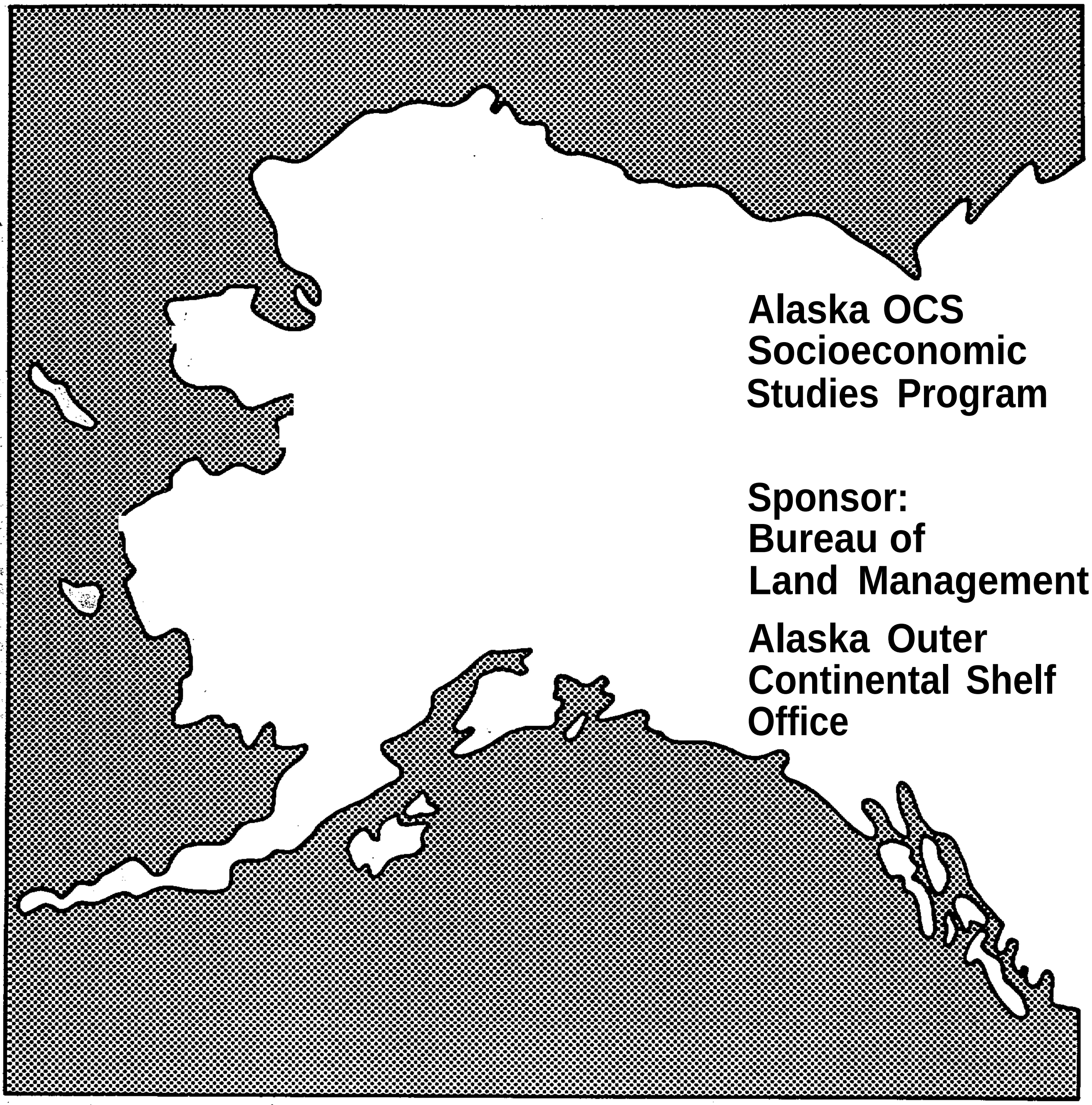
Technical Report
Number 35a



Alaska OCS
Socioeconomic
Studies Program

Sponsor:
Bureau of
Land Management

Alaska Outer
Continental Shelf
Office

Western Gulf of Alaska
Petroleum Development Scenarios
Executive Summary

The United States Department of the Interior was designated by the Outer Continental Shelf (OCS) Lands Act of 1953 to carry out the majority of the Act's provisions for administering the mineral leasing and development of offshore areas of the United States under federal jurisdiction. Within the Department, the Bureau of Land Management (BLM) has the responsibility to meet requirements of the National Environmental Policy Act of 1969 (NEPA) as well as other legislation and regulations dealing with the effects of offshore development. In Alaska, unique cultural differences and climatic conditions create a need for developing additional socioeconomic and environmental information to improve OCS decision making at all governmental levels. In fulfillment of its federal responsibilities and with an awareness of these additional information needs, the BLM has initiated several investigative programs, one of which is the Alaska OCS Socioeconomic Studies Program.

The Alaska OCS Socioeconomic Studies Program is a multi-year research effort which attempts to predict and evaluate the effects of Alaska OCS Petroleum Development upon the physical, social, and economic environments within the state. The analysis addresses the differing effects among various geographic units: the State of Alaska as a whole, the several regions within which oil and gas development is likely to take place, and within these regions, the various communities.

The overall research method is multidisciplinary in nature and is based on the preparation of three research components. In the first research component, the internal nature, structure, and essential processes of these various geographic units and interactions among them are documented. In the second research component, alternative sets of assumptions regarding the location, nature, and timing of future OCS petroleum development events and related activities are prepared. In the third research component, future oil and gas development events are translated into quantities and forces acting on the various geographic units. The predicted consequences of these events are evaluated in relation to present goals, values, and expectations.

In general, program products are sequentially arranged in accordance with BLM's proposed OCS lease sale schedule, so that information is timely to decision making. In addition to making reports available through the National Technical Information Service, the BLM is providing an information service through the Alaska OCS Office. Inquiries for information should be directed to: Program Coordinator (COAR), Socioeconomic Studies Program, Alaska OCS Office, P. O. Box 1159, Anchorage, Alaska 99510.

TECHNICAL REPORT NO. 35a

ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM
WESTERN GULF OF ALASKA (KODIAK)
PETROLEUM DEVELOPMENT SCENARIOS

EXECUTIVE SUMMARY

Prepared for

BUREAU OF LAND MANAGEMENT
ALASKA OUTER CONTINENTAL SHELF OFFICE

Prepared by

DAMES & MOORE

March 1979

Contract No. AA550-CT6-61,
Task 9BA

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NOTICES

1. This document is disseminated under the sponsorship of the U.S. Department of the Interior, Bureau of Land Management, in the interest of information exchange. The U.S. Government assumes no liability for its content or use thereof.

2. This final report is designed to provide preliminary petroleum development data to the groups working on the Alaska OCS Socio-economic Studies Program. The assumptions used to generate off-shore petroleum development scenarios may be subject to revision.

3. The units presented in this report are metric with American equivalents except units used in standard petroleum practice. These include barrels (42 gallons, oil), cubic feet (gas), pipeline diameters (inches), well casing diameters (inches), and well spacing (acres).

ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM
Western Gulf of Alaska
Petroleum Development Scenarios
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1.0 INTRODUCTION

Purpose

In order to analyze the socioeconomic and environmental impacts of western Gulf of Alaska petroleum exploration, development, and production, it is necessary to make reasonable and representative predictions of the nature of that development. The petroleum development scenarios in this report serve that purpose; they provide a "project description" for subsequent impact analysis. The socioeconomic impact analysis of the Western Gulf of Alaska petroleum development postulated in this report will be contained in a subsequent report of this study program.

Particularly important to socioeconomic studies are the manpower, equipment, and material requirements, and the scheduling of petroleum development. The scenarios have to provide a reasonable range of technological, economic and geographic options so that both minimum and maximum development impacts can be discerned. The primary purpose of this report is, therefore, to describe in detail a set of petroleum development scenarios that are economically and technically feasible, based upon available estimates of oil and gas resources of the western Gulf of Alaska.

This study, along with other studies conducted by or for the Bureau of Land Management, including the environmental impact statements produced preparatory to OCS lease sales, are mandated to utilize U.S. Geological Survey estimates of recoverable oil and gas resources in any analysis requiring such resource data.

Scope

The petroleum development scenarios formulated in this report are for the proposed Western Gulf of Alaska (Kodiak) OCS lease sale No. 46, currently scheduled for the autumn of 1980. This is a first generation lease sale following an earlier Gulf of Alaska OCS lease sale (No. 39) in the northern gulf held in April of 1976; the sale will also follow a second generation lease sale for the Northern Gulf of Alaska (No. 55) scheduled for June 1980.

The study area considered in this investigation (Figure 1) is that defined in the draft environmental impact statement for the Western Gulf of Alaska, lease sale No. 46 (U.S. Department of the Interior, 1977, Appendix I). This area comprises 564 blocks or tracts (13 million hectares; 3.2 million acres) of the outer continental shelf located east of Kodiak, Afognak and Trinity Islands with a distance to shore ranging from 4.8 to 185 kilometers (3 to 115 miles). The tracts are located in water depths that range from approximately 35 to 300 meters (115 to 984 feet). Most of the area lies within the 200 meter (650-foot) isobath and a substantial proportion of that area is located in water depths ranging from 30 to 100 meters (98.4 to 328 feet).

The U.S. Geological Survey resource estimates that are used in this study are as follows (Von Huene et al., 1976):

	95 Percent Probability	5 Percent Probability	Statistical Mean
Oil (billions of barrels)	0	1.2	0.2
Gas (trillions of "cubic feet)	0	3.5	0.7

This study details scenarios for the five percent, statistical mean and 95 percent probability levels of the U.S.G.S. resource estimates. In addition, a scenario specifying exploration only is detailed. Since the 95 percent probability level identifies no commercial resources, the exploration only and 95 percent cases are essentially one and the same. Therefore, this study formulates three scenarios corresponding to the five percent, statistical mean resource levels and/or no commercial discoveries resulting in exploration only.

