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Liquid Hydrocarbon Production in the United States, 1946-75 and 1980 Projected, Highlighting Enhanced Recovery

UNITED STATES DEPARTMENT OF THE INTERIOR

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By M. Carrales, Jr., and Velton T. Funk

UNITED STATES DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary

BUREAU OF MINES

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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LIQUID HYDROCARBON PRODUCTION IN THE UNITED STATES, 1946-75 AND 1980 PROJECTED, HIGHLIGHTING ENHANCED RECOVERY

by

M. Carrales, Jr.,[1] and Velton T. Funk[1]

ABSTRACT

This Bureau of Mines publication presents short-range projections of domestic liquid hydrocarbon production through 1980. Appraisal of future crude oil production was made by evaluating the relationship between primary and enhanced oil recovery and the total crude oil producing trends in each of the oil-producing areas of the United States. Future natural gas liquid production was generally estimated by projecting historical production. Estimates of production were prepared for each of the oil producing areas and summarized for the Petroleum Administration for Defense (PAD) districts and total United States.

From 1975 to 1980, crude oil production for the conterminous United States is expected to decline from 7.8 to 6.4 million barrels of oil per day (BOPD), and it is expected to increase from 8.0 to 8.2 million BOPD for the total United States. However, these estimates do not include additional production expected from the Elk Hills field in California and the Yates field in Texas. If included, 1980 production for the conterminous United States would be 6.7 million BOPD and 8.4 million BOPD for the total United States.

INTRODUCTION

During the past 50 years the petroleum industry has greatly improved crude oil recovery technology. Research continues to improve primary and secondary recovery methods, as well as to develop tertiary recovery methods. The research is directed toward assuring maximum utilization of domestic oil resources that are the storehouse to which new discoveries will be added and from which future crude oil production must come. The rate at which crude oil can be withdrawn from this storehouse is critical in evaluating requirements for U.S. energy. Increasing oil imports and growth of energy consumption along with the prospect of future oil embargoes as experienced during the winter of 1973-74, emphasize the need to evaluate the short-range availability of domestic crude oil.

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This report presents an appraisal of domestic production for the short run to 1980, and also a historical review of the relationship between primary and enhanced oil production. Appraisal of domestic liquid hydrocarbon production is given for this time frame under an assumed set of supply conditions. Because of the long lead time required to discover and develop new oil reserves, most of the domestic oil production through 1980 is expected to come from known resources using present-day technology.

The term "enhanced oil recovery" used in this report is in its broadest sense. That is, it includes pressure maintenance and conventional secondary recovery methods, and the more exotic oil recovery methods such as thermal, carbon dioxide flooding, and the chemical flooding processes. The National Petroleum Council (NPC), in its recent report to the Department of the Interior, entitled "Enhanced Oil Recovery," December 1976, considers enhanced recovery in a narrower sense covering only the more advanced processes, and does not include the conventional secondary recovery methods. The Energy Research and Development Administration (ERDA) and the Federal Energy Administration (FEA) consider "enhanced oil recovery" to include only the advanced methods.

Since the mid-1950's, enhanced crude oil production has contributed substantially to the Nation's total annual oil production. This was brought about by improved pressure maintenance and waterflood technology necessitated by the decline in domestic exploration. With the large backlog of potential waterflood and pressure maintenance prospects available during the early 1950's, the use of enhanced oil recovery technology increased rapidly and continued to increase through the 1970's. Eventually, however, it is inevitable that the rate of growth in new enhanced recovery projects and resultant oil production will decrease as the backlog of prospects declines.

The basic premises of this study are that (1) development of tertiary recovery technology will be successful technically and economically but will not contribute much to the Nation's oil production by 1980 because of the lag time required between large-scale project initiation and the realization of significant improvement in the total output, and (2) there will be no major change in Government policies and regulations that will alter the economic climate for the petroleum industry and result in either a decrease or increase of the recent exploration trends. The premises differ from those used in other studies (5, 7)[2] that provide estimates of much higher oil production during 1980 as a result of escalating technology and exploration.

Terminology

Some of the terms in this report are explained as follows:

Condensate production.--There are no uniform definitions of condensate among the various States production included in this report. Therefore, if a State reported production as condensate, this reported production was used in the report as condensate.

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[2]Underlined numbers in parentheses refer to items in the list of references preceding the appendix.

Crude oil production.--Crude oil production figures used in this study, are those reported by the States and do not include lease condensate unless it is included in a State's total production.

Enhanced oil production.--Production from fields or reservoirs that are undergoing injection of fluid providing extraneous energy to the reservoir. Fluid injection methods included are pressure maintenance, secondary, thermal, and tertiary recovery. For some fields, total field production was classified as enhanced oil although only a small part of the produced oil could be directly attributed to the enhanced recovery process. This classification tends to overemphasize the growth of enhanced oil recovery in some areas, but this was done only when total field production was all that was published.

Liquid hydrocarbons.--All natural liquid fossil fuel hydrocarbon regardless of method of production. Liquid hydrocarbons include crude oil and natural gas liquids.

Natural gas liquid production.--Production which includes natural gasoline, liquefied petroleum gases (LPG), and condensate. Those hydrocarbon liquids recovered in connection with the processing of natural gas.

Pressure maintenance.--A method of enhanced recovery in which a fluid under pressure is injected into the producing formation to maintain adequate reservoir pressure or retard pressure decline to increase efficiency and recovery of crude oil.

Primary oil production.--Production obtained from reservoirs due to natural energy drive and/or artificial lift before any application of enhanced recovery methods.

Total wells drilled.--All wells drilled as reported in the Forecast Review issue of World Oil from 1947-75 (except service wells).

Data Sources and Estimating Methods

For consistency, historical production data were taken from State regulatory agency publications to the maximum extent possible. Other sources used were the annual reports of the American Petroleum Institute (API), Independent Petroleum Association of America, International Oil Scouts Association, Conservation Committee of California Oil Producers, National Stripper Well Association, and Federal Bureau of Mines Minerals Yearbook. In most cases, enhanced oil production data were obtained from State publications directly, or they were developed from a list of active enhanced recovery projects. There were some exceptions, such as New York, Pennsylvania, West Virginia, Kentucky, and Ohio, for which enhanced oil recovery data are not published. For these States, it was assumed that all enhanced oil production in each State would be classified as stripper production; therefore, enhanced oil production data were taken or derived from enhanced oil recovery information published by the National Stripper Well Association. Enhanced oil production for Missouri was obtained verbally (by telephone) from the Missouri Department of Natural Resources, Division of Research and Technical Information.

Some modifications of the published enhanced oil production data were made for this study. These modifications involved: (1) Deletion of cycling projects in Louisiana and Texas to avoid including condensate or natural gas liquids as crude oil production; (2) production from projects in Texas reported as active, but not yet started, was not included in the total enhanced production; (3) total oil production from the East Texas field was included as enhanced oil production; and (4) total enhanced oil production for Louisiana for each year after 1970 was obtained by adding the State enhanced oil production modified, as stated previously, to the enhanced oil production reported by the U.S. Geological Survey for the federally controlled Outer Continental Shelf. Total enhanced production for Texas and Louisiana as used in this report will probably vary from the State published figures because of the modifications.

In California most of the enhanced oil production was developed from a list of active water and/or gas injection projects. The remainder was obtained from the incremental oil production from fields with thermal projects excluding production from those fields listed in the active water and/or gas injection projects.

General assumptions for this study were made to establish a base to estimate future production. The three general assumptions were: (1) There would be no major changes in Government policy and regulation, (2) the economic climate would remain about the same with continuation of the two-tier price system, and (3) the domestic demand for crude oil would continue to exceed the domestic supply.

Several techniques were used in arriving at the estimates of future liquid hydrocarbon production. Historical data such as API proved reserves, annual reserve additions, API indicated additional oil reserves, exploratory and developmental drilling, types and depths of wells completed, relationship of primary and enhanced oil production, associated-dissolved and nonassociated natural gas production, and natural gas processing plant capacity were studied for each area to aid in selecting future producing trends. Based on the activities studied, considerable engineering judgment was applied in estimating the future production, especially where recent producing trends were increasing and in considering future production from new discoveries. In some producing areas where crude oil production had been declining for a long period of time and no new or significant changes in activities had occurred, future production was estimated based on decline-curve analysis which included the assumption that future discoveries would be similar to the recent past. In other areas, published estimates of future production for specific fields (6) were used to establish a portion of the future production for the area and the remaining production for the area was estimated by decline-curve analysis, assuming future discoveries will be similar to those of the recent past. In estimating future enhanced oil production, the relationship between primary and enhanced oil production as well as the API indicated additional oil reserves were the main factors considered. Several articles (1-4) pertaining to production in specific areas also proved helpful in preparing the estimates. It should be noted that for the States that produce relatively small quantities of oil, an unanticipated discovery could affect the 1980 production estimate significantly.

In general, natural gas liquids were not treated in as great detail as crude oil in the preparation of the estimates. Basically, historical producing trends were used in estimating natural gas liquid production. The producing trends in either natural gas liquid production or in crude oil plus natural gas liquid production (total liquid hydrocarbons) were projected.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the use of information from publications of State oil and gas agencies, State geologists, American Petroleum Institute, American Association of Petroleum Geologists, Independent Petroleum Association of America, Conservation Committee of California Oil Producers, International Oil Scouts Association, Interstate Oil Compact Commission, National Stripper Well Association, U.S. Geological Survey, and trade journals. The authors also acknowledge the assistance provided by Paul Biggs[3] in obtaining all producing data through 1974 for Arizona, Colorado, Montana, Nebraska, New Mexico, North Dakota, South Dakota, Utah, and Wyoming.

PROJECTION OF LIQUID HYDROCARBON PRODUCTION

The Nation's future supply of liquid hydrocarbons is dependent upon a number of known and unknown factors. The effect of each cannot be evaluated in its entirety due to interrelation of the various factors. However, estimates of future supply can be made if historic and current information is available and certain general assumptions are followed. The estimates presented in this report were made after reviewing such activities as drilling, proved reserves, and production for each area and establishing three general assumptions, namely that, (1) there would be no major changes in current Government policy and regulations, (2) the economic climate would remain about the same with continuation of the two-tiered price system for crude oil, and (3) the domestic demand for crude oil would continue to exceed domestic supply. The estimates of liquid hydrocarbon production through 1980 were done by State and by State subdivisions for Louisiana and Texas, and summarized by PAD districts (fig. 1) and the United States. Total, enhanced, and primary crude oil production for 1971-75 and estimates of 1980 production are presented in tables 1, 2, and 3, respectively, by State and State subdivisions of Louisiana and Texas, and summarized by PAD districts and total United States. It should be noted that the estimates presented in these tables do not include additional production expected from Elk Hills in California (development of the Naval Petroleum Reserve, 200 thousand barrels per day) and the Yates field in Texas (50 thousand barrels per day). However, an estimate of these production estimates are included in the narrative. It should also be noted that the dashed lines on the graphs in this report do not necessarily indicate production during the interim.

TABLE 1. - Total crude oil production, in thousand barrels

District and State	Production					Estimated production
	1971	1972	1973	1974	1975[P]	1980[1]
PAD district I:						
Florida........................	5,347	16,704	32,709	36,360	41,211	36,067
New York.......................	1,126	1,018	967	914	890	610
Pennsylvania...................	3,798	3,441	3,282	4,000	3,910	3,237
Virginia.......................	1	([2])	([2])	3	2	([2])
West Virginia..................	2,969	2,677	2,385	2,665	2,479	2,313
Total......................	13,241	23,840	39,343	43,942	48,492	42,227
PAD district II:						
Illinois.......................	39,084	34,874	30,669	27,553	26,080	15,582
Indiana........................	6,658	6,130	5,312	4,919	4,638	2,985
Kansas.........................	78,532	73,542	66,227	61,692	59,108	46,414
Kentucky.......................	10,692	9,702	8,687	7,960	7,554	5,126
Michigan.......................	11,898	12,990	14,530	18,102	24,413	35,232
Missouri.......................	66	60	60	56	57	54
Nebraska.......................	10,062	8,705	7,204	6,611	6,115	4,206
North Dakota...................	21,654	20,624	20,235	19,697	20,440	18,983
Ohio...........................	8,286	9,358	8,796	9,544	11,704	11,941
Oklahoma.......................	210,372	207,123	189,404	176,716	163,117	143,524
South Dakota...................	230	219	276	406	482	466
Tennessee......................	398	197	201	769	682	481
Total......................	397,932	383,524	351,601	334,025	324,390	284,994
PAD district III:						
Alabama........................	7,794	9,688	11,106	10,929	10,132	8,125
Arkansas.......................	17,371	17,668	17,307	15,784	15,607	14,370
Louisiana, total...............	832,382	784,701	724,986	641,225	571,046	334,277
Offshore....................	422,504	410,214	395,466	359,398	325,787	207,924
Onshore.....................	409,878	374,487	329,520	281,827	245,259	126,353
Mississippi....................	63,429	60,493	55,601	50,407	46,195	37,416
New Mexico.....................	117,410	110,525	100,986	98,695	94,740	82,920
Texas, total...................	1,182,371	1,263,412	1,257,057	1,225,166	1,185,683	1,037,951
RRC 1......................	21,545	23,599	20,356	18,321	17,691	14,956
RRC 2......................	73,250	78,568	74,014	68,444	65,033	57,100
RRC 3......................	154,690	172,143	169,636	168,499	160,991	150,092
RRC 4......................	67,192	58,885	50,789	42,629	35,318	18,085
RRC 5 and 6................	165,250	186,546	183,807	174,267	166,705	142,168
RRC 7B.....................	36,530	38,000	36,257	35,967	34,806	33,359
RRC 7C.....................	35,981	35,115	33,566	29,181	28,171	21,855
RRC 8 and 8A...............	551,995	598,454	622,668	626,813	620,265	560,866
RRC 9......................	51,302	49,231	45,560	41,691	38,373	25,329
RRC 10.....................	24,636	22,871	20,404	19,354	18,330	14,141
Total......................	2,220,757	2,246,487	2,167,043	2,042,206	1,923,403	1,515,059
PAD district IV:						
Colorado.......................	27,391	32,015	36,590	37,508	37,928	29,242
Montana........................	34,599	33,904	34,620	34,019	32,846	31,027
Utah...........................	23,630	26,570	32,544	39,363	39,571	31,000
Wyoming........................	148,114	140,011	141,914	139,997	127,241	110,463
Total......................	233,734	232,500	245,668	250,887	237,586	201,732
PAD district V (without Alaska):						
Arizona........................	1,236	993	804	740	635	353
California.....................	358,423	346,792	335,741	322,519	322,278	299,693
Nevada.........................	113	100	96	129	115	85
Total......................	359,772	347,885	336,641	323,388	323,028	300,131
Total United States (without Alaska)............	3,225,436	3,234,236	3,140,296	2,994,448	2,856,899	2,344,143
Alaska.........................	77,951	72,770	72,323	70,639	69,772	650,430
Total United States...........	3,303,387	3,307,006	3,212,619	3,065,087	2,926,671	2,994,573

[P] Preliminary.

[1] Does not include additional production of 50,000 BOPD from Yates field in Texas and 200,000 BOPD from Elk Hills field in California.

[2] Negligible.

TABLE 2. - Crude oil production by enhanced recovery methods, in thousand barrels

District and State	Production				Estimated production	
	1971	1972	1973	1974	1975	1980
PAD district I:						
Florida.........................	635	579	603	32,135	32,438	26,501
New York.......................	1,042	865	824	762	713	536
Pennsylvania...................	1,520	1,500	1,727	1,680	1,788	2,198
Virginia.......................	0	0	0	0	0	0
West Virginia..................	594	535	481	535	509	463
Total......................	3,791	3,479	3,635	35,112	35,448	29,698
PAD district II:						
Illinois.......................	28,012	25,642	21,916	19,424	18,870	11,224
Indiana........................	3,503	3,086	2,649	2,514	2,335	1,707
Kansas.........................	17,875	17,416	14,713	13,334	12,432	10,208
Kentucky.......................	8,916	7,854	7,236	6,885	6,581	4,613
Michigan.......................	3,142	3,139	3,079	3,070	3,061	3,043
Missouri.......................	26	24	28	22	17	11
Nebraska.......................	5,497	4,530	3,113	2,975	2,661	1,697
North Dakota...................	10,178	10,683	10,118	9,848	10,220	9,662
Ohio...........................	120	90	85	87	77	65
Oklahoma.......................	[e]105,314	100,182	100,624	96,046	88,469	82,963
South Dakota...................	0	0	0	0	0	0
Tennessee......................	0	0	0	0	0	0
Total......................	182,583	172,646	163,561	154,205	144,723	125,193
PAD district III:						
Alabama........................	6,736	6,447	5,710	7,166	6,391	4,498
Arkansas.......................	5,764	5,121	4,516	5,353	4,330	3,304
Louisiana, total...............	240,300	220,487	187,053	154,979	127,965	52,708
Offshore....................	141,192	127,255	112,080	95,895	81,409	37,619
Onshore.....................	99,108	93,232	74,973	59,084	46,556	15,089
Mississippi....................	4,107	6,336	9,275	8,632	10,471	17,239
New Mexico.....................	53,806	49,117	49,698	59,737	56,646	56,752
Texas, total...................	673,908	728,070	753,171	[e]740,582	720,305	620,726
RRC 1......................	4,342	10,812	8,712	[e]7,098	6,599	4,687
RRC 2......................	11,056	11,707	14,108	[e]13,788	13,497	12,385
RRC 3......................	48,013	51,283	52,544	[e]51,677	50,755	46,358
RRC 4......................	37,109	29,346	25,295	[e]20,120	15,050	6,087
RRC 5 and 6................	123,404	136,617	134,228	[e]127,089	121,253	99,392
RRC 7B.....................	15,398	17,294	16,661	[e]17,010	16,425	17,257
RRC 7C.....................	13,273	9,254	8,822	[e]8,260	7,696	5,404
RRC 8 and 8A...............	382,849	425,954	458,140	[e]464,149	460,186	410,185
RRC 9......................	28,189	27,014	27,199	[e]24,560	22,696	15,267
RRC 10.....................	10,275	8,789	7,462	[e]6,831	6,148	3,704
Total......................	984,621	1,015,578	1,009,423	976,449	926,108	755,227
PAD district IV:						
Colorado.......................	15,294	19,086	23,804	25,187	25,790	18,476
Montana........................	27,740	27,170	28,340	28,497	28,109	27,674
Utah...........................	17,297	16,701	14,161	14,318	13,477	11,622
Wyoming........................	104,517	99,044	103,484	100,991	95,989	89,391
Total......................	164,848	162,001	169,789	168,993	163,365	147,163
PAD district V (without Alaska):						
Arizona........................	0	0	0	0	0	0
California.....................	210,216	207,817	206,524	204,880	207,288	200,562
Nevada.........................	0	0	0	0	0	0
Total......................	210,216	207,817	206,524	204,880	207,288	200,562
Total United States (without Alaska).............	1,546,059	1,561,521	1,552,932	1,539,639	1,476,932	1,257,843
Alaska.........................	67,117	66,569	66,429	67,269	66,967	649,505
Total United States...........	1,613,176	1,628,090	1,619,361	1,606,908	1,543,899	1,907,348

[e] Estimate.

TABLE 3. - Crude oil production by primary methods, in thousand barrels

District and State	Production				Estimated production	
	1971	1972	1973	1974	1975	1980[1]
PAD district I:						
Florida........................	4,712	16,125	32,106	4,225	8,773	9,566
New York.......................	84	153	143	152	177	74
Pennsylvania...................	2,278	1,941	1,555	2,320	2,122	1,039
Virginia.......................	1	([2])	([2])	3	2	([2])
West Virginia..................	2,375	2,142	1,904	2,130	1,970	1,850
Total....................	9,450	20,361	35,708	8,830	13,044	12,529
PAD district II:						
Illinois.......................	11,072	9,232	8,753	8,129	7,210	4,358
Indiana........................	3,155	3,044	2,663	2,405	2,303	1,278
Kansas.........................	60,657	56,126	51,514	48,358	46,676	36,206
Kentucky.......................	1,776	1,848	1,451	1,075	973	513
Michigan.......................	8,756	9,851	11,451	15,032	21,352	32,189
Missouri.......................	40	36	32	34	40	43
Nebraska.......................	4,565	4,175	4,091	3,636	3,454	2,509
North Dakota...................	11,476	9,941	10,117	9,849	10,220	9,321
Ohio...........................	8,166	9,268	8,711	9,457	11,627	11,876
Oklahoma.......................	e 105,058	106,941	88,780	80,670	74,648	60,561
South Dakota...................	230	219	276	406	482	466
Tennessee......................	398	197	201	769	682	481
Total....................	215,349	210,878	188,040	179,820	179,667	159,801
PAD district III:						
Alabama........................	1,058	3,241	5,396	3,763	3,741	3,627
Arkansas.......................	11,607	12,547	12,791	10,431	11,277	11,066
Louisiana, total...............	592,082	564,214	537,933	486,246	443,081	281,569
Offshore....................	281,312	282,959	283,386	263,503	244,378	170,305
Onshore.....................	310,770	281,255	254,547	222,743	198,703	111,264
Mississippi....................	59,322	54,157	46,326	41,775	35,724	20,177
New Mexico.....................	63,604	61,408	51,288	38,958	38,094	26,168
Texas, total...................	508,463	535,342	503,886	e 484,584	465,378	417,225
RRC 1.......................	17,203	12,787	11,644	e 11,223	11,092	10,269
RRC 2.......................	62,194	66,861	59,906	e 54,656	51,536	44,715
RRC 3.......................	106,677	120,860	117,092	e 116,822	110,236	103,734
RRC 4.......................	30,083	29,539	25,494	e 22,509	20,268	11,998
RRC 5 and 6.................	41,846	49,929	49,579	e 47,178	45,452	42,776
RRC 7B......................	21,132	20,706	19,596	e 18,957	18,381	16,102
RRC 7C......................	22,708	25,861	24,744	e 20,921	20,475	16,451
RRC 8 and 8A................	169,146	172,500	164,528	e 162,664	160,079	150,681
RRC 9.......................	23,113	22,217	18,361	e 17,131	15,677	10,062
RRC 10......................	14,361	14,082	12,942	e 12,523	12,182	10,437
Total....................	1,236,136	1,230,909	1,157,620	1,065,757	997,295	759,832
PAD district IV:						
Colorado.......................	12,097	12,929	12,786	12,321	12,138	10,766
Montana........................	6,859	6,734	6,280	5,522	4,737	3,353
Utah...........................	6,333	9,869	18,383	25,045	26,094	19,378
Wyoming........................	43,597	40,967	38,430	39,006	31,252	21,072
Total....................	68,886	70,499	75,879	81,894	74,221	54,569
PAD district V (without Alaska):						
Arizona........................	1,236	993	804	740	635	353
California.....................	148,207	138,975	129,217	117,639	114,990	99,131
Nevada.........................	113	100	96	129	115	85
Total....................	149,556	140,068	130,117	118,508	115,740	99,569
Total United States (without Alaska)............	1,679,377	1,672,715	1,587,364	1,454,809	1,379,967	1,086,300
Alaska.........................	10,834	6,201	5,894	3,370	2,805	925
Total United States.........	1,690,211	1,678,916	1,593,258	1,458,179	1,382,772	1,087,225

e Estimate.

[1] Does not include additional production of 50,000 BOPD from Yates field in Texas and 200,000 BOPD from Elk Hills field in California.

[2] Negligible.

PAD DISTRICTS

▨ Oil producing states,1975
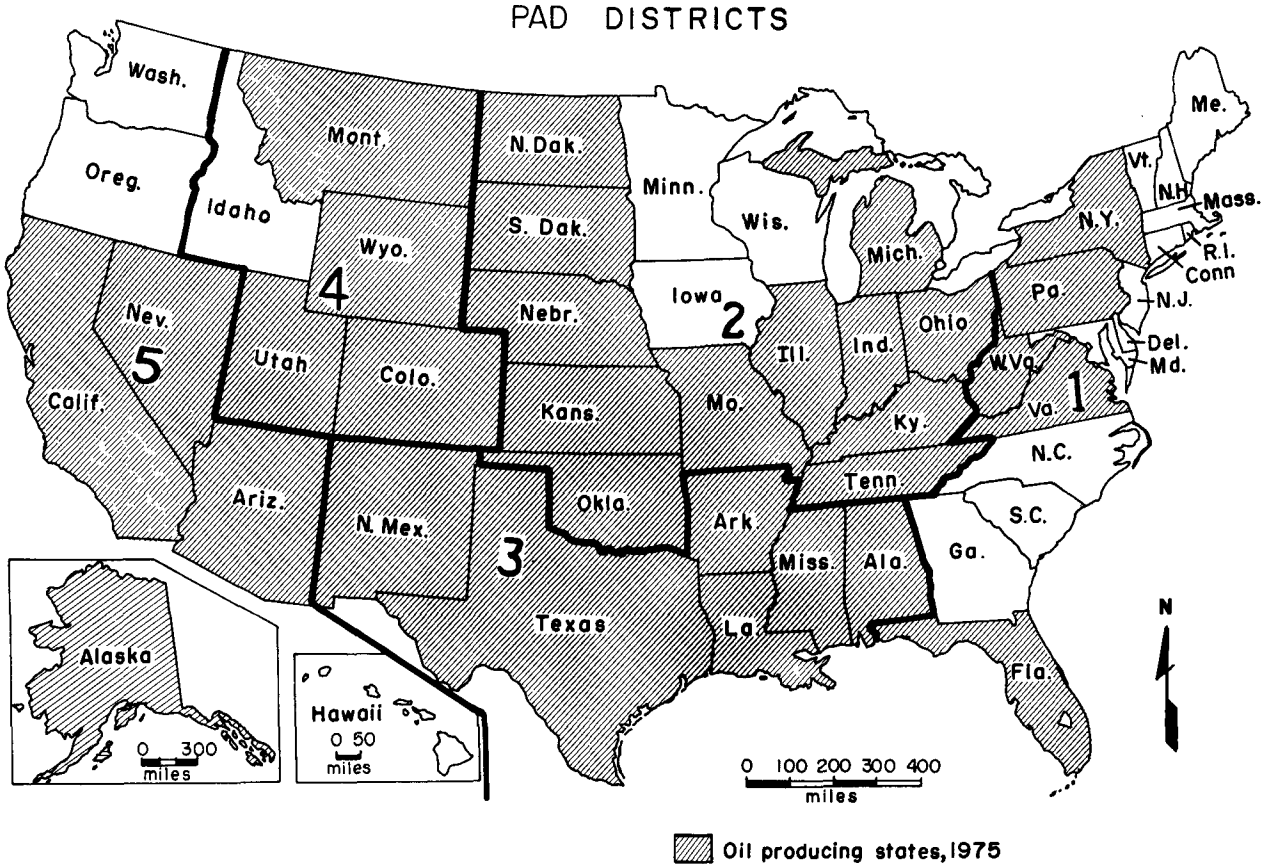
FIGURE 1. - Petroleum Administration for Defense (PAD) districts.

United States

Total Wells Drilled

As the Nation's economic situation improved following World War II, and manpower and equipment became available, the petroleum industry intensified its drilling effort. As a result, the petroleum industry increased the total number of wells drilled steadily after 1946, and by 1956 doubled those drilled in 1946. Following a peak of 57,628 in 1956, total wells drilled gradually declined to a 25-year low of 25,357 in 1971 before resuming an upward trend. The 15-year decline in drilling, starting in 1956, was brought about by the combined effects of several factors, among which were the reduction in the number of promising geological prospects for exploration, geological prospects in deeper formations, drilling in remote locations under adverse environmental conditions, the changing price-to-cost relationship, increased enhanced recovery operations, and governmental regulations and policy. The reversal in drilling activity after 1973 took place at a time when the price paid for crude doubled and the gas price of natural gas sold intrastate increased to more than $1.00 per thousand cubic feet (Mcf) in some areas. Of significance is whether this upward trend in total wells drilled stimulated by increased prices can continue after total wells drilled reached 37,266 in 1975.

Proved Oil Reserve

Historically, proved oil reserve increased from 20.87 billion barrels at yearend 1946 to 31.72 billion barrels at yearend 1959. This steady increase in reserve can be attributed mainly to the large increase in drilling during the 1946-56 period and to the rapid expansion of enhanced oil recovery projects. After 1959, proved oil reserve was maintained relatively constant between 30 and 32 billion barrels through 1968. Following a drop to 29.63 billion barrels of oil at yearend 1969, proved oil reserve increased substantially to 39.00 billion barrels at yearend 1970 with the discovery of the Prudhoe Bay field reserves in Alaska. However, proved oil reserve in the United States declined steadily after 1970 to 32.68 billion barrels at yearend 1975, despite an upsurge in drilling activity after 1973.

For comparison purposes, annual production is expressed as a percent of proved reserve at the beginning of the year as shown in table A-2 in the appendix. This percentage gives an indication of how fast the available reserves are being depleted. As shown in table A-2, from 1946 through 1965 the percentage of reserve being produced remained fairly constant in the conterminous United States. After 1965, the percentage of reserves being produced increased from 8.7 percent in 1965 to 11.7 percent in 1975.

Relationship Between Primary and Enhanced Oil Production

The historical, present, and estimated future relationship between primary and enhanced oil production in PAD districts I-IV, PAD district V without Alaska, Alaska, and the United States with and without Alaska is shown in table 4. It is evident from the tabular data in table 4 that, historically, enhanced oil production has accounted for a substantial share of the total crude oil production in most of the producing areas shown. Only in PAD districts I and II are the enhanced oil production percentages expected to decrease between 1975 and 1980. This expected decrease will be due mainly to the addition of primary oil production from recent oil discoveries. For the remaining districts III through V (without Alaska) increases in enhanced oil production as a percent of total crude oil production are expected to follow the general trend in growth rates through 1980. In Alaska, enhanced oil production as a percent of total crude oil production is expected to increase to almost 100 percent because future production from the Prudhoe Bay field will be classified as being produced using enhanced recovery methods. For the United States, enhanced oil production surpassed primary oil production in 1973, and it is estimated to increase to about 64 percent by 1980.

TABLE 4. - Primary and enhanced crude oil production as percent of total crude oil production
by PAD districts, Alaska, and total United States with and without Alaska[1]

Year	PAD district I		PAD district II[2]		PAD district III[3]		PAD district IV		PAD district V without Alaska		U.S. total without Alaska		Alaska		U.S. total	
	Primary	Enhanced	Primary	Enhanced	Primary	Enhanced	Primary	Enhanced	Primary	Enhanced	Primary	Enhanced	Primary	Enhanced	Primary	Enhanced
1946.	20.4	79.6	94.1	5.9	83.1	16.9	85.9	14.1	89.3	10.7	85.8	14.2	-	-	85.8	14.2
1947.	20.7	79.3	93.8	6.2	83.2	16.8	88.4	11.6	89.4	10.6	85.8	14.2	-	-	85.8	14.2
1948.	19.5	80.5	92.2	7.8	83.8	16.2	88.9	11.1	89.8	10.2	85.9	14.1	-	-	85.9	14.1
1949.	20.6	79.4	91.8	8.2	82.9	17.1	87.5	12.5	82.9	17.1	84.2	15.8	-	-	84.2	15.8
1950.	19.6	80.4	91.6	8.4	83.3	16.7	85.2	14.8	76.3	23.7	83.1	16.9	-	-	83.1	16.9
1951.	19.7	80.3	90.2	9.8	84.4	15.6	85.9	14.1	76.4	23.6	83.7	16.3	-	-	83.7	16.3
1952.	20.3	79.7	88.5	11.5	84.1	15.9	84.7	15.3	77.0	23.0	83.2	16.8	-	-	83.2	16.8
1953.	18.6	81.4	87.4	12.6	83.4	16.6	85.0	15.0	75.2	24.8	82.4	17.6	-	-	82.4	17.6
1954.	19.7	80.3	82.7	17.3	82.6	17.4	82.1	17.9	69.2	30.8	80.0	20.0	-	-	80.0	20.0
1955.	20.5	79.5	78.6	21.4	82.5	17.5	82.8	17.2	69.4	30.6	79.5	20.5	-	-	79.5	20.5
1956.	20.1	79.9	76.9	23.1	83.3	16.7	81.4	18.6	67.4	32.6	79.4	20.6	-	-	79.4	20.6
1957.	21.9	78.1	74.5	25.5	83.7	16.3	81.4	18.6	66.5	33.5	79.2	20.8	-	-	79.2	20.8
1958.	28.4	71.6	71.2	28.8	81.2	18.8	82.3	17.7	65.5	34.5	77.0	23.0	100.0	0	77.0	23.0
1959.	29.1	70.9	70.0	30.0	79.6	20.4	80.6	19.4	65.2	34.8	75.8	24.2	100.0	0	75.8	24.2
1960.	28.8	71.2	66.9	33.1	77.1	22.9	76.3	23.7	57.3	42.7	72.4	27.6	100.0	0	72.4	27.6
1961.	38.5	61.5	63.6	36.4	76.8	23.2	71.3	28.7	51.8	48.2	70.6	29.4	100.0	0	70.6	29.4
1962.	44.5	55.5	61.8	38.2	74.8	25.2	68.6	31.4	48.5	51.5	68.5	31.5	100.0	0	68.6	31.4
1963.	43.6	56.4	59.3	40.7	72.7	27.3	67.0	33.0	43.7	56.3	66.2	33.8	27.3	72.7	66.1	33.9
1964.	41.1	58.9	58.7	41.3	71.6	28.4	41.6	58.4	41.3	58.7	63.0	37.0	29.1	70.9	62.9	37.1
1965.	47.6	52.4	58.1	41.9	69.3	30.7	40.8	59.2	38.4	61.6	61.1	38.9	29.1	70.9	61.0	39.0
1966.	56.6	43.4	56.9	43.1	64.5	35.5	34.4	65.6	39.7	60.3	57.8	42.2	18.5	81.5	57.6	42.4
1967.	49.7	50.3	55.9	44.1	64.6	35.4	29.6	70.4	38.3	61.7	57.4	42.6	55.1	44.9	57.4	42.6
1968.	47.1	52.9	53.9	46.1	62.8	37.2	34.9	65.1	34.0	66.0	55.7	44.3	79.4	20.6	56.2	43.8
1969.	50.0	50.0	53.0	47.0	60.8	39.2	40.2	59.8	31.0	69.0	54.5	45.5	25.1	74.9	53.8	46.2
1970.	53.3	46.7	53.1	46.9	59.2	40.8	24.8	75.2	32.4	67.6	52.7	47.3	19.6	80.4	51.9	48.1
1971.	71.4	28.6	54.1	45.9	55.7	44.3	29.5	70.5	41.6	58.4	52.1	47.9	13.9	86.1	51.2	48.8
1972.	85.4	14.6	55.0	45.0	54.8	45.2	30.3	69.7	40.3	59.7	51.7	48.3	8.5	91.5	50.8	49.2
1973.	90.8	9.2	53.5	46.5	53.4	46.6	30.9	69.1	38.7	61.3	50.5	49.5	8.1	91.9	49.6	50.4
1974.	20.1	79.9	53.8	46.2	52.2	47.8	32.6	67.4	36.6	63.4	48.6	51.4	4.8	95.2	47.6	52.4
1975[4]	26.9	73.1	55.4	44.6	51.9	48.1	31.2	68.8	35.8	64.2	48.3	51.7	4.0	96.0	47.2	52.8
1980[4]	29.7	70.3	56.1	43.9	50.2	49.8	27.1	72.9	33.2	66.8	46.3	53.7	.1	99.9	36.3	63.7

[1] Does not include additional production expected in 1980 of 50,000 BOPD from Yates field in Texas and 200,000 BOPD from Elk Hills field in California.

