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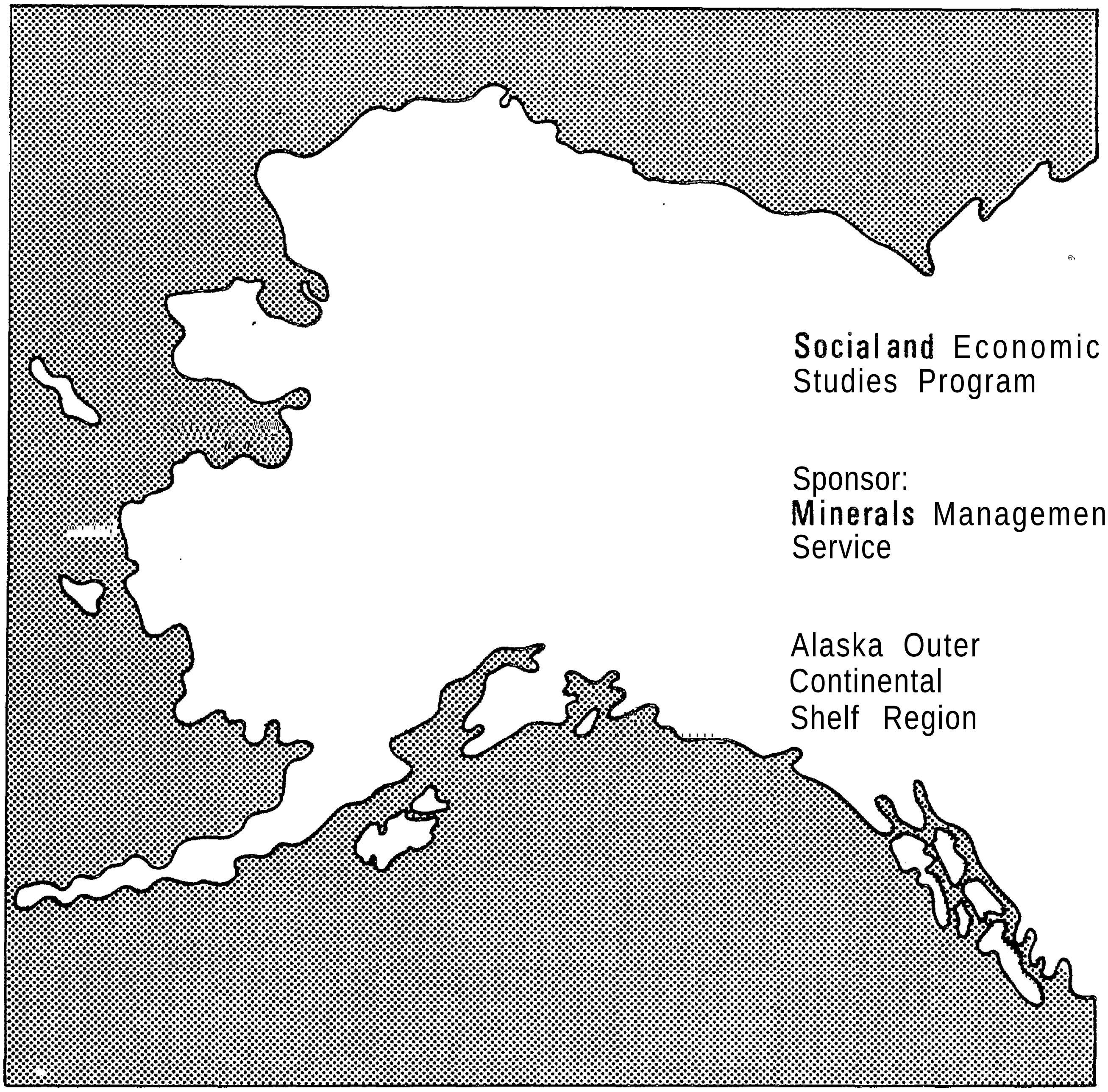

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Alaska Outer
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Shelf Region

Barrow Arch Transportation Systems Impact Analysis

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SOCIAL AND ECONOMIC STUDIES PROGRAM
ALASKA OCS REGION

BARROW ARCH TRANSPORTATION SYSTEMS IMPACT ANALYSIS

Prepared for

MINERALS MANAGEMENT SERVICE
ALASKA OUTER CONTINENTAL SHELF REGION
Anchorage, Alaska

Prepared By

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NOTICE

Social and Economic Studies Program
Alaska OCS Region

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ABSTRACT

"BARROW ARCH TRANSPORTATION SYSTEMS ANALYSIS"

This report, prepared for the Minerals Management Service (MMS), evaluates future effects on regional air, marine, highway, rail, and pipeline transportation systems from petroleum development in an offshore location known as the Barrow Arch Planning Area. The principal assessment technique is a comparative analysis of future conditions without and with the proposed development. Future conditions without the development mostly represent an extrapolation of current trends and conditions, while future conditions with the development are driven by an industrial development scenario prepared by MMS. The analysis looked at transportation services to the nearby North Slope Inupiat Eskimo coastal villages of Point Lay, Point Hope, Wainwright, and Barrow; the more southerly coastal communities of Kivilina and Kotzebue, and the petroleum industry enclave at Prudhoe Bay/Deadhorse. Certain indirect effects of Barrow Arch development were also evaluated at the Fairbanks and Anchorage International Airports and at the ports of Anchorage, Whittier, and Valdez.

The Barrow Arch Planning Area is located in the Chukchi Sea between the offshore federal-state boundary and the Russia Convention Line of 1867, generally between latitudes 68 17' N. and 73 N. The environment is arctic with fog in summer, very cold winds in winter, and precipitation

on 200 to 300 days a year. From early December to May, 98 to 99 percent of the Chukchi Sea is covered with moving pack ice. The open water season averages about 90 days from early July to late September.

Major economic activities currently include the North Slope Borough government, the Borough's capital improvements program, tourism, and continuing petroleum development on the North Slope and in offshore waters of the Beaufort Sea. Generally, these activities are expected to continue with increased intensity in petroleum development and reduced intensity in the capital improvements program. Following current trends, total employment on the North Slope is expected to peak between 1992 and 1994 at a level almost 63 percent greater than in 1983. The addition of Barrow Arch employment, which is expected to peak in 1994, raises total North Slope employment that year by an additional 18.7 percent, a rise of almost 89 percent when compared to 1983 levels.

The marine and aviation systems in this region are most important, respectively, for the movement of goods and people. However, the infrastructure for both modes is not well developed and maintenance is a problem due to the climate and remoteness. Except for Kotzebue, none of the other coastal communities have any port facilities. All marine cargo is shipped on ocean going barges during the open water summer season and delivered over the beach by lighterage vessels. This extra handling greatly raises the cost of marine transportation to local people. By the mid 1990's, marine activity is expected to increase 122 percent without the Barrow Arch development. Virtually this entire change is attributable to the increased demands of the petroleum industry working onshore and offshore in lease areas already sold. The addition of Barrow Arch development increases marine activities by a factor of 15 due to localized barge, tug, and supply boat tripmaking.

The aviation facilities in this region are slightly more developed with each community having a gravel airstrip, except at Kotzebue and Barrow where the main runways are paved. The smaller communities' runways tend to be relatively short and poorly maintained limiting air cargo service. The exception is Wainwright, at which the North Slope Borough recently constructed a new longer runway. Scheduled passenger and freight service is available in all communities, although the general quality is less than comparable services in the Lower 48. Aviation activity along the west coast of the North Slope Borough is expected to increase 32 percent by the mid 1990's and double by 2010, without Barrow Arch development. This increase is due entirely to population changes in the coastal villages. During the peak industrial period of the mid 1990's, BarrowArch development increases aviation activity an additional 15 percent.

One alternative suggested for moving recovered resources to market is a pipeline with parallel service road linking the BarrowArch resources to the Trans-Alaska Pipeline System (TAPS). Since no improvements are assumed for TAPS, this alternative would be constrained by the capacity of TAPS and its supporting marine transportation system operating between Valdez and west coast ports. The pipeline portion of this system between TAPS and the Barrow Arch area, however, could improve the economics of petroleum development in the National Petroleum Reserve - Alaska (NPR-A). The adjacent service road, if further developed, would improve surface access to areas now accessible only by air in winter. However, such improved access is viewed as a threat to Inupiat cultural values. Another resource movement alternative is the use of ice breaking tankers shuttling between the Barrow Arch area and an Aleutian transshipment port. This alternative would further increase marine traffic levels in the Bering Sea and could have great environmental impact, particularly during winter ice conditions. The' tanker alternative would also provide no improvement to the current infrastructure or service delivery problems in the Barrow Arch area.

Highway and rail transportation are also likely to be effected by the Barrow Arch sale. Presently, the Dalton Highway in combination with the Alaska Highway provides a direct route from the Lower 48 to the North Slope; while the Dalton Highway in combination with the Parks Highway provides a link to the Ports at Anchorage and Whittier. "Dalton Highway truck traffic is expected to increase by a factor of 2.5 by 1992 based on activities associated with existing leases. Barrow Arch development causes an additional increase of about three percent during the mid 1990's peak. Along the Alaska and Parks highways trucks bound for the North Slope presently constitute about four percent and nine percent of average daily traffic, respectively. During the peak years of Barrow Arch development., this truck traffic increases to 10 percent and 22 percent, respectively, assuming no growth in the other components of daily traffic..

The Alaska Railroad provides an alternative link between Fairbanks and the ports at Anchorage and Whittier. Based on increasing demands from existing leases, rail usage by the petroleum industry may increase from about two percent of all rail traffic to about five percent in the mid 1990's. With the addition of Barrow Arch development, rail demands are expected to increase an additional three to four percent. Since the railroad is underutilized, and is generally expected to remain so, these small increases do not impact available capacity.

I

INTRODUCTION

This report was prepared for the Minerals Management Service (MMS), Alaska Outer Continental Shelf (OCS) Region, to determine potential transportation impacts from OCS development in an offshore location designated as the Barrow Arch Planning Area. The report evaluates the effects of prospective OCS development on existing transportation systems, extensions to existing systems, and new transportation systems that may be constructed to serve OCS activities. This study of transportation impacts is one of several elements of a larger integrated effort to evaluate the broad range of likely environmental, social, and economic impacts of this lease offering. In turn, the series of Barrow Arch studies are part of MMS Alaska OCS Region's Social and Economic Studies Program (SESP), which seeks to evaluate likely effects of each proposed federal OCS lease sale in all Alaska offshore planning areas.

The original focus of this report was on events expected from Lease Sale 85, the first lease sale in the planning area. However, the sale was cancelled in March 1984. As a result, the first lease sale scheduled for the Barrow Arch Planning Area will be Sale 109 scheduled for February 1987. Except for the timing of Barrow Arch development events (see Chapter V), and the effect this change has on portions of the impacts analysis, the information contained in this report is equally applicable to Sale 109.

Study Scope and Organization

In land areas adjacent to the Barrow Arch Planning Area, as in many local areas of western and arctic Alaska, air transportation is the primary mode for moving people and marine transportation is the primary mode for moving goods. Consequently, a major portion of this study is devoted to determining the potential influence of Barrow Arch OCS development on air and marine transportation services in the adjacent region.

An extensive logistical supply system utilizing both normally available and special transportation services is needed to sustain OCS development activities. This supply system may extend far beyond the lease offering area and the adjacent onshore region affecting various inter- and intrastate transportation systems. These systems may include air, water, highway, and rail transportation systems throughout Alaska, as well as linkages to Canada and the Lower 48 states. Therefore, the secondary focus of this study is on determining the affects of Barrow Arch OCS development on the interstate and intrastate transportation systems linked to the Barrow Arch Planning Area.

In addition to the logistical support system, a means must be found for transporting the recoverable oil and gas resources. Typically, this would entail development of a new marine tanker system or overland pipeline system. Despite, the climatic and environmental conditions in this area of Alaska, either alternative may be utilized. Thus, another emphasis of this study is the identification and assessment of alternative oil and gas transportation systems.

The evaluation is presented in four sections, as described below. Each section constitutes a chapter in this report.

- "Chapter II outlines general background information% pertaining to: environmental constraints of the Barrow Arch Planning Area; the general nature of OCS transportation requirements; and a description of the study area boundary. By defining the study area and general OCS transportation requirements, the geographical and system related limits to this study are established.

- Chapter III presents a description of the aviation and marine transportation systems currently serving communities adjacent to the Barrow Arch Planning Area, as well as the highway, railroad and pipeline systems serving this region. This baseline describes available services and facilities, evaluates historic travel demand trends, and presents an analysis of capacity limitations of the facilities and services. Included also is information about service costs, regulatory controls, quality of service, current regional issues affecting each system, and contemporary trends in related technologies that may affect future development of the various systems.

- Chapter IV presents a forecast of future demands and service requirements for applicable transportation systems elements, based on the assumption the lease sale is not held. This forecast, labeled the "Base Case", extrapolates existing trends and conditions without considering expected events following the proposed lease sale. The economic and population forecasts, together with the transportation demand forecast, provides a comparative base for evaluating a subsequent forecast that includes the relevant OCS events (See Chapter V discussion below). The Base Case is evaluated for its affects on existing facility and service capacity restraints. Any mitigating affects of planned improvements are also identified.

- Chapter V presents a forecast of future demands and service requirements assuming the lease sale is held and that a particular scenario of OCS related events follows the sale.

This forecast is labeled the "OCS Case". The scenario is provided by MMS partly based upon an earlier assessment of petroleum technology (see Dames & Moore, et al., 1982a), and information developed by the government's geologist, engineers, and planners. Revised economic and population forecasts, which reflect the addition of OCS events and, therefore, new economic activity, serve as the basis for a new transportation demand forecast. Information similar to that developed for the Base Case is prepared for each element of affected transportation systems. The analysis focuses on the incremental difference between the Base Case and OCS Case forecast - the difference is presumed to be the affect of the lease offering.

Study Limitations

This document attempts to address the information needs of the federal environmental impact statement (EIS), within the narrow framework of transportation systems. The EIS must be prepared by MMS prior to conducting the planned lease sale. MMS decision makers are expected to also use the report throughout the federal OCS leasing process. In addition, certain information needs of local and state level organizations are served by this report. However, several important limitations placed on this study reduce the broader usefulness of this report.

The development of a “transportation plan” to deal with OCS transportation issues was not a purpose of the study, nor was the study to investigate measures to ameliorate potentially negative affects. These limitations were imposed by MMS because many other factors beyond those identified herein will enter the federal decision-making process. The State, as well as local governments and other agencies, groups and individuals, must be provided the opportunity to make independent assessments of alternatives and mitigating factors in the context of their mandated responsibilities. Within the federal OCS managements process, the opportunity to present plans and suggest mitigating measures exists through the mechanism of the EIS. By making this report available, it is hoped the information will be useful to these various entities as they plan for the proposed lease offering and respond to the federal government's decisions.

II

IDENTIFICATION OF AFFECTED TRANSPORTATION SYSTEMS

This chapter explores the linkage between OCS transportation demands, OCS technology, and the harsh arctic environment of the Barrow Arch Planning Area. Its primary purpose is to provide an understanding about why certain portions of transportation systems were included and why others were excluded from this report. A secondary purpose is to provide background information pertaining to: Barrow Arch environmental constraints; ongoing oil and gas development in close proximity to the Barrow Arch area; and transportation demands of OCS development, generally. The chapter concludes with the identification of a study area, the definition of which is provided in terms of prominent transportation features.

Environmental Characteristics

There are several environmental characteristics of the Barrow Arch Planning Area which constrain human activities. These constraints also limit the operation of existing transportation systems and can be expected to greatly influence the technology employed by the petroleum industry as they explore and develop the area. The majority of these constraints are climatic, as described below. Most of the material presented herein is drawn from a study of Chukchi Sea petroleum technology (Dames & Moore, et al., 1982a) and from the U.S. Coast Pilot (U.S. Dept. of Comm., NOAA, 1983).

The Barrow Arch Lease Sale will be the first lease sale in what the MMS has identified as the Barrow Arch Planning Area. The general location of the Barrow Arch Planning Area is in the northeast Chukchi Sea, as shown in Figure 1. The area is bounded on the south by a line beginning at the 3-geographical-mile limit of Alaska waters westward of Point Hope running westward to the United States - Russia Convention Line of 1867. The western boundary follows the Convention Line to the Planning Area northern boundary at latitude 73° N. The eastern boundary follows the 162° W meridian running south to latitude 71° N where the boundary turns eastward until it again reaches the 3-mile limit of Alaska waters. The remainder of the planning area boundary is the Federal/State 3-Geographical-Mile Line extending along the coast from latitude 71° N to latitude 68° 17' N.

METEOROLOGY

The National Weather Service classifies the climate of Alaska's northern and northwestern coast as arctic. Cool marine winds characterize summer weather with frequent but light precipitation and considerable cloudiness and fog. In winter the cloudiness decreases and very cold

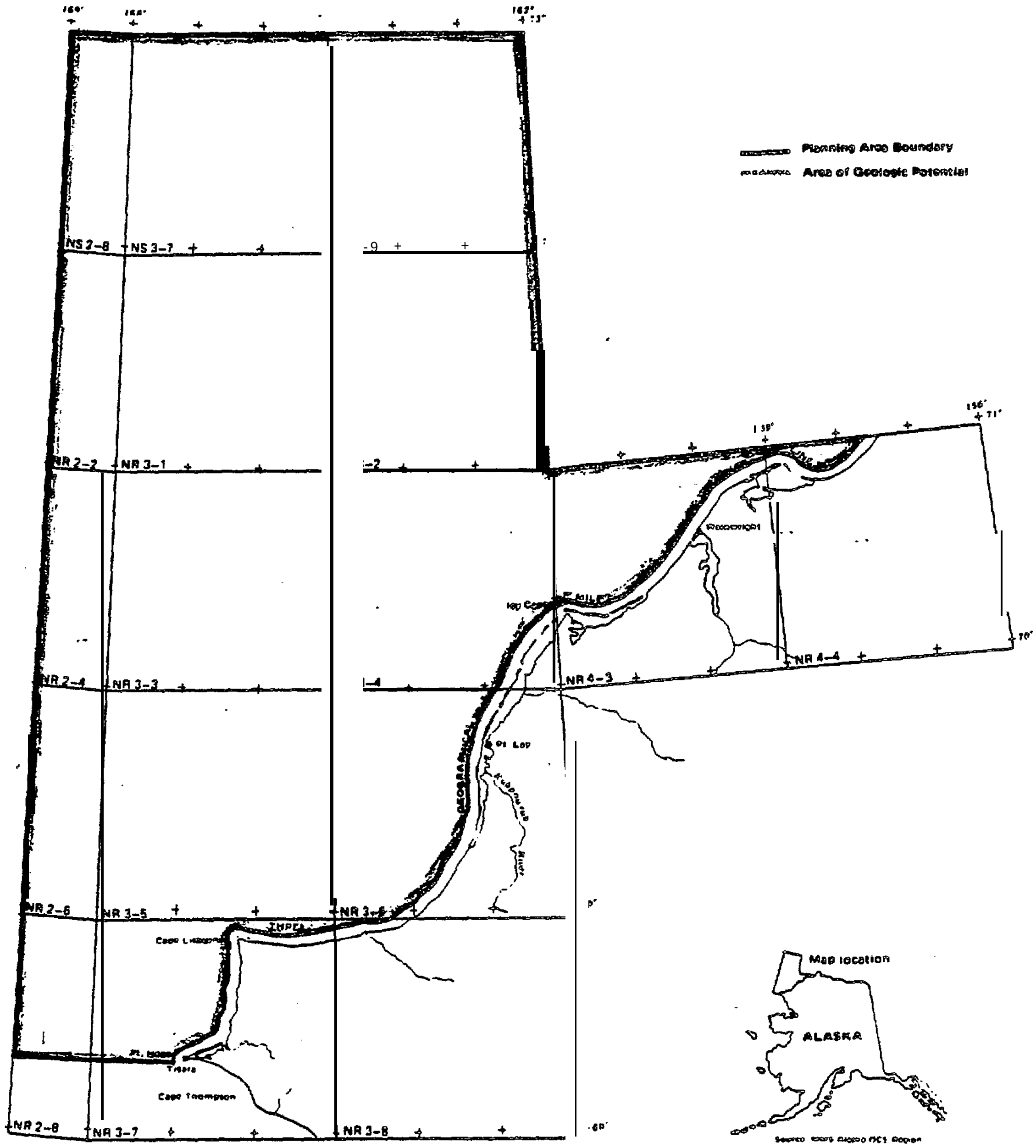


FIGURE 1

BARROW ARCH PLANNING AREA

SOURCE: U.S. Department of the Interior,
Minerals Management Service, 1983b.

winds prevail. A light snow cover is established by mid-September and persists until June or July. Below freezing air temperatures are the rule except in June, July, August, and early September.

The U.S. Coast Pilot for the Arctic Ocean area (U.S. Dept.. of Comm., NOAA, 1983) provides a general description of the region's weather. Winters are cold and summers cool. In November, average daily maximums drop to around -10° C (14° F) or below, while average minimums are around -18° C (0° F).. February is generally the coldest month. Average maximums range from just above -17° C (1° F') at Kotzebue to -25° C (-13° F) east of Cape Lisburne. Low temperatures in the -30° C (-22° F) range are common. Extremes of -45° C (-49° F) or colder have been recorded.

Some form of measurable precipitation falls on. about 200 to 300 days per year. Annual precipitation over most of the arctic coastal region is very light, ranging from 10 to 40 cm (4 to 16 in) annually in the northern Chukchi Sea. The heaviest precipitation occurs in July, August, and September, averaging 5 to 10 cm (2 to 4 in) each month. Snow can appear in any month and usually predominates beginning in September. Annual snowfall can range from 30 to 150 cm (12 to 59 in) depending' upon location and elevation.

Other types of precipitation experienced include rime or granular ice, which occurs over most arctic coastal regions throughout the year, and hoarfrost, which occurs in winter. Although the relative humidity is generally high with values ranging from 60 to 90 percent throughout the year, the absolute humidity is very low.

Over the open waters of the Chukchi Sea average windspeeds range from 14 to 18 knots and gales blow about 2 percent of the time. High winds may occur any time of the year with winds reaching 28 knots up to 5 percent of the time. It has been estimated that the 100-year wind speed may exceed 179 km/h (111 mi/h). Sustained winds of 93 to 105 km/h (58 to 65 mi/h) have been recorded with gusts going much higher (Dames & Moore, et ale, 1982a). Maximum velocities typically occur in the coldest months. Normal wind conditions are fairly constant along the arctic coast year-round (U.S. Dept of Comm, NOAA, 1983). Exposed Locations may be subject to winds with a yearly average of 24 to 3.2 km/h (15 to 20 mi/h). Other locations experience winds averaging 18 to 21 km/h (11 to 13 mi/h).

Fog is the major restriction to visibility, although blowing snow (which may appear in any month) can pose an equally serious obstruction. Along the coast dense fog is likely to occur on 30 to 100 days each year. Offshore and inland areas are much less prone to fog. Advection or sea fog is the primary restriction to visibility during the warmer months of June through September and is most dense during the morning hours. Coastal areas have advection fog for up to 15 to 20 days per month in summer. Visibility is less than 3.2 km (2 mi) 10 to 25 percent of the time. The fog persists due to strong temperature inversions that prevent turbulent dissipation. During the winter, radiation fog, ice fog, and steam fog all contribute to reduced visibility. In general, summer fog conditions tend to be about twice as bad as winter conditions at coastal stations.

BATHYMETRY

The Chukchi Sea is shallow with a mean depth of about 40 m (130 ft). In the vicinity of Icy Cape, between Point Lay and Wainwright, nearshore depths are usually less than 20m (66 ft) and remain less than 60m (200 ft) throughout most of the shelf. The maximum recorded depth is 70 m (230 ft) . To the south, between Icy Cape and Cape Lisburne, the sea is shallow (less than 25 m [80 ft]) and the bottom is flat and featureless. Between Point Belcher and Point Franklin depths reach 40 m (130 ft) within 8 km (5 mi) of shore. Nearshore depths are generally shallow with sand spits and shoals that shift continuously due to currents, storms, and seasonal ice gouging. Additional information about the nearshore conditions is provided in the description of marine transportation facilities in Chapter III.

TIDES, STORM SURGES, AND WAVES

Deviations in sea level produced by meteorological forces are a significantly greater problem than tides in the Barrow Arch Planning Area. Along the northern Chukchi coast, astronomic tides average approximately 30 cm (1 ft). The mean tidal range at Wainwright is reported to be 15 cm (6 in), while tides at Kiwalik in Kotzebue Sound are reported to be 80 cm (2.7 ft). The meteorological deviations, known as storm surges or storm tides, are produced by wind stresses and barometric pressure gradients acting on the water surface. The dominent storm track is to the northeast. from storm systems originating in the Aleutian chain. The most severe surges, often accompanied by high waves, occur during September and October when storm frequencies are highest and open water exists. A storm in 1963 produced a storm surge of 3 m (10 ft) and" waves of the same height resulting in extensive coastal flooding, ice grounding and shoreline erosion in the vicinity of Barrow.

Wave generation in the Chukchi Sea is limited to the summer open-water season when the pack ice retreats a relatively short distance offshore. Under these conditions, wave heights of 6 m (20 ft) or more occur less than 1 percent of the time. Extreme wave conditions have not been measured, but have been calculated from available data. The 10-year storm is expected to have sustained winds of 75 knots and an extreme wave height of 23.5 m (77 ft); the 50-year storm, winds of 90 knots with 31 m (102 ft) waves; the 100-year storm, winds of 97 knots with 35 m (115 ft) waves (Dames & Moore, et al., 1982a). Since these calculations did not allow for the probability that wind fetch and wave height are reduced by the presence of ice cover, Dames & Moore believe the extreme wave conditions are more likely to be one--half of these values. A conceptual design study of an arctic terminal for ice-breaking tankers in the vicinity of Wainwright (see Bechtel, Inc., 1979) estimated a storm surge of 3.3 m (11 ft) and a maximum wave height of 10.3 m (34 ft).

SEA ICE

Freeze-up generally begins by late September or early October and breakup occurs late the following June or early July. From the beginning of December through May, 98 to 99 percent of the Chukchi Sea is covered with ice. From August to October ice coverage is least, but still averages 40 percent. The first continuous fast-ice sheet is usually formed nearshore by mid to late October. This fast-ice sheet continues to extend and thicken throughout the winter. " In general, stable land-fast ice is formed out to the 15 m (50 ft) isobath by December, and out to the 30m (100 ft) isobath by March or April. North of Icy Cape, the fast ice freezes to thicknesses of 1.8 to 2.4 m (6 to8 ft). South of Icy Cape, the normal winter thickness is 0.6 to 1.2m (2 to 4 ft). The fast ice zone is generally most extensive between Cape Lisburne and Point Lay where shallow waters predominate, and narrowest north of Icy Cape where bottom depth increases more rapidly and the shelf is vulnerable to pack ice incursion.

Pack ice in the Chukchi Sea is continually in motion. During the winter and spring, Chukchi Sea ice is more dynamic than Beaufort Sea ice. The Beaufort Sea has a large area of stable landfast ice often with an even larger area of immobile pack ice attached to it. Along the Chukchi coast, heavy pack ice begins to close in by October with new ice forming along its margin and in open-water areas between the pack ice and the shorefast ice. In heavy ice years, the pack ice lies close to the Chukchi coast and can unexpectedly be blown inshore even in midsummer. Ice movements can be rapid. Pack ice is much more mobile than land-fast ice with movements of 10 to 20 'km (6 to 12 mi) per day being commonplace. When it is blown ashore, ice keels, which can extend up to 20 m (67 ft) deep, sometimes gouge into the sea floor.

Between the fast-ice and the moving pack ice there is an extremely active flaw zone lead system. This lead system often extends from Point Barrow to Cape Lisburne and new ice in the flaw zone is continually being formed, detached, piled-up, and transported southward. In some years, the flaw zone may exceed 50 km (30 mi) in width near its southern end. The flaw zone becomes particularly pronounced from near Point Lay to Point Barrow during periods of strong easterly winds. Normally, polar pack ice is 3 to 4 m (10 to 13 ft) thick at the end of winter and decreases to 2 to 3 m (6 to 10 ft) thick during the summer.

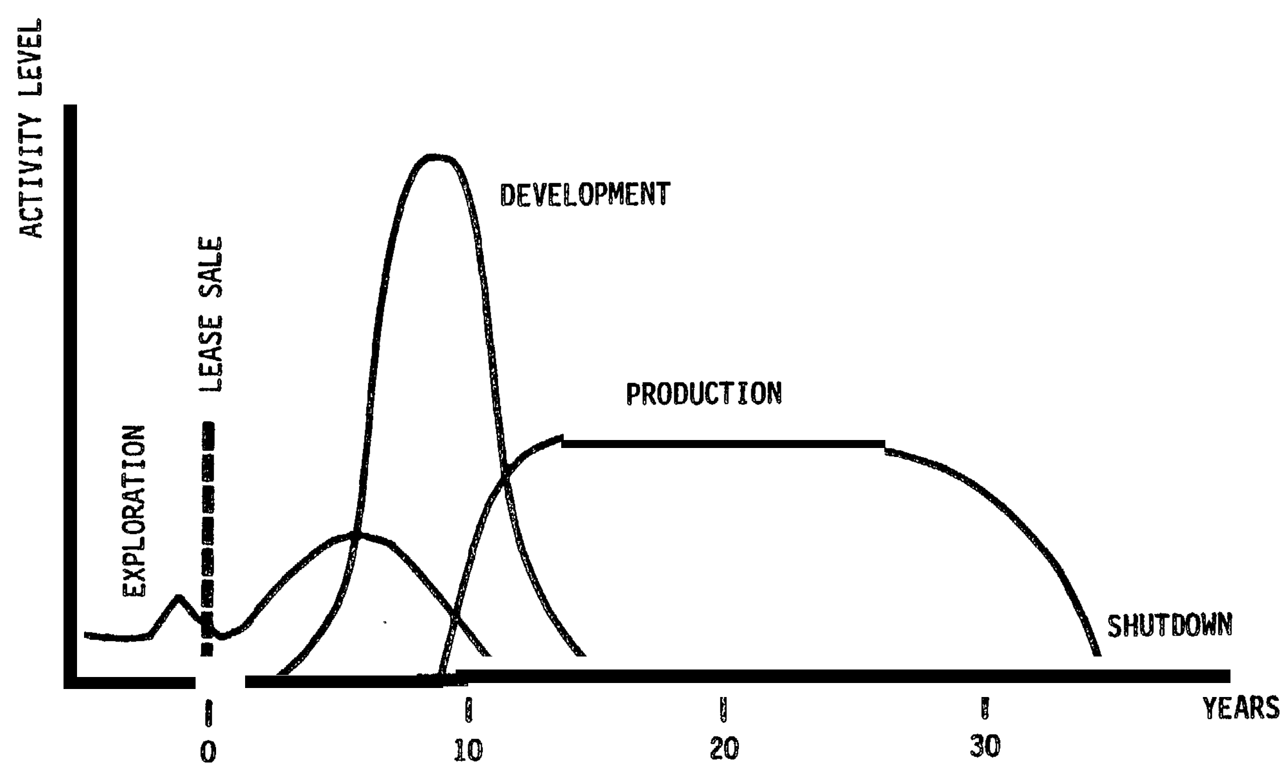
General Nature of OCS Transportation Demands

There "are four generally recognized phases of OCS development: Exploration, Development, Production and Shutdown. The relative intensity and duration of each phase is depicted in Figure 2. Although the phases overlap generally as shown, there is no typical span of time to each phase, nor is there a typical activity level. The initial lease on Federal offshore lands is normally available for a five-year time period, however, a ten-year lease will be issued for Barrow Arch development. The lease can be canceled or renewed dependingon the level of activity or results of drilling. In most of MMS's oil and gas scenarios, a typical time frame from lease sale to shutdown is 30 to 40 years depending on the level of resources discovered and rate of production. In this report most impacts are forecast to 2000, with some extended to 2010. Therefore, only the first 16 to 26 years of development activity are presented.

Each phase of development has its own transportation requirements. However, it should be noted that movement of rigs, platforms, and other special pieces of equipment, as well as other materials associated with

FIGURE 2

PHASES OF OFFSHORE OIL AND GAS DEVELOPMENT



SOURCE: Adapted from: The Conservation Foundation, 1977.

OCS development., require specialized transportation services. Offshore oil and gas activities, which occurred first in the Gulf of Mexico and later in the North Sea, as well as other parts of the world, have produced specialized technologies and equipment together with companies to operate them. Oil and gas companies contract with these specialists when the need arises rather than develop such capabilities in-house. It is assumed, marine carriers now serving Alaska would not compete for business where specialized vessels or expertise are required for such activities as moving goods from supply base to offshore work sites, laying underwater pipelines, or in moving and positioning a rig. Generally, the greater the degree of specialization required the smaller the range of impacts on existing transportation systems.

EXPLORATION PHASE

The exploration phase includes pre- and post-lease sale activities to discover and assess the location, quantity, and recoverability of oil and gas reserves. During this state of development, when the prospect for new resources is unknown, oil companies and drilling contractors seek to minimize the investment in permanent facilities or equipment. Some typical presale activities that place demands on transportation resources include environmental and biological testing of waters in the sale area, preliminary sounding to determine subsea geologic structures, possible drilling of a COST (Continental Offshore Stratigraphic Test) well to verify the geology, and movement of men and materials to support these and other activities. After the sale is held, offshore transportation activities might include, among other things, movement and positioning of the exploration drilling rigs and the movement of supplies and personnel to and from the rigs.

Offshore, there is a need to employ ocean tugs and anchor boats to position the drilling rigs in the tract. During this period, survey crews are making sure the rig is positioned properly. Once in place and anchored, drilling can begin. To support the drilling activities, supply boats deliver casing, drilling mud and other chemicals, fresh water, fuel, and consumable provisions on a regularly scheduled basis. "Generally, two supply boats are assigned to each rig. However, if many rigs are operating there is some economy of scale and the number of boats per rig is less. When crews rotate on the rigs, they may be transported in crew boats or by helicoptor. In Alaska, helicopters are more. typical.

Onshore, there is a need to establish a temporary support base. The main purpose of this base is the transfer of materials and, in some cases, workers, between shore and offshore operations. A typical temporary base occupies about 5-10 acres on an all-weather harbor; includes berthage of about 200 ft of wharf per rig; dock space for loading and unloading; warehousing; open storage areas for pipe, other tubular goods, and drilling supplies; a helipad; and space to house supervisory and communications personnel. In some areas it may not be possible, nor desirable for competitive reasons, to locate all facilities on a single site. It is also possible that each drilling company will establish its own service base. However, in this analysis a single consolidated base of larger than typical size is assumed due to the environmental conditions. In part, storage requirements are dependent on proximity of the base to material suppliers, on the pace of drilling activities, and, in the Arctic, on accessibility allowed by environmental constraints.

DEVELOPMENT PHASE

If sufficient recoverable resources are discovered through exploration, the industry may decide to proceed with development of the field. During development, production wells are drilled, and offshore and onshore facilities are completed. Generally, a field is put into production as soon as practicable, and the oil recovered in as short a period as possible in order to maximize productivity of costly capital intensive equipment. Consequently, there is a tendency to sacrifice development costs to assure that established production schedules are met.

In addition to servicing the drilling and other activities, which are an extension of the exploration phase, transportation services are needed to bring in construction materials for development of onshore facilities. These facilities typically include an expanded service base, a marine terminal for the storage and transshipment of oil, and/or an LNG terminal serving a similar function if gas is associated with the oil field. The construction activity may also involve expansion of existing marine facilities to provide the necessary berths and servicing facilities for supply boats and various line-haul carriers bringing in materials. Oil companies working adjacent leases may agree to jointly operate a supply base, and this practice will be assumed. Unit agreements are also assumed in the development of oil terminals and LNG plants.

Offshore and onshore pipeline construction also begins during the development phase. The offshore pipeline requires a heavy cement coating in order to overcome buoyancy. Depending on the location, the pipe could be coated either at a yard outside the lease sale area or at a construction base in the lease area. If the coating is done in the lease sale area, the raw pipe materials as well as cement, aggregate, and associated products must be brought into the area early so that the coating can be completed in advance of construction. Once coated, these pipes are then delivered to a lay barge which actually constructs the pipeline and lays it on the ocean floor. Later bury barges will bury the pipe. The lay and bury barges are serviced by supply boats and anchor boats, which position the barge in the correct location for the pipeline and keep the pipe laying and burying process supplied with required materials. Personnel working on the offshore pipeline are likely to be housed aboard accommodation barges anchored near the work barges. Helicopters are used to ferry personnel to and from shore locations.

Development phase employment is characterized by extreme peak demands due largely to the need to begin production as soon as possible. The construction and field development employment associated with this stage impose significant transportation demands on intrastate and interstate aviation transportation. The demand for workers typically cannot be met locally, either because a large number of workers are needed, or because special skills are required, or for both reasons. For example, many OCS rig workers are highly qualified personnel not generally found in Alaska. They commute to Alaska from a residence somewhere outside the state, work on the rigs for a specified period (typically two weeks) and return home. After two or so weeks at home the cycle is repeated.

PRODUCTION PHASE

The production-stage may continue for 20 or more years and involves the continuous production and transportation of oil and/or gas resources. Activities of special concern during this stage include the maintenance of sufficient pressure to bring oil and gas to the surface; the prevention of blow-outs, spills and leakages; waste disposal problems; and the monitoring of all production functions. This stage requires long term storage facilities to support offshore activities, as well as more permanent facilities to support services for workers. The production phase is typically characterized by a gradually declining level of oil/gas production over a relatively long period of time. OCS employees who operate and maintain the pumps and similar type equipment associated with production tend to be Alaska-based personnel due to the duration of this phase of work. A considerable travel demand is placed on the intrastate aviation system because many of these employees are expected to locate in or near Anchorage or Fairbanks and "commute" to work. In addition to employee transportation, other transportation demands during this stage are related to movement of recovered resources. If oil tankers or LNG tankers are used, a fleet of tankers services each type resource on a regularly scheduled basis. Due to environmental conditions in the Chukchi Sea, an overland pipeline to the Trans-Alaska Pipeline System (TAPS) may be more feasible than tankers. This could have the effect of transferring some Barrow Arch development impacts to the port at Valdez.

SHUTDOWN PHASE

When the petroleum resources cease to be economically or technically recoverable industry closes down its production operations and plugs and abandons the wells. Many of the support facilities used by the oil companies during the exploration, development, or production phases may also be abandoned. Transportation demands during this phase of development are associated with the movement of recoverable pieces of equipment and machinery that have sufficient salvage value to warrant removal. Once these pieces of equipment are removed, the need for transportation services ceases.

Study Area

The concept of study area as used in this report refers to the primary and secondary transportation linkages to the Barrow Arch Planning Area which require investigation in the context of this study. The primary transportation systems are those serving communities adjacent to the Planning Area or those systems likely to be constructed within or adjacent to the Planning Area. In this study, these systems include the aviation and marine systems and either a pipeline or tanker system for moving resources to market. Secondary transportation systems are those indirectly linked to the Barrow Arch Planning Area because they serve as intermediate carriers of either local people or goods, or OCS personnel and materials. Examples include the Alaska Railroad and the highway network between Fairbanks and Southcentral Alaska ports.

Oil and gas exploration and development is not a new phenomenon to Arctic Alaska, or to the Arctic generally. The U.S. Government has sponsored offshore lease sales in the arctic since 1979 and conducted exploration activities in the National Petroleum Reserve - Alaska (NPR-A) since 1944 (for location see Figure 1). Federal offshore sales have included the Joint Federal/State Beaufort Sea Sale (December 1979), OCS sale 71 (October 1982), and OCS sale 87 (August 1984). Each of " these sales were in the Diapir Field Planning Area in the Beafort Sea immediately east of the Barrow Arch Planning Area (see Figure 1).