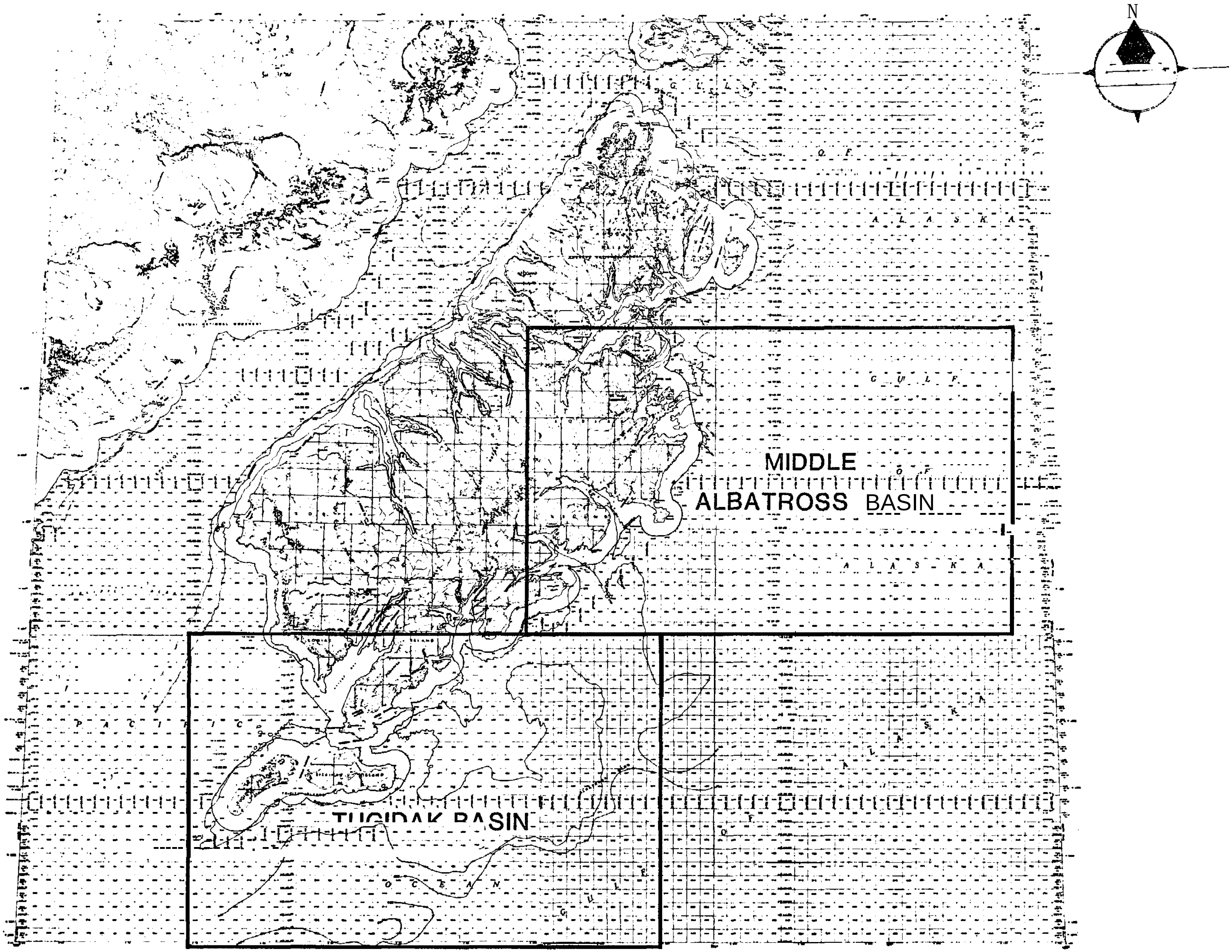


FIGURE 1

WESTERN GULF OF ALASKA, LOCATION OF STUDY AREA

KILOMETERS 0 5 10 20 30 40 50 60

STATUTE MILES 0 5 10 20 30 40

Methodology

The construction of petroleum development scenarios commences with allocation of the U.S.G.S. resource estimates between several sub-basins of the Kodiak Tertiary Province and the formulation of a set of reservoir, hydrocarbon and production assumptions, which include basic analytical assumptions necessary to conduct the economic analysis.

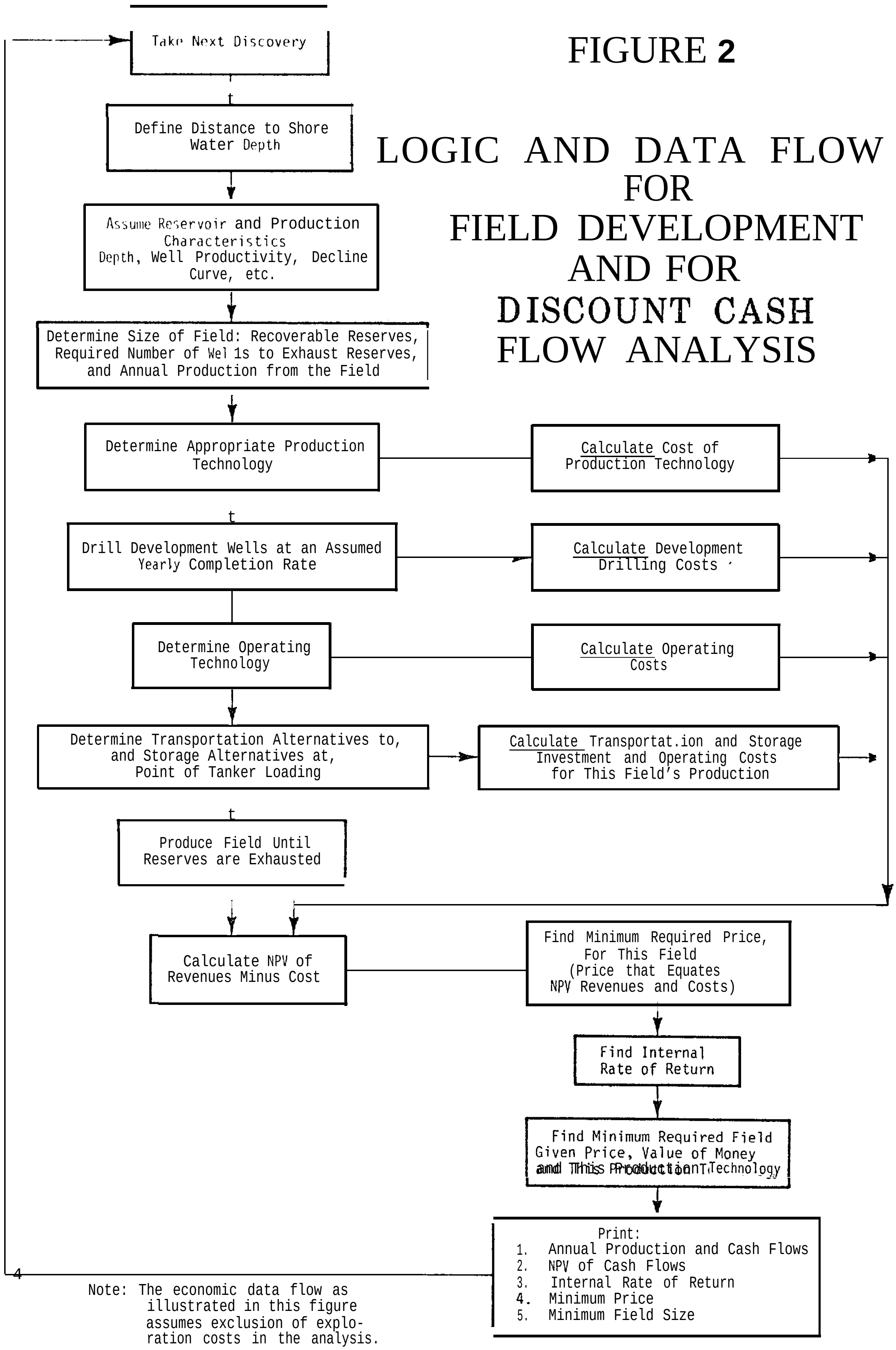
A review of existing and imminent petroleum exploration, development and transportation technologies in similar operating environments is made in order to construct a technology model which identifies a number of production system options to be screened in the economic analysis. An integral part of this review is the identification of petroleum development and operating costs which are the basic input in the economic analysis. The scheduling of field development construction activities is also a product of the technology review and provides the basic input for the analysis of manpower requirements both in terms of the individual petroleum facility/activity components and the total scenario manpower estimates.

The siting criteria and potential sites for onshore petroleum facilities such as oil terminals, LNG plants and staging areas along the Kodiak shoreline are examined to provide locational criteria for scenario facility siting and to determine ranges of pipeline distances to be screened in the economic analysis.

The objective of the economic analysis is to evaluate the relationships among several likely oil and gas production technologies suitable for conditions in the Gulf of Alaska and the minimum field sizes required to justify each technology at various water depths. The logic and data flow of this analysis are illustrated in Figure 2. The model calculates the net present value of developing certain field sizes with a given technology appropriate for a selected water depth and distance from shore. The water depth and distance to shore values selected for input into the model are representative ranges anticipated in the lease areas.

FIGURE 2

LOGIC AND DATA FLOW FOR FIELD DEVELOPMENT AND FOR DISCOUNT CASH FLOW ANALYSIS



Note: The economic data flow as illustrated in this figure assumes exclusion of exploration costs in the analysis.

Field sizes selected for economic screening are consistent with the resource estimates and allocations; test cases using raw cost data were run prior to the full analysis to establish the range of parameters for input to the economic analysis (e.g. the smallest field size to be considered).

Although the economic analysis defines those cases which are uneconomic (under the assumptions of the analysis, there still remain an infinite number of permutations of field size, production technologies and discovery locations which are demonstrated to be economic. From these permutations, a set of skeletal scenarios are defined based primarily on variation in potential for onshore development, which is a function of such factors as field size, field distribution, location, and production technology. Essentially, the skeletal scenarios defined varying amounts of oil that would be brought to shore vs. offloaded directly to tankers offshore.

The detailed (selected) scenarios are described according to environmental setting, development scheduling, facility equipment and manpower requirements. Although the scenarios are in essence hypothetical developments, they have been formulated to provide reasonable and representative predictions, given the available data base, on the course of possible petroleum development in the Gulf of Alaska given the potential resource base identified by the U.S.G.S.

This study was conducted concurrently with a similar study of the northern Gulf of Alaska second generation OCS lease sale (No. 55). The data collection, analytical procedures and economic screening parameter selection were structured to be applicable, when appropriate, to both studies. The economic analysis, for example, encompasses anticipated conditions in both areas; when contrasts exist that affect the analysis, they are noted in the text.

2.0 SUMMARY OF FINDINGS

Selected Petroleum Development Scenario>

Three scenarios are detailed describing exploration only (no commercial resources), a high find case corresponding to the five percent probability resource level estimate of the U.S. Geological Survey and a medium find case corresponding to the statistical mean resource level estimate. At the direction of BLM staff, the five percent resource scenario rather than considering oil and gas resources together, detailed separate scenarios for oil and gas production to explore the possibility that the Kodiak Tertiary Province may be gas prone, yielding only natural gas.

The principal resource assumption affecting the scenario development is that 80 percent of the oil and gas resources are located in the Albatross Basin and the remaining 20 percent in the Tugidak Basin. The Albatross Basin resources are assumed to be located beneath the central Albatross Bank offshore of Kodiak Island,

EXPLORATION ONLY SCENARIO

The exploration only scenario postulates that 17 exploration wells are drilled over a three year period following the lease sale with only non-commercial finds (Table 1). Exploration is centered on the Albatross Bank with lesser interest shown in the Tugidak Basin.

The U.S. Geological Survey resource estimate corresponding to the 95 percent probability that there is at least that resource present is zero. This is because, in frontier areas such as the Kodiak shelf lacking in geologic data, a marginal or conditional factor is applied to the resource estimate which specifies the chance of no commercial oil or gas. The U.S. Geological Survey estimates that the probability of no commercial oil or gas is 60 percent. Thus, any probability estimate greater than 60 percent implicitly means no commercial resources.

TABLE 1

EXPLORATION ONLY SCENARIO

Basin	YEAR AFTER LEASE SALE 1 No. of Rigs	No. of Wells	2 No. of Rigs	No. of Wells	3 No. of Rigs	No. of Wells
Albatross	2	4.8	2	4.8	1	1.4
Tugidak	1	2.4	1	2.4	1	1.2
Portlock	--	--	--	--	--	--
TOTALS	3	7.2	3	7.2	2	2.6

TOTAL WELLS = 17

The principal exploration base is postulated to be Seward (as was the case during the exploration program following lease sale no. 36 in the northern Gulf of Alaska) with Kodiak and Homer performing minor roles.

FIVE PERCENT PROBABILITY RESOURCE LEVEL SCENARIO - OIL ONLY

The major characteristics of this scenario are shown in Table 2 and illustrated in Figure 3 and 4. This scenario represents a high find case of oil resource discovery but with only a 1 in 20 chance that that amount of resource will be discovered. The total reserves discovered and developed are:

	Oil (mmbbl)	Gas - Associated (Bcf)
Albatross Basin	950	560
Tugidak Basin	250	140

The associated gas reserves are too small to be economic and are used to power the platforms with the remainder reinfected.