[2] Includes estimate of enhanced oil production for 1971 in Oklahoma.

[3] Includes estimates of enhanced oil production for 1958-59 and 1974 in Texas.

[4] Calculated from estimated production.

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Primary Oil Production

As shown in figure 2, primary oil production for the conterminous United States increased from 1.49 billion barrels in 1946 to a peak of 2.03 billion barrels in 1956. During this period drilling also had a tremendous growth which resulted in a significant gain in excess producing capacity. Other factors contributing to producing capacity were proration practices; steady increase in imports; improved technology in finding, developing, and producing oil; and substantial reserve additions. After 1956, primary oil production generally declined except for a minor rise in 1967. This decline in primary oil production includes the loss in production due to the reclassification of primary oil production into enhanced oil production where new enhanced recovery projects were initiated. The minor rise in 1967 was caused by an increase in primary oil production in PAD district III. It is estimated that primary oil production will decline from 1.38 billion barrels in 1975 to 1.09 billion barrels in 1980.

Enhanced Oil Production

Enhanced oil production for the conterminous United States was about 246.4 million barrels in 1946, about 14.2 percent of the total oil production. Following World War II many enhanced recovery projects became feasible as the economic situation improved. By 1956 enhanced oil production reached 528.0 million barrels, about 20.6 percent of the total crude oil production. The industry shifted emphasis in investment after 1956 from the high-risk exploratory ventures to improved recovery from known sources as evidenced by the decline in drilling and the sharp increase in enhanced oil production. An additional incentive toward increased enhanced oil production was less restriction by proration on secondary recovery, thus enabling enhanced oil production to increase considerably. Enhanced oil production peaked at 1.56 billion barrels, or 48.3 percent of the total crude oil production in 1972, and has since declined. Enhanced oil production is expected to decline from 1.48 billion barrels in 1975 to 1.26 billion barrels in 1980.

Total Crude Oil Production

Total crude oil production for the conterminous United States increased from 1.74 billion barrels in 1946 to a peak of 3.26 billion barrels in 1970. Primary oil production accounted for most of the increase in total crude oil production from 1946 through the midfifties, but thereafter enhanced recovery was the dominant method. The high growth in total crude oil production during the sixties virtually eliminated the excess producing capacity developed after World War II. Despite increased production in some areas, a direct result of the recent upsurge in drilling activity, total crude oil production declined after 1970 for the conterminous United States to 2.86 billion barrels in 1975. The decline established after 1970 is expected to continue through 1980 to an estimated 2.34 billion barrels of crude oil. Including Alaska in the projection, the United States production in 1980 is expected to be 2.99 billion barrels, slightly greater than the 1975 level. This projection assumes production from the Prudhoe Bay field in Alaska at the projected rate of 1.6 million BOPD in 1980. This projection does not include additional
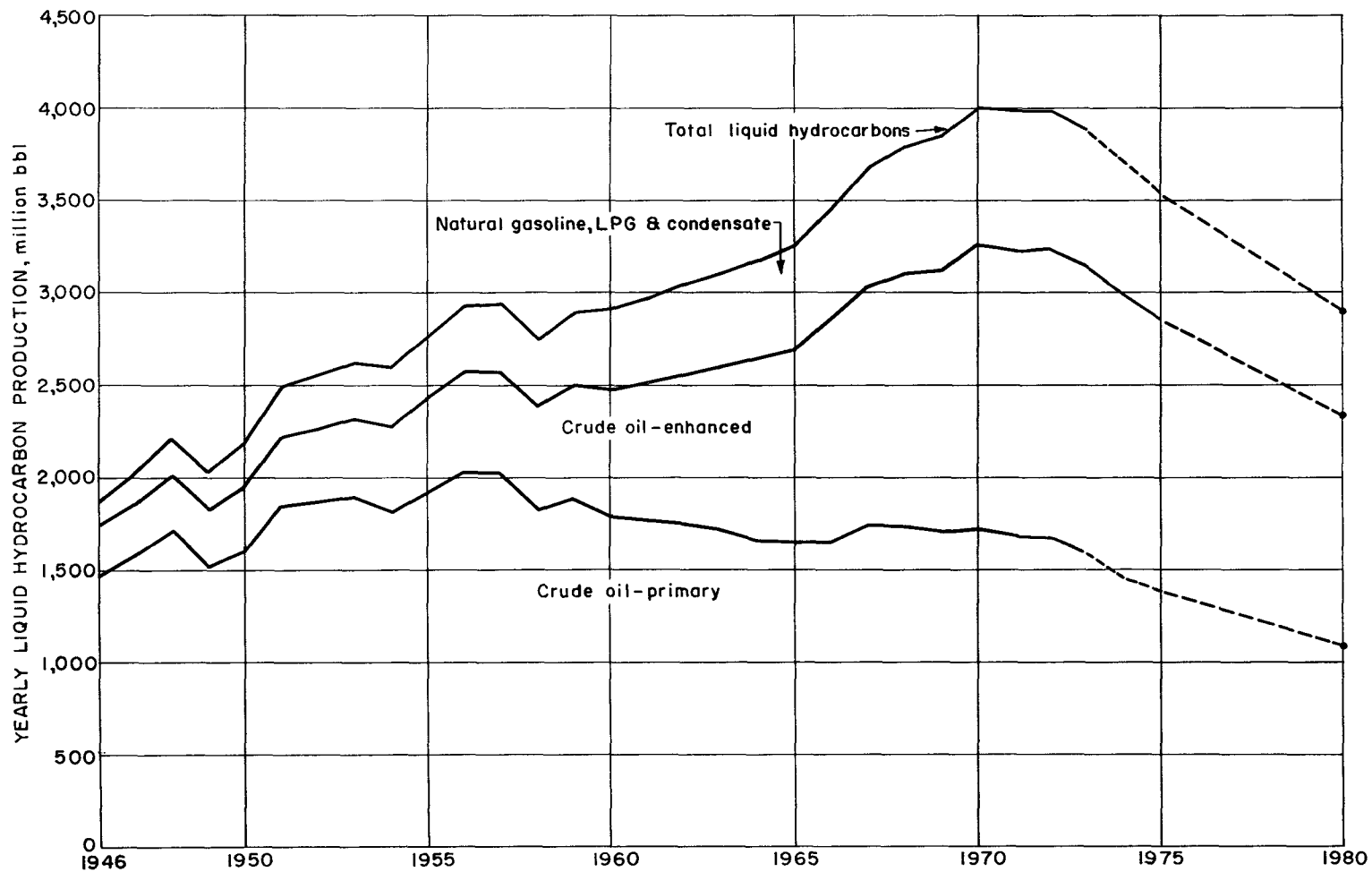
FIGURE 2. - United States (without Alaska) liquid hydrocarbon production. (Does not include increased production for the Yates field in Texas Railroad Commission district 8 and the Elk Hills Naval Petroleum Reserve in California.)

production expected from the Elk Hills field in California (development of the Naval Petroleum Reserve following Congressional approval) and the Yates field in Texas (increased maximum efficient rate, MER). These developments occurred after estimates were completed. However, if included, crude oil production in 1980 would be 2.44 billion barrels for the conterminous United States and 3.09 billion barrels for the total United States.

Natural Gas Liquid Production

Natural gas liquid production in the conterminous United States increased steadily from 134.2 million barrels in 1946 to a high of 751.1 million barrels in 1972. Since then, natural gas liquid production declined to an estimated 690.3 million barrels in 1975. In view of the fact that natural gas production has been declining, natural gas liquid production is estimated to decline to 557.7 million barrels in 1980. Including Alaska, 1980 production is estimated at 558.4 million barrels, down from an estimated 691.1 million barrels in 1975.

Total Liquid Hydrocarbon Production

In 1946 total liquid hydrocarbon production in the conterminous United States was 1.87 billion barrels of which crude oil was 92.8 percent (fig. 2). Thereafter, total liquid hydrocarbon production increased to a high of 3.99 billion barrels in 1970. Crude oil's share then was reduced to 81.6 percent of the total liquid hydrocarbon production. Total liquid hydrocarbon production declined after 1970 and was down to 3.55 billion barrels in 1975. Crude oil production accounted for 80.5 percent of the total liquid hydrocarbons in 1975. It is estimated that total liquid hydrocarbon production will drop to 2.90 billion barrels in 1980. Including Alaska, the United States total liquid hydrocarbon production is estimated at 3.62 billion barrels in 1975 and 3.55 billion barrels in 1980. With inclusion of additional production expected from the Elk Hills field in California and the Yates field in Texas, total liquid hydrocarbon production in 1980 is estimated at 2.99 billion barrels for the conterminous United States and 3.64 billion barrels for the total United States.

The historical and estimated liquid hydrocarbon production shown in figure 2 was derived by summation of data for the five PAD districts without Alaska and is influenced by production in PAD district III to such an extent that the other districts are hidden. Therefore, to help in understanding the petroleum producing situation in each major producing area, the historical (1946-75) and 1980 estimated liquid hydrocarbon production is presented by PAD district with Alaska presented separately. Data for each PAD district were derived by summation of each State's data which is presented in the appendix for those who may by interested in specific States. A discussion of each PAD district and Alaska follows.

PAD District I

PAD district I ranked last among the five districts in crude oil production during 1975 with 48.5 million barrels, or about 1.7 percent of the total

crude oil produced in the conterminous United States. Historically, Pennsylvania had been the leading oil-producing State in this district until 1971 when Florida surpassed it following the discovery of the Jay field. In 1975 Florida accounted for 85.0 percent of the district's oil production compared with Pennsylvania's 8.1 percent. The remaining States and percentages of 1975 production were as follows: New York (1.8 percent), Virginia (less than 0.1 percent), and West Virginia (5.1 percent). As noted, Virginia contributed the least amount of production in this district, and future production through 1980 was considered negligible.

Total Wells Drilled

Total wells drilled in PAD district I declined from 4,293 during 1946 to a low of 1,521 total wells in 1954. Oil well drilling dominated during this period as there were about twice as many oil wells drilled as there were gas wells. After 1954, total wells drilled remained at a low level through 1973, except for a period of increased drilling of 2,612 wells in 1964 and 2,744 wells in 1965, mainly as a result of increased activity in deep gas drilling. After a general decline from 1965, total wells drilled increased to 2,375 in 1974 and to 2,403 in 1975. Florida contributed little to total drilling effort in this district during 1946-70. However, drilling increased in Florida after 1970 with development of the Jay and Blackjack, Creek fields.

Proved Oil Reserve

The API proved reserve in this disctict at yearend 1946 was 209.4 million barrels. Proved reserve was up as high as 228.9 million barrels at yearend 1956 but declined thereafter to a low of 129.3 million barrels at yearend 1969. With new oil discoveries in the Florida Panhandle, reserves increased to a high of 396.2 million barrels by yearend 1974 but dropped to 352.0 million barrels by yearend 1975.

Primary Oil Production

Primary oil production declined from 4.2 million barrels in 1946 to 3.0 million barrels in 1960 (fig. 3). However, by 1970, primary oil production had doubled from that of 1960 and increased to 35.7 million barrels in 1973 mainly as a result of development of the Jay field in Florida. In March 1974, pressure maintenance was initiated in the Jay field; thus, its production was classified as enhanced in 1974 and that caused the steep drop in primary production that year. Primary oil production increased to 13.0 million barrels in 1975 and is estimated to be 12.5 million barrels in 1980.

Enhanced Oil Production

Enhanced recovery has been an effective method of production in this district. In 1946 enhanced oil production was about 79.6 percent of total oil production (table 4). This level was maintained through the late fifties but declined to about 9.2 percent in 1973. With the initiation of pressure maintenance in the Jay field of Florida, the percentage of total crude oil
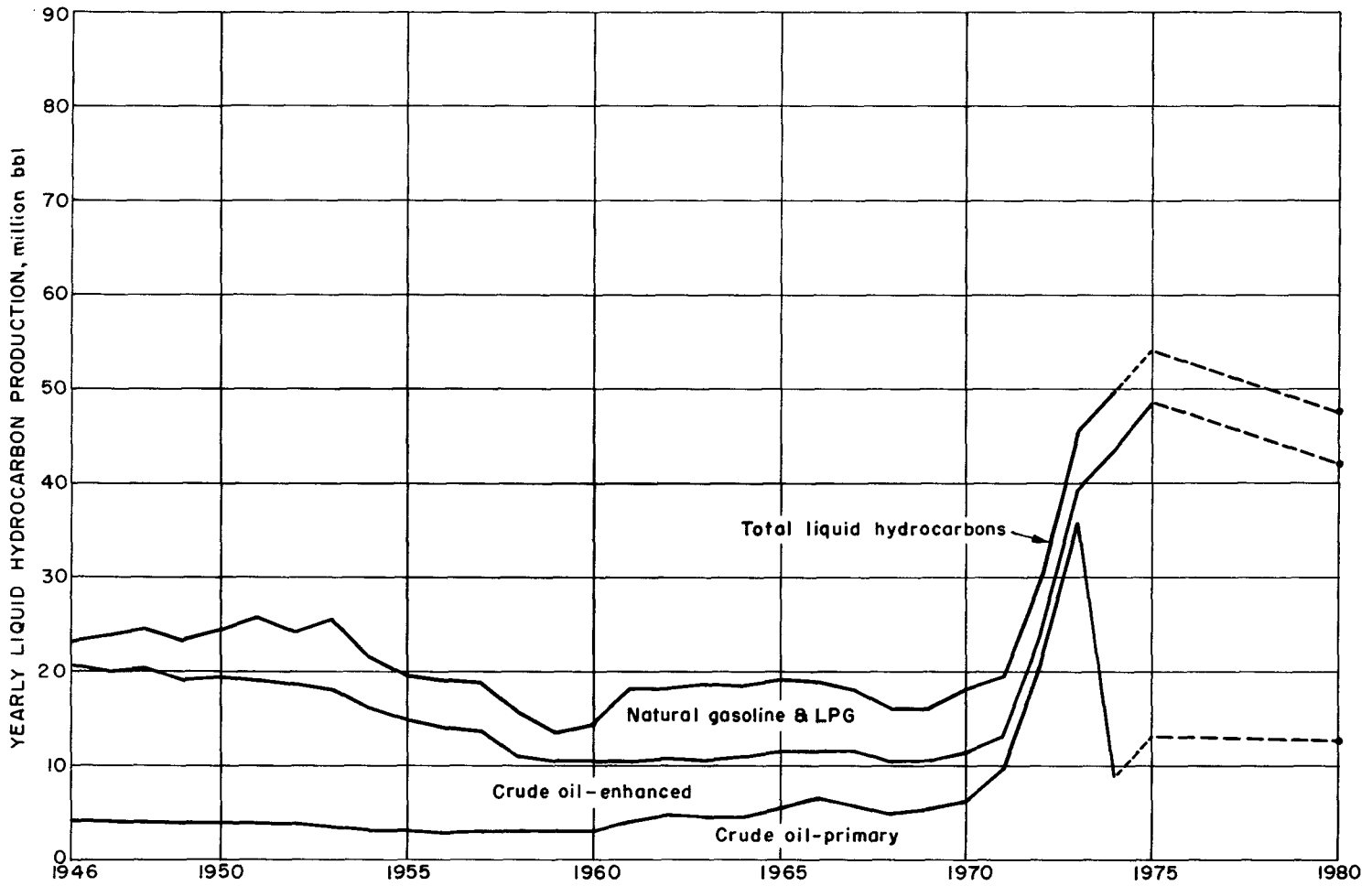
FIGURE 3. - PAD district I liquid hydrocarbon production.

production from enhanced oil was up to 79.9 percent in 1974. Enhanced oil production is expected to be about 30 million barrels in 1980, or about 70 percent of total oil production.

Total Crude Oil Production

As shown on figure 3, enhanced oil production dominated crude oil production through 1965. After 1965 a balance between primary and enhanced oil production was maintained through the late sixties, but thereafter, with discovery of the Jay field in Florida, primary oil production increased dramatically. In 1974 pressure maintenance was begun in the Jay field; therefore, enhanced recovery once again dominated total crude oil production. Total crude oil is expected to increase after 1975 and then decline to about 42 million barrels in 1980.

Natural Gas Liquid Production

Production of natural gas liquids in this district has been somewhat erratic during the 1946-75 period, increasing noticeably in the early fifties and then again in the early sixties. Peak production of 8.1 million barrels was attained in 1963 and has generally declined since then. It was estimated that production would drop from 5.5 million barrels in 1975 to 5 million barrels in 1980.

Total Liquid Hydrocarbon Production

As shown on figure 3, since 1946 total liquid hydrocarbon production generally followed the trend in crude oil production except during the early fifties and early sixties when increases in natural gas liquid production occurred. In 1946 total liquid hydrocarbon production was 23.3 million barrels, of which 88.7 percent was crude oil. In 1951 and 1963 when the large increases in natural gas liquid production occurred, the percentage of total liquid hydrocarbon production from crude oil was down to 75.1 and 56.5 percent, respectively. Thereafter, crude oil's share of total liquid hydrocarbon production increased to 89.8 percent in 1975. Total liquid hydrocarbon production is estimated to decline from 54.0 million barrels in 1975 to 48 million barrels in 1980.

PAD District II

PAD district II produced 324.4 million barrels of oil during 1975, or about 11.4 percent of the total for the conterminous United States. The oil-producing States in this district in descending order of production during 1975 and the corresponding percentages of total district production are as follows: Oklahoma (50.3 percent), Kansas (18.2 percent), Illinois (8.1 percent), Michigan (7.5 percent), North Dakota (6.3 percent), Ohio (3.6 percent), Kentucky (2.3 percent), Nebraska (1.9 percent), Indiana (1.4 percent), Tennessee (0.2 percent), South Dakota (0.2 percent), and Missouri (less than 0.1 percent).

Total Wells Drilled

From 1946 to 1955 total wells drilled almost doubled from 11,272 to 21,387 wells. After 1955, the number of total wells drilled generally declined to a low of 7,418 in 1971. However, after some relatively small gains in total wells drilled during 1972 and 1973, total wells drilled increased to 11,495 in 1975. Of significance in this district is the dominance of oil wells drilled compared with gas wells throughout the 1946-75 period.

Proved Oil Reserve

From yearend 1946 proved oil reserve in this district more than doubled to a peak of 4.30 billion barrels of oil at yearend 1956, 1 year after the total wells drilled peaked. Expansion of enhanced recovery projects in some areas also contributed to the increase in proved reserve. After 1956, proved reserve declined to a level of 2.23 billion barrels of oil at yearend 1975. The increased drilling activity of 1974-75 resulted in arresting the decline. This increased drilling activity in terms of total wells drilled, however, was about half of the peak wells drilled in 1955 and very close to that achieved in 1946.

Primary Oil Production

As shown in figure 4, primary oil production increased from 327.8 million barrels of oil in 1946 to a peak of 379.7 million barrels of oil in 1956. Thereafter, there was a general decline in production through 1975. This decline appeared to be arrested during the 1970-74 period because of increased oil production in Michigan, and to a lesser extent in Ohio, South Dakota, and Tennessee. These four States accounted for 14.3 percent of total primary oil production in this district in 1974, and an estimated 19 percent in 1975. Primary oil production in this district is expected to decline from an estimated 180 million barrels of oil in 1975, slightly less than in 1974, to 160 million barrels in 1980.

Enhanced Oil Production

During the 1946-75 period, enhanced oil production as a percent of the total crude oil produced in this district increased steadily from 5.9 percent in 1946 to a high of 47.0 percent in 1969, and then down to 46.2 percent in 1974 (table 4). This growth in enhanced oil production is attributed mainly to successful waterflooding in Illinois, Kansas, North Dakota, and Oklahoma. Enhanced oil production in 1980 is estimated to be 125 million barrels, about 44 percent of the total crude oil production. Enhanced oil production is expected to decline faster than primary production reflecting the decline in oil production from the old abundant waterfloods in this district. The estimated 1980 enhanced production does not include an estimate for Tennessee because of the lack of historical production data for the repressuring project that was started early in 1976.
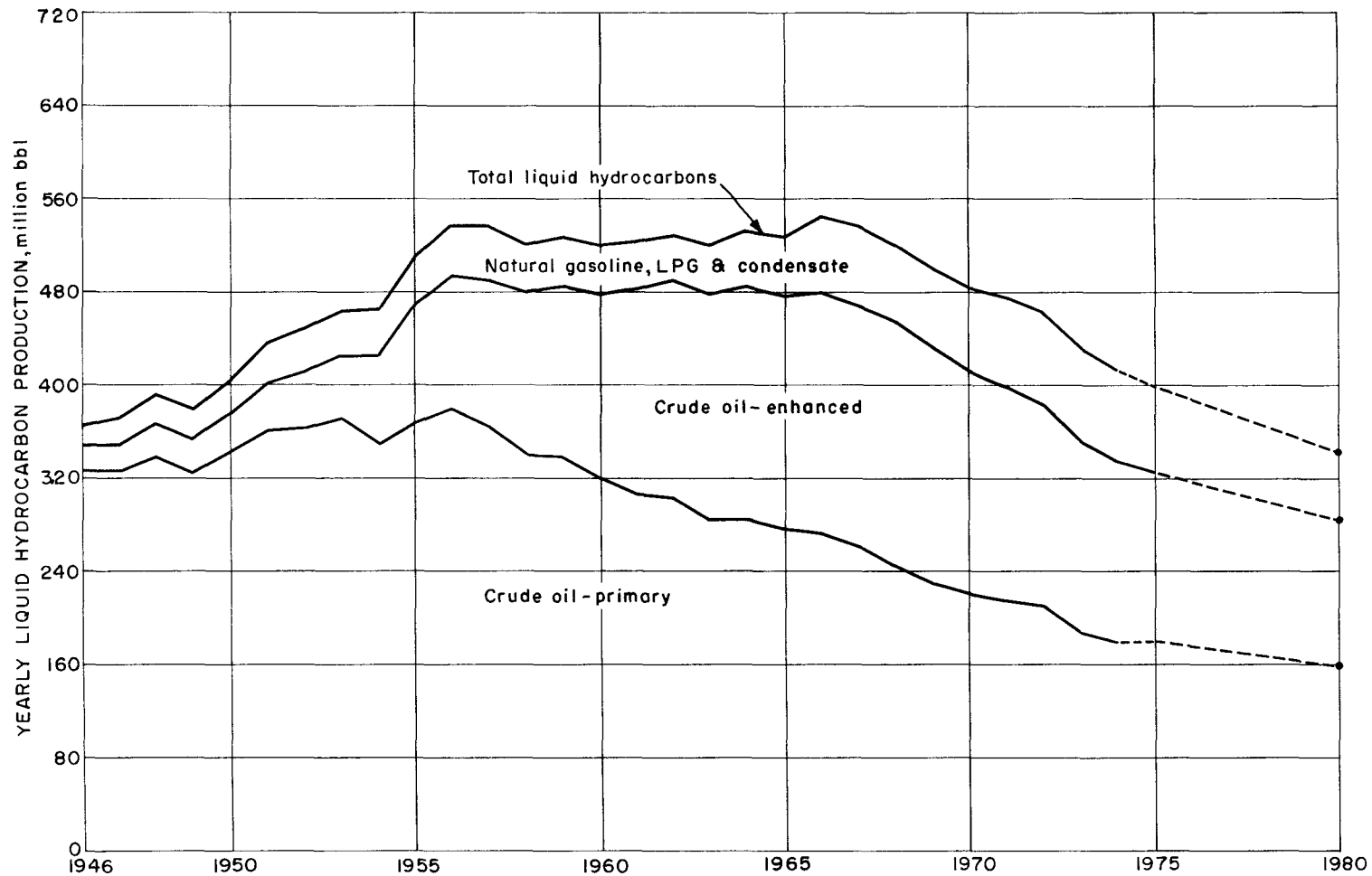
FIGURE 4. - PAD district II liquid hydrocarbon production.

Total Crude Oil Production

Total crude oil production increased from 348.4 million barrels in 1946 to a peak of 494.0 million barrels in 1956. Increased rates of production were not only a direct result of increased drilling, but were influenced by successful hydraulic fracturing and waterflooding of reservoirs. Total oil production in this district was maintained at a level above 475 million barrels through 1966 primarily because of increased enhanced crude oil production. After 1966, total crude oil production generally declined through 1975 even with increased production from Michigan and Ohio during 1970-75. Michigan had numerous Niagaran reef discoveries during 1969-75 that resulted in an alltime high output of 24.4 million barrels in 1975, slightly more than twice the 1970 output. Ohio produced 11.7 million barrels of oil in 1975, an increase of 1.8 million barrels from that of 1970. The effect of increased production has somewhat altered the apparent established trend of 1966-72. Therefore, oil production in this district is expected to decline at a lesser rate from 342.4 million barrels in 1975 to 285 million barrels in 1980. The increased exploratory activities in Michigan could have a considerable influence on the total oil production during 1980 in this district.

Natural Gas Liquid Production

Natural gas liquid production in this district had a significant growth during the 1946-73 period, increasing from 17.5 million barrels to a high of 80.7 million barrels. However, it is estimated that natural gas liquid production will decline from 74.4 million barrels in 1975 to 58 million barrels in 1980.

Total Liquid Hydrocarbon Production

In 1946 total liquid hydrocarbon production was 365.9 million barrels, of which 95.2 percent was crude oil (fig. 4). Total liquid hydrocarbon production increased to a high of 545.0 million barrels in 1966. Since then, total liquid hydrocarbon production declined to an extimated 398.8 million barrels in 1975 of which 81.4 percent was crude oil. Total liquid hydrocarbon production is expected to continue to decline to 343 million barrels in 1980.

PAD District III

PAD district III was the leading producer among the districts with 1.92 billion barrels or 67.3 percent of the total crude oil produced in the conterminous United States during 1975. Texas was the leading oil-producing State in this district with 1.19 billion barrels, or 61.7 percent of the total. Louisiana followed with 571.0 million barrels, or 29.7 percent of the total production. The remaining States and percentages of total production for the district were: Alabama (0.5 percent), Arkansas (0.8 percent), Mississippi (2.4 percent), and New Mexico (4.9 percent).

Total Wells Drilled

This district had a sizable drilling effort after 1946 that resulted in an alltime high in wells drilled that has not been equaled. From 10,585 total wells drilled in 1946, the number of wells drilled increased to a peak of 29,649 in 1956 and declined to 12,163 in 1971. The recent change in the economic situation, however, reversed the decline and in 1975 total wells drilled was 17,340. Although the recent increase in drilling was substantial, the 1975 level was only 58.5 percent of the 1956 peak.

Proved Oil Reserve

Proved oil reserve in PAD district III increased gradually from 14.38 billion barrels at yearend 1946 to 21.28 billion barrels at yearend 1959. Between 1959 and 1967 proved oil reserve remained fairly constant and totaled 21.49 billion barrels at yearend 1967. Thereafter, proved reserve gradually declined to a low of 14.88 billion barrels at yearend 1975, about the same as that in 1946. The recent increase in drilling activity has not reversed the decline in proved oil reserve.

Primary Oil Production

Primary oil production in PAD district III increased gradually from 824.6 million barrels in 1946 to a high of 1.28 billion barrels in 1957 (see fig. 5). After 1957, primary oil production dropped to a low of 1.10 billion barrels in 1960 and remained fairly constant between 1960 and 1966 although total oil production was gradually increasing. This can be attributed principally to increased enhanced recovery activities which resulted in a reclassification of production from primary to enhanced. Primary oil production started to increase in the late sixties and reached a high of 1.31 billion barrels in 1970 as it responded to increased market demand. Subsequently, primary oil production started a steep decline as excess producing capacity was virtually eliminated. The decline in primary oil production is estimated to continue from 997.3 million barrels in 1975 to 760 million barrels in 1980.

Enhanced Oil Production

Enhanced oil production increased from 16.9 percent of the total crude oil production in 1946 to 47.8 percent in 1974 (table 4). The upswing in enhanced oil production began after 1960, mainly as a result of significant increases in enhanced recovery projects in Texas and Louisiana. However, in recent years there has been a reduction in active projects in Louisiana, which has contributed to the reduction in enhanced oil production. These two States accounted for most of the 926.1 million barrels of enhanced oil estimated for 1975. Enhanced oil production is expected to be 755 million barrels in 1980, about half of the total oil production.
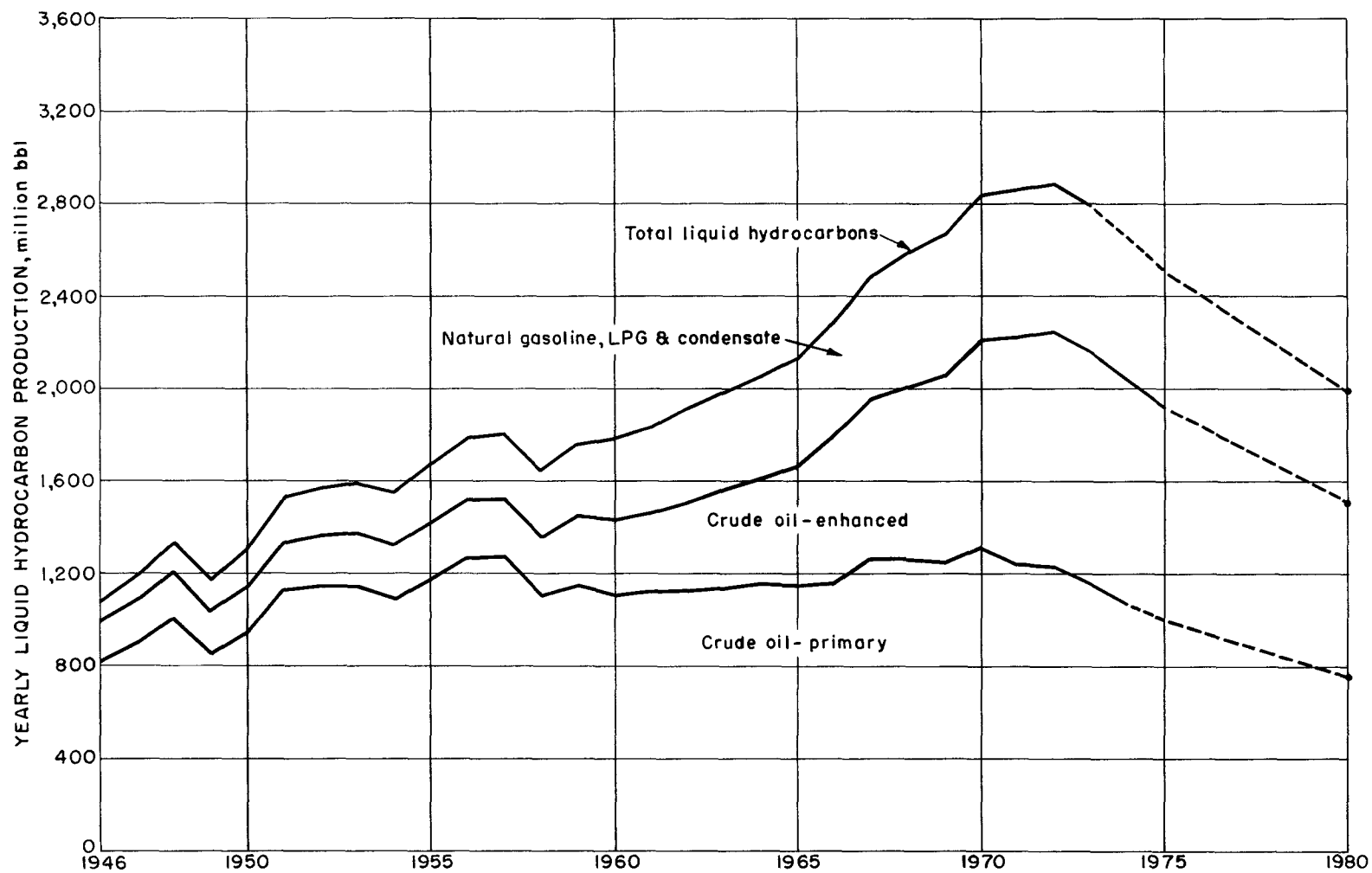
FIGURE 5. - PAD district III liquid hydrocarbon production. (Does not include increased production (50 thousand BOPD) from the Yates field in Texas Railroad Commission district 8.)

Total Crude Oil Production

Total crude oil production in PAD district III increased from 991.9 million barrels in 1946 to a high of 2.25 billion barrels in 1972. During the period of increased drilling activity (1946-56), there was a considerable growth in excess producing capacity, mainly in Texas and Louisiana. Also, excess producing capacity was augmented by an increase in enhanced recovery projects. This is evidenced by a decline in drilling after 1958 when oil production increased as domestic demand for crude oil increased. However, much of the increase came from enhanced recovery projects. Excess producing capacity was greatly reduced by the early seventies, and after 1972, total crude oil production began to decline. By 1974 excess producing capacity was virtually eliminated. Total crude oil production was estimated at 1.92 billion barrels for 1975 and 1.52 billion barrels for 1980. The estimates for Texas were made for each Railroad Commission (RRC) district and then totaled for the State. These estimates do not include additional production expected from the Yates field because of increased maximum efficient rate of the field in mid-1976. If included, crude oil production in 1980 would change slightly to 1.53 billion barrels in this district.

Natural Gas Liquid Production

Natural gas liquid production in PAD district III had an unusually rapid growth, from 91.0 million barrels in 1946 to a peak of 634.4 million barrels in 1972. After 1972, natural gas liquids declined to 580.0 million barrels in 1975. In view of the decline in proved reserve of natural gas liquids in Texas and Louisiana which supply most of the natural gas liquids in this district, future natural gas liquid production is estimated to decline to 472 million barrels in 1980.

Total Liquid Hydrocarbon Production

In 1946, the liquid hydrocarbon production was 1.08 billion barrels, of which 91.6 percent was crude oil production (fig. 5). Total liquid hydrocarbon production increased to a peak of 2.88 billion barrels in 1972 and declined sharply thereafter to 2.50 billion barrels in 1975, of which 76.8 percent was crude oil production. Continuation of the decline is expected to result in 1.99 billion barrels of production in 1980. However, with the additional production expected from the Yates field, total liquid hydrocarbon production in 1980 would change slightly to 2.00 billion barrels.

