ALASKA NORTH SLOPE

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INTRODUCTION

The last American Frontier, Alaska, is for the most part a harsh and demanding wilderness - a land of extremes. There are places where winter temperatures reach a painfully cold -85°F and summer highs reaching a sweltering 95°F. For most of the year Alaska's North Slope (area between Brooks Range and Arctic Ocean) remains an icy desert, receiving less than six inches of moisture annually. Despite these extremes, Alaska's North Slope has an abundant amount of wildlife. The summer months bring the Caribou back to their traditional camping grounds. Today there is still room for the Caribou to graze peacefully in a largely unspoiled environment.

It is in this Arctic wilderness that Atlantic Richfield Company and Exxon first discovered Prudhoe Bay Field in 1968.

HISTORY

The U.S. Government, interested in the possibility of discovering oil, did some geological surveys of oil seeps found in the Brooks Range. In 1923, Warren Harding set aside 36,000 square miles of land north of the Brooks Range as the Naval Petroleum Reserve #4 (or NPR 4). Alaska gained military importance during World War II when Japan invaded the Aleutian Islands. Development started in 1944 and continued until 1953. Eighty wells were drilled during this time with only two drilled as deep as production at Prudhoe Bay. On June 1, 1977, NPR-4 was transferred from the Navy to the Department of Interior. The United States Geological Survey is responsible for exploration and the Bureau of Land Management is responsible for surface management. Husky Oil is NPR Alaskan Operator which drilled three development wells and six exploratory wells in 1978.

The oil industry began a rapid development in Alaska after Richfield's oil hit in the Kenai Peninsula in 1957. Sinclair Oil and Gas moved the first geophysical crew to the North Slope in 1961. The first well, Gubik Unit No. 1 was spudded on July 13, 1963, but was unsuccessful. At least ten dry holes were drilled before oil was discovered. In 1966, ARCO drilled the Susie Unit No. 1, a dry hole to the depth of 13,500 ft at a cost of $4.5 million. In April, ARCO moved 60 miles north to drill Prudhoe Bay State No. 1, on acreage leased by ARCO, the operator, and Exxon. In February of 1968, they hit oil at a depth of 8,800 feet at a cost of $4.9 million. Before completion of the discovery well, another rig was moved to a location seven miles southeast and began drilling the Sag River State No. 1. The Sag River well confirmed a major discovery which has been described as the largest in North America.

The Prudhoe Bay field stretches about 45 miles east-west and as much as 20 miles north-south. The field consists of three different oil reservoirs at depths between 5,500 and 10,000 feet. These accumulations have been designated by the Alaska Oil and Gas Conservation Committee as the Kuparuk River oil pool, Prudhoe oil pool, and Lisburne oil pool. The Kuparuk is located in the western portion of the field and is the shallowest of the three reservoirs. The Lisburne, in the eastern portion of the field, is

the deepest known accumulation.

The Prudhoe oil pool is located in the central portion of the field and is the largest of the three reservoirs. Recoverable reserves from the Prudhoe oil pool are estimated at 9.6 billion barrels of oil and 26 trillion cubic feet of gas. To satisfy crude oil demands of the United States, the current activity in Prudhoe Bay is directed toward development of this reservoir.

Unitization was completed on April 1, 1977, with SOHIO operating the Western Area and ARCO operating the Eastern Area. (Fig. 1)

FIELD DEVELOPMENT

By the end of June 1977, 104 wells were available for production; of these, 68 wells had been placed in production by the end of the year. Of the 104 wells, 48 were in the Western Area (SOHIO) and 56 were in the Eastern Area (ARCO). Initially, 720 MBPD was all Trans-Alaska Pipeline Systems (TAPS) could handle due to an accident at Pump Station 8. By April 1978, with Pump Station 8 repaired, production increased to 1.16 MMBPD. TAPS achieved the current rate of 1.5 MMBPD during November 1979.

Current gas production is approximately 1.7 MMMSCFPD plus condensate. Since the initial commissioning of facilities, 99.3% of all gas produced has either been injected into the reservoir or used as fuel.

Water production associated with the oil production has been relatively low. Water will gradually increase through 1987, when a rate of 1.0 MMBPD will be reached. This is assuming sea water injection commences in 1984. (Fig. 2)

RESERVOIR SURVEILLANCE

Reservoir behavior is being monitored with the following types of measurements in producing wells: periodic tests of oil, gas, and water flow rates; reservoir pressure; gas-oil contact movement; water-oil contact movement; and flow meter surveys.

The periodic flow tests are used to compute daily volumes of fluids from each well and to generate reliable well production histories.

Pressure data, measured or extrapolated from build-up surveys, will be used to monitor the depletion of sizeable portions of the reservoir. The surveys will also be of value in the determination of formation transmissibility and possible shale configurations.

