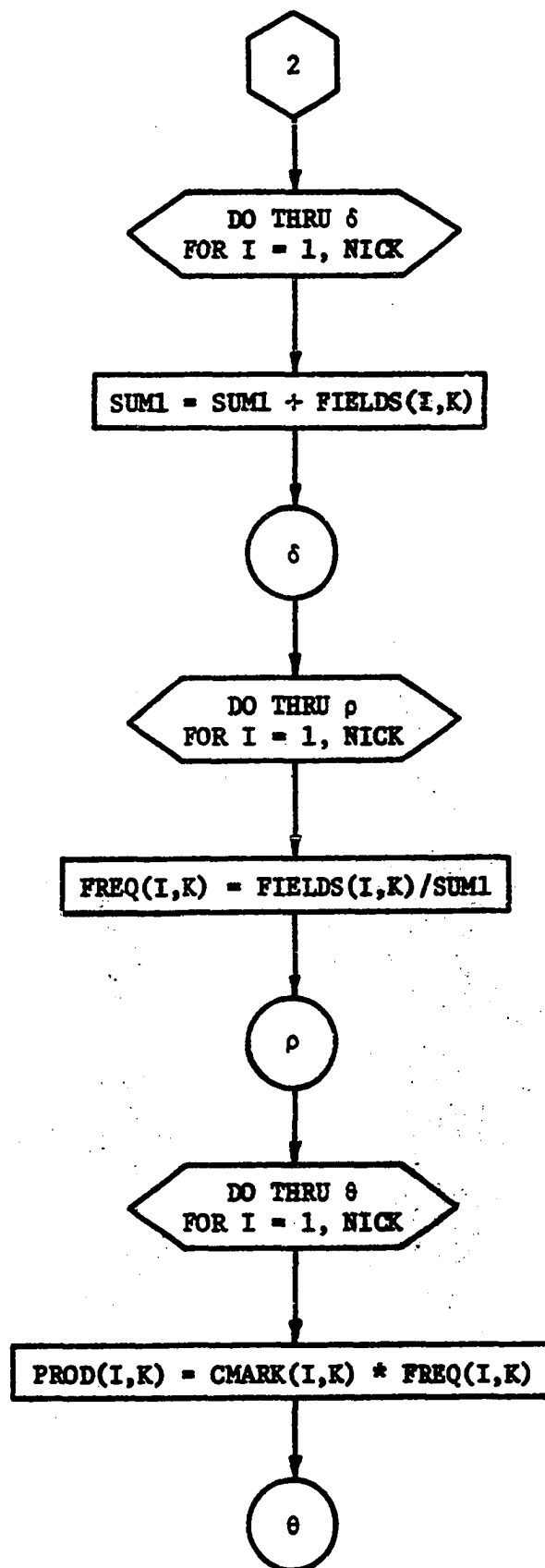


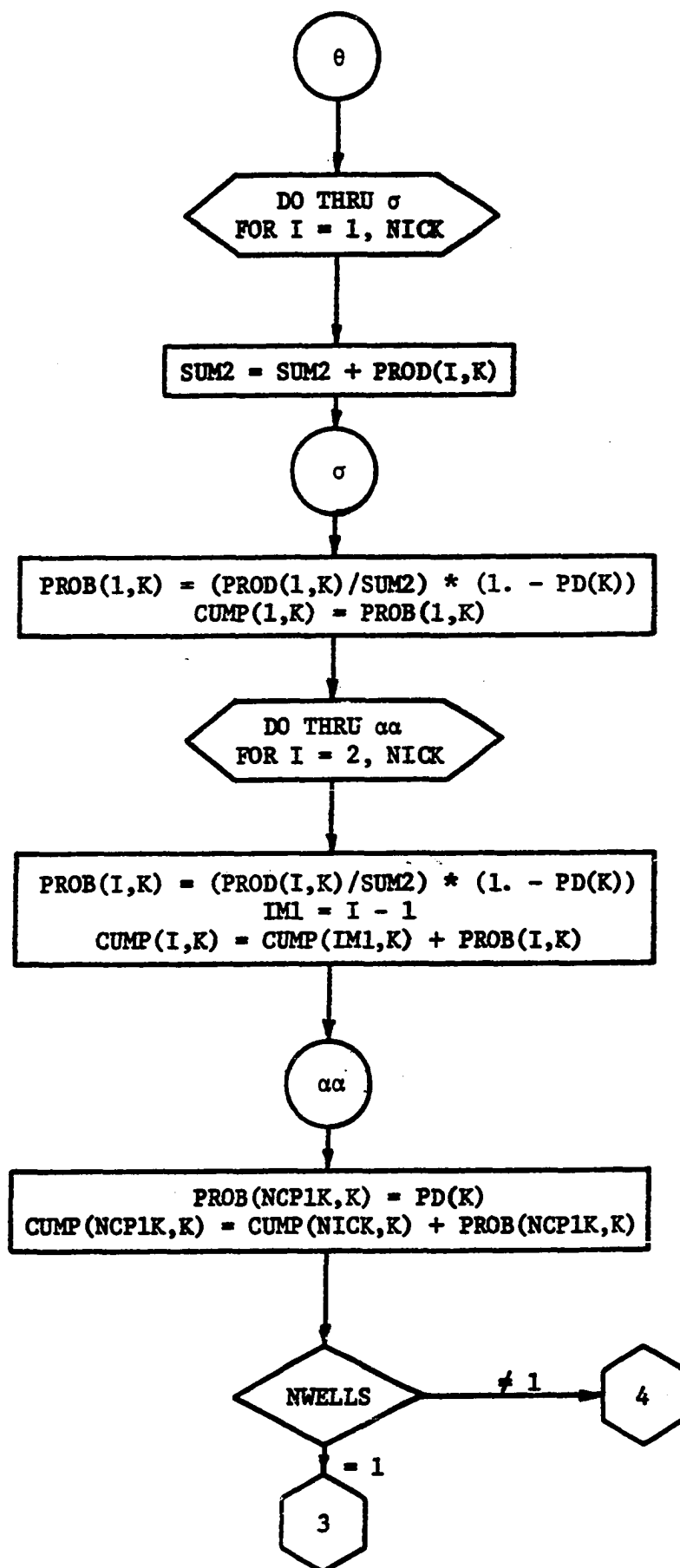


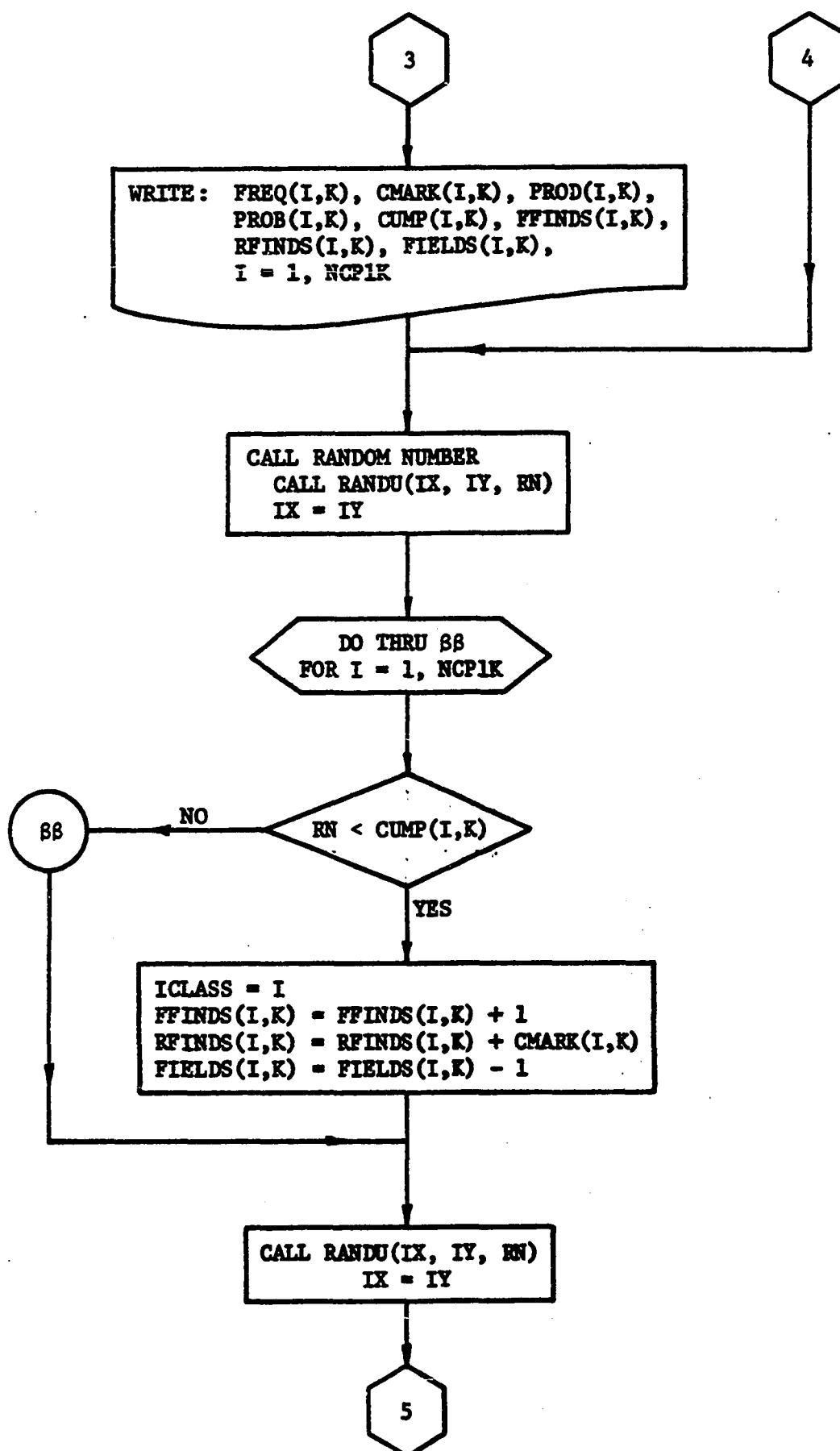
FLOW CHART FOR SUBROUTINE SINGLE

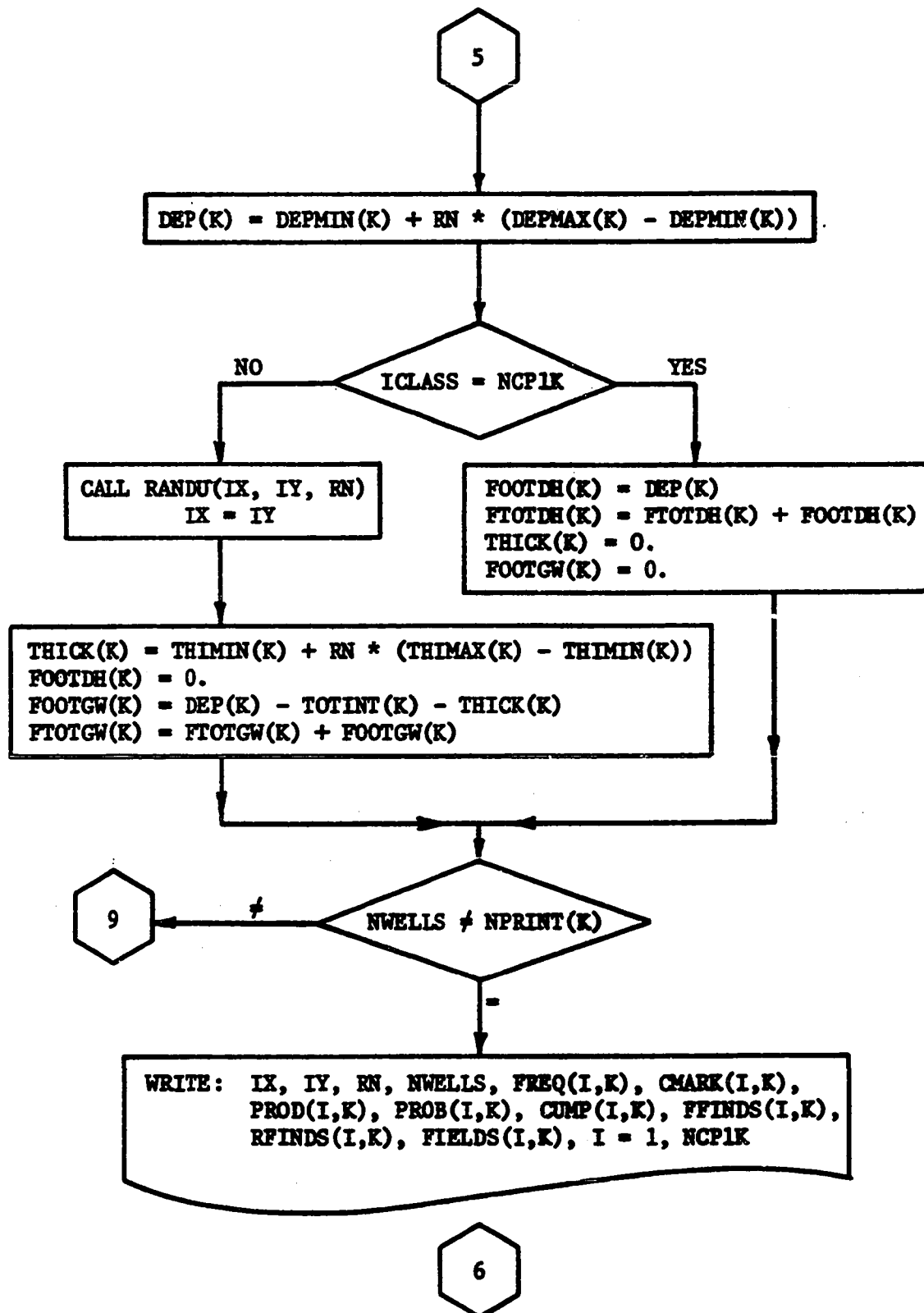


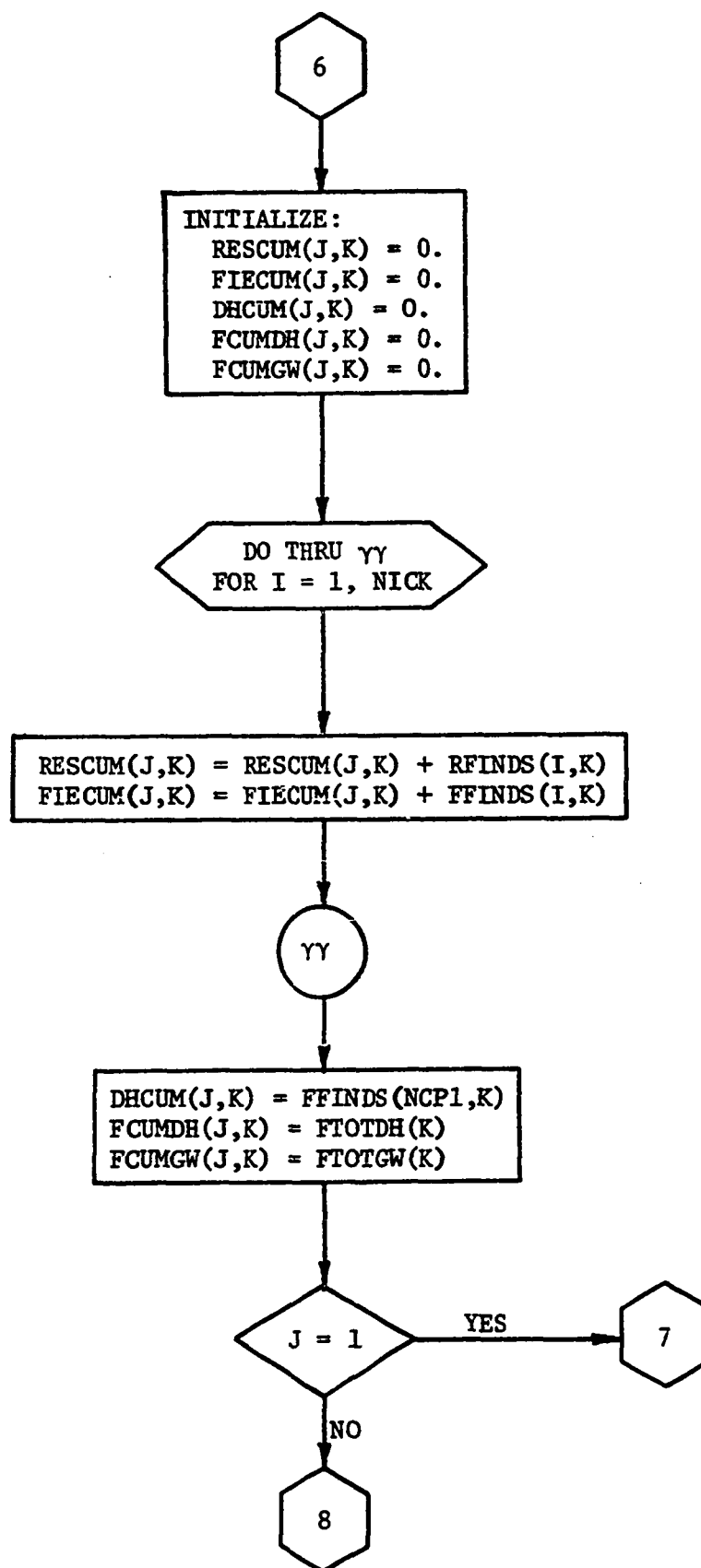


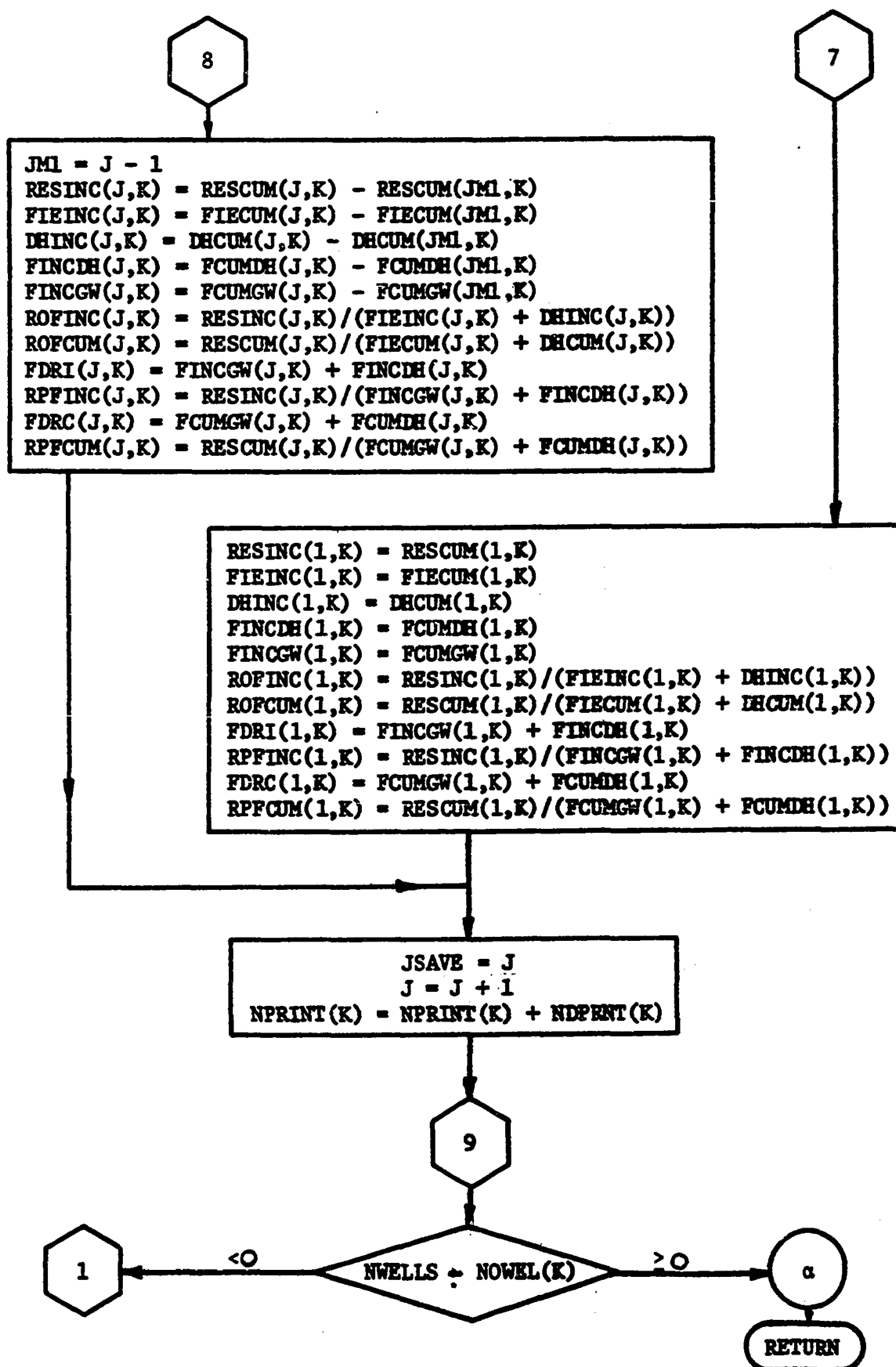




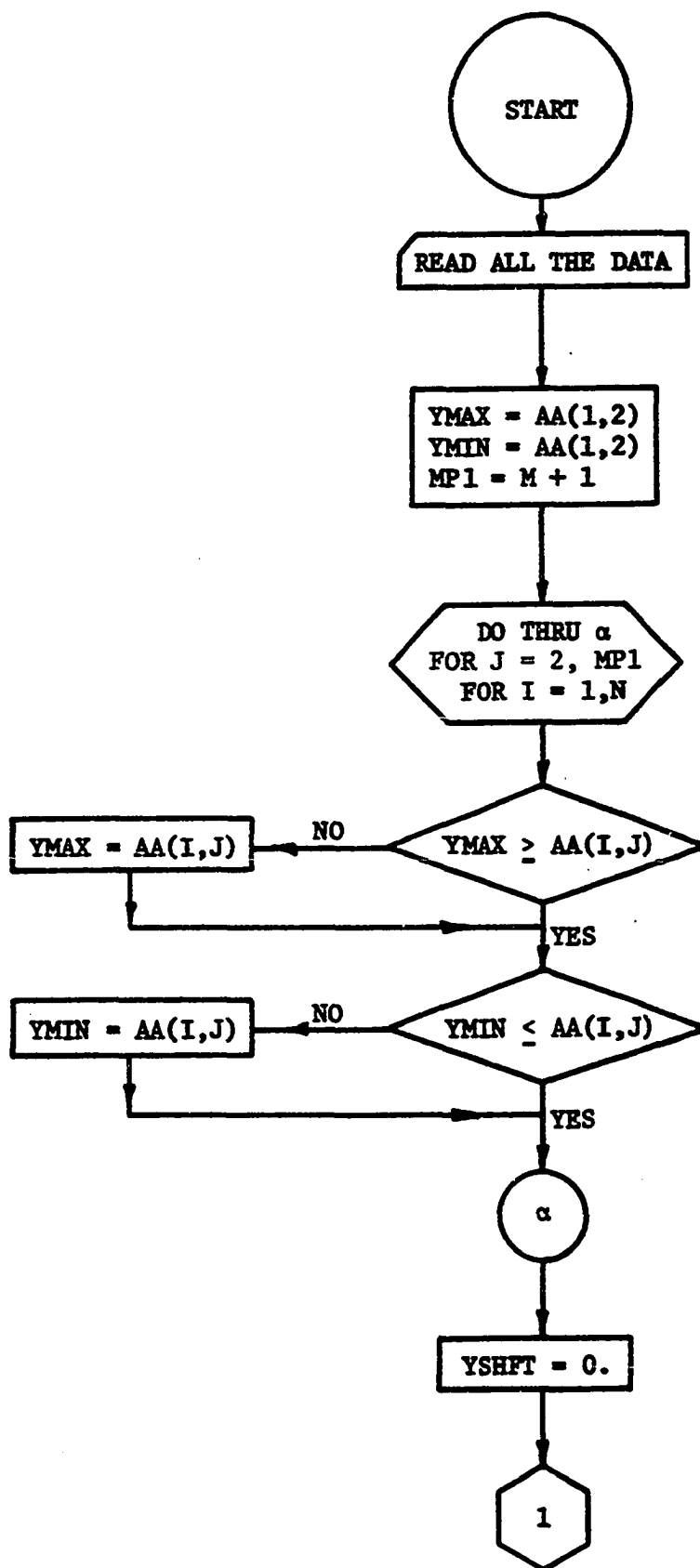


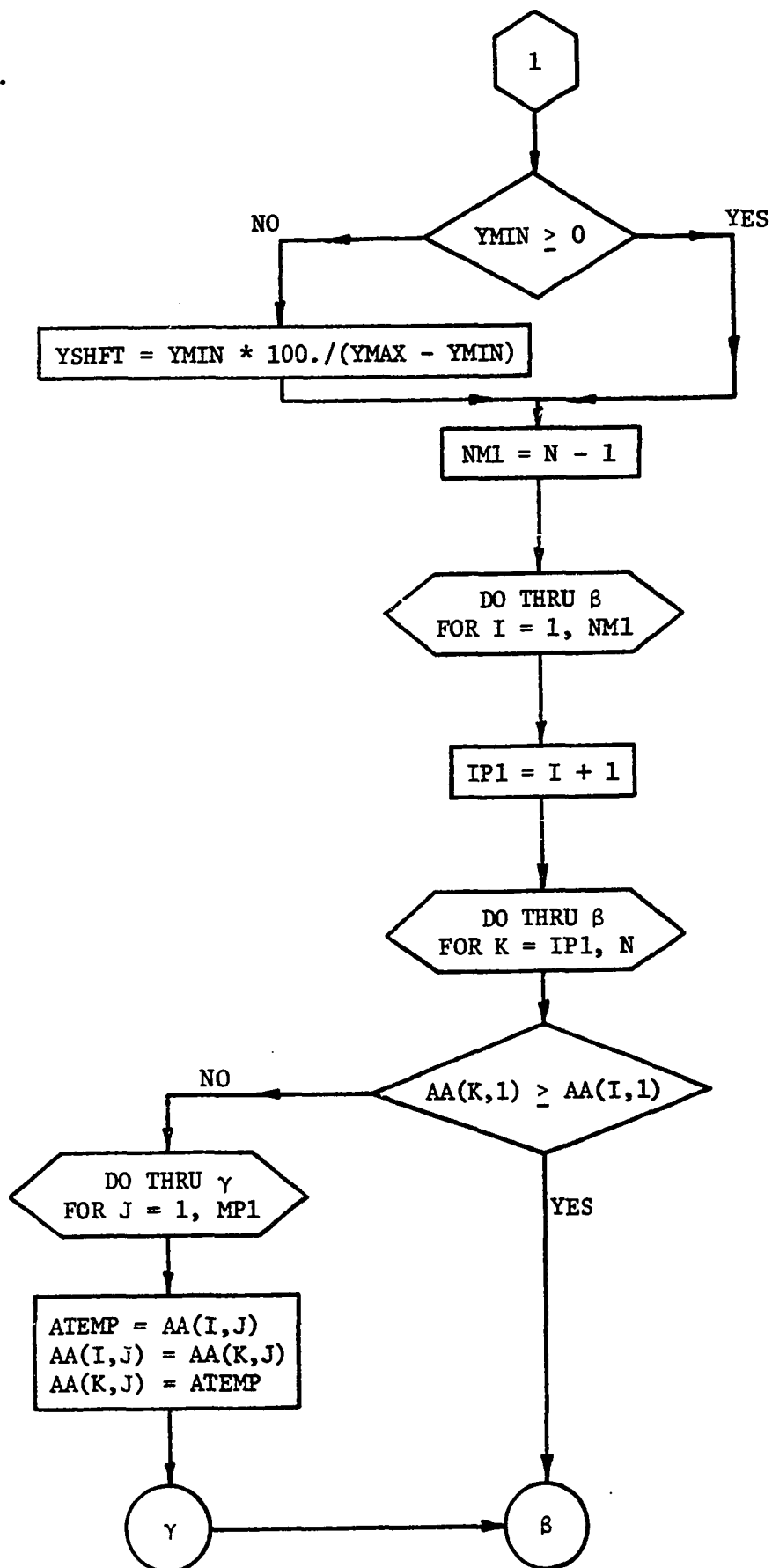


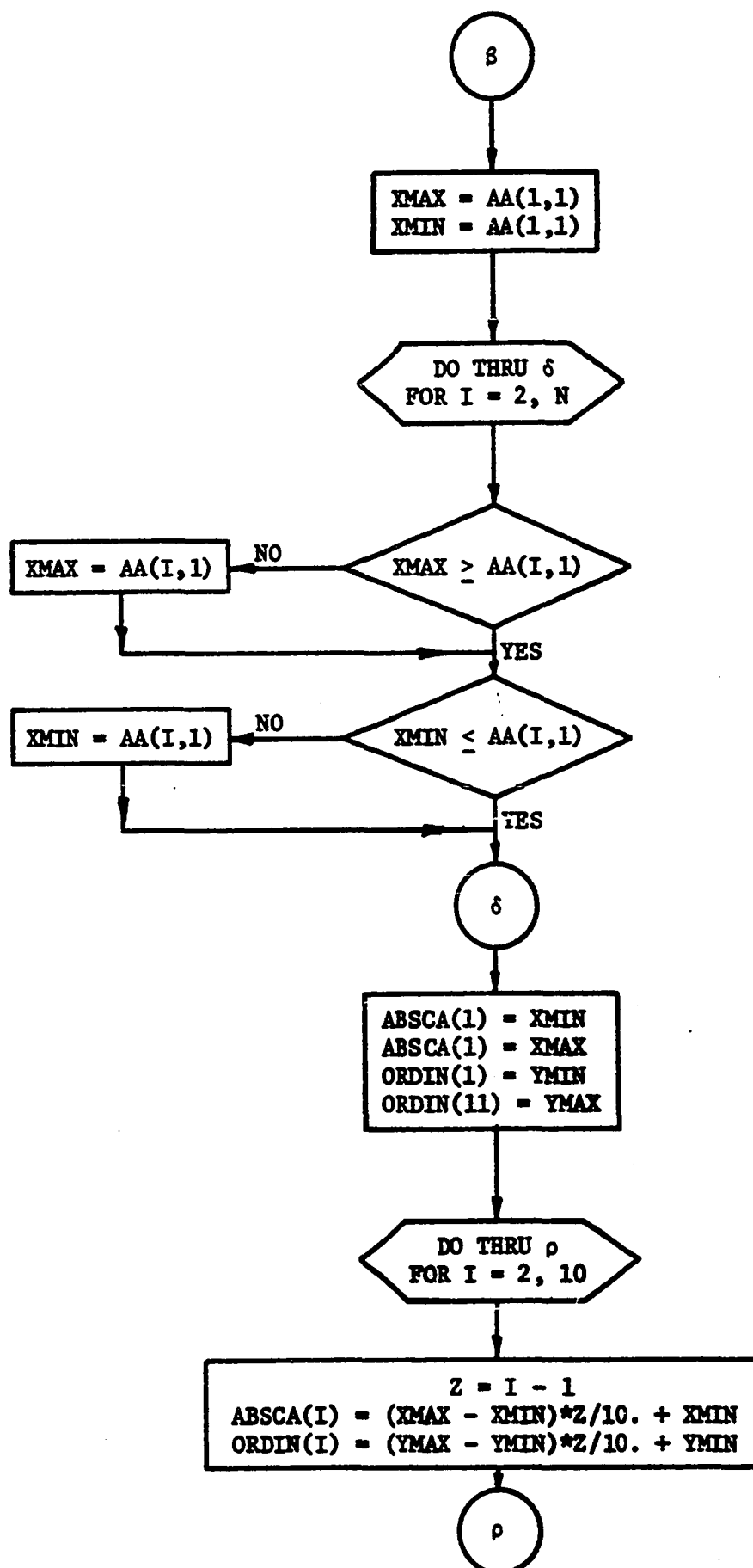


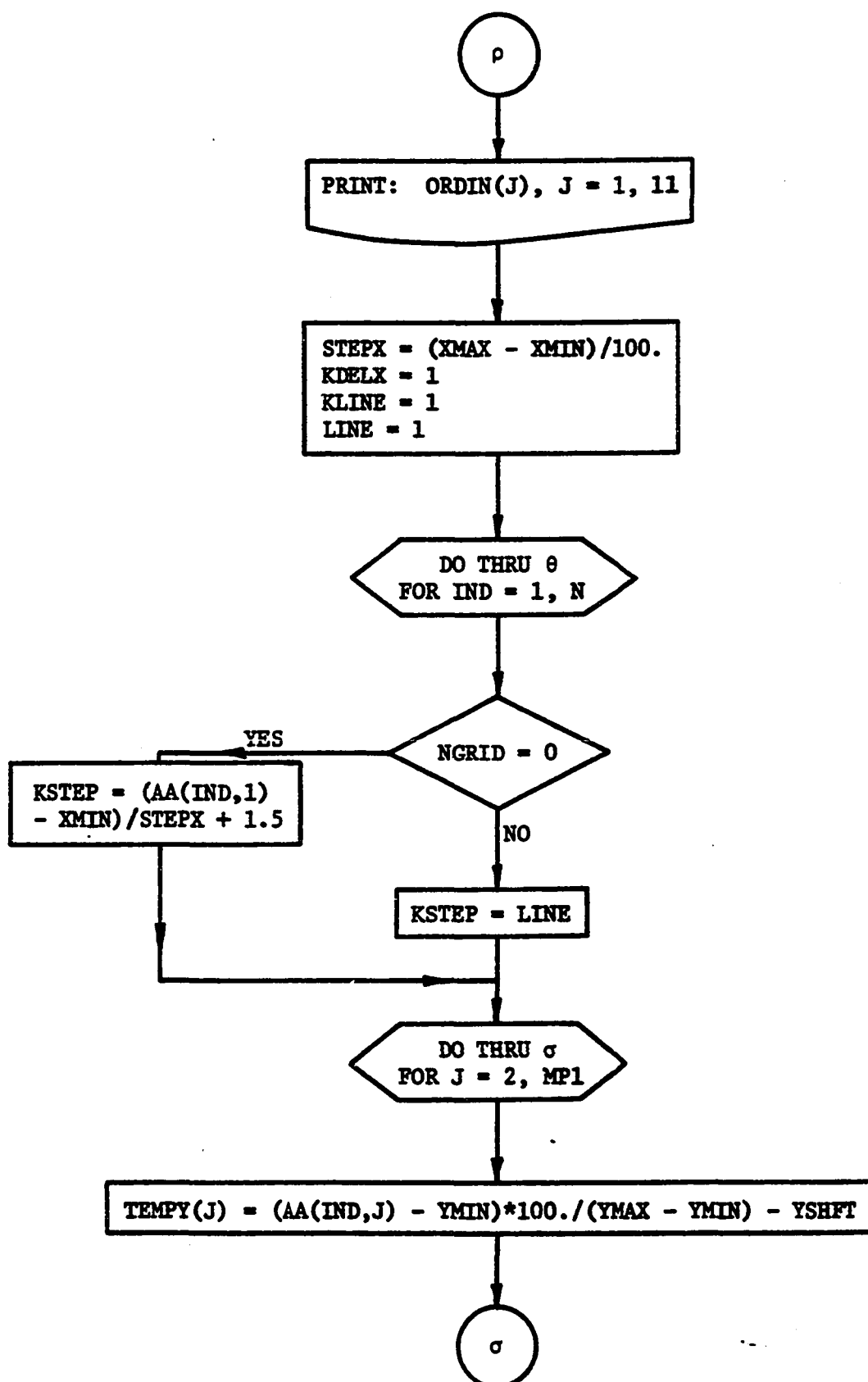


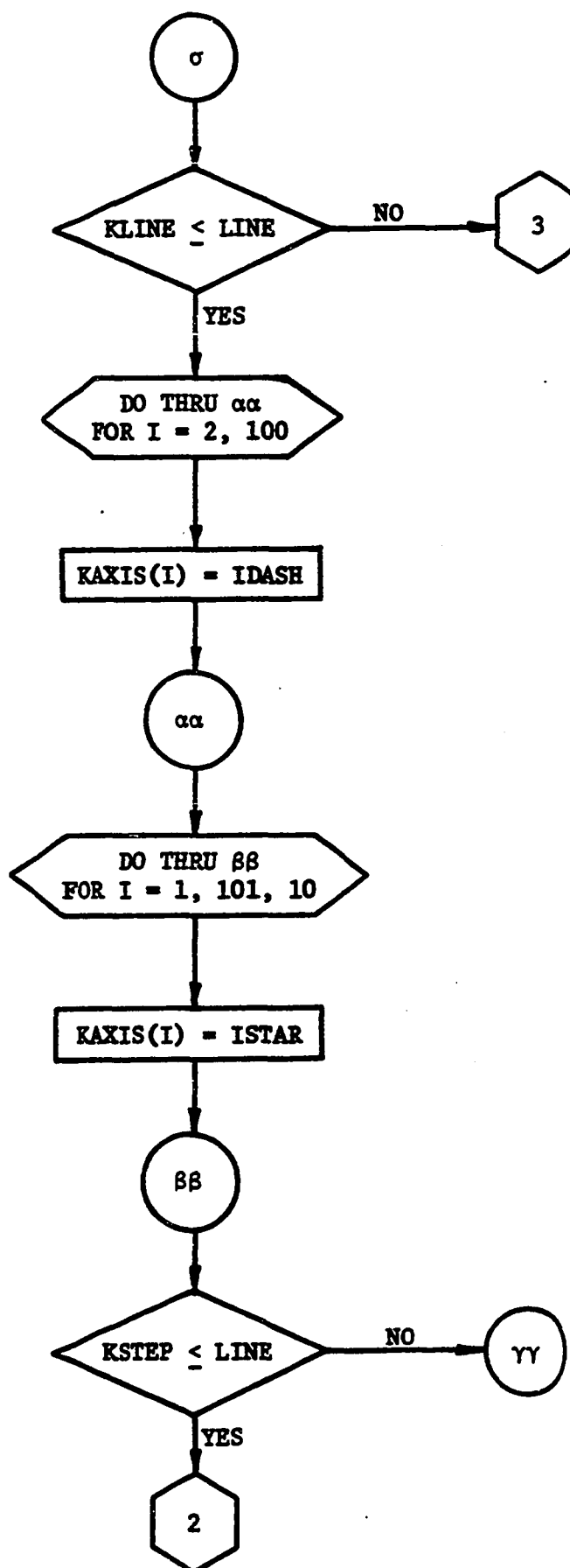
FLOW CHART FOR SUBROUTINE YGRAPH

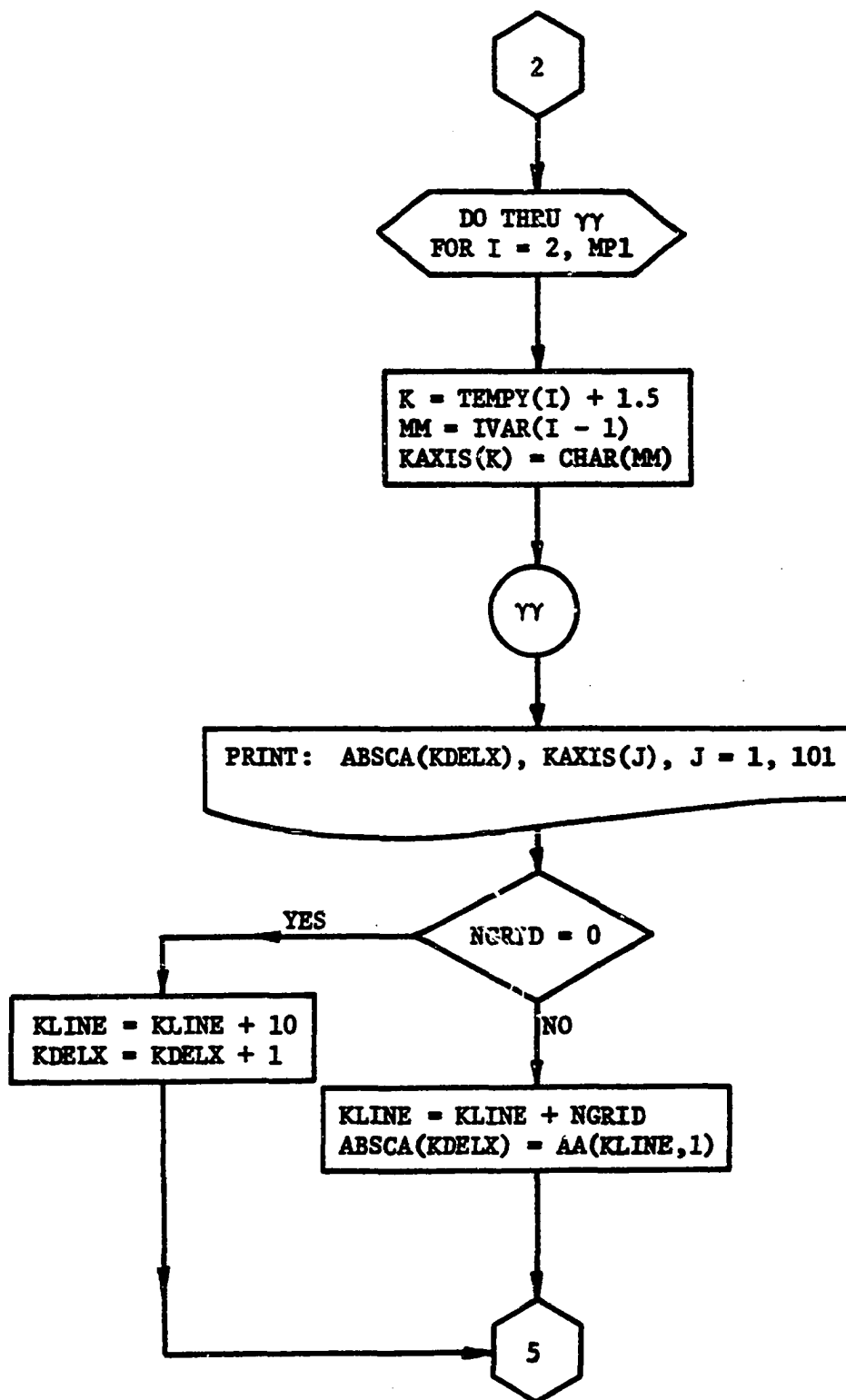


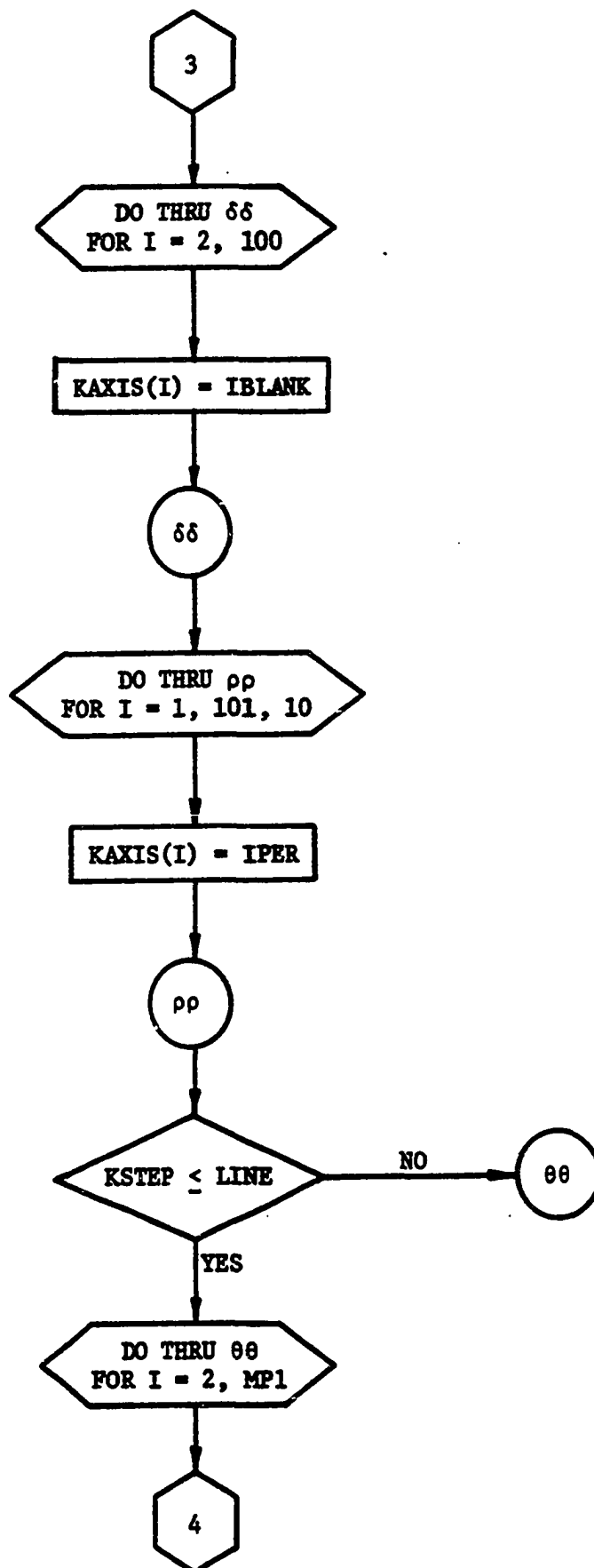


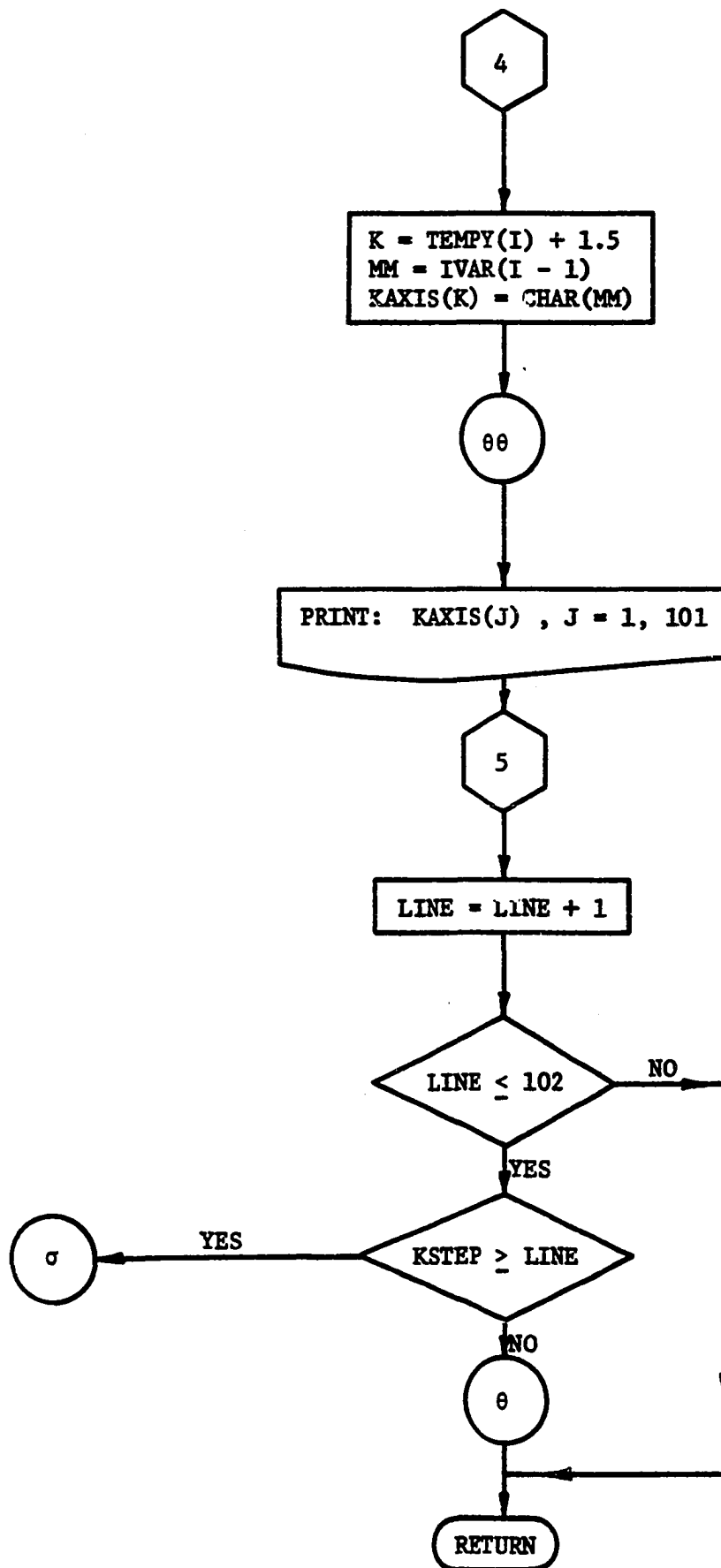












COMPUTER PROGRAMS

```

SJC8          ,KP=29,TIME=20,PAGES=100
C *****
C * MULT=MULTIPLIER *
C * NR=NUMBER OF RUNS *
C * IX=INITIAL RANDOM INTEGER *
C * ITLIM=TIME LIMIT IN YEARS *
C * AGR=EMPIRICAL CONSTANTS *
C * TO=TIME ZERO *
C * NC=NUMBER OF CLASSES *
C * PD=PROB.OF DRY HOLE *
C * KCNEL=NC.OF WELLS LIMIT *
C * NOPRNT=NO.OF WELLS INCREMENT *
C * DEPMIN=MIN.DEPTH *
C * DEPMAX=MAX.DEPTH *
C * THIMIN=MIN.THICKNESS *
C * THIMAX=MAX.THICKNESS *
C * TOTINT=TOTAL INTERVAL *
C * DISCUM=CUM.DISCOVERY FOR ALL K BASINS *
C * GWFOC=TOTAL FCCTAGE DRILLED IN ALL K BASINS *
C * GWFOOT=CUM.FCCTAGE DRILLED *
C * RESEC=CUM.RESERVE *
C * RESERV=INC.RESERVE FOR ALL K BASINS *
C * GWFOI=INC.FCOTAGE DRILLED IN ALL K BASINS *
C * DISCRA=DISCOVERY RATE FOR ALL K BASINS *