PAD District IV

PAD district IV produced 237.6 million barrels of oil during 1975, about 8.3 percent of the total oil production for the conterminous United States. Wyoming led all States in this district in oil production during 1975 with 127.2 million barrels, or 53.6 percent of the total production. Utah followed with 39.6 million barrels of oil (16.6 percent), and for the first time surpassed Colorado which produced 37.9 million barrels of oil (16.0 percent). Montana produced 32.8 million barrels or about 13.8 percent of the total production.

Total Wells Drilled

PAD district IV had a sizable increase in total wells drilled, from 671 wells in 1946 to a high of 2,900 wells in 1956. Few gas wells were drilled during the 1946-56 period. After 1956, total wells drilled declined to 2,348 wells in 1957 and remained relatively constant through 1967. In 1968 total wells drilled were close to the 1956 level. This level was surpassed in 1969 with 3,182 wells. The upsurge in drilling activity was mainly due to discovery of large oil reserves in several fields in Montana and Wyoming, and also development in Colorado's southwestern area and Denver basin. As a result of the favorable oil and gas price changes, the 1975 level was 3,901 wells drilled, the highest during the 1946-75 period. Emphasis was on gas drilling also after 1970.

Proved Oil Reserve

Proved oil reserve in PAD district IV at yearend 1946 was 993.5 million barrels. By yearend 1958 proved oil reserve had increased more than twofold to 2.34 billion barrels and remained fairly constant through 1961. Yearend reserves declined annually, except for increases in 1968 and 1972, to 1.53 billion barrels at yearend 1975. The total effect of the recent discoveries in Montana, Utah, and Wyoming is not presently known, and only time will tell if these discoveries will arrest the decline in oil reserve.

Primary Oil Production

As shown on figure 6, primary oil production increased rapidly from 51.5 million barrels in 1946 to 194.6 million barrels in 1959. Thereafter, it declined to a low of 67.7 million barrels of oil in 1967, resulting from the reduction in drilling activity and reclassification of some of the primary oil production into enhanced oil production. Discoveries in the late sixties boosted primary oil production to 100.7 million barrels in 1969. In 1970, it declined to a low of 60.3 million barrels and increased steadily to 81.9 million barrels in 1974. Primary oil production is expected to decline to 74.2 million barrels in 1975 and to 55 million barrels in 1980.

Enhanced Oil Production

Enhanced oil production had a slow start in PAD district IV because the number of projects started were limited by a lack of gas for injection and a lack of readily accessible crude oil market. Enhanced oil production increased steadily from 14.1 percent of the total production in 1946 to 67.4 percent in 1974 (table 4). Prior to 1959, only Colorado and Wyoming contributed to enhanced oil production. Shortly after 1959, enhanced oil recovery operations were started in Montana and Utah. The initiation of enhanced recovery operations early in the life of some of the oil discoveries of the late sixties contributed significantly to the growth in enhanced oil production. Enhanced oil production was estimated at 69 percent of the total, equivalent to 163 million barrels of oil in 1975 and 73 percent in 1980, equivalent to 147 million barrels of oil. Wyoming is expected to be the major supplier of enhanced oil production during this period.
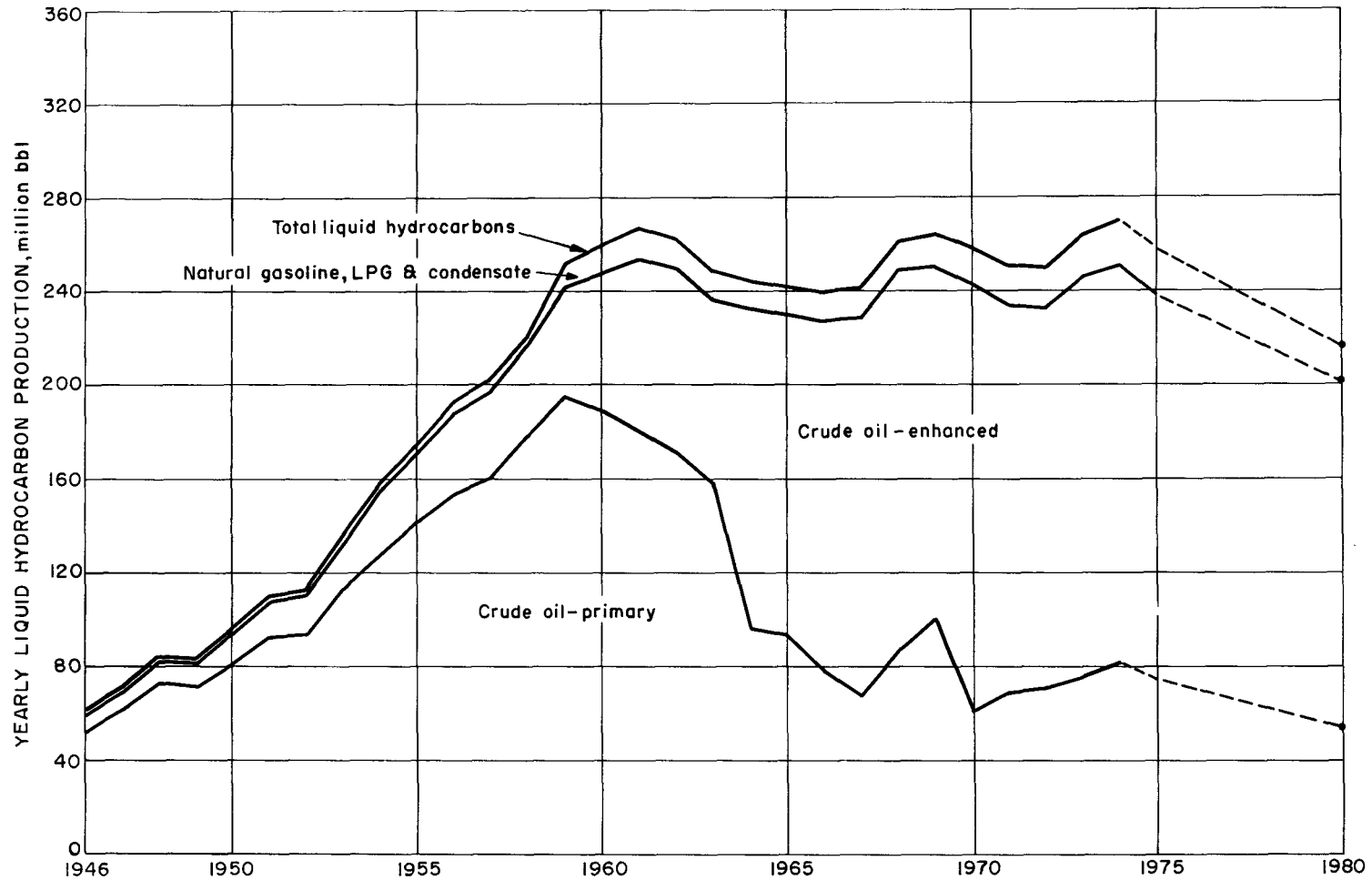
FIGURE 6. - PAD district IV liquid hydrocarbon production.

Total Crude Oil Production

Total crude oil production increased rapidly, from 60.0 million barrels of oil in 1946 to a high of 253.7 million barrels in 1961. Thereafter it declined slowly to 228.7 million barrels in 1967 during a period when drilling activity was reduced, but enhanced oil recovery was increased. Successful drilling in the late sixties boosted crude oil production to 250.5 million barrels in 1969. Crude oil production declined to 237.6 million barrels in 1975 and is expected to decline to 202 million barrels of oil in 1980.

Natural Gas Liquid Production

Limited gas production in PAD district IV resulted in production of only 1.4 million barrels of natural gas liquids in 1946. Since 1946, natural gas liquid production steadily increased to an estimated high of 20.1 million barrels in 1975. However, natural gas liquid production is estimated to decline to 15 million barrels by 1980.

Total Liquid Hydrocarbon Production

Total liquid hydrocarbon production increased sharply from 61.3 million barrels in 1946 to a high of 266.5 million barrels in 1961 (fig. 6). Crude oil production accounted for 97.7 percent of the total liquid hydrocarbon production in 1946 and 95.2 percent in 1961. After 1961, total liquid hydrocarbon production generally declined, but after a couple of periods of increased drilling activity production reached a high of 269.9 million barrels in 1974 and declined to 257.7 million barrels in 1975. Crude oil production as a percent of total liquid hydrocarbon production was 92.2 percent in 1975. Total liquid hydrocarbon production is expected to decline to 217 million barrels in 1980.

PAD District V (Without Alaska)

PAD district V without Alaska produced 323.0 million barrels of oil in 1975. California was the major producer with 322.3 million barrels of oil, or 99.8 percent of the total. Arizona produced 635,000 barrels of oil, and Nevada produced 115,000 barrels.

Total Wells Drilled

Most of the drilling activity in PAD district V without Alaska was confined to California. Total wells drilled increased from 1,865 in 1946 to 2,628 in 1948 and remained at about this level through 1957, except for a steep drop in 1950. After a sharp decrease in 1958 to 1,457 wells drilled, oil discoveries in California in the early sixties caused an increase in drilling activity as total wells drilled increased to 2,614 in 1962. Again drilling began a slight decline, but with the advent of thermal recovery methods in the midsixties, total wells drilled were up again in 1967 at a level of 2,771. Thereafter, total wells drilled declined to a low of 1,182 in 1973, but increased to 2,046 wells in 1975. Increased drilling activity in 1974 and 1975 was mainly due to developmental drilling in shallow, low-gravity-oil

reservoirs in California. Arizona and Nevada had sporadic drilling activity which contributed little to the overall drilling activity of the district. These States drilling activity was most intense during the sixties.

Proved Oil Reserve

Discussion of proved oil reserve in PAD district V without Alaska is confined to California's reserve because reserves were not reported separately for Arizona and Nevada for the 1946-75 period by the API. Proved oil reserve increased from 3.29 billion barrels at yearend 1946 to 3.76 billion barrels at yearend 1948 and was maintained at about that level through 1959 but declined to 3.60 billion barrels of oil at yearend 1963. Offshore discoveries and initiation of thermal recovery methods boosted proved reserve to a high of 4.61 billion barrels of oil at yearend 1966, but then proved oil reserve began a decline which was not arrested until 1974, coincidental with the latest increase in drilling activity. At yearend 1975, proved oil reserve was 3.65 billion barrels, up from 3.49 billion barrels at yearend 1973.

Primary Oil Production

As shown on figure 7, primary oil production in PAD district V without Alaska increased from 281.0 million barrels of oil in 1946 to a high of 306.5 million barrels in 1948. It generally followed a decline thereafter through 1974. Primary oil production was down to 118.5 million barrels in 1974 and was estimated to be 116 million barrels in 1975 and 100 million barrels for 1980. All production from Arizona and Nevada was considered primary oil production.

Enhanced Oil Production

Enhanced oil production in PAD district V without Alaska came entirely from California and has generally increased since 1946. In 1946, it was 10.7 percent of the total crude oil production and within 5 years the percentage had more than doubled. The percentage continued to increase and surpassed the midway point by 1962, before the emphasis on thermal recovery began. Enhanced oil production as a percentage of the total oil production then increased to a high of 69.0 percent in 1969 when oil production from thermal operations peaked. After 1969, the percentage dropped a few points because of project abandonments but was up to 63.4 percent by 1974. The percentage was estimated at 64 percent for 1975 and is expected to increase to 67 percent in 1980, assuming that the success of enhanced recovery methods coupled with the recent favorable price increases continue. In terms of volume, enhanced oil production is expected to decline slightly from that of 1975, to 201 million barrels in 1980.

Total Crude Oil Production

Total crude oil production in this district without Alaska increased from 314.6 million barrels in 1946 to a high of 365.0 million barrels of oil in 1953. While primary oil production declined from 281.0 million barrels to 274.3 million barrels during this period, enhanced oil production more than
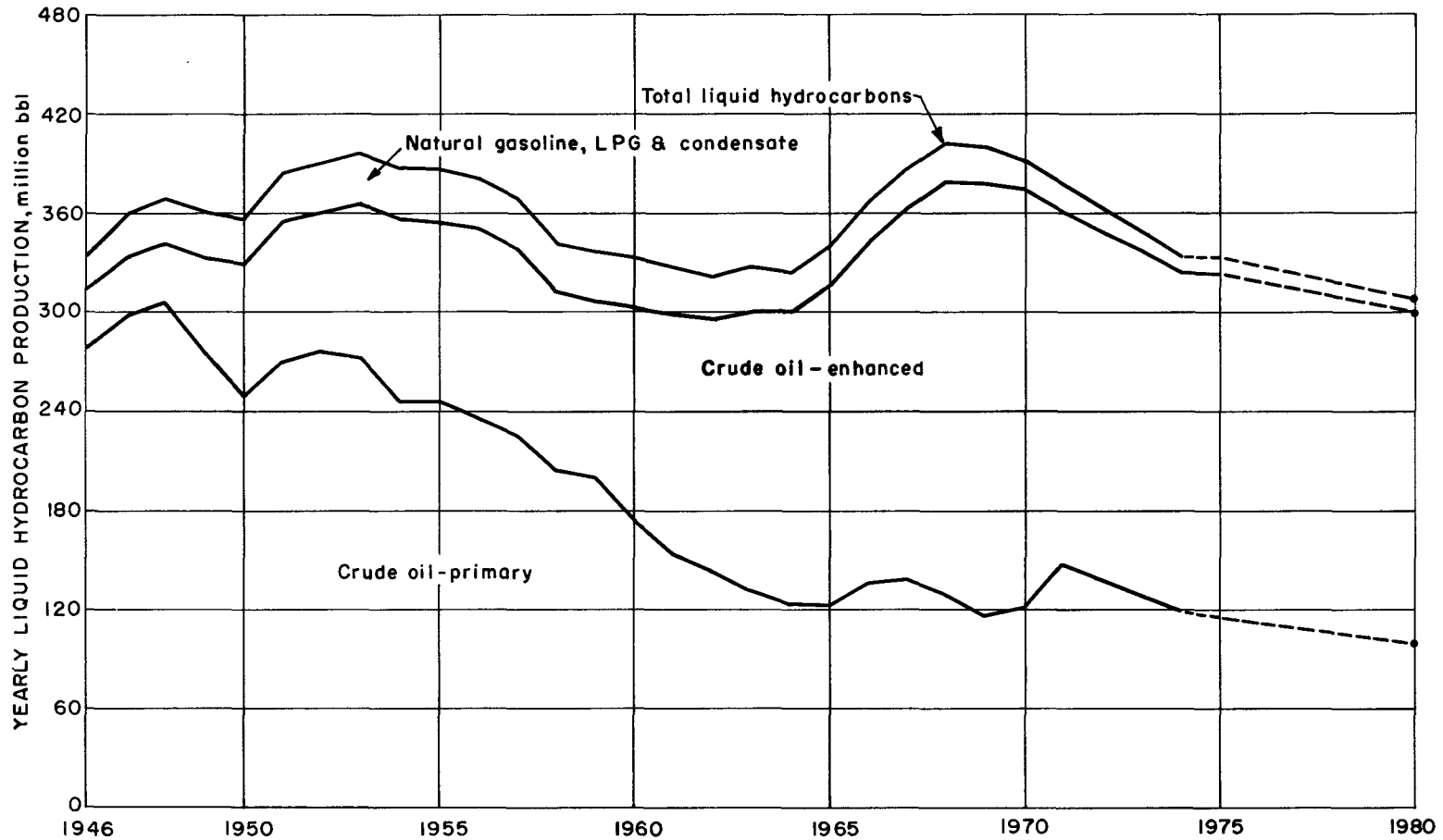
FIGURE 7. - PAD district V (without Alaska) liquid hydrocarbon production. (Does not include increased production (200 thousand BOPD) from the Elk Hills Naval Petroleum Reserve in California.)

doubled during the same period from 33.6 million barrels to 90.7 million barrels. After 1953, oil production generally declined to a low of 295.6 million barrels of oil in 1962. Total oil production increased after 1962 with the advent of thermal recovery methods to a peak of 378.6 million barrels of oil in 1968 and started a decline that was altered in 1975. Thus, total crude oil production is expected to decline from 323.0 million barrels in 1975 to 300 million barrels in 1980. This estimate does not include an estimated 200,000 BOPD expected from the Elk Hills field in 1980 due to development of this Naval Petroleum Reserve. If included, crude oil production in 1980 would be 373 million barrels.

Natural Gas Liquid Production

All production of natural gas liquids in this district without Alaska is from California, and most is extracted from gas produced with oil. Natural gas liquid production has been minor relative to oil production during the 1946-75 period. Natural gas liquid production increased from 21.7 million barrels in 1946 to a peak of 31.4 million barrels in 1954, and after a decline through 1969, it started a steep decline through 1974. Natural gas liquid production is estimated at 10 million barrels in 1975 and 8 million barrels for 1980.

Total Liquid Hydrocarbon Production

Total liquid hydrocarbon production increased from 336.3 million barrels in 1946 to a high of 369.1 million barrels in 1953 (fig. 7). After 1953, total liquid hydrocarbon production declined to a low of 322.4 million barrels in 1962. The upsurge in total crude oil production, mainly due to success in thermal recovery in California, boosted total liquid hydrocarbon production to a peak of 400.6 million barrels in 1968. Thereafter it declined to a low of 333.4 million barrels in 1975. Total liquid hydrocarbon production for 1980 is estimated at 308 million barrels. With inclusion of additional oil production expected from the Elk Hills field in California, total liquid hydrocarbon production in 1980 would be 381 million barrels.

Alaska

Alaska is in PAD district V but was treated separately in this study since most of Alaska's future production is highly dependent on completion of the Alaskan pipeline from Prudhoe Bay. First commercial oil production in this State was in 1959. In 1975 Alaska produced 69.8 million barrels of oil which placed it seventh in the Nation among the oil-producing States. Alaska has been one of the top 10 oil-producing States in the Nation since 1968.

Total Wells Drilled

Some exploratory drilling was done in 1957 which resulted in the discovery of the Swanson River field. Drilling continued after 1957 and in 1959, a total of 14 wells were drilled. Total wells drilled increased to a high of 49 in 1961. More than half of the total wells drilled then were oil wells. After a decline in drilling, total wells were up to about the same level in 1966 as

in 1961 with development of the Cook Inlet fields. Total wells drilled peaked in 1969 at 106 wells following discovery of the Prudhoe Bay field. With delay in the development of the Prudhoe Bay field, total wells drilled declined after 1969 and did not increase significantly until 1975 as development of the Prudhoe Bay field was accelerated due to the start of the 798-mile pipeline from Prudhoe Bay to Valdez in 1974.

Proved Oil Reserve

Proved oil reserve in Alaska was 3.8 million barrels at yearend 1959 and increased to 432.3 million barrels at yearend 1969, prior to the large reserve addition from the Prudhoe Bay field. At yearend 1970, oil reserve increased to 10.15 billion barrels with the addition of the Prudhoe Bay field reserve. However, to date, a relatively small amount of oil has been produced from this field because pipeline facilities have not been completed. Proved oil reserve was 10.04 billion barrels at yearend 1975, slightly lower than that of 1970.

Primary Oil Production

Primary oil production started at a low of 36,000 barrels in 1958 and increased to 10.3 million barrels in 1962 following discovery of oil in the Cook Inlet (see fig. 8). After 1962, it gradually declined to a low of 2.6 million barrels of oil in 1966. Continued development in the Cook Inlet area increased primary oil production to a peak of 52.5 million barrels in 1968. Since then, primary oil declined continuously to a level of approximately 2.8 million barrels in 1975. Gas produced with the oil from the giant Prudhoe Bay field has to be injected into the reservoir because of Alaska's no-flare ruling. By definition, the oil produced is classified as enhanced oil production. It is assumed that secondary recovery methods of operation will immediately be applied to other fields that are discovered. On this premise, primary oil production is estimated to decline to 925,000 barrels in 1980.

Enhanced Oil Production

Enhanced oil production began in 1963 with gas injection in the Swanson River field and totaled 7.8 million barrels of oil that year. By 1974 enhanced oil production was 67.3 million barrels of oil. The gains in enhanced oil production resulted from the initiation of pressure maintenance projects in fields in offshore Cook Inlet early in the life of the fields because of rapidly declining reservoir pressure. Enhanced oil production was estimated to decline slightly from 1974, to 67.0 million barrels of oil in 1975. By 1980 it was estimated at 649.5 million barrels of oil with the addition of expected production from the Prudhoe Bay field. It was assumed that production from south Alaska would decline through 1980, and that all new production from Prudhoe Bay would be enhanced.
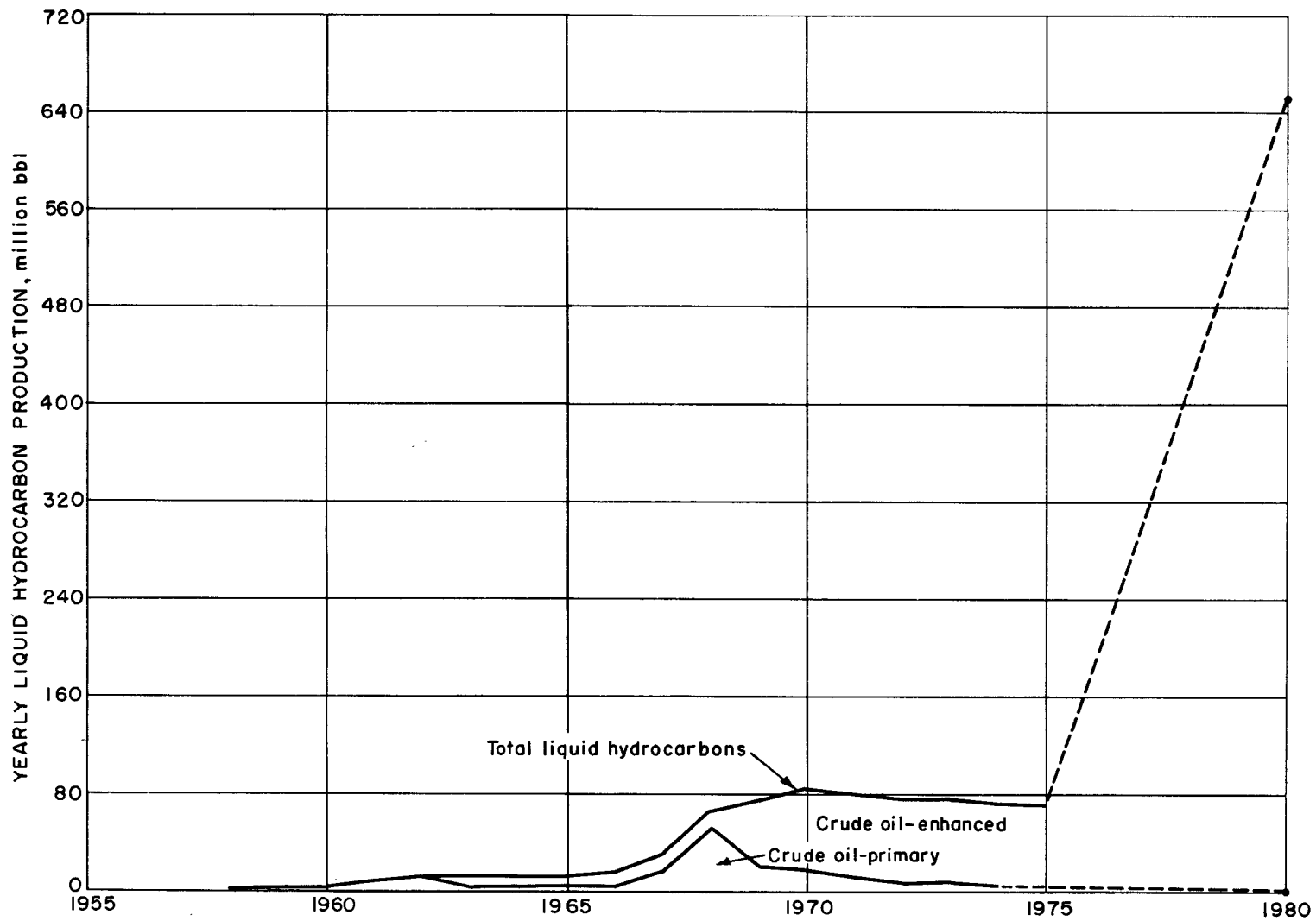
FIGURE 8. - Alaska (PAD district V) liquid hydrocarbon production.

Total Crude Oil Production

Total crude oil production in Alaska increased gradually from a low of 36,000 barrels in 1958 to 14.4 million barrels of oil in 1966. The following year production doubled and continued to increase to a high of 82.7 million barrels of oil in 1970. Thereafter, total oil production declined to 69.8 million barrels in 1975. The 1980 estimate of 650.4 million barrels assumes a general decline in oil production from south Alaska, completion of the pipeline from the Prudhoe Bay field by mid-1977, and a producing rate of 1.6 million BOPD from the Prudhoe Bay field.

Natural Gas Liquid Production

Natural gas liquid production started in 1968 and since then has been minimal relative to oil production. Natural gas liquid production increased from 7,000 barrels in 1968 to 811,000 barrels in 1973. Thereafter, natural gas liquid production declined to an estimated 768,000 barrels in 1975. Production is estimated to decline to 670,000 barrels in 1980. This estimate does not include future natural gas liquid production from the Prudhoe Bay field. No estimate was made due to the lack of data to use as a basis.

Total Liquid Hydrocarbon Production

Total liquid hydrocarbon production was equivalent to oil production from 1958 through 1967 (fig. 8). In 1968 total liquid hydrocarbon production was 66.2 million barrels. In 1970 total liquid hydrocarbon production was at a high of 83.3 million barrels. Thereafter, total liquid hydrocarbon declined to 70.5 million barrels in 1975. Total liquid hydrocarbon production is expected to increase to 651 million barrels in 1980. The large increase in total liquid hydrocarbon production is principally due to the estimated production of 1.6 million BOPD from the Prudhoe Bay field.

CONCLUDING STATEMENT

The results as projected in this report are dependent on the assumed conditions selected to prepare the estimates. Unforeseen economic and operating conditions between 1975 and 1980 could affect the outcome. As an example, the level of production from the Prudhoe Bay field in Alaska could vary greatly from the 1.6-million-barrel-per-day oil production level assumed in this study for 1980. New production from the Naval Petroleum Reserve No. 1, Elk Hills field, in California is uncertain and may have a direct bearing on actual 1980 production. Accelerated Federal offshore leasing could have an effect by 1980, although it is not likely due to the normal time lag between discovery of reserves and initial crude oil or gas production.

In view of the information developed in this study, enhanced oil production has contributed substantially to total crude oil production in the past. It is estimated that enhanced oil production as a percentage of total crude oil production will continue to increase through 1980 in all districts except in PAD districts I and II. For the United States, enhanced oil production surpassed primary oil production in 1973, and it was estimated at 53 percent

of the total oil production in 1975. With the inclusion of production from Alaska, enhanced oil production as a percentage of total crude oil is estimated at 64 percent in 1980.

Drilling activity increased between 1971 and 1975 in response to more favorable crude oil prices and to free-market intrastate gas prices. This resulted in reversal of the downward trend in crude oil production in several areas of the country but did not stop the decline in U.S. total production and proved reserve. Oil reserves are being used faster than new reserves are found. Unless significant breakthroughs in new and innovative enhanced recovery methods are developed or major new fields discovered which can be placed in production before 1980, proved reserve and production in the conterminous United States will continue to decline through 1980.

As previously stated, unforeseen developments can affect the projections. The following tabulation is presented to incorporate into the 1980 estimate of crude oil production additional production expected due to developments that occurred after 1975:

Oil production, 1,000 bbl

	1975[P]	1980
Conterminous United States[1]......................	2,856,899	2,344,143
Alaska...	69,772	650,430
Elk Hills field, Calif............................	([2])	73,200
Yates field, Tex.................................	([2])	18,300
Total United States......................	2,926,671	3,086,073

[P] Preliminary.

[1] Total in 1980 does not include additional production expected due to the change in maximum efficient rate of the Yates field in Texas and the development of Naval Petroleum Reserve in Elk Hills field, Calif.

[2] 1975 production included in the conterminous United States total.

With the continuation of declining production of crude oil and natural gas liquids, total liquid hydrocarbon production for the conterminous United States is expected to decline from 3.55 billion barrels in 1975 to 2.90 billion barrels in 1980. Natural gas liquid production is estimated to drop from 690.3 million barrels to 558 million barrels during the same period. Including Alaska, total liquid hydrocarbon production would decline from 3.62 billion barrels in 1975 to 3.55 billion barrels in 1980. However, with inclusion of additional production expected due to developments which occurred after 1975 (development of the Elk Hills field in California and the increased maximum efficient rate for the Yates field in Texas) total liquid hydrocarbon production in 1980 is estimated at 2.99 billion barrels for the conterminous United States and 3.64 billion barrels for the total United States.

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APPENDIX

Historical liquid hydrocarbon production data 1946-74 and the 1980 estimated production are presented graphically by State and State subdivisions of Louisiana and Texas. For the subdivisions of Texas, total liquid hydrocarbon production data were not shown on the graphs for the years during the 1946-64 period because natural gas liquid production data were not readily available for those years. Condensate production could not be obtained for all States; therefore, it is shown for only those States that reported condensate separate from crude oil and for those States for which condensate was reported with the crude oil but could be separated by identifying the gas condensate fields. Table A-1 consists of enhanced oil production as a percent of total crude oil production for the United States and selected States and State subdivisions, and table A-2 shows the annual oil production as a percent of the proved oil reserve at the beginning of the year for the United States without Alaska, States, and State subdivisions.

TABLE A-1. - Annual enhanced production as a percent of total crude oil production for United States and selected States and State subdivisions

Year	U.S. total	Texas[1] Total	RRC 1	RRC 2	RRC 3	RRC 4	RRC 5 and 6	RRC 7B	RRC 7C	RRC 8 and 8A	RRC 9	RRC 10	Louisiana Total	In-land	Off-shore	New Mexico	Okla-homa[2]	Kan-sas	Arkan-sas	Illi-nois	Michi-gan	Indi-ana	Alaska	Cali-fornia	Wyo-ming	Colo-rado
1946	14.2	18.3	6.3	0.5	3.8	11.1	70.1	5.6	0	([3])	2.4	0.4	10.2	10.2	0	7.8	9.6	2.3	38.8	5.1	2.7	2.2	-	10.7	21.6	0
1947	14.2	18.2	5.4	.5	3.8	19.5	68.0	5.0	0	0.3	2.6	13.1	11.9	11.9	0	7.3	8.9	3.8	39.7	5.9	2.2	2.3	-	10.6	16.4	4.5
1948	14.1	17.4	3.8	2.5	6.3	19.5	65.7	3.8	0	1.8	2.9	13.4	10.7	10.7	0	6.4	11.5	5.6	37.7	5.7	3.0	1.7	-	10.2	14.2	7.4
1949	15.8	18.7	2.9	4.2	6.2	22.7	68.9	3.6	8.5	3.1	3.3	12.8	9.0	9.0	0	6.6	11.1	7.0	35.7	6.2	2.9	1.5	-	17.1	18.7	5.4
1950	16.9	18.3	2.9	5.0	6.9	21.9	70.3	3.5	3.9	4.5	4.1	13.2	7.8	8.0	0	6.5	11.1	7.0	43.3	7.3	3.0	1.9	-	23.7	20.3	6.3
1951	16.3	17.2	2.6	5.4	8.8	20.3	65.1	3.3	2.3	5.8	5.0	14.1	6.5	6.7	0	5.4	10.4	7.0	44.0	15.6	3.7	5.9	-	23.6	19.7	5.3
1952	16.8	18.1	2.7	5.1	9.4	21.3	62.9	5.9	3.0	9.0	7.3	16.7	5.9	6.1	0	4.2	10.3	8.7	42.1	20.7	4.5	18.6	-	23.0	19.2	12.2
1953	17.6	19.0	1.7	5.0	10.8	20.0	62.2	6.5	4.9	12.1	9.5	17.7	7.8	8.1	0	3.0	11.1	9.5	39.8	23.7	10.2	19.5	-	24.8	16.0	18.2
1954	20.0	20.0	1.6	4.8	10.6	20.6	62.2	6.7	12.3	15.0	10.8	15.5	9.4	10.1	0	2.8	19.6	9.5	37.3	28.8	9.7	21.4	-	30.8	19.6	20.6
1955	20.5	20.4	1.8	5.0	10.2	20.7	59.8	6.8	10.4	18.6	10.4	15.1	9.3	10.3	.2	2.6	23.5	12.5	37.8	34.0	15.5	34.9	-	30.6	17.0	23.3
1956	20.6	19.7	1.6	4.9	10.0	20.4	58.4	7.0	9.3	18.6	10.8	14.0	8.4	9.8	.2	2.7	25.8	12.1	38.2	39.1	23.9	36.0	-	32.6	18.6	26.3
1957	20.8	19.6	1.8	4.6	10.1	20.4	56.0	8.0	10.6	18.9	11.4	13.1	7.8	8.4	.2	2.7	27.8	13.6	38.8	47.9	28.1	35.0	-	33.5	20.0	26.7
1958	23.0	24.0	2.0	3.7	13.7	26.4	55.3	11.1	16.2	27.2	13.7	15.5	6.9	8.6	.4	4.8	31.7	14.3	35.1	54.7	30.1	34.5	0	34.5	26.7	15.9
1959	24.2	27.2	2.9	4.1	13.7	27.0	55.8	15.2	27.5	29.9	25.7	19.3	6.0	6.6	3.8	5.9	34.1	15.0	39.7	58.5	24.6	33.8	0	34.8	25.4	30.1
1960	27.6	31.5	3.7	3.4	13.5	31.1	57.0	18.2	31.5	36.6	33.0	25.1	6.8	7.8	3.6	7.0	36.1	17.0	43.0	64.1	33.7	35.4	0	42.7	24.9	44.7
1961	29.4	32.0	3.9	3.3	13.0	29.7	55.8	17.6	28.0	38.0	33.7	30.5	6.3	6.9	4.7	10.1	40.1	18.0	43.5	68.0	25.5	36.0	0	48.3	26.4	50.8
1962	31.4	34.1	10.3	6.5	18.5	48.3	50.5	25.6	28.7	35.6	43.9	36.7	7.4	8.3	5.2	12.7	42.2	18.6	47.2	65.2	26.3	48.9	0	51.5	27.7	49.4
1963	33.9	35.5	14.4	7.4	18.8	48.0	48.3	27.7	31.3	38.6	47.5	32.3	11.4	13.9	6.0	15.0	44.9	19.8	48.9	68.2	23.1	51.4	72.6	56.4	25.4	68.0
1964	37.1	35.7	18.0	8.1	17.9	45.0	48.5	26.5	34.9	39.7	47.1	29.7	12.4	10.3	16.3	28.7	46.6	17.7	52.5	70.6	21.5	53.8	70.9	58.7	60.5	75.5
1965	39.0	39.8	20.1	12.7	19.9	48.9	52.2	29.2	36.4	44.9	51.4	32.7	14.0	10.5	20.4	29.6	47.0	18.1	53.4	70.6	22.2	57.2	70.9	61.6	61.4	70.4
1966	42.4	43.6	19.5	15.0	21.5	52.3	56.1	31.6	32.4	52.1	50.7	30.6	23.4	22.5	24.8	29.8	47.2	17.5	51.0	70.4	21.1	60.4	81.5	60.4	71.8	72.6
1967	42.6	46.3	18.0	17.0	22.6	52.8	59.0	33.9	33.3	57.0	51.8	30.0	20.1	17.3	24.5	29.1	47.6	19.5	47.4	73.1	23.1	66.0	44.9	62.3	74.0	68.6
1968	43.8	48.3	21.4	14.0	24.9	52.1	60.1	37.3	35.2	59.9	53.7	35.5	21.6	16.5	28.6	38.5	49.7	21.5	46.0	73.9	24.8	57.8	20.6	66.6	71.1	66.4
1969	46.2	51.0	22.5	14.0	27.6	52.6	61.1	40.8	37.0	63.7	54.1	38.3	25.0	18.1	33.2	29.5	50.7	23.2	40.6	73.8	26.0	57.1	74.9	69.5	63.5	63.9
1970	48.1	52.9	25.7	15.3	30.4	54.6	59.1	36.7	36.9	66.6	54.2	39.0	26.4	19.6	33.9	29.9	52.1	21.6	35.4	71.0	25.4	51.4	80.4	67.9	78.1	58.4
1971	48.8	57.0	20.2	15.1	31.0	55.2	74.7	42.2	36.9	69.4	54.9	41.7	28.9	24.2	33.4	45.8	50.1	22.8	33.2	71.7	26.4	52.6	86.1	58.7	70.6	55.8
1972	49.2	57.6	45.8	14.9	29.8	49.8	73.2	45.5	26.4	71.2	54.9	38.4	28.1	24.9	31.0	44.4	48.4	23.7	29.0	73.5	24.2	50.3	91.5	59.9	70.7	59.6
1973	50.4	59.9	42.8	19.1	31.0	49.8	73.0	46.0	26.3	73.6	59.7	36.6	25.8	22.8	28.3	49.2	53.1	22.2	26.1	71.5	21.2	49.9	91.9	61.5	72.9	65.1
1974	52.4	60.4	38.7	20.1	30.7	47.2	72.9	47.3	28.3	74.0	58.9	35.3	24.2	21.0	26.7	60.5	54.4	21.6	33.9	70.5	17.0	51.1	95.2	63.5	72.1	67.2

[1] Includes estimates of enhanced oil production for 1958-59 and for 1974.
[2] Includes estimate of enhanced oil production for 1971.
[3] Negligible, less than 0.1 percent.