Three fields are discovered within 48 kilometers (30 miles) of each other on the middle Albatross Bank in water depths of 61 to 91 meters (200 to 300 feet). The fields share a pipeline to an oil terminal on the north shore of Ugak Bay on the east coast of Kodiak Island.

A single field with reserves of about 250 million barrels is discovered in the Tugidak Basin. An offshore loading production system employing a single steel platform with no storage capability loading to tankers via an SPM is selected to develop this field.

FIVE PERCENT PROBABILITY RESOURCE LEVEL SCENARIO - NON-ASSOCIATED GAS ONLY

The major characteristics of this scenario are shown on Table 3 and illustrated in Figures 5 and 6. This scenario assumes discoveries of non-associated gas only. The total resources discovered are:

TABLE 2

5% PROBABILITY RESOURCE LEVEL SCENARIO
OIL AND ASSOCIATED GAS PRODUCTION ONLY

Basin	Field Size: Oil (MMBBL)	Field Size: Gas[4] (BCF)	Production System	Platforms No./Type[1]	Number of Production Wells	Peak Production: Oil (MB/D)	Peak Production: Gas (MMCF/D)	Water Depth: meters	Water Depth: feet	Oistance to Shore Terminal[2]: kilometers	Oistance to Shore Terminal[2]: miles	Pipeline Diameter (inches): Oil	Pipeline Diameter (inches): Gas
Albatross	500	--	Steel platforms with shared trunkline to shore	2 S	80	192	--	61-91	200-300	32-56	20-35	--	--
Group 1	250	--	Steel platform with shared trunkline to shore	1 S	80	192	--	61-91	200-300	32-56	20-35	28-30[3]	--
	200	--	Steel platform with shared trunkline to shore	1 S	40	96	--	61-91	200-300	32-56	20-35	--	--
Tugidak	250	--	Steel platform with no storage, offshore loading	1 S	40	65	--	61-91	200-300	--	--	--	--
Portlock	--	--	--	--	--	--	--	--	--	--	--	--	--

[1] S = Steel, C = Concrete

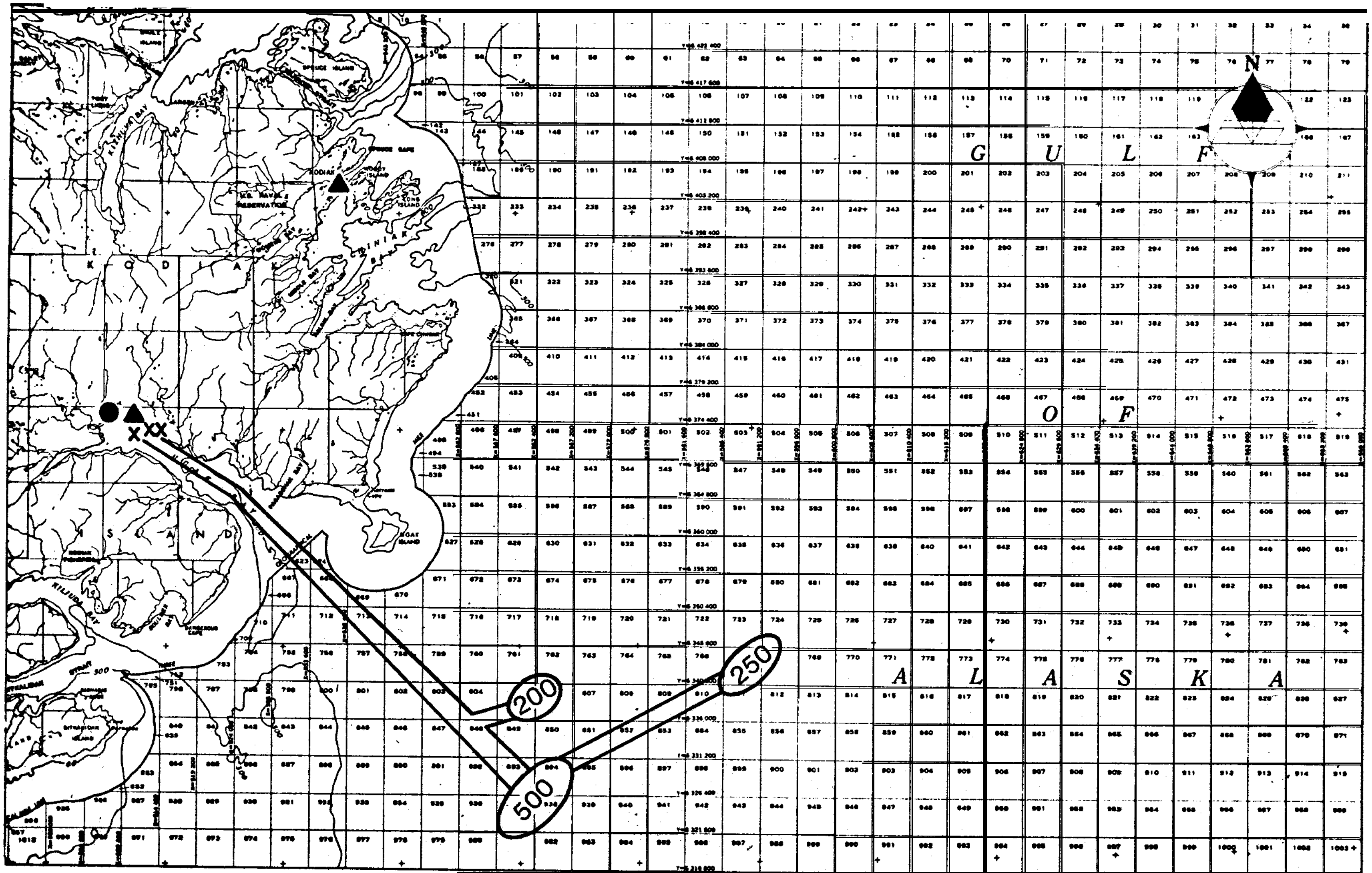
[2] Shore terminal for Albatross is Ugak Bay area.

[3] Group 1 fields share a pipeline to Ugak 8ay: peak throughput, 384 MB/D.

[4] A low gas-oil ratio or non-commercial associated gas is implicit - associated gas is assumed to be used as platform fuel and reinfected (see text).

FIGURE 3

OIL - 5% PROBABILITY RESOURCE LEVEL SCENARIO



KEY: OIL FIELD
GAS FIELD A.G. = ASSOCIATED GAS
OIL & ASSOCIATED GAS FIELD

NOTE: OIL FIELD SIZE GIVEN IN MILLION BARRELS (MMbbl)
GAS FIELD SIZE GIVEN IN BILLION CUBIC FEET (Bcf)

XXX LANDFALL
LNG PLANT
SERVICE BASE
OIL TERMINAL
PUMP STATION
PIPELINE &/OR ROAD CORRIDOR

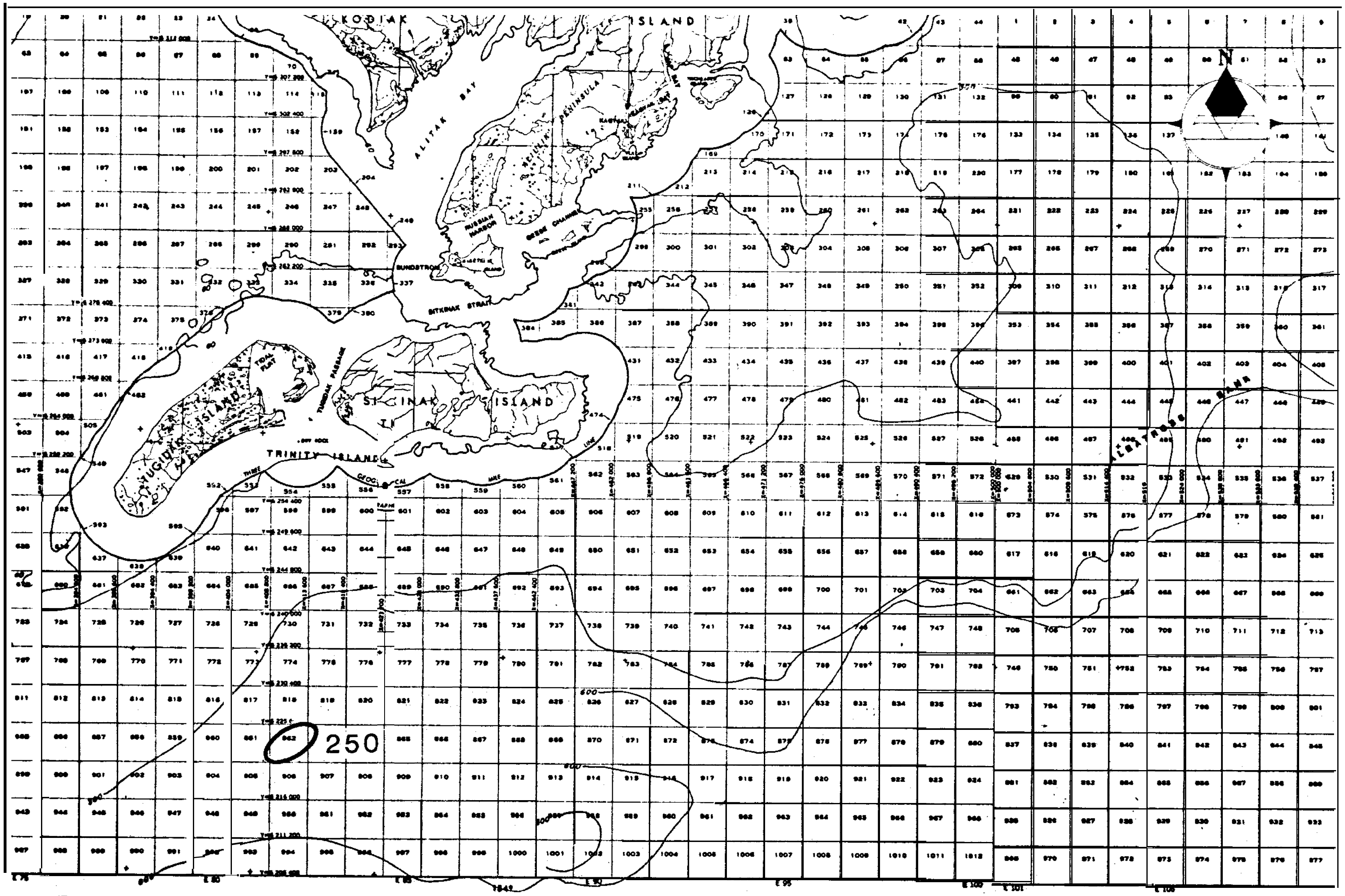
STATUTE MILES
0 5 10 20 30 40

ALBATROSS BASIN

FIELD AND ONSHORE SITE LOCATIONS

FIGURE 4

OIL - 5% PROBABILITY RESOURCE LEVEL SCENARIO



KEY: OIL FIELD

GAS FIELD A.G. = ASSOCIATED GAS

OIL & ASSOCIATED GAS FIELD

NOTE: OIL FIELD SIZE GIVEN IN MILLION BARRELS (MMbbl)
GAS FIELD SIZE GIVEN IN BILLION CUBIC FEET (Bcf)