Neutron logs, run in both the open hole and in the casing, have been useful in gauging changes in gas saturation. It has been found that small gas saturations, on the order of 6%, are detectable.

The pulsed neutron tools are presently being used to monitor the changes in water saturation. The distinction between oil and water is less sharply defined than in the case of neutron logs distinguishing between gas and oil.

Flow meter surveys provide a useful indication of the flow contributed from various producing intervals within a well.

The distribution of bottom-hole surveys obtained from June 1977 to April 1980 is:

Reservoir Pressure	898
Flowmeter	407
Gas Oil Contact Movement	285
Water Oil Contact Movement	110
Total Surveys	1,700

PRODUCTION FACILITIES

At start-up, ARCO initially had two flow stations commissioned, with three drillsites connected to each station. SOHIO had two gathering centers receiving production, with four drill pads connected to each center. The flow stations and gathering centers each separate oil, water and gas. Oil is shipped to TAPS at Pump Station No. 1. (Figs. 3 and 4). Gas is delivered to the Central Compressor Plant (CCP) at 600 psi. CCP then compresses the gas in two stages from 600 psi to 4500 psi and injects the gas into the Sadlerochit formation gas cap. Eighteen injection wells have been drilled to sustain a 1.6 MMMSCFD gas injection rate. Water is presently being injected into the Tertiary and Cretaceous sands. The Central Power station, operated by SOHIO, has a current "firm" capacity of 104 megawatts with an ultimate "firm" capacity of 124 megawatts.

Since start-up, wells and facilities have been added to provide for an average oil off-take of 1.5 million barrels per day. To sustain this higher rate, two additional separation centers were built. Gathering Center No. 3 became operational in April 1978, and Flow Station No. 3 came on stream in March 1979. The two additional separation centers process oil and gas from seven additional drill pads. As of January 1, 1981, there were 275 wells available for production.

FUTURE DEVELOPMENT SYSTEMS

Through 1982, field production will be sustained by development drilling. In the main field area, a total of 540 wells will be drilled on 160 acres spacing. (Fig. 5) Beginning in 1982, low pressure separation (LPS) will permit the reduction of wellhead pressure from 600 psig to approximately 150 psig. This will allow increases of oil production by higher reservoir drawdown and production from low GOR wells. Additional compressors will be installed at each separation center to compress the low pressure gas to 600 psig, which is the Central Compressor Plant's minimum suction pressure requirement.

With decreasing field pressure and increasing water production, gas lift methods will be utilized to maintain field production. Gas used for lift will be compressed to 2100 psig and cooled to 150°F. The ultimate artificial lift program should be complete by 1987.

Produced Water Injection pumps are scheduled to start coming online in mid 1981 and completed in 1987. It is estimated that the Unit will be producing 1,000 MBWPD by 1988.

Seawater Injection Plant is scheduled for startup in 1984 with an injection rate of 2.0 MMBPD of water. Water will be taken from the Beaufort Sea, treated by filtration and deaeration equipment, heated, and then pumped to two field injection plants, where its pressure will be boosted to 3200 psig. From the injection plant, the water will be distributed via manifolds and pipelines to the drillsites and the well pads. The ARCO's injection plant will house three 400 MBPD pumps and SOHIO's injection plant will initially house two pumps.

CONSTRUCTION OF FACILITIES

The oil processing and support facilities are enclosed in interlocking sections

called modules. Joined together like pieces of a giant erector set, they are insulated by steel encased walls against the icy wind blasts from the north. An example of the sophisticated complex is the Central Compressor Plant which is composed of 41 separate module units. Some modules stand as high as nine story buildings and weigh up to 1,900 tons.

Fabrication sites are in Texas, California, Oregon, and Washington. The 1975 sea-lift was the largest with 44 barges. Nineteen barge trips were aborted due to bad weather. The barges were turned south to offload their cargo for overland transportation north. Over 60,000 tons (3,500 truck loads) of cargo were diverted from the barges to travel overland to Prudhoe Bay.

The modules are moved into place by the use of specially designed crawlers. The modules are then set on piles that rise eight feet off the ground, allowing air to circulate beneath them, eliminating heat transfer to the ground and minimizing snow drifts.

ENVIRONMENT

After the discovery of oil at Prudhoe Bay, ARCO retained Angus Gavin, naturalist, to conduct detailed investigation of the wildlife populations of the North Slope. In surveys that have been conducted, no apparent effects on the wildlife have been noted with the influx of people. Populations of waterfowl have stayed remarkably stable. Fluctuation in population of foxes, snowy owls, weasels, and to some degree wolves, are governed by the population of lemmings (rodents) which fluctuates dramatically every few years. Every aspect of the North Slope development requires an ongoing environmental review for approvals from Corps of Engineers and various State agencies.