C * COISR=CUM.DISCOVERY RATE FOR ALL K BASINS *
C * DISRAT=DISCOVERY RATE *
C * GWFOIN=INC.GAS WELL FOOTAGE *
C * CDSRA=CUM.DISCOVERY RATE *
C * RESEIN=INC.RESERVE *
C *****
1  DIMENSION UPL(15,10),FIELDS(15,10),FREQ(15,10),CMARK(15,10),PROC(1
    15,10),PROB(15,10),CUMP(15,10),FFINDS(15,10),RFINDS(15,10),RESCUM(1
    25,10),FIECUM(15,10),DHCUM(15,10),RESINC(15,10),FIEINC(15,10),DHINC
    3(15,10),ROFINC(15,10),ROFCUM(15,10),FCUNDH(15,10),FCUMGW(15,10),FI
    4NCDH(15,10),FINCGW(15,10),RPFINC(15,10),RPFECUM(15,10),FORC(15,10),
    5FDRI(15,10)
2  DIMENSION A(10),B(10),TZERO(10),NC(10),PD(10),NOWEL(10),NOFFNT(10)
    1,DEPMIN(10),DEPMAX(10),THIMIN(10),THIMAX(10),TOTINT(10),NCP1(10),N
    2CM1(10),DEP(10),THICK(10),FTOTDH(10),FTOTGW(10),FCOTDH(10),FCOTGW(
    310),APRINT(10),DISCUM(30),RESEC(30,10),GWFOOT(30,10),GWFOC(30),R
    4ESEIN(30,10),GWFOIN(30,10),DISRAT(30,10),CDSRA(30,10),RESERV(30),G
    5WFOOI(30),DISCRA(30),COISR(30),IVAR(10),C(10),D(10)
3  DIMENSION AA(30,10),BB(30,10),CC(30,10),EE(30,10),FF(30,10),GG(30,
    110)
4  COMMON UPL,FIELDS,FREQ,CMARK,PROD,PRCB,CUMP,FFINDS,RFINDS,RESCUM,F
    1IECUM,DHCUM,RESINC,FIEINC,CHINC,ROFINC,ROFCUM,FCUNDH,FCUMGW,FINCDH
    2,FINCGW,RPFINC,RPFECUM,NC,IX,PD,NOWEL,NOPRNT,NR,MULT1,MULT2,CEPMIN,
    3DEPMAX,THIMIN,THIMAX,TOTINT,NCP1,IY,RN,NWELLS,JSAVE,A,B,TZERO,MULT
    43,NCM1,DEP,THICK,FTOTDH,FTOTGW,FOOTDH,FOOTGW,NPRINT,ITLIM,DISCUM,R
    5ESEC,GWFOOT,GWFOC,RESEIN,GWFOIN,DISRAT,CDSRA,RESERV,GWFOI