XXX LANDFALL

LNG PLANT

SERVICE BASE

OIL TERMINAL

PUMP STATION

PIPELINE &/OR ROAD CORRIDOR

KILOMETERS

0 5 10 20 30 40 50 60

STATUTE MILES

0 5 10 20 30 40

TUGIDAK BASIN

FIELD AND ONSHORE SITE LOCATIONS

TABLE 3

5% PROBABILITY RESOURCE LEVEL SCENARIO
NON-ASSOCIATED GAS ONLY

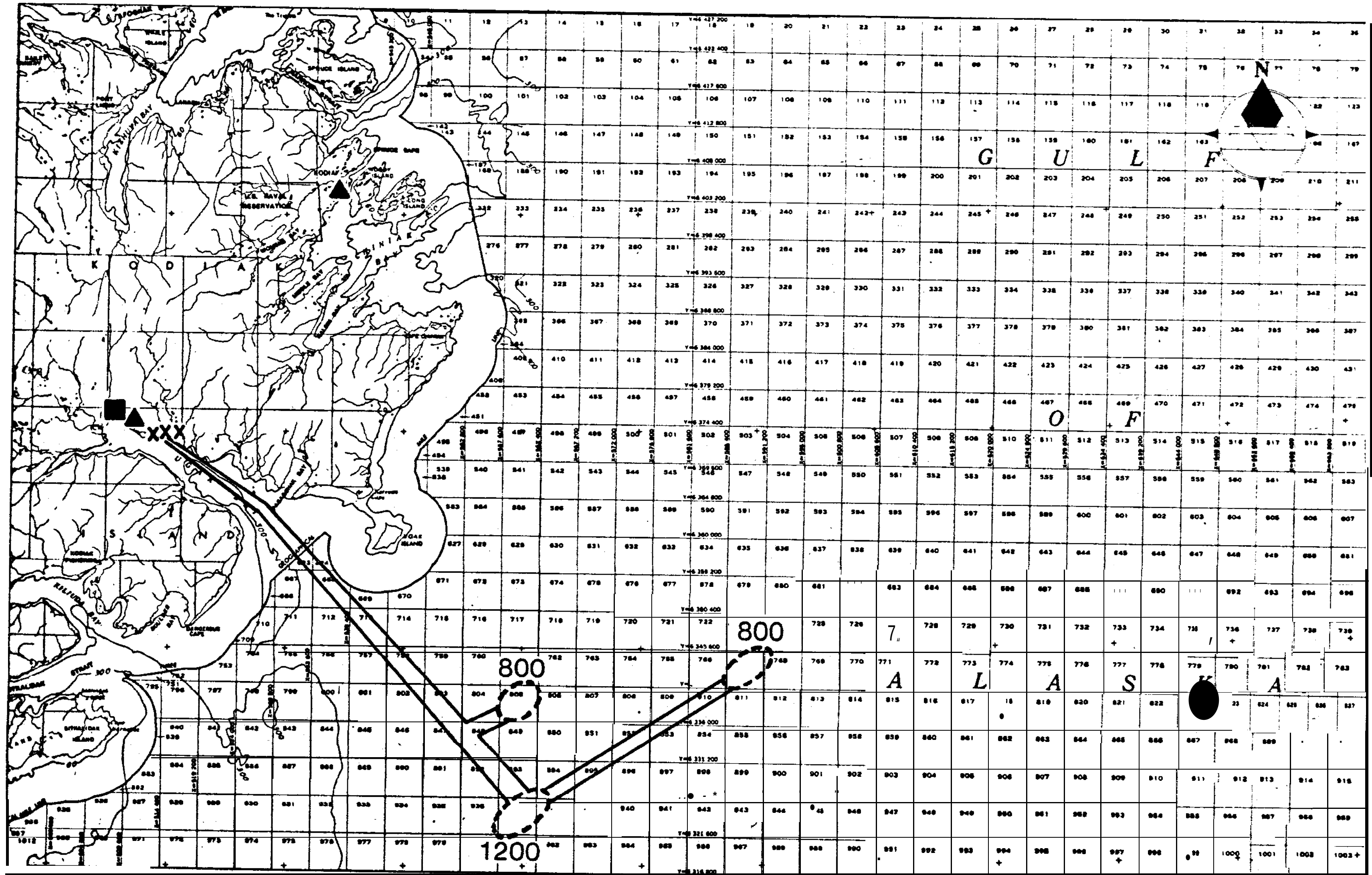
Basin	Field Size: Oil (MMBBL)	Field Size: Gas (BCF)	Production System	Platforms No./Type[1]	Number of Production Wells	[illegible]: Oil (MB/D)	[illegible]: Gas (MMCF/D)	Water Depth: meters	Water Depth: feet	Distance to Shore Terminal[2]: kilometers	Distance to Shore Terminal[2]: miles	Pipeline Diameter (inches): Oil	Pipeline Diameter (inches): Gas
Albatross	--	1200	Steel platform with shared gas pipeline to shore	1 S	8	--	192	61-91	200-300	32-56	20-35	--	26-18
		800	Steel platform with shared gas pipeline to shore	1 S	8	--	192	61-91	200-300	32-56	20-35	--	--
		800	Steel platform with shared gas pipeline to shore	1 S	8	--	192	61-91	200-300	32-56	20-35	--	--
Tugidak	--	700	Not produced - uneconomic	--	—	-	--	--	-		-	--	--

[1] S = Steel, C = Concrete

[2] Ugak Island area

FIGURE 5

NON-ASSOCIATED GAS - 5% PROBABILITY RESOURCE LEVEL SCENARIO

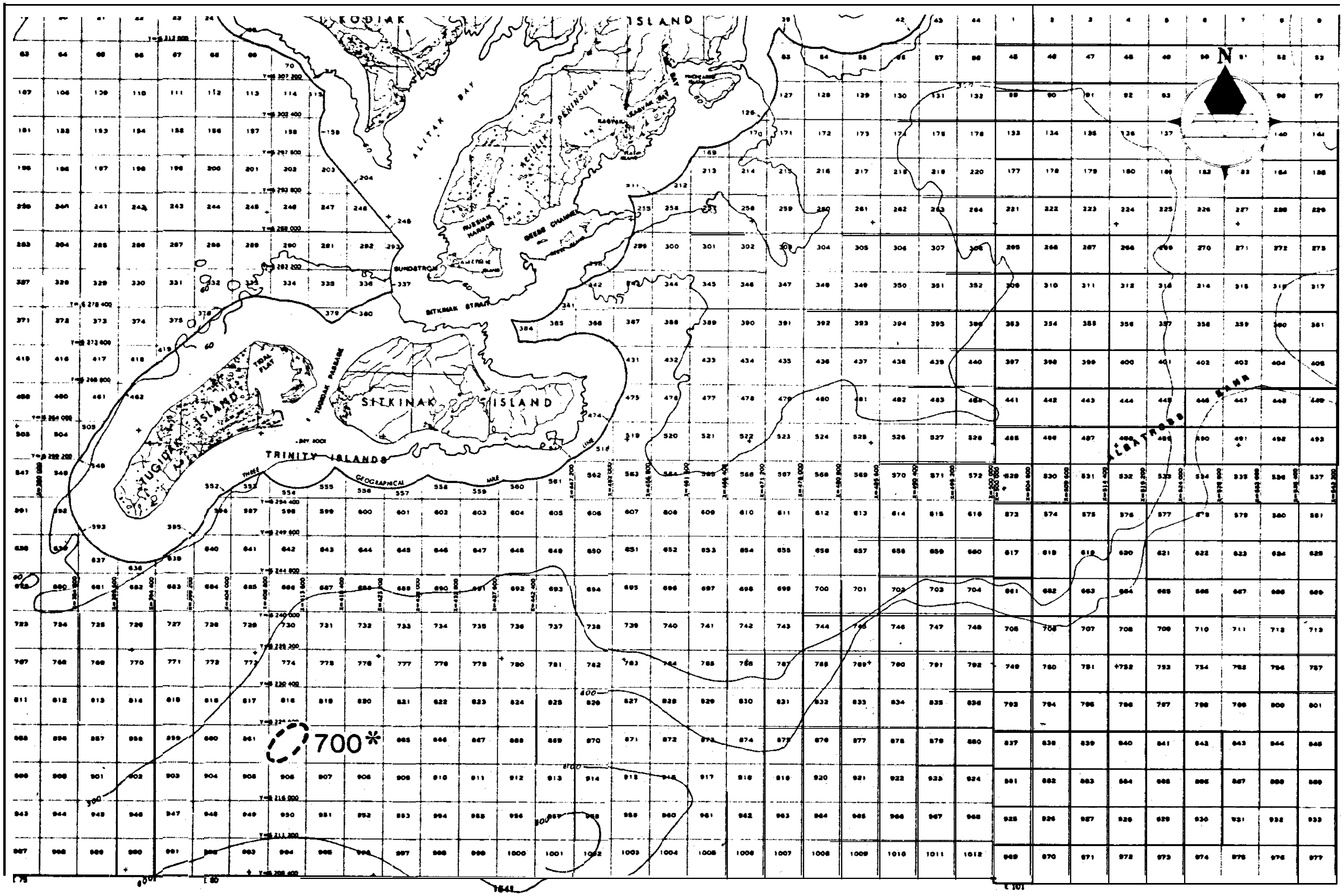


ALBATROSS BASIN

FIELD AND ONSHORE SITE LOCATIONS

FIGURE 6

NON-ASSOCIATED GAS - 5% PROBABILITY RESOURCE LEVEL SCENARIO



KEY: OIL FIELD

GAS FIELD A.G. = ASSOCIATED GAS

OIL & ASSOCIATED GAS FIELD

NOTE: OIL FIELD SIZE GIVEN IN MILLION BARRELS (MMbbl)
GAS FIELD SIZE GIVEN IN BILLION CUBIC FEET (Bcf)

XXX LANDFALL

LNG PLANT

SERVICE BASE

OIL TERMINAL

PUMP STATION

PIPELINE &/OR ROAD CORRIDOR

* NON-COMMERCIAL

KILOMETERS

0 5 10 20 30 40 50 60

STATUTE MILES

0 5 10 20 30 40

TUGIDAK BASIN

FIELD AND ONSHORE SITE LOCATIONS

Basin	Non-Associated Gas (Bcf)
Albatross	2,800
Tugidak	700

The gas resources in the Tugidak Basin, even though they are found in one field, prove to be uneconomic and are not developed.

The Albatross reserves consist of three fields located within 48 kilometers (30 miles) of each other on the middle Albatross Bank in water depths of 61 to 91 meters (200 to 300 feet) about 80.5 kilometers (50 miles) southeast of Kodiak. The fields share a trunk pipeline to an LNG plant designed to process its anticipated peak production of nearly 600 mmcfd located on the north shore of Ugak Bay. The liquefied gas is exported to the lower 48 by a fleet of three LNG tankers. Field construction support bases are located at Seward and Kodiak.

STATISTICAL MEAN PROBABILITY RESOURCE LEVEL SCENARIO

The major characteristics of this scenario are presented in Table 4 and illustrated in Figure 7. This scenario represents a medium find case of resource discovery. The total reserves discovered and developed are: (1)

	Oil (MMbbl)	Associated Gas (bcf)	Non-Associated Gas (bcf)
Albatross Basin	160	--	--

The only commercial discovery made is located on the middle Albatross Bank about 80.5 kilometers (50 miles) southeast of the city of Kodiak in a water depth of about 61 meters (200 feet). The reserves (160 mmbbl)

(1) The oil and gas resources of the western Gulf of Alaska as estimated by the U.S. Geological Survey at the statistical mean level (200 mmbbl oil, 700 bcf gas) when allocated 80 percent to the Albatross Basin, 20 Percent to the Tugidak Basin result in one economic oil field in the Albatross Basin. "The remainder of the oil and all the gas are uneconomic and cannot be produced under the technological and economic assumptions of this analysis. Furthermore, to be economic all the oil would have to be found in a single field as indicated in this scenario.