SUMMARY

One of the most important outcomes of the development of Prudhoe Bay was the confrontation between wilderness preservation and resource development. No longer can we afford to rush into a place to develop it without giving any thought to what we are doing to its environment. On the other hand, we as a resource-thirsty nation, cannot afford to set aside land rich in natural resources. A way must be found in which we can develop the land without destroying its inherent beauty and wildness. The Prudhow Field and the TAPS pipeline have been an expensive yet successful project showing how man and his technology can co-exist with nature in her primitive state.

REFERENCES

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Conservation Hearing Testimony for Alaska Oil and Gas Conservation Commission, Anchorage, Alaska, May 7-8, 1980.

ARCO Alaska, Inc. and Exxon Company, USA, "Welcome to Prudhoe Bay", Anchorage, Alaska

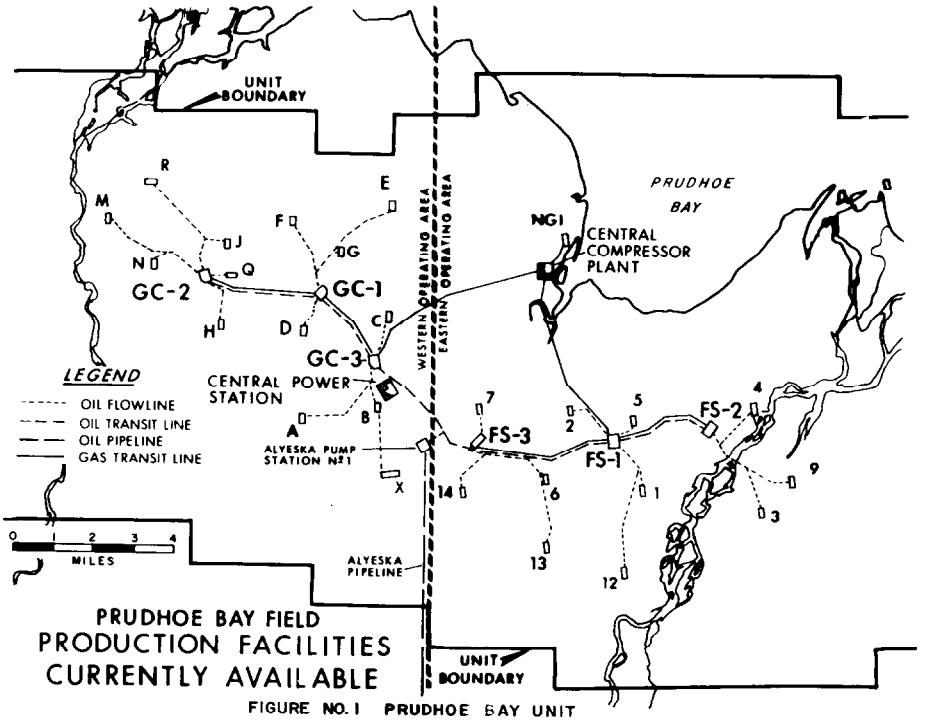

FIGURE NO. 1 PRUDHOE BAY UNIT

PRUDHOE BAY FIELD
PREDICTED PRODUCTION PERFORMANCE

SEA WATER INJECTION COMMENCING 1984
GAS SALES COMMENCING LATE 1985

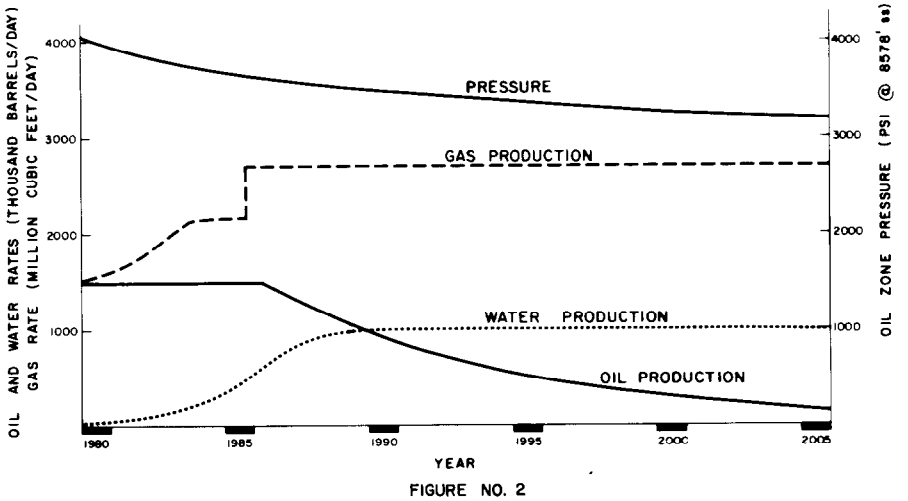

FIGURE NO. 2

PRUDHOE BAY UNIT
WESTERN OPERATING AREA

INITIAL INDIVIDUAL FLOWLINE PRODUCING SYSTEM

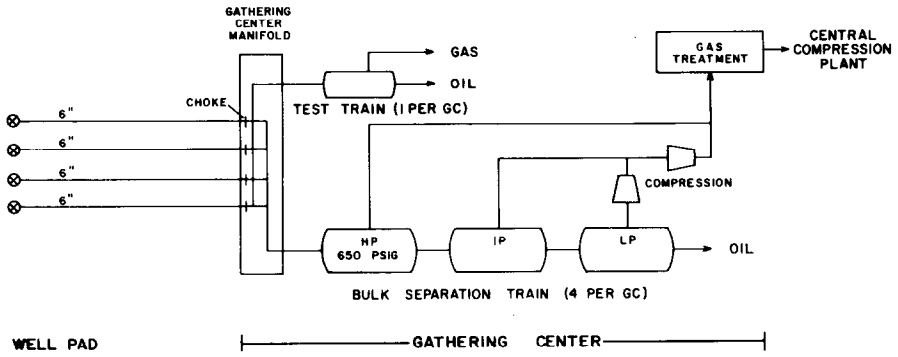

FIGURE NO. 3

PRUDHOE BAY UNIT
EASTERN OPERATING AREA

COMMON FLOWLINE PRODUCING SYSTEM

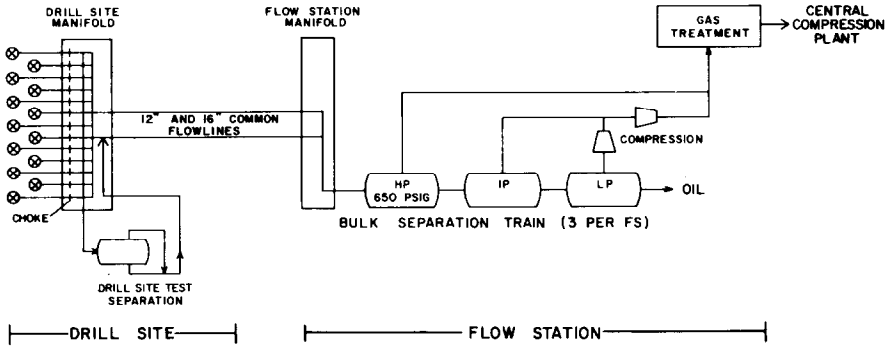

FIGURE NO. 4

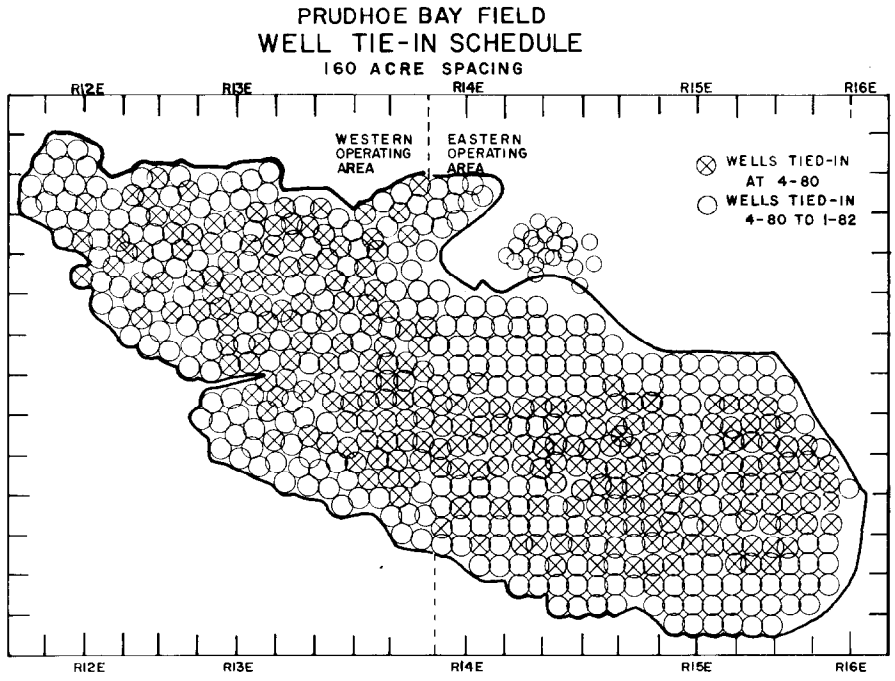

FIGURE NO. 5