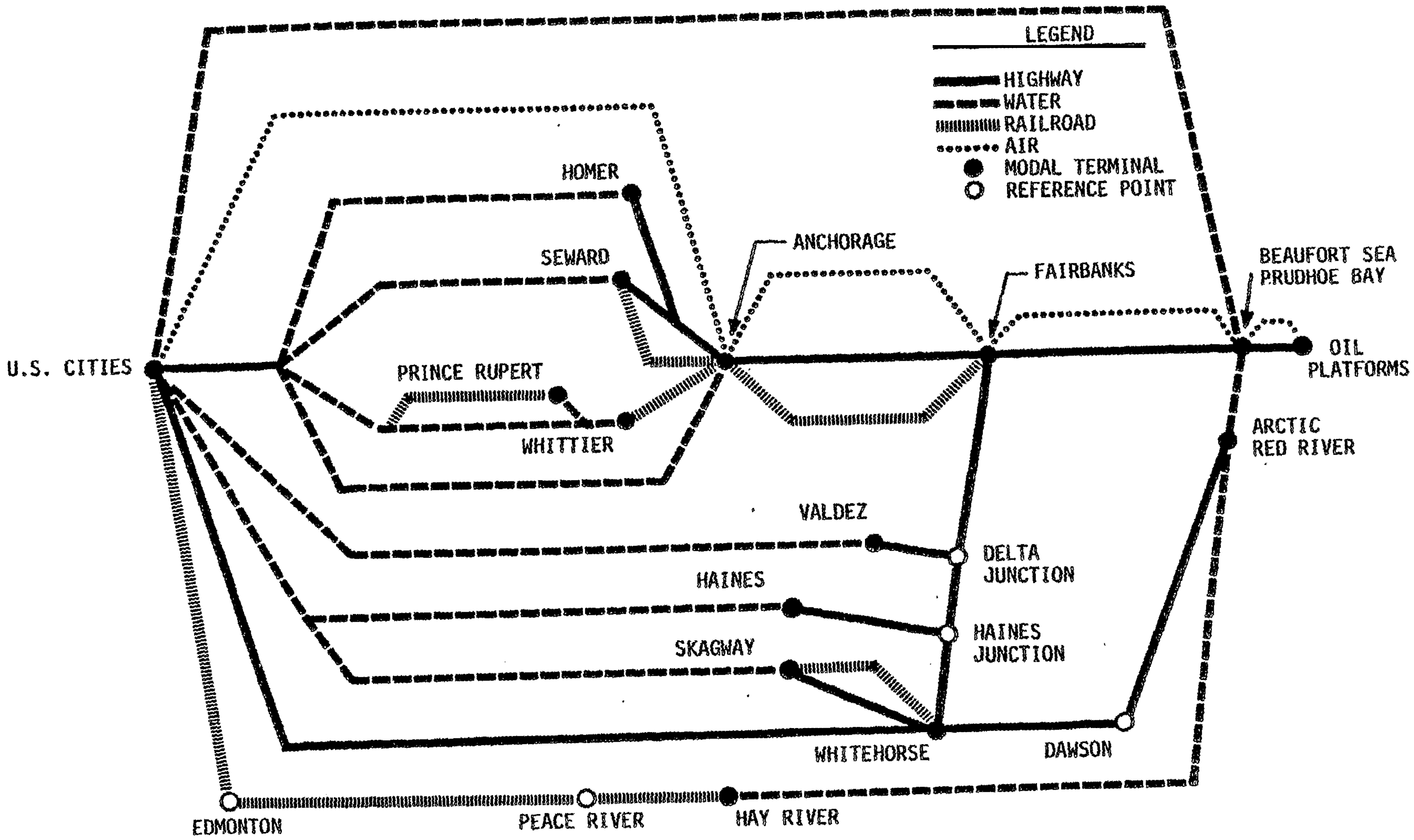
The state of Alaska and Canada have also sponsored offshore and onshore sales in this area since 1964 and 1972, respectively. State sales have resulted in the formation of severs? production units including the Kuparuk River Field, Sagavanirktok Delta and Duck Island unit, Milne Point, Gwydyr Bay, and Point Thompson units. Chapter IV contains additional details about current and expected oil and gas development in areas proximate to the Barrow Arch Planning Area.

The important point here is that the transportation systems serving Arctic Alaskan areas generally, and the North Slope in particular, already support a high level of oil and gas development activity. The extent of these transportation systems can be seen in Figure 3, which illustrates the various modes and routes serving Prudhoe Bay. Details of those portions of the systems shown in Figure 3, which are also expected to support Barrow Arch development are presented in Chapter III. Geographically, the study area encompasses the western North Slope and a central north-south corridor extending from the North Slope to Southcentral Alaska Ports and is bounded on the east and west by the highway system serving this corridor. Specifically, the study area for this analysis includes:

- Portions of the marine transportation system serving villages adjacent to the Planning Area and portions of the marine system serving Southcentral Alaska ports. The specific North Slope communities affected are Barrow, Wainwright, Point Lay, and Point Hope because of their coastal locations. In addition, the community of Kotzebue must be included since it serves as an intermediate transshipment point. With respect to Southcentral ports, the facilities at Anchorage, Whittier, Valdez, and Seward serve as major ports of entry for goods shipped to the North Slope and, therefore, should be examined in this study. Finally, if oil and gas resources are to move by tankers, this alternative needs to be explored as part of the marine transportation system.

FIGURE 3

ALTERNATIVE TRANSPORTATION ROUTES TO PRUDHOE BAY



Source: Prince William Sound Transportation Study (Alaska DOT/PF, 1981)

- Portions of the aviation system serving the above referenced North Slope communities and the intermediate air terminals at Fairbanks and Anchorage, which serve as major distribution hubs for both in-state and out-of-state OCS personnel commuting to North Slope locations;

- Portions of the Alaska Railroad that serve as an alternative freight link between Southcentral ports and Fairbanks;

- If constructed, the pipeline from the Barrow Arch Planning Area to TAPS is a key alternative to the use of tankers. This pipeline would constitute an extension of the TAPS system requiring the total system to be examined.

- Portions of the highway system linking Southcentral ports to Fairbanks and areas further north. These highways serve as an alternative freight link to the North Slope. If the above pipeline extension is constructed, the highway system also would be extended, in effect, by a service road parallel to the pipeline.

Based on the above, the study area is defined on the basis of the various transportation modes and the more important transportation terminals, particularly those that serve as transfer or transshipment points for people and goods moving to the Barrow Arch Planning Area. Chapter III, presented next, establishes current demand levels and an estimate of capacity for existing portions of these various systems. Subsequent forecasts of transportation demands with and without the BarrowArch Lease Sale (Chapters IV and V, respectively) expand the description of expected transportation infrastructure changes and the effects that increased demands and infrastructure changes have on transportation services.

III

EXISTING TRANSPORTATION SERVICES AND DEMANDS

This chapter seeks to define the present. status of those transportation systems potentially affected by OCS development in the Barrow Arch region. The systems are presented by mode in the following order: marine, air, highway, rail, and pipeline. To the extent applicable, each mode is presented in two parts. The first part describes those portions of the system which serve the existing transportation demands of coastal communities in the Barrow Arch region. Since only the marine and air systems currently serve these communities, this part of the discussion is absent from the remaining three modes. The second part describes those portions of the system which serve existing oil and gas industry needs in the region or those portions of the system which are available in other areas of the state to serve future industry related demands likely to be generated from offshore development in the Barrow Arch region.

Marine Transportation

Marine transportation provides a vital link for the movement of refined petroleum products and a variety of general freight to communities in the Barrow Arch region. Most of these commodities originate in Seattle, Washington and are shipped during the open water summer season. The movement of these goods is handled by oceangoing vessels, principally tug-barge combinations. With the exception of Kotzebue, none of the coastal communities adjacent to the Barrow Arch Planning Area has dock facilities; all goods must be delivered over the beach. None of the coastal communities can receive oceangoing barges directly due to the shallow coastal waters. Goods are either transshipped through the Port of Kotzebue and delivered by shallow draft coastal barge, or goods are delivered by lighter directly from the oceangoing barges, which anchor several miles offshore. In the discussion that follows, the Port of Kotzebue is treated as a separate entity and the other communities are treated collectively since they lack facilities.

Several ports in Southcentral Alaska serve as a gateway for goods delivered to North Slope locations by means other than marine transportation. "The most important of these ports are Anchorage, Whittier, Seward and Valdez. A summary of the facilities and operations at these ports is included in the following discussion.

FACILITIES AND OPERATIONS

This section provides background information about harbor conditions, type of docks and available space, cargo handling equipment, and operating conditions. Historic patterns of demand for marine transportation services are also included.

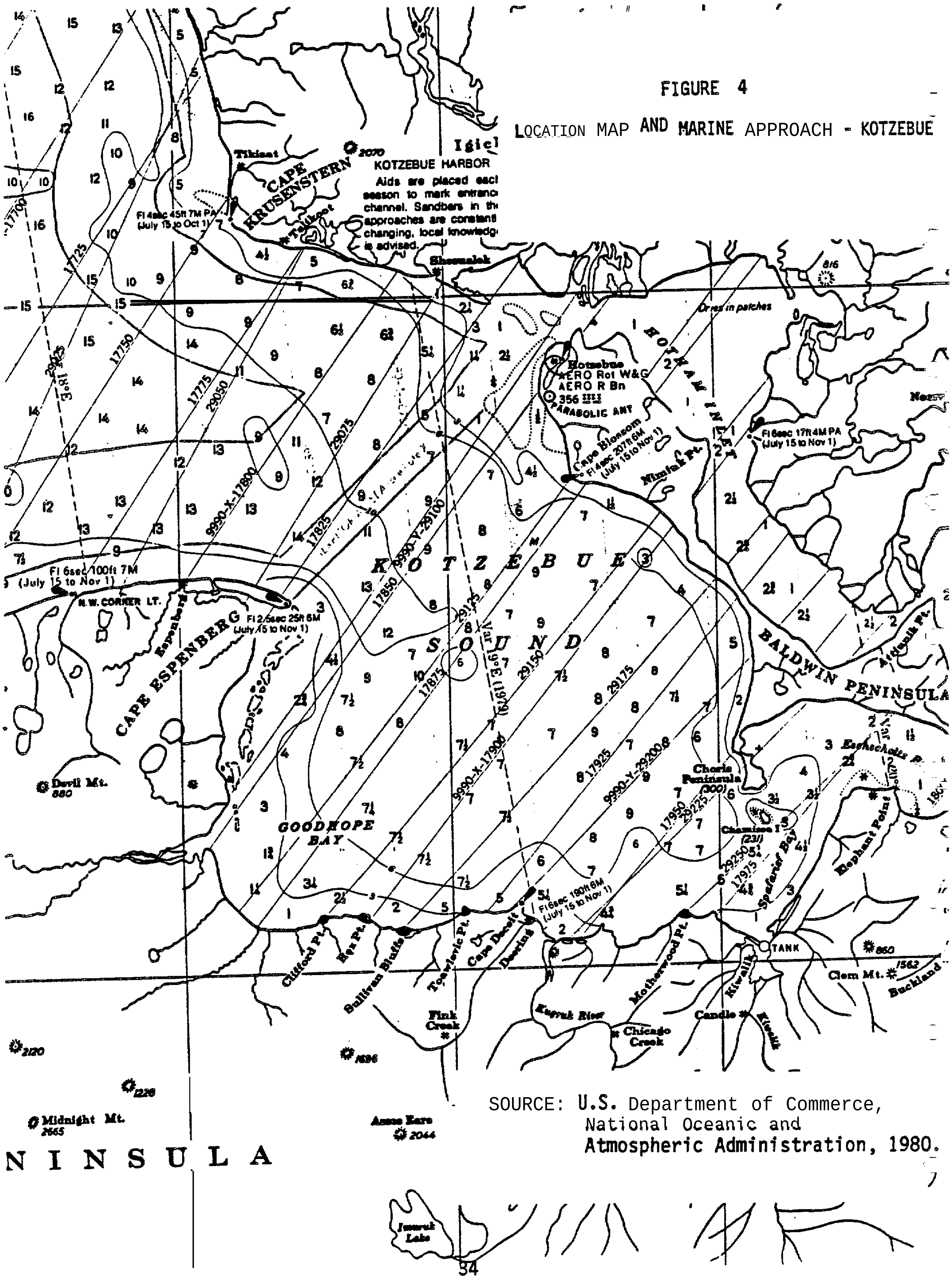
Kotzebue

Within the marine transportation system serving western and arctic Alaska, Kotzebue serves as the central redistribution point for communities in the Kobuk region and to a lessor extent provides a similar service for those communities along the arctic coast to Barrow. Arriving oceangoing vessels must anchor as far as 12 miles from the port due to shallow water in Kotzebue Sound. (see Figure 4). The principal anchorage is located 3 to 6 miles southwest of Cape Blossom and is linked to the port via a 12 mile channel. Goods are moved from the anchorage to the port by lighter. Under good weather conditions, once the linehaul barges have been unloaded to the point where their draft is less than 6 feet, they can be brought up the channel to the dock and unloaded directly. During 1979 and 1980, nine oceangoing barges arrived at Kotzebue.

Transshipment to destinations beyond Kotzebue is accomplished by means of shallow draft coastal and river barges. Cargo destined for coastal and riverine communities is often reconsolidated before continuing its journey. Deliveries to coastal villages are accomplished over the beach since none of the communities have dock facilities. Principal rivers served are the Kobuk and Noatak. The Kobuk river has a navigable depth of 1.5 meters (5 feet) up to Kiana. However, deliveries to the upper

FIGURE 4

LOCATION MAP AND MARINE APPROACH - KOTZEBUE



SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1980.

reaches of the Kobuk and to the entire Noatak river must be made during the early days of spring breakup when water depths are greatest.

The Kotzebue dock consists of' a linear tied-back sheet pile bulkhead with earth backfill. Water depth at the dock face varies from 1.8 to 2.4 meters (6 to 8 feet). Onshore, adjacent to the dock is a freight " terminal and bulk petroleum terminal. Arctic Lighterage Corporation owns and operates the dock and freight terminal and is the contract operator of the petroleum facility. The petroleum facility is owned by Cheveron, USA and handles three grades of gasoline, diesel fuel, aviation fuel, and heating fuel. About 390 feet. of berthing space is available at the dock allowing space for from one to three berths, the number depending upon barge length and cargo. The arrangement of the freight and petroleum terminals is such that simultaneously the dock could handle dry cargo at one berth, either dry cargo or liquid bulk at the second, and the third could handle loading of a river barge using roll-on-roll-off (RO/RO) features recently completed.

The freight terminal is equipped with an 80 ton (short tons) capacity Manitowoc 4000 crawler crane, several smaller cranes, a 25 ton forklift, a number of smaller forklifts, and other cargo handling equipment. The freight terminal handles mostly dry cargo containerized in 2.4 by 2.4 by 6.1 meters (8 by 8 by 20 foot) seavans and flatracks. In the terminal, cargo being transshipped to outlying villages is either repacked into containers destined for a specific village or is repacked as breakbulk cargo. Storage capacity consists of 929 square meters (10,000 square feet) of covered storage and slightly less than 465 square meters (5,000 square feet) of open storage area. The open storage area is adjacent to and on the dock revetment. There is room for 250 to 300 containers on the revetment.

The use of lighters to offload oceangoing ships and to deliver cargo to outlying villages severely limits the capacity of the port. Arctic Lighterage reports an unloading rate of 1,000 to 1,200 short tons in an 18 hour period in calm seas (Louis Berger & Associates, Inc, et al., 1979). However, the lighterage operation often is interrupted by storm induced drawdown of nearshore waters, and by large offshore waves (Tetra Tech and Wright Forssen Associates, 1983), thereby further reducing capacity at the port.

Throughput tonnage data for the period 1975 - 1980 is given in Table 1. For the period illustrated, inbound bulk fuel as a percentage of total inbound tonnage ranged from about 73 to 99 percent with an average of 84.7 percent. Outbound, bulk fuel ranged from 70 to 82 percent of total outbound tonnage. The ratio between outbound and inbound tonnage has ranged from about 23 to 41 percent with an average of about 29 percent. Total tonnage has remained fairly constant over the entire period.

TABLE 1

WATERBORNE CARGO AT THE PORT OF KO ZE≥UE
1975 - 1980

	Inbound			Throughput	Outbound		
Year	Bulk Fuel	Dry Cargo	Total	Total	Bulk Fuel	Dry Cargo	Total
1975	19,659	6,989	26,648	33,452	N/A	N/A	6,804
1976	22,312	176	22,488	31,631	N/A	N/A	9,143
1977	20,890	3,017	23,907	31,737	6,388	1,442	7,830
1978	24,335	3,993	28,328	35,815	N/A	N/A	7,487
1979	23,427	4,167	27,594	35,395	5,528	2,273	7,801
1980	20,873	5,489	26,362	32,531	4,501	1,668	6,469

Source: Feasibility Analysis, Kotzebue Deepwater Port/Airport
(Tetra Tech & Wright Forssen Assoc., 1983)

At least 18 destinations are being served through Kotzebue. The largest volumes are transshipped to the communities of Kiana, Noorvik, Salawik, and, in 1979, Barrow. The distribution of outbound tonnage from Kotzebue as a percentage of total outbound tonnage is presented in Table 2, by destination community. The large variation in tonnage for Barrow is not explained in the source document, however, speculation might lead to a conclusion that in 1980 goods were shipped directly to the community instead of through Kotzebue.

Kivalina

The general location and marine approach to Kivalina is shown in Figure 5. Kivalina currently lacks marine facilities and receives marine goods shipments through Kotzebue. This situation is expected to change with development of the Red Dog mine located about 60 miles inland from Kivalina. The current mine development plan indicates ore will be crushed and chemically concentrated near the mine site. The concentrate will be hauled by truck via a new road to a new port site and shipped to the Lower 48 for processing to refined metals. Assuming financing is available at acceptable rates, market conditions hold, and environmental constraints can be overcome, first shipments to market are planned for 1988. To complete this development plan and meet this schedule, construction of the road must begin in 1985. Construction of the dock, as well as improvements to the airfield, would take place during 1986 and 1987. Mining, crushing, and chemical reduction equipment are

TABLE 2

DISTRIBUTION OF TRANSSHIPPED TONNAGE FROM KOTZEBUE
1979 and 1980

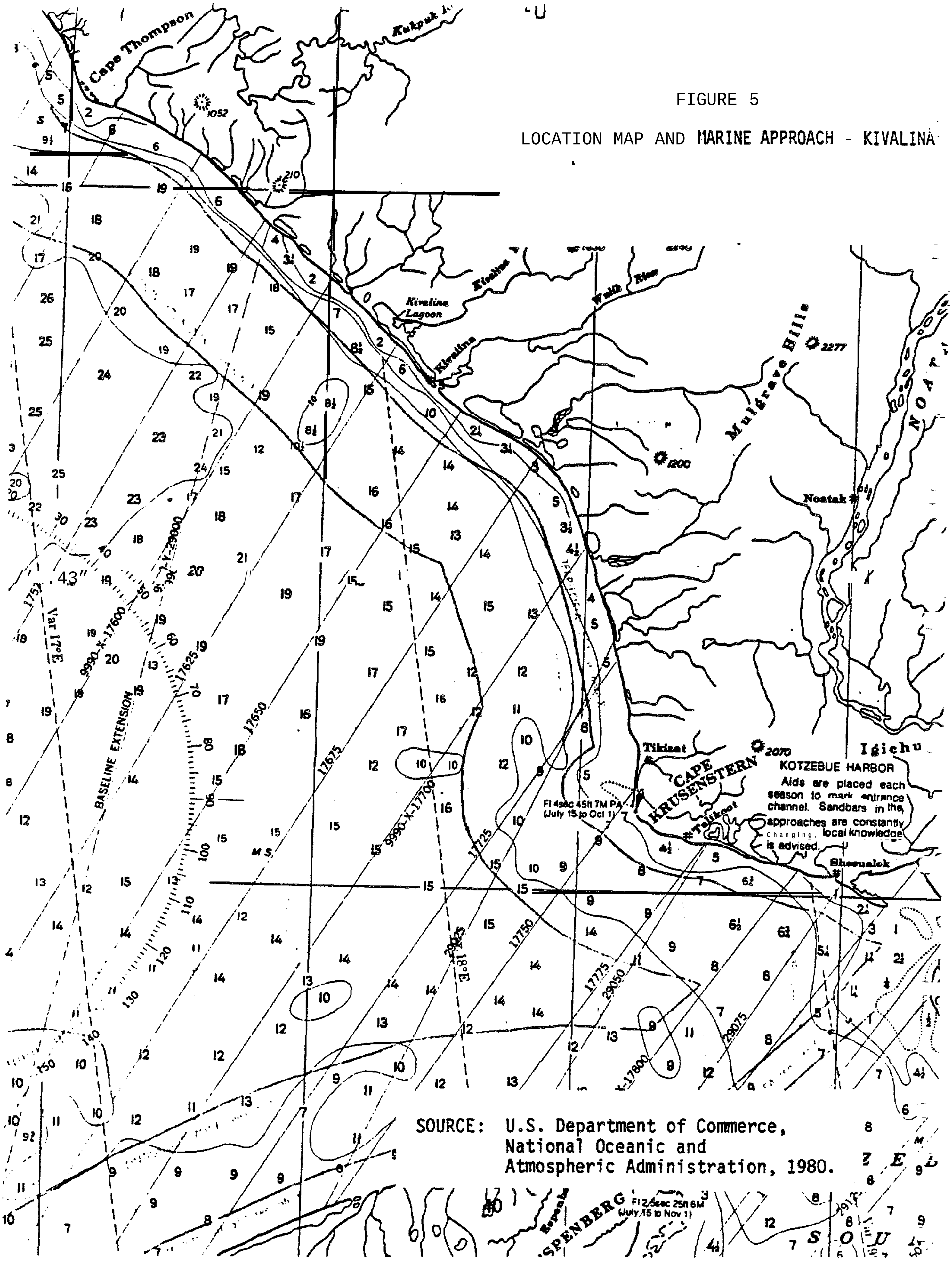
	1979		1980	
Destination	Tonnage	Percent of Total	Tonnage	Percent of Total
Noatak	422	5.4	443	7.2
Shungnak	704	9.0	510	8.3
Kiana	1,040	13.3	1,138	18.4
Ambler	366	4.7	443	7.1
Kobuk	148	1.9	64	1.0
Noorvick	850	10.9	1,066	17.3
Selawik	1,060	13.6	1,319	21.4
Deering	308	3.9	222	3.6
Buckland	575	7.4	345	5.6
Shishmaref	191	2.4	173	2.8
Nome	72	0.9	167	6.0
Lisburne	3	.03	---	---
Point Lay	8	0.1	22	0.3
Barrow	1,924	24.7	1	.02
Kivalina	83	1.1	147	2.4
Point Hope	10	0.1	8	0.1
Wainwright	7	0.1	4	.06
Kiwaulik	33	0.4	---	---
TOTALS	7,801	100.0 (1)	6,169	100.0 (1)

Note: (1) Percentages do not add to 100.0 due to rounding.

Source: Feasibility Analysis, Kotzebue Deepwater Port/Airport
(Tetra Tech & Wright Forssen Assoc., 1983)

FIGURE 5

LOCATION MAP AND MARINE APPROACH - KIVALINA



SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1980.

e to be moved to the site during 1986 and 1987.

The mine would operate year-round, with all marine shipments inbound and outbound taking place during the open-water summer season. This mode of operation requires storage facilities at the port for fuel, supplies, chemical concentrates, and concentrate ores. During the first five years inbound shipments are estimated to be 5,530 tons per year and outbound shipments are estimated to be 479,000 tons per year. After five years, inbound shipments jump to 20,221 tons per year and outbound shipments increase to 754,000 tons per year. (U.S. Environment Protection Agency, Region 10, et al., 1983)

Except for fuel, most of the inbound freight would be containerized. Outbound concentrated ore shipments would be handled as a bulk product. These concentrates would be shipped over the road in oversized double truck-trailer units. Each truck would weigh approximately 114 tons and each trailer 108 tons. Nine to 12 daily round trips are required during the first five years; 16 to 20 round trips after production expands. The need to ship products during the summer requires 8.5 months of concentrate storage capacity at the port. How this storage requirement is met depends on the method selected to transfer concentrates to the ocean-going ore ships. Two transfer methods have been suggested, both utilize a causeway/dock structure. The dock would be constructed of sheet piles or a concrete caisson and the causway would be earth filled.

The causeway/dock would extend approximately 400 feet from shore to a water depth of about 15 feet. The dock face would be about 150 feet long and is intended to handle lighter barges, the capacity of which vary from 1,000 tot-is to 5,000 tons, depending on the transfer method.

In one transfer method, the concentrates are stored at an onshore staging area located along the causeway and are moved by covered conveyor belt to a barge loader structure mounted on the dock face. Two 5,000 ton lighter barges and two support tugs are used to move the concentrate to an offshore location for subsequent transfer to ocean-going ore carriers. Clam shell cranes mounted on the ocean-going ships are used to transfer the concentrate.

The second transfer method would utilize an artificial island to load the ore ships. The island would consist of a 250,000 ton surplus oil tanker balasted to the sea bottom about 4,000 feet offshore. The tanker could accommodate storage of the concentrates, as well as fuel and supplies. Onboard concentrate storage capacity would be sufficient to load three to five ocean bulk carriers, The bow of the island tanker would be modified to accomodate a 1,000 ton self-propelled, self-unloading lighter discharging directly by conveyor belt into the ship.

The fuel storage requirements on the 'island' or the shore are about

214,000 bbls, of which only about 120,000 bbls (about 56 percent) are required for the mining project. The remaining capacity is dedicated for fuel distribution to other nearby villages. Small riverine barges operating from either the tanker or the dock would transport the fuel. There is some question as to wether or not this activity can be sustained when the mine goes into full operation (Tetra Tech and Wright Forssen Associates, 1983).

Other Northwestern Alaskan Communities

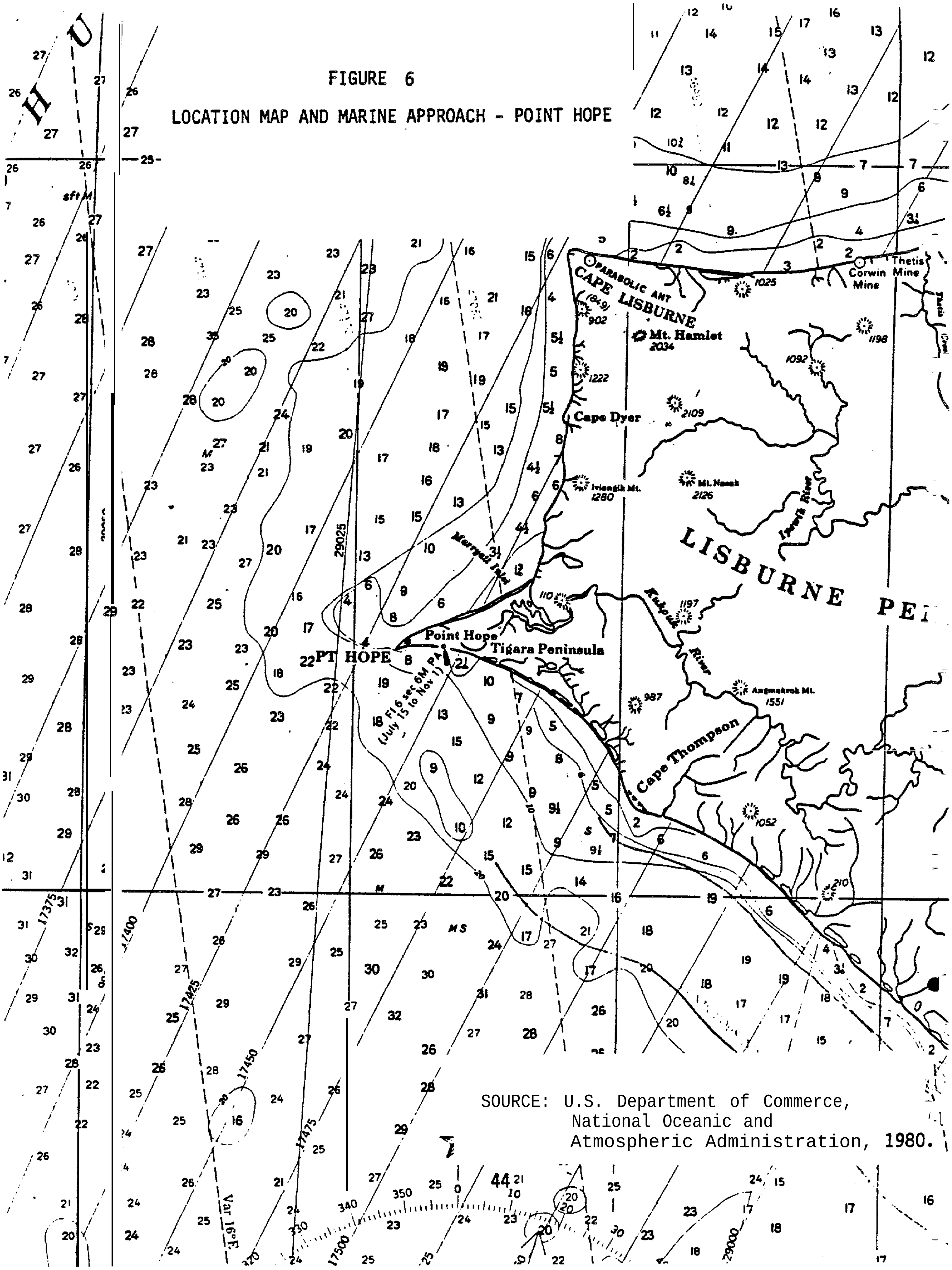
Due to the lack of marine facilities at Point Hope, Point Lay, Wainwright, and Barrow they are treated here collectively. Although each community is common in this respect, each has unique problems regarding marine transportation. To the-extent these problems are known they are cited. Figures 6 through 9 identify the location and marine approach to these communities.

All goods brought to these communities must be delivered over the beach. Typically, oceangoing barges hauling general freight and bulk petroleum anchor some distance offshore and transfer cargo to shallow draft lighter barges or landing craft. The distance of the anchorages offshore varies from about one mile at Barrow to about a half mile at Wainwright and Point Lay.

The ocean barges vary in size and capacity depending on function. Tank

FIGURE 6

LOCATION MAP AND MARINE APPROACH - POINT HOPE



SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1980.

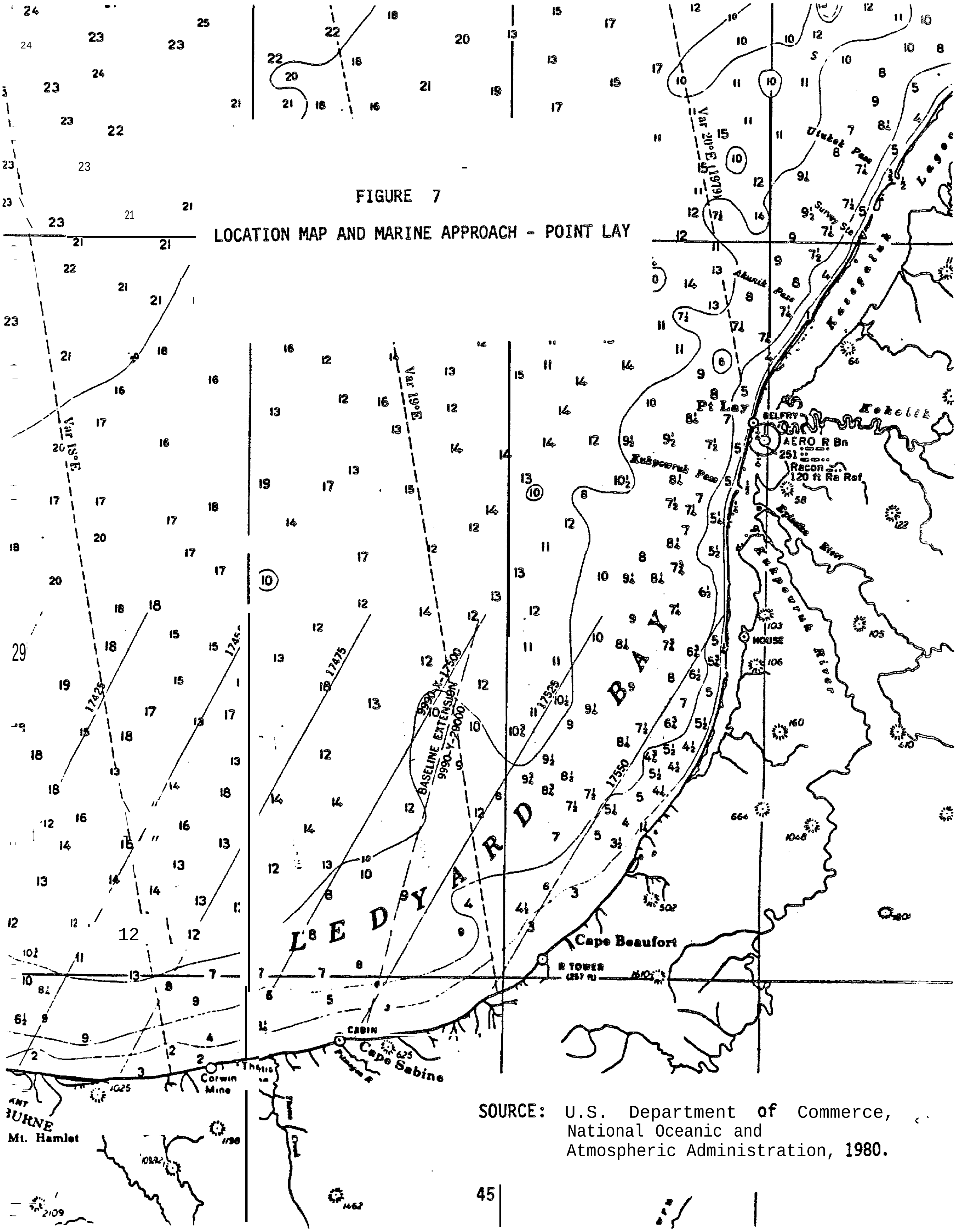


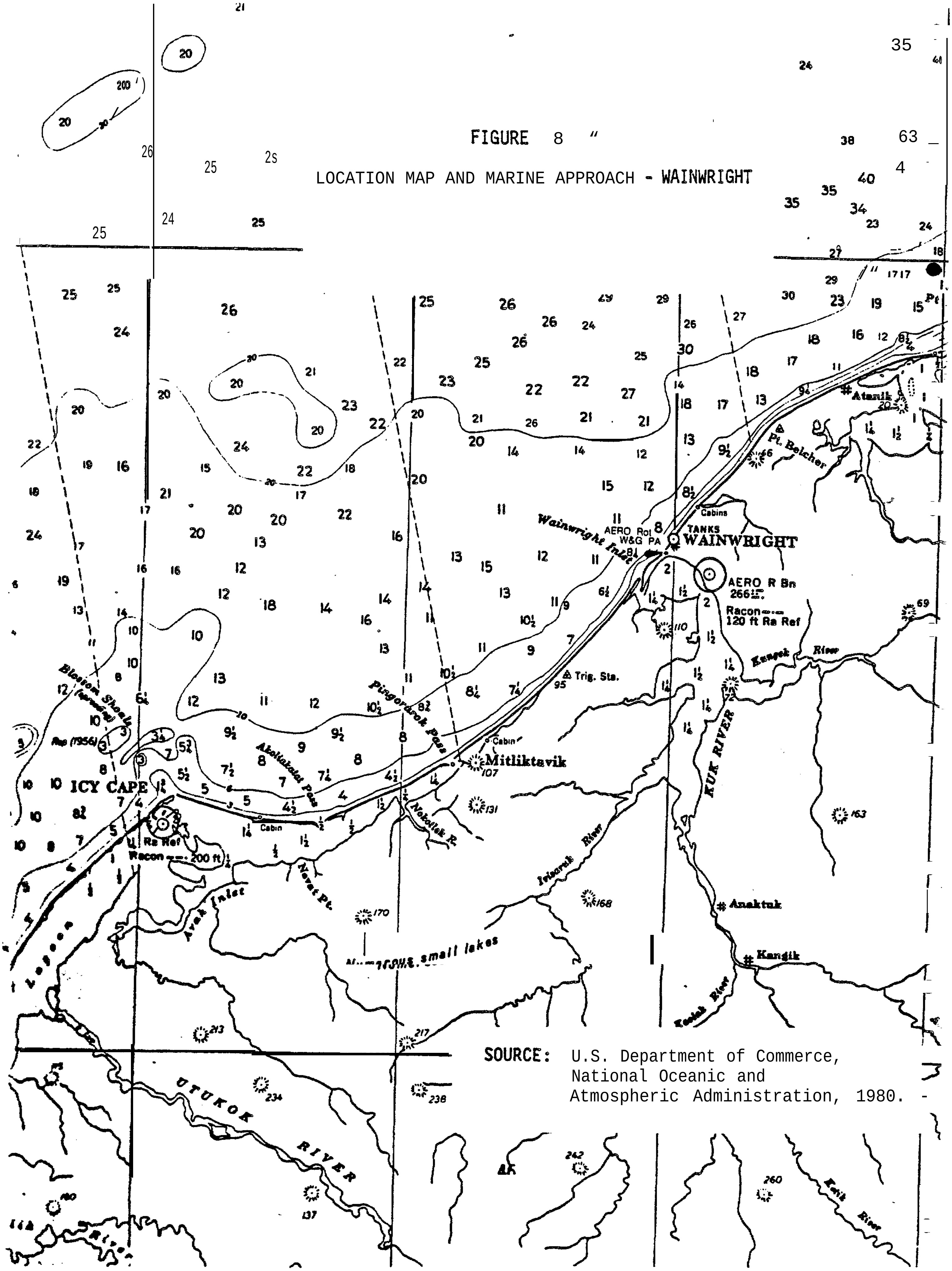
FIGURE 7

LOCATION MAP AND MARINE APPROACH - POINT LAY

SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1980.

FIGURE 8

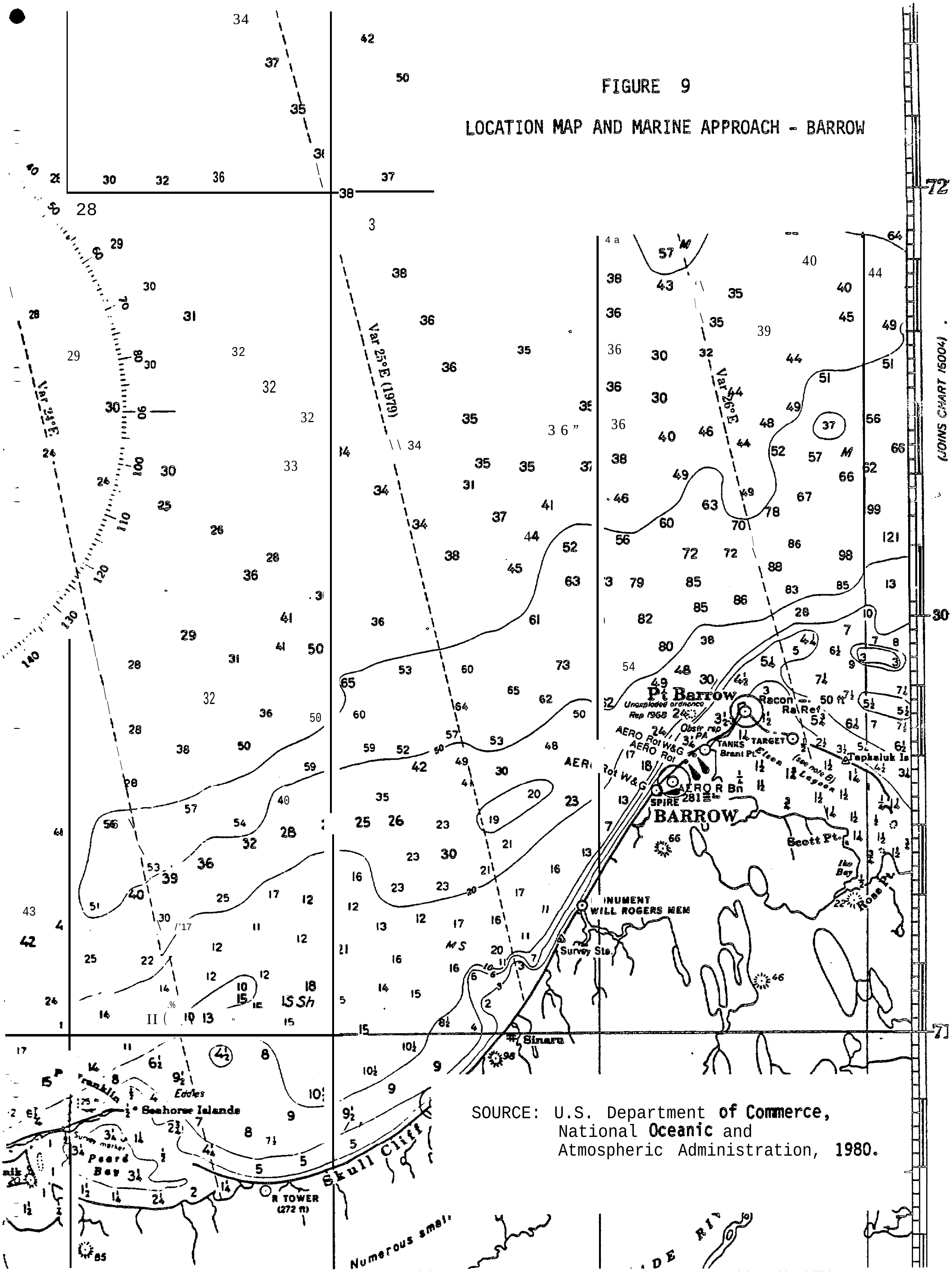
LOCATION MAP AND MARINE APPROACH - WAINWRIGHT



SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1980.