5  COMMON DISCRA,COISR,IVAR,C,D,FORC,FDRI
C
C  CONVERT MULTIPLIER 1 AND 2 AND 3 INTO REAL VARIABLES
C
6  REAL MULT1(10),MULT2(10),MULT3(10)
7  READ(5,3)NR
C
C  DO LOOP FOR READING INPUT DATA FOR EACH NO. OF RUNS
C
8  DO 500 K=1,NR

```

```

9      READ(5,2)IX
10     READ(5,549)ITLIM
11     READ(5,501)A(K),B(K),TZERO(K)
12     C      READ(5,501)B(K),TZERO(K)
13     READ(5,10)NC(K),PD(K),NOWEL(K),NDPRNT(K)
14     READ(5,231)MULT1(K),MULT2(K)
15     READ(5,9)DEPMIN(K),DEPMAX(K),THIMIN(K),THIMAX(K),TOTINT(K)
16     NICK=NC(K)
17     READ(5,20)(UPL(I,K),FIELDS(I,K),I=1,NICK)
18     500 CONTINUE
19     WRITE(6,4)NR,IX
20     CALL SINGLE
21     C
22     C      DO LOOP FOR PRINTING INPUT DATA & RESULTS FOR EACH NO. OF RUNS
23     C
24     DO 581 K=1,NR
25     WRITE(6,30)NC(K),PD(K),NOWEL(K),NDPRNT(K)
26     WRITE(6,32)MULT1(K),MULT2(K)
27     WRITE(6,11)DEPMIN(K),DEPMAX(K),THIMIN(K),THIMAX(K),TOTINT(K)
28     WRITE(6,502)A(K),B(K),TZERO(K)
29     C      WRITE(6,502)B(K),TZERO(K)
30     C
31     C      PRINT HEACINGS
32     C
33     WRITE(6,40)
34     NICK=NC(K)
35     WRITE(6,20)(UPL(I,K),FIELDS(I,K),I=1,NICK)
36     C
37     C      PRINT HEADINGS
38     C
39     WRITE(6,132)
40     C
41     C      PRINT VALUES FOR CUM.RESERVES,CUM.NO.OF FIELDS,CUM.NO.OF DRY HOLES,IN
42     C      C.RESERVES,INC.NO.OF FIELDS,INC.NO.OF DRY HOLES,INC.RESERVE PER FIELD
43     C      CUM.RESERVE PER FIELD
44     C