TABLE A-2. - Annual oil production as a percent of the reserve at beginning of year for United States without Alaska, States, and State subdivisions

Year	U.S. total without Alaska	PAD district I				PAD district II									PAD district III				
		Florida	New York	Pennsylvania	West Virginia	Illinois	Indiana	Kansas	Kentucky	Michigan	Nebraska	North Dakota	Ohio	Oklahoma	Alabama	Arkansas	Louisiana	Mississippi	New Mexico
1946	8.7	-	6.0	11.8	7.7	21.6	16.2	17.8	18.8	26.5	58.0	-	11.8	15.4	48.7	9.2	9.0	9.3	7.2
1947	8.9	-	6.3	13.0	7.5	19.1	16.2	19.1	16.2	23.7	24.5	-	12.4	15.8	79.1	10.5	9.5	12.9	7.5
1948	9.3	33.3	6.2	10.5	7.5	17.7	17.3	19.2	13.4	27.3	-	-	13.5	16.3	17.3	10.1	9.8	14.4	8.9
1949	7.8	31.7	6.3	10.4	7.7	16.3	19.3	14.8	16.0	23.8	33.6	-	12.2	12.1	12.6	9.4	9.8	9.8	8.6
1950	7.9	17.6	6.5	11.6	7.4	13.5	20.4	14.6	18.5	23.9	81.6	-	12.0	12.3	18.1	9.8	10.5	8.9	7.4
1951	8.8	22.9	7.2	10.7	6.9	11.0	18.5	15.6	18.4	17.8	28.5	-	11.5	13.3	19.1	8.2	10.1	9.2	9.1
1952	8.2	24.5	7.4	11.7	6.8	9.4	23.4	14.4	20.1	20.9	15.0	28.5	12.7	12.8	13.8	8.2	9.9	9.0	9.8
1953	8.3	16.6	7.1	8.7	8.1	9.4	22.0	12.5	20.4	21.4	28.1	6.9	13.5	12.8	10.7	8.0	9.3	9.3	9.5
1954	7.8	19.6	6.6	8.3	7.9	10.5	18.1	12.9	16.2	19.7	31.4	4.8	12.2	10.5	9.2	7.4	8.2	9.3	8.9
1955	8.2	22.3	6.3	8.4	6.4	12.5	16.0	12.3	18.3	18.9	31.1	8.3	11.9	10.3	9.1	7.5	8.3	8.7	10.0
1956	8.5	13.8	6.4	8.8	4.8	11.9	20.0	12.5	16.3	18.2	29.2	6.9	8.8	10.5	14.4	8.5	8.3	10.1	10.6
1957	8.4	15.9	6.6	6.1	4.3	10.9	17.4	12.5	11.7	18.6	31.3	6.7	8.7	10.5	17.1	9.3	8.1	10.0	11.1
1958	7.8	18.9	4.6	5.3	4.2	12.2	17.4	12.7	11.5	18.6	31.8	5.4	9.5	10.2	17.3	9.2	7.3	10.6	11.5
1959	8.1	14.4	5.5	5.1	4.2	12.6	16.1	12.9	22.4	23.4	32.8	5.7	8.5	10.2	14.5	7.8	7.9	12.5	11.4
1960	7.8	14.7	5.3	5.2	4.4	13.1	16.3	12.3	15.9	28.7	29.2	5.7	6.8	10.2	21.4	8.4	7.4	12.9	10.2
1961	7.9	15.0	5.2	5.2	5.2	13.9	17.3	12.7	14.0	24.4	28.8	5.5	7.6	10.5	20.4	9.4	7.7	13.1	10.0
1962	8.0	17.2	5.7	5.1	6.9	15.6	19.2	12.7	15.0	21.7	24.8	6.1	7.7	11.0	20.7	9.6	8.5	13.3	9.6
1963	8.2	13.0	7.2	5.2	5.8	16.1	20.0	12.6	15.6	21.4	22.3	6.2	7.8	11.3	23.8	10.6	8.8	14.7	9.8
1964	8.5	12.1	10.2	5.6	5.7	17.0	17.5	12.6	20.2	22.4	22.4	6.6	18.0	12.2	19.3	11.5	9.4	14.5	10.7
1965	8.7	16.2	12.0	5.6	6.0	16.3	18.2	13.0	16.7	25.0	24.2	7.0	13.0	13.0	16.3	12.2	9.9	15.3	11.8
1966	9.1	12.6	14.5	5.6	6.7	16.4	18.5	13.6	17.3	27.1	19.9	6.9	10.8	14.3	12.3	11.5	11.1	17.1	13.0
1967	9.7	13.6	19.4	6.1	6.3	16.5	21.1	13.5	15.8	18.5	23.1	7.8	9.8	14.7	8.6	11.2	12.6	15.3	11.6
1968	9.9	14.2	10.5	6.5	6.2	16.9	18.4	15.0	15.3	20.6	21.7	8.6	9.8	14.9	9.6	11.0	12.8	15.3	13.1
1969	10.3	23.3	9.6	7.5	6.0	16.0	19.8	14.6	16.9	21.7	22.7	7.9	8.3	15.5	10.6	10.7	13.2	19.5	13.9
1970	11.1	31.5	10.5	7.3	6.0	15.7	18.0	14.8	15.7	23.0	24.7	9.3	7.7	15.2	10.7	13.4	13.7	17.9	14.7
1971	11.0	6.9	10.7	8.3	5.7	16.6	18.2	14.3	17.3	25.0	24.6	11.3	6.5	15.4	11.9	13.4	14.0	17.8	14.9
1972	11.5	7.8	9.5	7.3	5.3	15.9	19.9	14.8	18.6	20.9	24.1	12.1	7.2	14.1	15.8	15.5	14.4	17.7	16.2
1973	11.9	15.7	10.4	8.8	7.2	16.6	18.4	14.7	18.3	22.1	24.0	11.9	6.9	13.8	19.3	15.1	14.3	17.1	16.5
1974	11.8	19.6	10.7	8.6	8.2	17.5	18.1	15.3	19.9	24.8	23.2	11.0	7.3	13.0	20.5	15.0	14.0	17.4	14.5
1975	11.7	13.5	8.0	6.3	8.0	15.9	18.7	14.9	20.5	29.8	22.7	11.6	7.7	12.4	14.5	14.7	13.2	17.5	14.5

Year	PAD district III--Continued													PAD district IV				PAD district V	
	Texas													Colorado	Montana	Utah	Wyoming	Alaska	California
	Total	RRC 1	RRC 2	RRC 3	RRC 4	RRC 5	RRC 6	RRC 7B	RRC 7C	RRC 8[1]	RRC 8A[2]	RRC 9	RRC 10						
1946	7.0	13.0	7.6	6.7	7.7	4.7	5.9	18.2	7.7	6.4	-	16.7	10.2	4.6	8.1	-	6.4	-	9.5
1947	7.0	10.4	7.4	7.0	7.7	4.9	4.9	19.2	9.9	7.5	-	15.3	9.8	5.2	8.7	-	7.6	-	10.1
1948	7.6	10.1	7.9	7.3	7.3	6.0	5.0	22.4	10.5	9.2	-	14.6	10.2	4.5	8.3	-	8.2	-	10.3
1949	5.9	10.5	5.4	5.4	5.3	4.7	4.3	17.0	8.3	6.3	-	12.9	9.7	6.4	8.1	77.6	6.7	-	8.8
1950	6.1	11.1	5.7	5.7	5.7	4.8	4.5	16.7	9.6	5.9	-	13.1	10.1	6.7	7.6	7.8	8.8	-	8.6
1951	7.3	13.5	7.2	6.8	7.0	7.0	5.1	16.0	15.3	7.4	-	13.2	10.2	8.2	8.2	6.2	8.2	-	9.5
1952	6.6	14.3	7.0	6.7	7.0	6.5	4.2	17.2	7.5	6.4	-	13.8	10.3	9.3	8.9	5.7	7.2	-	9.6
1953	6.7	17.6	7.0	6.6	6.9	7.2	3.8	18.2	8.9	7.2	6.3	14.0	10.4	11.7	7.7	4.2	7.8	-	9.5
1954	6.3	20.8	5.8	6.1	6.3	6.6	3.6	19.2	10.2	7.3	5.2	13.1	9.2	14.4	6.7	5.1	7.0	-	9.1
1955	6.8	24.3	6.4	6.3	6.4	7.2	3.6	18.0	10.8	8.3	5.7	13.5	9.9	16.1	5.7	5.9	7.6	-	9.1
1956	7.2	19.1	6.7	6.6	6.5	6.9	3.7	19.4	10.8	9.2	6.2	14.5	10.0	17.5	7.3	6.8	7.7	-	9.2
1957	7.2	18.1	6.4	6.3	6.1	6.4	3.6	18.8	9.9	9.5	6.3	14.5	11.0	15.1	8.1	7.5	8.0	-	9.0
1958	6.2	13.5	5.2	5.4	5.2	5.4	2.9	15.9	8.4	8.9	4.8	14.5	11.3	15.6	9.0	17.6	8.0	-	8.3
1959	6.6	12.6	5.5	5.3	5.4	5.4	3.0	17.1	8.8	9.2	6.0	15.6	12.3	11.8	9.0	20.1	8.9	-	7.9
1960	6.0	13.4	5.3	4.8	5.2	5.2	2.8	16.4	9.3	8.4	4.5	13.5	12.0	12.3	9.8	19.3	9.3	14.8	8.1
1961	6.1	11.9	5.6	4.8	5.7	5.5	3.0	14.9	9.6	8.0	4.6	13.6	12.6	13.4	11.5	15.6	10.0	23.2	8.2
1962	6.0	12.7	4.0	5.0	6.0	5.2	2.9	15.3	9.7	8.2	4.7	13.9	13.0	10.1	12.7	13.4	9.9	12.1	8.2
1963	6.2	12.1	4.3	5.4	6.9	5.6	2.9	16.4	10.3	8.2	4.8	14.5	13.8	9.8	12.4	16.9	10.3	12.7	8.2
1964	6.4	12.3	4.5	5.5	7.7	5.8	2.9	16.5	10.8	7.9	5.1	15.1	14.8	9.3	11.3	12.9	11.2	14.8	8.3
1965	6.5	13.0	4.7	5.4	8.2	5.8	2.9	16.8	11.4	8.2	5.2	15.1	15.4	9.6	13.0	11.4	11.7	13.4	7.7
1966	7.0	12.9	5.2	5.9	10.0	6.4	3.3	16.2	13.2	8.7	5.4	15.7	10.9	10.0	12.9	12.1	11.5	9.0	7.5
1967	7.5	13.2	6.0	6.7	11.6	7.0	3.6	13.9	13.1	9.0	6.1	16.1	11.3	9.7	12.4	11.4	12.9	9.0	7.8
1968	7.4	10.7	6.6	7.0	12.4	7.9	3.9	13.9	12.6	7.6	6.8	13.9	11.5	9.4	15.6	11.7	13.7	17.4	8.6
1969	8.0	11.4	7.8	7.5	12.7	9.2	4.4	15.8	12.4	8.4	7.5	15.7	11.2	6.6	13.0	12.6	13.7	19.8	8.6
1970	9.2	10.7	8.7	8.8	13.7	12.2	6.0	15.5	11.7	9.2	9.7	16.1	11.6	6.4	13.6	11.9	15.6	19.2	8.8
1971	9.0	13.6	8.7	9.2	12.8	13.1	5.9	15.2	11.9	9.2	8.5	14.2	11.4	6.9	14.3	12.9	14.1	.8	9.0
1972	9.7	15.1	10.1	10.6	14.1	17.1	7.1	17.7	13.9	8.1	10.2	13.8	11.4	9.7	14.9	15.9	13.9	.7	9.4
1973	10.4	13.8	11.7	11.1	15.0	20.8	7.4	15.0	14.1	8.1	12.4	14.2	11.6	11.3	14.3	13.1	14.6	.7	9.4
1974	10.4	12.7	10.2	11.4	14.0	15.8	7.5	15.1	14.4	8.3	12.9	11.6	11.5	12.1	15.8	14.8	15.0	.7	9.1
1975	10.7	13.1	10.4	11.9	14.9	17.4	7.7	13.7	13.8	8.1	14.2	10.2	10.7	12.9	15.6	15.6	14.4	.7	9.1

[1] Includes RRC 8A prior to 1953.
[2] RRC 8A separated from RRC 8 in 1953.

Source: Percentages calculated from data published by the American Petroleum Institute.
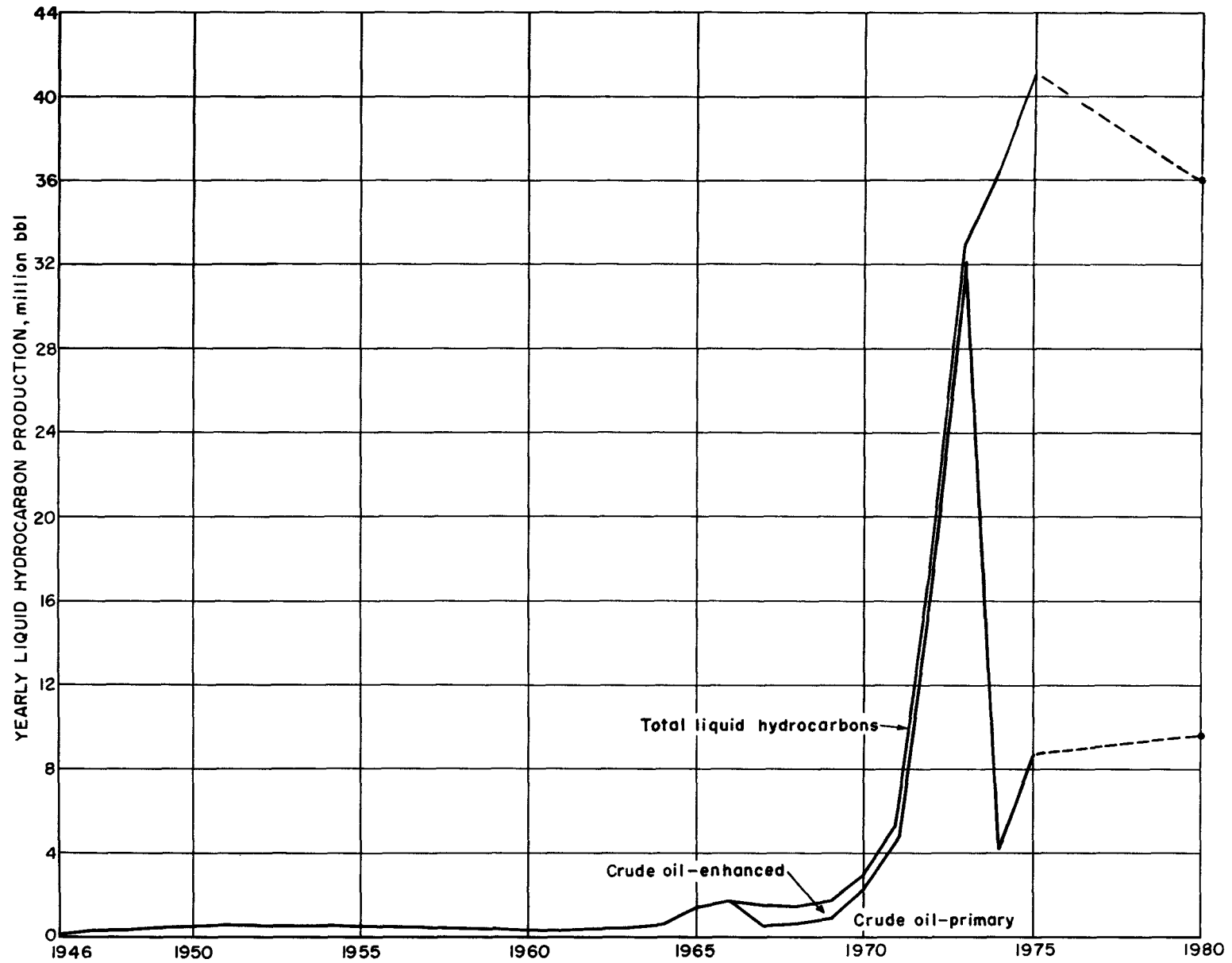
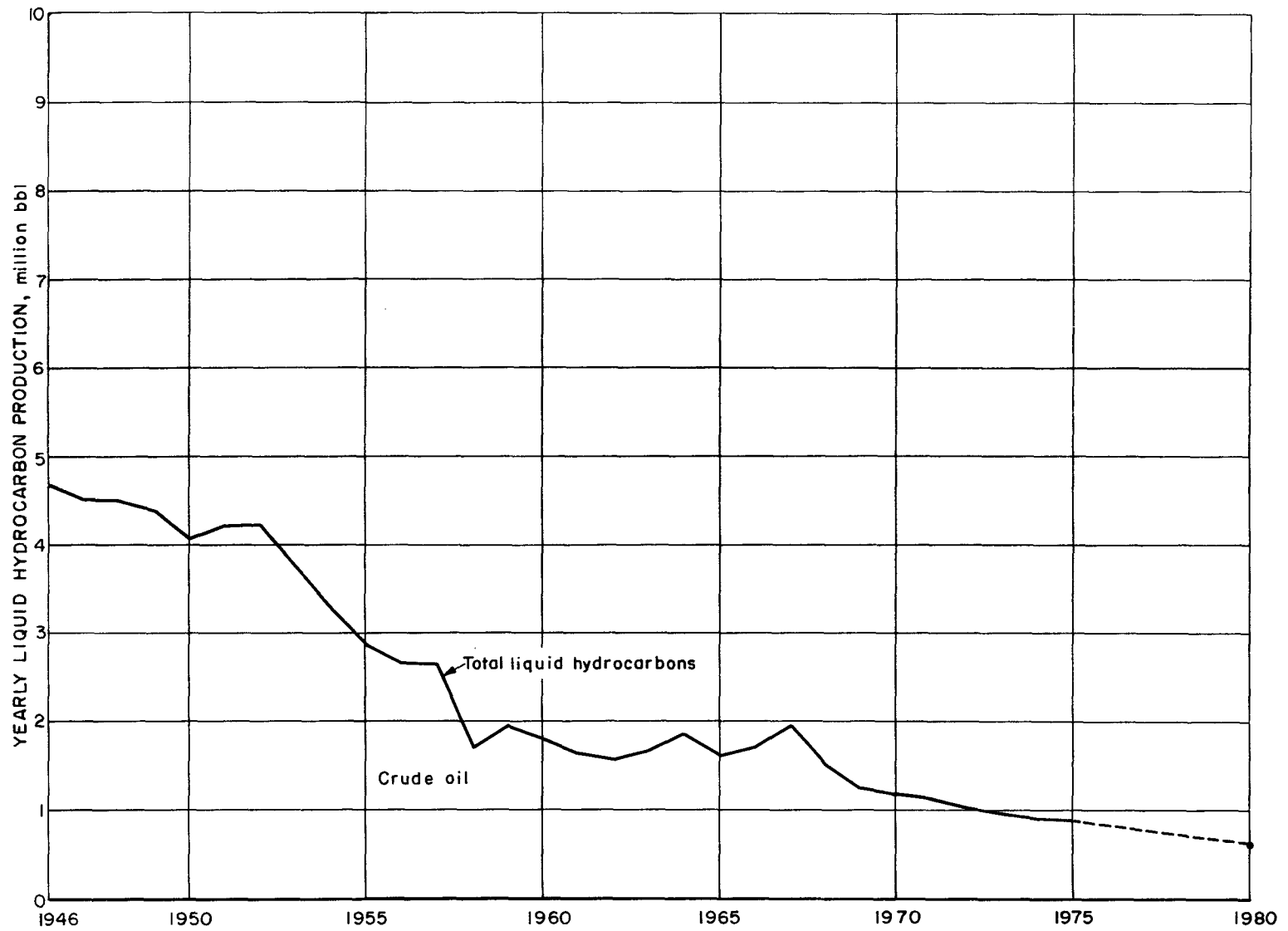FIGURE A-1. - Florida (PAD district I) liquid hydrocarbon production.

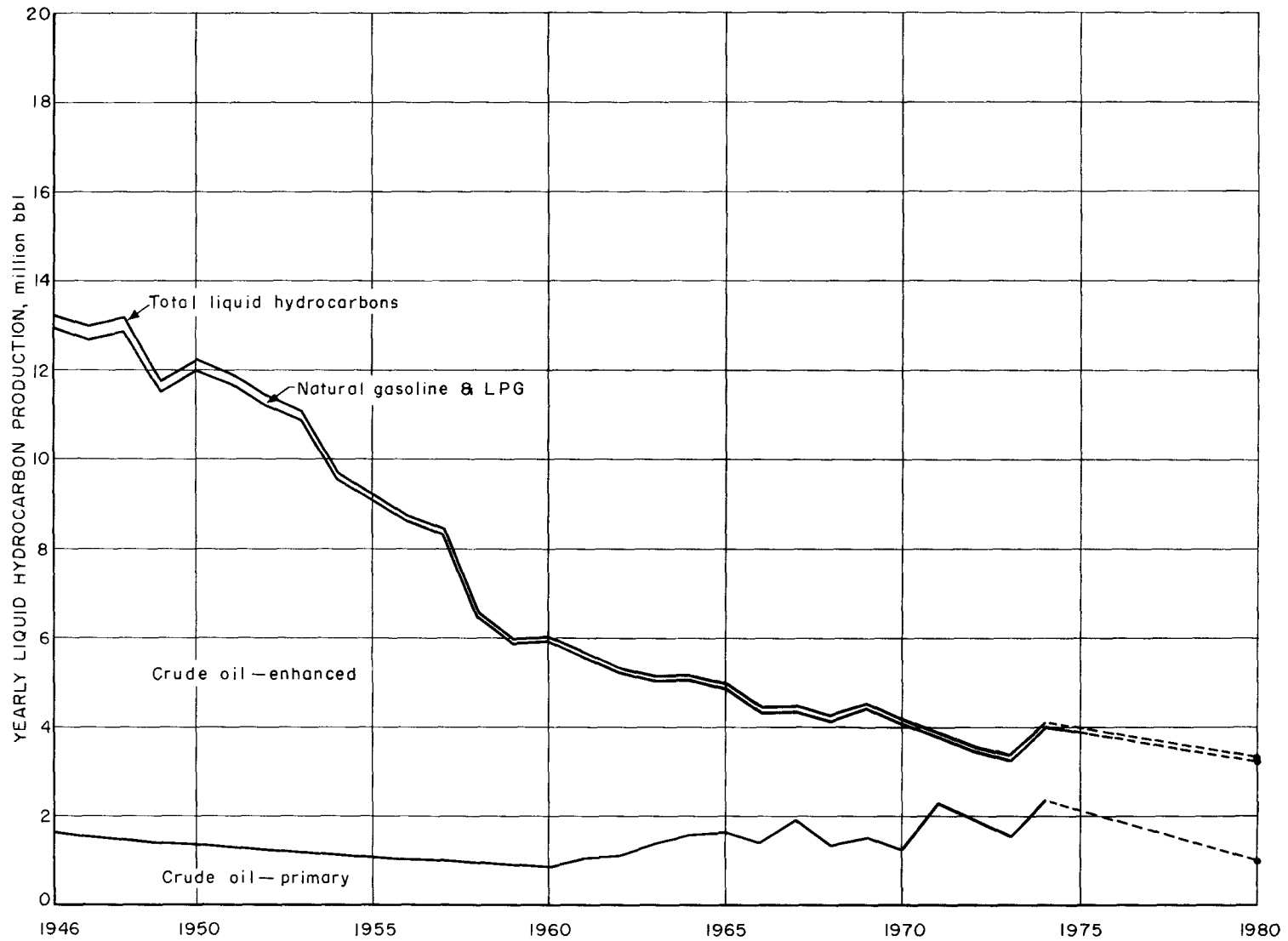FIGURE A-2. - New York (PAD district I) liquid hydrocarbon production.

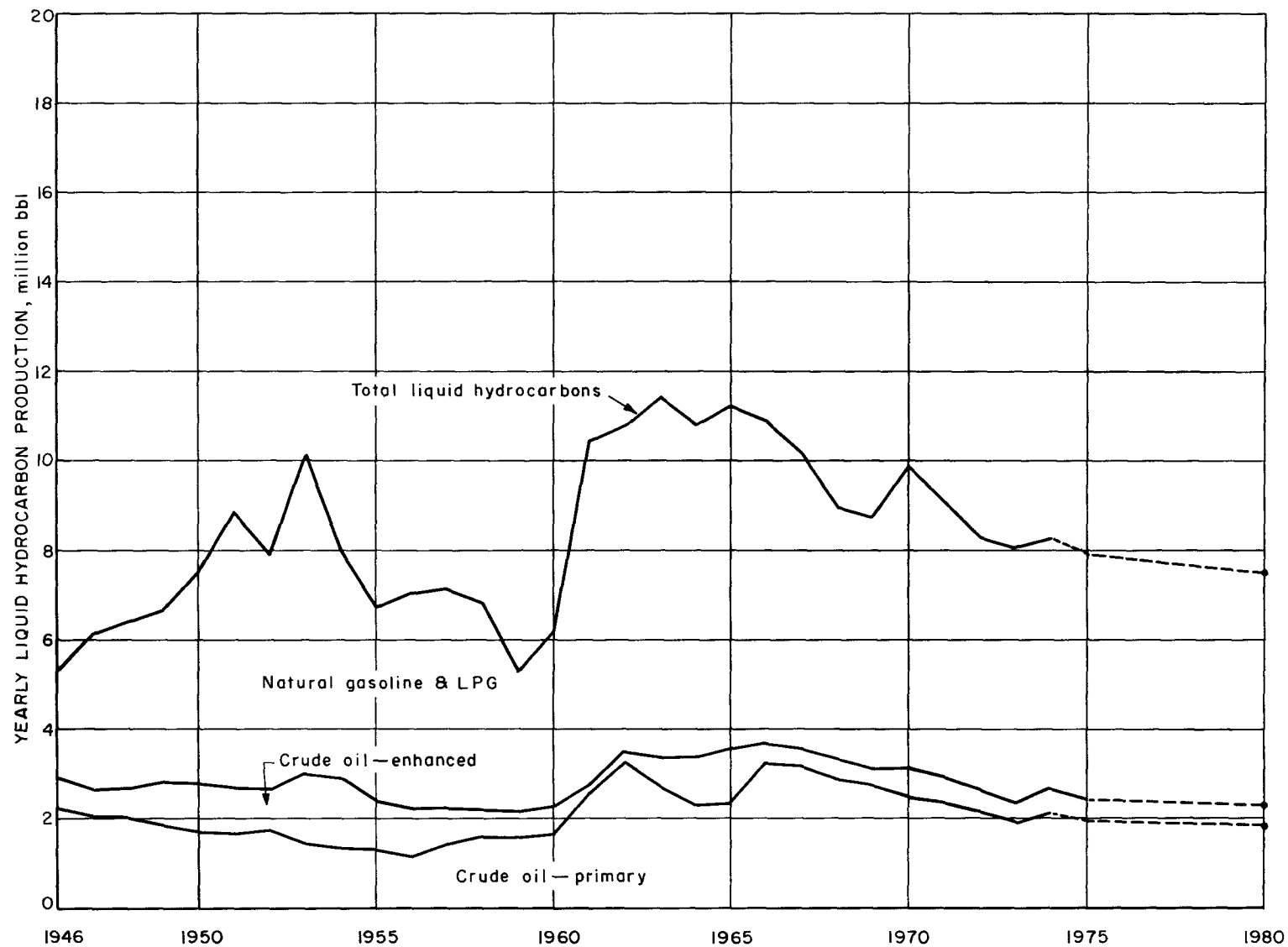FIGURE A-3. - Pennsylvania (PAD district I) liquid hydrocarbon production.

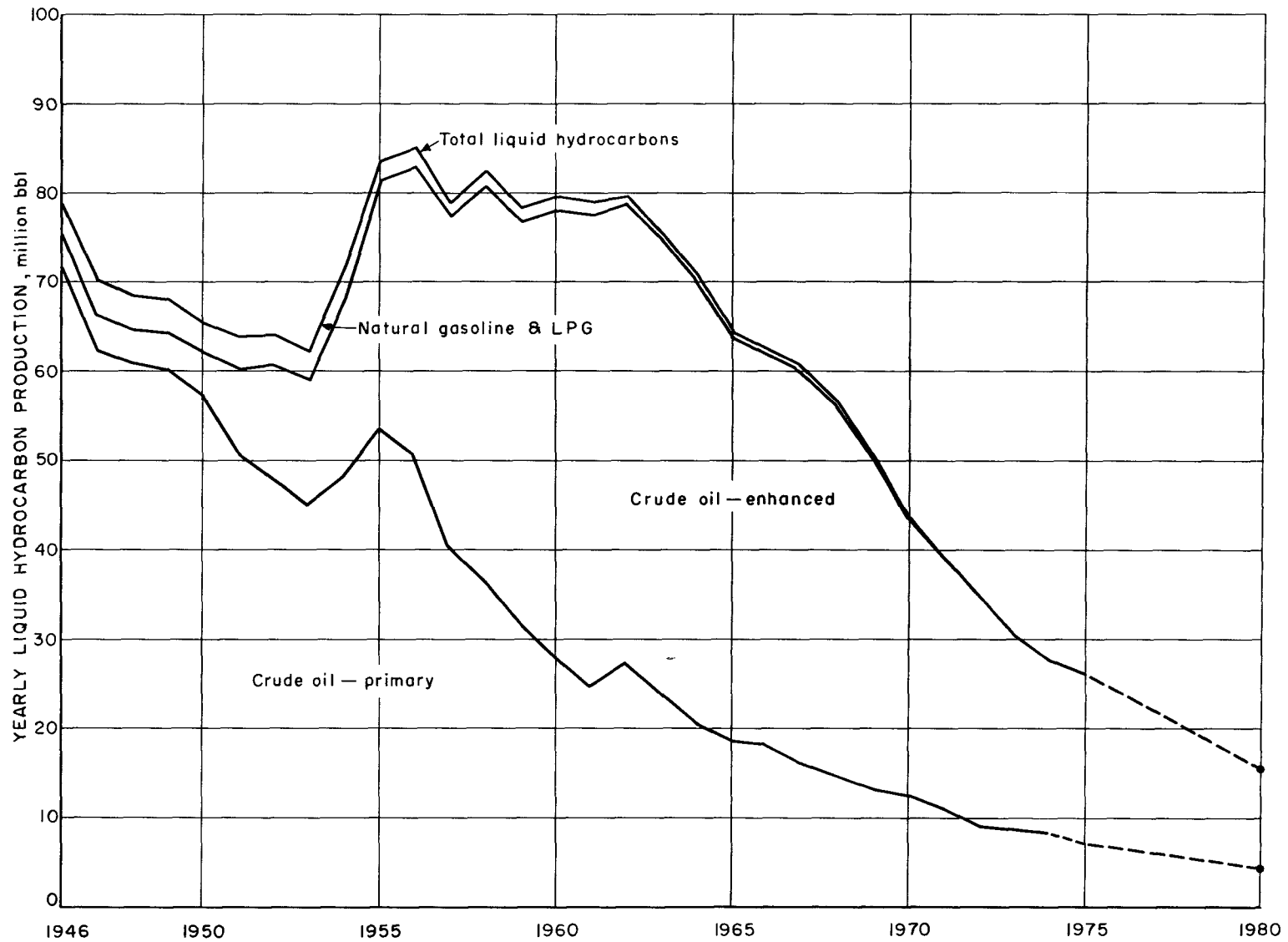FIGURE A-4. - West Virginia (PAD district I) liquid hydrocarbon production.