FIGURE 9

LOCATION MAP AND MARINE APPROACH - BARROW



SOURCE: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1980.

barge capacities range between 100,000 and 150,000 barrels of liquid cargo; dry cargo barge capacities range from 1,500 to 5,600 tons; a combination barge has a dry cargo capacity ranging from 1,000 to 9,000 tons and liquid cargo capacity ranging from 9,000 to 52,800 barrels. In addition, various carriers may incorporate an accommodation barge containing complete living quarters for as many as 32 people with a 50-ton capacity crane to assist unloading. The ocean tugs used to move these barges range from 2,800 to 7,000 horsepower.

Depending on the location, it may be possible to beach the smaller size shallow draft ocean going barges. This technique is employed at all locations except Point Lay, where a 1.3 mile wide shallow lagoon separates the landing spit from the mainland. At Point Lay, where the lagoon is only two to three feet deep, a lagoon barge with a dry cargo capacity of 15 tons and liquid cargo capacity of 7,500 gallons is employed, together with a 80 horsepower barge pusher. If the lagoon barge is not available, the carrier will employ small boats brought along for this purpose. Local umiaks (open boat made of skins) may also be used to transport cargo across the lagoon. The lagoon barge, its pusher, arid the small boats (except the Umiaks) are carried on the larger ocean going barges.

The beach landing of a barge and subsequent unloading process are a study of iniative and improvisation. The exact landing site may vary slightly year to year due to ice gouging and shifting bottom gravel (see the environmental discussion in Chapter II). Once the barge is beached, a front end loader or bulldozer owned by the village (or maintained in the village by the North Slope Borough) is used to construct a ramp using beach gravel. With the ramp in place unloading can begin. Depending on the nature of the cargo, unloading may be done by hand using local labor, by a rough terrain forklift (about 8,000 lb. capacity), by a truck mounted hydraulic crane (about 30-ton capacity), or all the above. The forklift and truck mounted crane is brought ashore by the carrier. Deep gravel on the beach at. Point Hope requires the use of low ground pressure vehicles at this location.

Various floating hoses and pumping gear are employed to pump liquid cargo as close as possible to its final destination. Project COOL BARGE, which delivers fuel and general freight to various government installations, employs flat bed trucks and 5,000 gallon portable tanks to move liquid cargo ashore when hoses cannot be used. This requires landing the trucks and fuel tanks. If hoses are employed, a tanker barge is brought close to shore and floating hose connections are made to small pipelines which run from the beach site to storage tanks. The size of these pipelines is typically 4" or 6", although an $" line is available at Point Barrow. (Military Sealift Command, Department of the Navy, 1982)

During the unloading process, which continues around the clock, careful watch is maintained on the wind and weather conditions. When winds or weather threaten to move the ice pack toward shore, the unloading operation stops and the ocean barges are moved to a safer location until the ice pack is no longer a threat..

In 1982, Bowhead Transportation Company delivered 2,250 tons of dry cargo and 1.5 million gallons of liquid cargo to the communities of Barrow, Wainwright, Point Lay; and Point Hope. For 1983, Bowhead is forecasting the movement of 4,500 tons of dry cargo and 7.5 million gallons of liquid cargo (Edsall, J.L., 1983). Exact details about quantities delivered to each village are not available in a suitable format, however, most of this cargo, both solid and liquid, is delivered to Barrow. The magnitude of COOL BARGE cargo delivered to Barrow Arch communities is considerably ?ess than consumer cargo carried by Bowhead. Table 3 provides-a summary of COOL BARGE cargo delivered to sites near or adjacent to the North Slope communities of Barrow, Wainwright, and Point Lay, as well as Kotzebue. COOL BARGE cargo for Kivalina is delivered through Kotzebue.

Southcentral Alaska Ports

The capability of Southcentral Alaskan ports to serve freight traffic destined for North Slope offshore and onshore oil and gas development is an important consideration in this study. The ports of interest are

TABLE 3

COOL BARGE DELIVERED TONNAGE
1977 - 1981

	Barrow			Kotzebue			Point Hope			Point Lay			Wainwright		
Year	Bulk Tons	Dry Tons	Total Tons	Bulk Tons	Dry Tons	Total Tons	Bulk Tons	Dry Tons	Total Tons	Bulk Tons	Dry Tons	Total Tons	Bulk Tons	Dry Tons	Total Tons
1977	6,166	393	6,559	1,718	265	1,983	-	-	-	-	2	2	125	5	5
1978	5,027	2.078	7.105	1,423	98	1,621	-	-	-	-	11	11	127	12	2
1979	5,683	99	5.882	1,434	147	1,581	53	2	55	-	7	7	-	7	7
1980	2,076	1 7	2, 93	1,445	180	1,625	-	-	-	-	7	7	-	5	5
981	1,254	63	1,3 7	1. 77	220	1.397	-	-	-	-	8	8	-	10	12

SOURCE: Military Seal ft mm d Department of the Navy, 1982.

Anchorage, Whittier, Seward, and Valdez. Table 4 summarizes the major freight handling facilities at each of these ports. A brief discussion of each port follows.

Port of Anchorage. The Port of Anchorage has four public berths and six private berths. The public berths serve as terminals for deep draft ships and the private berths serve specialized barge shipments. Ice strengthened deep draft ships call on the port year-round, however, barge traffic is limited to months when Cook Inlet is free of ice (mid-March to mid-November). One of the public docks is used solely for petroleum deliveries. The other three public docks are used primarily for containerized freight but can also handle general cargo. Handling equipment at the container port includes two 27.5 ton container handling cranes and four level-luffing gantries with 40 ton capacities. Two portable bridges used for roll-on/roll-off (RO/RO) service are also available. Table 5 provides an estimate of the capacity of the Port. of Anchorage for different cargo handling categories and berth occupancy levels. It should be noted that the capacity for each handling category is based on the assumption that only that category is handled throughout the available berth period. Consequently, total port capacity is not the sum of the individual capacities.

Whittier. The principal facility at Whittier is the Alaska Railroad dock, which operates as a rail-barge terminal. The facility

TABLE 4

SUMMARY OF PORT FACILITIES AT ANCHORAGE, WHITTIER, SEWARD, AND VALDEZ

Port	Berthing Space and Length	Water Depth	Storage and Warehouse Space	Rail Access	Equipment and Facilities
Anchorage	4 Public 6 Private (see Table 5)	35 ft.	covered: 530,000 cu.ft. open: 29 acres	Yes	2 container cranes; RO/RO ramps; 2 gantry cranes; petroleum pipeline; cement facility.
Whittier	1 - 427 ft.(Public) 2 - 350 ft. (Alaska Railroad)	35 ft.	N/A	Yes	2 rail-barge slips with rail transfer bridges; ferry dock.
Seward	2 - 635 ft. (Alaska Railroad)	35 ft.	covered: 24,000 sq.ft. open: 112,000 sq.ft.	Yes	1 concrete and steel pier; rail spurs; 24" wood chip pipeline; 2 - 6" petroleum pipelines; container and neobulk special handling facilities.
Valdez	4 - 500 ft.	30-34 ft.	20,000 sq.ft.	None	3 warves with rail transfer bridges; petroleum pier.

SOURCES: State of Alaska, Department of Transportation and Public Facilities, 1981a; also Frederic R. Harris, Inc., 1979.

TABLE 5

PORT CAPACITY AT ANCHORAGE, WHITTIER, SEWARD, AND VALDEZ
(In Short Tons)

			Trailers		Neobulk		Dry Bulk		Liquid Bulk		Rail car	
	High(1)	Low(2)	High	Low	High	Low	High	Low	High	Low	High	Low
Port of Anchorage												
General Cargo Terminal No. 1			1,228	589			'404	194				
General Cargo Terminal Nos. 2 & 3	2,046	1,432			1,116	781						
Petroleum Terminal									3,169	1,524		
Anderson Terminal					2,327	1,917						
Pacific Western Cement							837	586				
Pacific Western Cargo					856	599						
Kaiser Cement							209	159				
Oceaneering					1,591	1,232						
TOTAL	2,046	1,432	1,228	589	5,890	4,529	1,450	939	3,169	1,524		
Port of Whittier												
Alaska Railroad Car Barge Slip											648,000	453,600
Port of Seward												
Alaska Railroad Dock	1,917	1,340			1,044	731	552	251	679	475		
Port of Valdez												
Valdez City Dock	248	119			270	130						
Valdez Petroleum Dock									1,656	795		
Crowley Dock	149	71			152	73			281	135	360	173
Valdez Alaska Terminals	198	95			203	97						
Valdez Marine Terminal									181,232	154,008		
TOTAL	595	285			625	300			183,269	154,938	360	173

Notes:
(1) Based on berth occupancy using a ratio of berth waiting time to berth service time equal to 0.25.
(2) Based on berth occupancy using a ratio of berth waiting time to berth service time equal to 0.10.
Source: SouthCentral Region of Alaska, Deep-Draft Navigation Study (Alaska Consultants and PRC Harris, 1981).

consists of a dock with a rail bridge and a small switching yard immediately behind the dock. Loaded railroad cars, which originate in Seattle (via Hydro-Train) or Prince Rupert (via Canadian National Railroad), are pulled off the barge by small yard engines and assembled into trains for movement to Anchorage and Fairbanks. The trains are classified according to destination in Anchorage, consequently, the small yard at Whittier provides only storage space for outbound railcars. It is estiated that the Whittier facility could handle up to 30,000 rail cars per year without major modifications (State of Alaska, Department of Transportation and Public Facilities, 1981a). This figure would likely never be achieved, however, due to the uneven timing of rail barge arrivals. About 25 percent of total inbound freight handled by the ARR passes through Whittier, while only 2 percent of the southbound export tonnage moves through this port.

Seward. Port facilities at Seward include two public and three private docks. Those docks generally accessible to the public include the City Pier and the Alaska Ferry Terminal, both of which are owned by the City. Those docks operated as private facilities are owned by the Alaska Railroad, the University of Alaska, and Seward Fisheries. Before the 1964 earthquake, Seward was the principal port in southcentral Alaska because ships did not operate in Cook Inlet during the winter. When the earthquake destroyed Seward's dock facilities, actions by the shipping companies to ice strengthen the ship hulls shifted traffic to

Anchorage and Whittier. All of Seward's current facilities have been rebuilt since 1964.

The most important facility in Seward relative to this study is the Alaska Railroad Dock. This facility currently operates as a breakbulk port, handling cargo in containers and other large items, such as mobile homes. The usable berthage at the pier is 183 m (600 ft) on either side and 61 m (200 ft) at the end. The east side berth is serviced by two gantry cranes with maximum capacity of 45 short tons and maximum radius of 32 m (105 ft). Forklifts are also available with capacities up to 35 short tons. The ARR also has a 24,000 sq.ft. warehouse at Seward, which is served by a railroad spur and three truck delivery ramps. Outside storage consists of 112,000 sq.ft. of paved storage in the dock area and additional acreage within the rail terminal area. The facility can be floodlit at night for continuous operations. Other services available include potable water, deisel fuel via a pipeline (west side berth only), all other fuels via tank truck, and some marine repair facilities.

Valdez. The port of Valdez is situated at the head of an all-weather, deep water harbor close to the open waters of the Gulf of Alaska and the Pacific ocean. There are four major commercial dock facilities in Valdez: the City Dock, the Alaska State Ferry Dock, the tanker facilities at the Alyeska Terminal, and a smaller petroleum dock.

The petroleum dock, operated by the Valdez Dock Company, services 17,000 and 19,000 dwt tankers that deliver petroleum supplies to the city. The City dock has a 152 m (500 ft) face with a water depth of 10 m (33 ft) and about 20,000 sq.ft. of heated storage space. During construction of the Alyeska Pipeline and Terminal, Crowley Maritime Corporation operated a rail-barge facility at the City dock. This terminal no longer functions, but can be reactivated. The loading and unloading of barges was similar to that at Whittier, except the railcars were stored at the terminal since Valdez has no rail access. The railroad cargoes were transfered to trucks for movement to interior Alaska locations. The Alaska State Ferry M/V Tustumena must use the City dock during the summer season because it is incompatible with the State Ferry dock.

The Alyeska Terminal, located across the harbor from these other facilities, is the terminus for the Alyeska Pipeline (see later discussion under Pipeline Transportation). The pipeline transports 1.4 million barrels of crude oil daily to the terminal for storage, treatment, and transfer to oil tankers. Relevant terminal facilities include: 18 crude oil storage tanks, 2 metering facilities, a ballast treatment facility, refined fuel storage tanks, and 4 berths. The crude oil storage tanks have an individual capacity of 510,000 barrels and a collective capacity of 9.18 million barrels. The four tanker berths at the terminal are numbered 1, 3, 4, and 5. Space is reserved for future construction of berth number 2. Berth 1 is a floating berth, while the others are fixed. The floating berth handles tankers between 16,000 and 120,000 dwt, and serves as the receiving dock for the terminal's refined operating fuel. Berth 3 handles tankers up to 250,000 dwt, and berths 4 and 5 are for tankers up to 265,000 dwt or larger (Alyeska Pipeline Service Company, rid.). Presently, the terminal generates about 11 trips per week by tankers in the 250,000 dwt class (Valdez Community Development Department, et al., 1982). Crude oil is gravity-fed to tankers through four hydraulically-controlled metal arms located on each berth. The four 12" arms at Berth 1 can handle 80,000 barrels per hour, and the four 16" arms on each of the fixed berths have a capacity of 110,000 barrels per hour.

Throughput tonnage at these four Southcentral ports over the period 1950 through 1978 are shown in Table 6. The dominance of Seward prior to the 1964 earthquake is evident by examining the percentage of total tonnage for those years prior to 1964. The subsequent emergence of Anchorage as the principal southcentral port is also evident by examining percentage of total tonnage for those years after 1964. With start up of the Trans-Alaska Pipeline (TAPS) in 1976, throughput tonnage at Valdez leaped tenfold giving this port a significant percentage of total tonnage. Excluding the oil shipped through Valdez, Anchorage receives about 68.2 percent of throughput tonnage at the four ports, Whittier about 16.5 percent, Seward about 3.8 percent, and Valdez about 11.5 percent. These figures reflect the nine-year average throughput tonnage

TABLE 6

FREIGHT TRAFFIC AT FOUR SOUTHCENTRAL PORTS
1950 - 1978

Year	Anchorage Tons	Anchorage Percent of 4 ports	Whittier Tons	Whittier Percent of 4 ports	Seward Tons	Seward Percent of 4 ports	Valdez Tons	Valdez Percent of 4 ports	Total Tons
1950	50,625	6	265,625	32	482,953	52	85,963	10	831,283
1951	110,756	10	297,421	27	572,470	52	125,583	11	1,106,230
1952	122,264	12	237,297	24	549,408	55	95,656	9	1,004,625
1953	137,192	15	131,758	14	587,201	63	70,918	8	927,069
1954	170,309	18	120,606	13	565,013	59	96,278	10	952,206
1955	170,195	18	139,439	15	524,796	57	94,615	10	929,045
1956	201,139	19	175,538	16	633,489	59	58,420	6	1,068,586
1957	170,006	20	100,588	12	529,834	61	62,627	7	863,055
1958	214,281	25	129,969	15.	450,705	53	57,361	7	852,316
1959	221,387	24	118,831	13	556,124	59	42,470	4	938,812
1960	246,758	23	115,420	11	628,422	59	72,746	7	1,063,246
1961	267,679	25	119,212	11	631,209	59	54,849	5	1,072,995
1962	351,963	29	132,427	11	670,037	56	41,620	4	1,196,047
1963	381,764	32.7	121,000	10.4	622,000	53.2	42,022	3.6	1,166,786
1964	748,802	59.2	303,000	24	186,000	15	25,605	2.1	1,263,407
1965	1,080,094	80.3	177,000*	13.2	37,000	2.7	51,336	3.8	1,345,430
1966	1,008,999	-	N/A*	-	49,326	-	188,093		1,246,418*
1967	1,405,128	-	N/A*	-	90,857	-	215,022	-	1,711,007*
1968	1,310,981	68.2	312,000	16.2	117,329	6.1	181,945	9.5	1,922,255
1969	1,807,405	66.7	485,000	18	60,084	2.2	354,935	13.1	2,707,424
1970	1,936,976	69.4	348,954	12.5	29,309	1	477,677	17.1	2,792,916
1971	1,782,064	61.2	713,290	24.5	126,664	5.5	288,728	9.9	2,910,746
1972	2,058,199	68.1	646,609	21.4	61,726	2.1	253,505	8.4	3,020,039
1973	2,624,765	77.9	392,491	11.6	51,913	1.5	301,076	8.8	3,370,245
1974	2,340,181	68.2	662,315	19.3	71,844	2.1	356,967	10.4	3,431,307
1975	2,936,159	63.3	667,112	14.3	382,051	8.2	654,514	14.1	4,639,836
1976	2,932,468	70.9	457,038	11.1	236,722	5.7	507,672	12.3	4,133,900
1977	2,267,081	16.9	414,054	3.1	89,449	0.6	10,666,972	79.4	13,437,556
1978	2,226,158	3.8	333,673	0.6	92,554	0.2	55,551,933	95.4	58,204,318

* Total tons for 1967 and 1968 assumes Whittier tonnage at 1965 level.

SOURCE: U.S. Army Corps of Engineers, Annual.

preceding startup of the oil pipeline (1968-1976). Average annual growth in throughput tonnage over the past ten years (1968-1976) has been 6.3 percent at Anchorage and 2,150 percent at Valdez. Average annual growth at Seward and Whittier has been erratic over this period and actual growth may be negative.

MARINE CARRIERS

Marine freight carriers serving the Barrow Arch region can be divided into two general categories: 1) common and contract carriers; and 2) lighterage carriers. The services provided by each type carrier are typically tug and barge. The carriers are regulated by either the Interstate Commerce Commission (ICC); Federal Maritime Commission (FMC); or both. The exception to both service characteristic and regulation is the Bureau of Indian Affairs (BIA) annual resupply program using the cargo ship NORTH STAR III.

Common Carriers

Common carriers hold themselves out to the general public and are required to publish scheduled routes and sailing dates, as well as transportation rates and charges. Common carriers providing services from Seattle, Washington to Kotzebue and Chukchi Sea coastal communities include Pacific Alaska Line-West (PAL-West), Alaska Cargo Lines, and Bowhead Transportation Company. Bowhead is a joint venture of the

Ukpeagvik Inupiat Corp. (Barrow, Alaska) and Blackstock Construction Company (Seattle, Washington) and operates as a non-vessel common carrier chartering space from contract carriers. Both PAL-West and Bowhead serve Point Hope, Point Lay, Wainwright, and Barrow directly, as well as other North Slope communities.

Generally, each carrier schedules two or three trips each year. Pacific Alaska typically uses two 4,200 horsepower tugs and two 122 by 23 m (400 by 76 ft) container barges with capacity of about 9,100 dwt. Most of these barges carry their own crane and forklift equipment for handling and transferring cargo.

Other marine common carriers provide service to the ports of' Anchorage, Whittier, Seward, and Valdez. Sea-Land operates a container steamship fleet serving Anchorage, Kodiak, Cordova, and the Aleutian Islands. The service to Anchorage began in 1964. Ships operating this route have had their hulls reinforced to permit winter operations in Cook Inlet. During the 1976-1977 TAPS pipeline construction boom, five vessels provided four round-trips a week between Anchorage and Seattle. Another carrier operating between Anchorage and Seattle is Totem Ocean Trailer Express (TOTE), who has provided roll-on/roll-off trailer van service since 1975. By use of a unique transfer bridge, TOTE maintains a very short turn-around time at Anchorage (less than 12 hours) allowing each of its two ships to maintain a schedule of one round-trip per week. In

1979, TOTE and Sea-Land were estimated to each have captured 45 percent of marine traffic destined for Anchorage (Peter Eakland & Associates, 1979c).

Alaska Hydro-Train, a subsidiary of Crowley Maritime, ships railcar barges to Whittier, which are then carried by the Alaska Railroad to final destinations. Two sizes of barges are employed: one has a capacity of 52 railcars, the second a capacity of 40 railcars. Crowley Maritime also owns the railcar facility in Valdez, but it has not been used much since the Trans Alaska Pipeline was completed. Railbarge service is also offered by the Canadian National Railways, which operates the Aqua-Train service between Prince Rupert, B.C. and Whittier. Service is provided approximately once every ten days. This route primarily serves shipments originating in the Midwestern United States.

Contract Carriers

Contract or charter carriers are used by major shippers, such as petroleum companies, to move specialized and oversized cargo throughout Alaska, as the need develops. An example of the use of this type of carrier is the movement of supplies to Prudhoe Bay for the development of oil and gas on Alaska's North Slope. Crowley-Maritime has handled most of the Prudhoe Bay traffic since 1968. The annual tonnage volumes for the Prudhoe Bay Sealift are shown in Table 7. The largest shipment

TABLE 7

R DHO BAY SEALIFT TRAFFIC
1968 - 1982

Year	Tonnage (short tons)	Tugs	Barges
1968	7,000 -est.	2	3
1969	75,000	16	32
1970	187,000	18	36
1971	16,000	3	6
1972	3,000	1	2
1973	21,000	4	8
1974	67,000	8	16
1975	153,000	24	48
1976	65,000	11	22
1977	46,000	4	7
1978	40,000	5	10
1979	10,000	1	2
1980	47,000	5	10
1981	70,000 -est.	7	14

SOURCE: Peter Eakland and Associates, 1981.

was made in 1970 when 187,000 tons were shipped using 18 tugs and 36 barges. Kodiak Marine Transportation, a subsidiary of Nabors Drilling, operates a fleet of five barges and two tugs, which made its first sealift to Prudhoe Bay in September 1981. Its cargo consisted of 500,000 gallons of fuel and miscellaneous construction equipment I Peter Eakland &Associates, 1981). Crowley Maritime and Dillingham Mar" time (Ocean Division) also provides contract tug and barge service in Alaska. Their principle place of operations to date have centered in the Gulf of Alaska, however, Crowley does maintain a major operation in western Alaska through its subsidiary, Alaska Puget United Transportation Company (APUTCO).

APUTCO is the contract operator of the "COOL BARGE", which makes deliveries of dry cargo, reefer, and bulk petroleum to Department of Defense and other federal agency coastal installations in western Alaska. Their barges call at Kotzebue two to three times each season and at least once at Point Hope, Point Lay, Point Barrow, Wainwright, and Cape Lisburne. APUTCO's contract with the Navy Sealift Command, which was renewed following competitive bid in 1982, also allows it to provide transportation services to the general public in the communities it serves, if space is available on the barge. The volume of tonnage carried under these circumstances could not be determined from available documents.

Puget Sound Tug and Barge Company is a contract operator who makes bulk petroleum deliveries for Chevron USA, Inc. on a scheduled basis to distribution centers in western Alaska. Their barges normally call on Kotzebue two times during the season. Puget Sound Tug and Barge also moves a substantial volume of construction equipment on a non-scheduled contract basis.

The only cargo ship regularly serving the western and arctic coasts of Alaska is the Bureau of Indian Affairs ship NORTH STAR III. The ship takes bulk cargo and petroleum products, as well as reefer cargo, to coastal villages from the Aleutian Islands to Barter Island in the Beaufort Sea. Two voyages are made each year. The first voyage serves communities between the Aleutian Islands and Cape Prince of Wales; the second voyage serves communities north of Wales and Little Diomede Island. Since 1982, the NORTH STAR III no longer serves the North Slope villages of Barrow, Wainwright, Point Lay, and Point Hope having been replaced by Bowhead Transportation (Edsall, J.L., 1983). Service continues, however, to Kivalina and Kotzebue.

COSTS OF MARINE SERVICE

Marine shipping rates established by the carriers reflect the physical characteristics of a given community (e.g. the lack of port facilities), the characteristics of the commodity itself, and the carrier. There is a great deal of variation among both commodities and ports, both of which influence cost. Table 8 compares costs for shipping similar quantities and items to Anchorage and to Kotzebue from Seattle. Part of the difference can be explained by the need to lighter goods at Kotzebue. The extra handling costs, potential damage costs, and the added time required to do this task must be accounted for in the rates. Commodity values also affect pricing levels. The higher value commodities tend to be less dense, shipped in smaller quantities and carry a higher rate than do lower value, bulkier items. The handling requirements for a particular commodity also affect price. This is illustrated in Table 9 by the sharp differences in the rate between container and less then container loads.

Table 10 provides an example of the costs of chartering tug and barge equipment that is similar to the operation currently run by Bowhead Transportation Company. If sufficient demand exists, this approach might prove less costly then common carrier shipment. It has been estimated that a shipper with 1,200 tons or more will find charter service attractive (State of Alaska, Department of Transportation and Public Facilities, 1982a).

TABLE 8

SELECTED MARINE TARIFF DATA - 1980

Commodity and Minimum Quantity	Seattle to Anchorage(1)	Seattle to Kotzebue (2)
Foodstuffs		
5,000	---	---
10,000	...	13.75
20,000	---	11.75
60,000	5.15	10.44
81,000	4.25	---
99,000	3.82	8.43
Lumber		
10,000	---	11.79
24,000	...	9.03
38,000	5.90	---
72,000	4.02	---
114,000	2.94	---
Machinery		
16,000	...	14.13
24,000	10.78	11.35
30,000	7.68	..-
42,000	7.13	..-
72,000	5.80	---
120,000	4.74	---
Iron & Steel		
10,000	---	10.96
24,000	9.35	10.27
35,000	6.11	8.18
76,000	3.86	---
96,000	...	..-
132,000	3.30	---

Notes: (1) Service by Sea-Land Service Company
(2) Service by Foss Alaska Line and Arctic Lighterage Company.

Source: State Transportation Policy Plan - 1982, (State of Alaska, DOT/PF, 1982a)

TABLE 9

SELECTED COMMODITY RATES BETWEEN
SEATTLE AND POINTS IN ALASKA
(In $ Per Hundred Pounds)

Commodity	Rate	Min. Weight In Pounds
Building Materials - Cement, Lime, Plaster Gravel, Drilling Mud or Compounds, Sand, Stucco, Magnesite, and Fire Clay		
Less than Container Load (1)	$16.74	---
Container Load	16.15	24,000
Container Load	11.40	34,000
Buildings or Houses		
Less than Container Load	41.50	---
Container Load	37.40	10,000
Dairy Products	28.31	---
Groceries		
Less than Container Load	17.50	---
Container Load	14.16	22,000
Iron and Steel Articles		
Less than Container Load	18.16	---
Container Load	13.61	30,000
Lumber Articles		
Less than Container Load	18.26	---
Container Load	13.15	24,000
Machinery - Appliances		
Less than Container Load	54.00	---
Container Load	36.60	10,000
Motor Vehicles	45.53	---
Paints, Varnishes, and Lacquers		
Less than Container Load	18.75	---
Container Load	14.30	24,000
Petroleum Products in Bulk (2)		
Barrow - Gasoline	.55/gal.	50,000gal.
Diesel Fuel/Heating Oil	.52/gal.	50,000gal.
Point Hope - Gasoline	.55/gal.	50,000gal.
Diesel Fuel/Heating Oil	.52/gal.	50,000gal.
Point Lay - Gasoline	.55/gal.	50,000gal.
Diesel Fuel/Heating Oil	.52/gal.	50,000gal.
Wainwright - Gasoline	.55/gal.	50,000gal.
Diesel Fuel/Heating Oil	.52/gal.	50,000gal.

Notes: (1) A container is 20 feet long.
(2) Subject to availability of space.

SOURCE : Bowhead Transportation Company, 1983.

TABLE 10

CHARTER BARGE RATE, SEATTLE TO ALASKA, 1980

Seatt e to Location	Cost(1)	Trip Length(2) (days/nautical miles)
Kodiak	$ 300,000	15 / 1,238
Unalaska	390,000	21 / 1,719
Bethel	450,000	25 / 2,065
Dillingham	450,000	25 / 2,028
Nome	480,000(3)	27 / 2,499
Kotzebue	555,000(3)	32 / 2,759

Notes: (1) Based on one 4,000-horsepower tug and two 300-foot barges. Individual rates for a tug: $10,750 per day; for a barge $1,900 per day. Charter rates above do not include loading and lashing costs at Seattle (about $27.00 per ton), nor marine cargo insurance (about 2% to 7% of cargo value).

(2) Includes 5 days unloading time at destination.

(3) Does not include lighterage fees.

Source: State Transportation Policy Plan - 1982, (State of Alaska, DOT/PF, 1982a)

Air Transportation

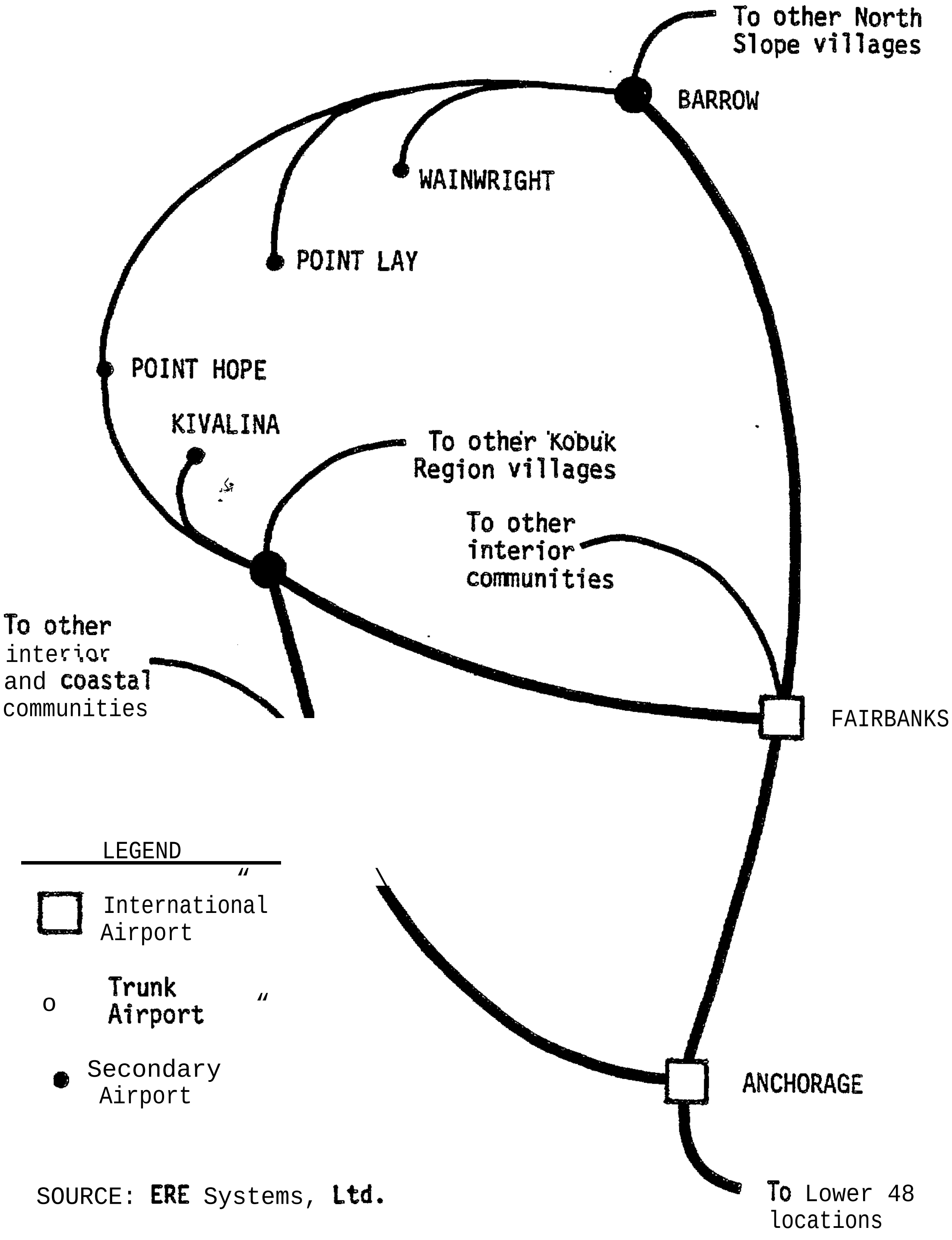
Air transportation serving the Barrow Arch region provides an important year-round service linking each community to regional, state, and interstate, destinations. The emphasis in this section of the baseline is on defining the character of air travel in the Barrow Arch region. Of particular interest to subsequent study efforts are those air routes and facilities most likely to be affected by potential OCS personnel and air freight movements. Because OCS aviation activities are expected to be oriented toward Anchorage and Fairbanks, the baseline discussion includes certain aspects of operations at these airports. "

Although landing facilities can be found throughout the study area, a large number of them are privately owned, and many are in need of maintenance. A landing facility is near or adjacent to each community being studied. Commercial aviation services are available in the Barrow Arch area year-round. Both scheduled and contract services are offered. Scheduled air service links the smaller communities of Kivalina, Point Hope, Point Lay and Wainwright to Anchorage, Fairbanks, and the lower 48 states through regional "hub" airports at Barrow and Kotzebue. Air 'Taxi service is also available between the hub airports and the smaller communities. The following sections identify facilities, carriers, and traffic levels at these terminals.

AIR TERMINALS

The following describes existing aviation facilities and includes: ground facilities used by aircraft, including runways, taxiways, and aprons; visual and instrument. landing aids; available services such as control towers, fuel, weather reporting, maintenance, and others; and terminal facilities for handling cargo and passengers.

The State of Alaska has established three major categories for Alaskan airports: International Airports, which provide service for international, interstate, and intrastate needs; Trunk Airports, which distribute goods and passengers to smaller secondary airports; and Secondary Airports, which are those located in the smaller communities. Any other airports fall into the secondary airport category. Designations are assigned to airports according to peak use of the airport. The airports at Kivalina, Point Hope, Point Lay, and Wainwright are secondary airports; Barrow and Kotzebue are trunk airports, Anchorage and Fairbanks are international airports. Figure 10 illustrates the pattern of scheduled air service and airport categories for the Barrow Arch study area. The pattern is best described as hub and spoke. Linehaul services are available between each hub and Anchorage and Fairbanks. From the hubs, feeder services radiate to the smaller villages. The descriptions that follow provide a more detailed summary of each airport identified in Figure 10.



SOURCE: ERE Systems, Ltd.

FIGURE 10

SCHEMATIC PRESENTATION OF SCHEDULED AIR SERVICE
TO THE BARROW ARCH REGION

Barrow

The airport at Barrow, known as the Wiley Post - Will Rodgers Memorial Airport, serves the community of Barrow and functions as a regional transportation center for the North Slope Borough villages of Wainwright, Atkasook, Nuiqsut, and Point Lay. Point Hope is served primarily through Kotzebue. The airport is located directly adjacent to the southside of the Barrow townsite, as shown in Figure 11. Landing facilities at Barrow consist of a single asphalt runway, designated runway 6-24, which is 1,981 m (6,500 ft) long and 46 m (150 ft) wide with 61 m (200 ft) of unpaved overrun at each end (Alaska Transportation Consultants, Inc., 1983). This runway is classified as an air carrier runway. Two taxiways 23 m (75 ft) wide connect the runway to the parking apron area. The airport is owned and operated by the State of Alaska Department of Transportation and Public Facilities (ADOT/PF).

Facilities at the Barrow airport include an attended FAA Flight Service Station, a Weather Station (located in the city about one-quarter mile from the airport), a passenger terminal, storage building, and several hanger-office buildings used by air taxi operators. The terminal building, constructed about 1979, is owned and operated by Mien Airlines. The structure is about 132 by 60 ft (7,920 sq.ft.) and contains a 40 by 60 ft (2,400 sq.ft.) area for ticket counters, lobby, and a secured departure lounge, together with a 16 by 40 ft (640- sq.ft.)

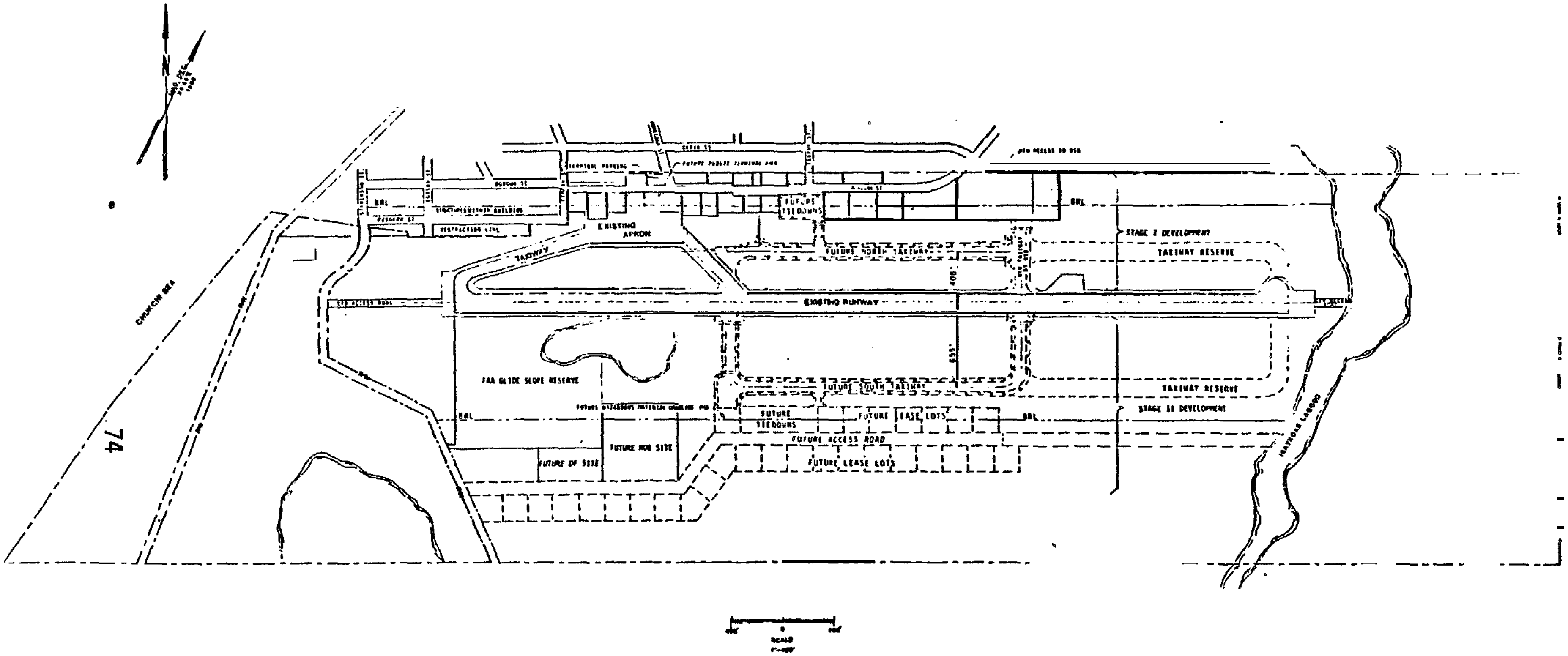


FIGURE 11

B RROW AIRPORT DEVELOPMENT AND LAND USE PLAN

Source: Airport Development and Land Use Plans Barrow Airport (Alaska Transportation Consultants, 1983 area for baggage claim. The remainder of the building contains restrooms, offices, and a restaurant. The storage building, also owned by Wien, is 60 by 60 ft (3,600 sq.ft.) and is located adjacent to the terminal. Wien also maintains fuel storage tanks with a capacity of 50,000 gallons for use only by their own aircraft.