45     WRITE(6,133)(RESCUM(J,K),FIECUM(J,K),CHCUM(J,K),RESINC(J,K),FIEINC
46     I(J,K),DHINC(J,K),ROFINC(J,K),RCFCUM(J,K),J=1,JSAVE)
47     WRITE(6,399)
48     C
49     C      PRINT VALUES FOR CUM.DRY HOLE FOOTAGE,CUM.GAS WELL FOOTAGE,CUM.FOOTAG
50     C      E CRILLED,INC.DRY HOLE FOOTAGE,INC.GAS WELL FOOTAGE,INC.FCOTAGE DRILL
51     C      ED,INC.RESERVE PER FOOT,CUM.RESERVE PER FOOT
52     C
53     WRITE(6,401)(FCUNDH(J,K),FCUMGW(J,K),FDRC(J,K),FINCDH(J,K),FINGCW(
54     I(J,K),FORI(J,K),RPFINC(J,K),RPFICUM(J,K),J=1,JSAVE)
55     581 CONTINUE
56     DO 915 IN=1,10
57     915 IVAR(IN)=IN
58     C
59     C      IT=TIME INCREMENT
60     C
61     DO 550 IT=1,ITLIM
62     C
63     C      INITIALIZE CUM.DISCOVERY,AND TOTAL FOOTAGE DRILLED TO ZERC
64     C
65     DISCUM(IT)=0.
66     GWFOOD(IT)=0.
67     TIME=IT
68     DO 504 K=1,NR

```

```

40      IF (TIME.LE.TZERO(K)) GO TO 506
41      TX=TIME-TZERO(K)
      C
      C CALCULATING GAS WELL FOOTAGE USING HYPERBOLIC EQUATION WHICH IS IN TH
      C E FORM OF..... $Y=(T-T_0)/(A+B(T-T_0))$ .....
      C
42      GWFOOT(IT,K)=TX/(A(K)+B(K)*TX)
      C
      C CALCULATING GAS WELL FOOTAGE USING LOGISTIC EQUATION WHICH IS IN THE
      C FORM OF..... $Y=C/(1+D*EXP(-A*(T-T_0)))$ .....
      C
      C      C(K)=1./B(K)
      C      D(K)=99.*EXP(A(K))
      C      GWFOOT(IT,K)=C(K)/(1.+D(K)*EXP(-A(K)*TX))
      C
      C CALCULATING GAS WELL FOOTAGE USING STRAIGHT LINE EQUATION WHICH IS IN