TABLE 4

STATISTICAL MEAN RESOURCE LEVEL SCENARIO
OIL AND ASSOCIATED GAS PRODUCTION

Basin	Field Size: Oil (MMBBL)	Field Size: Gas[3] (BCF)	Production System	Platforms No./Type[1]	Number of Production Wells	Peak Production: Oil (B/D)	Peak Production: Gas (MMCF/D)	Water Depth: meters	Water Depth: feet	Distance to Shore Terminal[2]: kilometers	Distance to Shore Terminal[2]: miles	Pipeline Diameter (inches): Oil	Pipeline Diameter (inches): Gas
Albatross	160	--	Steel platform with no storage offshore loading	1 S	40	65	--	61	200	--	--	--	--
Tugidak	--	--	--	--	--	--	--	--	--	--	--	--	--
Portlock	--	--	--	--	--	--	--	--	--	--	--	--	--

[1] S = Steel, C = Concrete

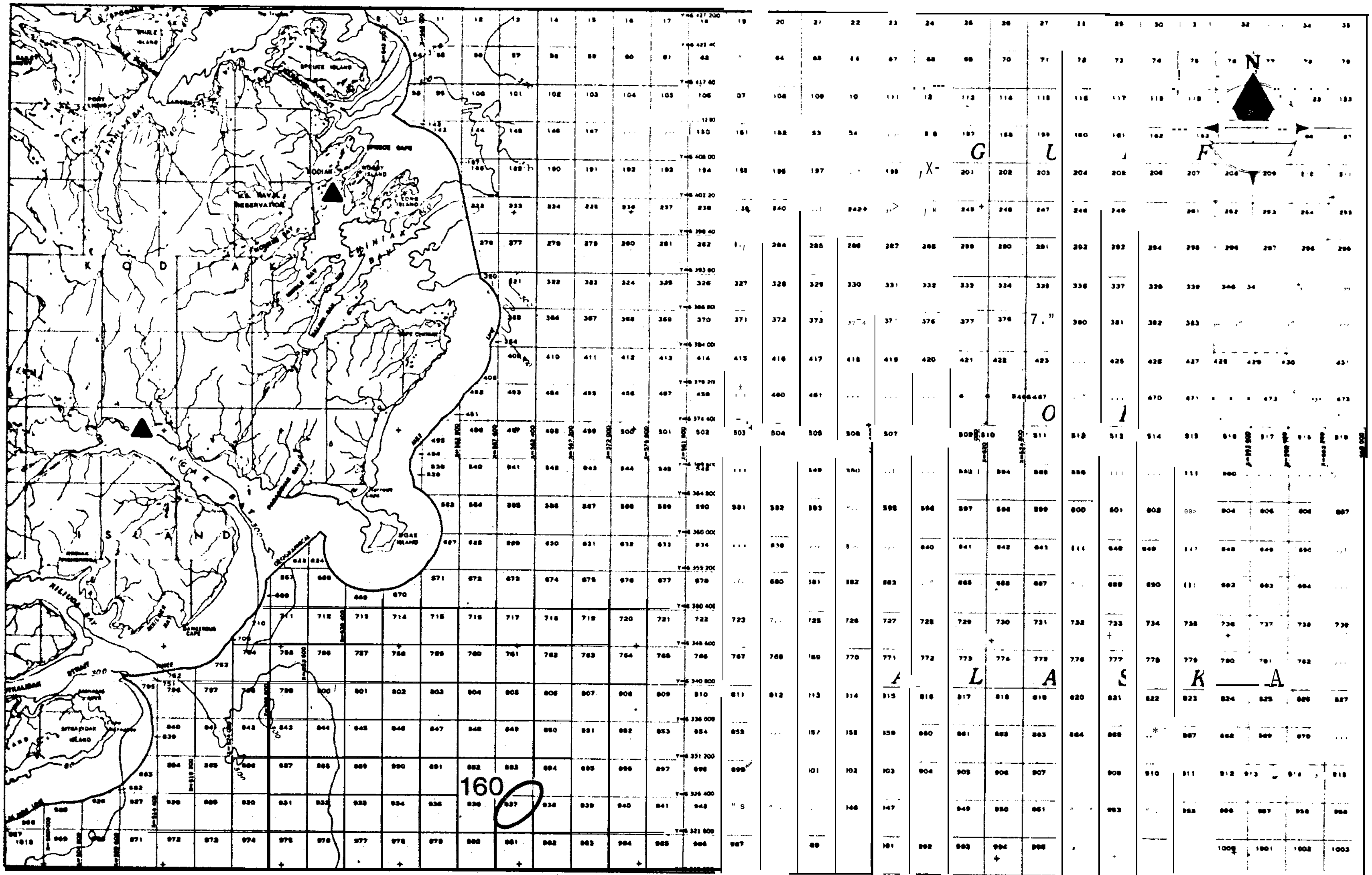
[2] Ugak Bay area

[3] A low gas-oil ratio or non-commercial associated gas is implicit - associated gas is assumed to be used as platform fuel and reinfected.

Note: The oil and gas resources of the western Gulf of Alaska as estimated by the U.S.G.S. at the statistical mean level (200 mmbbl oil, 700 bcf gas), when allocated 20 percent to the Tugidak Basin, 80 percent to the Albatross, and 0 percent to the Portlock Basin, result in one economic oil field in the Albatross Basin. The remainder of the oil is uneconomic and cannot be produced under the technological conditions as assumptions of this analysis.

FIGURE 7

OIL-STATISTICAL MEAN RESOURCE LEVEL SCENARIO



KEY: OIL FIELD

GAS FIELD A.G. = ASSOCIATED GAS

OIL & ASSOCIATED GAS FIELD

NOTE: OIL FIELD SIZE GIVEN IN MILLION BARRELS (MMbbl)
GAS FIELD SIZE GIVEN IN BILLION CUBIC FEET (Bcf)

XXX LANDFALL

LNG PLANT

SERVICE BASE

OIL TERMINAL

PUMP STATION

PIPELINE &/OR ROAD CORRIDOR

KILOMETERS

0 5 10 20 30 40 50 60

STATUTE MILES

0 5 10 20 30 40

ALBATROSS BASIN

FIELD AND ONSHORE SITE SITE LOCATIONS

are insufficient to justify a pipeline to shore and shore terminal. An offshore loading system using an SPM and “dedicated” tankers. A single steel platform without storage capacity is selected; the increased production afforded by storage is not deemed to offset the incremental investment in a storage buoy.

Kodiak is used as the construction support base and field operation center. The single steel platform and topside modules are fabricated on the U.S. West Coast and transported to Alaska by barge.

Employment

Tables 5 through 8 present summaries of manpower requirements for the four scenarios. Figures 8 through 11 show graphically the annual monthly average manpower requirements. Maximum manpower demand created by the five percent oil scenario occurs in year 7 when a total of 33,323 man-months of labor are consumed by exploration and development activity. The average monthly manpower requirement in year 7 is 2,777 people. On-site labor consumption in year 7 is 21,228 man-months (this is the amount of direct labor input required by the various tasks, excluding time off by crews).

The five percent gas scenario requires about 12 percent fewer man-months of employment in its peak year of work than the five percent oil scenario. Maximum manpower demand in the five percent gas scenario occurs in year 5, when a total of 29,460 man-months are consumed. The average monthly manpower requirement in year 5 is 2,455 people. On-site labor consumption in year 5 is 18,665, although 20,297 on-site man-months of labor are required in year 4 (this is because onshore construction employment is greater in year 4 than year 5, offshore construction is greater in year 5 than year 4, and onshore construction is virtually all on-site labor while offshore construction has a large off-site component).

TABLE 5

SUMMARY OF MANPOWER REQUIREMENTS FORALL INDUSTRIES - EXPLORATION ONLY SCENARIO
ONSITE AND TOTAL

YEAR AFTER LEASE SALE	ONSITE (MAN-MONTHS)			TOTAL (MAN-MONTHS)			TOTAL LABOR FORCE (MONTHLY AVERAGE)		
	OFFSHORE	ONSHORE	TOTAL	OFFSHORE	ONSHORE	TOTAL	OFFSHORE	ONSHORE	TOTAL
1	3127.	482.	3609.	5611.	662.	6273.	468.	56.	523.
2	3127.	482.	3609.	5611.	662.	6273.	468.	56.	523.
3	1059.	162.	1221.	1887.	222.	2109.	158.	19.	176.

TABLE 6

SUMMARY OF MANPOWER REQUIREMENTS FOR ALL INDUSTRIES - 5 PERCENT PROBABILITY RESOURCE LEVEL SCENARIO - OIL ONLY
ONSITE AND TOTAL

YEAR AFTER LEASE SALE	ONSITE (MAN-MONTHS) OFFSHORE	ONSITE (MAN-MONTHS) ONSHORE	ONSITE (MAN-MONTHS) TOTAL	TOTAL (MAN-MONTHS) OFFSHORE	TOTAL (MAN-MONTHS) ONSHORE	TOTAL (MAN-MONTHS) TOTAL	TOTAL LABOR FORCE (MONTHLY AVERAGE) OFFSHORE	TOTAL LABOR FORCE (MONTHLY AVERAGE) ONSHORE	TOTAL LABOR FORCE (MONTHLY AVERAGE) TOTAL
1	870.	134.	1004.	1560.	184.	1744.	130.	16.	146.
2	2118.	324.	2442.	3774.	444.	4218.	315.	37.	352.
3	2118.	324.	2442.	3774.	444.	4218.	315.	37.	352.
4	4211.	646.	4857.	7523.	886.	8409.	627.	74.	701.
5	3152.	6112.	9264.	5636.	6911.	12547.	470.	576.	1046.
6	5471.	4658.	10129.	10204.	5242.	15446.	851.	437.	1288.
7	12171.	9057.	21228.	23295.	10028.	33323.	1942.	836.	2777.
8	13620.	3948.	17568.	?6326.	5239.	31565.	2194.	437.	2631.
9	13594.	2614.	16208.	26479.	3822.	30301.	2207.	319.	2526.
10	13013.	2477.	15490.	25492.	3735.	29227.	2125.	31?.	2435.
11	11340.	2223.	13563.	22350.	3506.	25856.	1863.	293.	2155.
12	11760.	2268.	14028.	23160.	3576.	26736.	1930.	298.	2228.
13	10656.	2220.	12876.	20952.	3528.	24480.	1746.	294.	2040.
14	8448.	2124.	1057 C?.	16536.	3432.	19968.	1378.	286.	1664.
15	7344.	2076.	9420.	14328.	3364.	17712.	1194.	282.	1476.
16	6240.	2028.	8268.	12120.	3336.	15456.	1010.	278.	1288.
17	6240.	2028.	8268.	12120.	3336.	15456.	1010.	278.	1288.
18	6240.	2028.	8268.	12120.	3336.	15456.	1010.	278.	1288.
19	6240.	2028.	8268.	1.21.?0.	3336.	1545.6.	1010.	278.	1288.
20	6240.	2020.	8268.	12120.	3336.	15456.	1010.	278.	1288.
21	5412.	1869.	7281.	10506.	3142.	13648.	876.	262.	1138.
22	4992.	1824.	6816.	9696.	3072.	12768.	bed.	256.	1064.
23	3336.	1506.	4842.	6468.	2684.	9152.	539.	224.	763.
24	2496.	408.	2904.	4848.	528.	5376.	404.	44.	448.
25	1668.	249.	1917.	3234.	334.	3568.	270.	28.	298.
26	1248.	204.	145.2.	2424.	264.	2688.	202.	22.	224.
27	1248.	204.	1452.	2424.	264.	2688.	20.?.	22.	224.
28	1248.	204.	1452.	2424.	264.	2688.	202.	22.	224.
29	1248.	2'04.	1452.	2424.	264.	2688.	202.	22.	224.
30	1248.	204.	1452.	2424.	264.	2688.	202.	2?.	224.