Lighting at the airport consists of high intensity field and taxiway lighting, a double end rotating beacon, runway end identifier lights (REIL) on runway 24, a medium intensity approach lighting system (MALS) on runway 6, and visual approach slope indicators (VASI) on both runways (U.S. Dept. of Transportation, Federal Aviation Administration, Alaska Region, 1981). This lighting is powered by Barrow Utilities System, although the state maintains a 25 kilowatt generator for backup. Navigational aids include an instrument landing system for runway 6, a colocated VHF omnidirectional radio range and UHF tactical air navigation pulse type omnirange and distance measuring equipment (VORTAC), a non-directional beacon (NDB), runway visual range (RVR) equipment for runway 6, and a VHF direction finder.

Passenger service to Barrow from Anchorage and Fairbanks by scheduled carriers is provided by Wien Airlines and Mark Air. Both airlines use Boeing 737 jet aircraft along these routes. These aircraft are configured for both passengers and cargo with passenger capacity varying from 56 to 109 seats. Wien provides service from Anchorage daily in winter and 22 times per week during the summer. Wien also provides service from Fairbanks 11 times per week during the winter and 22 times per week during the summer. Mark Air provides two flights daily from Anchorage: the morning flight is direct; the afternoon flight stops in Fairbanks. After February 1, 1985, the afternoon flight will also stop at Prudhoe Bay. Flying time from Anchorage to Barrow is just under three hours with a stop in Fairbanks. Flying time from Fairbanks is about one hour twenty minutes.

Wien also offers through service at Barrow to outling villages. This service is provided by Cape Smythe Air Service, Inc., who operates as a scheduled carrier under subcontract to Wien. Service from Barrow to the outlying villages is also provided by several air taxi operators. Three air taxi service companies were based at the Barrow airport during 1983: Barrow Air, Inc.; Cape Smythe Air Service, Inc.; and Jen-Air. However, Jen-Air went out of business in late 1983. The two remaining companies have an operating permit limiting air taxi service to fixed wing aircraft with a capacity not exceeding 7,500 pounds or 30 passengers '(Alaska Transportation Commission, 1983). Table 11 provides a summary of the various air carriers based at Barrow and their operating authority, as granted by the Alaska Transportation Commission.

Passenger enplanments and deplanements at Barrow for the period 1976 - 1981 are shown in Table 12. Generally, enplanements/deplanements on Wien have increased 43 percent over the six years, averaging a little over 7 percent growth per year. Similarly, enplanements/deplanements

TABLE 11

AIR CARRIERS BASED IN BARROW

Air Carrier	Operating Authority
Barrow Air Inc.	Air Taxi
Cape Smyth Air Service, Inc.	Air Taxi Scheduled Carrier
Jen-Air	Air Taxi Scheduled Carrier

NOTES: (1) Jen-Air went out of business near the end of 1983.

SOURCE: Alaska Transportation Commission, 1983.

TABLE 12

ENPLANED PASSENGERS, FREIGHT, AND MAIL - BARROW, ALASKA
1976 - 1982

Year	Enplaned Passengers	Freight (1)	U.S. Mail(1)
1976	16,545	289.98	219.14
1977	15,025	210.41	318.65
1978	19,613	187.51	226.49
1979	22,611	279.18	399.62
1980	24,545	306.50	264.03
1981	23,347 .	708.28	435.98
1982	23,354	779.02	437.36

NOTES: (1) Revenue tons only.

SOURCE: U.S. Department of Transportation,
Federal Aviation Administration
and Civil Aeronautics Board, Annual.

on Cape Smythe Air Service flights have increased about 32 percent, averaging about 5.4 percent per year. Overall during this period, total passenger enplanements/deplanements for scheduled air carrier service at Barrow increased 80 percent, averaging 13.4 percent per year.

For purposes of subsequent analysis, aircraft operations for Barrow are shown in Table 13 as average daily operations by month. This provides a measure of the seasonality of airport activities. Construction, tourism, and other activities increase during the summer and the higher average number of operations during this period reflects the fact that the airlines alter their schedules to provide more flights. As shown, the average daily operations in the summer months are almost twice the winter months.

The theoretical capacity of a runway is a function of many factors. At Barrow, some of the factors influencing capacity include: lack of a taxiway at the east. end of the runway, severe weather affecting operating conditions, and equipment that enhances the ability to operate in adverse weather using instrument flight rules (IFR). A single runway with no restrictions can theoretically handle somewhere between 45 and 60 operations per hour (Horonjeff, R., 1975). At Barrow, the lack of a taxiway at one end of the runway slows down operations under certain wind conditions requiring a landing approach from west to east or a takeoff from east to west. It is estimated that these theoretical values would be reduced one-fourth to compensate for added time each aircraft

TABLE 13

AVERAGE DAILY OPERATIONS BY MONTH (1)
BARROW AIRPORT

Month	Percent of Total	Average Daily Number of Operations
	1977- 1981	
January	5.7	24
February	5.8	27
March	7.2	30
April	7.6	33
May	8.1	34
June	9.5	41
July	12.5	52
August	12.0	50
September	10.5	46
October	7.9	35
November	6.5	28
December	6.4	27

Note: (1) Monthly operations are shown as a percent of annual operations averaged over the period 1977 to 1981.

SOURCE: Alaska Transportation Consultants, Inc., 1983.

would need on the runway. Weather minimums also reduce capacity, although with an Instrument Landing System (ILS) the reduction isless sever-e. For this analysis, it was assumed weather would reduce capacity 20 percent. The results of' this analysis is that hourly capacity would range between 27 and 36 operations per hour and annual capacity would range from 236,500 to approximately 315,400 annual operations.

Kotzebue

Landing facilities at Kotzebue consist of two runways: runway 8-26 has an asphalt surface and is 1,798 m (5,900 ft) long and 46 m (150 ft) wide; runway 17-35 is a gravel-surfaced runway 1,219 m (4,000 ft) long and 35 m (115 ft) wide. Adjacent. to the gravel runway is a float facility reported to have a useable surface area 457 m (1,500 ft) long and 30 m (100 ft) wide. The airport, known as the Ralph Wien Memorial Airport, is located south of the city on a strip of land between Kotzebue Sound and a nearby lagoon, as illustrated in the airport layout, Figure 12. The airport is owned and operated by the State of Alaska, Department of Transportation and Public Facilities.

Lighting at the airport consists of runway end identifier lights (REIL) on runway 8-26, an omnidirectional approach lighting system (ODALS) on runway 26, and visual approach slope indicators (VASI) on runways 8 and 26. Navigational aids include a colocated VHF omnidirectional radio range and UHF tactical air navigation pulse type omnirange (VORTAC),

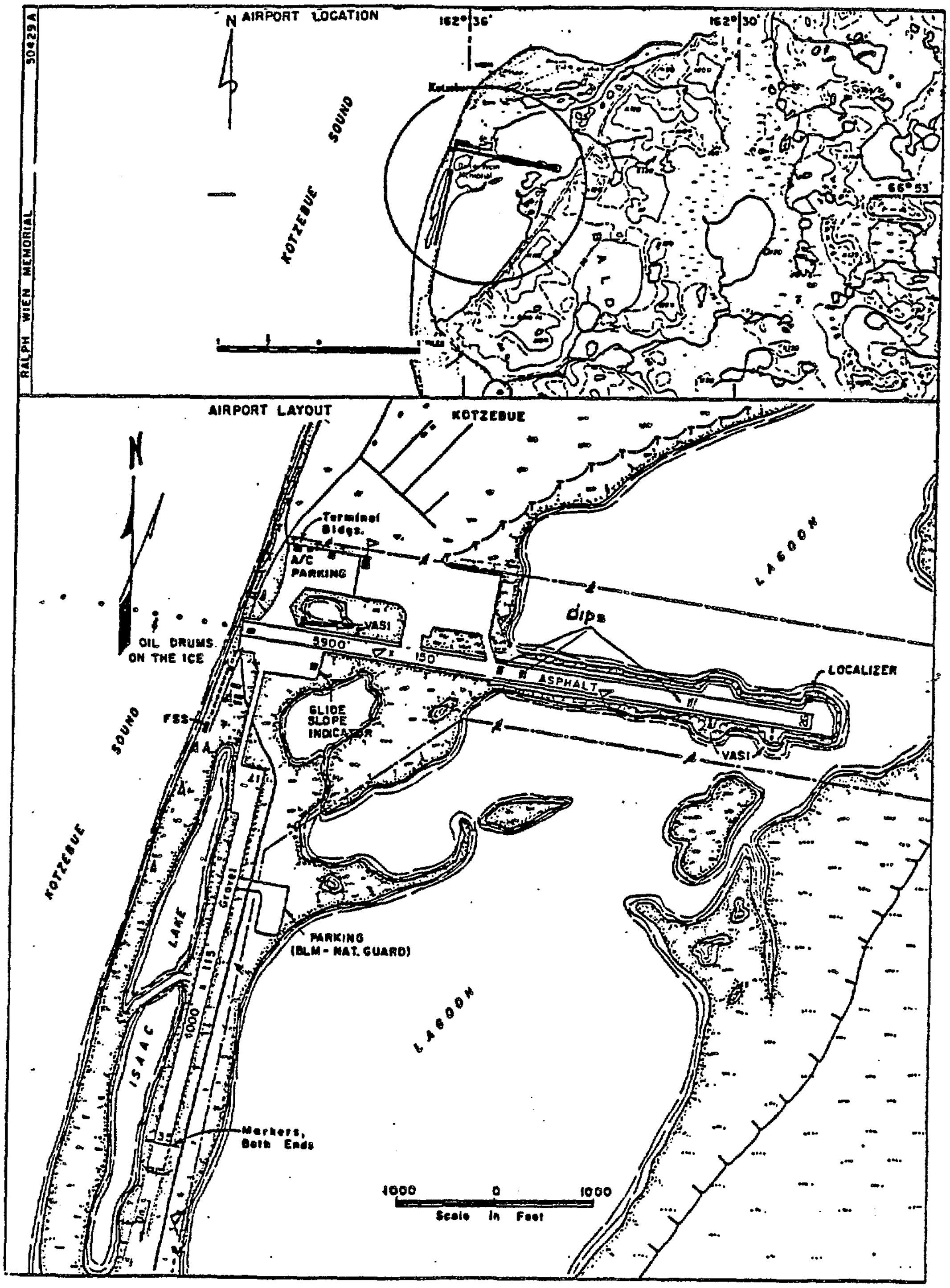


FIGURE 12

KOTZEBUE AIRPORT LAYOUT

SOURCE: U.S. Department of Transportation,
Federal Aviation Administration, 1983.

distance measuring equipment (DME), a non-directional beacon (NDB), runway visual range (RVR) equipment, arid a VHF direction finder.

Terminal facilities include a passenger terminal operated by Wien, a separate cargo building also operated by Wien, provisions for minor aircraft and engine repair, and a control tower. There is also fuel and oil available.

Scheduled passenger service is provided to Kotzebue from Anchorage and Fairbanks by Alaska Airlines and Wien Airlines. From Anchorage and from Fairbanks Alaska Airlines flies to Kotzebue ten times per week in the winter and 12 times per week during the summer. Wien Airlines flies between Anchorage and Kotzebue ten times per week during the winter and 21 times per week in the summer. From Fairbanks, Wien Airlines serves Kotzebue 12 times per week in the summer and 7 times per week during the winter.

Air taxi service is provided by five companies based at Kotzebue airport. These are identified in Table 14. All of these operators are permitted to provide air taxi service using aircraft with capacities not exceeding 7,500 pounds of cargo or 30 passengers.

Emplaned passengers, freight, and mail cargo volumes for Kotzebue over the period 1974-1981 are summarized in Table 15. Average annual growth

TABLE 14

AIR CARRIERS BASHI IN KOTZEBUE

Air Carrier	Operating Authority
Alaska Airships	Air Taxi
Baker Aviation, Inc.	Air Taxi
Northwestern Aviation	Air Taxi
Shellabarger Flying Service	Air Taxi
Walker Air Service	Air Taxi

Source: Air Carrier Certificates, Scope of Operating Rights (Alaska Transportation Commission, 1983)

TABLE 15

ENPLANED PASSENGERS, FREIGHT, AND MAIL - KOTZEBUE, ALASKA
1974 - 1982

Year	Enplaned Passengers	Freight (1)	U.S. Mail(1)
1974	29,674	1,809.21	1,148.86
1975	22,208	835.82	1,433.84
1976	27,379	906.46	1,488.65
1977	22,896	408.16	1,413.43
1978	23,557	294.37	1,268.57
1979	25,814	365.26	1,645.60
1980	32,098	1,203.16	1,425.26
1981	34,320	118.83	3,913.51
1982	32,919	2,088.89	2,375.02

NOTES: (1) Revenue tons only.

SOURCE: U.S. Department of Transportation,
Federal Aviation Administration
and Civil Aeronautics Board, Annual.

in passenger enplanments was about 2.2 percent over the period shown. Mail tonnage has increased 340 percent over the period, while freight tonnage has declined 93 percent. The precise reason for the decline in freight tonnage is not apparent from available data.

Kivalina

The airport at Kivalina is currently classified as part of the state system of secondary airports. Figure 13 identifies the location and general layout of this airport. The landing facilities consist of a single runway, number 11-29, constructed of pierced steel mat, which is 604 m (1,980 ft) long and 18 m (60 ft) wide. The airport is owned and operated by the Alaska Department of Transportation and Public Facilities. Since the airport has no lighting or approach aids except for reflective runway edge markers, the airport can only operate under visual flight rules (VFR).

The airport has several limitations that affect its utilization. The relatively short runway length is the major limitation to increased traffic at Kivalina, as is the condition of the runway. This limitation is expected to be removed during 1985 with construction of a new 914 m (3,000 ft) runway. The theoretical capacity of the existing airfield is guided by the fact that it has a single runway with no taxiway, a very poor quality runway surface, and is generally restricted to VFR , conditions. A single runway with no restrictions can theoretically

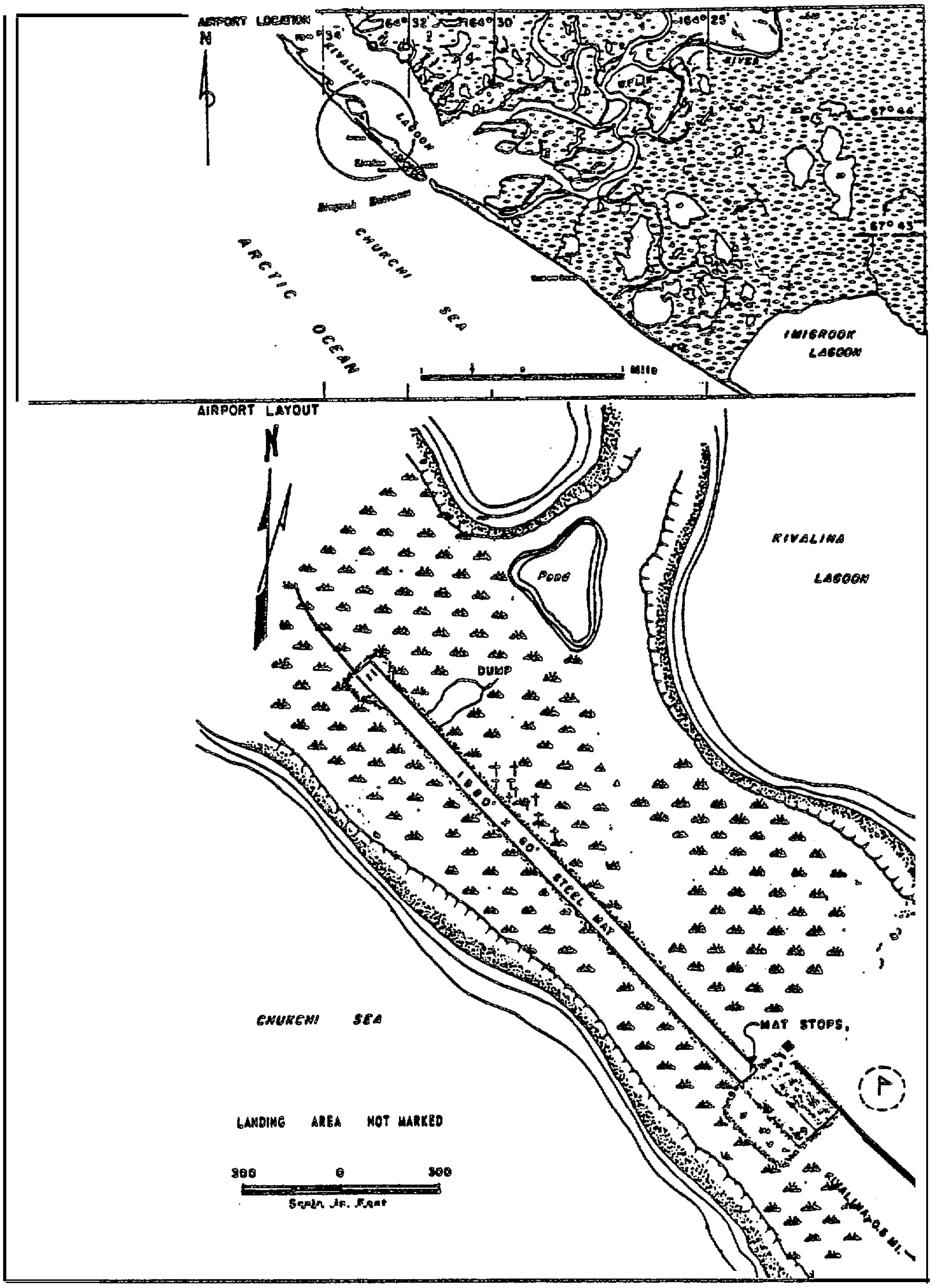


FIGURE 13

KIVALINA AIRPORT LAYOUT

SOURCE: U.S. Department of Transportation, Federal Aviation Administration, 1983.

handle somewhere between 45 and 60 operations per hour (Horonjeff, R., 1975). The lack of a taxiway and the poor condition of the runway is estimated to reduce these limits to one-third of their values. The VFR limitation further confines operations to a 7-hour winter or 16-hour summer period. Weather minimums also contribute to reduced operations, perhaps as much as 40 percent in the summer. Applying these limitations to the theoretical operations capacity produces a range between 36,700 and 72,000 annual operations. Averaging the high and low values and rounding produces an hourly capacity of between 12 and 18 operations with annual capacity then ranging between 43,800 and 65,700 operations. These figures are based on a four month summer period, which provides 1,947 operational hours, and an 8 month winter period, which provides 1,704 operational hours. "The new runway should allow a doubling of annual operations, but more importantly from the standpoint of improved services, will allow larger aircraft to use the airport.

Scheduled air carrier service to Kivalina is provided from Kotzebue by Wien Airlines (through its local subcontractor) twice a week throughout the year. For the 12 month period ending May 28, 1981, air carrier operations numbered approximately 500 while general aviation activities numbered approximately 100. During calendar year 1981, total enplaned passengers at Kivalina numbered 759; freight tonnage was 1.63 tons; and mail tonnage was 5.54 tons (U.S. Department of Transportation, Federal Aviation Administration & Civil Aeronautics Board, Annual). Air taxi service between Kivalina and Kotzebue is available from operator% based in Kotzebue.

Point Hope

The airport at Point Hope is currently classified as part of the state system of secondary airports. Figure 14 identifies the location and general layout of this airport. Landing facilities at Point Hope consist of a 1,219 meter (4,000 feet) long and 30 meter (100 feet) wide grav·l surfaced runway, numbered 1-19. It is owned and operated by the Alaska Department of Transportation and Public Facilities. The airport is equiped with a visual approach slope indicator (VASI) on runway 1, medium intensity runway edge lighting (MIRL), nondirectional radio beacon (NDB), direction finder, and remote communications outlet.

Total operations at the Point Hope airport for the 12 months ended September 2, 1982, were 1,000. Of this number, half of the flights were made by scheduled air taxi operators (under subcontract to Wien) and half by local and itinerant general aviation activities.

Scheduled service to Point Hope from Kotzebue is provided by Wien Airlines. Wien Airlines flies five flights per week during the winter and summer. Scheduled service is provided by Cape Smythe Air Service, Inc. and was also provided by Jen-Air before its demise. Cape Smythe Air Service, Inc. is required under their license with the Alaska

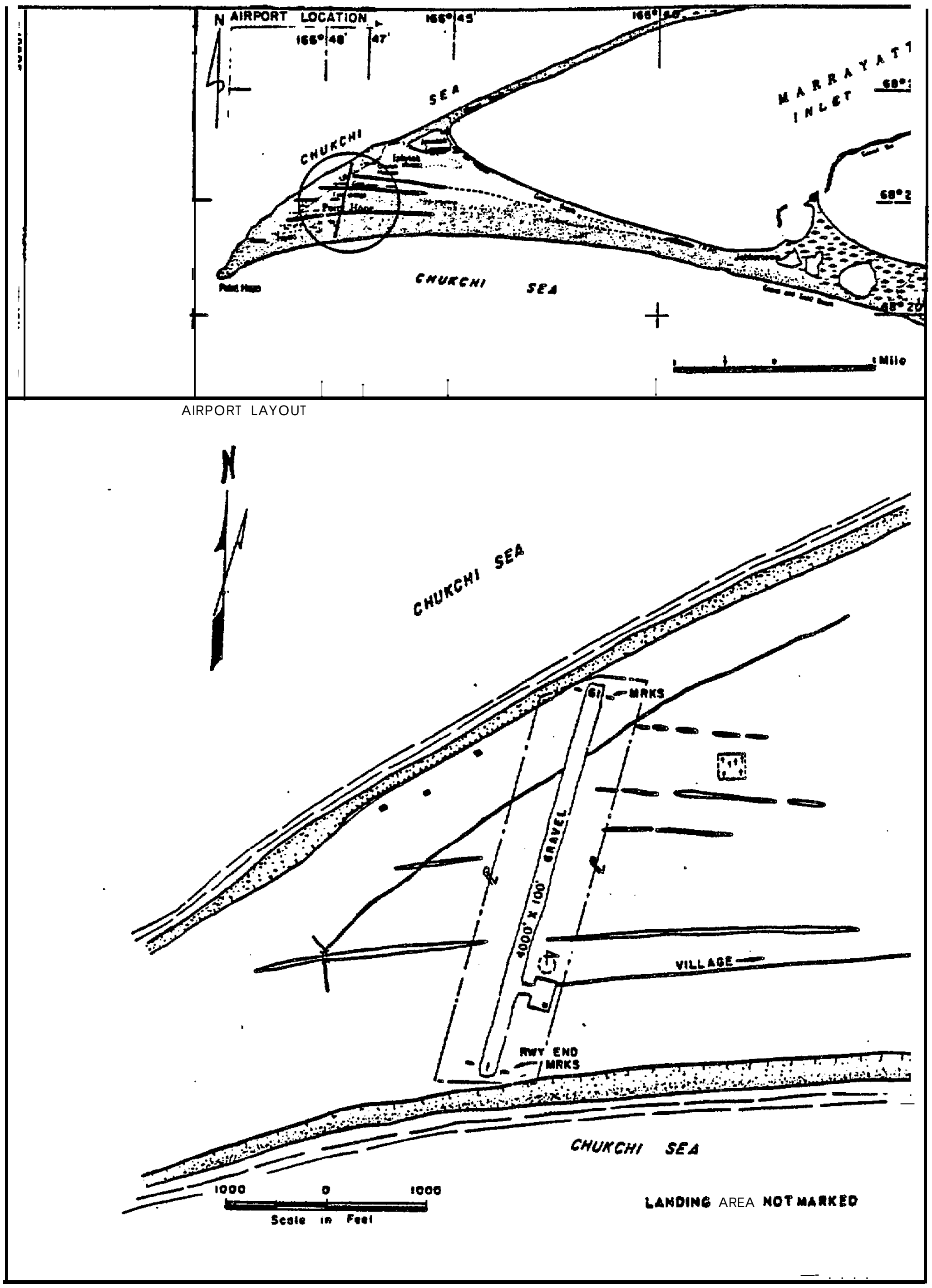


FIGURE 14

POINT HOPE AIRPORT LAYOUT

SOURCE : U.S. Department of Transportation, Federal Aviation Administration, 1983.

Transportation Commission to serve Point Hope from Barrow or Kotzebue a minimum of twice a week. Air taxi service is also available from operators based in Barrow and Kotzebue.

Point Lay

Like other small airports in the region, Point Lay is classified as part of the state system of secondary airports. In fact, two separate runways are located in the vicinity of Point Lay, one serves the adjacent DEW line station and the other served as the local airport before the DEW line station was built. Only the DEW line runway is presented here because only this newer runway is maintained. Figure 15 identifies the location and general layout of the DEW line runway. Landing facilities consist of a single gravel runway, number 5-23, which is 1,072 m (3,519 ft) long and 30 m (100 ft) wide. The airport is operated under a joint-use agreement between the Department of the Air Force and the North Slope Borough. The North Slope Borough has plans to extend the runway to 1,524 m (5,000 ft), which would significantly improve the size and type of aircraft capable of using the field. This change could greatly improve the quality of air service provided Point Lay.

Scheduled service is provided by Cape Smythe Air Service, Inc. which is required to provide service between Barrow or Kotzebue and Point. Lay a minimum of twice a week, under their operating permit with the Alaska

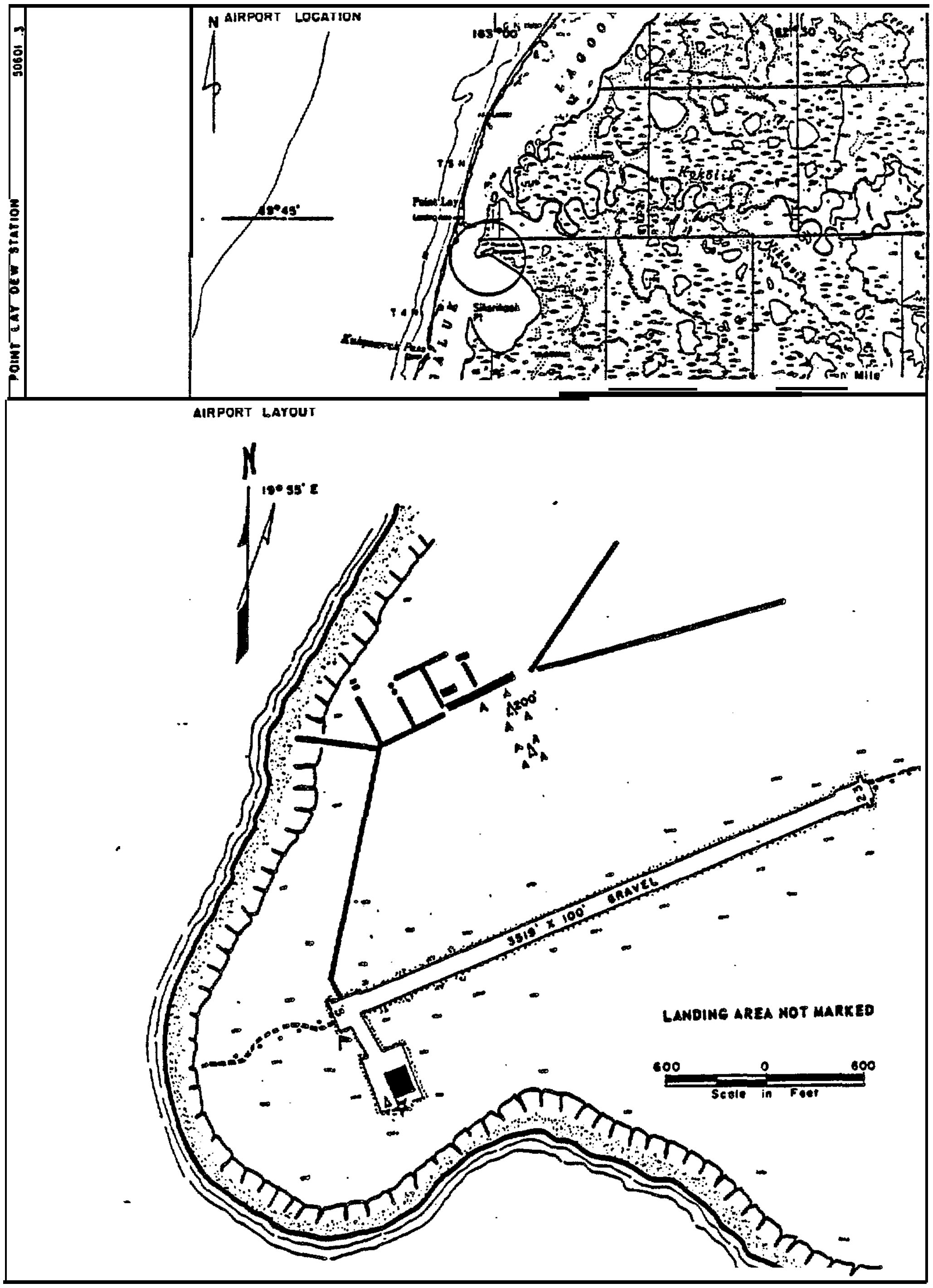


FIGURE 15

POINT LAY AIRPORT LAYOUT

SOURCE: U.S. Department of Transportation,
Federal Aviation Administration, 1983.

Transportation Commission. Before going out of business Jen-Air also operated scheduled flights between Barrow and Point Lay. Charter service is available from air taxi operators located in Kotzebue and Barrow. Operations information for this airport is not available in CAB's Airport Activity Statistics, however, some inference about the level of operations can be obtained from the air carrier's schedules. A flight schedule of twice a week produces 104 departures. Increased by 25 percent for other air taxi operations (26 total) and doubled to account for military traffic produces a figure of about 260 total departures. Assuming the number of landings equal the number of departures, total operations are about 520 annually.

Wainwright

The airport at Wainwright is classified as part of the state system of secondary airports. Like Point Lay, Wainwright has two runways one of which supports the nearby DEW line site. Both landing facilities at Wainwright are gravel surfaced. The North Slope Borough recently completed construction of a new 1,524 m (5,000 ft) long, 46 m (150 ft) wide, runway. The military owned and operated runway is 1,066 meters (3,500 feet) long and30 meters (100 feet) wide. Figure 16 identifies the location and general layout of the Borough's runway.

Scheduled air carrier service to Wainwright is provided from Barrow by Wien Airlines (through its local subcontractor) six times a week

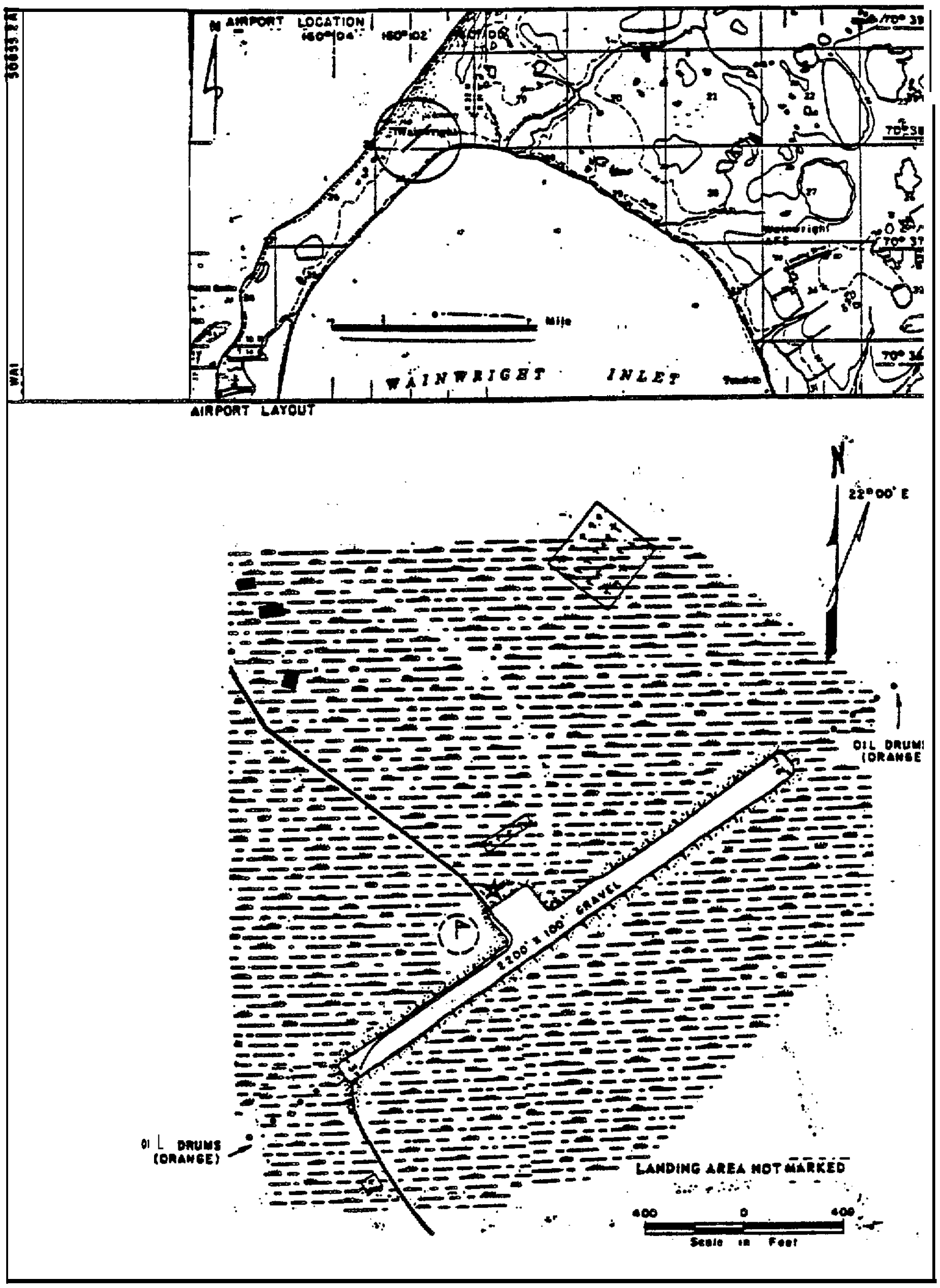


FIGURE 16

WAINWRIGHT AIRPORT LAYOUT

SOURCE: U.S. Department of Transportation,
Federal Aviation Administration, 1983.

throughout the year. For the 12 month period ending December 31, 1981, total departures performed was 471 operations. Enplaned passengers over this same period numbered 1,734, an average of 3.68 passengers per operation. Freight volume was 5.22 tons and mail volume was 8.10 tons. Air taxi service between Wainwright and Barrow is available from operators based in Barrow.

Anchorage International Airport

In addition to serving as principal airport for the Anchorage metropolitan area, the Anchorage International Airport provides a statewide and international service. In 1976, at the peak of the TAPS pipeline construction, the Anchorage International Airport had two east/west runways: runway 6R-24L (10,900 ft) and 6L-24R (10,500 ft). These are shown in Figure 17, which illustrates the airport layout. Both runways were (and are) served by a parallel east/west taxiway north of the runway system. A shorter north/south runway, 13-31 (4,070 ft) accomodated cross wind operations. That same year, this airport handled 236,000 operations (landings and take-offs), which is 77 percent of the 306,000 operations capacity estimated in the 1971 Master Plan (Quinton-Budlong, 1971). Subsequently, a new north-south runway, runway 14-32 (10,500 ft), has been constructed in place of the older one in order to accommodate larger jets in cross-wind conditions and to alleviate aircraft noise impact east of the airport by placing the majority of aircraft operations over The completed runway raises

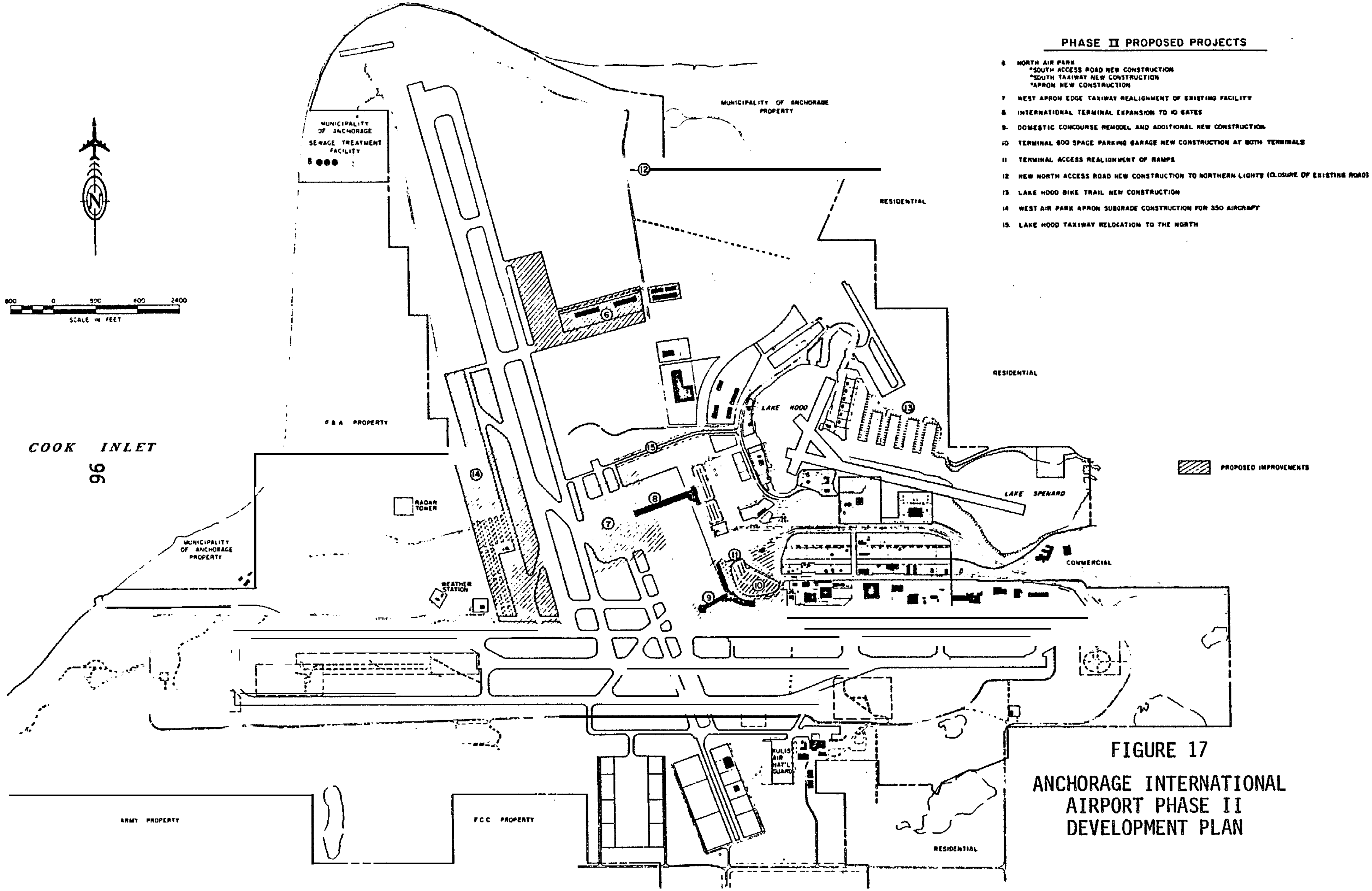


FIGURE 17
ANCHORAGE INTERNATIONAL AIRPORT PHASE II DEVELOPMENT PLAN

Source: A rport Master P an Study, Anchorage International Airport (State of Alaska DOT/PF, 1981b) the airport operational capacity to 334,000 operations, a 9 percent increase.

The total number of enplaned passengers at Anchorage International Airport has demonstrated a relatively steady growth from 1960 to 1976, as presented in Table 16. During 1976, enplaned passengers totaled 944,467. Certified air carriers accounted for 86.4 percent, commuter services for 10.2 percent, and international carriers for the remaining 3.4 percent of the enplanements (Moore, 1978). In 1979, passenger enplanements were approximately 1.12 million persons. Transit passengers, those who simply pass through the airport en route between two other airports, have also demonstrated steady growth since 1960, as shown in Table 17. In 1979, passenger in transit totaled 1.07 million persons. Approximately 3.6 million enplanements and 3.2 million through passengers are forecast by ADOT/PF in its current airport master plan. No specific horizon year is specified in the plan, although ADOT/PF expects these levels of passenger movements to occur by 1995 or 2000 (State of Alaska, Department of Transportation and Public Facilities, 1981b).