      C THE FORM OF..... $Y=A(T-T_0)$ .....
      C
      C      A(K)=1./B(K)
      C      GWFOOT(IT,K)=A(K)*TX
      C
      C CALCULATING GAS WELL FOOTAGE USING INCREASING DRILLING RATE FUNCTION
      C WHICH HAS AN EQUATION IN THE FORM OF.. $Y=A(T-T_0)/(TOTAL\ TIME-(T-T_0))$ ..
      C
      C      A(K)=1./B(K)
      C      GWFOOT(IT,K)=A(K)*TX/(ITLIN-TX)
      C      GO TO 510
43      506 GWFOOT(IT,K)=0.
44      RESECU(IT,K)=0.
45      GO TO 512
46      510 IF (GWFOOT(IT,K).GE.FDRC(JSAVE,K)) GO TO 511
47      DO 509 J=1,JSAVE
48      IF (GWFOOT(IT,K).GT.FDRC(J,K)) GO TO 509
49      IF (J.NE.1) GO TO 555
50      IF (FDRC(1,K).EQ.0.) GO TO 666
51      AINT=GWFOOT(IT,K)/FDRC(1,K)
52      GO TO 667
53      666 RESECU(IT,K)=0.
54      GO TO 512
55      667 CINT=AINTE*RESCUM(1,K)
56      RESECU(IT,K)=CINT
57      GO TO 512
58      555 JN1=J-1
59      IF (FDRC(J,K).EQ.FDRC(JN1,K)) GO TO 600
60      AINT=(GWFOOT(IT,K)-FDRC(JN1,K))/(FDRC(J,K)-FDRC(JN1,K))
61      GO TO 650
62      600 RESECU(IT,K)=(RESCUM(J,K)+RESCUM(JN1,K))/2.
63      GO TO 512
64      650 CINT=AINTE*(RESCUM(J,K)-RESCUM(JN1,K))
65      RESECU(IT,K)=RESCUM(JN1,K)+CINT
66      GO TO 512
67      509 CONTINUE
68      511 RESECU(IT,K)=RESCUM(JSAVE,K)
69      512 DISCUM(IT)=DISCUM(IT)+RESECU(IT,K)
      C
      C      GWFOOT(IT)=TOTAL FOOTAGE DRILLED IN ALL K BASINS
      C
71      GWFOOT(IT)=GWFOOT(IT)+GWFOOT(IT,K)
72      504 CONTINUE
73      503 CONTINUE