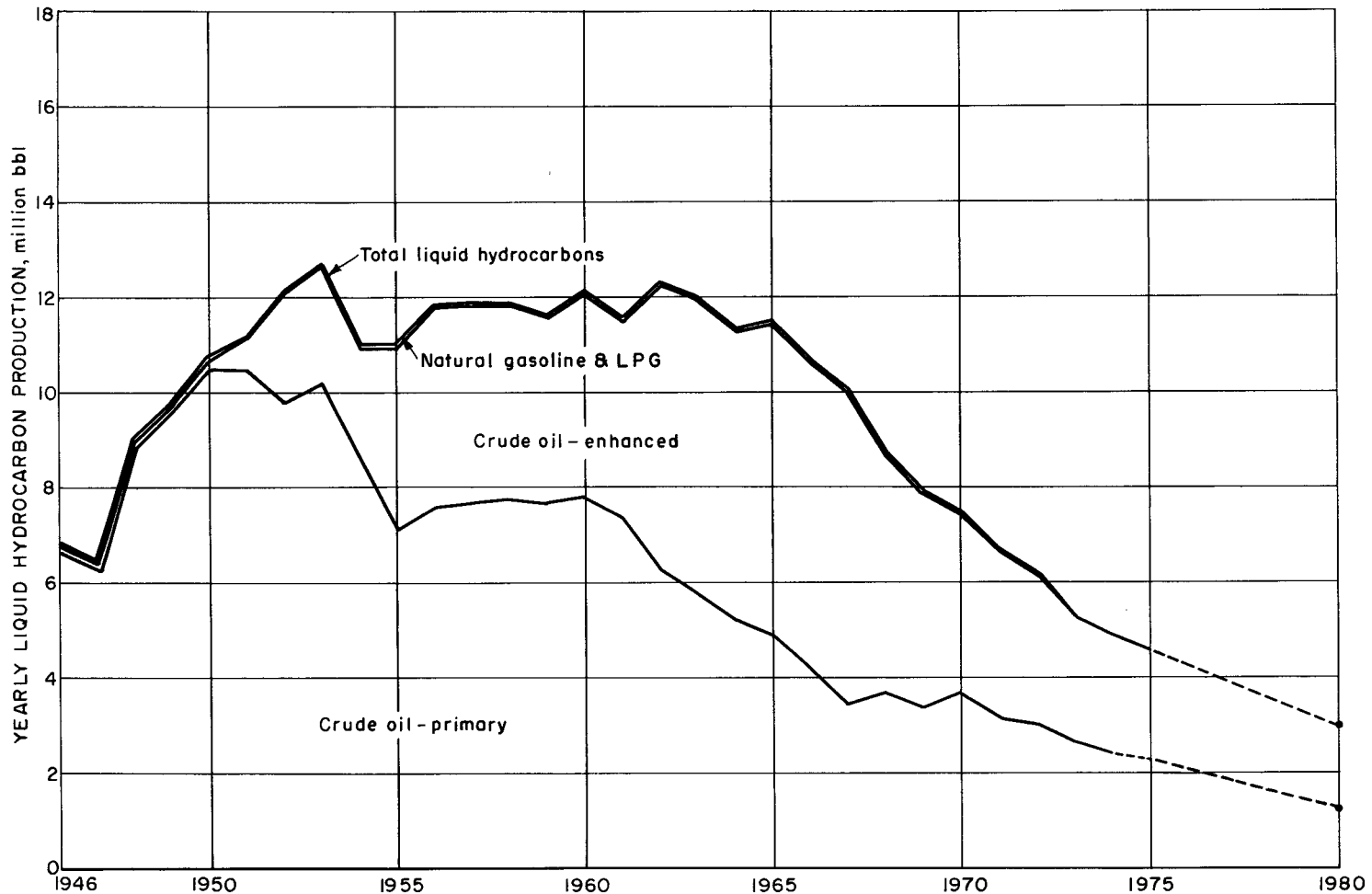FIGURE A-5: - Illinois (PAD district II) liquid hydrocarbon production.