TABLE 7

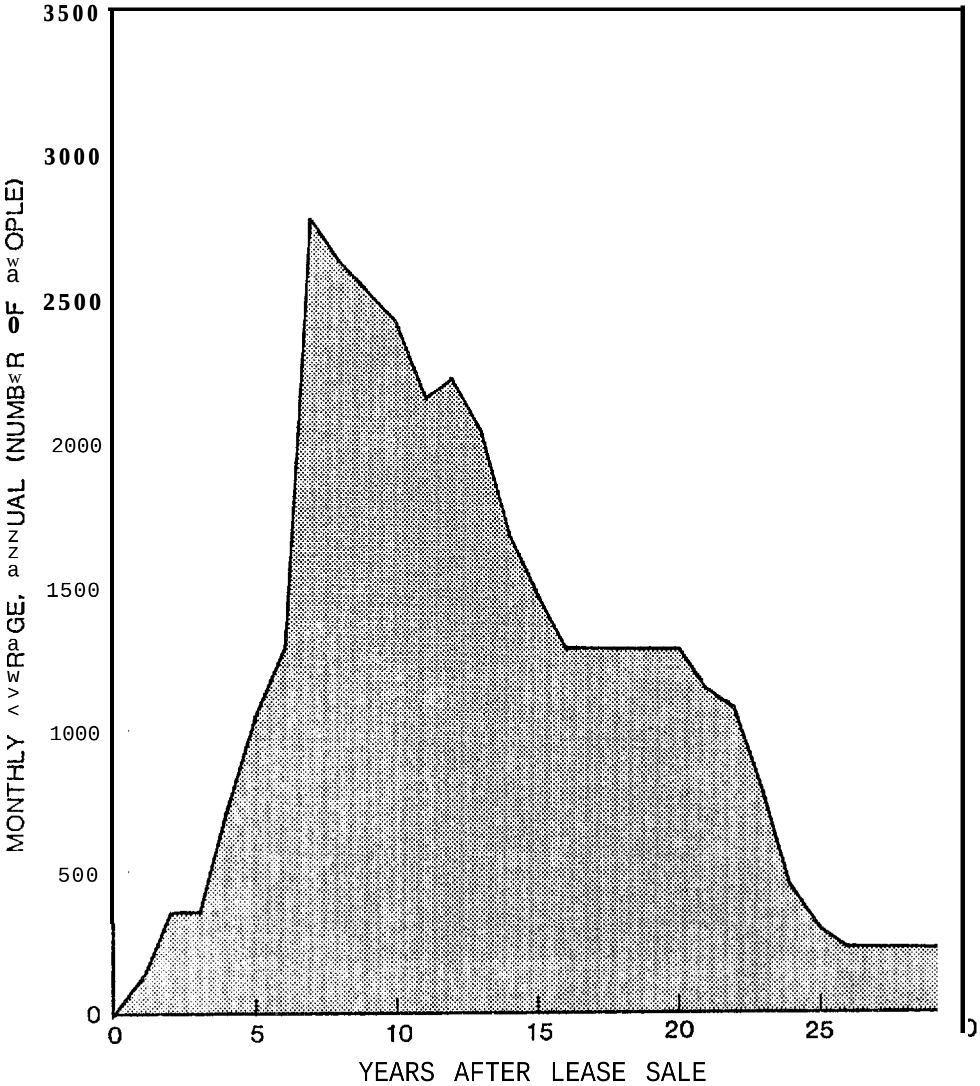
SUMMARY OF MANPOWER REQUIREMENTS FOR ALL INDUSTRIES - 5 PERCENT PROBABILITY RESOURCE LEVEL SCENARIO - GAS ONLY
ONSITE AND TOTAL

YEAR AFTER LEASE SALE	ONSITE (MAN-MONTHS)			TOTAL (MAN-MONTHS)			TOTAL LABOR FORCE (MONTHLY AVERAGE)		
	OFFSHORE	ONSHORE	TOTAL	OFFSHORE	ONSHORE	TOTAL	OFFSHORE	ONSHORE	TOTAL
1	1034.	160.	1194.	1862.	220.	2082.	156.	19.	174.
2	2118.	324.	2442.	3774.	444.	4218.	315.	37.	352.
3	2118.	8192.	10310.	3774.	9177.	12951.	315.	765.	1080.
4	7539.	12758.	20297.	13928.	14318.	28245.	1161.	1194.	2354.
5	11368.	7297.	18666.	21207.	8253.	29460.	1768.	688.	2455.
6	8916.	2120.	11036.	16764.	3087.	19851.	1397.	258.	1655.
7	6140.	1469.	7606.	11806.	2339.	14144.	984.	195.	1179.
8	3696.	1116.	4812.	7248.	1956.	9204.	604.	163.	767.
9	2688.	1008.	3096.	5232.	1848.	7080.	436.	154.	590.
10	2016.	936.	2952.	3888.	1776.	5664.	324.	148.	472.
11	2256 ,	1032.	3288.	4368.	1872.	6240.	364.	156.	520.
12	2496.	1128.	3624.	4848.	1968.	6816.	404.	164.	568.
13	2736.	1224.	3960.	532d .	2064.	7392.	444.	172.	616.
14	2736.	1224.	39611.	5328.	2064.	7392.	444.	172.	616.
15	2736.	1224.	3960.	5328.	2064.	7392.	444.	172.	616.
16	2736.	1224.	3960.	5328.	2064.	7392.	444.	172.	616.
17	2736.	1224.	3960.	5328.	2064.	7392.	444.	172.	616.
18	3240.	1278.	4518.	6300.	2148.	8448.	525.	179.	704.
19	3744.	1332.	5076.	7272.	2232.	9504.	606.	186.	792.
20	3744.	1332.	5076.	7272.	2232.	9504.	606.	186.	792.
21	3744.	1332.	5076.	7272.	2232.	9504.	605.	186.	792.
22	3000.	1182.	4182.	5820 .	2052.	7872.	485.	171.	656.
23	2256.	1032.	3288.	4368.	1872.	6240.	364.	156.	520.
24	2256.	1032.	3288.	4368.	1$72.	6240.	364.	156.	520.
25	2256.	1032.	3288.	4368.	1872.	6240.	364.	156.	520.
26	2256.	312.	2568.	4368.	43.?.	4800.	364.	36.	400.

TABLE 3

SUMMARY OF MANPOWER REQUIREMENTS FOR ALL INDUSTRIES - STATISTICAL MEAN RESOURCE LEVEL SCENARIO
ONSITE AND TOTAL

YEAR AFTER LEASE SALE	ONSITE (MAN-MONTHS)			TOTAL (MAN-MONTHS)			OTAL LABOR FORCE (MONTHLY AVERAGE)		
	OFFSHORE	ONSHORE	TOTAL	OFFSHORE	ONSHORE	TOTAL	OFFSHORE	ONSHORE	TOTAL
1	2093.	322.	2415.	3749.	442.	4191.	313.	37.	350.
2	2118.	324.	2442.	3774.	444.	4218.	315.	37.	352.
3	1059.	162.	1221.	1887.	222.	2109.	158.	19.	176.
4	0.	5628.	5628.	0.	6247.	6247.	0.	521.	521.
5	2625.	352.	2977.	4973.	387.	5360.	415.	33.	447.
6	5195.	634.	5828.	0045.	668.	10713.	837.	56.	893.
7	1848.	198.	2046.	3660.	228.	3888.	305.	19.	324.
8	2352.	252.	2604.	4632.	312.	4944.	386.	26.	412.
9	2352.	252.	2604.	4632.	312.	4944.	386.	26.	412.
10	2352.	252.	2604.	4632.	312.	4944.	386.	26.	412.
11	1568.	168.	1736.	3064.	228.	3292.	256.	19.	275.
12	1248.	204.	1452.	2424.	264.	2688.	202.	22.	224.
13	1248.	204.	1452.	2424.	264.	2688.	202.	22.	224.
14	1248.	204.	1452.	2424.	264.	2688.	202.	22.	224.
15	1248.	204.	1452.	2424.	264.	2688.	202.	22.	224.
16	1248.	204.	1452.	2424.	264.	2688.	202.	22.	224.
17	1248.	204.	1452.	2424.	264.	2688.	202.	22.	224.
18	1248.	204.	1452.	2424.	264.	2688.	202.	22.	224.
19	1128.	156.	1284.	2184.	216.	2400.	182.	18.	200.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.