```



```

74      550 CONTINUE
      C
      C  CALCULATION FOR T=1.
      C
75      DO 820 K=1,NR
76      RESEIN(1,K)=RESECU(1,K)
77      GWFOIN(1,K)=GWFOOT(1,K)
78      IF(GWFOOT(1,K).EQ.0)GO TO 854
79      CDSRA(1,K)=RESECU(1,K)/GWFOOT(1,K)
80      IF(GWFOIN(1,K).EQ.0.)GO TO 853
81      DISRAT(1,K)=RESEIN(1,K)/GWFOIN(1,K)
82      GO TO 856
83      854 CDSRA(1,K)=0.
84      853 DISRAT(1,K)=0.
85      856 CONTINUE
      C
      C  CALCULATION FOR T>1.
      C
86      DO 815 IT=2,ITLIM
87      ITM1=IT-1
88      RESEIN(IT,K)=RESECU(IT,K)-RESECU(ITM1,K)
89      GWFOIN(IT,K)=GWFOOT(IT,K)-GWFOOT(ITM1,K)
90      IF(GWFOOT(IT,K).EQ.0)GO TO 857
91      CDSRA(IT,K)=RESECU(IT,K)/GWFOOT(IT,K)
92      IF(GWFOIN(IT,K).EQ.0.)GO TO 862
93      DISRAT(IT,K)=RESEIN(IT,K)/GWFOIN(IT,K)
94      GO TO 815
95      857 CDSRA(IT,K)=0.
96      862 DISRAT(IT,K)=0.
97      815 CONTINUE
98      820 CONTINUE
99      RESERV(1)=DISCUM(1)
100     GWFOOI(1)=GWFOOO(1)
101     IF(GWFOOO(1).EQ.0)GO TO 859
102     CDISR(1)=DISCUM(1)/GWFOOO(1)
103     IF(GWFOOI(1).EQ.0.)GO TO 838
104     DISCRA(1)=RESERV(1)/GWFOOI(1)
105     GO TO 839
106     859 CDISR(1)=0.
107     838 DISCRA(1)=0.
108     839 CONTINUE
109     DO 833 IT=2,ITLIM
110     ITM1=IT-1
111     RESERV(IT)=DISCUM(IT)-DISCUM(ITM1)
112     GWFOOI(IT)=GWFOOO(IT)-GWFOOO(ITM1)
113     IF(GWFOOO(IT).EQ.0)GO TO 876
114     CDISR(IT)=DISCUM(IT)/GWFOOO(IT)
115     IF(GWFOOI(IT).EQ.0.)GO TO 848
116     DISCRA(IT)=RESERV(IT)/GWFOOI(IT)
117     GO TO 849
118     876 CDISR(IT)=0.
119     848 DISCRA(IT)=0.
120     849 CONTINUE
121     833 CONTINUE
122     DO 804 K=1,NR
123     IST=2
124     IF(K-2) 67,68,69
125     67 IST1=IST+1
126     NN=18
127     GO TO 71

```

```

128      68 IST1=IST+3
129      NN=16
130      GO TO 71
131      69 IST1=IST+2
132      NN=17
133      71 CONTINUE
134      DO 914 IM=IST1,ITLIN
135      IM1=IM+1-IST1
136      AA(IM1,1)=IM
137      BB(IM1,1)=IM
138      CC(IM1,1)=IM
139      914 CONTINUE
140      KK=K+1
141      DO 916 IM=IST1,ITLIN
142      IM1=IM+1-IST1
143      AA(IM1,KK)=RESEIN(IM,K)
144      BB(IM1,KK)=RESECU(IM,K)
145      CC(IM1,KK)=CDSRA(IM,K)
146      EE(IM1,1)=GWFOOT(IM,K)
147      FF(IM1,1)=GWFOOT(IM,K)
148      GG(IM1,1)=GWFOOT(IM,K)
149      EE(IM1,KK)=RESEIN(IM,K)
150      FF(IM1,KK)=RESECU(IM,K)
151      GG(IM1,KK)=CDSRA(IM,K)
152      916 CONTINUE
      C
      C PRINT HEACINGS
      C
153      WRITE(6,805)K
154      WRITE(6,901)
155      DO 800 IT=1,ITLIN
156      WRITE(6,900)IT,GWFOIN(IT,K),RESEIN(IT,K),GWFOOT(IT,K),RESECU(IT,K)
157      1,DISRAT(IT,K),CDSRA(IT,K)
      800 CONTINUE
      C
      C MM=NO. OF CURVES IN ONE PLOT
      C
158      MM=1
159      NGRID=0
160      WRITE(6,997)K
      C
      C CALL GRAPHING SUBPROGRAM
      C
161      CALL YGRAPH(AA,MM,NN,NGRID)
162      WRITE(6,998)K
163      CALL YGRAPH(BB,MM,NN,NGRID)
164      WRITE(6,999)K
165      CALL YGRAPH(CC,MM,NN,NGRID)
166      WRITE(6,931)K
167      CALL YGRAPH(EE,MM,NN,NGRID)
168      WRITE(6,932)K
169      CALL YGRAPH(FF,MM,NN,NGRID)
170      WRITE(6,933)K
171      CALL YGRAPH(GG,MM,NN,NGRID)
172      804 CONTINUE
173      KK=2
174      IST=2
175      IST1=IST+1
176      DO 981 IM=IST1,ITLIN
177      IM1=IM+1-IST1

```

```

178      AA(IMI,1)=IN
179      BB(IMI,1)=IN
180      CC(IMI,1)=IN
181      AA(IMI,KK)=RESERV(IM)
182      BB(IMI,KK)=DISCUM(IM)
183      CC(IMI,KK)=CDISR(IM)
184      EE(IMI,1)=GWFOO(IM)
185      FF(IMI,1)=GWFOO(IM)
186      GG(IMI,1)=GWFOO(IM)
187      EE(IMI,KK)=RESERV(IM)
188      FF(IMI,KK)=DISCUM(IM)
189      GG(IMI,KK)=CDISR(IM)
190      981 CONTINUE

C
C PRINT HEADINGS
C
191      WRITE(6,951)
192      WRITE(6,914)
193      WRITE(6,915)(IT,GWFOO(IT),RESERV(IT),GWFOO(IT),DISCUM(IT),DISCRA
194      1(IT),CDISR(IT),IT=1,ITLIN)
195      WRITE(6,982)

C
C NN=NO.OF DATA POINTS
C
196      NN=18
197      CALL YGRAPH(AA,MM,NN,NGRID)
198      WRITE(6,983)
199      CALL YGRAPH(BB,MM,NN,NGRID)
200      WRITE(6,984)
201      CALL YGRAPH(CC,MM,NN,NGRID)
202      WRITE(6,934)
203      CALL YGRAPH(EE,MM,NN,NGRID)
204      WRITE(6,935)
205      CALL YGRAPH(FF,MM,NN,NGRID)
206      WRITE(6,936)
207      CALL YGRAPH(GG,MM,NN,NGRID)

C
C FORMAT STATEMENTS
C
207      3 FORMAT(15)
208      2 FORMAT(15)
209      545 FORMAT(15)
210      501 FORMAT(3E15.7)
211      C 501 FORMAT(2E15.7)
212      10 FORMAT(110,F5.2,2I10)
213      231 FORMAT(2F10.3)
214      9 FORMAT(5F10.2)
215      20 FORMAT(2F10.0)
216      4 FORMAT(2X,'NO.OF RUNS=',I2/2X,'IX=',I3)
217      30 FORMAT(1H1,2X,'NO.OF CLASSES=',I2/2X,'PROB.OF DRY HOLE=',F4.2/2X,'
218      1NO.OF WELLS LIMIT=',I5/2X,'NDPRNT=',I5)
219      32 FORMAT(2X,'MULTIPLIER1=',F6.2/2X,'MULTIPLIER2=',F6.2)
220      11 FORMAT(2X,'MIN.DEPH=',F10.2/2X,'MAX.DEPH=',F10.2/2X,'MIN.THICKNE
221      1SS=',F5.2/2X,'MAX.THICKNESS=',F9.2/2X,'TOTAL INTERVAL=',F9.2)
222      502 FORMAT(2X,'A(K)='E15.7/2X,'B(K)='E15.7/2X,'TZERO(K)='E15.7)
223      C 502 FORMAT(2X,'B(K)='E15.7/2X,'TZERO(K)='E15.7)
224      40 FORMAT(6X,'UPL(I)',1X,'FIELDS(I)')
225      132 FORMAT(1H1,2X,'RESERVE CUM.',5X,'FIELD CUM.',3X,'DRY HOLE CUM.',
226      1,2X,'RESERVE INC.',5X,'FIELD INC.',3X,'DRY HOLE INC.',2X,'INC.RES/
227      2WELLS',2X,'CUM.RES/CUM.W')