The International Airport also serves an important role in moving freight and passengers to, from, and within Alaska. This is evident in the historic growth of inbound and outbound cargo, which is summarized in Table 18. In 1976, throughput tonnage at the airport amounted-to

TABLE 16

ENPLANED PASSENGERS - ANCHORAGE INTERNATIONAL AIRPORT
1960 - 1982

Year	Domestic Passengers: Five Major Carriers	Domestic Passengers: Commuter Carriers	Domestic Passengers: Total Domestic	International Passengers	Total Enplaned Passengers
1960	(1)	(1)	(1)	(1)	118,480
1961					130,387
1962					140,881
1963					156,026
1964					185,384
1965					211,001
1966					224,344
1967					300,609
1968	382,749	1,676	389,824	8,353	398,177
1969	384,445	18,089	420,205	11,542	431,747
1970	365,235	22,214	407,547	9,375	416,942
1971	403,897	28,214	432,646	12,735	445,381
1972	427,925	36,859	464,840	14,563	479,403
1973	453,383	39,050	492,433	20,037	512,470
1974	552,263	52,890	605,153	23,209	628,362
1975	711,648	67,302	778,950	26,528	855,478
1976	815,817	96,434	912,332	32,135	944,467
1977			833,791	28,183	861,974
1978			850,812	9,652	860,464
1979			885,829	21,327	907,156
1980			872,659	14,349	887,008
1981			938,578	19,799	958,377
1982			1,040,152	1,753	1,041,905

NOTE: (1) Not reported separately until 1968.

SOURCES: For data through 1976: State of Alaska Department-of Transportation and Public Facilities, 1981b.
For data after 1976: U.S. Department of Transportation, Federal Aviation Administration and Civil Aeronautics Board, Annual.

TABLE 17

TRANSIT PASSENGERS
Anchorage International Airport
1960 - 1976

Year	Domestic Inter-& Intra-State	International American Carriers	International Foriegn Carriers	Total Transit Passengers
1960	(1)	(1)	33,650	54,210
1961			43,597	122,483
1962			47,589	121,209
1963			42,856	171,763
1964			62,099	180,900
1965			69,884	167,853
1966			79,424	359,943
1967			97,909	360,631
1968	91,171	304,815	127,692	473,871
1969	95,874	427,622	161,925	659,613
1970	70,702	508,192	221,826	790,317
1971	58,533	411,591	204,806	674,374
1972	48,419	230,246	334,663	612,671
1973	45,955	202,173	491,388	738,947
1974	64,866	248,560	513,852	828,409
1975	107,735	194,977	559,045	861,957
1976	103,113	195,778	622,%3	921,444

Note :
(1) Not reported until 1968.

SOURCE: State of Alaska, Department of Transportation and Public Facilities, 1981b.

TABLE 18

INBOUND AND OUTBOUND CARGO - ANCHORAGE INTERNATIONAL AIRPORT
1960 - 1982

Year	Inbound Cargo (lbs.)	Outbound Cargo (lbs.)	Ratio of Outbound to Inbound	Total Inbound and Outbound(lbs.)
1960	12,627,502	24,919,794	1.97	37,547,296
1961	14,507,499	26,277,533	1.81	40,785,032
1962	14,926,390	27,530,757	1.84	42,457,147
1963	15,159,422	27,898,062	1.84	43,057,484
1964	22,350,000	33,530,500	1.50	55,880,508
1965	20,373,527	31,935,908	1.57	52,309,435
1966	20,611,961	45,011,663	2.18	65,623,624
1967	24,221,696	55,884,882	2.31	80,106,578
1968	27,680,428	70,235,549	2.54	97,915,977
1969	32,498,138	55,504,116	1.71	88,002,254
1970	34,621,429	61,702,914	1.78	96,324,343
1971	42,141,960	73.876.551	1.52	106,018,511
1972	37,993,640	70,272,993	1.85	108,266,633
1973	52,404,785	74,165,742	1.42	126,570,527
1974	74,056,971	97,455,842	1.32	171,512,813
1975	99,226,828	141,329,814	1.42	240,556,642
1976	94,816,531	142,839,555	1.51	237,656,086
1977		104,717,080		
1978		282,839,460		
1979		275,008,780		
1980		328,375,060		
1981		340,479,900		
1982		412,523,540		

SOURCES: For data through 1976: State of Alaska Department of Transportation and Public Facilities, 1981b.
For data after 1976: U.S. Department of Transportation, Federal Aviation Administration and Civil Aeronautics Board, Annual.

107.8 thousand metric tons (118.8 thousand tons), which was 11.1 percent of the Port of Anchorage's throughput for general cargo in that year. By 1979, cargo entering or leaving Anchorage reached one-quarter billion pounds (125 thousand tons) and is forecast by ADOT/PF to reach 1.1 billion pounds (550 thousand tons) by 1996. Transiting cargo, which in 1979 was about 1 billion pounds (500 thousand tons), is forecast to reach 6.2 billion pounds (3.1 million tons) in 1996.

Annual aircraft operations at the airport have exhibited growth trends similar to those for enplaned and transit passengers, as shown in Table 19. In general, air carrier and air taxi operations, as well as general aviation operations have tripled since 1960. Over the same time period, military operations have declined. The overall affect on total airport operations has been a gradual rise in operations from a level of about 96,000 in 1960 to a level of about 210,000 in 1979 (representing average annual growth of about 5.8 percent).

Fairbanks International Airport

The Fairbanks International Airport serves as principal airport for the City of Fairbanks and surrounding areas and is particularly important to the interior region of Alaska. This facility handled 174,528 take-offs and landings in 1980, which is about 40 percent of the runway capacity estimated in the 1980 Master Plan. A diagram of the airport layout is provided in Figure 18. Two runways are paved: runway 1L-19R is 3,139 m

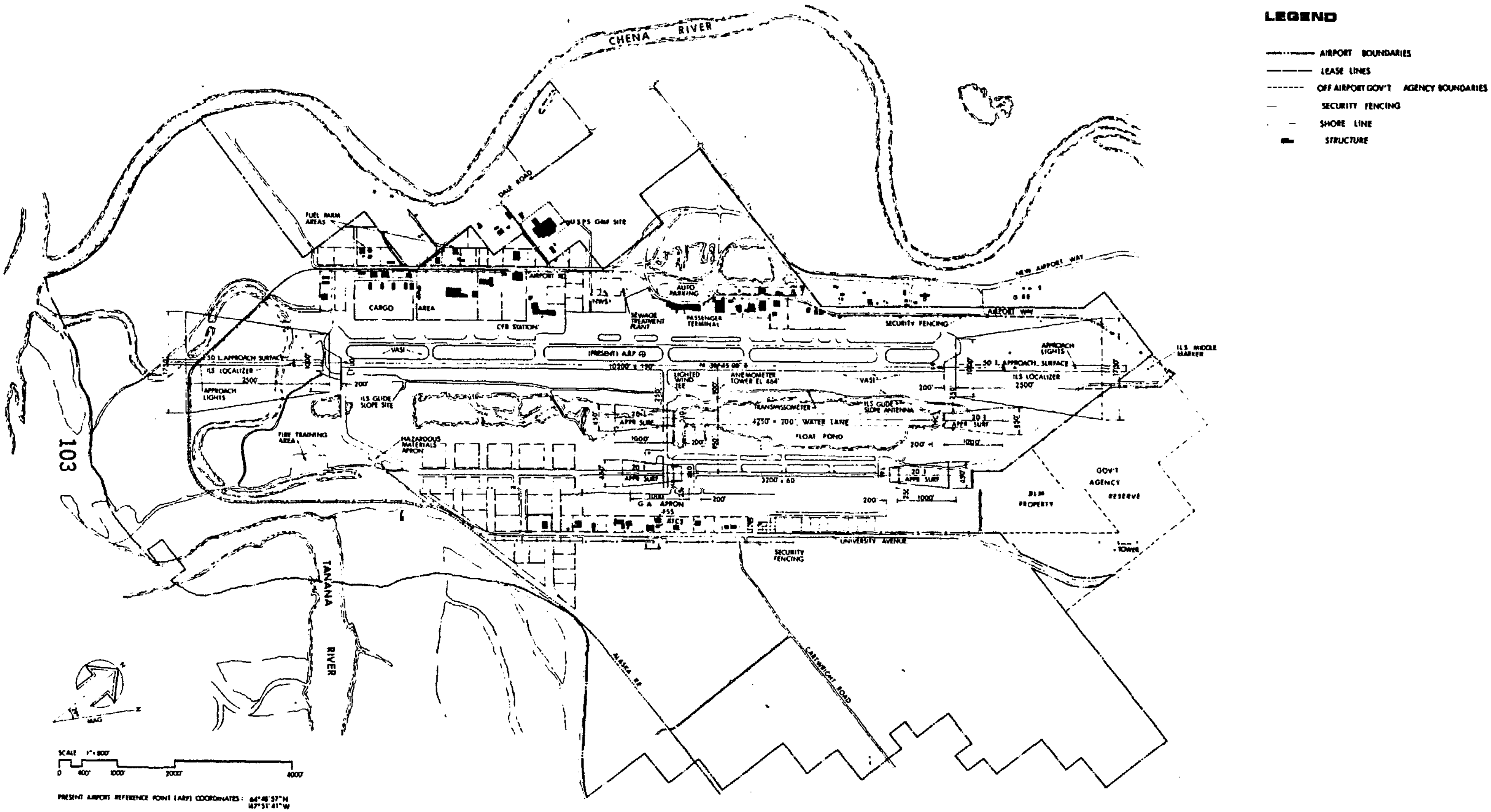


FIGURE 18

FAIRBANKS INTERNATIONAL AIRPORT LAYOUT

Source: Airport Master Plan Study, Fairbanks International Airport, (Unwin, Scheben, Korynta & Huttle; et al., 1980)

TABLE 19

ANNUAL AIRCRAFT OPERATIONS AT N G INTERNATIONAL AIRPORT
1960 - 1979

	Itinerant Operations					Local Operations			
Year	Air Carrier	Air taxi	General Aviation	Military	Total	Civil	Military	Total	Total Operations
1960	28,364	(1)	25,273	11,325	64,962	20,405	10,543	30,948	95,910
1961	35,958		21,689	12,902	70,549	12,256	7,635	19,891	90,440
1962	35,420		19,405	8,103	62,928	16,007	6,659	22,661	85,594
1963	30,022		17,414	3,436	50,872	17,111	5,855	22,966	73,833
1964	18,490		19,113	1,680	40,283	15,086	4,556	19,641	59,924
1965	23,723		25,869	2,219	51,811	26,778	3,892	30,670	82,481
1966	30,254		36,689	2,135	69,078	32,214	2,889	35,103	104,181
1967	39,927		47,852	2,495	90,274	39,980	3,683	43,663	133,937
1968	44,145		50,450	2,272	96,867	64,652	3,478	68,130	164,997
1969	50,271		50,398	1,976	102,645	50,558	1,853	52,411	155,056
1970	46,597		44,748	2,296	93,641	45,690	2,582	48,278	141,913
1971	45,789	3,989	39,586	2,337	91,701	51,880	2,095	53,975	45,676
1972	45,997	6,984	51,899	2,539	107,419	63,852	2,917	66,769	174,188
1973	43,067	8,601	53,213	2,600	107,481	64,301	2,641	66,942	174,423
1974	49,076	11,692	59,688	2,405	122,861	68,440	1,724	70,164	193,025
1975	56,068	17,155	64,145	2,433	139,801	66,497	1,322	67,819	207,620
1976	56,992	31,936	76,909	1,550	167,387	80,997	970	81,967	249,354
1977	56,408	33,078	89,937	1,974	187,398	71,184	776	71,960	259,358
1978	60,822	39,872	81,313	1,985	183,992	36,445	482	36,927	220,918
1979	61,923	32,817	77,663	2,791	175,194	32,557	n.a.	32,557	207,751

Note:
(1) For years prior to 1971, Air Taxi operations where recorded under General Aviation.

n.a. = Not avai ab e.

SOURCE: Peat, Marwick Mitchell & Co. and Unwin, Scheben, Korynta, and Huettl, Inc., 1981.

(10,300 ft) long; runway 1R-19L is 975 m (3,200 ft) long. A gravel taxiway (T-4) south of runway 1R-19L is used in the summer as a 1096 m (3,600 ft) runway for aircraft equipped with large tundra-tires and in the winter for aircraft equipped with skis. This gravel strip can also be used by other small aircraft at their own discretion.

During 1979, enplaned passengers totaled 242,783 representing a 4.0 percent annual average growth rate over the period since 1970. This growth is evident in Table 20, which summarizes enplaned passengers, cargo and revenue landings over the period 1970-1979. In general, the latter two subjects in Table 20, have actually declined: enplaned cargo by almost 29 percent; and revenue landings by almost 31 percent. As many as 387,000 enplaned passengers are forecast by ADOT/PF for fiscal year 1985 and 721,000 enplaned passengers are forecast for fiscal year 2000.

Like Anchorage, this airport serves an important role in moving freight and passengers to, from, and within Alaska. In 1979, throughput tonnage at Fairbanks International Airport amounted to 44,361 metric tons (shown as 48,797 tons in Table 20). By comparison, this volume is about 39 percent of the tonnage moved through Anchorage International Airport during the same year. Cargo tonnage is forecast to be 70,000 metric tons (77,000 tons) by 1985; 86,364 metric tons (95,000 tons) by 1990; and 130,909 metric tons (144,000 tons) by the year 2000 (Unwin, Scheben,

TABLE 20

ENPLANED PASSENGERS AND CARGO AND LANDING OPERATIONS (1)
FAIRBANKS INTERNATIONAL AIRPORT
1970 - 1982

Year	Enplaned Passengers	Cargo (2)	Revenue Landings
1970	172,805	68,474	18,970
1971	149,589	43,621	11,525
1972	146, 635	38,604	9,977
1973	142,073	33,765	8,189
1974	164,183	69,662	13,669
1975	.293,429	188,413	28,556
1976	357,359	105,863	22,601
1977	327, 990	59,955	12,717
1978	265,202	63,817	14,298
1979	242,783	48,797	13,136
1980	206,836	7, 470	
1981	239,195	13,131	
1982	269,740	15,484	

NOTES: (1) Data through 1979 includes both CAB-Certified airlines and commuter airlines. After 1979, only CAB-Certified airlines are included.
(2) Cargo data includes freight, express, and mail.

SOURCES: For data through 1979: Unwin, Scheben, Korynta, and Huettl, et al., 1980.
For data after 1979: U.S. Department of Transportation, Federal Aviation Administration and Civil Aeronautics Board, Annual.

Korynta, and Huttle; et al., 1980).

The growth in aircraft operations at Fairbanks International Airport has averaged about 13.2 percent per year since 1960. Historical growth patterns for the period 1960 - 1980 can be observed in Table 21. Air carrier operations grew at an average rate of about 1 percent per year. General aviation, on the other hand, appears to have made significant growth, almost quadrupling when the two general aviation categories are considered together. Military operations have remained fairly constant over the time period, while air taxi operations have declined as much as 69 percent since 1975. Part of this decline can be attributed to improvements in scheduled services; part of the decline can be attributed to the fall off in activities related to the TAPS pipeline.

AIR TRANSPORTATION OPERATORS

Air Carriers

The Alaska Transportation Commission (ATC) regulates all common air carriers operating within the State of Alaska and jointly regulates with the Civil Aeronautics Board (CAB) those carriers that operate interstate routes.

The only air carriers presently servicing the Barrow Arch region (Barrow, Kivalina, Kotzebue, Point Hope, Point Lay, and Wainwright) are

TABLE 21

HISTORICAL AIRCRAFT OPERATIONS
Fairbanks International Airport
Fiscal Years 1960 - 1980

Year	Air Carrier	Air Taxi	General Aviation Itinerant	General Aviation Local	Military	Total Operations
1960	17,764	(1)	21,475	14,640	3,086	65,965
1965	9,537		17,714	8,627	3,365	39,243
1970	31,277		42,880	32,089	724	106,970
1971	19,331		41,716	36,494	1,186	98,727
1972	14,536		48,497	42,194	1,934	107,161
1973	11,561		54,759	57,355	2,200	125,875
1974	13,056		67,531	59,624	2,062	142,273
1975	18,490	46,218	51,154	63,013	1,490	180,365
1976	19,334	37,272	49,633	83,877	1,358	191,474
1977	15,872	32,731	54,644	103,563	1,411	208,221
1978	13,205	26,905	49,413	74,932	1,398	165,853
1979	19,292	15,139	47,262	63,649	1,485	146,827
1980	21,434	14,361	59,917	76,799	2,017	174,528

NOTE:
(1) Not reported until FY 1975. Includes commuter airline operations.

SOURCE: Unwin, Scheben, Korynta, and Huettl, Inc., 1981.

Wien Airlines, Alaska Airlines, and other smaller carriers such as Cape Smythe Air Service, Inc. based in Barrow. Some of these air carriers are required to provide a minimum service of two flights per week into the smaller communities. Table 22 summarizes the routes each carrier currently operates and identifies the number of flights summer and winter.

Air Taxi

Air Taxi carriers operate from fixed bases of operation that are specified in their operating rights. Although most operate aircraft with certified gross take-off weights less than 5,670 kilograms. (12,500 pounds), the ATC has authority to grant certificates to operators having larger aircraft. Operators must provide "safe, adequate, efficient, and continuous service from and maintain bases of operation at listed locations (in their operating rights)" (Alaska Transportation Commission, 1983). Air taxi operators specialize in serving locations inaccessible by highway. Examples of air taxi operators serving the Barrow Arch area are Cape Smythe Air Service, Inc., and Barrow Air, Inc., both based in Barrow, and the following based in Kotzebue: Alaska Airships, Baker Aviation, Inc., Northwestern Aviation, Shellabarger Flying Service, and Walker Air Service. Jen-Air, before going out of business, also provided an air taxi service from Barrow.

TABLE 22

PASSENGER SERVICE PROVIDED BY SCHEDULED CARRIERS
(Measured in Flights Per Week)

Scheduled Carrier	Route	Summer Service	Winter Service
Wien Airlines	Anchorage-Barrow	22	7
	Anchorage-Kotzebue	21	10
	Anchorage-Prudhoe Bay	26	31
	Barrow-Wainwright		6
	Fairbanks-Barrow	22	11
	Fairbanks-Kotzebue	7	12
	Fairbanks-Prudhoe Bay	14	15
	Kotzebue-Kivalina		2
	Kotzebue-Point Hope		5
Alaska Airlines	Anchorage-Kotzebue	12	10
	Anchorage-Prudhoe Bay	21	
	Fairbanks-Kotzebue	12	10
	Fairbanks-Prudhoe Bay	7	

Source: Carriers schedules.

Contract Carriers

Contract carriers are private for-hire carriers who are not generally restricted by location in their operating authorities. They operate under one or more contracts of a continuing nature for a limited number of persons, as in a charter service, or they perform a specialized service for specific individuals or concerns. The principal contract carrier in the study area is MarkAir (formerly Alaska International Air), who maintains a hanger-office in Barrow.

Scheduled-Carriers

Scheduled carriers offer services to the public generally and operate aircraft between paired points. The primary source of revenue is individual passenger fares or per pound cargo rates. The Alaska Transportation Commission has only one category of scheduled carriers, but the CAB makes a distinction between major trunk airlines and commuter services. Commuter services are considered to fly aircraft with gross weights less than 5,670 kilograms (12,500 pounds), and trunk airlines are those that offer flights greater than 805 km (500 mi), usually with jet service. Wein Airlines and Alaska Airlines are the only trunk airlines operating scheduled service in the area. Due to airline deregulation, other airlines would probably like to enter this market. Until recently, there were two commuter airlines operating in the study area: Cape Smythe Air Service, Inc. and Jen-Air.

Since Jen-Air went out of business Cape Smythe has no competition for these services.

REGULATIONS

The Federal Aviation Administration within the U.S. Department of Transportation, through its flight standards program, "promotes safety of flight of civil aircraft in air commerce by assuring the airworthiness of aircraft, the competence of airmen, the accuracy of navigational aids and the adequacy of flight procedures in air operations," (U.S. Dept. of Transportation, Federal Aviation Administration, Alaska Region, 1981). To accomplish these goals, FAA personnel inspect, evaluate, review and certify as appropriate, aircraft, air carriers, general aviation activities, and navigational aids. Also, the FAA provides a large percentage of funds used in Alaska to upgrade runways and landing aids at airports. Grants can be provided to either the State of Alaska, local governments, or other eligible political subdivisions. The State of Alaska, Department of Transportation and Public Facilities operate the Anchorage and Fairbanks International Airports, and controls design standards for other airports at: Barrow, Kivalina, Kotzebue, Point Hope, Point Lay, and Wainwright.

Fares and routes fall under the jurisdiction of the Civil Aeronautics Board for interstate carrriers and the Alaska Transportation Commission for intrastate carriers. In the spring of 1979, decisions were made in the West Coast Service Investigations that authorized additional routes for all certified carriers who were a party to the investigations. The Board's policy of deregulation is designed to increase service yet, at the same time, maintain acceptable profits for the carriers. Guidelines are being established that will guarantee essential service to small communities. Communities served by none or one certified air carrier would be eligible for subsidies. For planning purposes, the CAB recognizes Anchorage, Fairbanks, and Juneau as the State's transportation hubs.

Interstate air freight transportation has been deregulated by the CAB; deregulation of interstate air passenger transportation is proceeding on a five-year timetable.

TECHNOLOGY

Major trunk carriers, because of the long distances they serve, can benefit from new generations of aircraft that have increased performance and lower operating costs. The Boeing 757 and 767 series of aircraft are excellent examples. The major commuter airlines may also benefit from the newer generations of aircraft. However, the smaller airlines, who operate over relatively short distances, may not benefit at all, either because they lack the financial capacity to purchase the equipment., or because much of the equipment cannot be used effectively on the routes they serve.

Technology improvements are occurring in rotary wing as well as fixed wing aircraft. Boeing-Vertol is marketing the commercial version of its Chinook helicopter developed originally for the military. Fitted for passenger use, it has a capacity of 44 pasengers and a range of 982 kilometers (600 miles). This helicopter is already in use transporting personnel to and from platforms in the North Sea. The cargo version has a shorter range, but it has lifting capability of up to 12.7 metric tons (14 tons) (Louis Berger and Associates, et al., 1979).

According to the WAATS study, major breakthroughs are not expected in those areas of aviation technology that could have a significant impact on aviation in western Alaska. However, modest improvements in short take-off and landing (STOL) capabilities are expected to continue, along with a slow but steady improvement in aircraft operating characteristics and economy. It is probable that increased application of existing technologies in terms of ground-to-wound communications and weather reporting will have greater impact on increased aircraft utilization, economy and reliability of service in western Alaska than will new technologies.

Highway Transportation

Major elements of the Alaska highway network are illustrated in Figure 19. Of particular interest to this study are those highways that provide an overland link between the southcentral ports of Anchorage, Whittier, Seward, and Valdez and the current oil and gas development on the North Slope. These highways of interest are indicated in bold on Figure 19, and include the Parks Highway, Richardson Highway, Dalton Highway, and portions of the Elliott Highway.

FACILITIES AND TRAFFIC

The facilities of the highway system are primarily the traveled roadways and bridges. A description of each of the relevant highways is included below. Each description includes, where information was available, general highway design characteristics such as roadway width and pavement condition, as well as highway capacity and level of service. A brief explanation of highway capacity and level of service are presented in the following paragraphs.

The capacity of a highway is the measure of its ability to accommodate a stream of moving vehicles. Thus, highway capacity is a rate not a quantity. Several factors including roadway conditions, vehicle performance, operational controls, and environmental elements, among

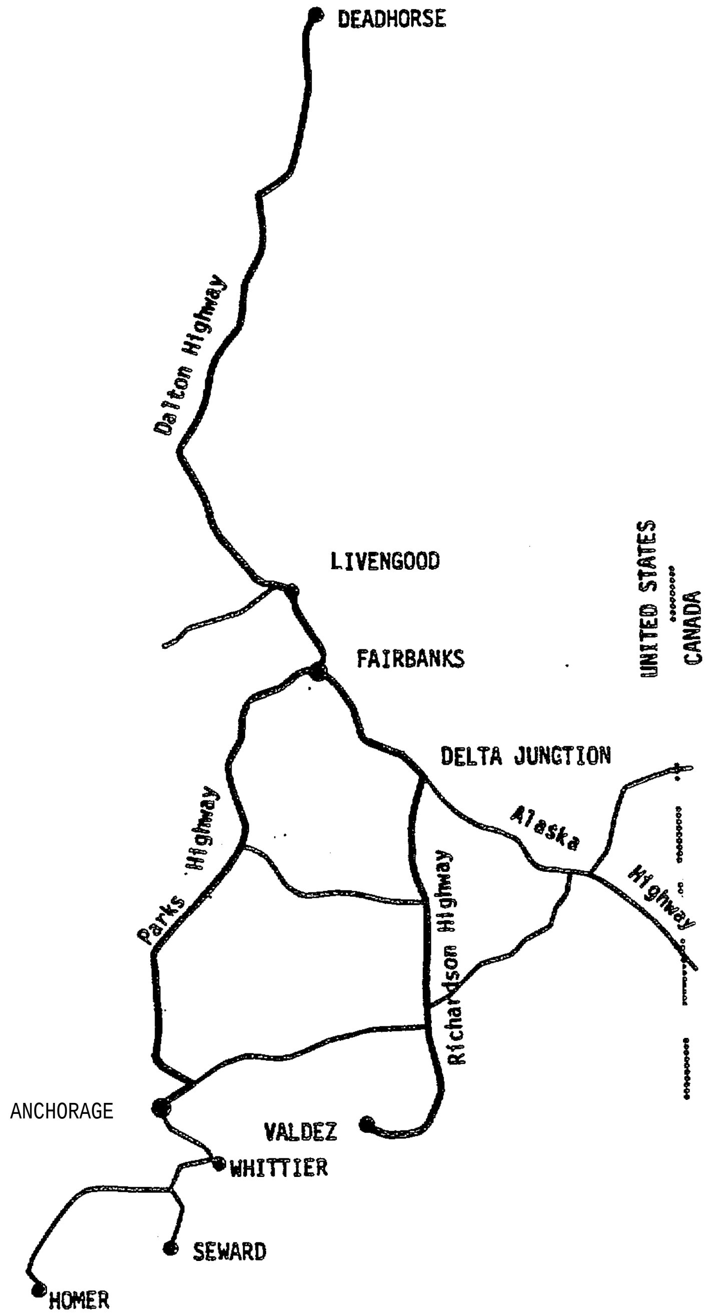


FIGURE 19

ALASKA HIGHWAY SYSTEM SERVING PRUDHOE BAY

SOURCE: ERE Systems, Ltd.

others, affect the maximum service rate or “capacity” of a highway. Under ideal conditions the capacity of a single traffic lane would probably be in the range of 2,400 passenger vehicles per hour. Actual traffic conditions differ from the ideal, however, and adjustments must be made for such things as intersections, pedestrian traffic, the number of trucks, width of the road, horizontal and vertical alignment (curves and grades), restricted passing sight distances (on two- and three-lane highways), and other factors. The consequence of these adjustments is a much lower operating capacity.

For example, the capacity of a highway with lanes 10 feet wide is 19 percent less than a highway with lanes 12 feet wide (the accepted standard), all other factors being equal. If a highway has 12 foot lanes, but also has obstructions (such as electric or telephone poles) within 2 feet of the pavement edge, the effective width of the lanes is reduced to about 10 feet and capacity is reduced 17 percent from the accepted 12 foot 1 ane standard (See Highway Research Board, 1965). The combination of narrow lanes and obstructions further reduce capacity. In the example above the reduction ranges from 25 to 37 percent depending on traffic flow conditions and whether or nor obstructions are on one or both sides of the lane. Similar adjustments to ideal capacity can be made for the various other factors that affect capacity. These adjustments can be made individually or in different combinations.

Level of service is a qualitative measure of a combination of factors including speed, comfort, convenience, economy and safety. Based on experience, the travel speed and the ratio of service volume to capacity have been identified as the two most important factors affecting level of service. The level of service is rated from "A" to "F", as generally defined below.

- Level of Service A - describes a condition of free flow, with low volumes and high speeds. Traffic density is low, with speeds controlled by driver desires, speed limits, and physical roadway conditions. There is little or no restriction in maneuverability due to the presence of other vehicles, and drivers can maintain their desired speeds with little or no delay.

- Level of Service B - is within the zone of stable flow, with operating speeds beginning to be restricted somewhat by traffic conditions. Drivers still have reasonable freedom to select their speed and lane without the likelyhood of restricting traffic flow. The lower limit (lowest speed, highest volume) of this level of service has been associated with service volumes used in the design of rural highways.

- Level of Service C - is also within the zone of stable flow, but speeds and maneuverability are more closely controlled by the higher volumes. Most of the drivers are restricted in their freedom to select their own speed, change lanes, or pass. A relatively satisfactory operating speed is still obtained, with service volumes perhaps suitable for urban design practice.

- Level of Service D - approaches unstable flow, with tolerable operating speeds being maintained though considerably affected by changes in operating conditions. Fluctuations in volume and temporary restrictions to flow may cause substantial drops in operating speeds, Drivers have little freedom to maneuver, and comfort and convenience are low, but conditions can be tolerated for short periods of time.

- Level of Service E - represents operations at much lower operating speeds than level of service D, with volumes at or near the capacity of the highway. At capacity, speeds are typically, but not always, in the neighborhood of 30 mph. Flow is unstable, and there may be stoppages of momentary duration.

- Level of Service F - describes forced flow operations at low speeds, where volumes are below capacity. These conditions usually result from queues of vehicles backing up from a restriction downroad. Speeds are reduced substantially and stoppages may occur for short or long periods of time because of the downroad congestion. In the extreme, both speed and volume can drop to zero.

Dalton Highway - Elliot Highway

What is now named the Dalton Highway was formerly the North Slope Haul Road. It has also been referred to as the Prudhoe Bay Highway (see State of Alaska, Department of Transportation and Public Facilities, 1982b). The road is a two lane gravel highway extending from the Elliott Highway near Livengood north to the Prudhoe Bay oil fields. North of the Yukon River Bridge, this road was constructed as part of the Trans-Alaska Pipeline System.

The haul road was constructed 8.5 m (28 ft) wide with two traffic lanes. It has a gravel base of three to six feet depending on soil conditions and was constructed by dumping fill directly on the original soil surface (Bechtel, Inc., 1974).

Bridges at major creek and river crossings are timber with steel pilings. They were built in 6.1 and 9.1 m (20 and 30 ft) span lengths. The State of Alaska built the Yukon River Bridge, others were built by the Alyeska Pipeline Service Company.

Permanent access roads were constructed from the main road to the pump stations and to a few sites at which unmanned communications equipment is located. Temporary roads were provided for access to pipeline right-of-way material sites and some valve locations.

Until recently, the Dalton Highway was a private road which allowed travel by permit only, and permits were issued only to those with bonafide reasons to use the road. Prior to assuming responsibility for this highway, the State studied several alternatives pertaining to use of the road. These alternatives included seasonal industrial use (primarily petroleum related), year-round industrial use, and three combinations of year-round industrial use with variations in seasonality and the degree of public access (see State of Alaska, Office of The Govenor, Division of Policy Development & Planning, 1977). The state choose to allow seasonal (summer) public access as far as the Yukon River bridge in 1976, and in 1981 extended public access almost as far as the North Slope Borough boundary.

South of the Yukon River bridge, there are campgrounds and trail access points, as well as a gas station at the bridge. North of the bridge, 200 miles of highway are open to the public. However, there are only two recreation areas with toilets and trash pickup along this stretch of road, and only one gas station located at Coldfoot.

In March 1982, the Bureau of Land Management (BLM) issued 30-year leases for public facilities at the Yukon River Bridge and at Coldfoot. Both sites are expected to include a gas station and a lodge. A restaurant, store, and guest quarters were to be added to existing facilities at Coldfoot during 1983. The present facilities at the Yukon River Bridge will remain in operation through 1985, when they are expected to be replaced by a new lodge and camping accommodations. Once these facilities are in place, an increase in recreational travel on the Dalton Highway at least as far as Coldfoot can be expected.

Historic traffic patterns along the Dalton Highway are shown as Annual Average Daily Taffic (AADT) in Table 23. Traffic volumes on the Fox-Livengood link (Elliot Highway) were fairly constant between 1970 and 1973, with AADT of 58. Pipeline construction increased AADT over this link to 263 in 1974 and to 750 in 1975. Following completion of the pipeline, AADT declined to 470 in 1977 and 400 in 1978. After 1978, as more oil fields were developed on the North Slope, traffic again increased. Contributing to the rise in traffic volumes since then is tourist related travel attracted to the public access portions of the highway and other local travel brought on by a gradually improving economic situation in Fairbanks.

TABLE 23

ANNUAL AVERAGE DAILY TRAFFIC (AADT) ON THE DALTON HIGHWAY (1)
At Specified Counter Locations
(1977 - 1981)

Year	Chena River Fairbanks mile .57	N. of Fox Springs mile 11.56	Mt. Caribou mile 186
1977	10945	(2)	(3)
1978	11873		
1979	11673	494	
1980	12048	655	
1981	13830	659	139

Notes:

(1) The Alaska Department of Transportation and Public Facilities previously refered to this highway as the Prudhoe.

(2) The Fox Springs counter was not operating prior to 1979.

(3) The Mt. Caribou counter was not operating prior to 1981.

SOURCE: State of Alaska, Department of Transportation and Public Facilities, 1982b.

During 1981, ADOT/PF placed a traffic counter farther north at Caribou Mountain (about 60 miles north of the Yukon River Bridge), thereby providing a glimpse at the patterns of predominately petroleum related highway traffic. AADT along this northern segment of the highway was 139 in 1981, the first year measured. Approximatley 66 percent of the traffic on the Dalton Highway is estimated to include large trucks (Louis Berger & Associates, Inc., et al., 1982). These trucks haul construction equipment, drill pipe, cement, drilling mud, cable, machinery, fuel, and food. Virtually all the remaining vehicles along this portion of the highway are also associated with petroleum development.

Monthly average daily traffic ranged from 166 to 180 vehicles during the period April through August 1981 with little variation month to month. During the other months of the year, monthly average daily traffic ranged from 106 to 117 vehicles per day, also with little variation month to month. The highest recorded 24 hour traffic level was 252 vehicles (about 181.3 percent of AADT) during August. The 30th highest hourly volume (also referred to as the "Design Hourly Volume") was 18 vehicles, or approximately 12.9 percent of AADT. This volume was also recorded in August.

During the course of an average day, hourly traffic counts between 10 a.m. and 5 p.m. average about 6.0 percent of daily traffic with a peak of about 6.3 percent between 1 and 2 p.m. The low period of the day is the hours between 1 and 7 a.m., which average about 1.5 percent of daily traffic. The lowest percentage by hour, 1.0 percent, occurs between 4 and 5 a.m. During the remainder of the hours from 7 to 10 a.m. and from 5 p.m. to 1 a.m. traffic averages 4.5 percent of daily traffic. This pattern of usage can best be explained by the continuous sunshine during the summer months in combination with the heavy demand period.

A breakdown of traffic by type of commodity is given in Table 24. This table shows weekly traffic counts for selected one week periods in fall, winter, and spring and also shows average truck load weights over two one-year periods. Excluding the miscellaneous and empty categories, the construction materials category and the oil drilling materials and equipment category dominate truck traffic volumes. The average truck weights shown are tare weights (weight without the container - i.e. weight of the load) for semi-trailers.

The capacity of the Dalton Highway is influenced by the terrain, the large percentage of trucks in the traffic stream, condition of the road, and environmental factors including blowing dust and snow, ice, and the winter darkness. Although there are no established data on the capacity of two lane gravel surfaced roads, the following attempts to establish a service volume for the Dalton Highway for purposes of this analysis. The formula used is:

TABLE 24

WEEKLY TRAFFIC COUNTS AND AVERAGE TRUCK LOAD WEIGHTS BY COMMODITY
DALTON HIGHWAY

Commodity	Weekly Traffic Counts			Average Truck Load Weights in pounds (4)	
	Fall (1)	Minter(2)	Spring(3)	1979	1980
Construction Material	28	46	24	44,606	43,844
Food	7	5	6	37,454	39,184
Fuel	16	18	15	59,219	34,370
Chemicals	9	13	1	40,569	43,328
Oil Drilling Material and Equipment	13	73	90	45,164	59,985
Other Equipment	21	12	19	14,179	36,665
Miscellaneous	47	63	59	31,249	33,545
Empty	76	152	157		
Weekly Total	217	382	371		

Notes : (1) Week of 25 - 31 October 1979.
(2) Week of 25 - 31 January 1980.
(3) Week of 24-30 April 1980.
(4) Tare Weights for Semi -trailers.

SOURCE : Louis Berger & Associates, Inc. et al. 1979.

$$SV = 2{,}000 \times (v/c) \times W1 \times T1$$

in which:

- SV = service volume (mixed vehicles per hour, total for both directions);
- 2,000 = a constant representing the theoretical maximum volume of passenger cars per hour, both directions, on a two lane road;
- v/c = volume to capacity ratio;
- W1 = adjustment for lane width and lateral clearance at given level of service;
- T1 = truck factor at given level of service.

Since no one answer is correct for this analysis, an attempt was made to develop a range of service volume values. A level of service "C" is used in this evaluation. The design speed of the Dalton Highway is 45 mph (Louis Berger & Associates, Inc., et al. 1979). However, trucks operate at an average speed that is lower then this. The operating speed was assumed to be about 40 mph. Stretches of the road where passing sight distances are greater than 1,500 ft were assumed to vary from 80 percent of a given section length in relatively flat rolling areas to as low as 40 percent of a given section length in mountainous terrain. The combination of these assumptions provides a v/c ratio ranging from 0.46 to 0.32 (see Table 10.7, Highway Research Board, 1965).

In adjusting for lateral clearance (factor W1, above), a 12 ft lane width is assumed. To provide a range to this factor, obstructions are assumed to be located two feet from the edge of the traffic lane in one instance and beyond six feet in the other. These conditions create a W1 factor of 0.92 and 1.00 respectively (see Table 10.8, Highway Research Board, 1965). For simplicity, only the smaller value is used here.

The truck factor (T1) is critical to this calculation and is the most difficult to develop. Trucks are currently 66 percent of the traffic mix on the Dalton Highway, as noted earlier. This means that, in a vehicle stream of 46 vehicles per hour (the highest hourly volume observed), approximately 30 vehicles are trucks. On most normal routes, trucks would constitute less than 20 percent of the traffic mix and most capacity analysis data-reflects values for truck percentages at or below 20 percent. To utilize this factor, the truck traffic must be converted to passenger car equivalents. In mountainous terrain at level of service "C", a truck is equal to 10 passenger cars; while in rolling terrain at the same level of service, a truck is equal to only 5 passenger cars (see Table 10.9a, Highway Research Board, 1965). Using the 30 trucks per hour figure produces 300 and 150 equivalent passenger cars. To find the percentage adjustment values, these equivalent passenger cars must be added to the remaining vehicle stream (i.e. 16 vehicles). That is to say in mountainous terrain the 46 mixed vehicles are equivalent to 316 passenger cars, and in rolling terrain the 46 mixed vehicles are equivalent to 166 passenger cars. Therefore, T1 for mountainous terrain is about 0.146 and for rolling terrain is about 0.277.

Inserting these various values for v/c, W1, and T1 in the formula presented earlier produces a service volume of 86 vehicles per hour, both directions, in mountainous terrain; and a service volume of 234 vehicles per hour, both directions, in rolling terrain. Since traffic may get worse at certain times and level of service "C" cannot be maintained, an analysis was also done at level of service "D". At this reduced level of service, the service volume in mountainous terrain shifts about 17 percent to 101 vehicles per hour and the service volume in rolling terrain shifts about 20 percent to 280 vehicles per hour. When compared to the 30th highest hourly value of 18 vehicles and the highest recorded hourly value of 46 vehicles, it appears that portions of the Dalton Highway have sufficient capacity to handle additional traffic. However, this analysis is based solely on geometric design Consideration. As noted earlier, environmental factors such as frost heaving, blowing snow, ice on the roadway, and other conditions may create seasonal obstacles that greatly reduce the ability of the road to carry this traffic.