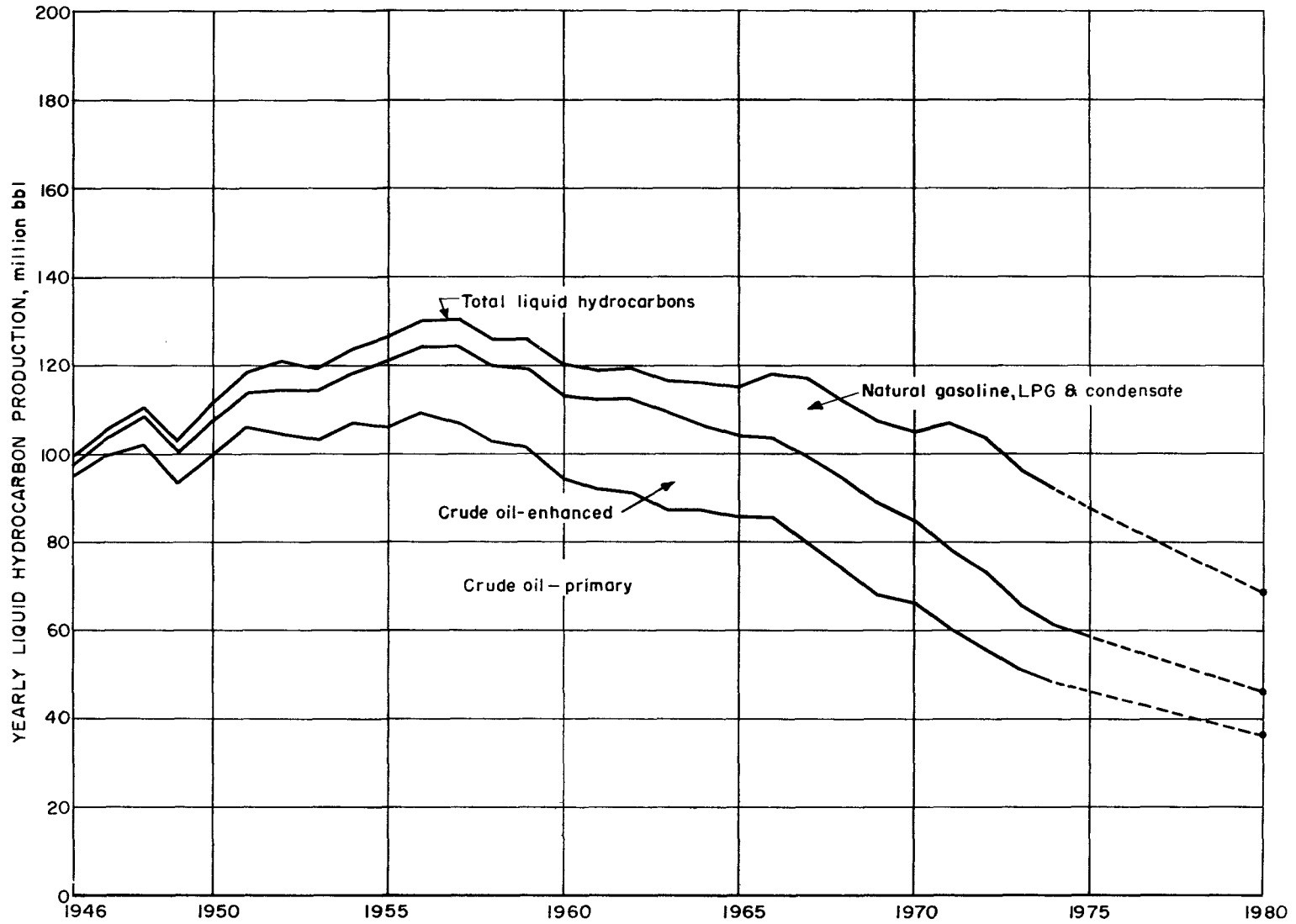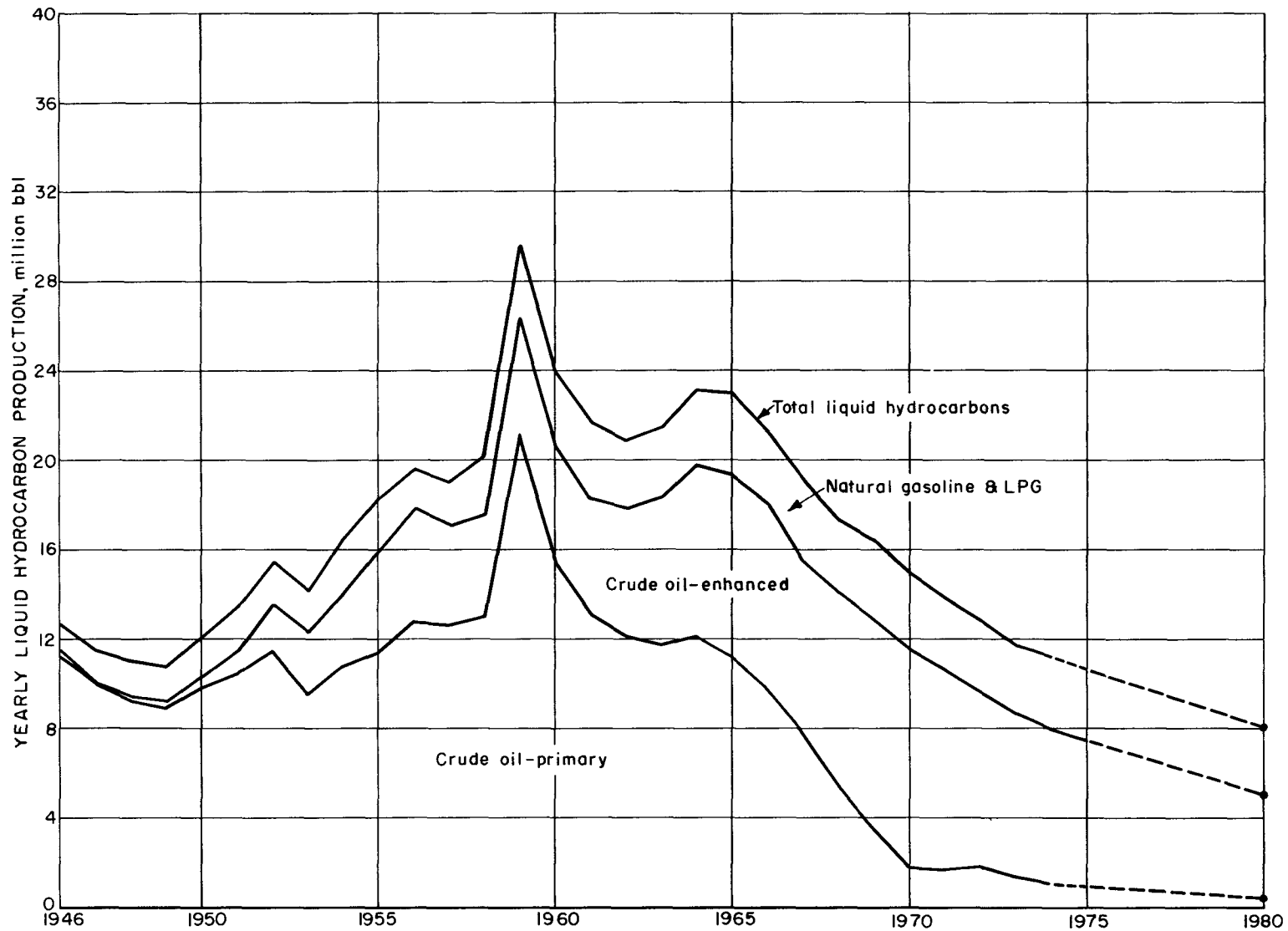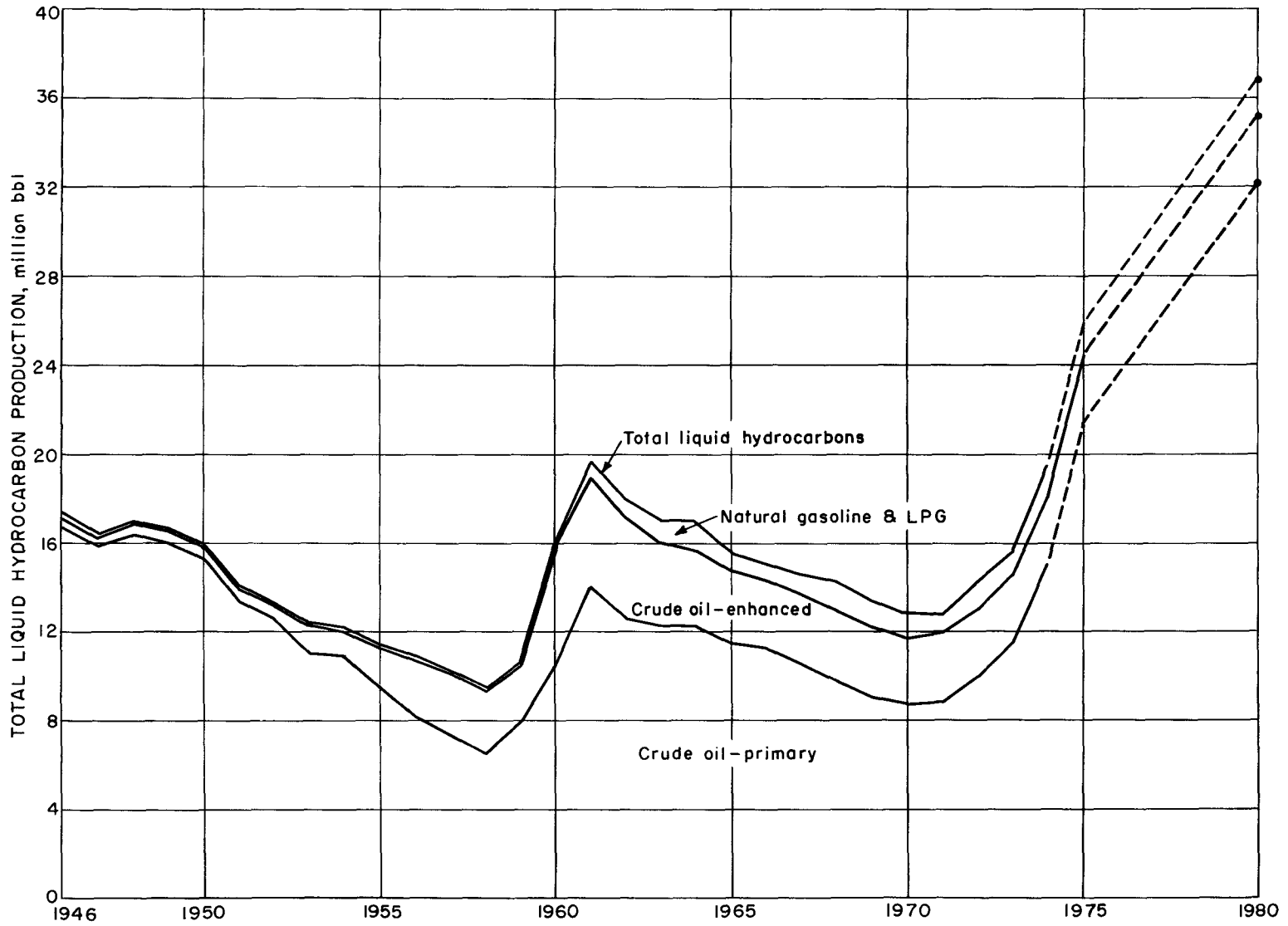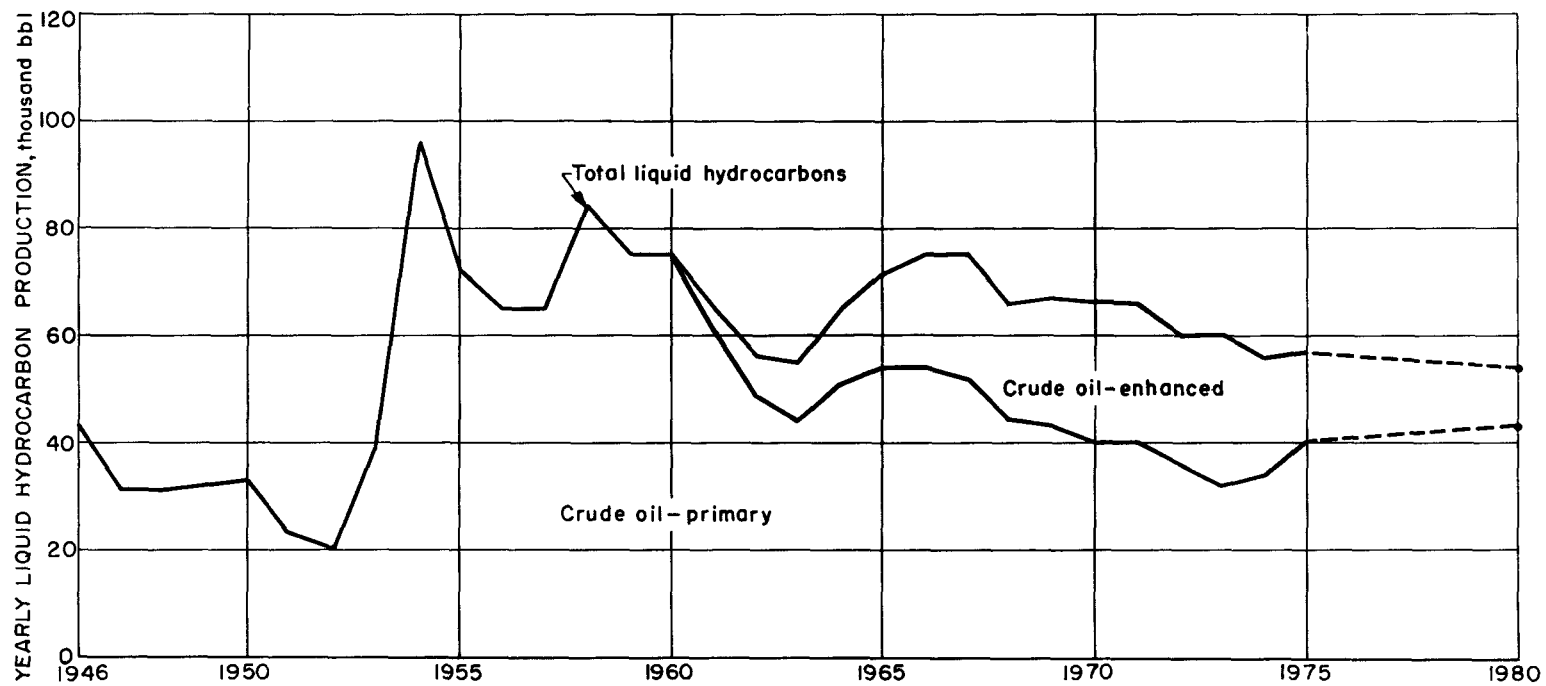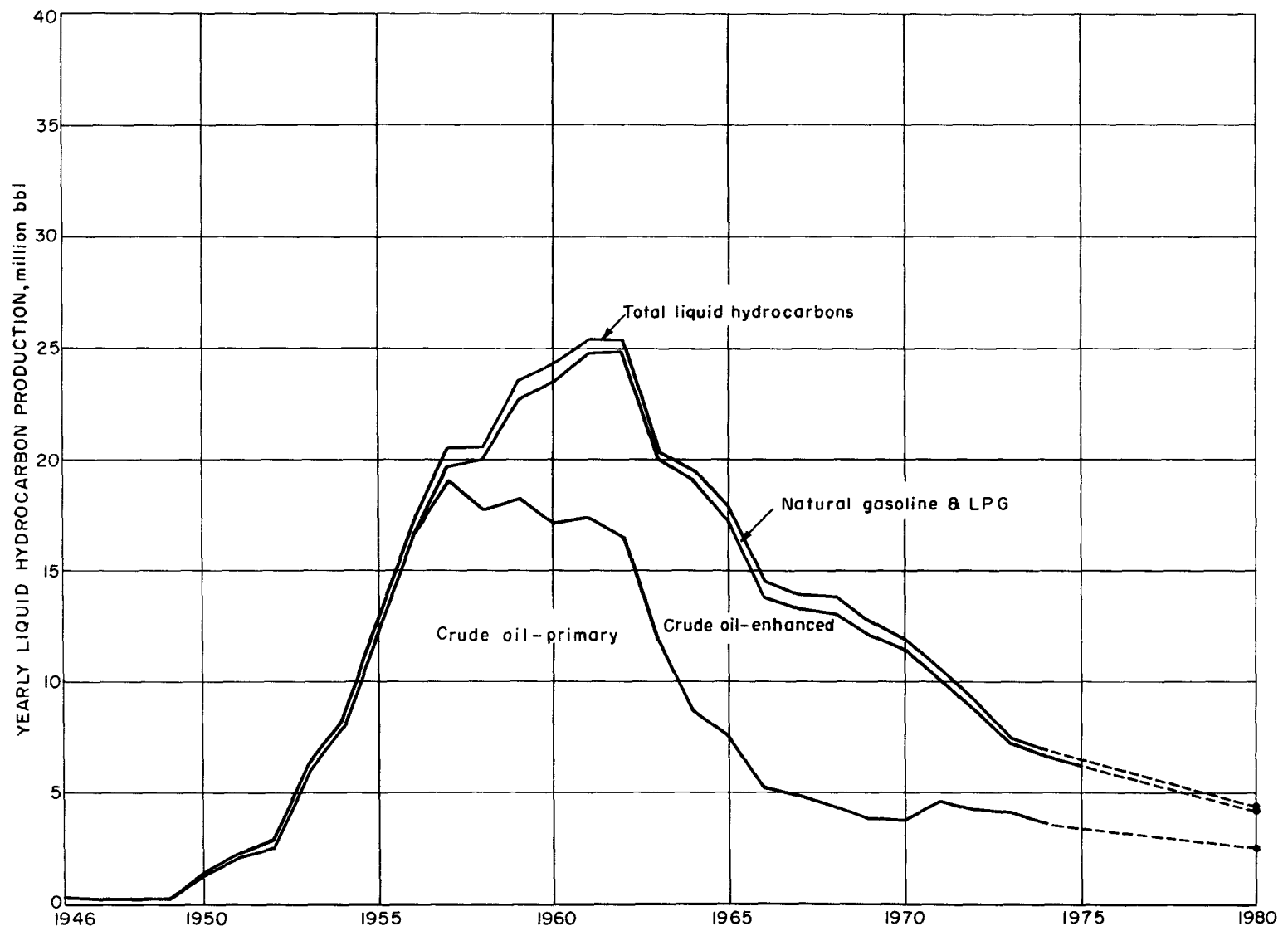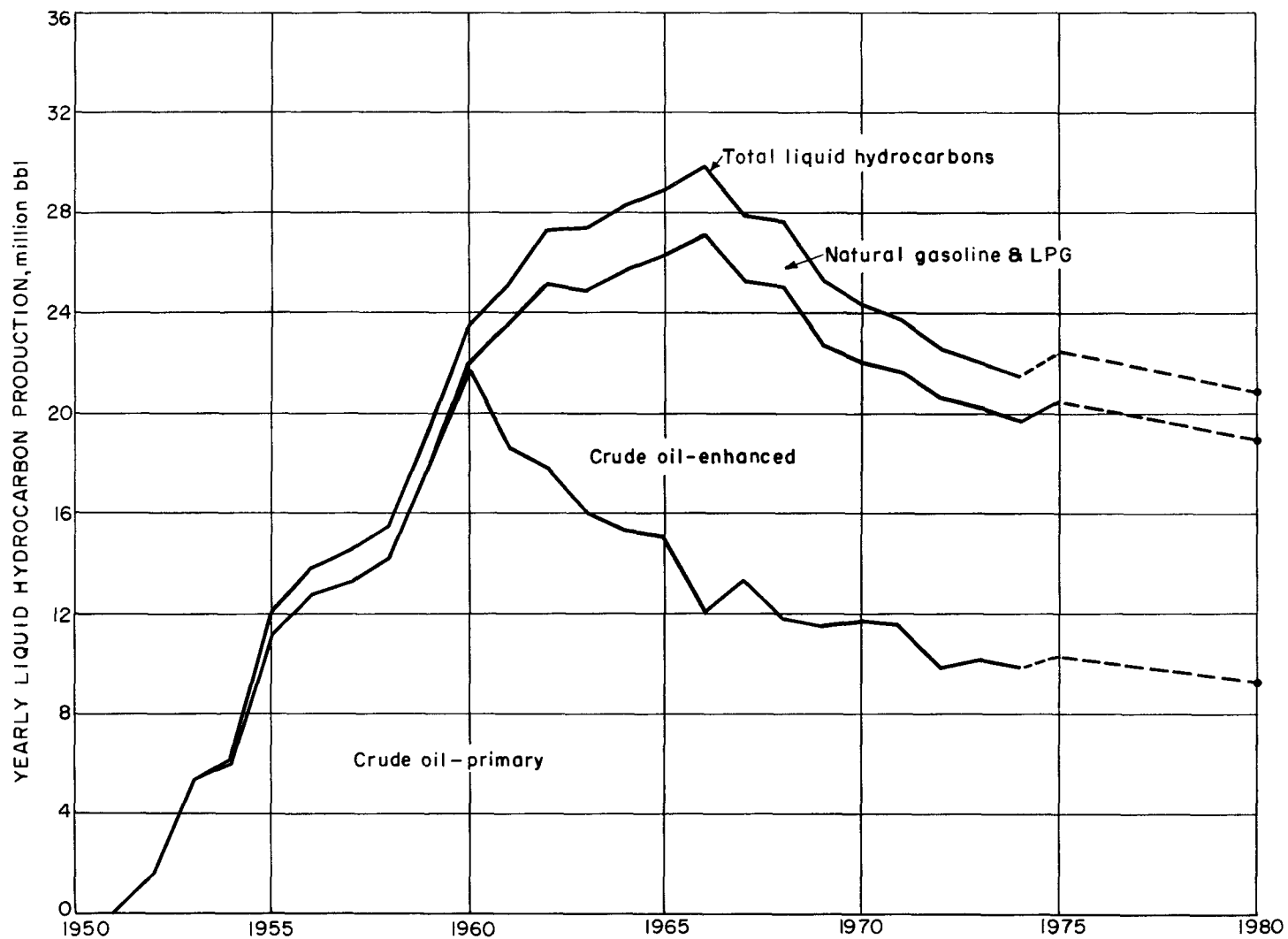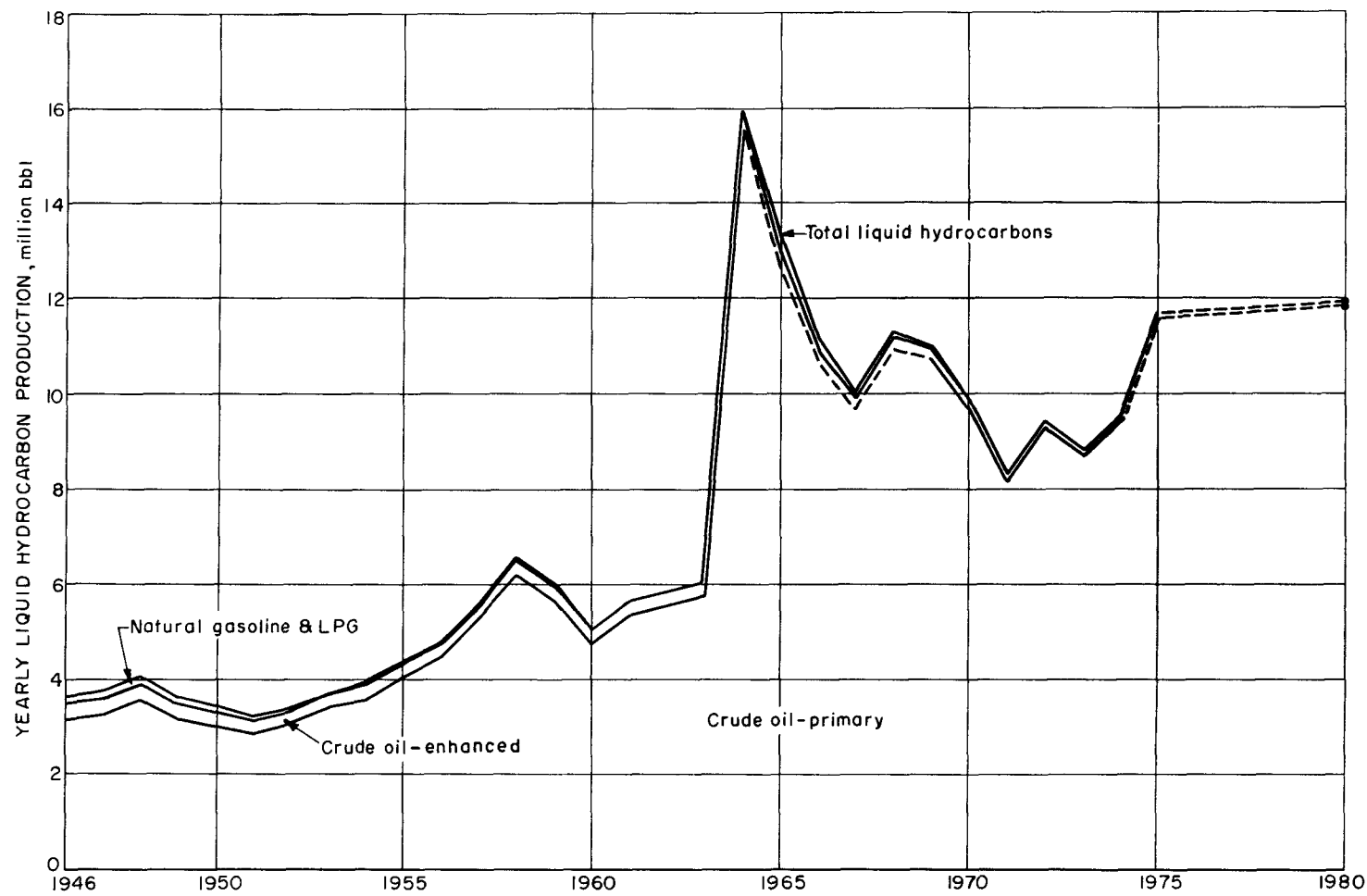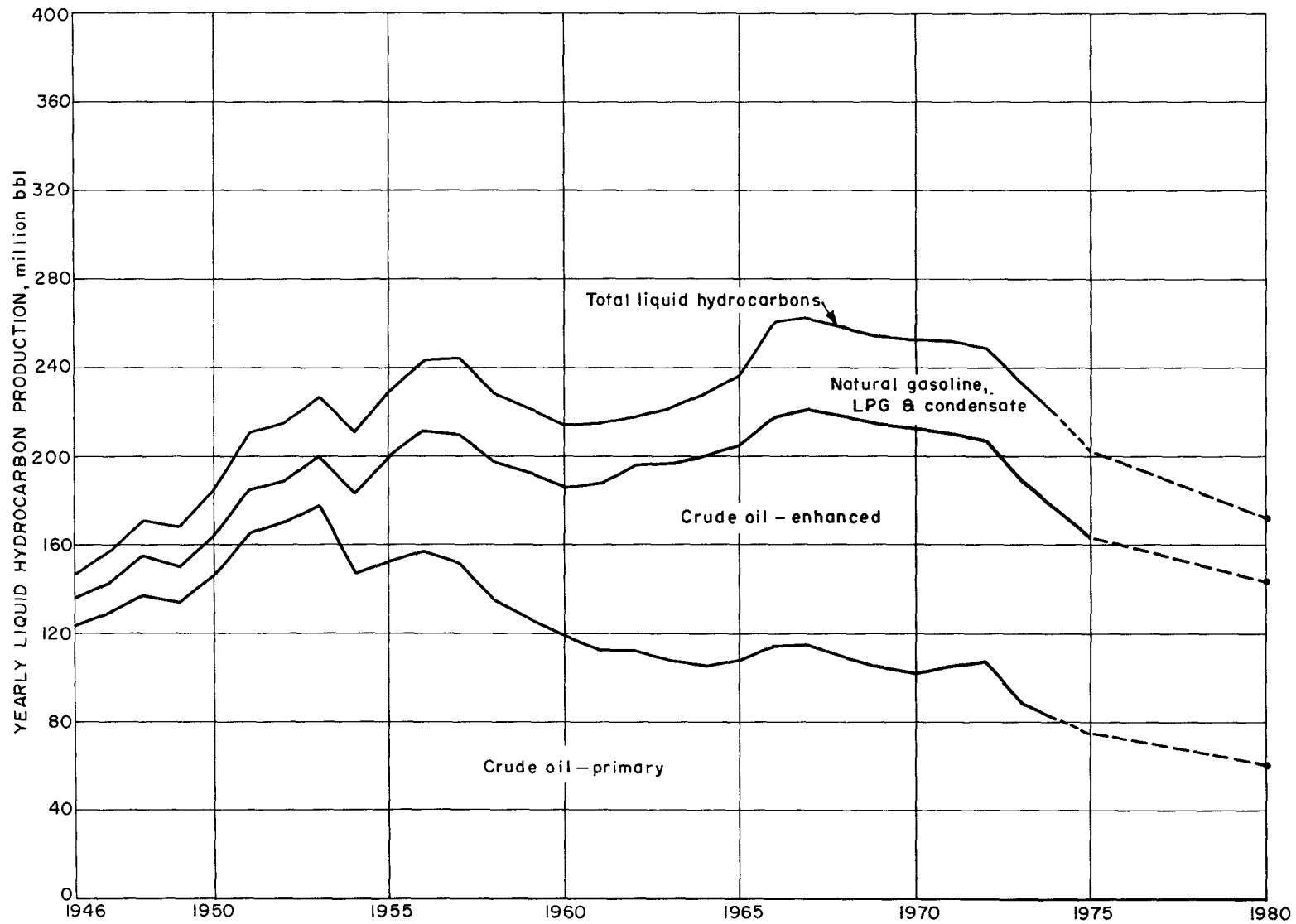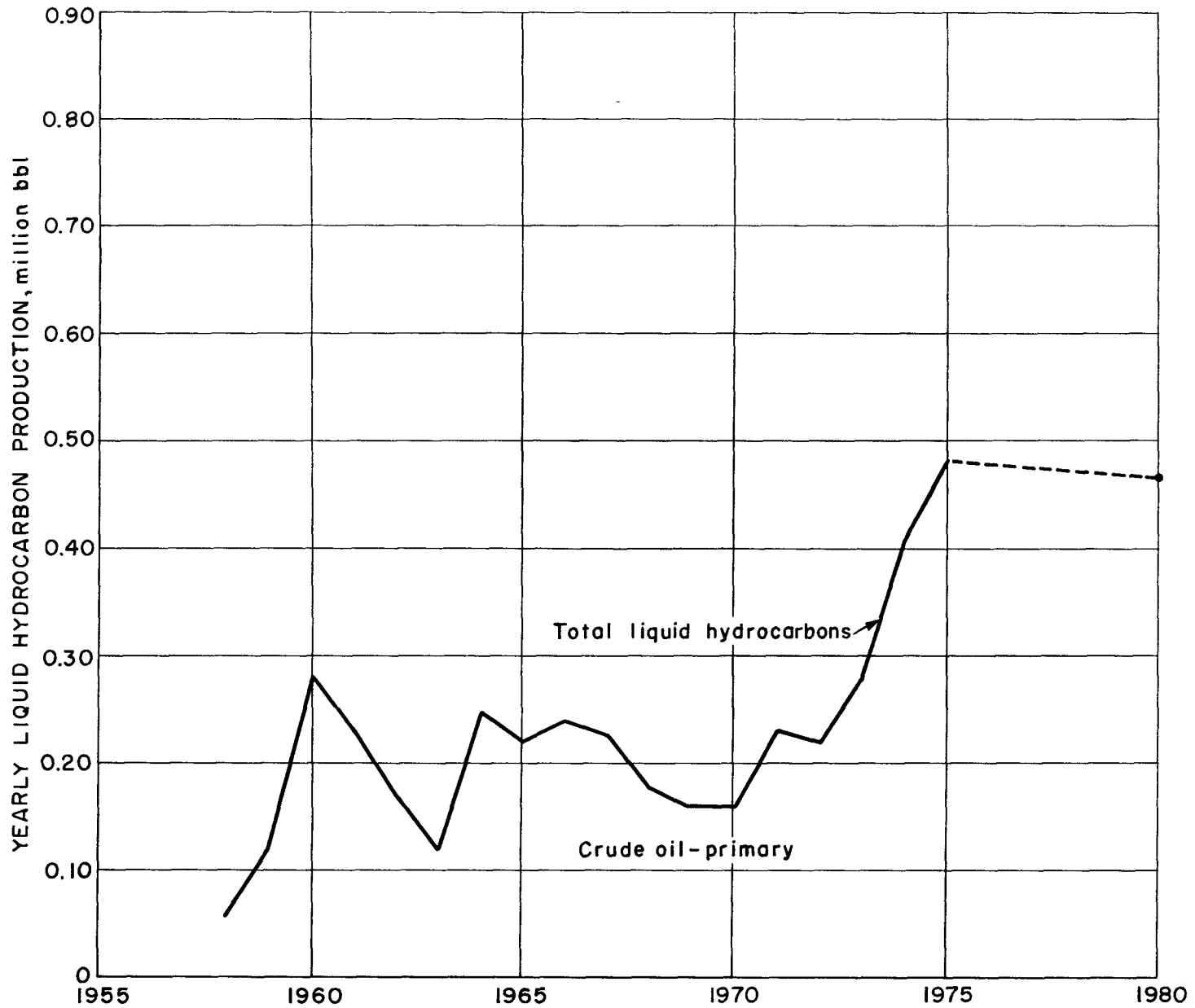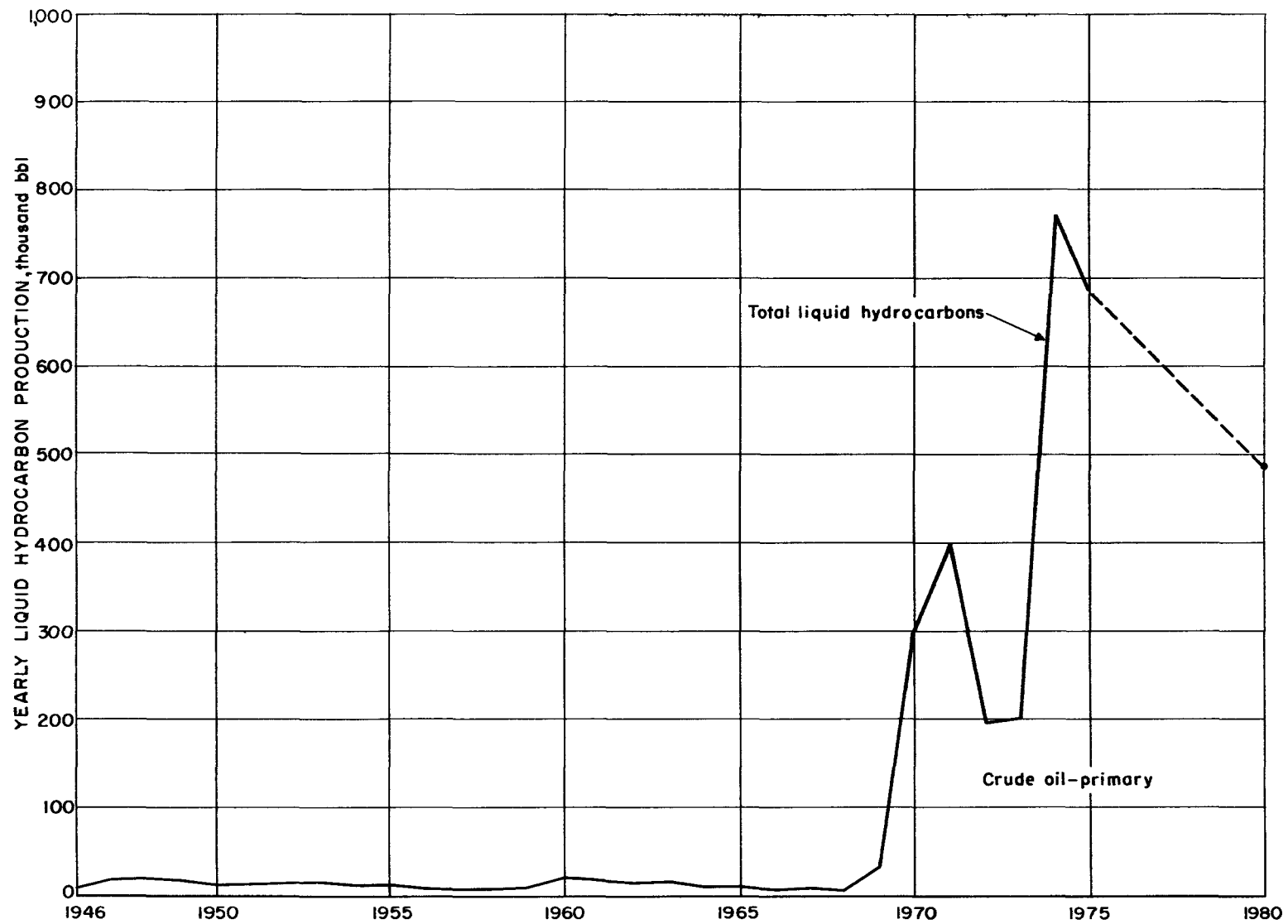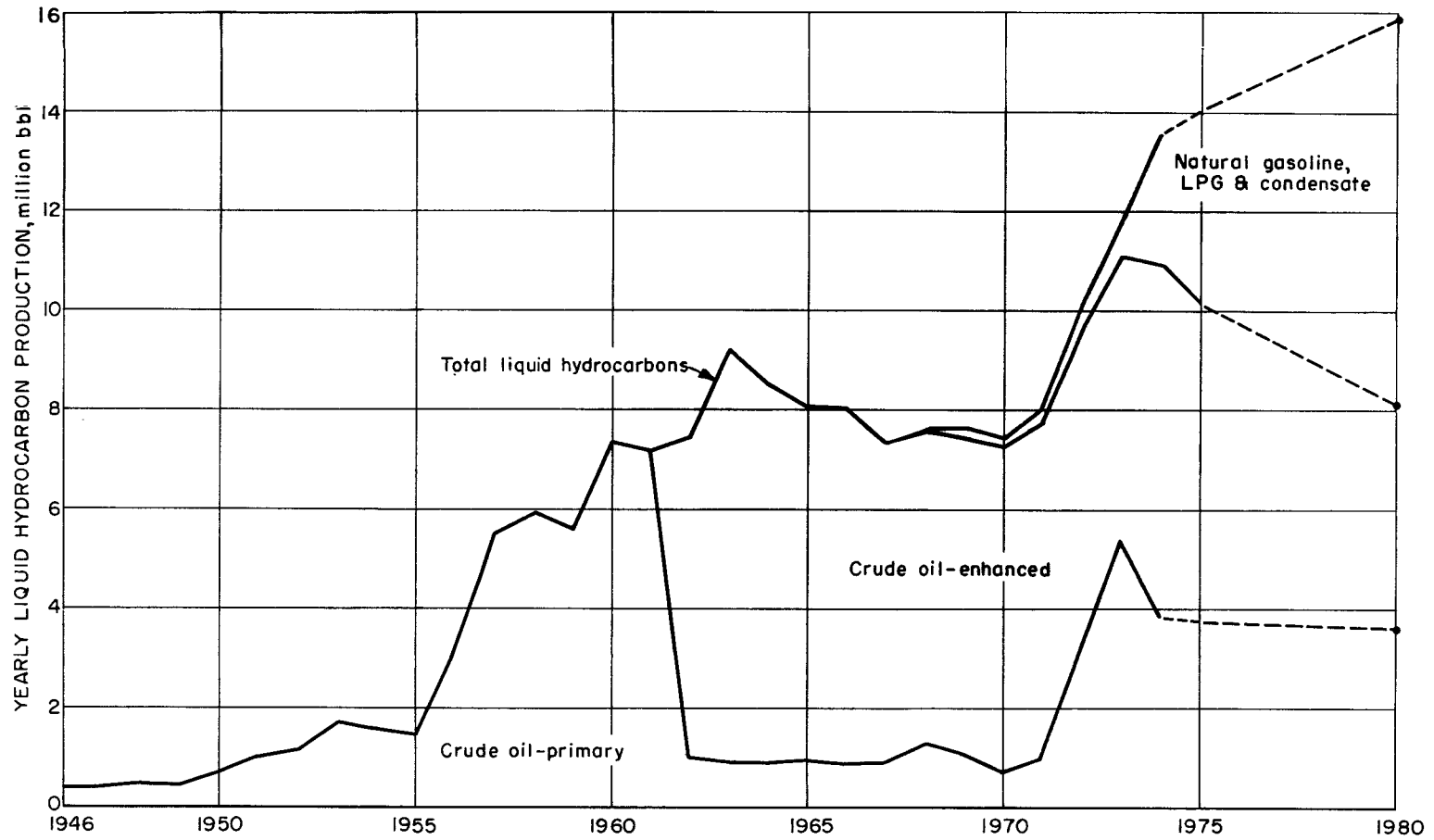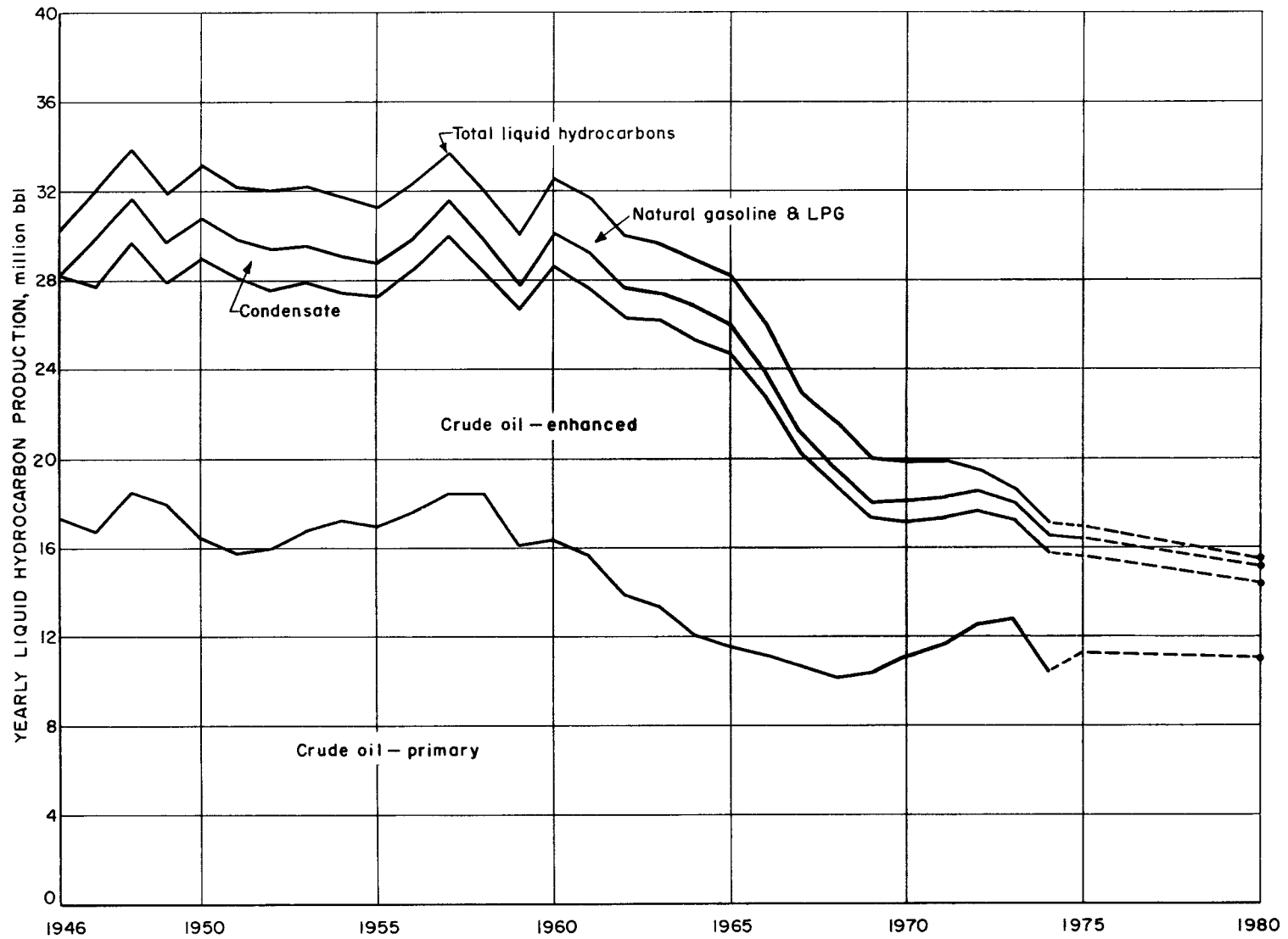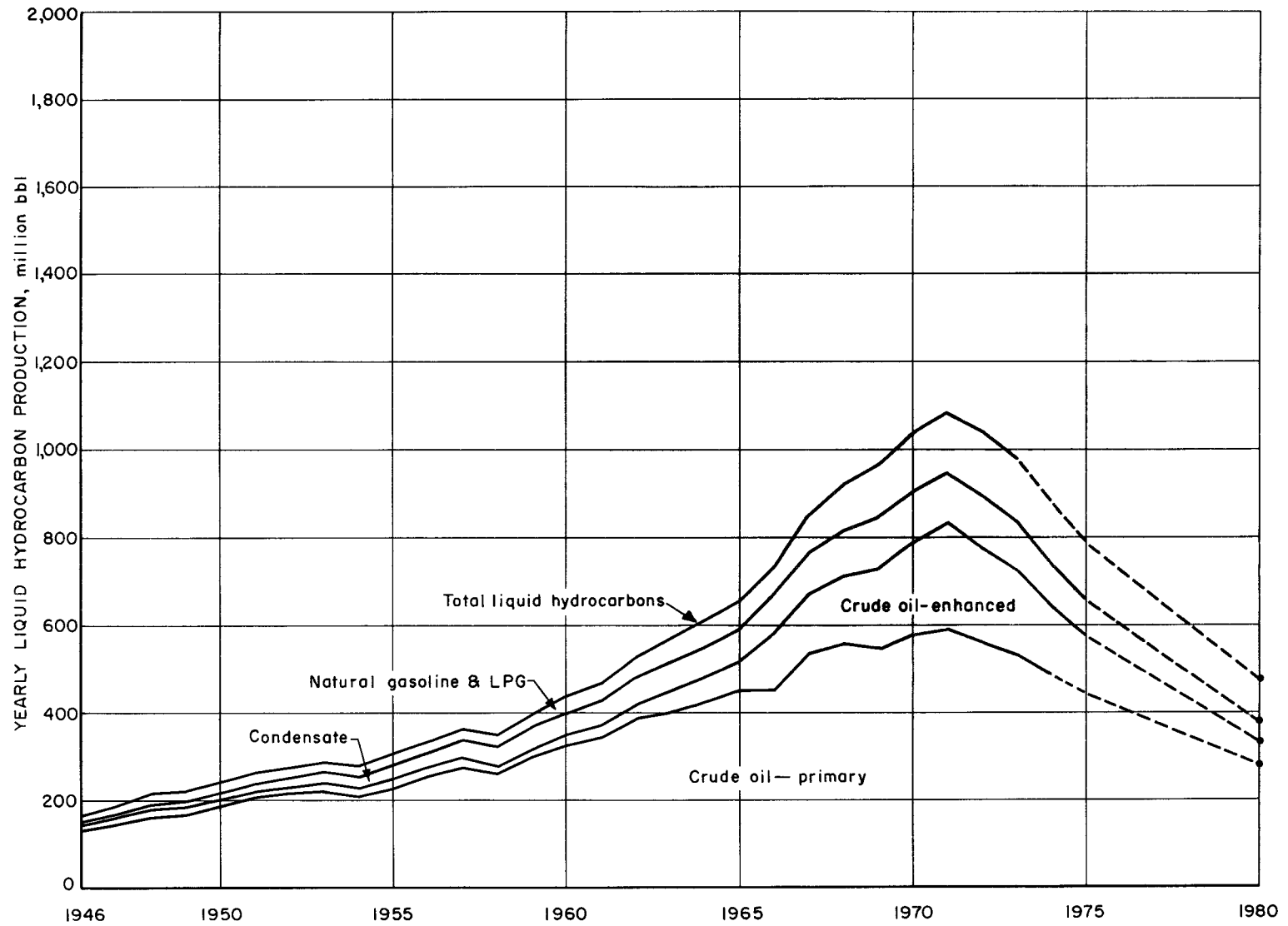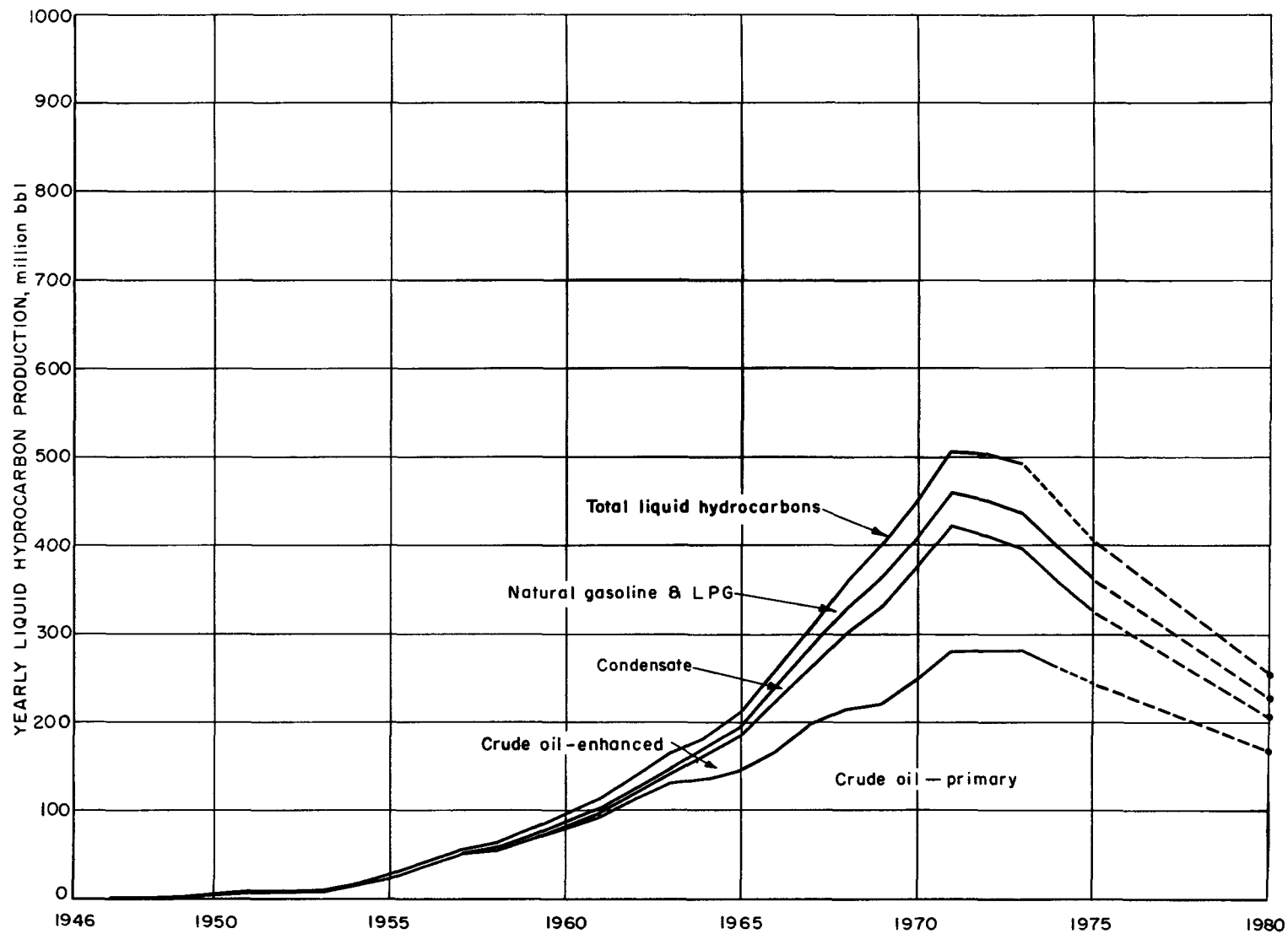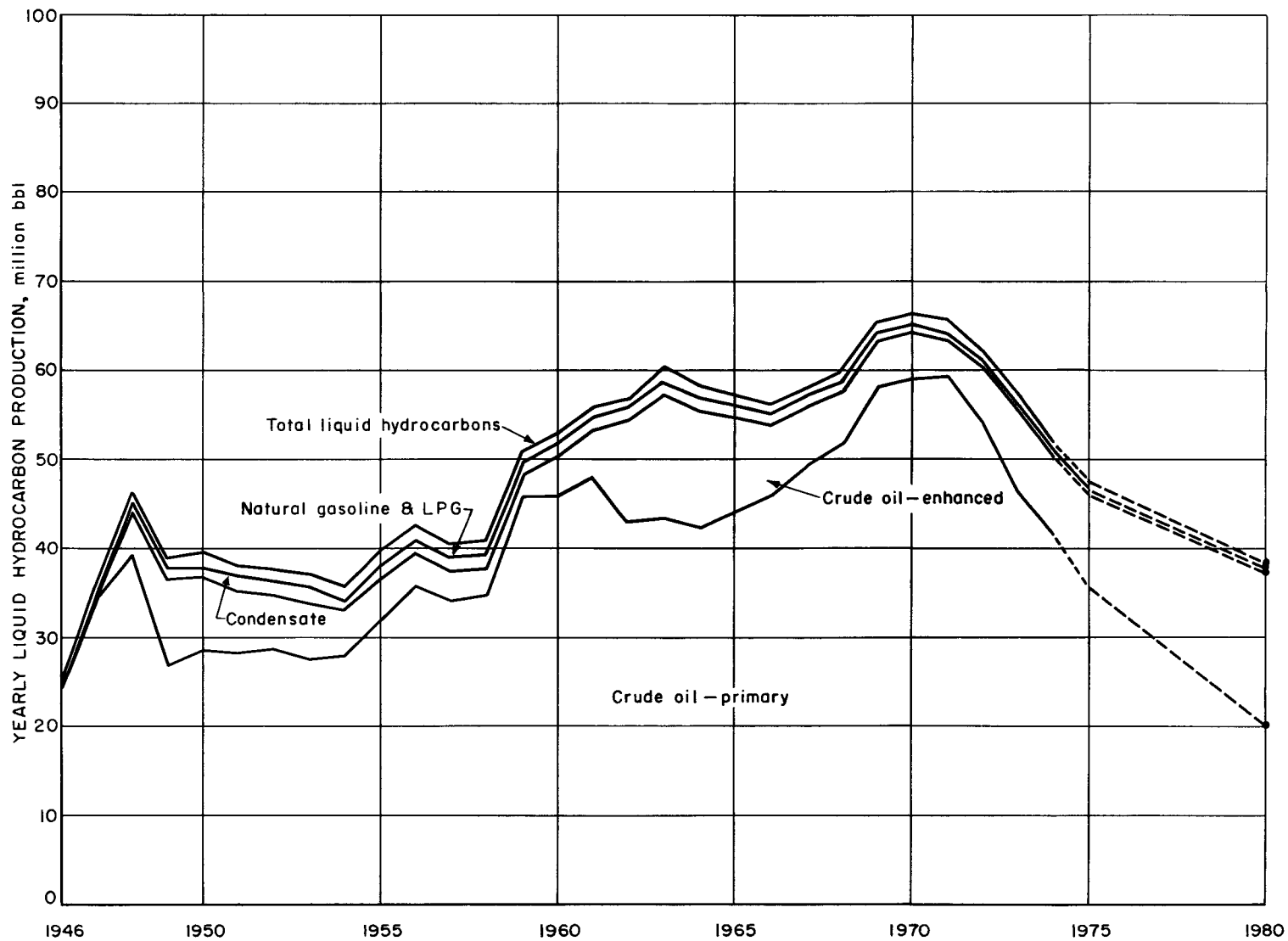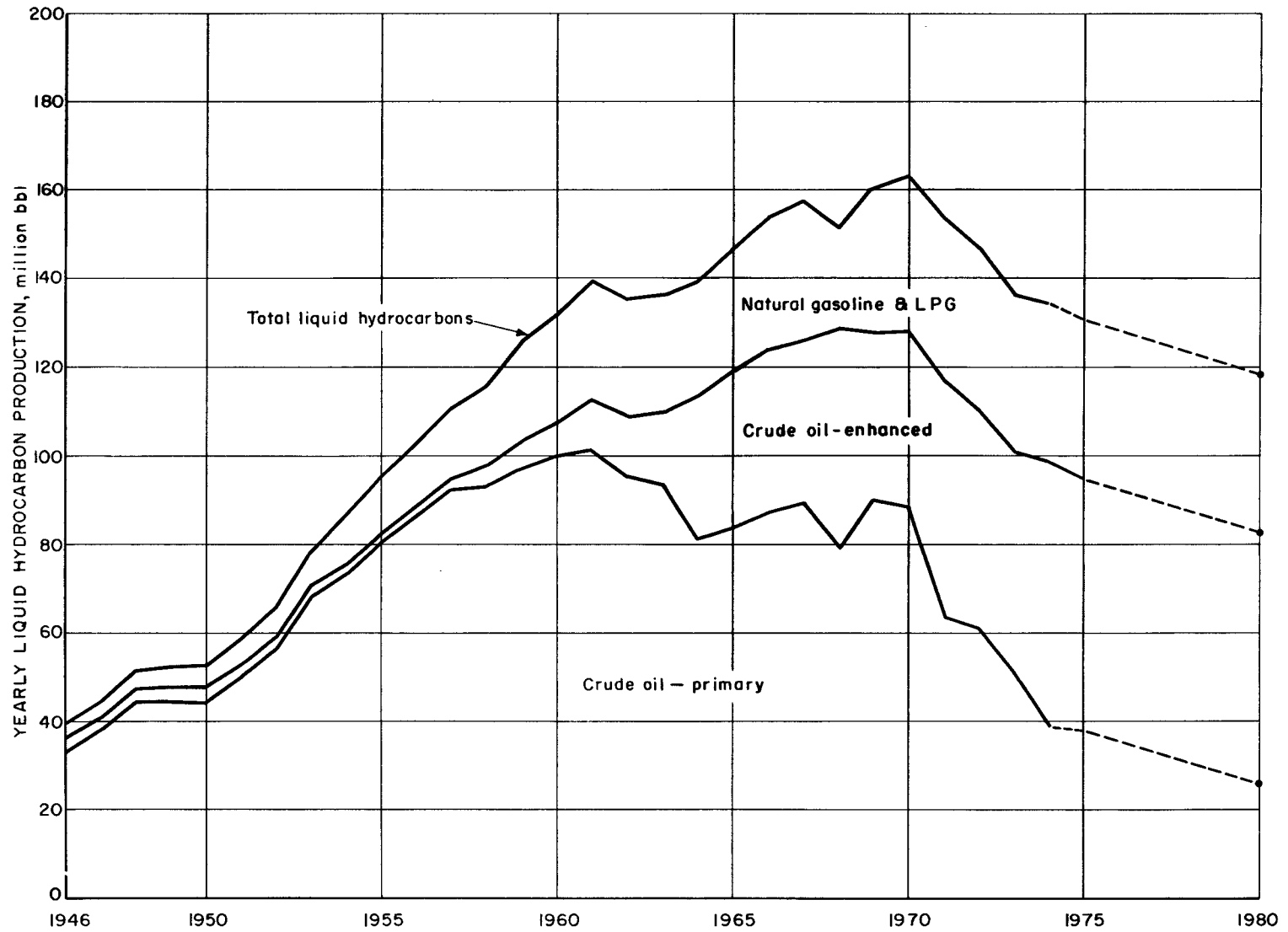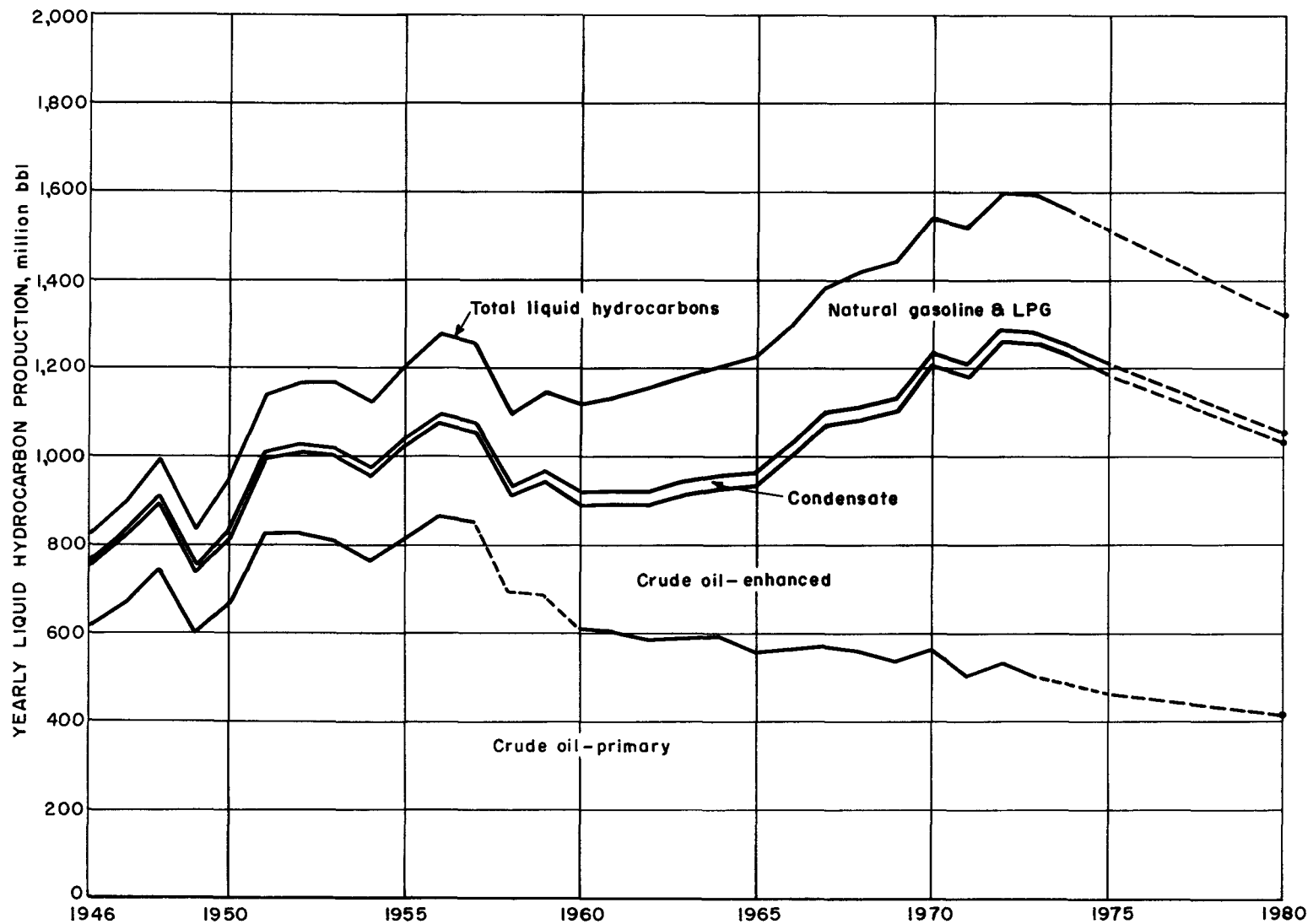FIGURE A-6. - Indiana (PAD district II) liquid hydrocarbon production.

FIGURE A-7. - Kansas (PAD district II) liquid hydrocarbon production.

FIGURE A-8. - Kentucky (PAD district II) liquid hydrocarbon production.

FIGURE A-9: - Michigan (PAD district II) liquid hydrocarbon production.

FIGURE A-10. - Missouri (PAD district II) liquid hydrocarbon production.

FIGURE A-11. - Nebraska (PAD district II) liquid hydrocarbon production.

FIGURE A-12. - North Dakota (PAD district II) liquid hydrocarbon production.

FIGURE A-13. - Ohio (PAD district II) liquid hydrocarbon production.

FIGURE A-14. - Oklahoma (PAD district II) liquid hydrocarbon production.

FIGURE A-15. - South Dakota (PAD district II) liquid hydrocarbon production.

FIGURE A-16. - Tennessee (PAD district II) liquid hydrocarbon production.

FIGURE A-17. - Alabama (PAD district III) liquid hydrocarbon production.

FIGURE A-18. - Arkansas (PAD district III) liquid hydrocarbon production.

FIGURE A-19. - Louisiana (PAD district III) liquid hydrocarbon production.