```

```

222 133 FORMAT(/,8E15.7)
223 399 FORMAT(///,2X,'CUM.DRY HOLE',3X,'CUM.GAS WELL',3X,'CUM.FOOTAGE',4X
    1,'INC.DRY HOLE',3X,'INC.GAS WELL',3X,'INC.FOOTAGE',5X,'INC.RESERVE
    2',4X,'CUM.RESERVE',/,4X,'FOOTAGE',8X,'FOOTAGE',8X,'DRILLED',2X,'FCO
    3TAGE',8X,'FCOTAGE',8X,'CRILLED',8X,'PER FOOT',7X,'PER FOOT')
224 401 FORMAT(/,8E15.7)
225 805 FORMAT(1H1,/,55X,'REGION',I3)
226 901 FORMAT(//,5X,'TIME',5X,'INC.FOOTAGE',7X,'INC.RESERVE',7X,'CUM.FOOT
    1AGE',7X,'CUM.RESERVE',5X,'DISCOVERY RATE',3X,'CUM.DISCOVERY RATE',/
    283X,'(INC.RES/INC.FT)',3X,'(CUM.RES/CUM.FT)')
227 900 FORMAT(1+0,2X,15,6E18.7)
228 997 FORMAT(1+1,/,41X,'PLOT OF INC.RESERVE VS.TIME FOR REGION',I3)
229 998 FORMAT(1H1,/,41X,'PLOT OF CUM.RESERVE VS.TIME FOR REGION',I3)
230 999 FORMAT(1+1,/,29X,'PLOT OF CUM.DISCOVERY RATE VS.TIME FOR REGION',I
    13)
231 931 FORMAT(1H1,/,42X,'PLOT OF INC.RESERVE VS.FOOTAGE FOR REGION',I3)
232 932 FORMAT(1H1,/,42X,'PLOT OF CUM.RESERVE VS.CUM.FOOTAGE FOR REGION',I
    13)
233 933 FORMAT(1H1,/,32X,'PLOT OF CUM.DISCOVERY RATE VS. CUM.FCCTAGE FOR R
    1EGION',I3)
234 951 FORMAT(1H1,/,41X,'COMPOSITE PARAMETERS FOR ALL K BASINS')
235 914 FORMAT(//,5X,'TIME',5X,'INC.FOOTAGE',7X,'INC.RESERVE',6X,'TOTAL FO
    1OTAGE',5X,'CUM.DISCOVERY',5X,'DISCOVERY RATE',3X,'CLM.DISCOVERY RA
    2TE',/51X,'DRILLED',26X,'(INC.RES/INC.FT)',2X,'(CUM.RES/TOTAL FT)')
236 915 FORMAT(1+0,2X,15,6E18.7)
237 982 FORMAT(1H1,/,41X,'COMPOSITE PLOT OF INC.RESERVE VS.TIME')
238 983 FORMAT(1H1,/,40X,'COMPOSITE PLOT OF CUM.DISCOVERY VS.TIME')
239 984 FORMAT(1H1,/,32X,'COMPOSITE PLOT OF CUM.DISCOVERY RATE VS. TIME')
240 934 FORMAT(1H1,/,38X,'COMPOSITE PLOT OF INC.RESERVE VS.FOOTAGE')
241 935 FORMAT(1+1,/,36X,'COMPOSITE PLOT OF CLM.DISCOVERY VS.CUM.FCCTAGE')
242 936 FORMAT(1H1,/,29X,'COMPOSITE PLOT OF CUM.DISCOVERY RATE VS.CUM.FOOT
    1AGE')
243 STOP
244 END

245 SUBROUTINE SINGLE
C *****
C * UPL=UPPER LIMIT *
C * FIELDS=NUMBER OF FIELDS *
C * FREQ=FREQUENCY *
C * CHARK=CLASS MARK *
C * PROD=PRODUCT *
C * PROB=PROBABILITY *
C * CUMPR=CUM.PROBABILITY *
C * FFINDS=NO.OF FIELDS FIND *
C * RFINDS=RESERVE FIND *
C * RESCUM=CUM.RESERVE *
C * FIECUM=CUM.FIELDS FIND *
C * DFCUM=CUM.NO.OF DRY HOLE *
C * RESINC=INC.RESERVE *
C * FIEINC=INC.FIELDS FIND *
C * DHINC=INC.NO.OF DRY HOLE *
C * RCFINC=INC.RESERVE PER FT.DRILLED *
C * RCFCUM=CUM.RESERVE PER FT.DRILLED *
C * FCUMDH=CUM.DRY HOLE FOOTAGE *
C * FCUMGW=CUM.GAS WELL FOOTAGE *
C * FORDC=CUM.FCOTAGE DRILLED *
C * FINCDH=INC.DRY HOLE FOOTAGE *
C * FINCGW=INC.GAS WELL FOOTAGE *
C * FORDI=INC.FOOTAGE DRILLED *

```

```

C * RPFINC=INC.RESERVE PER FOOT *
C * RPFCEUM=CUM.RESERVE PER FOOT *
C *****
246 DIMENSION UPL(15,10),FIELDS(15,10),FREQ(15,10),CMARK(15,10),PROD(1
15,10),PROB(15,10),CUMP(15,10),FFINDS(15,10),RFINDS(15,10),RESCUM(1
25,10),FIECUM(15,10),DHCUM(15,10),RESINC(15,10),FIEINC(15,10),DHINC
3(15,10),ROFINC(15,10),ROFCUM(15,10),FCUMDH(15,10),FCUMGW(15,10),FI
4NCDH(15,10),FINGGW(15,10),RPFINC(15,10),RPFCEUM(15,10),FDRFC(15,10),
5FDRI(15,10)
247 DIMENSION A(10),B(10),TZERC(10),NC(10),PD(10),NWEL(10),NDPENT(10)
1,DEPMIN(10),DEPMAX(10),THIMIN(10),THIMAX(10),TOTINT(10),NCP1(10),N
2CM1(10),DEP(10),THICK(10),FTOTCH(10),FTOTGW(10),FOOTDH(10),FOOTGW(
310),NPRINT(10),DISCUM(30),RESECU(30,10),GWFOOT(30,10),GWFOCC(30),R
4ESEIN(30,10),GWFOIN(30,10),DISRAT(30,10),COSRA(30,10),RESERV(30),G
5WFOCI(30),DISCRA(30),COISR(30),IVAR(10),C(10),D(10)
248 DIMENSION AA(30,10),BB(30,10),CC(30,10),EE(30,10),FF(30,10),GG(30,
110)
249 COMMON UPL,FIELDS,FREQ,CMARK,PFCO,PRCE,CUMP,FFINDS,RFINDS,RESCUM,F
1IECUM,DHCUM,RESINC,FIEINC,DHINC,ROFINC,ROFCUM,FCUMDH,FCUMGW,FINC DH
2,FINGGW,RPFINC,RPFCEUM,NC,IX,PD,NWEL,NPRINT,NR,MULT1,MULT2,DEPMIN,
3DEPMAX,THIMIN,THIMAX,TOTINT,NCP1,IY,RN,NWELLS,JSAVE,A,E,TZERC,MULT
43,NCH1,DEP,THICK,FTOTDH,FTOTGW,FOOTDH,FOOTGW,NPRINT,ITLIM,DISCUM,R
5SESECU,GWFOOT,GWFOCI,RESEIN,GWFOIN,DISRAT,COSRA,RESERV,GWFOCI
250 COMMON DISCRA,COISR,IVAR,C,D,FDRFC,FDRI
251 REAL MULT1(10),MULT2(10),MULT3(10)
252 !XX=IX
253 DO 1000 K=1,NR
254 !X=IXX
255 NWELLS=0
256 NCP1(K)=NC(K)+1
257 NCP1K=NCP1(K)
258 FREQ(NCP1K,K)=0.
259 PRCD(NCP1K,K)=0.
260 FIELDS(NCP1K,K)=0.
C
C J=NC, CF WELLS PER PASS THROUGH SUBROUTINE SINGLE
C
261 J=1
C
C CALCULATING THE CLASS MARKS
C
262 CMARK(1,K)=SORT(UPL(1,K)*MULT1(K)*UPL(1,K))
263 NCP1(K)=NC(K)+1
264 NCP1K=NCP1(K)
265 CMARK(NCP1K,K)=0.
266 NCM1(K)=NC(K)-1
267 NCM1K=NCM1(K)
268 DO 35 I=2,NCM1K
269 IM1=I-1
270 35 CMARK(I,K)=SORT(UPL(I,K)*UPL(IM1,K))
271 NICK=NC(K)
272 CMARK(NICK,K)=SORT(UPL(NCM1K,K)*MULT2(K)*UPL(NCM1K,K))
273 NCP1(K)=NC(K)+1
274 NCP1K=NCP1(K)
275 DO 111 I=1,NCP1K
276 FFINDS(I,K)=0.
277 111 RFINDS(I,K)=0.
278 FTOTDH(K)=0.
279 FTOTGW(K)=0.
280 NPRINT(K)=NPRINT(K)

```

```

281      36 NWELLS=NWELLS+1
      C
      C CALCULATING THE FREQUENCIES
      C
282      SUM1=0.
283      NICK=NC(K)
284      DO 15 I=1,NICK
285      15 SUM1=SUM1+FIELDS(I,K)
286      DO 25 I=1,NICK
287      25 FREQ(I,K)=FIELDS(I,K)/SUM1
      C
      C CALCULATING THE PRODUCTS
      C
288      DO 45 I=1,NICK
289      45 PROD(I,K)=CMARK(I,K)*FREQ(I,K)
290      NCP1(K)=NC(K)+1
291      NCP1K=NCP1(K)
292      SUM2=0.
293      DO 55 I=1,NICK
294      55 SUM2=SUM2+PROD(I,K)
      C
      C CALCULATING THE PROB.
      C
295      PRCB(I,K)=(PROD(I,K)/SUM2)*(1.-PD(K))
296      CUMP(I,K)=PROB(I,K)
297      DO 65 I=2,NICK
298      65 PROB(I,K)=(PROD(I,K)/SUM2)*(1.-PD(K))
299      IM1=I-1
300      CUMP(I,K)=CUMP(IM1,K)+PROB(I,K)
301      PROB(NCP1K,K)=PD(K)
302      CUMP(NCP1K,K)=CUMP(NICK,K)+PROB(NCP1K,K)
303      IF (NWELLS.NE.1) GO TO 169
304      NCP1(K)=NC(K)+1
305      NCP1K=NCP1(K)
306      DO 106 I=1,NCP1K
307      106 FFINDS(I,K)=0.
308      RFINDS(I,K)=0.
309      WRITE(6,206)
310      WRITE(6,296)
311      WRITE(6,50)(FREQ(I,K),CMARK(I,K),PROD(I,K),PRCB(I,K),CUMP(I,K),FFI
INDS(I,K),RFINDS(I,K),FIELDS(I,K),I=1,NCP1K)
312      169 CONTINUE
      C
      C GENERATING THE RANDOM NUMBERS
      C
313      CALL RANDU(IX,IY,RN)
314      IX=IY
315      NCP1(K)=NC(K)+1
316      NCP1K=NCP1(K)
317      DO 75 I=1,NCP1K
318      75 IF (RN.LT.CUMP(I,K)) GO TO 76
319      GO TO 75
320      76 ICLASS=I
321      FFINDS(I,K)=FFINDS(I,K)+1.
322      RFINDS(I,K)=RFINDS(I,K)+CMARK(I,K)
323      FIELDS(I,K)=FIELDS(I,K)-1.
324      GO TO 177
325      75 CONTINUE
326      177 CONTINUE
327      CALL RANDU(IX,IY,RN)

```

```

328      IX=IY
329      CEP(K)=DEPMIN(K)+RN*(DEPMAX(K)-DEPMIN(K))
330      IF (ICLASS.EC.NCPIK)GO TO 328
331      CALL RANDU(IX,IY,RN)
332      IX=IY
333      THICK(K)=THIMIN(K)+RN*(THIMAX(K)-THIMIN(K))
334      FOOTDH(K)=0.
335      FOOTGW(K)=DEP(K)-TOTINT(K)-THICK(K)
336      FTOTGW(K)=FTOTGW(K)+FOOTGW(K)
337      GO TO 329
338 328 FOOTDH(K)=DEP(K)
339      FTOTDH(K)=FTOTDH(K)+FOOTDH(K)
340      THICK(K)=0.
341      FOCTGW(K)=0.
342 329 CONTINUE
343      NCPI(K)=NC(K)+1
344      NCPIK=NCPI(K)
345      IF (NWELLS.NE.NPRINT(K)) GO TO 88
346      WRITE(6,199)
347      WRITE(6,200)IX,IY,RN
348      WRITE(6,212) NWELLS
349      WRITE(6,49)
350      FIELDS(NCPIK,K)=-FIELDS(NCPIK,K)
351      WRITE(6,50)(FREQ(I,K),CHARK(I,K),PROD(I,K),PROB(I,K),CUM(I,K),FFI
INDS(I,K),RFINDS(I,K),FIELDS(I,K),I=1,NCPIK)
352      FIELDS(NCPIK,K)=-FIELDS(NCPIK,K)
353      RESCUM(J,K)=0.
354      FIECUM(J,K)=0.
355      DHCUM(J,K)=0.
356      FCUMDH(J,K)=0.
357      FCUMGW(J,K)=0.
358      DO 85 I=1,NICK
359      NCPI(K)=NC(K)+1
360      NCPIK=NCPI(K)
361      RESCUM(J,K)=RESCUM(J,K)+RFINDS(I,K)
362      FIECUM(J,K)=FIECUM(J,K)+FFINDS(I,K)
363 85 CONTINUE
364      CHCUM(J,K)=FFINDS(NCPIK,K)
365      FCUMDH(J,K)=FTOTDH(K)
366      FCUMGW(J,K)=FTOTGW(K)
367      IF (J.EQ.1) GO TO 86
C
C  CALCULATION FOR J>1
C
368      JM1=J-1
369      RESINC(J,K)=RESCUM(J,K)-RESCUM(JM1,K)
370      FIEINC(J,K)=FIECUM(J,K)-FIECUM(JM1,K)
371      CHINC(J,K)=CHCUM(J,K)-DHCUM(JM1,K)
372      FINCDH(J,K)=FCUMDH(J,K)-FCUMDH(JM1,K)
373      FINCGW(J,K)=FCUMGW(J,K)-FCUMGW(JM1,K)
C
C  RCFINC=INCREMENTAL RESERVE PER FT.DRILLED=INC.PRODUCTIVITY
C
374      RCFINC(J,K)=RESINC(J,K)/(FIEINC(J,K)+CHINC(J,K))
C
C  ROPCUM=CUMULATIVE RESERVE PER FT.DRILLED=CUM.PRODUCTIVITY
C
375      ROPCUM(J,K)=RESCUM(J,K)/(FIECUM(J,K)+DHCUM(J,K))
376      FORI(J,K)=FINCGW(J,K)+FINCDH(J,K)
377      RPFINC(J,K)=RESINC(J,K)/(FINCGW(J,K)+FINCDH(J,K))