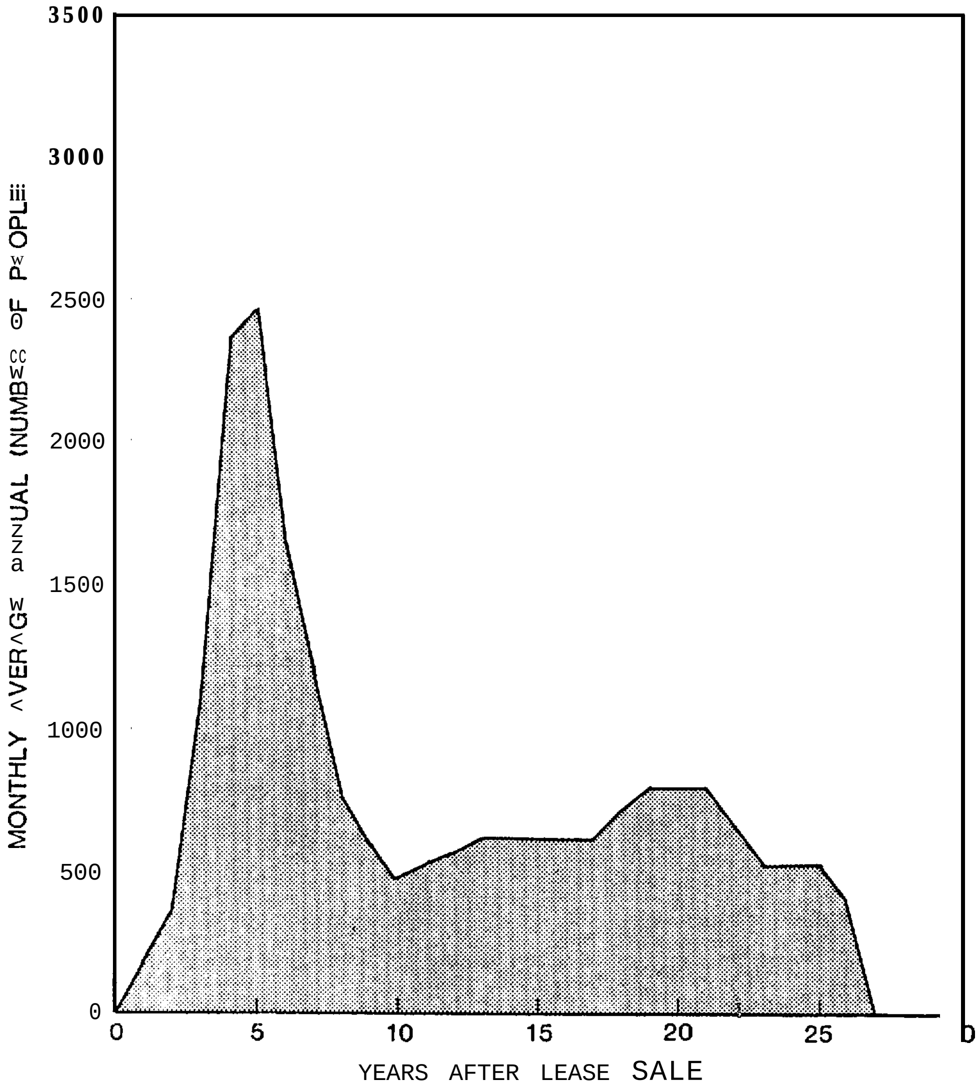


SOURCE: DAMES & MOORE

NOTE: ANNUAL PEAK LABOR FORCE REQUIREMENTS EXCEED THESE AVERAGES; REFER TO TABLES IN SECTION 9.0

FIGURE 8

MANPOWER REQUIREMENTS,
MONTHLY AVERAGE NUMBER OF PEOPLE PER YEAR,
KODIAK 5% OIL SCENARIO

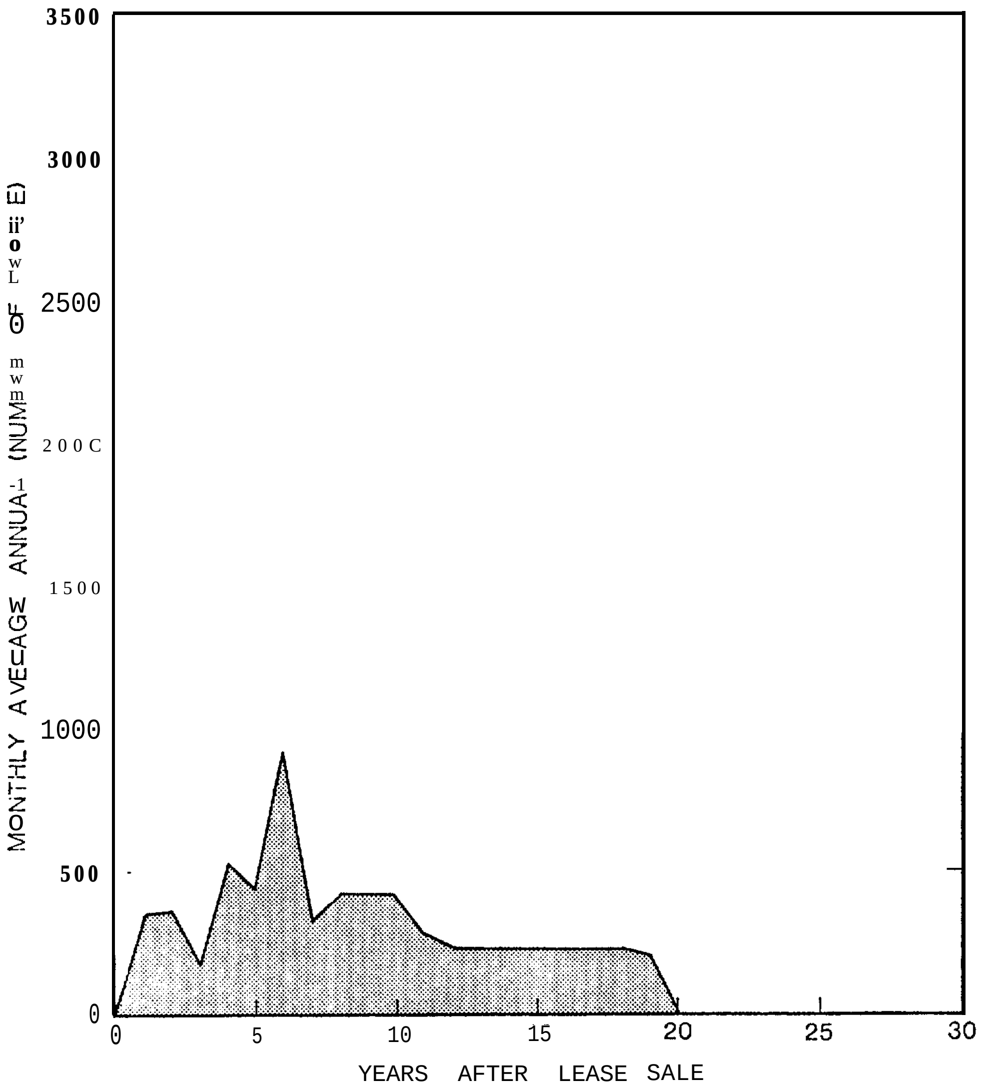


SOURCE: DAMES & MOORE

NOTE: ANNUAL PEAK LABOR FORCE REQUIREMENTS EXCEED THESE AVERAGES; REFER TO TABLES IN SECTION 9.0

FIGURE 9

MANPOWER REQUIREMENTS,
MONTHLY AVERAGE NUMBER OF PEOPLE PER YEAR,
KODIAK 5% GAS SCENARIO

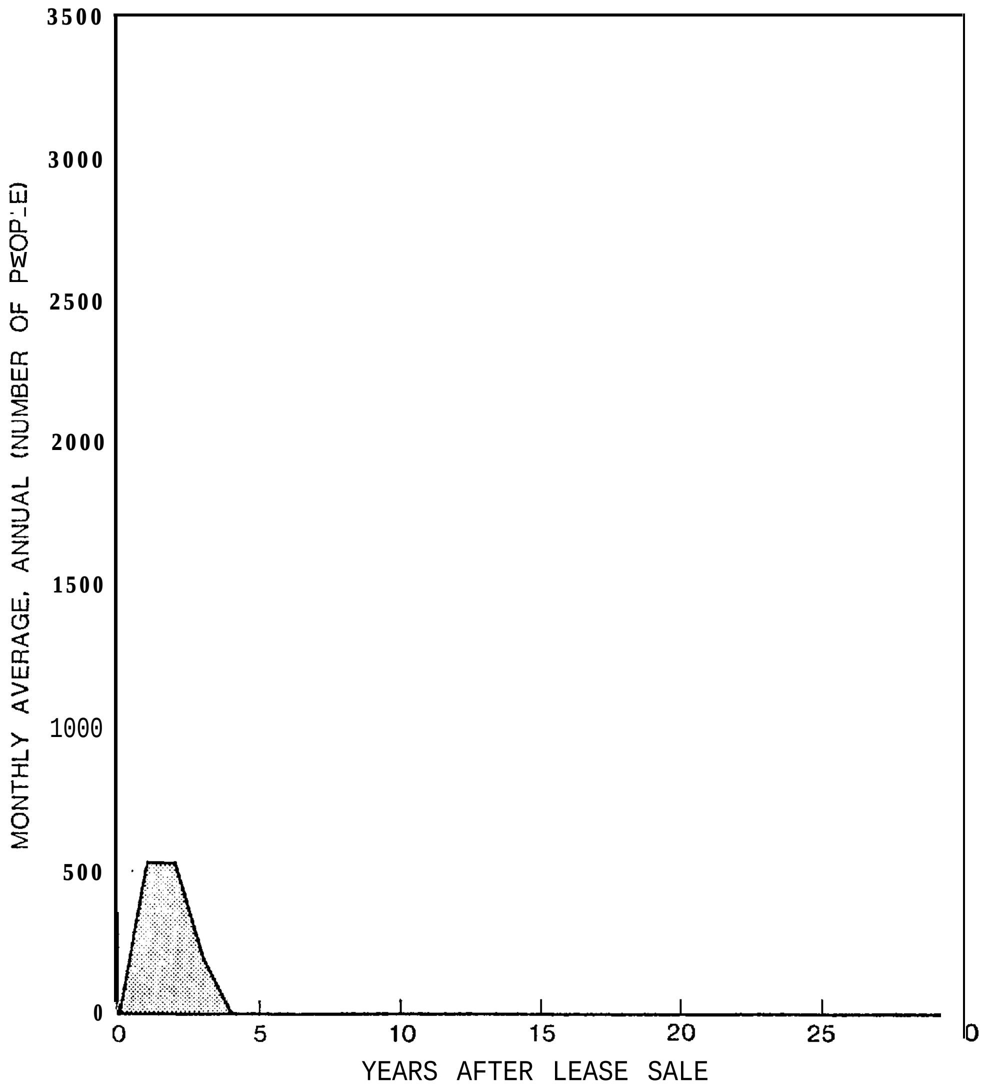


SOURCE: DAMES & MOORE

NOTE: ANNUAL PEAK LABOR FORCE REQUIREMENTS EXCEED THESE AVERAGES; REFER TO TABLES IN SECTION 9.0

FIGURE 10

MANPOWER REQUIREMENTS,
MONTHLY AVERAGE NUMBER OF PEOPLE PER YEAR,
KODIAK STATISTICAL MEAN SCENARIO



SOURCE: DAMES & MOORE

NOTE: ANNUAL PEAK LABOR FORCE REQUIREMENTS EXCEED THESE AVERAGES; REFER TO TABLES IN SECTION 9.0

FIGURE 11

MANPOWER REQUIREMENTS,
MONTHLY AVERAGE NUMBER OF PEOPLE PER YEAR,
KODIAK 95% SCENARIO
EXPLORATION ONLY

The statistical mean scenario generates a relatively small labor force because it involves few onshore facilities (the field development plan calls for a single platform and offshore loading, no shore terminal, and gas is not commercial). Maximum manpower demand created by this scenario occurs in year 6 when a total of 10,713 man-months of labor are consumed. The average monthly manpower requirement in year 6 is only 839 people. On-site labor consumption in year 6 is 5,828 man-months.

Resource Economics

The economic characteristics of several likely oil and gas production systems suitable for the harsh condition of the Gulf of Alaska are analyzed in this report with the model illustrated in Figure 2. The model is a standard discount cash flow algorithm designed to handle uncertainty among the variables and driven by the investment and revenue streams associated with a selected production technology.

This analysis focuses attention on (1) the engineering technology required to produce reserves in the Gulf of Alaska, and (2) the uncertainty of the interrelated values of the economic and engineering parameters. In view of the uncertainty, it is important to emphasize that there is no single-valued solution for any calculation reported in the analysis. Field development costs associated with the different production systems as well as oil and gas prices have been estimated as a range of values. Sensitivity and Monte Carlo procedures have been used to bracket rather than pin-point the decision criteria calculated with the model.

Two vital pieces of information are estimated in this analysis:

- The minimum economic field size to justify development of a known field with a selected technology in the Gulf of Alaska.

- The minimum required price to justify development of a field in the Gulf of Alaska.

Both are very sensitive to water depth, and to the value of money used to discount cash flows. At water depths of 30.5 meters (100 feet), 91 meters (3oO feet), and 183 meters (600 feet), the calculated minimum prices and field sizes are bracketed between 10 percent and 15 percent discount rates.

The essential findings of this report are summarized below. The single value calculations below are the mid-range values although upper and lower limits were also evaluated.

- No oil field smaller than 110 MMbbl at 10 percent value of money is economic in the Gulf of Alaska with any production system tested in 91 meters (300 feet) of water. At 15 percent value of money the minimum field size is 215 MMbbl. Fewer than one percent of oil fields discovered in the U.S. are larger than 100 MMbbl. Of 5,374 fields discovered in the U.S. since 1970, only nine exceeded either 50 MMbbl or 300 Bcf (Oil and Gas Journal, July 13, 1978, p. 33).'

- In 183 meters (600 feet) of water no oil production system with the price of oil at $12.00 is economic in the Gulf of Alaska no matter how large the discovered field -- under the assumptions of this analysis, including 2500 B/D initial well production rate -- if the operator requires a 15 percent return on his investment.

- An initial well productivity higher than 2500 B/D is required to earn the 15 percent hurdle rate in 183 meters (600 feet) of water in the Gulf of Alaska. Assuming 7500 B/D initial well productivity the minimum field size for development is 320 million barrels.