Richardson Highway - Alaskan Highway

The Richardson Highway is a two-lane road that begins in Valdez and extends 362 miles to Fairbanks, intersecting with the Alaska Highway at.

Delta Junction. The Richardson Highway was originally paved in the early 1950's. During construction of the Trans-Alaska Pipeline, heavy traffic reduced the pavement to gravel along some stretches. As a consequence of the pipeline traffic, and because the roadway has sharp curves, steep grades, and short sight distances, the road is being reconstructed. Already completed are the first 130 miles from Valdez to Gakona Junction and the last 100 miles from Delta Junction to Fairbanks. As part of the reconstruction, roadway alignment, grades, and width are being improved. The older parts of the road are still narrow with a 6.1 to 7.3 m (20 to 24 ft) width and no shoulders; the newer sections have been built 7.3 m (24 ft) wide to accommodate two 12 foot travel lanes with 2.4 m (8 ft) shoulders for a total width of 12.2 m (40 ft).

Historic traffic patterns on the Richardson Highway and on the Delta Junction-Fairbanks portion of the Alaska Highway, as shown in Tables 25 and 26 respectively, generally corrolate with the pipeline peak. From 1970 to 1973 the overall AADT declined rapidly, a fact that can be explained by the opening of the Parks Highway in 1973, which provided an alternative route between Anchorage and Fairbanks (see below). During construction of the pipeline between 1974 and 1976, traffic volumes rose significantly. After the pipeline, traffic levels dropped off. North of Gulkana, traffic volumes continued to decline through 1981, while south of there to Glennallen traffic volumes fell but remained steady. Nearer Valdez, traffic volume dropped but has again started to increase.

TABLE 25

ANNUAL AVERAGE DAILY TRAFFIC (AADT) ON THE RICHARDSON HIGHWAY
At Specified Counter Locations
(1964 - 1981)

Year	Ernestine Maintenance Station mile 66.71	Gulkana Airfield mile 122.66	Trims Maintenance Station mile 223.61
1964	85	343	234
1965	101	417	269
1966	124	405	230
1967	122	445	263
1968	123	483	248
1969	151	625	289
1970	164	638	36.7
1971	172	568	300
1972	217	649	222
1973	213	521	154
1974	284	617	205
1975	696	999	552
1976	562	1111	697
1977	367	651	3.12
1978	275	543	207
1979	197	638	202
1980	231	594	198
1981	309	693	186

SOURCE: State of Alaska, Department of Transportation and Public Facilities, 1982b.

TABLE 26

ANNUAL AVERAGE DAILY TRAFFIC (AADT) ON THE ALASKAN HIGHMAY
BETWEEN FAIRBANKS AND DELTA JUNCTION
At Specified Counter Locations
(1960 - 1981)

Year	Birch Lake Maintenance Station mile 241.81	Moose Creek mile 279.24	West of Fort Wainwright mile 293.35
1960	(1)	(2)	4419
1961			4183
1962			4711
1963			4683
1964	423		4652
1965	550		4695
1966	544		4825
1967	554		3717
1968	534		4523
1969	569		5676
1970	575		5647
1971	585		5489
1972	567		5926
1973	451		6693
1974	456		7783
1975	643		10150
1976	595		11266
1977	699		11145
1978	730		11022
1979	493		9944
1980	574		9501
1981	669	4247	10665

Notes:
(1) The Birch Lake counter was not operating prior to 1964.
(2) The Moose Creek counter was not operating prior to 1981.

SOURCE: State of Alaska, Department of Transportation and Public Facilities, 1982b.

Parks Highway

Prior to 1973, travel between Anchorage and Fairbanks was by means of the Glenn, Richardson, and Alaskan Highways. Although portions of the Parks Highway provided access to rural areas north of Wasilla and west of Fairbanks, the Parks Highway was not completed until 1973. The result was a more direct link between Anchorage and Fairbanks with improved access to Mt. McKinley National Park. Subsequently, in 1977-1978, portions of the highway from Healy to Nenana were reconstructed. The roadway is functionally classifiedas an interstate highway. The lanes have been built to the modern 3.7 m (12 ft) standard with 2.4 m (8 ft) paved shoulders.

Traffic patterns along the Parks Highway are shown in Table 27. Traffic counters at. Willow and near the Ester Scalehouse reflect the early function of local access. Since 1973 additional counters have been added to monitor traffic patterns. The East Fork Maintenance Station traffic counter (mile 150) best reflects the long distance travel patterns of the road. Between 1973 and 1981 traffic increased on the average about 10 percent each year. Much of the traffic is recreational oriented. It is estimated that, south of McKinley Park camper vehicles made up 15 percent of the AADT in 1980 (Louis Berger & Assoc., et al., 1982). The 30th highest hourly volume in 1981 was 116 at the East Fork Station. May through September is the busiest period along the highway

TABLE 27

ANNUAL AVERAGE DAILY TRAFFIC (AADT) ON THE PARKS HIGHWAY
At Specified Counter Locations
(1965 - 1981)

Year	Willow Maintenance Station mile 35.95	East Fork Maintenance Station mile 150.58	west of Ester Scalehouse mile 314.87	Chena River Fairbanks mile 320.63
1965	150	(1)	260	(2)
1966	156		266	
1967	182		309	
1968	240		358	
1969	290		364	
1970	381		364	
1971	456		448	
1972	707		507	
1973	737	334	637	
1974	793	387	854	
1975	943	516	1136	
1976	1077	452	994	
1977	1024	481	814	4089
1978	1158	468	820	4725
1979	1248	442	834	4694
1980	1288	468	874	4847
1981	1367	610	991	5627

Notes:
(1) The East Fork Maintenance Station counter was not operating prior to 1973.
(2) The Chena River counter was not operating prior to 1973.

SOURCE: State of Alaska, Department of Transportation and Public Facilities, 1982b.

with a peak in July and August. Weekends during this season, are the busiest days of the week reflecting the recreational aspect of the traffic.

MOTOR CARRIERS

Truck freight service is available on demand to any customer along the highway system if the customer has a full truckload of goods to move, or can afford to pay the higher rate per pound for a partial truckload. Most trucking firms offer the option of "consolidating" loads, where a customer's load waits for some period of time while other orders are accumulated to make a full truckload.

In addition to services on demand, communities along the Parks Highway have available regularly scheduled service from trucking firms operating between Anchorage and Fairbanks. Customers along the Richardson and Alaska Highways have regularly scheduled service from trucking firms based in Tok, as well as Fairbanks, and Anchorage. A listing of the firms, routes, commodities, and frequency of service are provided in Table 28.

TABLE 28

TRUCK FREIGHT SERVICE
ANCHORAGE - FAIRBANKS - PRUDHOE BAY

Trucking Firm	Route	Frequency	Commodity or Customer
Weaver Brothers	Unscheduled Fairbanks-Prudhoe	On Demand On Demand: usually 10 trucks/slay	General Goods Oil Companies
Sourdough Express	Unscheduled Fairbanks-Prudhoe	On Demand On Demand: usually 10 trucks/day	General Goods Oil Companies
	Parks Highway	On Demand	Business & Contractors
	Richardson Highway	On Demand	Business & Contractors
Lynden Transport	Fairbanks-Anchorage Fairbanks-Prudhoe	On Demand 5 trucks/day	General Goods Oil Companies
Tok Distributing Services	Fairbanks-Anchorage	4 trucks/day	General Goods
Mukluk Freight Lines	Fairbanks-Anchorage	1 truck/week	General Goods

SOURCE: Louis Berger & Associates, Inc. et al. 1982.

Railroad Transportation

Two railroad transportation systems serve Alaska: the Alaska Railroad linking southcenteral and interior Alaska; and the White Pass and Yukon Railroad linking Skagway, Alaska and Whitehorse in the Yukon Territory of Canada. Only the Alaska Railroad is of interest to this study. The Alaska Railroad was originally an operating element of the Federal Railroad Administration as authorized by the Alaska Railroad Enabling Act of March 12, 1914, as amended. Subsequent acts of the U.S. Congress and the Alaska Legislature, authorized transfer of the railroad to the State. This transfer takes place on January 6, 1985.

The Alaska Railroad operates freight and passenger services on 769 km (478 mi) of single mainline track extending from the deep-water ports of Seward and Whittier through Anchorage to Fairbanks. Figure 20 provides an illustration of the Alaska Railroad System. In addition to the main line, the system includes six branch lines: a 20 km (12.4 mi) line to the Port of Whittier, a 4.3 km (2.7 mi) branch to Anchorage International Airport, a 11.3 km (7 mi) line between Matanuska and Palmer, a 7.2 km (4.5 mi) branch between Healy and Suntrana, a 45 km (28 mi) branch extending between Fairbanks and Eielson Air Force Base, and a 16.1 km (10 mi) Fairbanks International Airport branch. There are a total of' 1,052.1 km (653.8 mi) in the system when yard track, siding,

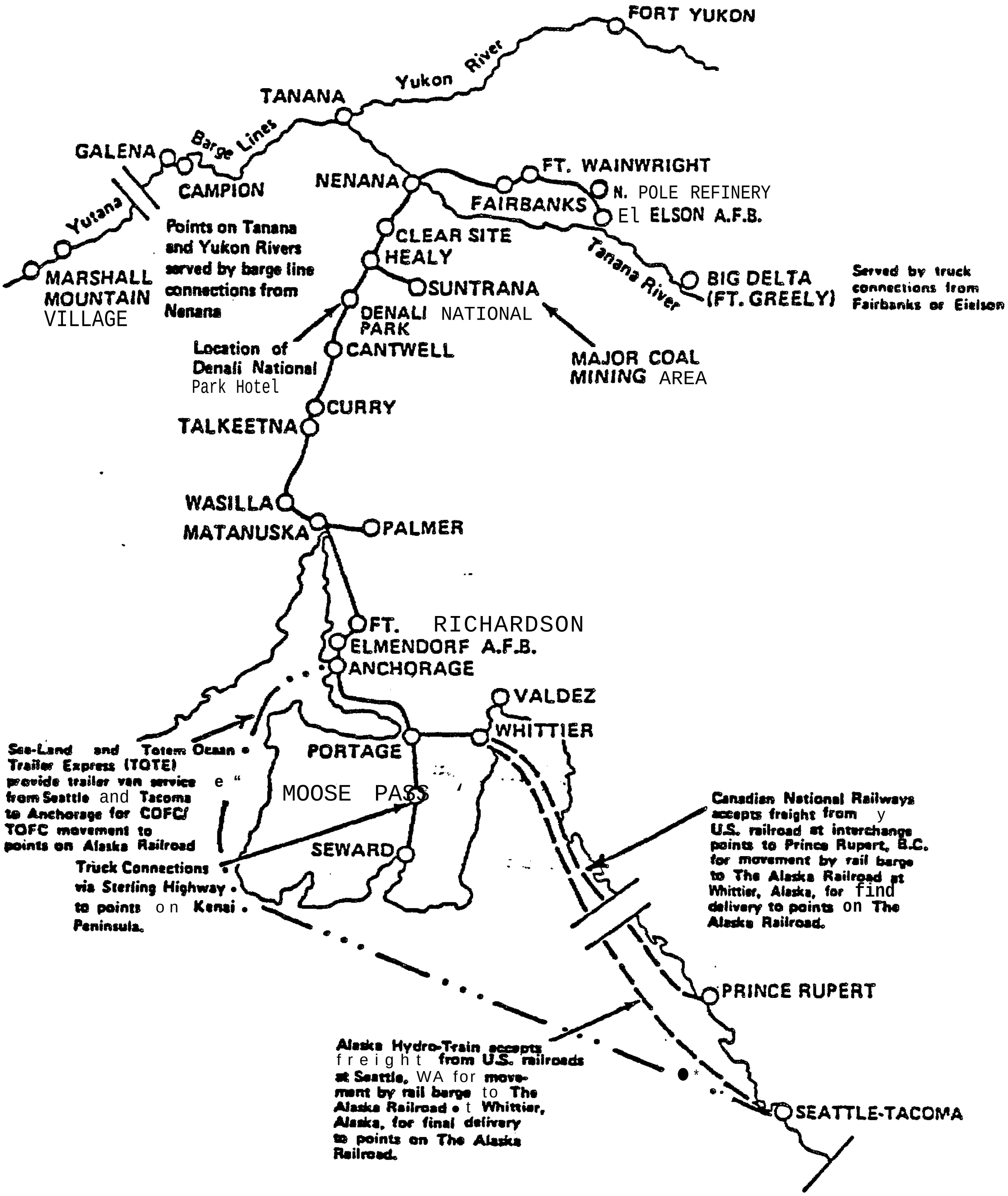


FIGURE 20

ALASKA RAILROAD ROUTE MAP

SOURCE: Alaska Railroad, Annual.

spurs, and passing track are included.

FACILITIES AND EQUIPMENT

For purposes of this report, the facilities of the railroad have been organized to include the trackbed, operating equipment, and land and buildings. These various elements are discussed below.

Trackbed

The trackbed is defined to include the track structure, consisting of the ties, ballast, subgrade, and rail; as well as bridges and tunnels. The discussion begins with the subgrade and progresses through the track structure to bridges and tunnels.

One of the more significant maintenance problems for the railroad is the subgrade. The subgrade consists of crushed stone and pit run gravel ranging in depth from as little as 2 feet to 10 feet. During construction of the railroad in the 1920's, many areas of underlying permafrost were disturbed resulting in alignments subject to severe subsidence or frost jacking action. In numerous instances, the subgrade is of insufficient depth and width for subsurface conditions. Many of the adverse effects associated with frost heaving and subsidence are due to improper drainage around fill material and the degradation of permafrost through water impoundment by the side of the track. Drainage in other locations is also a problem. In some places, ice formation blocks culverts and threatens to build up in winter and cross the track surface. In spring, runoff in these culverts is blocked and treatens to inundate the track. To avoid these situations special maintenance must be performed, including the installation of coal fired heaters to keep culverts open and, in areas of severe and repeated glaciation, the removal of ice.

Ballast is used to bring track to its final elevation, to stabilize lateral movement of the rails, to provide drainage, and to distribute the load uniformly to the subgrade. Like the subgrade, ballast consists of crushed stone and pit run gravel. It ranges in depth from4 to 12 inches. In areas with permafrost related problems, ballast must be replenished or removed to bring the tracks to their correct elevation. Shims (leveling wedges) under the track are as large as three inches in a number of problem areas (Louis Berger & Associates, Inc., et al., 1982).

Both concrete and treated hemlock are used for ties. Due to the subgrade and ballast problems, ties in some areas are replaced as often as every other year. In 1981 in one area near Dunbar, over 2,000 ties were replaced. These ties were last replaced in 1979 (Louis Berger & Associates, Inc., et al., 1982).

Rail is measured in pounds per yard. The optimum weight to use on a particular section of line is dependent on traffic conditions (density, wheel loads, and speed), subgrade, ballast, and ties. Mainline track consists of 115 pounds per yard rail; branch line track is composed of a mixture of 70, 75, 90, and 115 pound track. The mainline track was laid new between 1948 and 1951, when much of the railroad was rebuilt. Most track on the line is in good to fair condition, due in part to the low density of traffic on the railroad. However, where track curvature along the mainline is notable, particularly in more mountainous stretches, excessive wear is indicated at almost all 6 to 10 degree curves and on some stretches excessive engine burns are evident (Louis Berger & Associates, Inc., et al., 1982). The mainline track is maintained to accommodate 100-ton capacity cars. However, because of excessive wear caused by trains, composed entirely of 100-ton capacity cars, 80-ton loading limits have been instituted for bulk products on the mainline. To replace worn track on the mainline, 115 pound track has been cannibalized from branch lines, spurs, and side track.

The horizontal and vertical alignment of the track play a significant role in determining the capacity of the Alaska Railroad, as shown in Table 29. The mainline has only mild gradients along the water level route between Whittier and Anchorage and up the Susitna Valley as far north as Gold Creek. However, severe grades on the next 35 miles to the summit of the Alaska Range reduce the tonnage ratings of locomotives by

TABLE 29

PHYSICAL CHARACTERISTICS OF THE ALASKA RAILROAD
Main Line and Major Branches

Line Segment	Distance	Tonnage Rating (1) Northbound	Tonnage Rating (1) Southbound	Passing Sidings Over 3,000 ft.	Industrial Tracks Between Stations (2)
Seward-Divide	9.1	875	4000	0	0
Divide-Primrose	6.4	1600	850	0	0
Primrose-Hunter	21.6	1600	4000	2	3
Hunter-Grandview	4.9	900	4000	0	0
Grandview-Spencer	10.9	4000	640	1	2
Spencer-Portage	8.4	4000	3000	1	0
Portage-Whittier	12.4	2600	3000	1	0
Portage-Potter	36.4	4000	3000	1	0
Potter-Anchorage	13.7	2000	2500	1	22
Anchorage-Matanuska	36.4	1850	3000	3	5
Matanuska-Palmer	6.5	2000	4000	0	6
Matanuska-Gold Creek	112.5	1850	2500	8	9
Gold Creek-Hurricane	18.2	1100	2500	0	0
Hurricane-Honolulu	7.3	1100	1325	1	0
Honolulu-Colorado	8.4	1100	1800	1	0
Colorado-Summit	15.4	1800	1800	1	1
Summit-Healy	45.6	2700	1800	1	6
Healy-Nenana	53.6	4000	1800	1	7
Nenana-Fairbanks	58.6	3000	3000	4	4
Fairbanks-Eielson	28.0	3000	2000	0	9

Notes:
(1) Tonnage ratings are based on 3,000 horsepower locomotives.
(2) Additional industrial tracks are located in yards, at military bases (Fort Richardson, Elmondorf AFB, Eiel son AFB, Fort Wainwright) and at Anchorage and Fairbanks International Airports.

SOURCE: Bivens & Associates, Inc. et al., 1981 about 40 percent.. The mainline north of the Alaska Range generally has mild gradients, except, for a five-mile stretch, The most severe gradients occur along the line between Portage and Seward. Here, steep gradients reduce locomotive tonnage ratings as much as 75 percent. Track curvature, or horizontal alignment, along the mainline is notable, particularly along the more mountainous stretches. Evidence of the problem is indicated by track wear as discussed above.

Bridges, like mainline track, are maintained to accommodate 100-ton cars. Although many of the bridges are old, most are in good condition. Some of the bridges are subject to the same permafrost related problems as the roadbed. Some bridges are subsiding; some are subject to frost jacking. One bridge near Happy has had 5.1 to 10.2 cm (2 to 4 in). sections removed from piers and abutments every year for the past ten years. Other bridges are being raised a few inches every year (Louis Berger & Associates, Inc., et al., 1982).

Tunnels in some areas are problems due largely to permafrost or drainage conditions. In these situations, rock is deposited on the tracks. Usually the walls are shored and special maintenance is instituted to insure removal of rock that falls on the trackbed.

Operating Equipment

The Alaska Railroad Fleet can be divided into two categories: locomotives and rolling stock. The locomotive fleet is composed of 65 vehicles that range in age from 3 to over 30 years. The more modern component of the fleet consists of 31 units of various size and age. Fifteen are 3,000 horsepower road switcher locomotives built (or rebuilt) between 1975 and 1978. These are comparable to those on most U.S. railroads. Ten are 1,600 horsepower units built in 1951 and rebuilt in 1977. Three are 2,500 horsepower units built in 1964, which are due to be rebuilt. Two 2,400 horsepower units built in 1956 and rebuilt in 1974 are recent acquisitions.

The older component of the fleet consists of 1,600 and 1,500 horsepower engines built in 1951 and 1953. Four 300 horsepower switch engines were built in 1944. These older locomotives are used in service yards and as backups around the system. Several are being cannibalized to provide parts for other units. Generally, the railroad is operating its newer locomotives and storing, or using sparingly, a large percentage of its remaining fleet. Over half the locomotive fleet is over thirty years old and is either near the end of, or well past, their useful life (Bivins & Associates, Inc., et al., 1981).

The rolling stock consists of both passenger and freight equipment, but this report only focuses on the latter. The majority of the freight

cars are open freight types including flatcars, gondolas, open hoppers, dump and ballast cars. These are used for handling bulk materials. Tank cars are also included, but most are privately owned and are assigned to the railroad. The significant feature of the railroad's freight stock is its age. Over 90 percent of the freight stock is over ten years old; 80 percent of all rolling stock is over twenty years old. The age of the railroad's fleet creates problems not only from future maintenance standpoint, but also in terms of the limited capacity of' older cars and the ability to interchange traffic with other railroads.
9 The Alaska Railroad tank cars with 10,000 gallon capacity are relatively obsolete (Louis Berger & Associates, Inc., et al., 1982). The boxcar fleet, used principally between Seattle and Alaska, is particularly outmoded. Flatcars, the majority of which have 70 or less tons capacity, and hopper cars which are heavily utilized for coal, sand, and gravel movements, could not accomodate substantial traffic -increases. Federal safety standards place limitations on the age of equipment that can be used in interline service and prohibit some of the railroad's equipment from operating on Pacific Northwest area railroads. There is also a reluctance on the part of some outside carriers to permit their equipment to operate on the Alaska Railroad because of equipment utilization considerations.

The Alaska Railroad also operates a variety of maintenance related and emergency equipment. This equipment includes rolling shop facilities, cranes and wreckers required to perform general car and locomotive maintenance, snow plows, and special cars for crew quarters, storage, water, and other uses.

Land and Buildings

Right-of-way lands are generally 61 m (200 ft) wide along main track lines. The right-of-way widens where control of washouts and steep cuts is required or where fill is involved. The right-of-way narrows where acquisition of a 61 m (200 ft) width was hindered, such as on military reservations and along spur lines. The top part of Table 30 summarizes land use by the Alaska Railroad. Approximately 31 percent of the acreage is dedicated to right-of-way; another 12 percent is used for storage, maintenance, and terminals; while the remainder is devoted to various secondary support uses. The Alaska Railroad maintains yards at Seward, Whittier, Anchorage, Healy, Nenana, and Fairbanks.

Heated building space owned by the Railroad is summarized by major category in the lower part of Table 30. The Alaska Railroad owns about 136 heated buildings encompassing 70,776 sq.m (761,825 sq.ft). Over half this total is located in Anchorage, where the railroad maintains its headquarters, main service and repair shops, and warehouse space. Other concentrations of railroad buildings are in Whittier, Fairbanks, Healy, and Seward, all in conjunction with the yards. Additional railroad buildings include stations, section houses, living quarters for

TABLE 30

SUMMARY OF ALASKA RAILROAD
LAND USE AND HEATED BUILDING SPACE

LAND USE BY MAJOR TYPE

Land Use Type	Acreage (1)
Right-of-Way TOTAL	12,000
Non Right-of-Way TOTAL	26,200
Active and Future Material Source Laads	9,000
Parts, Storage, Maintence and Terminals	4,400
watershed, Future Development and Other	11,800
Other Leased	1,000
TOTAL	38,200

HEATED BUILDING SPACE BY MAJOR TYPE

Building Type	Number of Buildings	Gross Square Feet	Percent of Total Square Feet
Offices	8	58,157	7.63
Housing	23	59,732	7.84
Storage	13	300,703	39.47
Service	70	338,076	44.38
Utility	22	5,157	0.68
Total	136	761,825	100.00

Note:
(1) Rounded to nearest 100 acres.

SOURCE: Louis Berger & Associates, Inc. et al. 1982.

section crews, and dormitory and food facilities at various locations along the railroad.

OPERATIONS AND TRAFFIC

Railroad operations and traffic focus on the frequency of rail operations and type of rail service. From an operational perspective, the Alaska Railroad is a specialized Class II or Class III railroad. A Class II railroad is an Interstate Commerce Commission classification denoting revenues between $10 and $50 million per year. The railroad operates through trains with a limited number of customers and, 'therefore, few on-route customer sidings. There is relatively little switching and yard classification work and only a minor interchange of traffic with other carriers.

The type of rail service required reflects the major user's demands. The Alaska Railroad's major users are identified in Table 31, together with a summary of the products or services required and level of dependence on rail service. The movement of bulk products dominate service requirements.

Although the railroad offers both freight and passenger service, operations are such that types of service can be associated with particular routes. Of interest in this report are the freight

TABLE 31

MAJOR ALASKA RAILROAD USERS

User Category	Location	Products/Service	Level of Dependence
Military	Elmendorf AFB, Fort Richardson, Clear AFB, Fort Wainwright, Eielson AFB, Galena AFB , Campion AFB Galena	coal, refined petroleum products, equipment, other	high
Government	Anchorage International Airport, Fairbanks International Airport, MUS Fairbanks, University of Alaska	refined petroleum products, coal	moderate to high
Commercial and Industrial Users	Usibelli Coal Mine, Healy, North Pole Refinery, Petroleum Companies in Anchorage and Fairbanks	coal, sand and gravel, cement, forest products	moderate to high
Private Carriers	Yutana Barge, Nenana, Canadian National Railways in Prince Rupert, Alaska Hydro-train Seattle, Sealand, Local Motor Carriers in Fairbanks, Nenana, and Anchorage	refined petroleum products, industrial equipment, other	low to moderate
Tourists	Whittier, Anchorage, Fairbanks, Mt. McKinley National Park, other	transportation	high, seasonal

SOURCES: Louis Berger & Associates, Inc. et al. 1982.
ERE Systems, Ltd.

operations. Freight service is offered as both unit trains and mixed freight/passenger trains. Unit trains serve a single commodity such as coal or gravel. A summary of the average frequency of freight service during summer and winter is shown in Table 32. The unit gravel trains operated between Palmer and Anchorage have the greatest frequency at 4 trips per day, however, these operate only during the summer months. The next most frequent are the unit coal trains operated between Healy and Fairbanks 5 times per week. Both the Alaska Hydro Train and Canadian National Railways transport rail cars via barge to Whittier (see more detailed description under Marine Transportation - Whittier). Service to the railcar barges at Whittier is dependant on barge shipping schedules, consequently, the service frequency varies for each marine carrier.

Historically, the number of round trips made by Alaska Railroad freight trains has declined since the oil pipeline peak in 1976. A summary is shown in Table 33. The most significant decline occured on the Anchorage-Seward route where the number of trains declined 65 percent over the period 1976 to 1980. This trend is expected to be reversed when export coal shipments begin to Korea through Seward. Since 1979, the number of train round trips for several other origin - destination pairs again has begun to rise.

The length and configuration of freight trains varies by the type-of

TABLE 32

ALASKA RAILROAD FREIGHT TRAIN SERVICE(1)
Fiscal Year 1982

Origin-Destination Points	Summer	Winter
Freight Service		
Anchorage-Seward	Weekly	Weekly
Anchorage-Whittier (2)	1/week	1/week
Anchorage-Whittier (3)	Every 9 days	Bi-monthly
Anchorage-Palmer (local freight train)	Bi-weekly	Bi-weekly
Anchorage-Palmerp (unit gravel trains)	4 daily	---
Anchorage-Fairbanks	4 weekly	4 weekly
Healy-Fairbanks (unit coal trains)	5 weekly	5 weekly
Freight/Passenger Mixed Service		
Anchorage-Fairbanks	.3 weekly	3 weekly

Notes:

(1) The number of trains shown represents the average number of trains in each direction.

(2) Alaska Hydro TrainRailcar Barges.

(3) Canadian National Railway Railcar Barges.

SOURCES: Alaska Railroad, Annual.
Louis Berger & Associates, Inc. et al. 1982.

TABLE 33

APROXIMATE NUMBER OF FREIGHT TRAINS OPERATED BY THE ALASKA RAILROAD (1976 - 1980)

	Round Trips				
	1980	1979	1978	1977	1976
Freight Service					
Anchorage-Seward	46	53	46	68	132
Anchorage-Whittier	129	123	158	187	122
Anchorage-Palmer (Local)	32	32	38	36	37
Anchorage-Palmer (Gravel)	102	146	158	187	235
Anchorage-Fairbanks	181	192	213	271	340
Fairbanks-Healy (Coal)	145	139	139	156	191
Freight/Passenger Service					
Anchorage-Fairbanks	74	70	70	69	71
Industrial Switchers					
Fairbanks-.Eielson	260	243	243	260	330
Anchorage Airport	295	260	260	277	295

SOURCE: Louis Berger & Associates, Inc. et al. 1982.

service. Gravel related operations typically involve a unit train composed of 80 hopper cars. Coal freight trains range from 40 to 60 cars. Anchorage-Fairbanks freight trains range between 60 and 100 cars, while mixed trains between these points will have 20 to 25 freight cars. Freight trains between Whittier and Fairbanks are 45 to 50 cars in length, while trains from Nenana to Seward are composed of 40 to 60 cars.

Yard operations, like rail service generally, tend to serve specific commodity types. At Anchorage, the railroad's major classification yard, switching services are operated to make and break through-road freight trains. These serve container-on-flatcar (COFC) and trailer-on-flatcar (TOFC) needs for the railway barges at Whittier, local needs along the Anchorage. International Airport spur, and links to Elmendorf Air Force Base and Fort Richardson. The switching service at the Healy yard is primarily to facilitate coal movement. Fairbanks, which has a small classification yard, serves local industrial and COFC/TOFC facilities, as well as Fort Wainwright, Eielson Air force Base, and the North Pole Refinery. Whittier is used to serve railcar barge ships and is also used as a military dock and petroleum terminal (see discussion of Marine Transportation - Whittier earlier in this chapter). The Seward yard serves Seward port facilities. The Nenana yard exists primarily to serve that river port and to facilitate barge service connections to points on the Tanana and Yukon Rivers.

REVENUE TONNAGE

Traffic on the Alaska Railroad is divided into two components: local and interline. Local movements, which are strictly Alaska Railroad origins and destinations, generate the most tonnage, but produce relatively low levels of revenue per ton-mile. Interline traffic, which includes such things as the rail-barge service and COFC/TOFC traffic, generate less tonnage, but produce more revenue. The revenue implications of each traffic type are discussed in the following paragraphs.

Local freight service is typically directed toward the service and movement of five major commodity groups: gravel, which moves from the Palmer-Matanuska area south to Anchorage; coal, which moves from the Healy area north to Clear and the Fairbanks area; petroleum products, which move to and from various points between Fairbanks-North Pole and Anchorage; cement, which moves from Anchorage to Fairbanks; and pipe, which moves from either Seward or Anchorage ports to Fairbanks.

Revenue tonnage for these and other major commodity groups over the period 1972-1981 is summarized in Table 34. The most significant increase has been sand and gravel tonnage, although movement of this commodity is over only a short distance and the product itself is of relatively low value. Less spectacular increases have occurred in the categories of local piggyback freight (COFC/TOFC), forest products, and cement. Although bulk petroleum product tonnage has actually declined over the period illustrated, it is one of the more lucrative commodities.

Interline traffic is considerably different in volume and revenue characteristics. One major component is COFC/TOFC traffic forwarded by the railroad on substitute service agreements wit% Totem Ocean Trailer Express (TOTE)and Sea-Land Service Company between Anchorage and Fairbanks. This traffic amounts to only 90,000 to 100,000 tons annually, but, because of its sensitivity to delays and long distances, the service commands a premium rate. Another component of interline traffic is the railroad interchange with Alaska Hydro-Train and the Canadian National Railways (see discussion on Marine Transportation - Marine Common Carriers earlier in this chapter). This traffic includes a broad range of consumer and industrial goods. Alaska Hydro-Train movements total 200,000 to 300,000 tons annually; Canadian National Railways moves about 30,000 to 40,000 tons. While these movements comprise only 10 to 15 percent of total traffic tonnage, they generate 30 to 40 percent of the revenue because of the value of the traffic.

The distribution of railroad activities along the railroad is expressed as traffic density, which is defined as gross tons per mile. Gross

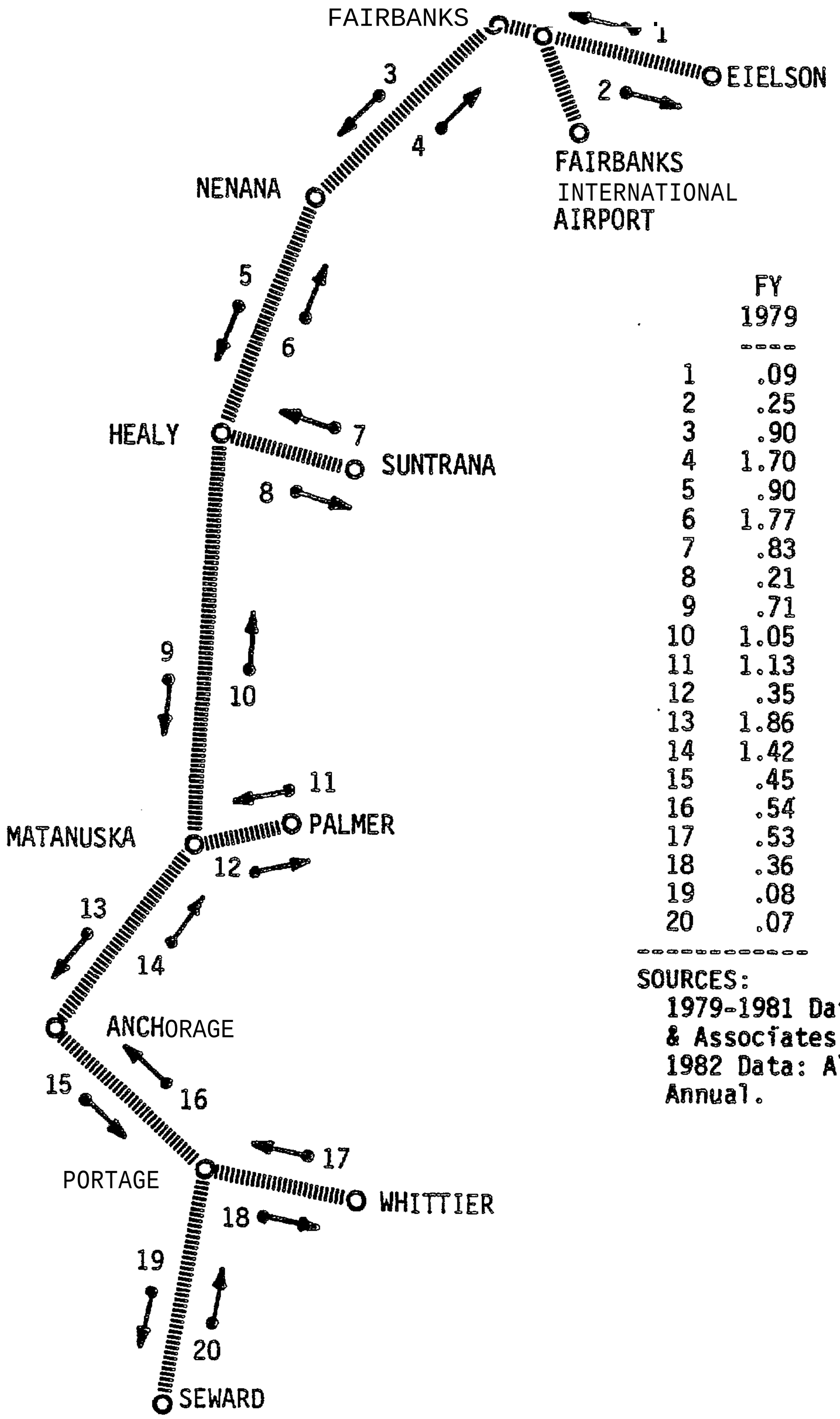
TABLE 34

ALASKA RAILROAD REVENUE TONS OF MAJOR COMMODITIES
Fiscal Years 1972 - 1981*
(Amounts in Thousands of ?'ens)

	Fiscal Year									
Commodity	1972	1973	1974	1975	1976*	1977	1978	1979	1980	1981
Sand and Gravel	3	2	1	1	104	700	727	637	396	1,797
Bulk Petroleum	406	363	414	557	624	532	374	220	252	379
Coal	607	565	563	584	607	550	593	524	590	653
Iron & Steel Pipe & Fittings	68	11	15	107	174	16	28	33	37	83
TOFC/COFC	35	48	57″	95	114	100	100	89	92	113
Forest Products	51	49	56	120	124	82	68	55	109	101
Manufactrued Iron & Steel	21	18	37	60	89	19	12	12	10	8
Cement	12	15	14	25	32	42	33	33	32	43
Machinery and Machines	16	12	21	60	31	47	47	24	16	28
Mfrs. and Misc. NOS	43	32	34	44	29	17	13	25	26	11
Other	344	216	165	209	260	200	183	156	181	146
TOTAL	1,606	1,331	1,377	1,862	2,188	2,305	2,178	1,808	1,741	3,362

*The Federal Government changed its fiscal year from July 1-June 30 to October l-September 30 beginning in FY 1977, resulting in a transition quarter in 1976. To avoid a 15-month fiscal year for comparisons, these statistics use July 1, 1975 through June 30, 1976 as FY 1976, and October 1, 1976 through September 30, 1977 as FY 1977, dropping the transition quarter.

SOURCE: Louis Berger & Associates, Inc. et al. 1982.



	FY 1979	FY 1980	FY 1981	FY 1982
1	.09	.11	.13	.12
2	.25	.30	.31	.24
3	.90	.94	1.08	1.32
4	1.70	1.82	2.01	2.36
5	.90	1.01	1.12	1.31
6	1.77	1.92	2.10	2.43
7	.83	.84	.85	.46
8	.21	.21	.22	.11
9	.71	.81	.96	1.08
10	1.05	1.11	1.28	1.52
11	1.13	.23	1.01	1.67
12	.35	.09	.30	.50
13	1.86	1.34	3.77	5.16
14	1.42	1.32	2.11	2.74
15	.45	.59	.93	1.23
16	.54	.68	.89	1.27
17	.53	.51	.64	.79
18	.36	.31	.37	.41
19	.08	.19	.16	.22
20	.07	.11	.12	.30

SOURCES:
1979-1981 Data: Louis Berger & Associates, Inc. et al. 1982.
1982 Data: Alaska Railroad, Annual.

FIGURE 21

TRAFFIC DENSITY ON THE ALASKA RAILROAD
Fiscal Years 1979-1981
(Millions of gross tons per mile)

tonnage includes empty cars, locomotives, and passenger trains. Figure 21 is a schematic presentation showing north and southbound traffic density for each major section of the Alaska Railroad. From this figure and accompanying data; heavily used portions of the railroad, in terms of gross tonnage, can be inferred.

Pipeline Transportation

Pipeline transportation is relevant to this study in the context of an alternative future routing for the movement of oil and gas resources from the Barrow Arch area to Lower 48 markets. Of particular interest to this study are the Trans-Alaska Pipeline System, the Alaska Highway Natural Gas Pipeline, the Barrow Natural Gas Pipeline, and the proposed pipeline system for NPR-A. These are of interest because any pipeline across the North Slope will either receive economic advantages from lines that preceed it or will provide an economic advantage to those that follow.

The speculative nature of some of these pipelines, however, is such that their consideration in this report is better left to the forecast phase of the study (see Chapters IV and V), rather then the baseline. In short, because of the speculative aspects of the Alaska Highway Natural Gas Pipeline and the NPR-A pipeline system, they were not considered to be a part of the baseline. Similarly, the Barrow Natural Gas Pipeline would be significant only if used for the movement of resources during the field production phase. It was thus left out of this discussion. The result of this analysis is that the following discussion of pipelines focuses only on the Trans-Alaska Pipeline System (TAPS).

The Trans-Alaska Pipeline System (TAPS) is an 1,287 km (800 mi) pipeline, 1.22 m (48 in) outside diameter, that is used to transport oil from the North Slope to a terminal at Valdez for transshipment to lower 48 markets. At present, the pipeline transports about 1.6 million barrels of crude oil daily. This level of operations is assumed to be the practical operating capacity of the pipeline without additional infrastructure changes. With the addition of several intermediate pump stations the pipeline could transport up to 2 million barrels per day, although with less efficiency. The general characteristics of the pipeline are summarized in Figure 22.