```

```

378      FDRC(J,K)=FCUMGW(J,K)+FCUMDH(J,K)
379      RPFUM(J,K)=RESCUM(J,K)/(FCUMGW(J,K)+FCUMDH(J,K))
380      GO TO 87
C
C   CALCULATION FOR J=1
C
381      86 RESINC(1,K)=RESCUM(1,K)
382      FIEINC(1,K)=FIECUM(1,K)
383      CHINC(1,K)=CHCUM(1,K)
384      FINCDH(1,K)=FCUMDH(1,K)
385      FINCGW(1,K)=FCUMGW(1,K)
386      ROFINC(1,K)=RESINC(1,K)/(FIEINC(1,K)+CHINC(1,K))
387      ROFCUM(1,K)=RESCUM(1,K)/(FIECUM(1,K)+CHCUM(1,K))
388      FDRI(1,K)=FINCGW(1,K)+FINCDH(1,K)
389      RPFINC(1,K)=RESINC(1,K)/(FINCGW(1,K)+FINCDH(1,K))
390      FDRC(1,K)=FCUMGW(1,K)+FCUMDH(1,K)
391      RPFUM(1,K)=RESCUM(1,K)/(FCUMGW(1,K)+FCUMDH(1,K))
392      87 JSAVE=J
393      J=J+1
394      NPFRINT(K)=NPRINT(K)+NDPRNT(K)
395      88 IF (NWELLS-NCWEL(K))91,92,92
396      91 GO TO 36
397      92 CONTINUE
398      1000 CONTINUE
C
C   FORMAT STATEMENTS
C
399      199 FORMAT(//,24X,'IX',18X,'IY',17X,'RANDOM NO. ')
400      200 FORMAT(20X,I10,10X,I10,10X,E15.7)
401      212 FORMAT(5X,'NO. OF WELLS=',I5)
402      206 FORMAT(45X,'INITIAL FIELD SIZE DISTRIBUTION')
403      296 FORMAT(//,4X,'FREQUENCY',5X,'CLASS MARK',7X,'PRODUCT',6X,'PROBABIL
        1ITY',5X,'CUM. PROB.',5X,'FIELD FIND',4X,'RESERVE FIND',2X,'FIELD RE
        2MAINING')
404      49 FORMAT(//,4X,'FREQUENCY',5X,'CLASS MARK',7X,'PRDUCT',6X,'FRCBAREIL
        1ITY',5X,'CUM. PROB.',5X,'FIELD FIND',4X,'RESERVE FIND',6X,'FIELD')
405      50 FORMAT(/,8E15.7)
406      RETURN
407      END
408      SUBROUTINE YGRAPH(AA,M, N, NGRID)
C
C   THIS SUBROUTINE PLOTS UP DIFFERENT PARAMETERS VS. TIME, INC. FOOTAGE, AN
C   D CUM. FOOTAGE
C   THIS SUBROUTINE PLOTS UP TO 8 VARIABLES VERSUS TIME, INC. FOOTAGE OR
C   CUM. FOOTAGE
C   THIS IS BOTH A X-T AND X-Y PLOT ROUTINE
C
409      DIMENSION UPL(15,10), FIELDS(15,10), FREQ(15,10), CMARK(15,10), PROC(1
        15,10), PROB(15,10), CUMF(15,10), PFINDS(15,10), RFINDS(15,10), RESCUM(1
        25,10), FIECUM(15,10), CHCUM(15,10), RESINC(15,10), FIEINC(15,10), OHINC
        3(15,10), ROFINC(15,10), ROFCUM(15,10), FCUMDH(15,10), FCUMGW(15,10), FI
        4NCDH(15,10), FINCGW(15,10), RPFINC(15,10), RPFUM(15,10), FDRC(15,10),
        5FDRI(15,10)
410      DIMENSION A(10), B(10), TZERO(10), NC(10), PD(10), NCWEL(10), NDFRAT(10)
        1, DEPMIN(10), DEPMAX(10), THIMIN(10), THIMAX(10), TCTINT(10), NCP1(10), N
        2CMI(10), DEP(10), THICK(10), FTOTDH(10), FTOTGW(10), FCCTDH(10), FCOTGW(
        310), NPFRINT(10), DISCUM(30), RESEC(30,10), GWFOOT(30,10), GWFOCC(30), R
        4ESEIN(30,10), GWFOIN(30,10), DISRAT(30,10), CDSRA(30,10), RESERV(30), G
        5WFOOI(30), DISCRA(30), CDISR(30), IVAR(10), C(10), D(10)

```



```

411     DIMENSION AA(30,10),BB(30,10),CC(30,10),EE(30,10),FF(30,10),GG(30,
110)
412     DIMENSION ABSCA(11),KAXIS(101),ORDIN(11),TEMPY(5)
413     COMMON UPL,FIELDS,FREQ,CMARK,PFCO,PRCB,CUMP,FFINDS,RFINDS,RESCUM,F
1IECUM,CHCUM,RESINC,FIEINC,DMINC,ROFINC,ROFCUM,FCUMDH,FCUMGW,FINCDH
2,FINCGR,RPFINC,RPFCUM,NC,IX,PD,NOWEL,NOPRNT,NP,MULT1,MULT2,DEPMIN,
3DEPMAX,THIMIN,THIMAX,TOTINT,NCP1,IY,FA,NWELLS,JSAVE,A,E,TZFO,MULT
43,NCM1,DEP,THICK,FTOTDH,FTOTGW,FOOTDH,FOOTGW,NPRINT,ITLIM,DISCUM,R
SESECU,GWFOOT,GWFOOD,RESEIN,GWFCIN,DISFAT,CDSRA,RESERV,GWFOOI
414     COMMON DISCRA,CDISR,IVAR,C,D,FDR,FDR1
415     REAL MULT1(10),MULT2(10),MULT3(10)
416     INTEGER CHAR(15)
417     DATA CHAR(1),CHAR(2),CHAR(3),CHAR(4),CHAR(5),CHAR(6),CHAR(7),
1 CHAR(8),CHAR(9),CHAR(10),CHAR(11),CHAR(12),CHAR(13),CHAR(14),
2 CHAR(15)/1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1HA,1HE,1HU,1PY,1HR,
3 1H /
418     DATA ISTAR,II,IPER,IDASH,IBLANK/1H*,1H1,1H.,1H-,1H /
419     YMAX=AA(1,2)
420     YMIN=AA(1,2)
421     MP1=M+1
422     DO 4 J=2, MP1
423     DO 4 I=1, N
424     IF(YMAX-AA(I,J)) 1, 2, 2
425     1 YMAX=AA(I,J)
426     2 IF(YMIN-AA(I,J)) 4, 4, 3
427     3 YMIN=AA(I,J)
428     4 CONTINUE
429     YSHFT=0.0
430     IF(YMIN) 5, 6, 6
431     5 YSHFT=YMIN*100.0/(YMAX-YMIN)
432     6 NM1=N-1
433     DO 8 I=1, NM1
434     IP1=I+1
435     DO 8 K=IP1, N
436     IF(AA(K,1)-AA(I,1)) 7, 8, 8
437     7 DO 88 J=1, MP1
438     ATEMP=AA(I,J)
439     AA(I,J)=AA(K,J)
440     AA(K,J)=ATEMP
441     88 CONTINUE
442     8 CONTINUE
443     C XMIN=AA(1,1)
444     C XMAX=AA(N,1)
445     XMAX=AA(1,1)
446     XMIN=AA(1,1)
447     DO 400 I=2,N
448     IF(XMAX-AA(I,1)) 221,222,222
449     221 XMAX=AA(I,1)
450     222 IF(XMIN-AA(I,1)) 224,224,223
451     223 XMIN=AA(I,1)
452     224 CONTINUE
453     400 CONTINUE
454     ABSCA(1)=XMIN
455     ABSCA(11)=XMAX
456     ORDIN(1)=YMIN
457     ORDIN(11)=YMAX
458     DO 9 I=2, 10
459     Z=I-1
460     ABSCA(I)=(XMAX-XMIN)*Z/10.0+XMIN
461     9 ORDIN(I)=(YMAX-YMIN)*Z/10.0+YMIN

```

```

460      PRINT 100, (ORDIN(J), J=1, 11)
461      STEPX=(XMAX-XMIN)/100.0
462      KDELX=1
463      KLINE=1
464      LINE=1
465      DO 29 IND=1, N
466      IF (NGRID .EQ. 0) GO TO 10
467      KSTEP=LINE
468      GO TO 11
469      10 KSTEP=(AA(IND,1)-XMIN)/STEPX+1.5
470      11 DO 12 J=2, MP1
471      12 TEMPY(J) = (AA(IND,J)-YMIN)*100./(YMAX-YMIN)-YSHFT
472      13 IF (KLINE-LINE) 14, 14, 21
473      14 DO 15 I=2, 100
474      15 KAXIS(I)=IDASH
475      DO 16 I=1, 101, 10
476      16 KAXIS(I)=ISTAR
477      IF (KSTEP-LINE) 17, 17, 19
478      17 DO 18 I=2, MP1
479      K=TEMPY(I)+1.5
480      MM=IVAR(I-1)
481      18 KAXIS(K)=CHAR(MM)
482      19 PRINT 101, ABSCA(KDELX), (KAXIS(J), J=1, 101)
483      IF (NGRID .EQ. 0) GO TO 20
484      KLINE=KLINE+NGRID
485      ABSCA(KDELX)=AA(KLINE,1)
486      GO TO 27
487      20 KLINE=KLINE+10
488      KDELX=KDELX+1
489      GO TO 27
490      21 DO 22 I=2, 100
491      22 KAXIS(I)=IBLANK
492      DO 23 I=1, 101, 10
493      23 KAXIS(I)=IPER
494      IF (KSTEP-LINE) 24, 24, 26
495      24 DO 25 I=2, MP1
496      K=TEMPY(I)+1.5
497      MM=IVAR(I-1)
498      25 KAXIS(K)=CHAR(MM)
499      26 PRINT 102, (KAXIS(J), J=1, 101)
500      LINE=LINE+1
501      IF (LINE-102) 28, 28, 30
502      28 IF (KSTEP-LINE) 29, 13, 13
503      29 CONTINUE
504      30 RETURN
505      100 FORMAT(////,9X,11(IPE10.2))
506      101 FORMAT(1PE13.2,2X,101A1)
507      102 FORMAT(15X,101A1)
508      END

```