FIGURE A-20. Louisiana, offshore liquid hydrocarbon production.
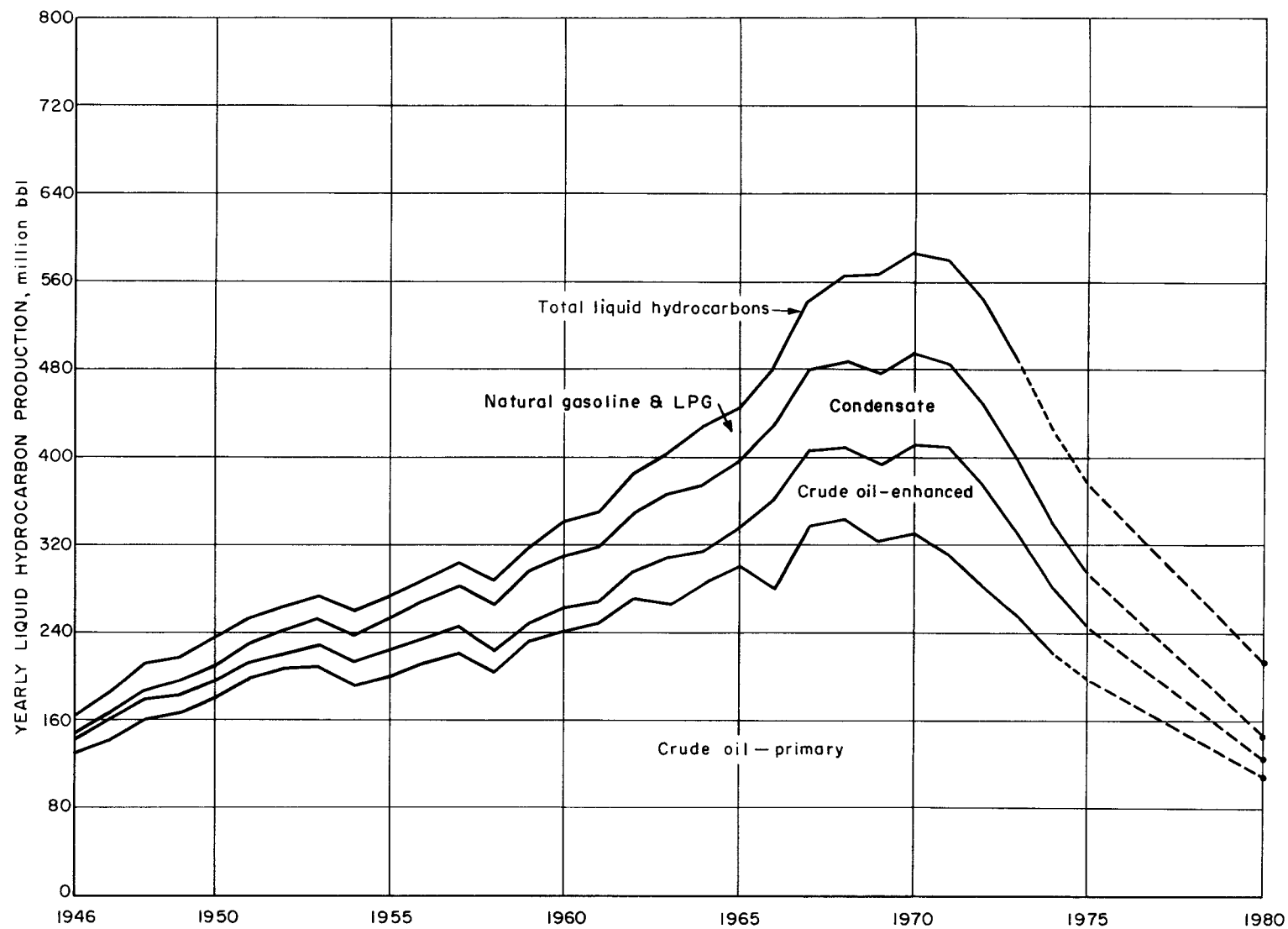
FIGURE A-21. - Louisiana, onshore liquid hydrocarbon production.

FIGURE A-22: - Mississippi (PAD district III) liquid hydrocarbon production.

FIGURE A-23. - New Mexico (PAD district III) liquid hydrocarbon production.

FIGURE A-24. - Texas (PAD district III) liquid hydrocarbon production. (Does not include increased production (50 thousand BOPD) from the Yates field in Texas Railroad Commission district 8.)
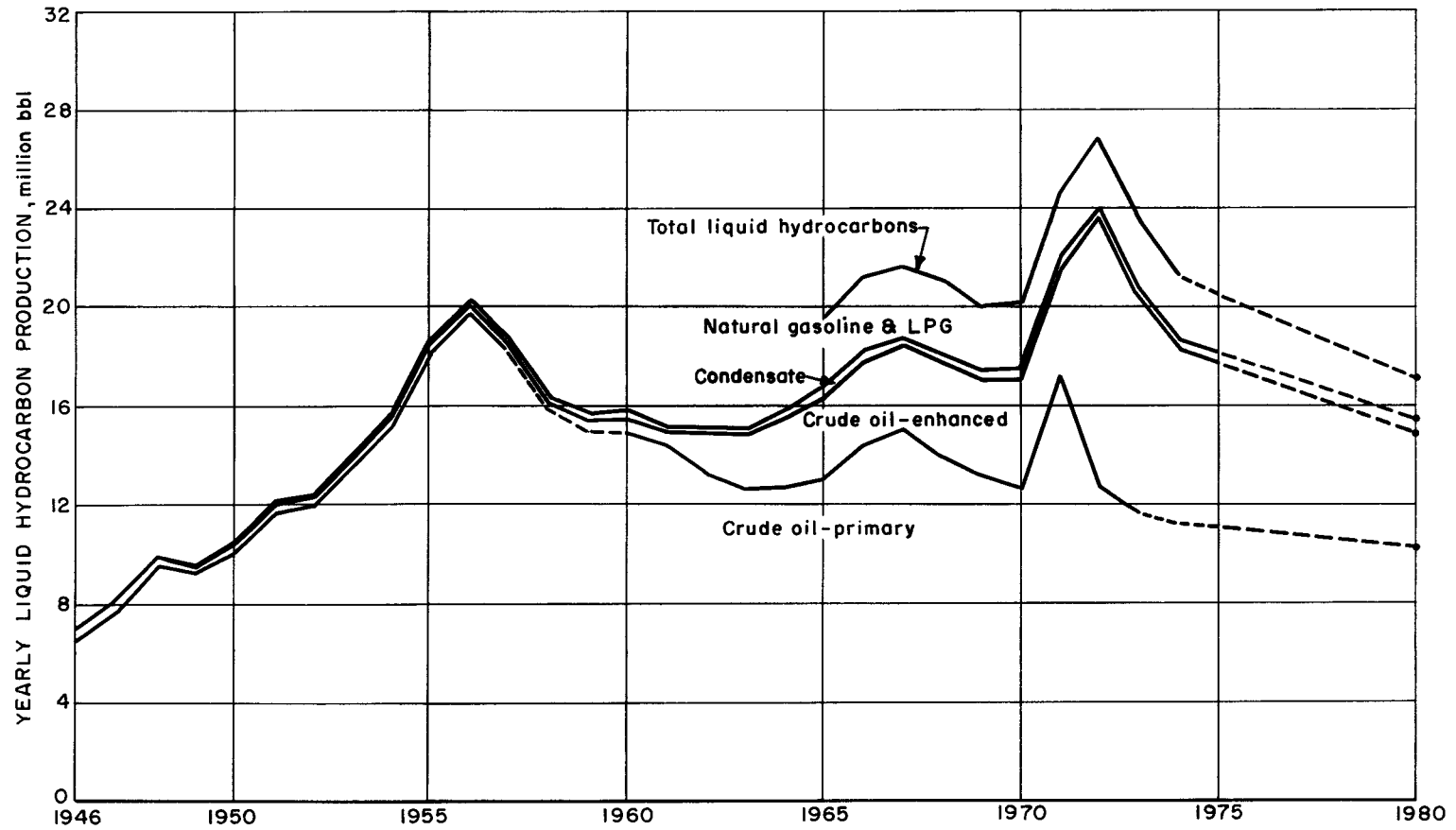
FIGURE A-25. - Texas Railroad Commission district 1 liquid hydrocarbon production.
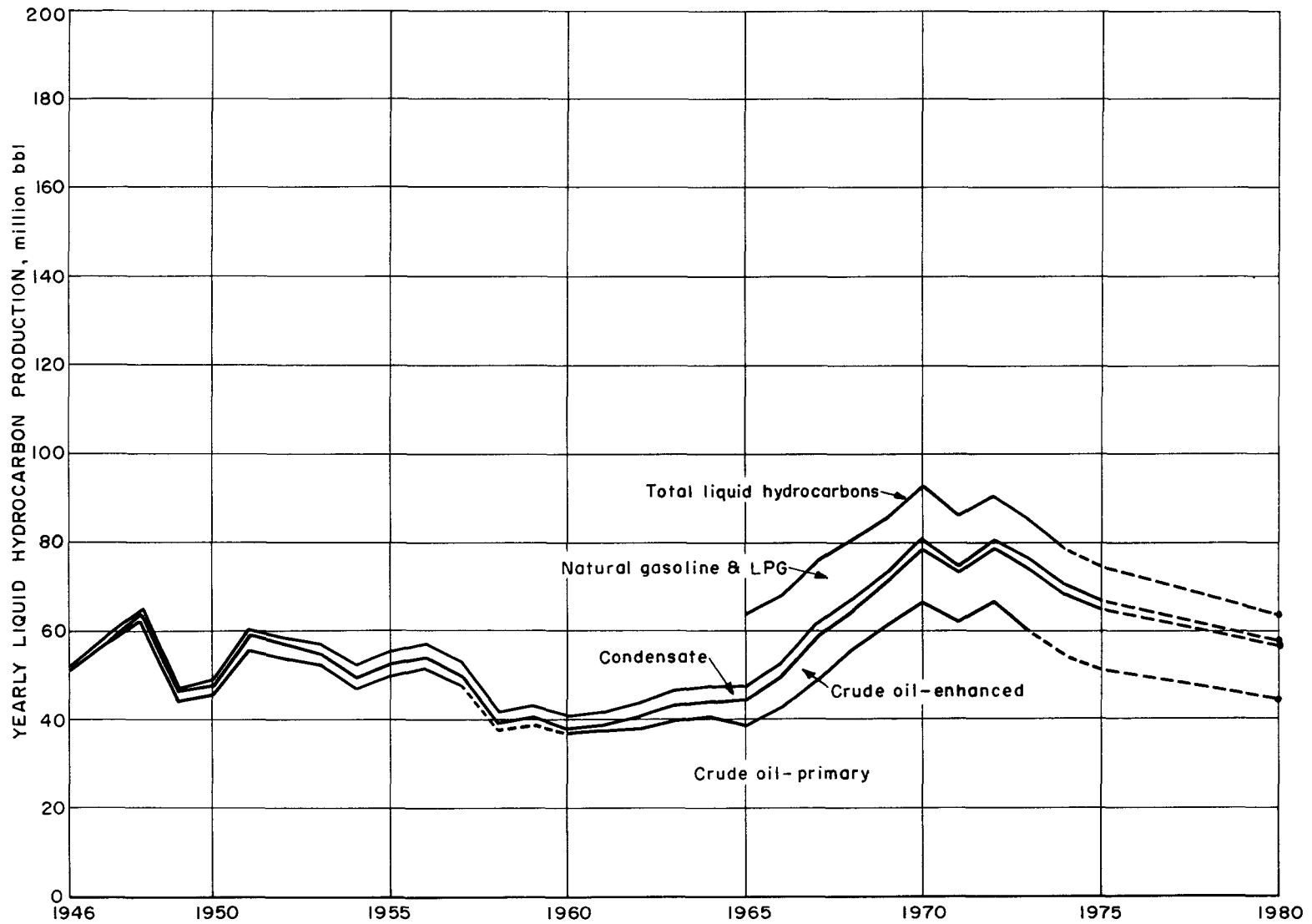
FIGURE A-26. - Texas Railroad Commission district 2 liquid hydrocarbon production.
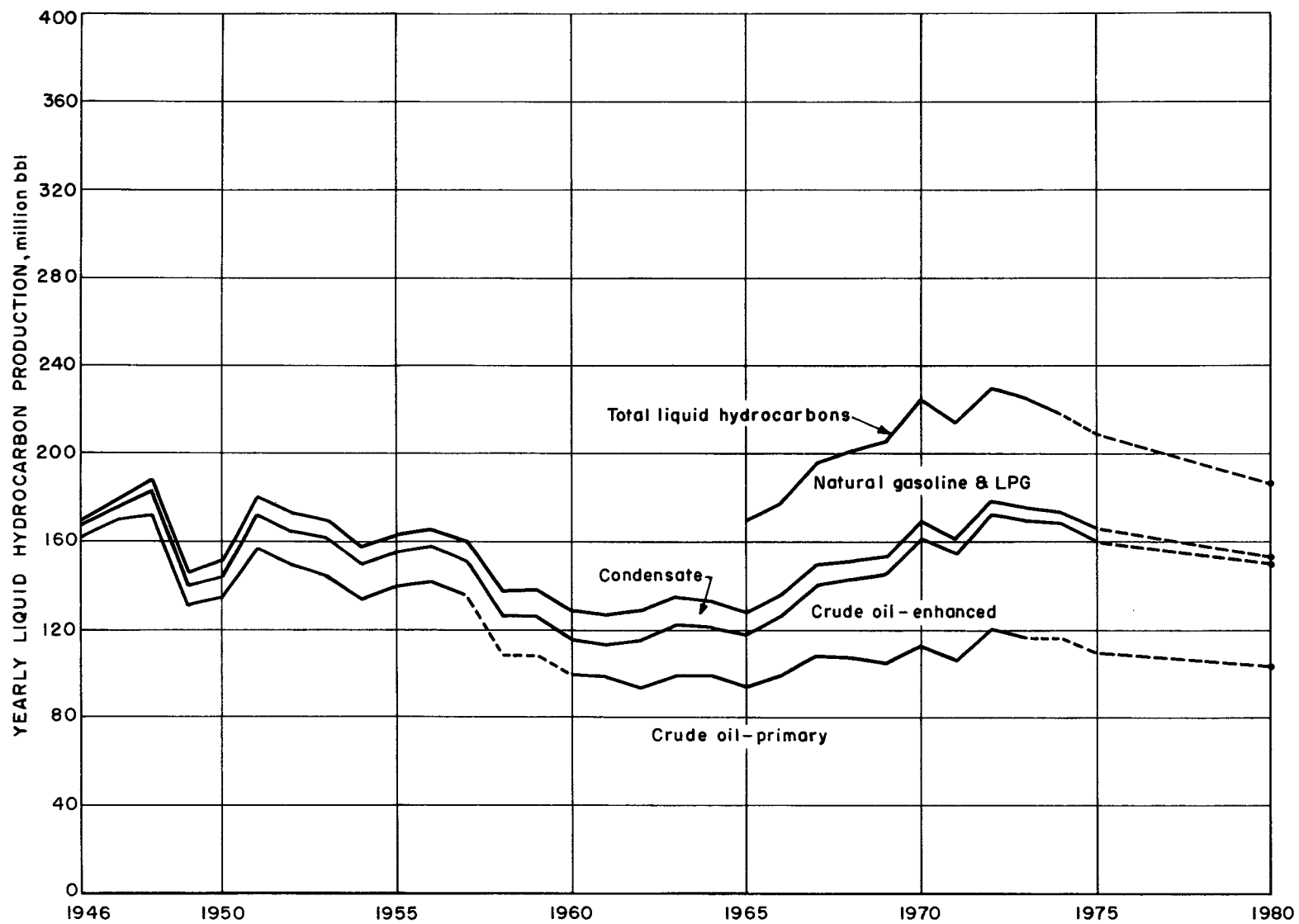
FIGURE A-27. - Texas Railroad Commission district 3 liquid hydrocarbon production.
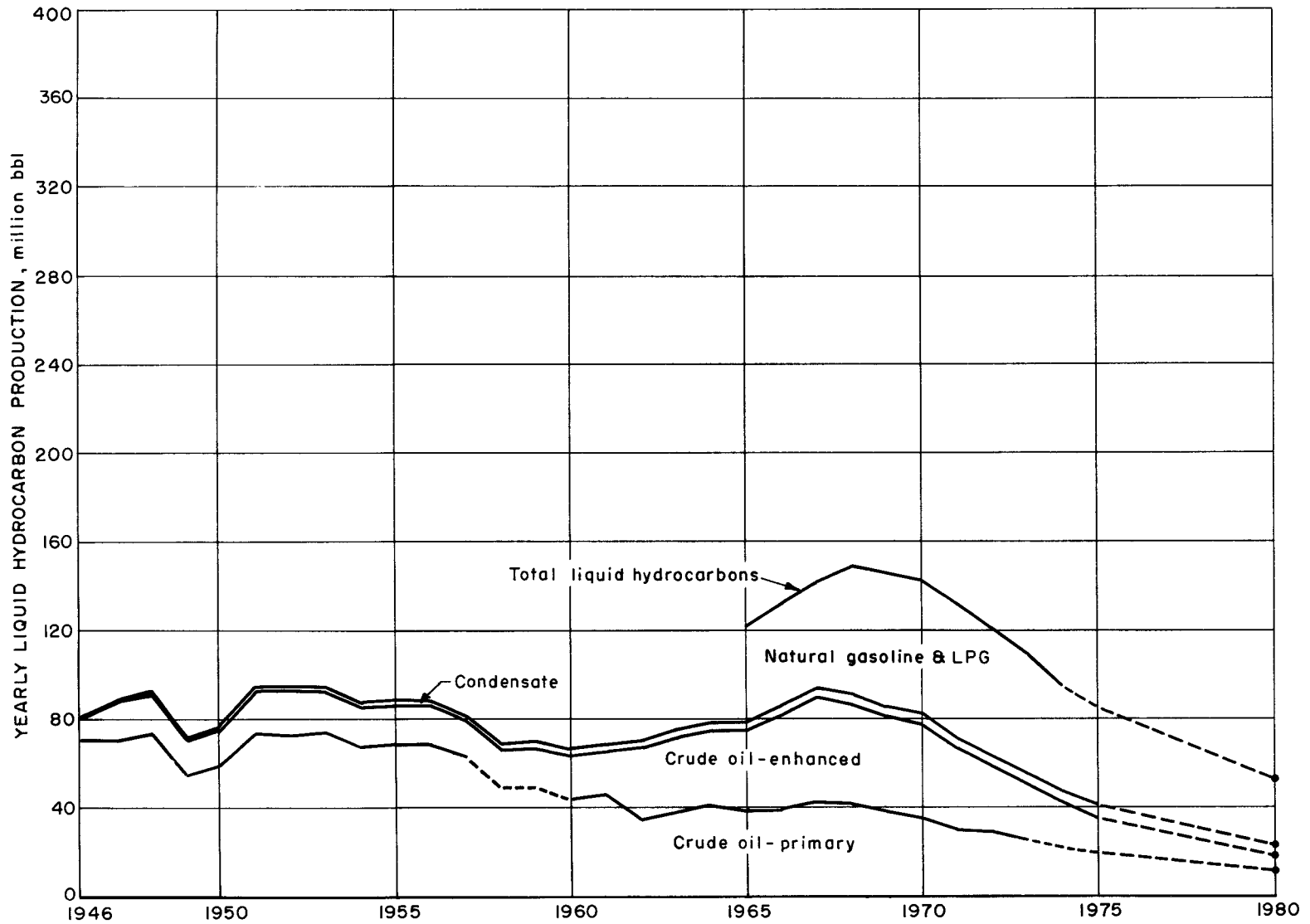
FIGURE A-28. - Texas Railroad Commission district 4 liquid hydrocarbon production.
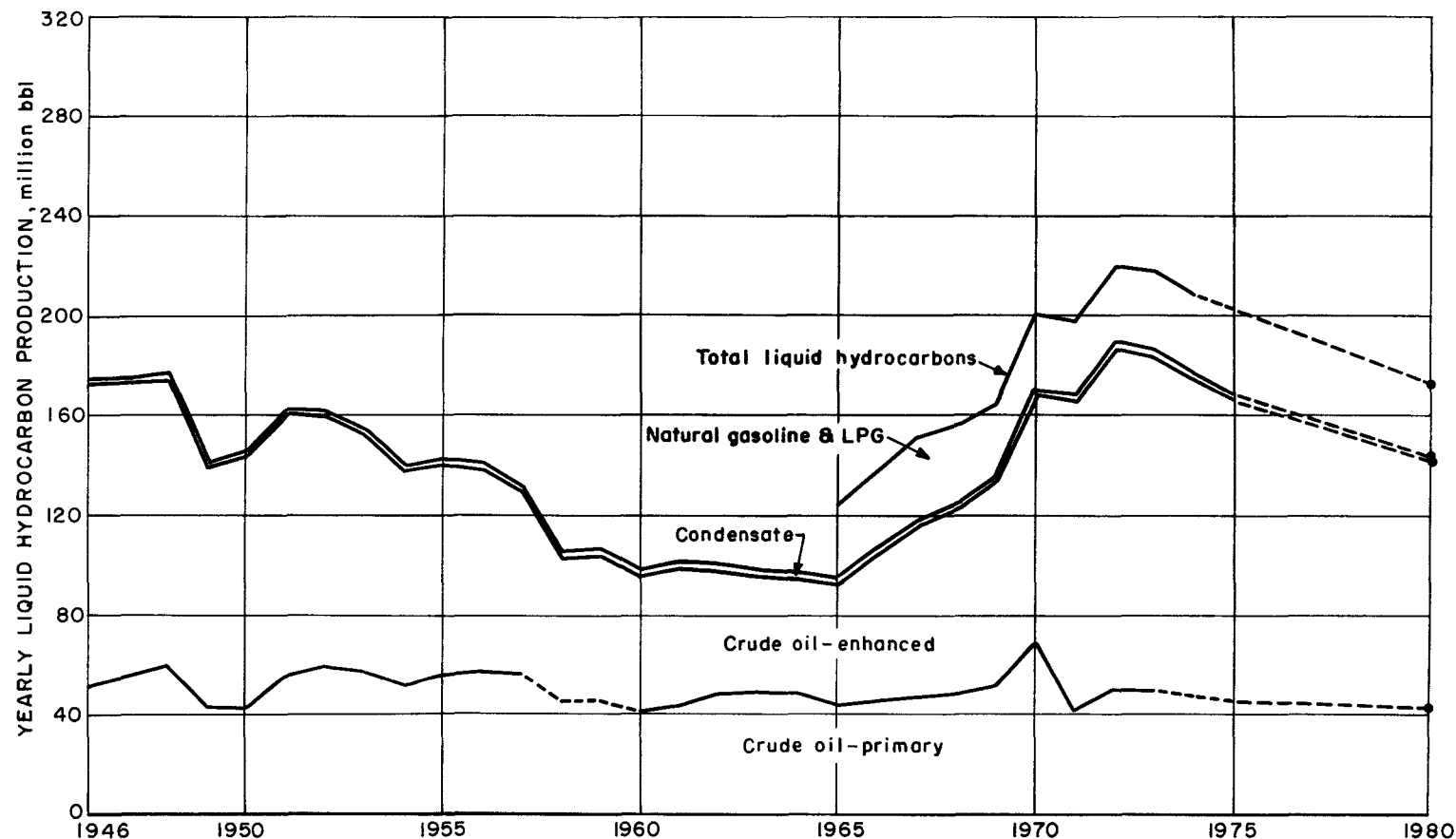
FIGURE A-29. - Texas Railroad Commission districts 5 and 6 liquid hydrocarbon production.
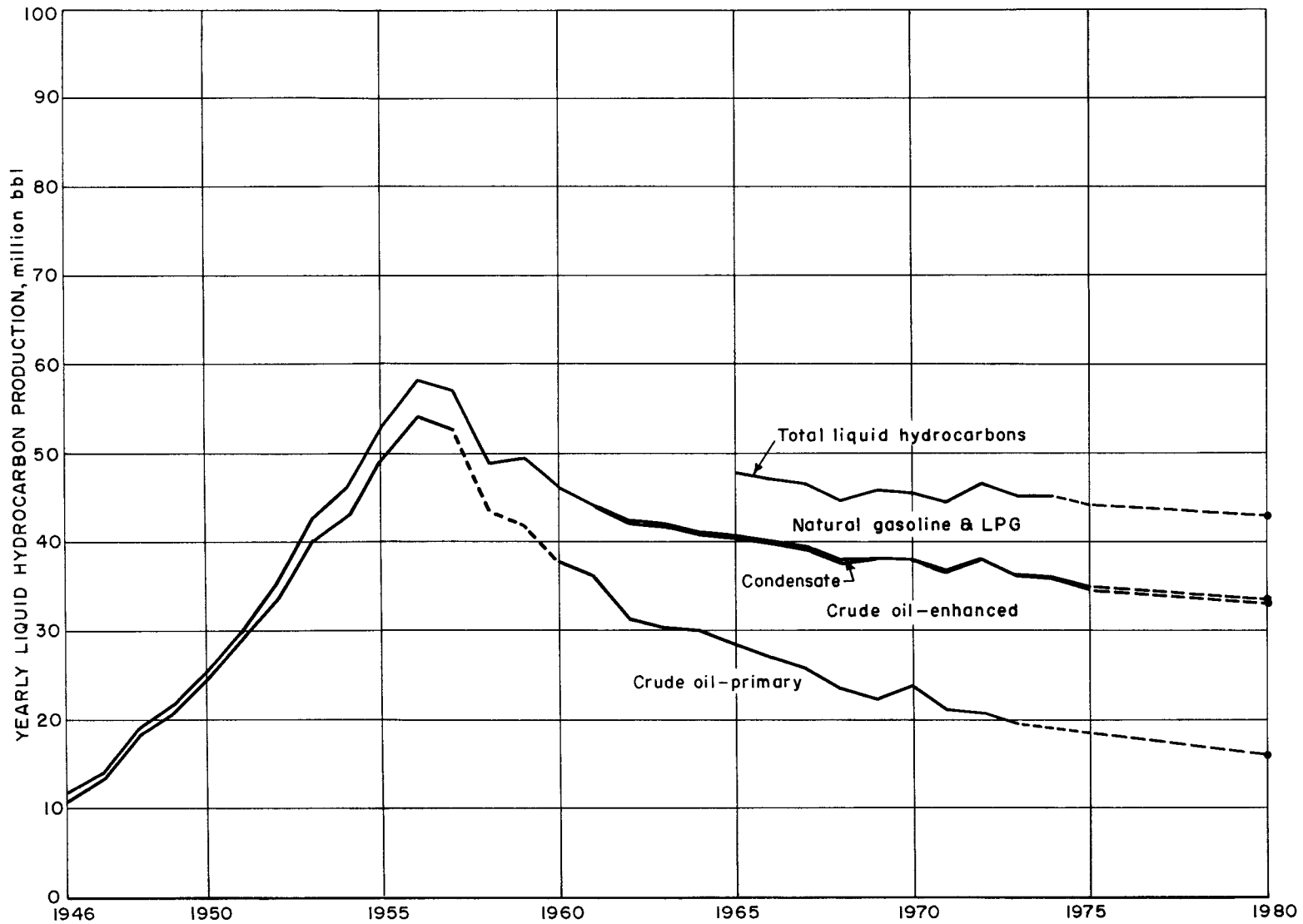
FIGURE A-30. - Texas Railroad Commission district 7B liquid hydrocarbon production.
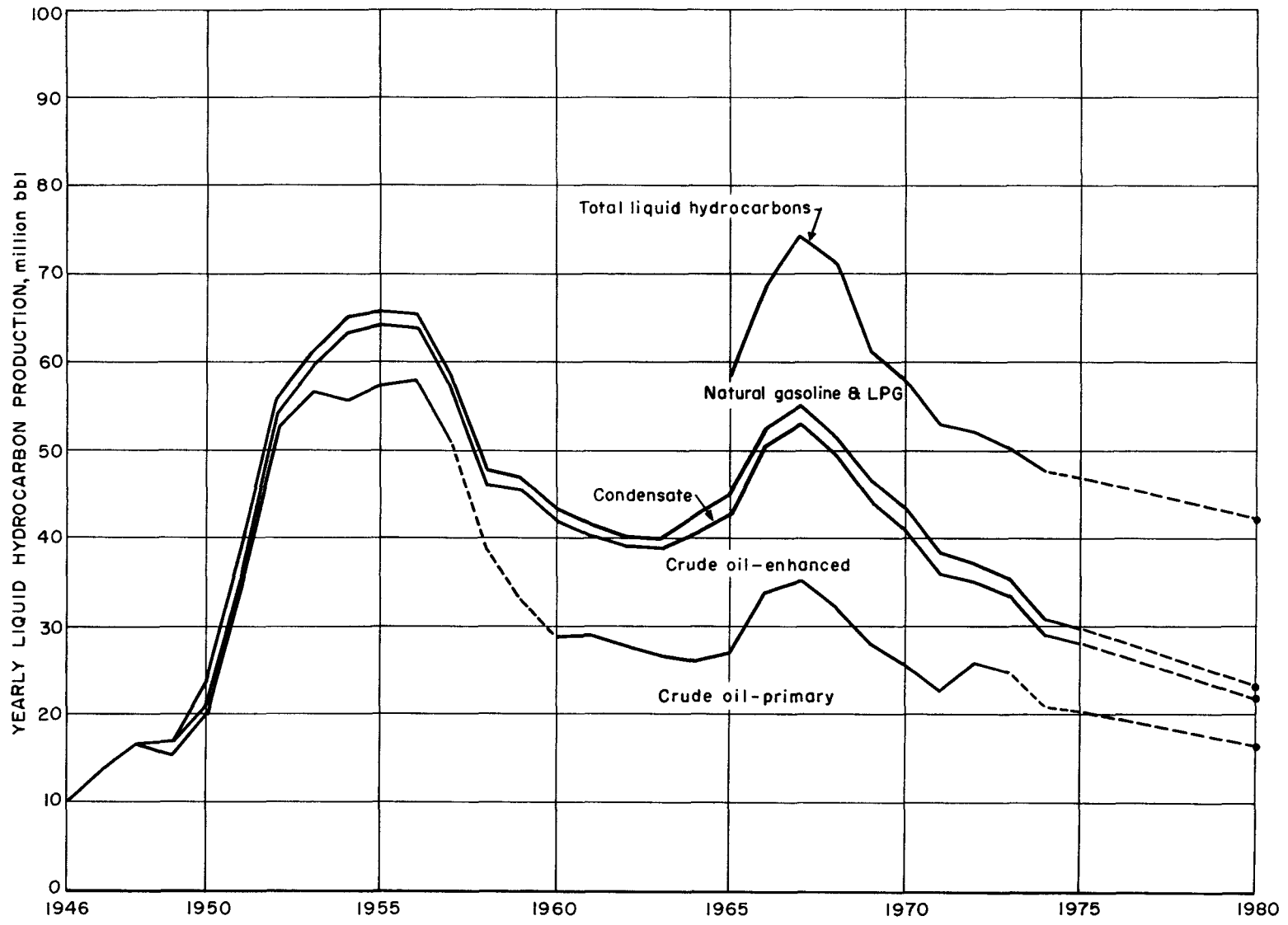
FIGURE A-31. - Texas Railroad Commission district 7C liquid hydrocarbon production.
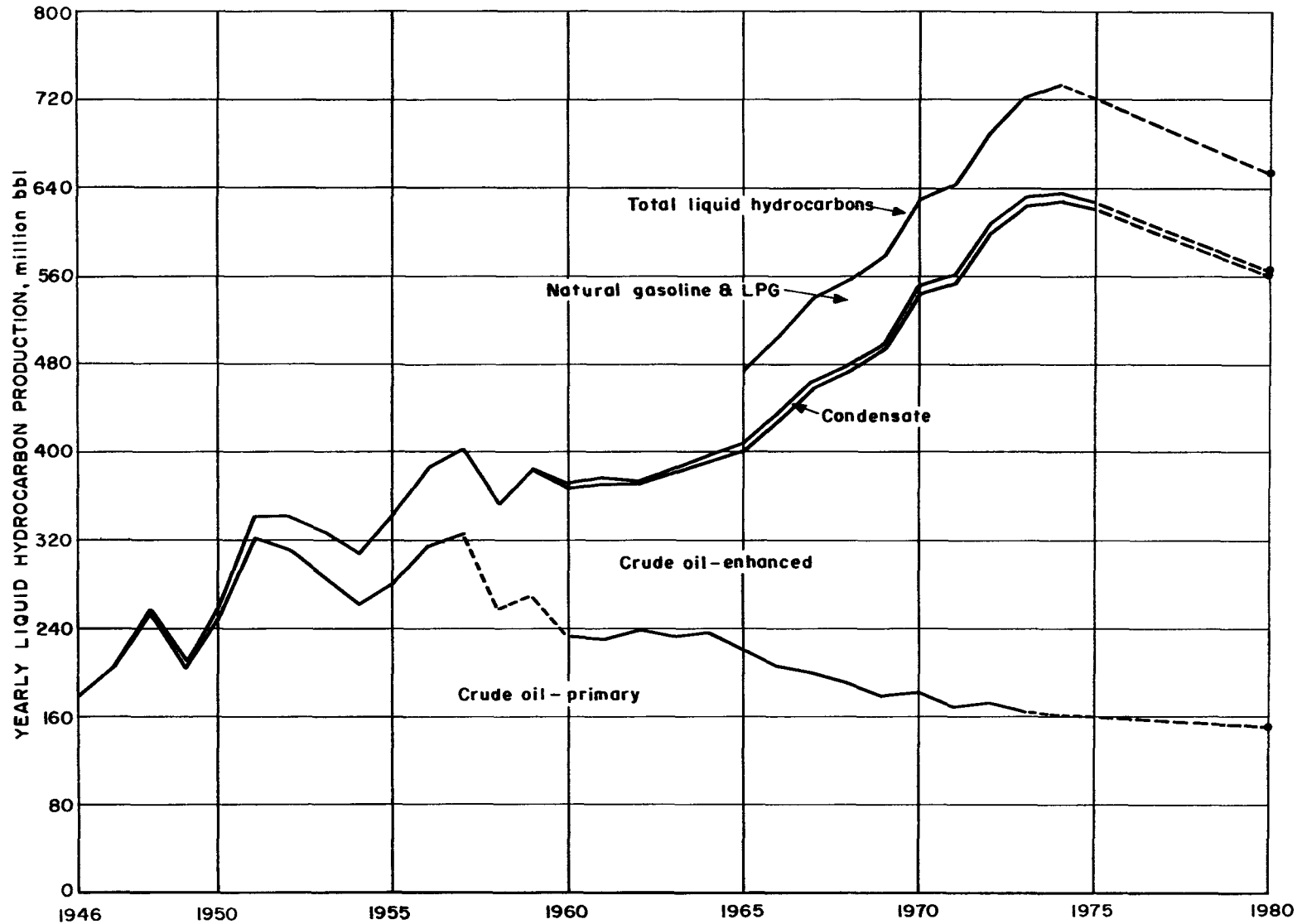
FIGURE A-32. - Texas Railroad Commission districts 8 and 8A liquid hydrocarbon production. (Does not include 50 thousand BOPD from the Yates field.)
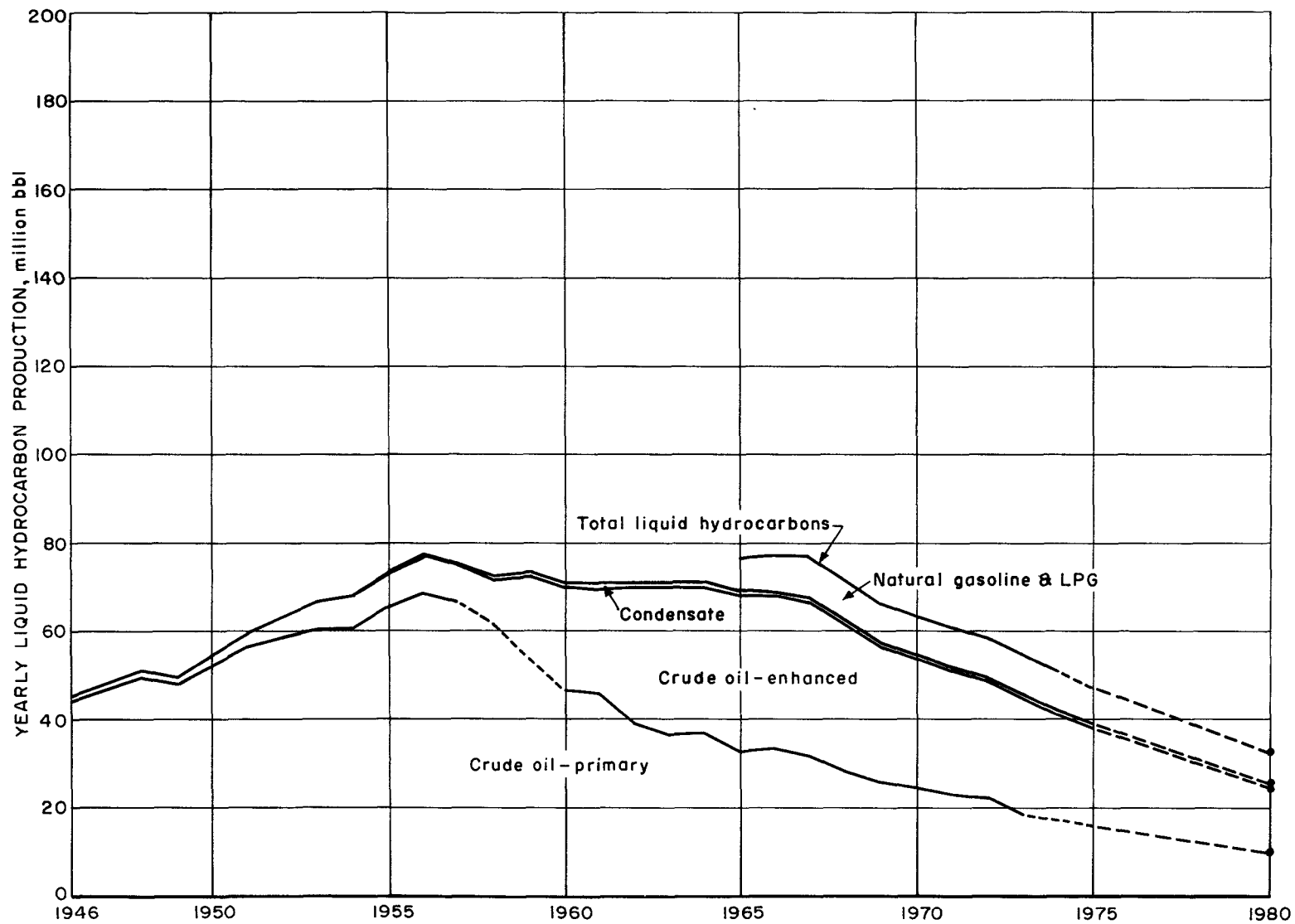
FIGURE A-33. - Texas Railroad Commission district 9 liquid hydrocarbon production.
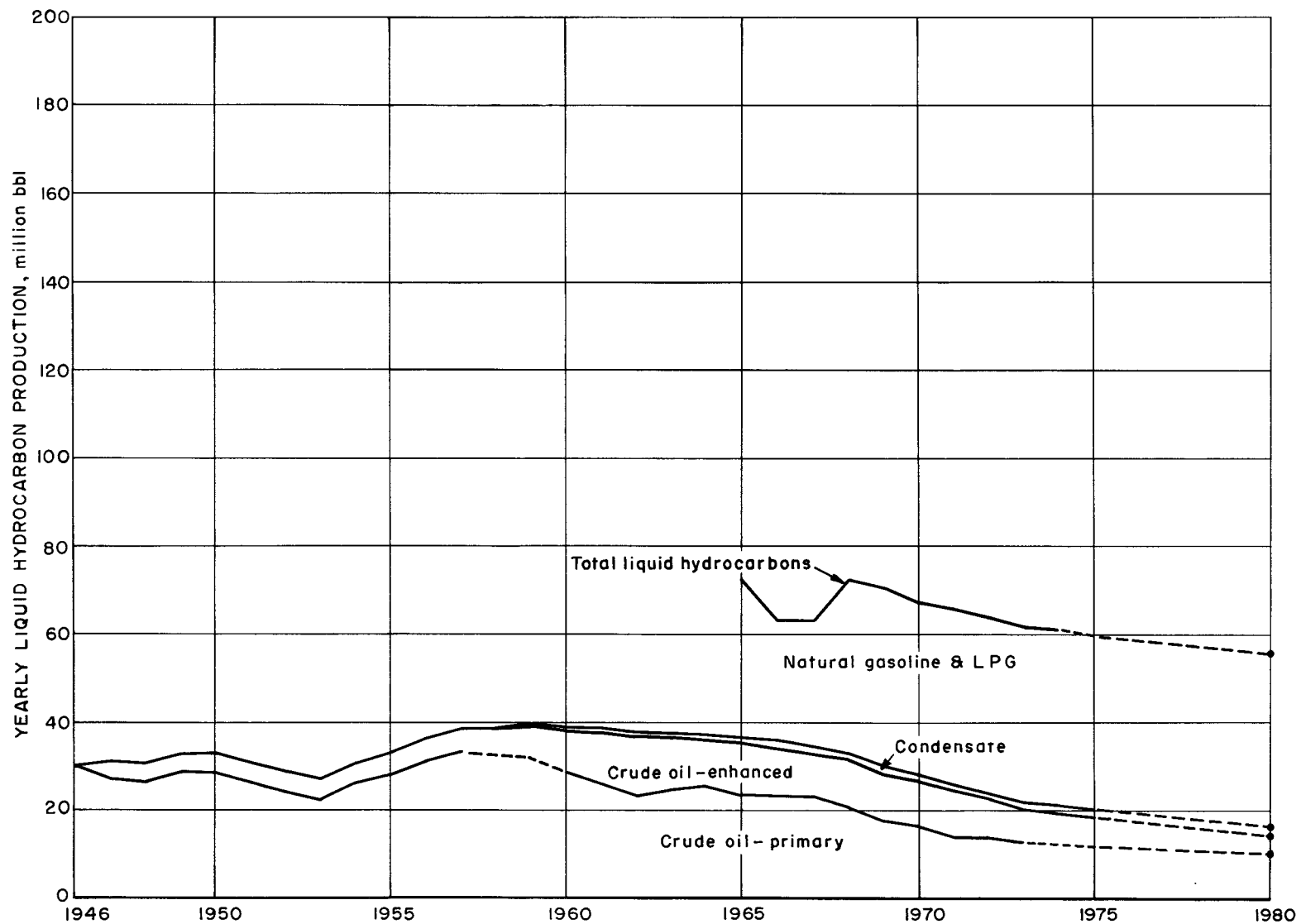
FIGURE A-34. - Texas Railroad Commission district 10 liquid hydrocarbon production.
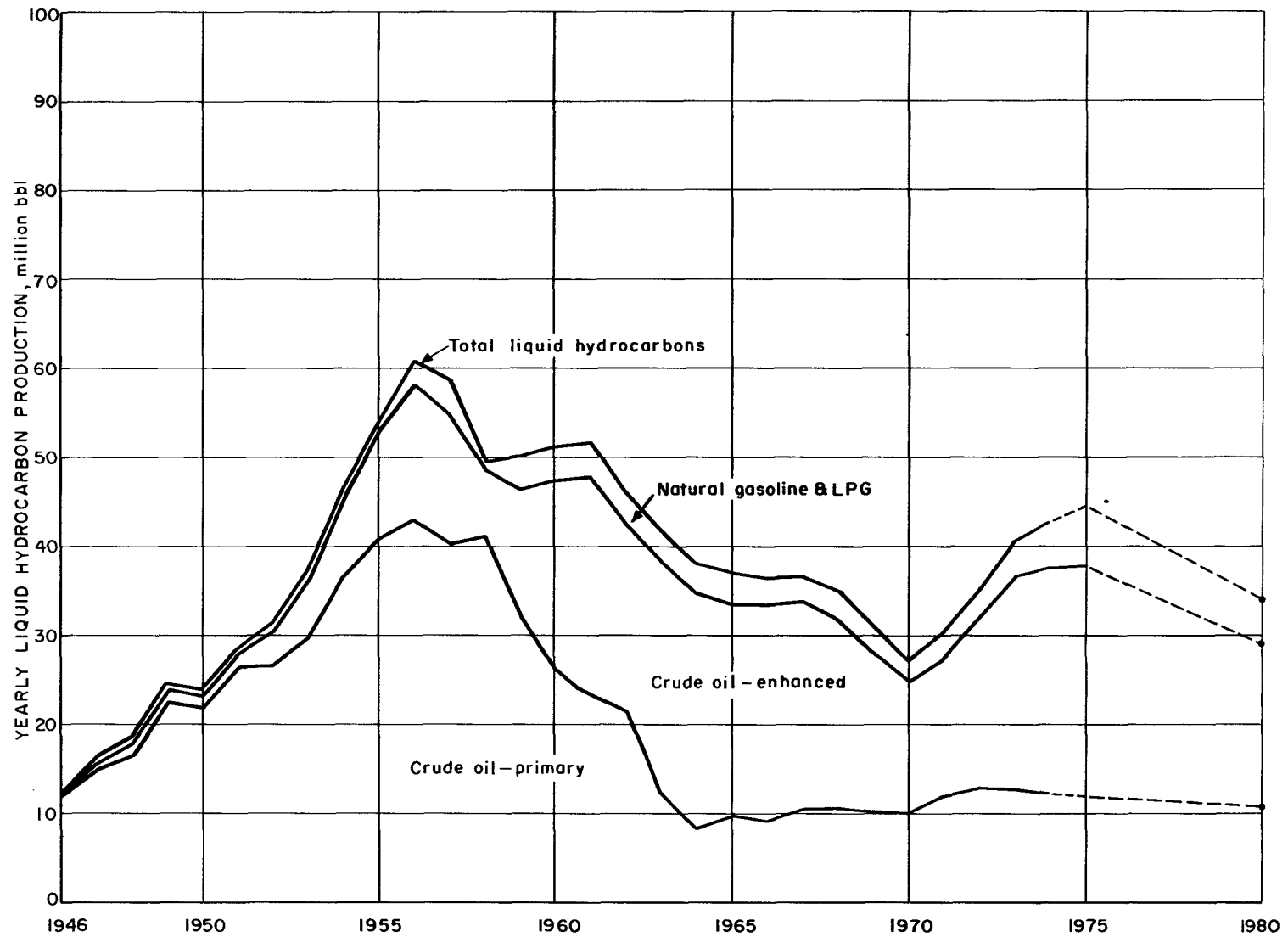
FIGURE A-35. - Colorado (PAD district IV) liquid hydrocarbon production.
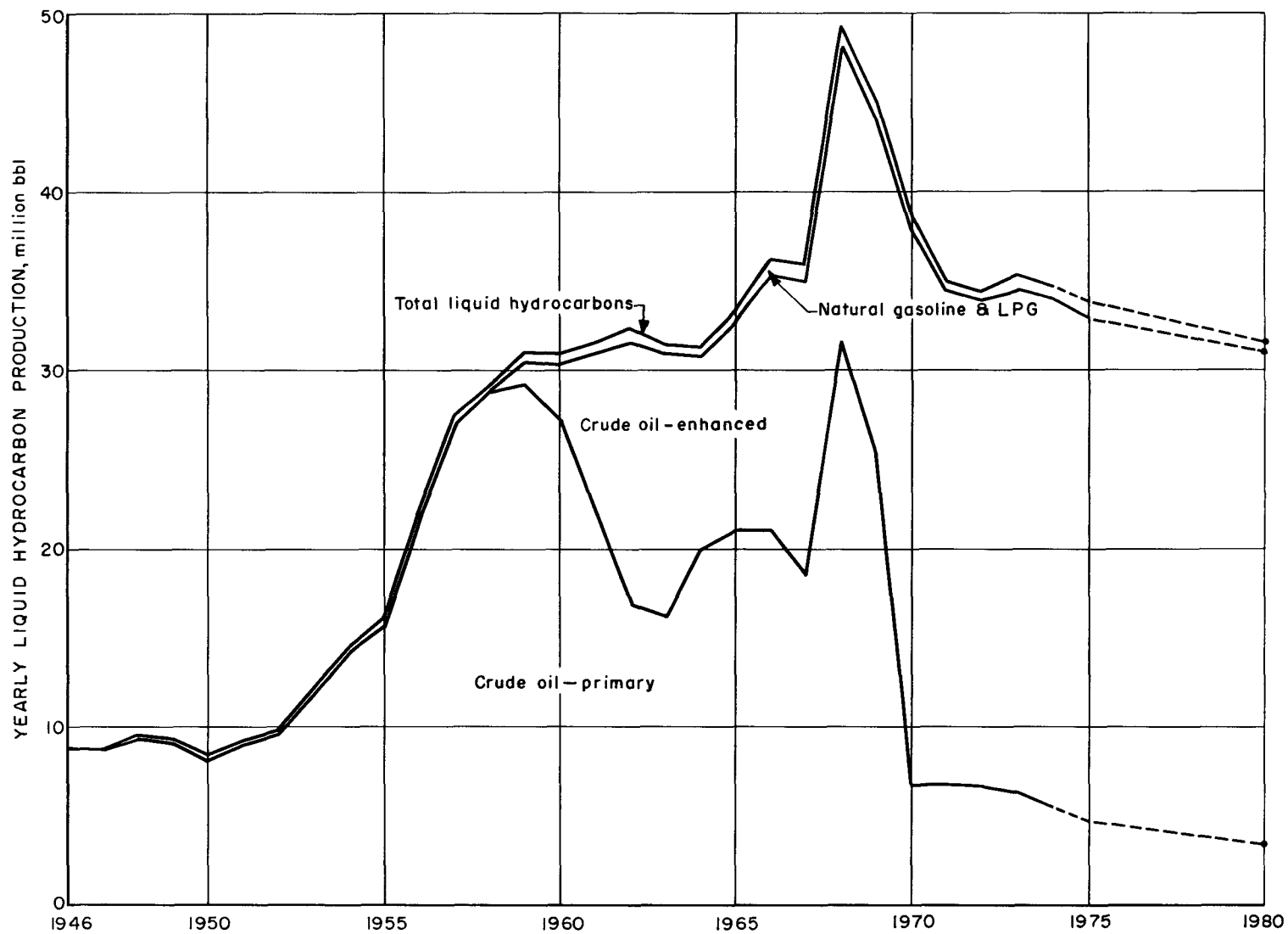
FIGURE A-36. - Montana (PAD district IV) liquid hydrocarbon production.
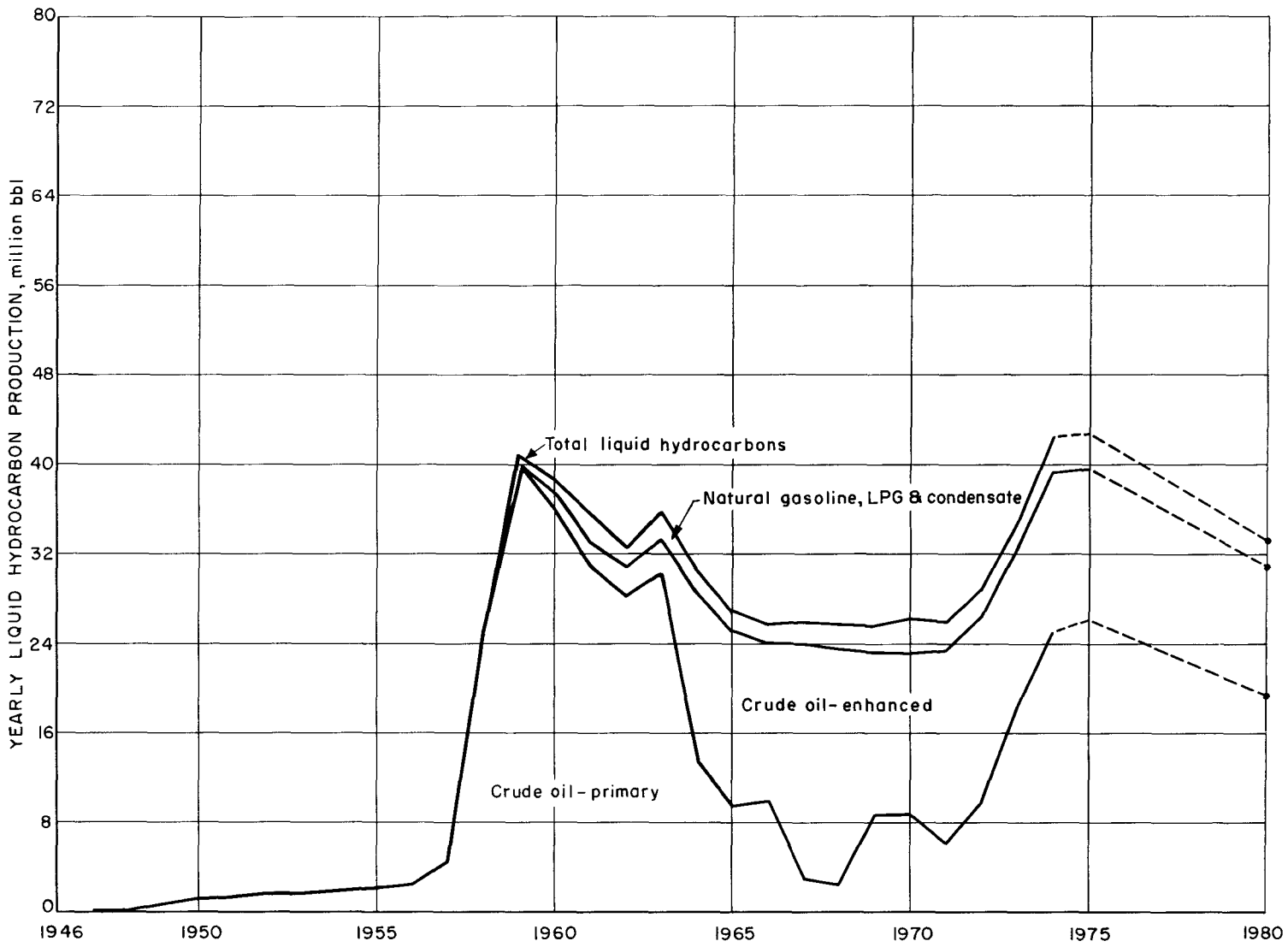
FIGURE A-37; - Utah (PAD district IV) liquid hydrocarbon production.
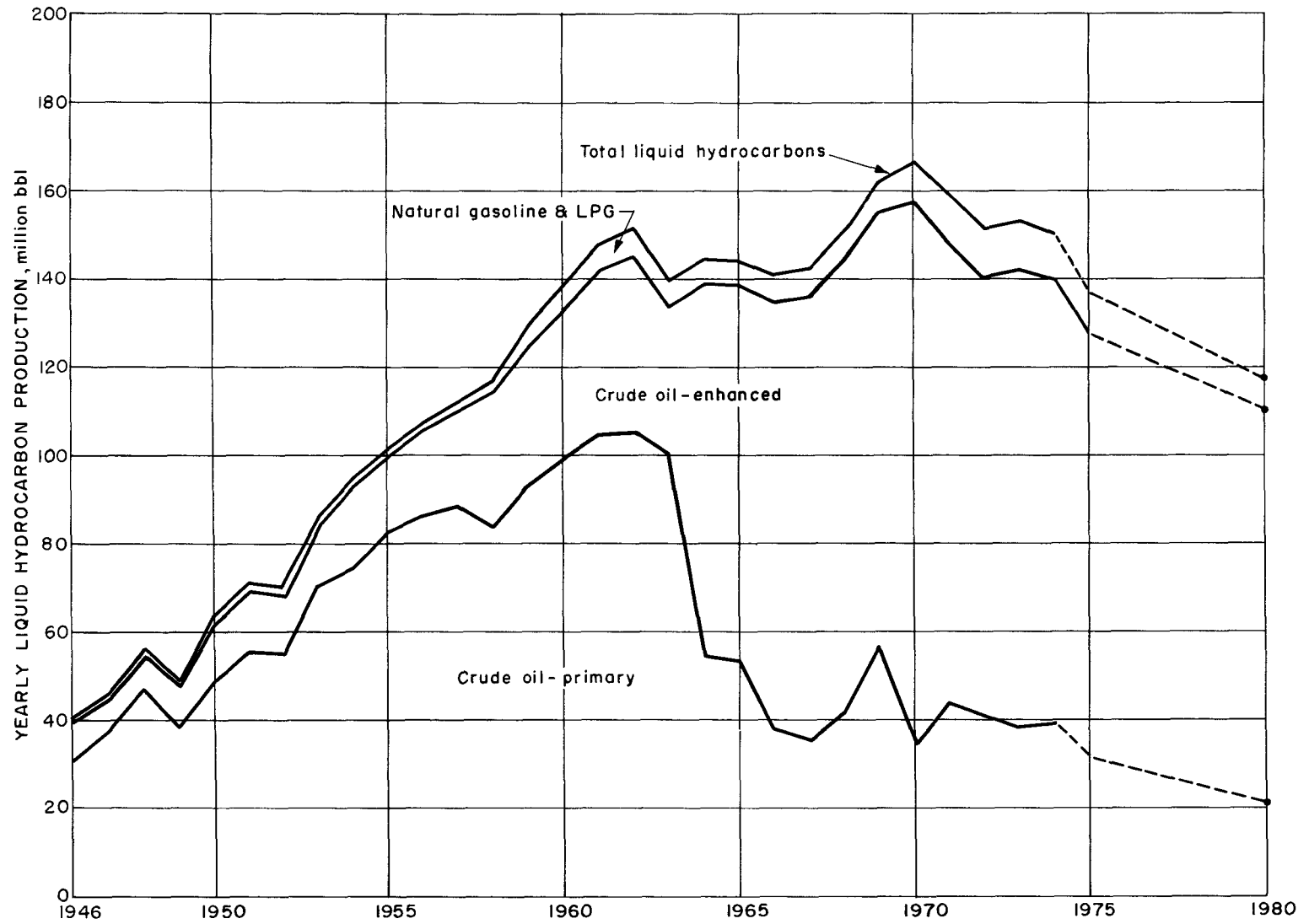
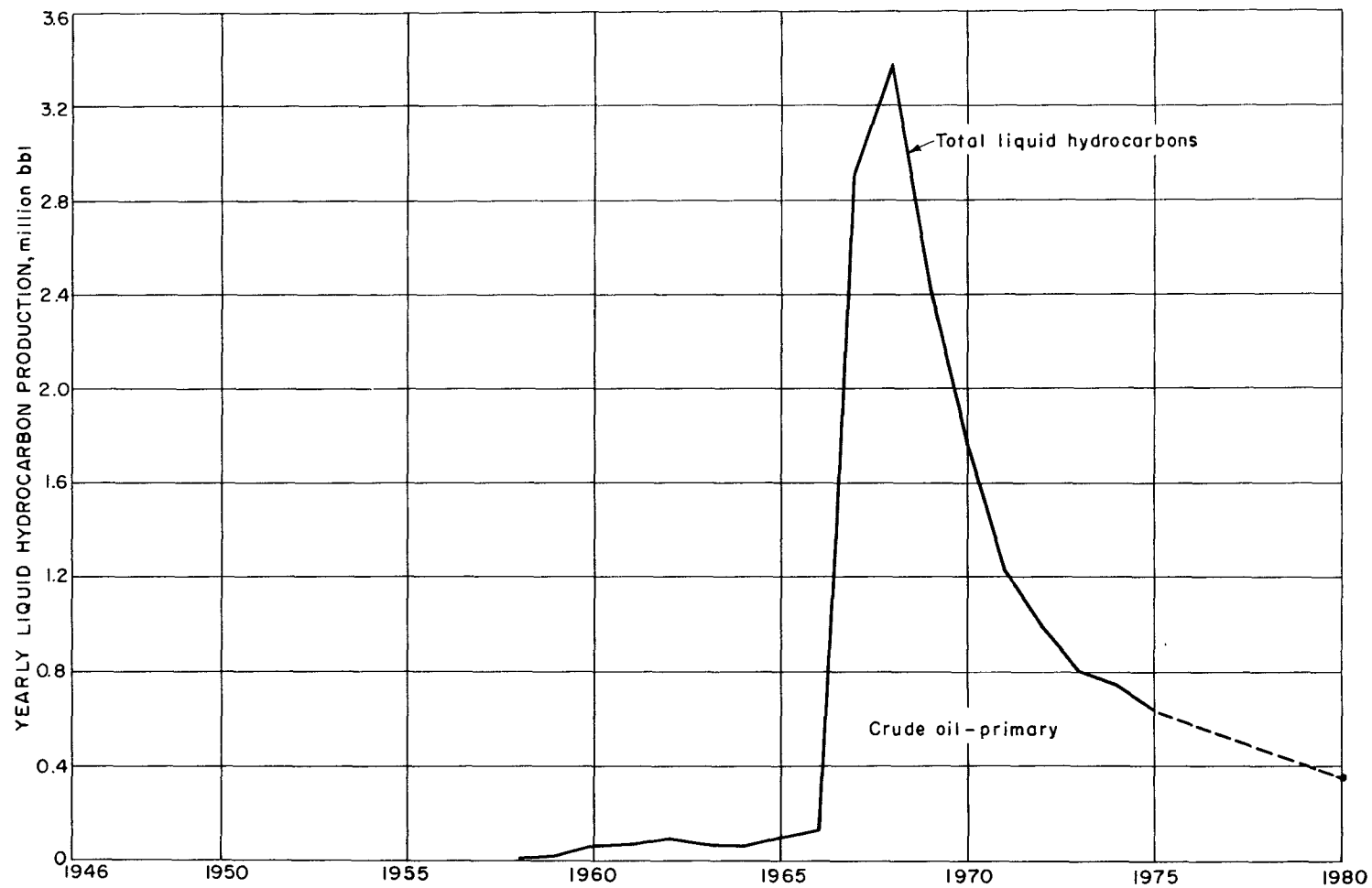FIGURE A-38. - Wyoming (PAD district IV) liquid hydrocarbon production.