The original annoucement to construct the pipeline was made in 1969, and work was started soon after. Construction activities were designed to spread outward from the camps. Priority was to go to the airports, access roads, additional camp facilities and other support facilities. In 1970, environmental groups filed suits to halt pipeline construction, Prior to action by the courts stopping construction, seven mobile camps were built and one pre-existing camp was expanded. (Bechtel, Inc., 1974)

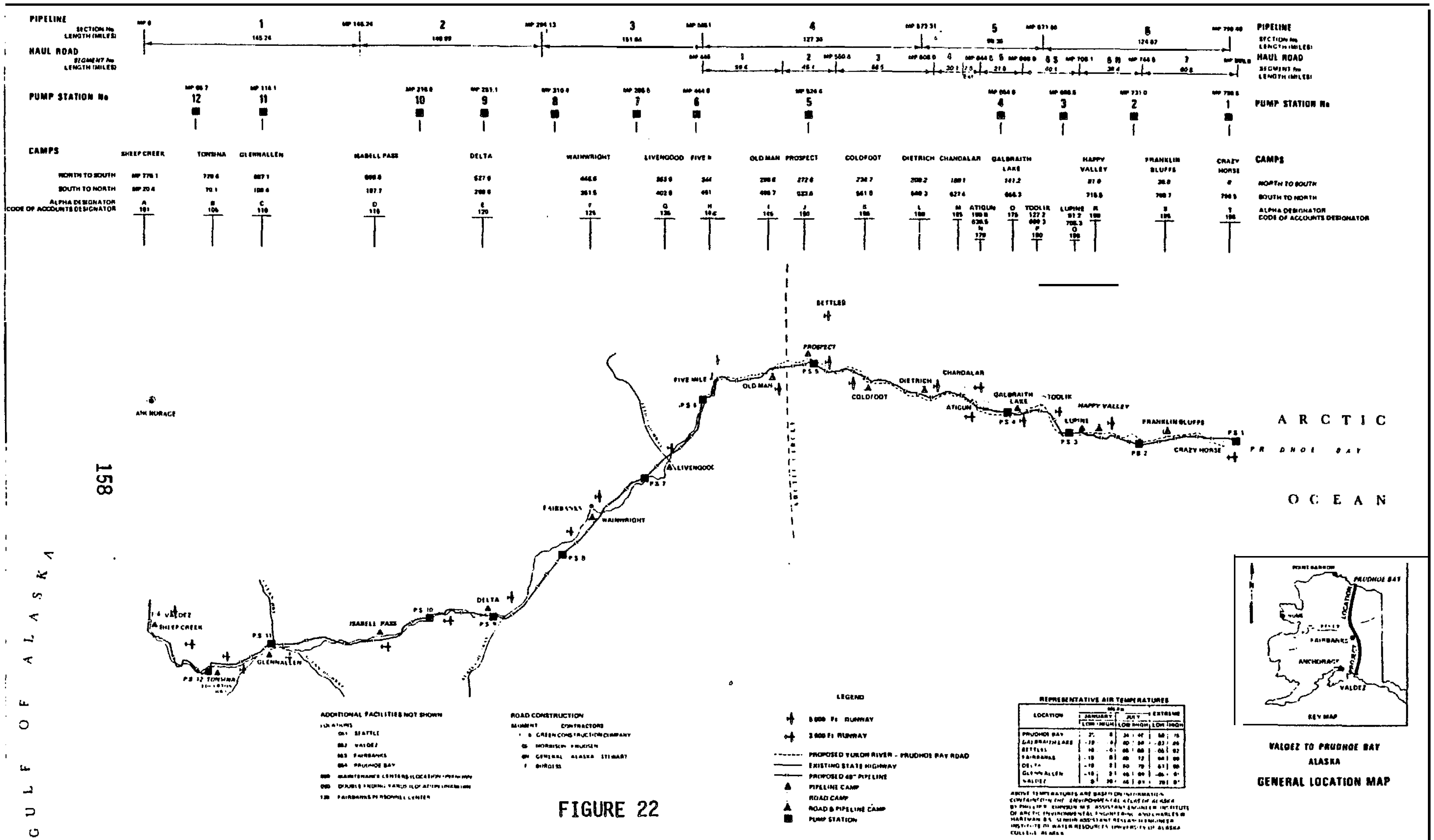


FIGURE 22

ROUTE MAP OF THE TRANS ALASKA PIPELINE

SOURCE: Bechtel, Inc., 1974.

Following a three and one-half year hiatus, Alyeska Pipeline Service Company, was notified they could begin construction of the pipeline. During 1974, the 579 km (360 mi) road from the Yukon River to Prudhoe Bay was completed, work was started on the pump stations and the Valdez terminal. In 1975, the first pipe was laid. By May of 1977, all pipe had been installed and hydrostatically tested. The pipeline began operation on June 20, 1977. (Alyeska Pipeline Service Co., n.d.)

Other than the pipeline itself, the outstanding transportation features of the pipeline system are the haul road, various transportation support facilities such as airfields and helicopter pads, and the marine tanker terminal at Valdez. The haul road is dealt with separately as part of the highway system discussed earlier in this Chapter. Similarly, the tanker operation at Valdez was discussed earlier as part of the marine transportation system. One aspect not discussed elsewere is the construction of airfields in support of the pipeline. Three permanent airfields were constructed for support of construction, operation, and maintenance of the pipeline system and road. These fields are 1,524 m (5,000 ft) long and are capable of handling Hercules L-382 aircraft. A minimum of five feet of gravel embankment and surfacing are in the runways. Four temporary airfields were built to support road and pipeline construction. Two of these airfields had 1,524 m (5,000 ft.) runways and two had 914 m (3,000 ft) runways (Bee.htel, Inc., 1974).

IV

FORECAST CONDITIONS
WITHOUT THE BARROW ARCH LEASE SALE

The information contained in this chapter focuses on a forecast of conditions without the proposed Barrow Arch lease offering. The forecast consists of three major components: marine transportation, air transportation, and land based transportation. The latter component includes overland pipelines, highways, and rail transportation. A fourth component dealing with economic conditions provides background to the transportation demand forecasts and is presented first.

Expected Economic Conditions

Changing levels of activity in the local economy Influence changes in demand for various transportation services. This section attempts to define in an abbreviated fashion the current state of the economy of the North Slope Borough and the changes likely to occur in the future without the Barrow Arch Lease Offering. For purposes of this report, the level of economic activity is measured by employment and population changes, as well-as per capita income. These factors were deemed to have the greatest influence on changes in demand for transportation services.

NORTH SLOPE ECONOMY

Over the past decade, the principal sources for social and economic change on the North Slope have been the North Slope Borough government and the petroleum industry. This characteristic is reflected in Alaska Department of Labor nonagricultural wage and salary employment data for the North Slope Borough for 1980, the most recent year for which statistics have been published. This data, summarized in Table 35, indicates an annual average of 6,115 jobs in the region with mining and government constituting the largest employment sectors. In 1980, mining (which includes petroleum development) made up 45.2 percent of employment; government made up 23.0 percent of employment. Most of the mining jobs were located in the Prudhoe Bay-Deadhorse and Kuparuk areas, while most of the government jobs were scattered among the region's traditional communities. Most jobs in the remaining sectors of the economy were also scattered among the region's traditional communities.

The following paragraphs look at the more significant sectors of the economy in slightly more detail. In the context of this report, the most important aspect of these descriptions are expected future trends. Much of the following material is drawn from Technical Report 101 (Alaska Consultants, Inc., et al., 1984).

TABLE 35

NONAGRICULTURAL WAGE AND SALARY EMPLOYMEN?'
NORTH SLOPE BOROUGH - 1980

Industry Classification	Annual Average
Mining	2,762
Contract Construction	705
Manufacturing	0
Transportation, Communications, and Public Utilities	422
Wholesale and Retail Trade	0
Finance, Insurance, and Real Estate	330
Services	83
Miscellaneous	406
Government	1,407
TOTAL	6,115

SOURCE: Alaska Department of Labor, "Statistical Quarterly", as reported in Technical Report 101 (Alaska Consultants, Inc., et al., 1984).

Government

Local government is the major employer in the region's villages and makes up 96 percent of government employment within the North Slope Borough. Evidence of this dominance can be seen in Table 36, which summarizes average annual full-time employment in North Slope Borough villages during 1982. During that year, the North Slope Borough directly or indirectly provided about two-thirds of all jobs in the villages, not counting jobs contributed by the Borough to the trade and services sectors {Alaska Consultants, Inc., et al., 1984). Local government accounted for 46.7 percent of average annual full-time village employment. An additional 22 percent were associated with contract construction activities conducted as part of the Borough's ongoing capital improvements program.

Since the mid 1970's, the North Slope Borough has undertaken an ambitious capital improvements program and expansion of public services. The Borough also operates certain utility services in the Deadhorse area and is currently involved in the development of an industrial park facility in the Kuparuk area. The Borough's capital improvements program has created temporary construction jobs in the particular village where projects are being built and has added a lesser number of permanent jobs associated with the operation and administration of completed facilities. The capital improvements program has also resulted n the hiring of additional administrative staff at Barrow. A

TABLE 36

AVERAGE ANNUAL FULL-TIME EMPLOYMENT
NORTH SLOPE BOROUGH VILLAGES - 1982

Industry Classification	Number of Persons	Percent of Total
Agriculture, Forestry and Fishing	0.0	0.0
Mining	50.5	2.6
Contract Construction	435.0	22.0
Manufacturing	0.0	0.0
Transportation, Communications and Public Utilities	188.0	9.5
Trade	110.5	5.6
Finance, Insurance and Real Estate	80.5	4.1
Services	108.5	5.5
Government	1,002.0	50.7
Federal	(66.5)	(3.4)
State	(13.0)	(0.7)
Local	(922.5)	(46.7)
TOTAL	1,975.0	100.0

SOURCE: Alaska Consultants, Inc., et al., 1984.

profile summary of the work force engaged in the capital improvements program during 1981 is presented in Table 37.

The Borough sustains its operations and capital improvements outlays from property taxes levied upon Prudhoe Bay and Kuparuk industrial properties and associated oil pipelines. However, the Borough is limited by recent State-imposed restrictions on the extent to which it can tax certain oil and gas properties (Alaska Consultants, Inc., et al., 1984). Unless these limitations are modified, that portion of the Borough's budget allocated to the operation and administration of new capital facilities will become an increasing concern. Over the next three to five years, this restriction is expected to limit further capital construction.

The Borough is also currently considering the need to slow its rate of general obligation bond sales in order to maintain its credit rating in the bond market. Since bonds provide the primary revenue source for capital construction projects, a reduction in the level of bond sales would likely lead to a leveling off, or possibly a reduction, of temporary construction employment in the villages. This, in turn, can be expected to reduce per capita income in the villages and, over the long term, most likely influence the purchase of transportation services in a negative way (Alaska Consultants, Inc., et al., 1984).

TABLE 37

NORTH SLOPE CAPITAL, IMPROVEMENT PROGRAM
1981 WORK FORCE PROFILE SUMMARY

Location	Workers	Local	Imported
Anaktuvuk Pass	97	40%	64%
Atqasuk	43	15%	85%
Barrow	686	70%	30%
Kaktovik	65	30%	70%
Nuiqsut	84	40%	60%
Point Hope	189	50%	50%
Point Lay	31	15%	85%
Deadhorse	N/A	0	100%
Wainwright	163	50%	50%
TOTALS	1,358	55%	45%

SOURCE: University of Alaska, Institute for Social and Economic Research, 1983b.

Both the state and federal governments were significant employers in Barrow and each had a minor number of employees at Deadhorse in 1982. Except for some federal jobs at Kaktovik and a state sponsored job at Point Hope, state and federal government employment is considered minor, however. No significant change is anticipated in the federal government's presence at the village level in the North Slope Borough. Likewise, no significant increase is expected in the number of state employees now working on the North Slope.

Oil and Gas Industry

Since the Borough derives almost all of its property tax revenues from oil and gas properties, the region's oil and gas industry will continue to play a vital 'role in the region's economic well being. Through the property tax mechanism the oil and gas industry indirectly funds a very large share of local government jobs. Given the current life of known oil and gas discoveries, together with relatively high probabilities of new discoveries following currently planned state and federal lease offerings onshore and offshore, it appears the oil industry will continue to be the seminal industry on the North Slope beyond the year 2000.

Mining activities on the North Slope date back to the early 1900's. However, these early activities ceased with creation of Naval Petroleum Reserve #4 (NPR-4) in 1923. A major exploration program in the Reserve was not initiated until 1944 and continued through 1953, at which time it was determined the remoteness and lack of major finds were serious obstacles to further development. In 1975, following the OPEC oil embargo, the need to develop strategic oil reserves prompted the Navy to begin a comprehensive evaluation of the Reserve. In 1981, the Department of the Interior took over what is now named the National Petroleum Reserve - Alaska (NPR-A) and has continued the Navy's evaluation program.

In response to a 1980 Congressional mandate, the Bureau of Land Management (BLM) began an oil and gas leasing program in NPR-A. Three sales have taken place since 1982, with successful bids received for approximately 1.3 million acres out of 6.76 million acres offered. Over the next four years, BLM plans to offer 8 million additional acres for lease in four sales averaging about 2 million acres each. The current size of the reserve is approximately 23.7 million acres. Based on this size, the 6.76 million acres already offered constitutes about 28.5 percent. of NPR-A lands and the additional 8 million acres to be offered constitute another 33.8 percent.

After the Navy completed its exploration program in 1953, no exploratory drilling was conducted on the North Slope for almost ten years. Some private drilling occured then in NPR-4 west of the present Prudhoe Bay field, but no commercial discoveries were made. Interest shifted to

State-selected lands along the Beaufort Sea coast, where during the the 1960's, the State held four competitive lease sales. The discovery well for the Prudhoe Bay field was spudded in 1967 and the find officially announced in July 1968. Since 1979, the State has held four lease sales in the North Slope region: two onshore sales in the Prudhoe Bay Uplands area, one each in 1980 and 1982; and two offshore/uplands sales in the Beaufort Sea, one each in 1982 and 1983.

Aside from the Prudhoe Bay field, major discoveries have been made on other State lands in the area between NPR-A and the Arctic National Wildlife Refuge. They include the Kuparuk field, the Lisborne formation, Flaxman Island, Point Thomson, Duck Island-Sag Delta, and other lesser fields. Of these, the Kuparuk field is one of the larger fields in the United States. Development of this field began in 1979, and the first phase of production began in 1982. Table 38 summarizes estimated reserves of currently leased onshore State lands on the North Slope.

Other onshore oil and gas related activities have been conducted in recent years. Approximately 4.5 million acres of federal land located between NPR-A and the Arctic National Wildlife Refuge are currently being studied by BLM to determine the feasibility of future oil and gas leasing. The coastal plain of the Refuge itself has been identified as a favorable area for significant accumulations of oil and gas.

TABLE 38

PROVEN AND PROBABLE OIL RESERVES ON CURRENTLY LEASED STATE OWNED NORTH SLOPE LANDS

Area	Range of Reserves (1) Low	Most Likely	High
Prudhoe Bay Unit - Sadlerochit Reserve	6,170	6,950	7,340
Sag River Reservoir	100	130	220
North Prudhoe Bay - West Dock Area	50	75	100
Kuparuk River Formation	600	1,000	1,500
Milne Point Area	30	45	80
Gwydyr Bay Area	50	80	120
Prdhoe Bay Lisburne Reservoir, Sag Delta Area, and Duck Island Area	460	650	975
Point Thomson Area and Flaxman Island Area	400	600	900
TOTALS (2)	7,860	9,530	11,215

NOTES: (1) All estimates as of July 1982. Reserves are given in millions of barrels.
(2) Totals without the Prudhoe Bay - Sadl erochit Reserve are: Low - 1,690 mmbl; Most Likely - 2,580 mmbl; and High - 3,875 mmbl.

SOURCE: Alaska Department of Natural Resources, Division of Minerals and Energy Management, as reported in Technical Report 101 (Alaska Consultants, Inc., et al., 1984).

Exploration activities proposed for the Refuge are aimed at identifying these high potential areas. The Arctic Slope Regional Corporation, which owns about 4.6 million acres, currently has about 4.3 million acres under lease to various petroleum companies. A total of eight exploratory wells have been drilled in areas southeast and west of NPR-A, southeast of Umiat, and near Point Lay. All these wells have been reported as dry holes (Alaska Consultants, Inc., et al., 1984).

Oil and gas exploration activities have also extended to offshore areas in the Beaufort Sea. In December 1979, a joint federal-state lease sale offered 514,202 acres. In September 1982, the federal government held a second lease sale in the Diapir Field (sale 71). Another four federal offshore lease sales are scheduled, two in the Beaufort Sea and two in the Chukchi Sea. The State has also been active offshore and is planning over the next five years: two sales in the Beaufort Sea; two in the Kuparuk Uplands; and one each in the Camden Bay, Prudhoe Bay Uplands, and Icy Cape areas. A summary of planned federal and state lease offerings in the North Slope region is presented in Table 39.

Due to the highly transient nature of oil and gas employment on the North Slope, employment data is difficult to obtain and use. A breakdown of oil related employment by type of camp is shown in Table 40. This data was collected by the Alaska Department of Labor during a State-supervised special census undertaken during January and February

TABLE 39

PLANNED FEDERAL AND STATE LEASE OFFERINGS
NORTH SLOPE REGION

Year	Proposed Date	Government Agency	Sale Number	Area
1984	5/84	State	43	Beaufort Sea
	6/84	MMS	87	Diapir Field
	7/84	BLM-NPR-A	--	NPR-A
1985	2/85	MMS	85	Barrow Arch
	5/85	State	47	Kuparuk Uplands
	7/85	BLM-NPR-A	--	NPR-A
1986	1/86	State	48	Kuparuk Uplands
	6/86	MMS	97	Diapir Field
	7/86	BLM-NPR-A	--	NPR-A
	9/86	State	50	Camden Bay
1987	1/87	State	51	Prudhoe Bay-Uplands
	2/87	MMS	109	Barrow Arch
	5/87	State	52	Beaufort Sea
	7/87	BLM-NPR-A	--	NPR-A
	9/87	State	53	Icy Cape

SOURCE: Alaska Department of Natural Resources, Division of Minerals and Energy Development, as reported in Technical Report 101 (Alaska Consultants, Inc., et al., 1984).

TABLE 40

POPULATION AT OIL-RELATED WORKSITES BY TYPE OF CAMP
NORTH SLOPE BOROUGH - 1981

Type of Camp	Number of Persons	Percent of Total
Operations	963	15.3
Trades, Construction	1,884	29.9
Oil Rig	1,431	22.7
Seismic Train	219	3*5
Technical Services and Fabrication	106	1.7
Government	35	0.6
Ground Transportation	284	4.5
Air Transportation	60	1.0
Supply, Services, Repair	404	6.4
General	920	14.6
TOTAL	6,306	100.0

SOURCE: Alaska Department of Labor, Research and Analysis Section, as reported in Technical Report 101 (Alaska Consultants, Inc., et al., 1984).

1982 (Alaska Consultants, Inc., et al., 1984). Among the ten categories of camps, employment related to construction and oil rig activities predominate. It should be noted that the data in Table 40 does not represent average annual full-time employment and, therefore, is not comparable to the data in Tables 35 or 36.

Other Economic Opportunities

Opportunities for other kinds of economic development rest in either tourism activities, mineral development, or the collective actions of the regional and village corporations. Tourism is a minor and extremely seasonal component within the North Slope economy. Most tourists visiting the North Slope travel in organized tours between June 1 and August 31. No current statistics are available on the number of tourists visiting Barrow or Prudhoe Bay; although, it's believed that Barrow receives between 4,000 and 5,000 visitors on such tours each year. There is potential for increased tourism in Barrow, which would result in increased services (hotels) and trade (restaurants and souvenir sales) employment., as well as providing additional income to local craftsmen. While the community recognizes the economic benefits of tourism, reservations about other impacts on the community from increased tourist traffic create an ambivalent attitude. Thus despite some growth, tourism is likely to remain a significant, but seasonal, element in the local economy. Some potential for tourism also exists in the smaller villages, particularly Anaktuvuk Pass and Kaktovik.

However, the expense of travel, the remoteness of the area, and the short summer season, among other factors, are likely to combine to discourage growth of tourism at a rate that yields significant economic benefits for the residents.

Although the North Slope region is generally not regarded as a favorable area for mineral discoveries, one of the world's most promising lead/zinc deposits, known as the Red Dog mine, is located in the southwestern portion of the Borough on NANA Regional Corporation Lands. The range of possible mining activities was presented in the Chapter III discussion of marine facilities at Kivalina. A decision as to whether or not to proceed with development of the mine has not yet been made. While it is too early to assess the likelihood of developing the mine, it should be noted that taxation of mineral properties by the Borough would not be subject to current State-imposed limitations on the Borough's ability to tax certain oil and gas properties. (Alaska Consultants, Inc., et al., 1984)

Under terms of the 1971 Alaska Native Claims Settlement Act (ANCSA), thirteen regional corporations and numerous village corporations were established to manage lands and to invest cash payments transferred to Alaska Natives. The Arctic Slope Regional Corporation (ASRC) is the regional entity for the North Slope and has received title to approximately 4.6 million acres of land within the region. Under' provisions of the Alaska National Interest Lands Conservation Act passed in 1980, the Corporation was given the option to exchange certain lands under certain conditions and recently exchanged approximately 101,272 acres of surface estate within the Gates of the Arctic National Park for 92,160 acres of subsurface estate in the coastal plain of the Arctic National Wildlife Refuge. Based on an enrollment. of about 3,900 persons, the Corporation was entitled to a cash payment of approximately $51 million from the so-called Native Fund. Virtually all of this sum has now been paid. The Corporation has invested its funds heavily in companies doing business on the North Slope resulting in the creation of a significant number of jobs in Barrow. Aside from its corporate headquarters, the Corporation has formed seven subsidiary companies with a range of services. Depending on the" success of oil and gas exploration activities on its lands and on the activities of its corporate subsidiaries, the Corporation should continue to play an important role in Barrow's future economy.

Each of the eight traditional villages of the North Slope have village corporations established under ANCSA. In general, these corporations have invested locally in village stores and fuel distributorships and most have participated in construction activities either alone or as part of joint ventures. In some cases corporations have also invested outside their village. While not large employers, the village corporations are large landowners and, as such, exert a considerable influence on village development. (Alaska Consultants, Inc., et al., 1984)

Based on these and various other trends, as well as assumptions about future changes, the University of Alaska, Institute of Social and Economic Research (ISER), utilized several of its econometric models to project future levels of employment in the North Slope Borough. The results of their analyses are displayed in Table 41. Overall, the increase in resident employment from 1981 to 2010 is expected to be about 41.2 percent, while the increase in non-resident employment is expected to be about 94 percent.

Resident employment, which combines the Native and non-Native resident categories, is expected to exhibit steady growth. Over the period between now and 1990, resident employment increases about 4 percent. From 1990 to 1995, resident employment rises 9.5 percent over 1981 levels and 5.3 percent over 1990 projections. Resident employment accelerates between 1990 and 2000 with growth over the decade of about 13.3 percent and again accelerates between 2000 to 2010 with growth of almost 19.8 percent.

Non-resident employment exhibits a pattern of intense growth during the first half of the forecast period, but levels off during the last half of the forecast period. From now to 1990, non-resident employment

TABLE 41

NORTH SLOPE EMPLOYMENT PROJECTIONS
WITHOUT THE BARROW ARCH LEASE OFFERING
1981 - 2010

Year	Total Employment	Total Native Employment	Total Non-Native Resident Employment	Total Non-Resident Employment
1980	6115	1211	473	4431
1981	7325	1249	512	5564
1982	8348	1272	538	6538
1983	9681	1262	539	7880
1984	8897	1255	541	7101
1985	10158	1250	545	8363
1986	10712	1248	549	8915
1987	11422	X248	553	9621
1988	11891	1249	559	10083
1989	12425	1253	565	10607
1990	14898	1259	572	13067
1991	13261	1267	579	11415
1992	15739	1277	587	13875
1993	13919	1288	595	12036
1994	15389	1301	604	13484
1995	13508	1315	614	11579
1996	13299	1331	623	11345
1997	13244	1348	634	11262
1998	12823	1367	644	10812
1999	12814	1387	656	10771
2000	12871	1408	667	10796
2001	12847	1430	679	10738
2002	12809	1454	692	10663
2003	13096	1478	705	10913
2004	13152	1504	718	10930
2005	X3282	1531	732	11019
2006	13409	1558	746	11105
2007	13396	1587	760	11049
2008	13437	1617	775	11045
2009	13213	1648	791	10774
2010	13285	1679	807	10799

SOURCE: Table A-6, Technical Memorandum BA-1, Methods, Standards, and Assumptions and Forecasts of Community Demographic and Economic Systems Without The Planned Barrow Arch Lease Sale (University of Alaska, Institute for Social and Economic Research, 1983a).

increases almost 2.35 times 1981 levels. In 1994, this category of employment peaks at a level only about 2.42 times as high as that experienced during 1981. Begining in 1995, non-resident employment begins to drop gradually through 2010. By 2010, nonresident employment is expected to decline to a level 1.94 times 1981 levels. This is almost a 20 percent drop from the high levels expected for 1994.

Another indicator of transportation demand is population. The population projections shown in Table 42 were also developed from ISER's North Slope models. It should be noted that Table 42 deals with only the resident population since the non-resident population equals non-resident employment (see Table 41). The forecast population is broken down by community, but illustrates only those communities that constitute the Barrow Arch impact area. Generally, each community population is expected to grow almost 95 percent during the period 1980 - 2010. The actual percentage in a specific community varies 2 percent to 3 percent above or below this value. For the entire North Slope Borough, resident population increases 1.95 times the 1980 level. The largest increase occurs among the Native resident population, where growth is 2.03 times the 1980 level. Resident non-Native population increases only about 49 percent over the 1980 - 2010 period.

A third socioeconomic indicator of transportation demand is per capita income. Projected per capita income data for the North Slope Borough is

TABLE 42

RESIDENT POPULATION FORECAST FOR SELECTED NORTH SLOPE BOROUGH VILLAGES
WITHOUT THE PLANNED BARROW ARCH LEASE OFFERING
1980 - 2010

YEAR	Atkasook	Barrow	Nuiqsut	Point Hope	Point Lay	Wainwright	Totals	Total North Slope Borough Population
1980	107	2207	208	464	68	405	3459	3827
1981	111	2291	214	480	71	421	3588	3969
1982	115	2365	221	496	74	434	3705	4098
1983	117	2420	227	508	76	445	3793	4195
1984	120	2477	232	519	77	455	3880	4293
1985	123	2534	237	531	79	466	3970	4392
1986	126	2592	243	544	81	476	4062	4493
1987	129	2652	248	556	83	487	4155	4597
1988	132	2711	254	569	85	498	4249	4700
1989	135	2772	259	581	86	509	4342	4804
1990	138	2834	265	594	88	521	4440	4911
1991	141	2897	271	608	90	532	4539	5021
1992	144	2961	277	621	92	544	4639	5132
1993	147	3027	283	635	94	556	4742	5246
1994	150	3093	289	649	96	568	4845	5360
1995	%53	3161	296	663	99	581	4953	5479
1996	157	3231	302	677	101	593	5061	5599
1997	160	3301	309	692	103	606	5171	5720
1998	164	3374a	316	707	105	620	5286	5847
1999	167	3447	323	723	108	633	5401	5975
2000	171	3523	330	739	110	647	5520	6107
2001	175	3600	337	755	112	661	5640	6239
2002	179	3679	344'	771	115	676	5764	6376
2003	182	3759	352	788	117	691	5889	6514
2004	186	3841	360	806	120	706	6019	6658
2005	190	3926	367	823	122	721	6149	6803
2006	195	4012	375	841	125	737	6285	6952
2007	199	4100	384	860	128	753	6424	7107
2008	.203	4190	392	879	131	770	6565	.7262
200?	207	4257	398	893	133	782	6670	7378
2010	209	4298	402	901	134	790	6734	7449

SOURCE: Tables C-17 and C-18, Technical Report 85, "A Description of the Socioeconomics of the North Slope Borough" (University of Alaska, Institute for Social and Economic Research, 1983b) shown in Table 43, together with total resident income. The focus in this table is also on the Borough resident, since the transient non-resident worker spends little, if any, money while on the North Slope. Total resident income increases approximately 37.8 percent between 1980 aand 2010. However, due to more rapidly rising population levels, average per capita income actually declines over this period from a rate of $17,717 per resident in 1980 to a level of $12,549 per resident in 2010, a decline of just over 29 percent.

In summary, over the past decade the primary source of socioeconomic change on the North Slope has been the North Slope Borough. The secondary source for economic change during this period has been North Slope oil development, which provides a tax base for the Borough. One of the Borough's economic goals has been to increase Inupiat employment opportunities and the Borough has been very successful in this respect largely through its capital improvement program. In the future, however, local employment opportunities will be affected by limitations on the operating budget and other factors influencing the capital improvements program.

One possible alternative is to increase resident employment in the petroleum industry. Historically, however, this industry has provided very little direct employment to Natives, who make up about 84 percent of total North Slope resident population. Part of this situation' can be

TABLE 43

PER CAPITA INCOME FORECAST - NORTH SLOPE BOROUGH . WITHOUT THE BARROW ARCH LEASE OFFERING 1980-2010

Year	Total Resident Income(1)	Per Capita Resident Income	Per Capita Native Income	Per Capita Non-Native Resident Income
1980	67,802	17,717	15,606	28,749
1981	70,818	17,835	15,641	28,652
1982	72,?92	17,760	15,503	28,652
1983	72,610	17,309	15,016	28,652
1984	72,562	16,904	14,581	28,652
1985	72,642	16,539	14,192	28,652
1986	72,840	16,212	13,845	28,652
1987	73,151	15,919	13,536	28,652
1988	73,570	15,655	13,259	28,652
1989	74,090	15,420	13,012	28,652
1990	74,707	15,208	12,792	28,652
1991	75,418	15,019	12,596	28,652
1992	76,217	14,850	12,420	28,652
1993	77,100	14,698	12,264	28,652
1994	78,066	14,562	12,124	28,652
1995	79,110	14,439	11,998	28,652
1996	80,229	14,329	11,886	28,652
1997	81,420	14,231	11,786	28,652
1998	82,682	14,142	11,696	28,652
1999	84,011	14,062	11,614	28,652
2000	85,406	13,989	11,541	28,652
2001	86,866	13,924	11,476	28,652
2002	88,388	13,864	11,416	28,652
2003	89,970	13,810	11,362	28,652
2004	91,613	13,761	11,313	28,652
2005	93,315	13,716	11,269	28,652
2006	95,076	13,675	11,228	28,652
2007	96,893	13,637	11,191	28,652
2008	98,769	13,602	11,157	28,652
2009	97,753	13,250	10,857	28,652
2010	93,484	12,549	10,276	28,652

NOTES: (1) Numbers shown in this column are in thousands of dollars.

SOURCE: Table A-14, Technical Memorandum BA-1, Methods, Standards, and Assumptions and Forecast% of Community Demographic and Economic Systems Without The Planned Barrow Arch Lease Sale (University of Alaska, Institute for Social and Economic Research, 1983a).

attributed to the pursuit of traditional Inupiat cultural activities such as hunting, fishing, and whaling. In the eyes of the petroleum industry, taking the time out from work to participate in these activities makes for a poor worker. Yet, cultural heritage is an important aspect of Native life and will continue to be in the future. How succeeding generations balance economic needs against cultural interests is one of the major social issues of contemporary Inupiat society. Unless specific efforts are made to reduce present constraints to Inupiat employment in the petroleum industry, or unless future workers choose economic interests over cultural interests, a reduced per capita income for North Slope residents is a likely outcome.

These potential changes in employment opportunities, and subsequent reduction in per capita income, can be expected to negatively influence the purchase of transportation services. These trends, in turn, similarly influence marine tonnage demand and intra- and interregional air travel demands. Overshadowing these trends is the growth of non-resident employment, which is related to oil and gas exploration and development activities. The apparent doubling of current non-resident employment can be expected to have a corresponding effect on non-resident transportation demands.

The influence of these various economic changes on the different transportation modes are discussed in the following sections, each dealing with a specific system.

Marine Transportation

The marine transportation forecast presented here is divided into two segments. The first segment addresses transportation demands and services provided to communities adjacent to the Barrow Arch Planning Area; the second segment addresses transportation demands and services provided specifically to the petroleum industry.

COMMUNITY DEMANDS AND SERVICES

As discussed in Chapter III, communities adjacent to the Barrow Arch Planning Area create transportation demands for a variety of dry goods and liquid bulk products. The liquid bulk items, which consists of various fuel products (principally heating oil, gasoline, and diesel fuel), make up 75 to 90 percent of all inbound marine goods, based on weight. Both the dry goods and liquid bulk products are moved from ocean-going barges to the beach via lighter barges. Dry goods are deposited on the beach or are moved inland with local equipment or by hand. Liquid bulk products are moved inland by fuel lines that extend from near the ocean to fuel tanks in or near each village.

Table 44 provides a forecast of dry goods and non-bulk liquids. The

TABLE 44

DRY GOODS AND NON-BULK LIQUIDS
MARINE TONNAGE DEMANDS
FOR SELECTED NORTH SLOPE BOROUGH VILLAGES
WITHOUT THE PLANNED BARROW ARCH LEASE OFFERING
1983 - 2010

Year	Barrow (1)	Point Hope	Point Lay	Wainwright	Total Tonnage Demand
1982	2956	372	56	326	3709
1983	3025	381	57	334	3797
1984	3096	389	58	341	3885
1985	3168	398	59	350	3975
1986	3240	408	61	357	4066
1987	3315	417	62	365	4160
1988	3389	427	64	374	4253
1989	3465	436	65	382	4347
1990	3543	446	66	391	4445
1991	3621	456	68	399	4544
1992	3701	466	69	408	4644
1993	3784	476	71	417	4748
1994	3866	487	72	426	4851
1995	3951	497	74	436	4959
1996	4039	508	76	445	5067
1997	4126	519	77	455	5177
1998	4218	530	79	465	5292
1999	4309	542	81	475	5407
2000	4404	554	83	485	5526
2001	4500	566	84	496	5646
2002	4599	578	86	507	5770
2003	4699	591	88	518	5896
2004	4801	605	90	530	6025
2005	4908	617	92	541	6157
2006	5015	631	94	553	6292
2007	5125	645	96	565	6431
2008	5238	659	98	578	6573
2009	5321	670	100	587	6677
2010	5373	676	101	593	6741

NOTE : (1) Figures are based on an assumed rate of 1.25 tons per capita for Barrow and 0.75 tons per capita for other villages.

SOURCE : ERE Systems, Ltd.

predominant indicator used to forecast dry goods demands is population. The method used to forecast those values is based upon an assumed per-capita tonnage demand of 1.25 torts per person for Barrow and 0.75 tons per person for the other villages. These per-capita rates were developed in two steps. The first step averages existing total demand levels (including both bulk and non-bulk products), to the extent these demand levels can be identified. The second step attempts to develop an average per-capita rate for only non-bulk products and is based on the assumption that dry goods and non-bulk products constituted about 25 percent of historic total demand. For purposes of this analysis, it was assumed per capita consumption remains unchanged throughout the forecast period, despite the forecast downward trend in per capita income (see Table 43 presented earlier). The implication of these assumptions is that by 1990, tonnage demands for these non-bulk products increase about 20 percent; by 2000, demands increase 49 percent; and by 2010 the increase is almost 82 percent.

Bulk products were also forecast using the per-capita method, but with different assumptions. Fuel constitutes vertually all of the bulk products delivered to BarrowArch communities and includes heating oil, diesel, gasoline, and aviation fuel. These products are unlikely to follow the same growth pattern as dry goods because the addition of new public facilities requires an increase in total fuel consumption. Bulk liquid tonnage demands for the four coastal communities are forecast in

Table 45. Per-capita fuel consumption for 1982 was developed by dividing existing fuel delivery data by the total population of the four communities that year (see Table 42). This rate of consumption was assumed to: increase at a rate of 4 percent per year through 1985, increase at a rate of 2 percent per year through 1990, and remain constant thereafter. The resulting increase in fuel tonnage for all four communities is about 52 percent by 1990; 93 percent by 2000; and about 136 percent by 2010. Since existing fuel consumption varies greatly from village to village, per-capita consumption was assumed to be equal in each community for purposes of breaking out total gallon demand by community.

The combined tonnage of dry goods and bulk liquids for all four communities is summarized in Table 46. Total marine tonnage demands are expected to increase 46 percent by 1990; 84 percent by 2000; and 125 percent by 2010. The most rapid growth occurs over the period between 1982 and 1990 when the annual average growth is 5.7 percent. Over the next two decades (1991-2000 and 2001-2010) growth averages 2.7 percent and 2.2 percent, respectively.

Despite these apparent high rates of growth, the tonnage forecast is insufficient to justify construction of new marine facilities. A considerable investment would need to be made in each village to overcome the physical limitations of the marine environment (shallow

TABLE 45

BULK LIQUIDS MARINE TONNAGE DEMAND
FOR SELECTED NORTH SLOPE BOROUGH VILLAGES
WITHOUT THE PLANNED BARROW ARCH LEASE OFFERING
1982 - 2010

Year	Assumed Per-Capita Consumption(1)	Total Demand (2) Gallons	Tonnage(3)	Break Out By Community Based on Population (4) Barrow	Point Hope	Point Lay	Wainwright
1982	980	3301000	14600	2317000	486000	72000	425000
1983	1019	3515000	15600	2466000	517000	77000	453000
1984	1060	3739000	16600	2625000	550000	81000	482000
1985	1102	3979000	17600	2793000	585000	87000	513000
1986	1146	4233000	18800	2971000	623000	92000	545000
1987	1169	4417000	19600	3101000	650000	97000	569000
1988	1193	4607000	20400	3233000	678000	101000	594000
1989	1217	4803000	21300	3372000	706000	104000	619000
1990	1241	5009000	22200	3516000	737000	109000	646000
1991	1266	5223000	23200	3666000	769000	113000	673000
1992	1266	5339000	23700	3747000	786000	116000	688000
1993	1266	5458000	24200	3831000	803000	118000	703000
1994	1266	5577000	24700	3915000	821000	121000	718000
1995	1266	5701000	25300	4001000	839000	125000	735000
1996	1266	5825000	25800	4089000	856000	127000	750000
1997	1266	5951000	26400	4178000	875000	130000 -	767000
1998	1266	6083000	27000	4270(300	894000	132000	784000
1999	1266	6216000	27600	4363000	915000	136000	801000
2000	1266	6352000	28200	4459000	935000	139000	818000
2001	1266	6490000	28800	4556000	955000	141000	836000
2002	1266	6633000	29400	4656000	975000	145000	855000
2003	1266	6778000	30100	4758000	997000	148000	874000
2004	1266	6927000	30700	4861000	1020000	151000	893000
2005	1266	7078000	31400	4969000	1041000	154000	912000
2006	1266	7233000	32100	5078000	1064000	158000	932000
2007	1266	.7393000	32800	5189000	1088000	162000	953000
2008	1266	7556000	33500	5303000	1112000	165000	974000
2009	1266	7676000	34100	5388000	1130000	168000	989000
2010	1266	7750000	34400	5440000	1140000	169000	999000

NOTES: (1) Per capita fuel consumption was assumed to increase at a rate of 4 percent per year through 1985, at a rate of 2 percent per year through 1990, and remain constant thereafter.
(2) Derived by multiplying per-capita consumption by the total population of the four communities (see Table 42).
(3) One ton of bulk liquid equals 225 gallons.
(4) The sum of these individual communities may not equal total demand due to rounding.

SOURCE: ERE Systems, Ltd.

TABLE 46

MARINE TONNAGE DEMANDS AND TRIP REQUIREMENTS FOR SELECTED NORTH SLOPE BOROUGH VILLAGES WITHOUT THE PLANNED BARROW ARCH LEASE OFFERING 1982 - 2010

	Marine Tonnage Demands			Marine Vessel Trip Requirements			
Year	Bulk Liquids (1)	Dry Goods (2)	Total	Bulk Fuel (3)	Dry Cargo (4)	Total	Tow or Tug Vessels (5)
1982	14600	3709	18309	3	1	4	3
1983	15600	3797	19397	4	1	5	4
1984	16600	3885	20485	4	1	5	4
1985	17600	3975	21575	4	1	5	4
1986	18800	4066	22866	4	2	6	5
1987	19600	4160	23760	4	2	6	5
1988	20400	4253	24653	5	2	7	5
1989	21300	4347	25647	5	2	7	5
1990	22200	4445	26645	5	2	7	5
1991	23200	4544	27744	5	2	7	5
1992	23700	4644	28344	5	2	7	5
1993	24200	4748	28948	5	2	7	5
1994	24700	4851	29551	5	2	7	5
1995	25300	4959	30259	6	2	8	6
1996	25800	5067	30867	6	2	8	6
1997	26400	5177	31577	6	2	8	6
1998	27000	5292	32292	6	2	8	6
1999	27600	5407	33007	6	2	8	6
2000	28200	5526	33726	6	2	8	6
2001	28800	5646	34446	6	2	8	6
2002	29400	5770	35170	6	2	8	6
2003	30100	5896	35996	7	2	9	6
2004	30700	6025	36725	7	2	9	6
2005	31400	6157	37557	7	2	9	6
2006	32100	6292	38392	7	2	9	6
2007	32800	6431	39231	7	2	9	6
2008	33500	6573	40073	7	2	9	6
2009	34100	6677	40777	7	2	9	6
2010	34400	6741	41141	7	2	9	6

NOTES :
(1) From Table 45
(2) From Table 44
(3) Each bulk fuel vessel trip is based on a barge capacity of 5,000 tons.
(4) Each dry cargo vessel trip is based on a barge capacity of 4,000 tons.
(5) Each tug or towboat is assumed to pull 2 barges. Bulk fuel and dry cargo tug requirements are calculated separately and added.