- The minimum sized gas field for development ranges between 0.5 and 0.65 Tcf in 91 meters (300 feet) of water at discount rates between 10 percent and 15 percent.

- In 183 meters (600 feet) of water the minimum size gas field for development ranges between 0.7 and 1.75 Tcf at discount rates between 10 percent and 15 percent.

- The economics of developing a single field favor a single steel platform with a pipeline to a shore terminal over offshore loading if the cost of the shore terminal is shared among producers of several fields in the Gulf of Alaska.

- Offshore loading systems without storage capacity are much less economic than either systems with storage or systems which will allow a pipeline to a shared shore terminal.

- The economic results are not very sensitive to the distance to shore that a pipeline must travel because its share of development cost is relatively small.

- Under the assumptions of the model, and assuming technical considerations related to reservoir thickness and depth not limiting, the decision to develop a field with two platforms requires a field with recoverable reserves greater than 500 MMbbl. The decision to add a third platform requires a field larger than 1.0 billion barrels. These field sizes represent those required to optimize the investment rather than the minimum field size for development. Smaller fields allow the minimum hurdle rate with two or three platforms. If technical considerations do not require the additional platform to reach the reservoir, the rate of return is higher with one or two instead of two or three platforms.

- If reservoir thickness or depth dictate development with two platforms of a field smaller than 500 MMbbl, the operator would have to be willing to accept a rate of return lower than 15 percent.

- The minimum required price in 1978 dollars to justify development of the most economic system identified in this report for fields smaller than 500 MMbbl -- the single steel platform with a pipeline to a shared shore terminal -- varies with field size, water depth and value of money.

	Water Depth			
	91 Meters (300 Ft.)		183 Meters (600 Ft.)	
Field Size	10%	15%	10%	15%
200 MMbbl	$10.00	$14.00	$15.00	>$20.00
350 MMbbl	$7.00	$10.00	$11.00	$16.00

- The minimum required price to justify development of a non-associated gas field varies with field size, water depth and value of money.

	Water Depth			
	91 Meters (300 Ft.)		183 Meters (600 Ft.)	
Field Size	10%	15%	10%	15%
1.0 Tcf/12 wells	$1.50	$2.10	$2.40	>$2.75
2.0 Tcf/16 wells	$0.75	$1.15	$1.70	$2.45

Technology

Review of current and imminent petroleum technologies indicates that the North Sea to some extent serves as a technology model although there are important environmental contrasts. While oceanographic and meteorologic conditions are similar in the North Sea and Gulf of Alaska (some what more severe storm conditions can be anticipated in the gulf), there are significant contrasts in geology which are particularly important with respect to the feasibility and design of fixed platforms and pipelines. The Gulf of Alaska lies in one of the most seismically active zones in the world and there are extensive areas of potential unstable bottom soils and soils with low bearing capacities. These factors pose design problems for both steel jacket and concrete gravity platforms, the principal types of platforms employed to data in the North Sea. Both platform types can be designed to withstand earthquake loadings but the application of concrete platforms is especially restricted by soil conditions. In the North Sea where seismic risk is minor, seismic loading is not required in platform design.

One of the advantages of the concrete platform has been its storage capability, which significantly improves the economics of offshore loading of crude. An offshore loading system is favored in situations where a pipeline to shore and marine terminal can not be economically justified -- generally where a field is distant from shore and isolated from other fields (with which it could possibly share pipelines and terminals). Offshore storage capability can also be provided by a permanently moored tanker (of uncertain feasibility in the Gulf of Alaska). Storage capability has also been incorporated in a number of proposed "hybrid" platform designs, such as the steel gravity platform, semi-submersible concrete (Condrill) platform and loading/mooring/storage (LMS) platform. Offshore storage may also be provided by steel and concrete storage/loading buoys separate from the drilling/production platform.

To develop marginal fields and fields in deeper water (other factors being equal, for a given field size the deeper the water the greater the field development costs using a fixed platform) a number of floating or compliant platform designs have been proposed. These designs have, in part, been necessitated by the fact that fixed steel or concrete platforms are reaching their limit of economic feasibility (under current economic conditions) at 183 meters (600 feet) water depth in storm-stressed environments such as the North Sea. In less severe operating environments fixed steel platforms have been installed in water depths greater than 183 meters (600 feet), e.g. Exxon's Hondo platform in 260 meters (848 feet) of water in the Santa Barbara channel and Shellts Cognac platform in 313 meters (1,025 feet) of water in the Gulf of Mexico. The floating and compliant platform designs include the guyed tower, articulated tower, tension leg platform and a variety of semi-submersible structures (including converted exploration rigs); the latter two designs are floating structures. Rather than resist environmental loading of waves etc. these platforms are designed to accommodate, to a lesser or greater extent, these forces. Floating and compliant structures require less materials (e.g. steel) to construct, and less offshore construction time. Floating systems involving subsea completed wells can reduce field development time and speed return on investment. For Gulf of Alaska fields, floating systems would also be favored in areas where soil conditions do not favor fixed platforms.

Undoubtedly, the trends in offshore petroleum development in the 1980's, as operations move into deeper waters and marginal fields need to be produced, will include increasing use of hybrid, compliant and floating platform designs and subsea completed wells. To improve the economics of those systems which do not produce into pipelines, offshore storage facilities will be required; probably semi-submersible or buoy structures. Steel jacket platforms and to a lesser extent concrete platforms will still have a major role, at least in waters of less than 183 to 305 meters (600 to 1,000 feet). The trend in design of these structures will (and has been) reduction of weight and material requirements such as steel.

In predicting the production technologies that may be used in Gulf of Alaska petroleum development in the 1980's, the review of petroleum technology has to consider the geography of the Gulf of Alaska, in particular two important considerations:

- The Gulf of Alaska is isolated from petroleum markets and transportation systems (pipelines etc.); most if not all petroleum production will be shipped to the lower 48 states;

- Most potential discovery sites (within the study area) are located less than 50 miles from shore; production through pipelines to shore, other factors being equal, is favored especially if a number of fields are sufficiently close together to share pipeline and shore terminal development costs.

In the selection of production systems for costing and economic screening, it is important to note that the available cost data base mainly pertains to conventional fixed platforms with pipeline-to-shore or offshore loading production systems, and there is little or no cost data on the various hybrid and floating/compliant platform systems summarized above. This has, in part, influenced the production systems selected for economic screening. The economic screening has identified those field sizes and locations where more cost effective technologies must be developed to develop such "marginal" fields.

The production systems selected for economic screening are systems currently used in the North Sea which, to various degrees, may have application in the Gulf of Alaska., These are:

- Floating production platform with maximum of 20 producing wells (subsea completions). Limited to 65 percent production due to no storage. Offshore loading with single point mooring. No water depth limitation.

- Single steel jacket platform, limited to 65 percent production due to no storage and inaccessibility of pipeline. Offshore loading with single point mooring. Water depths: 30.5 to 183 meters (100 to 600 feet).(1)

- Single steel jacket platform. Storage buoy allows full production equal to 96 percent of capacity. Water depths: 30.5 to 183 meters (100 to 600 feet).

- Single steel jacket platform. Pipeline to shore terminal shared with other producing fields allows full production equal to 96 percent of capacity. Water depths: 30.5 to 183 meters (100 to 600 feet).

---

(1) Water depth ranges specified are those screened in economic analysis of each system.

- Concrete platform. Storage allows full production equal to 96 percent of capacity. Offshore loading with single point mooring. Water depths: 91 to 183 meters (300 to 600 feet).

- Concrete platform as part of a multi-platform field. Pipeline to shore terminal allows full production equal to 96 percent of capacity. Water depths: 91 to 183 meters (300 to 600 feet).

- Multiple steel jacket platforms. Pipeline to shore terminal allows full production equal to 96 percent of capacity. Water depths: 30.5 to 183 meters (100 to 600 feet).

- Single or multiple steel platforms. Gas pipeline to shore, gas converted to LNG. Water depths: 30.5 to 183 meters (100 to 600 feet).

The systems specified above have all been used in the North Sea and are believed to be applicable (with suitable modification), to various degrees, for use in the Gulf of Alaska. While no steel jacket platform system producing direct to tankers in the North Sea to date has had sufficient storage capability to produce full-time at maximum rates (Shell's Brent field SPAR buoy with 300,000 bbl capacity comes closest to this), it has been assumed that offshore storage technology by the 1980's will provide sufficient storage capability in conjunction with production from a steel jacket platform to allow full-time or maximum production.

In the scenarios selected for detailed description, the production systems specified involve fixed platforms with some production to shore via pipeline and some oil production loaded directly to tankers offshore. The offshore loading systems include both platforms with and without storage capacity; for those with storage capacity a steel platform and adjacent storage buoy or concrete platform with internal storage have been indicated. There is insufficient data on bottom geology to properly assess problems relating to the feasibility of concrete platforms or similar gravity hybrids in the Gulf of Alaska except to identify active slump areas which obviously pose problems for fixed platforms, pipelines and subsea equipment. In terms of various industry viewpoints, concrete platforms have evolved from a cost effective alternative to steel platforms to a less favored and more expensive option. Nevertheless, concrete platforms or similar hybrids may have a role in Gulf of Alaska petroleum development and the scenario specifications reflect the same.

Petroleum Geology and Resource Estimates

The basis of the resource estimates used in this study for development of petroleum scenarios are the U.S. Geological Survey estimates of undiscovered oil and gas resources (Von Huene et al., 1976). These are:

	95 Percent Probability	5 Percent Probability	Statistical Mean
Oil (billions of barrels)	0	1.2	0.2
Gas (trillions of barrels)	0	3.5	0.7

By definition these resources are economically developable with current or imminently available technology (Miller et al., 1975). Allocation of the resources has been based upon an estimate that 80 percent will be located in the Albatross Basin and the remaining 20 percent in the Tugidak Basin.

There is no producing field analog or sufficient geologic data to establish with any certainty assumptions on reservoir and hydrocarbon characteristics of possible western Gulf of Alaska discoveries although some geologists have suggested that the Cook Inlet province may be an analog. However, a set of reservoir, hydrocarbon and production assumptions have been defined. These include:

- Average reservoir depth -- 2,286 meters (71,500 feet) oil; 3,810 meters (12,500 feet) gas.

- Recoverable reserves per acre -- 20,000 and 50,000 bbl.

- Wel 1 spacing -- variable, consistent with ranges in known producing fields.

- Individual well productivity -- oil - 2,500 barrels per day; gas - 25 million cubic feet per day.

- Gas resource -- scenarios were developed for oil production only (associated gas was assumed to be used as platform fuel and reinfected) and, at the direction of BLM staff, a scenario assuming only discoveries of non-associated gas since the possibility exists that the western Gulf of Alaska Tertiary Province may be gas prone.

- No gas-oil ratio assumed (see bullet above).

- No assumption was made on the physical properties of the oil.

REFERENCES

Miller, B. M., et al., 1975. Geological Estimates of Undiscovered Recoverable Oil and Gas Resources in the United States. U.S. Geological Survey, Circular 725, 78 p.

U.S. Department of Interior, 1977. Draft Environmental Impact Statement - Proposed Oil and Gas Lease Sale, Western Gulf of Alaska - Kodiak. Alaska OCS Office, Anchorage, Alaska. Two volumes.

Von Huene, R., et al., 1975. A Preliminary Summary of Petroleum Potential, Environmental Geology, and the Technology, Time Frame and Infrastructure for Exploration and Development of Western Gulf of Alaska. U.S. Geological Survey Open-File Report No. 75-536.