FIGURE A-39. - Arizona (PAD district V) liquid hydrocarbon production.
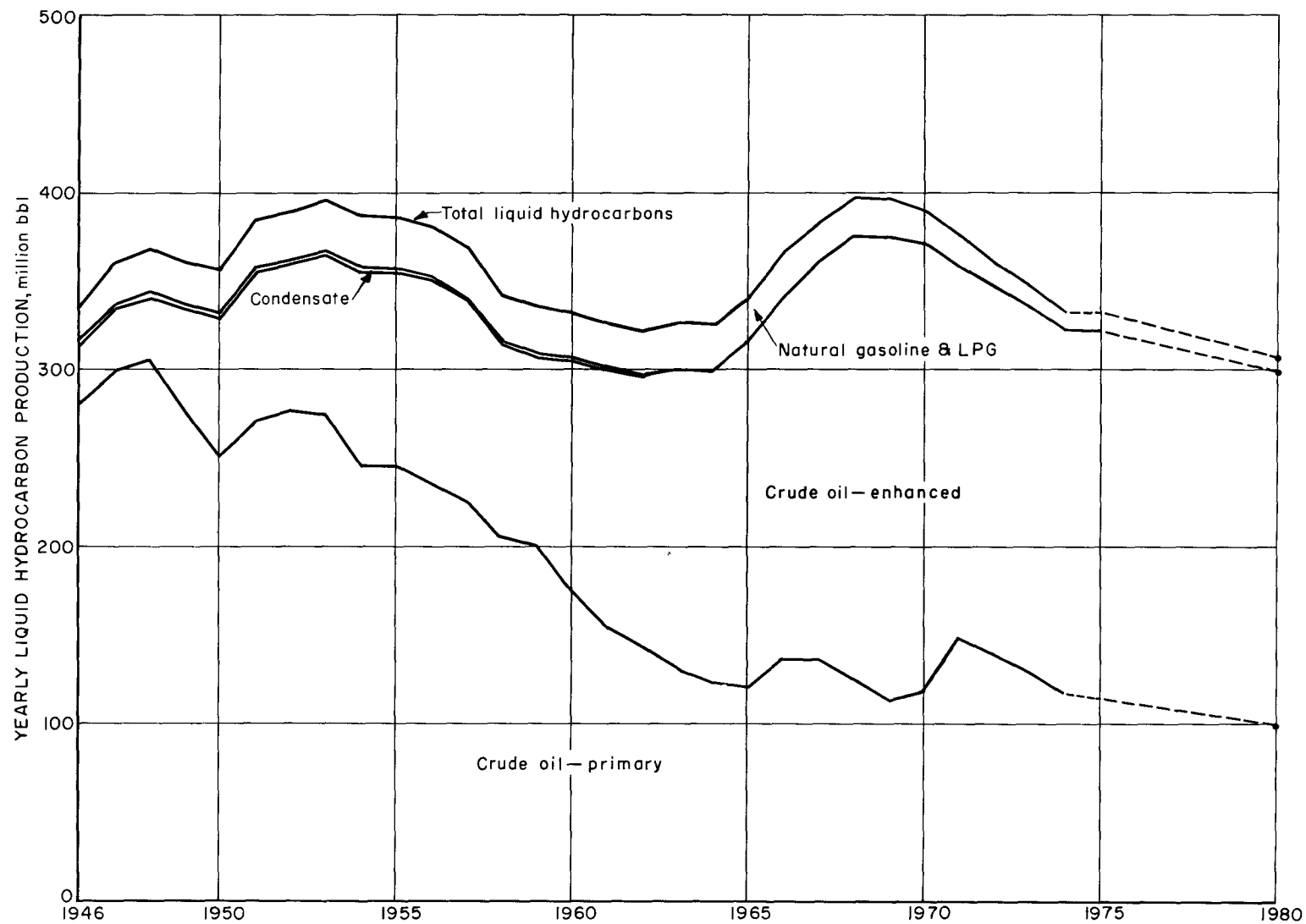
FIGURE A-40. - California (PAD district V) liquid hydrocarbon production. (Does not include increased production (200 thousand BOPD) from the Elk Hills Naval Petroleum Reserve in California.)
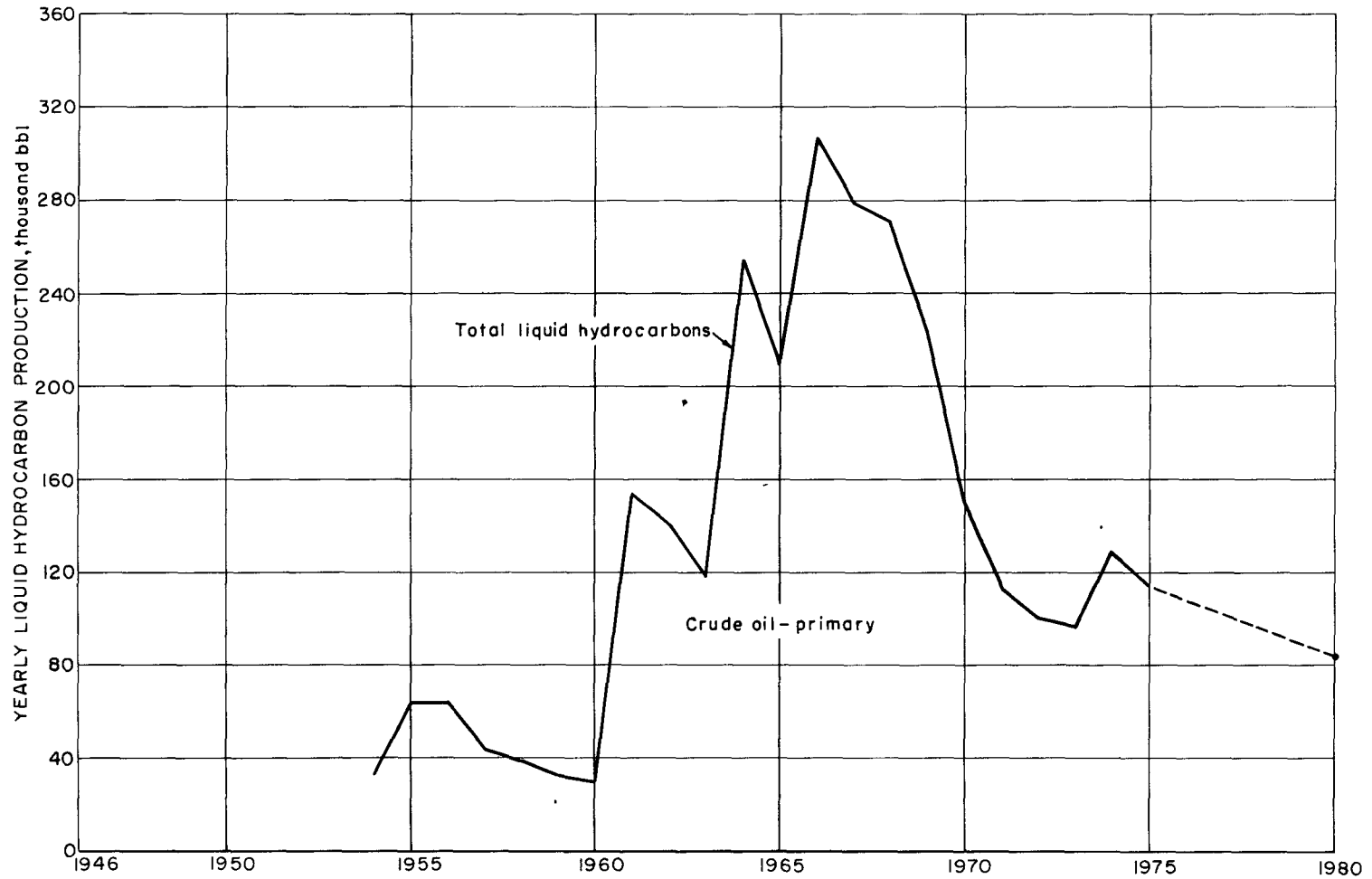
FIGURE A-41 - Nevada (PAD district V) liquid hydrocarbon production.