SOURCE: ERE Systems, Ltd.

water, continuous winds, waves, and ice conditions) sufficiently enough to alter the level of transportation service (i.e. eliminating the use of lighters to offload ocean barges). The consequence of these physical and cost limitations, is the continuance of lightening marine bulk liquids and dry goods supplies and the distribution of bulk fuel supplies via available fuel distribution lines. In conjunction with the Borough's consolidation of fuel storage, some improvements can be expected to be made to the distribution lines. The timing of these improvements are dictated as much by the economics of the waiting barges and lighters, as by the timing of the Borough's improvement program.

Table 46 also provides an estimate of marine vessel trip requirements. The data represents round trips by ocean going barges, but does not include the lighter barge trips, which are more numerous. The bulk fuel trip "requirements are based on a barge capacity of 5,000 tons (approximately 1,125,000 gallons), while dry cargo trip requirements are based on a barge capacity of 4,000 tons. During normal operations, a single barge may stop at all four communities (or more) rather then carrying all the goods or fuel for single village. Consequently, the effective capacity of these barges at each community is less than the assumed capacities when all communities are considered. During normal operations, needs other than barge capacity will determine the number of trips required, thus, this estimate could vary considerably. On the basis of these various assumptions, vessel trip requirements, including tow or tug vessels, more than double over the forecast period.

The Military Sealift Command's operation COOL BARGE, also serves DEW Line sites near or adjacent to these four communities. Although Navy planners have projected tonnage needs for a five year horizon period, the military mission is subject to considerable change year to year. Current and planned improvements to the various radar systems utilized at these sites presents a future picture wherein fewer personnel, or even no personnel, are required to operate these sites. Except during periods of new construction, the longer range tonnage forecast would seem to indicate a declining tonnage demand for COOL BARGE services to these sites. For these reasons, a more precise estimate of COOL BARGE demands was not made.

1NDUSTR% DEMANDS AND SERVICES

Oil industry demands for barge services vary considerably year to year (see Table 7 presented in Chapter III). These demands vary based on annual project requirements, which in turn depend on market conditions affecting the pace of oil development world wide. A forecast of sealift tonnage and corresponding traffic was made in a previous transportation study of the Diapir Field Lease Sale (Sale 87) and is presented in Table 47. These sealift requirements incorporate both onshore and offshore leasing areas. Approximately 90 percent of the tonnage consists of

TABLE 47

PETROLEUM INDUSTRY SEALIFT TONNAGE AND VESSEL REQUIREMENTS
WITHOUT THE BARROW ARCH LEASE OFFERING
1983 - 1996

	Total Sealift Requirements			Requirements at Wainwright		
Year	Tonnage	Barges 1)	Tugs(2	Tonnage	Barges(1)	Tugs(2)
1983	133000	28	14	2000	1	1
1984	168000	34	19	3000	1	1
1985	219000	45	23	4000	1	1
1986	231000	48	25	4000	1	1
1987	2[illegible]3000	56	29	16000	4	2
1988	253000	52	26	17000	4	2
1989	290000	60	31	29000	7	4
1990	238000	50	26	36000	8	4
1991	295000	61	31	29000	7	4
1992	313000	65	33	29000	7	4
1993	266000	55	28	29000	7	4
1994	197000	41	21	15000	4	2
1995	198000	41	21	15000	4	2
1996	71000	15	8	---	---	---

NOTES: (1) The effective load per barge is assumed to be 4,820 tons based on the five year average tons per barge experienced between 1979 - 1983.
(2) Each tug is assumed to transport up to two barges.

SOURCE: Technical Report 105, Diapir Field (Sale 87) Transportation Systems Impact Analysis (Louis Berger & Associates, Inc., 1983b).

modules and the remaining 10 percent is drilling supplies. The number of barges is based on an average load of 4,820 tons per barge. Table 47 also illustrates that portion of the sealift requirements expected to be landed in the vicinity of Wainwright. The tonnage represents approximately 45 percent of the drilling supplies needed for NPR-A exploration activities. No modules are included in the tonnage.

The combined effect of community and industry vessel requirements is 'illustrated in Table 48. Tug-barge combinations with a destination along the coast adjacent to the Barrow Arch Planning Area are shown in the second and third columns of the table. As noted, these numbers are derived from Tables 46 and 47. The number of tug-barge combinations with a destination further north is shown in the fourth and fifth columns. These latter vessels only pass through the Barrow Arch Planning Area on the way to and from Beafort Sea ports. The last two columns of the table adds west coast destination and in-transit vessel requirements. Based on the data presented, vessel requirements peak in 1992 at a level 2.4 times the 1983 level. In general, this forecast suggests a high level of demand over the decade 1985 - 1995.

Air Transportation

This section presents a forecast air transportation demands and services for conditions that might exist without the Barrow Arch Lease Sale. The

TABLE 48

COMBINED COMMUNITY AND INDUSTRY VESSEL REQUIREMENTS
WITHOUT THE BARROW ARCH LEASE OFFERING
1982 - 2010

	Destinations Along West Coast (1)		In Transit Through The Planning Area (2)		Total Vessel Requirements	
Year	Barges	Tugs	Barges	Tugs	Barges	Tugs
1982	4	3	26	13	30	16
1983	6	5	27	13	33	18
1984	6	5	33	18	39	23
1985	6	5	44	22	50	27
1986	7	6	47	24	54	30
1987	10	7	52	27	62	34
1988	11	7	48	24	59	31
1989	14	9	53	27	67	36
1990	15	9	42	22	57	31
1991	14	9	54	27	68	36
1992	14	9	58	29	72	38
1993	14	9	48	24	62	33
1994	11	7	37	19	48	26
1995	12	8	37	19	49	27
1996	8	6	15	8	23	14
1997	8	6	--	--	8	6
1998	8	6	--	--	8	6
1999	8	6	--	--	8	6
2000	8	6	--	--	8	6
2001	8	6	--	--	8	6
2002	8	6	--	--	8	6
2003	9	6	--	--	9	6
2004	9	6	--	--	9	6
2005	9	6	--	--	9	6
2006	9	6	--	--	9	6
2007	9	6	--	--	9	6
2008	9	6	--	--	9	6
2009	9	6	--	--	9	6
2010	9	6	--	--	9	6

NOTES : (1) Combines Table 46 data and "Requirements at Wainwright" from Table 47.
(2) Subtracts "Requirements at Wainwright" from "Total Sealift Requirements" in Table 47.

SOURCE: ERE Systems, Ltd.

analysis focuses on the communities of Wainwright and Barrow, the airport at Prudhoe Bay/Deadhorse, and the international airports at Fairbanks and Anchorage. The forecast was limited to these communities because, as noted in the next chapter, only these communities or facilities are likely to be affected by Barrow Arch petroleum development activities. As in the previous section on marine transportation, the forecast is divided into two subsections: one dealing with the demands created in the permanent communities (Barrow and Wainwright), the second dealing with industry demands.

COMMUNITY DEMANDS AND SERVICES

As mentioned above, the community level analysis is limited to Wainwright and Barrow since these are the only permanent communities likely to receive direct impacts from the proposed lease sale. At present, Wainwright is served by a scheduled air carrier from Barrow several times per week. At Barrow, air passengers can board commercial jets to Fairbanks and Anchorage and from these places have access to anywhere in the world. A new 5,000 foot gravel runway was recently completed at Wainwright and a paved jet runway is available at Barrow. Additional details about aviation facilities and services in these communities can be found in Chapter III.

Barrow

Air Carrier service to Barrow consists of both intrastate and regional operations. The predominant passenger activities are the intrastate movements between Barrow and Fairbanks and between Barrow and Anchorage, while the predominant aircraft activity involves the various air taxi operations. During the period 1980 - 1982, intrastate and regional air carrier service has operated at. an average level of about 23,700 enplanements per year at Barrow. It was estimated that approximately 11 percent of these enplanements were exclusively regional in nature. Over this same period regional air taxi and charter services enplaned approximately 11,600 passengers per year. Annual passenger enplanements from other services, such as freight. or general aviation activities, constituted less than 1.4 percent of total enplanements.

The method used to forecast future enplanements is based upon application of a per capita ratio developed from historic demand data. Multiplying this ratio by future population levels in the airport service area provides an estimate of future enplanements. In establishing this ratio, particular emphasis was given to the most recent years of operations. The service area for Barrow was defined to include Wainwright, Point Lay, Nuiqsut, and Atkasook. The service area population and resultant. forecast is summed in Table 49.

The per capita ratio used in forecasting intrastate and regional air

TABLE 49

AIR TRANSPORTATION DEMANDS AT BARROW, ALASKA
WITHOUT THE BARROW ARCH LEASE OFFERING
1980 - 2010

Year	Intrastate and Regional Air Carrier Air Trips Per Capita(1)	Regional Air Taxi Air Trips Per Capita(2)	'Regional Service Area Population(3)	Enplanements: Intrastate and Regional Air Carrier(4)	Enplanements: Regional Air Taxi(4)	Enplanements: Total Air Carrier & Air Taxi	Enplanements: Others(5)	Enplanements: Total
1980	8.20	3.69	2995	24545	11059	35604	500	36104
1981	7.51	3.70	3108	23347	11493	34840	500	35340
1982	7.28	3.84	3209	23354	12334	35688	608	36296
1983	7.30	3.93	3285	23967	12906	36873	660	37533
1984	7.31	3.99	3361	24583	13407	37990	712	38702
1985	7.33	4.04	3439	25216	13880	39096	766	39862
1986	7.35	4.07	3518	25847	14333	40180	822	41002
1987	7.36	4.11	3599	26495	14780	41275	879	42154
1988	7.38	4.13	3680	27145	15216	42361	938	43299
1989	7.39	4.16	3761	27798	15644	43442	999	44441
1990	7.41	4.18	3846	28483	16082	44566	1063	45629
1991	7.42	4.20	3931	29171	16516	45688	1128	46816
1992	7.44	4.22	4018	29876	16955	46832	1197	48028
1993	7.45	4.24	4107	30599	17400	47999	1267	49266
1994	7.47	4.25	4196	31325	17842	49167	1340	50507
1995	7.48	4.27	4290	32091	18304	50395	1416	51811
1996	7.50	4.28	4384	32859	18765	51624	1495	53119
1997	7.51	4.29	4479	33639	19228	52867	1575	54442
1998	7.53	4.30	4579	34458	19712	54171	1660	55831
1999	7.54	4.32	4678	35274	20192	55466	1747	57213
2000	7.56	4.33	4781	36123	20688	56811	1838	58648
2001	7.57	4.34	4885	36982	21188	58170	1931	60101
2002	7.59	4.35	4993	37875	21705	59581	2029	61609
2003	7.60	4.36	5101	38772	22222	60994	2129	63123
2004	7.62	4.37	5213	39703	22757	62459	2233	64692
2005	7.63	4.37	5326	40644	23296	63940	2340	66280
2006	7.65	4.38	5444	41628	23857	65485	2452	67937
2007	7.66	4.39	5564	42631	24427	67057	2568	69626
2008	7.68	4.40	5686	43653	25006	68658	2688	71346
2009	7.69	4.41	5777	44440.	25448	69888	2796	72684
2010	7.71	4.41	5833	44960	25737	70697	2888	73585

NOTES:
(1) Computation for 1980 and 1981 based on actual data. Per-capita rate is assumed to increase 0.25 percent per year through 1985, then increase only 0.20 percent per year through .2010.
(2) Computation for 1980 and 1981 based on actual data. Per-capita rate is assumed to increase at an average rate of 2.39 percent per year throughout the forecast period.
(3) Includes all communities listed in Table 42, except Point Hope.
(4) Oerived by multiplying applicable per capita rate by service area population.
(5) Other enplanements are expressed as a percentage of air carrier/air taxi enplanements. The percentage is assumed to increase from about 1.62 percent in 1981 to about 4.17 percent in 2010.

SOURCES: ERE Systems, Ltd., except actual data for 1980, 1981, and 1982 from "Airport Activity Statistics of Certified R[illegible]te Air Carriers "l(USOOT, FAA & [illegible], for 1980, 19[illegible] and 1982).

carrier enplanements was selected as 7.51 trips per capita for the base year 1981. Although experience indicates that the expected decline in per capita income would reduce travel demands of local residents, tourist travel and business travel demands are assumed to increase. Consequently, this ratio was assumed to increase 0.25 percent per year through 1985, reflecting a continuation of existing trends; and to increase only 0.20 percent per year through 2010, reflecting likely changes in per capita income and an expected slowdown of economic activity. A possible temporary offsetting factor to a decline in travel demands of local residents is the introduction of Competitive services, which would have the effect of slowing down the rise in travel costs. However, this factor was not incorporated in the analysis. Applying this varying ratio almost doubles intrastate and regional air carrier enplanements, as shown in Table 49. From a level of 23,347 in 1981, air carrier enplanements increase about 22 percent by 1990, about 55 percent by 2000, and about 93 percent by 2010. By 2010, passenger enplanements approach 44,960 per year.

A similar method was employed to forecast regional air taxi and charter enplanements. Because of expected modifications in the Borough's capital improvements program and the reduced availability of jobs, the current close relationship between job location and residence location is likely to change. The change is one of increasing distance between job and residence locations. Consequently, while the number of regional air trips per capita seems more likely to remain constant, or even decline, due to the expected drop in per capita income, the changing job-residence location relationship is more likely to cause a gradual increase in per capita trip making. For the sake of this analysis the per capita rate was assumed to increase along a logarithmic curve so that the rate of change per year decreases. Over the thirty-year forecast period the total change is about 19.5 percent. The resultant changes in per capita air taxi and charter enplanements are shown in Table 49. Applying these values more than doubles regional air taxi and charter enplanements. From a level of about 11,493 in 1981, air taxi and charter enplanements increase 40 percent by 1990, 80 percent by 2000, and increase about 1.24 times 1981 levels by 2010.

All other types of enplanements were also forecast. The methodology used to develop these figures assumed other enplanements become an increasing percentage of total air carrier and air taxi/charter enplanements. The percentage was. assumed to increase from about 1.62 percent in 1981 to about 4.17 percent in 2010. This approach reflects the changing relationship between job and residence location, as well as rising trends in private aircraft usage.

Total enplanements at Barrow are summed in the last column of Table 49. Between 1981 and 1990, enplanements are expected to increase almost 29 percent; from 1990 to 2000 almost 29 percent; and between 2000 and 2010 just over 25 percent. Relative to 1981, growth in 2000 and 2010 is 66 percent and 108 percent, respectively. Enplanements are assumed to equal deplanements, therefore, the enplanement data is doubled to get total passengers. The existing passenger terminal facility at Barrow is owned by Wien Air Alaska and operates at or near capacity when Wien's commercial flights arrive. Since Wien has only one B-737 aircraft at the terminal at any one time the terminal performs adequately. If a second air carrier were to provide air service to Barrow, or if additional air taxi operators provide services to the outlying villages, a public terminal may need to be constricted.

Other impacts can be expected from the concomitant increase in aircraft operations. The conversion of enplanements to aircraft operations is illustrated in Table 50. Intrastate air carrier operations are expected to continue to be all-jet service using combined passenger-cargo aircraft. As mentioned earlier, it was assumed that intrastate service -constitutes about 89 percent of the combined intrastate and regional enplanements. Due to the increasing importance of intraregional travel it was assumed that the 89 percent relationship would decline to about 85 percent over the 30-year forecast period. Based on an aircraft capacity of 60 passengers with a load factor ranging from 52 percent in 1980 to about 70 percent in 2010, intrastate air carrier operations increase about 45 percent over the 30-year forecast period. The increase to 1990 is about 14 percent and to 2000 is over 29 percent.

TABLE 50

AIRCRAFT OPERATIONS FORECAST - BARROW, ALASKA
WITHOUT THE BARROW ARCH LEASE OFFERING
1980 - 2010

Year	Intrastate Air Carrier(1)	Regional Air Carrier(2)	Air Taxi and Other Passenger(3)	Freight and al 1 Other(4)	Total Aircraft Operations	Peak Daily Aircraft Operations(5)
	Aircraft Operations					
1980	1464	586	10434	657	13141	54
1981	1256	952	11202	609	14019	58
1982	1299	1181	11523	737	14739	61
1983	1316	1226	11943	762	15247	63
1984	1333	1272	12291	784	15680	64
1985	1350	1319	12606	804	16080	66
1986	1367	1367	12899	823	16456	68
1987	1384	1417	13180	841	16822	69
1988	1401	1467	13446	859	17173	71
1989	1418	1519	13701	876	17513	72
1990	1436	1573	13960	893	17862	73
1991	1453	1628	14211	910	18202	75
1992	1471	1685	14462	927	18545	76
1993	1489	1743	14713	945	18890	78
1994	1507	1803	14958	961	19230	79
1995	1527	1866	15215	979	19587	80
1996	1546	1930	15467	997	19939	82
1997	1565	1995	15717	1015	20291	83
1998	1585	2064	15980	1033	20662	85
1999	1605	2133	16234	1051	21023	86
2000	1626	2206	16498	1070	21399	88
2001	1646	2280	16760	1089	21775	89
2002	1668	2357	17032	1108	22165	91
2003	1689	2435	17299	1128	22551	93
2004	1712	2517	17576	1148	22952	94
2005	1734	2600	17851	1168	23353	96
2006	1757	2688	18139	1189	23773	98
2007	1781	2777	18430	1210	24198	99
200B	1805	2869	18722	1231	24629	101
2009	1819	2947	18910	1246	24922	102
2010	1822	3008	18980	1253	25063	103

NOES: (1) Assumes intrastate air carrier operations decline from approximately 89 percent of total air carrier activity in 1980 to 85 percent 2010. Also assumes aircraft capacity of 60 passengers with load factors increasing from 52 percent in 1980 to 70 percent in 2010.

(2) Assumes regional air carrier operations increase from approximate y 11 percent of total air carrier activity in 1980 to 15 percent in 2010. Also assumes aircraft capacity of 6.78 passengers and a constant load factor of 65.7 percent.

(3) Assumes an average aircraft capacity of 6 passengers and a load factor increasing from 35 percent in 1980 to 45.2 percent in 2010.

Assumes freight and al 1 other operations constitute 5 percent of total operations.

(5) Derived as 1.5 times the annual daily average.

SOURCE: ERE Systems, Ltd.

The formula used to develop the intrastate air carrier forecast is:

$$\frac{\text{Intrastate and Regional Air Carrier Enplanements} \times \text{Intrastate Proportion of Enplanements}}{\text{Aircraft Seating Capacity} \times \text{Load Factor}}$$

Where:
- Air Carrier Enplanements come from Table 49;
- Intrastate Proportion of Enplanements is: $(1 - (0.11 + (0.00134 \times (19YY - 1980))))$;
- Aircraft Seating Capacity is: 60;
- Load Factor is: $(0.52 + (0.006 \times (19YY - 1980)))$;
- 19YY refers to the forecast year.

Cape Smythe Air Service is the regional air carrier currently providing scheduled service to North Slope communities. In this capacity, Cape Smythe operates as a subcontractor to Wien Air Alaska. Cape Smythe also operates as an air taxi operator. In general, regional air carriers operate with much smaller aircraft. For example, the equipment utilized by Cape Smythe for both scheduled and air taxi services includes four Cessna 207 series aircraft (5 seats], one Piper Aztec PA 23-250 (4 seats), and two DeHavilland Twin Otter DHC-6 (16 seats) (Louis Berger & Assoc. et al, 1979). From FAA/CAB data on aircraft utilization, as published in "Airport Activity Statistics of Certified Route Carriers" {U.S. Dept. of Transportation, Federal Aviation Administration & Civil

Aeronautics Board, annual), the average capacity of regional air carriers was estimated to be 6.78 passengers. This figure represents a weighted average of available passenger seating and number of flights and reflects the flexibility of regional operators to respond to changing demands. Aircraft capacity was assumed to remain constant over the forecast period, although the average size of such aircraft is likely to gradually increase.

Based on the assumed aircraft capacity, the load factor was estimated at 65.7 percent. Since the aircraft capacity was assumed to remain constant, the desire for increased efficiency in day to day operations argues for a rising load factor. However, expected changes in job-residence locations may not necessarily lead to more efficient operations until travel patterns stabilize. So the load factor was assumed to also remain constant over the forecast period.

Regional air carrier enplanements are expected to rise faster than intrastate enplanements so that over the forecast period regional enplanements increase from 11 percent to 15 percent of total air carrier enplanements. Applying the above capacity and load factor constraints, together with the changing relationship between regional and intrastate travel; to the air carrier enplanements data in Table 49 produces the regional air carrier forecast in Table 50. During the first ten years, operations increase about 65 percent; during the second decade the increase is almost 40 percent; and during the third decade the rate of change slows to 36 percent. Over the entire forecast period regional air carrier enplanements increase 2.16 times 1981 levels with an intermediate level of 1.31 times 1981 levels in 2000.

The formula used to calculate regional air carrier operations is:

$$\frac{\text{Intrastate and Regional Air Carrier Enplanements} \times \text{Regional Proportion of Enplanements}}{\text{Aircraft Seating Capacity} \times \text{Load Factor}}$$

Where:
- Air Carrier Enplanements come from Table 49;
- Regional Proportion of Enplanements is: (0.11 + (0.00134 x (19YY - 1980)));
- Aircraft Seating Capacity is: 6.78;
- Load Factor is: (0.657);
- 19YY refers to the forecast year.

Air taxi operators and private aircraft owners operate the smallest aircraft, but at Barrow constitute the greatest percentage of total aircraft operations. If it is assumed the air taxi operators have available almost the same mix of aircraft as described above, aircraft capacity can be assumed at about 6 passengers. Load factors were estimated to be about 35 percent in 1930 and were assumed to increase to about 45.2 percent by 2010. Applying these constraints to the air taxi enplanements in Table 49 produces the air taxi forecast in Table 50. By 1990, growth exceeds 1980 levels by almost 34 percent; by 2000 the change is about 58 percent; and by 2010 the change is about 82 percent over 1980 levels.

The formula used to calculate air taxi operations is:

$$\frac{\text{Regional Air Taxi Enplanements}}{\text{Aircraft Seating Capacity} \times \text{Load Factor}}$$

Where:
- Regional Air Taxi Enplanements come from Table 49;
- Aircraft Seating Capacity is: 6.0;
- Load Factor is: 0.35 + (0.0034 x (19YY - 1980)));
- 19YY refers to the forecast year.

Although freight tonnage demands were not forecast, an attempt was made to capture the incremental influence of freight and other nondescript aircraft operations. In light of changes to the Borough's capital improvements program, the growth in air freight tonnage is likely to slow down. However, increasing mail volumes and the shipment of additional foodstuffs and equipment to support added population levels should keep freight shipments growing at some level. In this analysis, freight operations were assumed to increase proportionally to other operations, which may overstate the more likely trend. These "freight and other" operations were forecast as 5 per-cent of the sum of intrastate, regional, and air taxi operations. Consequently, freight and other operations increase 35 percent by 1990, 63 percent by 2000, and about 91 percent by the end of the forecast period.

Total aircraft operations at Barrow are summed in Table 50. Generally, total aircraft operations increase 79 percent over the 1981 level of activity. These total operations generally fall below forecasts prepared by the Federal Aviation Administration (FAA) and above a contractor of the Alaska Department of Transportation. In its "Ten Year Plan" (U.S. Dept. of Transportation, Federal Aviation Administration, Alaska Region, 1981), the FAA forecasts 28,000 operations for 1992, which is almost 51 percent higher than the forecast 18,545 operations' shown in Table 50. Looking at this another way, FAA's forecast level of operations does not occur in the Table 50 forecast until some time after 2010. Alaska Transportation Consultants in their report "Airport Development & Land Use Plans - Barrow Airport" (Alaska Transportation Consultants, Inc., 1983), forecast 18,900 operations in 2000, which is 13 percent below the forecast of Table 50. This level of operations occurs in about 1993, seven years premature in reference to Table 50.

Based on runway capacity developed in Chapter III, the Barrow Airport can handle between 236,500 and 315,400 operations per year. On a daily basis this translates to a level of operations between 648 and 864 per day. Compared to the peak daily operations presented in Table 50, the existing runway facilities have sufficient capacity to handle expected increases in aircraft operations through 2010. The peak daily operations data in Table 50 was developed by multiplying by 1.5 the annual daily average aircraft operations, which is derived by dividing total operations by 365 days. As economic development occurs in Barrow, the problems at the airport are more likely to be the availability of space for on-airport leases, the ability of the water treatment plant to handle increased treatment demands, etc. Improvements to address these and other problems were suggested by the ATC study and should improve overall airport capacity.

Wainwright

This community was selected for analysis because it is expected to become a major staging base for most, if not all, of the oil and gas activities in the Barrow Arch lease area. This forecast of conditions without the lease sale is based on an extrapolation of existing trends. Air service to Wainwright comes from Barrow, Point Lay, and Atqasuk. 'The service consists mostly of scheduled regional air carrier activities, which for this analysis includes a scheduled charter service operated by the North Slope Borough, together with unscheduled air taxi and charter services, and general aviation operations. This analysis focuses on scheduled air carrier activities, total aircraft operations, and peak aircraft operations.

The method used to forecast future enplanements is based upon application of a per capita trip demand ratio developed from historic data. Based on the current operating schedules, approximately 672 scheduled aircraft operations (both landings and takeoffs) provide service to Wainwright. If these region-serving aircraft have the same operating characteristics as those flying from Barrow, aircraft seating capacity is about 6.78 passengers and the load factor is about 65.7 percent (see previous discussion and formula). Backing these numbers out. and dividing by the population of Wainwright (434 persons in 1982) produces a per capita trip rate of about 6.89. To produce the forecast shown in Table 51, this per capita rate was extrapolated using the same regional service assumptions from Barrow: per capita trip making would grow at an annual rate of 0.25 percent through 1985, then increase at an annual rate of only 0.20 percent through 2010.

It should be noted that the actual rate for air trip making in Wainwright is probably lower than that used here. One reason for the higher rate is that it reflects both enplanements and deplanements, whereas in the Barrow forecast it reflected only enplanements. Another reason is that the rate includes passengers who are in transit. Wainwright is one of the intermediate stops along routes serving other communities, therefore, arriving and departing aircraft have passengers with no origin or destination in Wainwright.

TABLE 51

AIR TRANSPORTATION DEMANDS AND AIRCRAFT OPERATIONS . WAINWRIGHT, ALASKA
WITHOUT THE BARROW ARCH LEASE OFFERING
1980 - 2010

Year	Air Trips Per Capita(1)	Wainwright Population(2)	Air Carrier Emplacements and Deplanements(3)	Air Carrier Operations(4)	Total Aircraft Operations(5)	Peak Daily Aircraft Operations(6)
1982	6.89	434	2992	672	1343	7
1983	6.91	445	3076	690	1381	8
1984	6.93	455	3153	708	1415	8
1985	6.95	466	3237	727	1453	8
1986	6.96	476	3313	744	1487	8
1987	6.97	487	3396	762	1525	8
1988	6.99	498	3480	781	1562	9
1989	7.00	509	3564	800	1600	9
1990	7.02	521	3655	821	1641	9
1991	7.03	532	3740	840	1679	9
1992	7.04	544	3832	860	1720	9
1993	7.06	556	3924	881	1762	10
1994	7.07	568	4017	902	1804	10
1995	7.09	581	4117	924	1849	10
1996	7.10	593	4211	945	1891	10
1997	7.11	606	4312	968	1936	11
1998	7.13	620	4420	992	1985	11
1999	7.14	633	4522	1015	2030	11
2000	7.16	647	4631	1040	2079	11
2001	7.17	661	4741	1064	2128	12
2002	7.19	676	4858	1091	2181	12
2003	7.20	691	4976	1117	2234	12
2004	7.21	706	5094	1144	2287	13
2005	7.23	721	5212	1170	2340	13
2006	7.24	737	5339	1199	2397	13
2007	7.26	753	5466	1227	2454	13
2008	7.27	770	5600	1257	2514	14
2009	7.29	782	5699	1279	2559	14
2010	7.30	790	5769	1295	2590	14

NOTES: (1) Per capita rate is assumed to increase 0.25 percent per year through 1985, then increase only 0.20 percent per year through 2010.
(2) From Table 42.
(3) Derived by multiplying Wainwright service area population by air trips per capita.
(4) Assumes aircraft capacity of 6.78 passengers and load factor of 65.7 percent.
(5) Assumes total aircraft operations are twice air carrier operations.
(6) Derived as twice the annual daily average.

SOURCE: ERE Systems, Ltd.

Multiplying this changing per capita ratio by increasing future population levels in Wainwright (from Table 42) provides an estimate of future enplanements and deplanements. Enplanements/deplanements change from a level of about 2,992 in 1982 to 5,769 in 2010, an increase of about 92.8 percent. The increase to 1990 is just above 22 percent and to 2000 is about 55 percent. Using the aircraft seating capacity and load factors discussed above, these enplanements/deplanement are Converted to air carrier operations. Regional air carrier operations increase from a level of about 672 in 1982 to 1,295 in 2010, the same percentage change as enplanements/deplanements.

Total aircraft operations at Wainwright were derived as a fixed percentage of air carrier operations. It was assumed that air carrier operations constitute about half of total operations at the airport. As a result the percentage changes in total aircraft operations at the airport over the thirty-year forecast period are identical to those for enplanements/depl anements. This forecast of total operations is highly sensitive to the fixed percentage assumption. For example, if air carrier operations were only one-third of total operations, total operations would be 50 percent higher, although they would retain the same relationship year to year. In the context of this analysis, the sensitivity is magnified when this forecast is used in the next chapter as the base to determine petroleum industry impacts.

Peak daily aircraft operations were assumed to be about twice the annual daily average reflecting a more intense seasonal peaking characteristic. Even at this level of peaking, the new runway with capacity between 20 and 30 operations per hour is more than capable of handling expected daily aircraft operations throughout the forecast period.

In general, aviation impacts at Wainwright of expected growth without the Barrow Arch Lease Sale should be minimized by the recent construction of a new 5,000 foot runway. The new runway will allow more fully loaded aircraft to land year round, consequently the level of aviation service to the community was greatly improved. This is particularly true with respect to air cargo activities. The level of enplanements and deplanements are not sufficient to justify construction of a terminal, however a terminal is included in the North Slope Borough's capital improvements program. The new runway has more than sufficient capacity to support forecast operations, even if it operates only during daylight hours.

INDUSTRY DEMANDS AND SERVICES

The aviation demands-of the petroleum industry on the North Slope include both freight and passenger components. For the most part, regular air freight demands can be met using commercial passenger or scheduled cargo flights. Therefore, regular air freight demands are assumed to be a part of the air passenger forecast. The demand for special air freight requirements, wherein whole drilling rigs or other such large pieces of equipment are air lifted from one place to another, are not well understood and have not been included in this analysis.

The passenger component of petroleum industry aviation travel demands deals exclusively with the movement of petroleum industry employees. Because of the way in which the petroleum industry operates on the North Slope, all employees are rotated between their residence and their job site on some recurring basis depending on the type of work being performed. Employees can be subdivided into onshore and offshore workers. Employees associated with onshore lease sales can be classified as onshore workers, while employees associated with offshore lease sales may be either onshore or offshore workers. Onshore workers arriving on the North Slope are usually driven overland to their temporary quarters and job site. Offshore workers arriving on the North Slope must travel by helicopter to offshore quarters and job site. Workers rotating back to their residence reverse the arrival process. The result of these characteristics is that offshore workers generate a greater demand for air travel then do onshore workers. However, with respect to commercial transportation for the residence-to-job or job-to-residence trip the trip demands of onshore and offshore workers are the same.

Of particular interest in this section is the establishment of industry, aviation demands for all North Slope petroleum activities and the distribution of these demands among the major airport facilities, more specifically the airport facilities at Prudhoe Bay/Deadhorse, Fairbanks, Anchorage, and Barrow. The analysis is simplified considerably by previous analyses of both offshore and onshore lease sales that have already occured or are scheduled to occur prior to the Barrow Arch Lease Sale. The most recent assessment was made in regard to the Diapir Field Lease Sale (number 87) and was reported in Technical Report 105, "Diapir Field (Sale 87) Transportation Systems Impact Analysis" (Louis Berger and Associates, Inc., 1983b). In this analysis, it was assumed the forecast conditions with the Diapir Field, as reported in Technical Report 105, constituted petroleum industry conditions and aviation demands without the Barrow Arch Lease Sale.

North Slope petroleum industry employment assumptions are summarized in Table 52. Forecast employment is presented for prior onshore and offshore lease sales. The onshore development areas represented in the forecast include Prudhoe Bay, Kuparuk, and other state and federal onshore developments. The offshore development areas include the Joint Federal-State lease area near Prudhoe Bay and those activities encompassed in Lease Sales 71 and 87. In general, total industry employment doubles by 2000, but peaks sharply in 1994 at a level 1.84

TABLE 52

ISER MAP MODEL - NORTH SLOPE OIL
INDUSTRY EMPLOYMENT ASSUMPTIONS
WITHOUT THE BARROW ARCH LEASE SALE

Year	Prudhoe Bay, Kuparuk and Other Onshore Developments	Prior OCS Lease Sales (1)	Total Annual Industry Employment
1981	3400	128	3528
1982	4300	385	4685
1983	4902	332	5234
1984	4302	478	4780
1985	4502	617	5119
1986	4902	797	5699
1987	4302	1307	5609
1988	4002	1657	5659
1989	4002	2805	6807
1990	4002	3816	7818
1991	3502	5275	8777
1992	3502	6053	9555
1993	3502	5352	8854
1994	3502	6531	10033
1995	3502	5646	9148
1996	3502	5044	8546
1997	3502	4602	8104
1998	3502	4388	7890
1999	3502	4185	7687
2000	3502	4198	7700

NOTES: (1) Includes the Joint Federal-State OCS Lease Sale and OCS Lease Sales 71 and 87.

SOURCE: University of Alaska, Institute for Social and Economic Research, 1983b.

times levels estimated for 1981. The impact of these employment levels on aviation demand at Prudhoe Bay/Deadhorse, Barrow, Anchorage, and Fairbanks are presented in the following subsections.

Prudhoe Bav/Deadhorse

The forecast of aviation demand at the Prudhoe Bay/Deadhorse airport is presented in Table 53. Enplaned passengers increase 45 percent by 1990 then decline gradually to approximately current levels between 1990 and 2010. In general, passenger traffic through 2000 can be expected to be at least 14 percent above existing levels. Passenger terminals operated by Wien and Alaska Airlines will need to be expanded to handle this additional traffic unless a third carrier also builds a terminal at Deadhorse. An airport land use study scheduled by the DOT/PF may consider consolidation of terminal facilities since lease space at the airport is at a premium. (Louis Berger & Associates, Inc., 1983b).

.Air cargo demands exhibit a similar trend increasing about 28 percent by 1994, but the decline is much sharper dropping 25 percent below current levels by 2000 and almost 34 percent below current levels by 2010. The increase through 1994 is not expected to have much effect on avaiable cargo handling facilities, although more storage space will probably be needed. (Louis Berger & Associates, Inc., 1983b).

Aircraft operations at Deadhorse generally maintain their existing level

TABLE 53

FORECAST AVIATION DEMAND AT DEADHORSE AIRPORT
WITHOUT THE BARROW ARCH LEASE OFFERING
1983 - 2010

Year	Enplaned Passengers	Air Cargo	Aircraft Operations
1983	130830	7400	45400
1984	114810	7220	39800
1985	141150	7020	41700
1986	147830	7300	45400
1987	142810	7100	39800
1988	138800	6840	37100
1989	161800	7080	37100
1990	189800	7860	37100
1991	123450	6780	32400
1992	159450	9360	32400
1993	137450	8800	32400.
1994	173450	9440	32400
1995	147450	8140	32400
1996	155450	7160	3'2400
1997	163450	6400	32400
1998	153450	5700	32400
1999	149450	5500	32400
2000	149450	5500	32400
2001	148715	5490	31940
2002	147980	5480	31480
2003	147245	5470	31020
2004	146510	5460	30560
2005	145775	5450	30100
2006	143240	5340	2%40
2007	140705	5230	29180
2008	138170	5120	28720
2009	135635	5010	28260
2010	133100	4900	27800

SOURCE: Technical Report 105, Tables 3.16 and 4.18.
(Louis Berger and Associates, Inc., 1983b)

through about 1986 and then gradually decline through 2010. By that year, operations are almost 39 percent below the 1986 and current levels. One of the reasons that operational impacts can be reduced is because the oil companies can schedule the flights in a manner that achieves a high average load factor,

Barrow Airport

Barrow is not one of the principal links in the movement of petroleum industry personnel or cargo and is, therefore, vertually unaffected. Trips are made to Barrow to coordinate petroleum activities with the North Slope Borough government, but beyond that the forecast presented in Table 50 represents expected demand.

Anchorage International Airport

Anchorage serves as the principal hub facility for Alaska. In this capacity, aviation demand from the North Slope petroleum industry is but a small part of total activities. The forecast presented in Table 54 takes into account economic activity throughout the state. Enplaned passengers at Anchorage increase dramatically over the forecast period, rising from about 1.41 million in 1983 to over 9.48 million in 2010. The level in 2010 is over 6.7 times current passenger traffic levels. It should be noted that these figures disregard passengers in transit, which at the present time are almost equal to enplaned passengers (see Tables 16 and 17, Chapter III). .

TABLE 54

FORECAST AVIATION DEMAND AT ANCHORAGE INTERNATIONAL AIRPORT
WITHOUT THE BARROW ARCH LEASE OFFERING
1983 - 2010

Yew	Enplaned Passengers	Air Cargo	Aircraft Operations
1983	1410000	794000	514000
1984	1566000	867000	524000
1985	1734000	990400	534920
1986	1875000	1105400	544760
1987	2017000	1234600	553020
1988	216.3000	1377700	563460
1989	2340000	15.39200	575560
1990	2518000	1718800	587840
1991	2633000	1918800	597440
1992	2864000	2142900	613180
1993	3036000	2391700	626340
1994	3275000	2672200	641920
1995	3479000	2983400	655720
1996	3724000	3332600	671160
1997	3989000	3722700	686540
1998	4252000	4157300	702060
1999	4541000	4643200	717860
2000	4854000	5186200	733860
2001	5317900	5792220	752600
2002	5781800	6467240	771340
2003	6245700	7217260	790080
2004	6709600	8048280	808820
2005	7173500	8966300	827560
2006	7635000	9977260	846188
2007	8096500	11087220	864816
2008	8558000	12302180	883444
2009	9019500	13628140	902072
2010	9481000	15071100	920700

SOURCE: Technical Report 105, Tables 3.14 and 4.17.
(Louis Berger and Associates, Inc., 1983b)

Air cargo tonnage demonstrates even greater growth during the forecast period, rising from a level of 0.79 million tons in 1983 to almost 15.1 million tons in 2010, a 19 fold increase,

Aircraft operations on the other hand do not rise as precipitously largely due to the fact that larger widebody jets are expected to make up a greater percentage of the aircraft fleet serving Anchorage. The effect of these changes in fleet mix can be seen in the operations forecast of Table 54. Operations increase from a level of 514,000 in 1983 to a level of 920,700 in 2010, an increase of only 79 percent.

Fairbanks International Airport

Fairbanks also serves as one of the major hub airports in the State and shares with Anchorage as a gateway to the North Slope. Forecast activities at Fairbanks International Airport are presented in Table 55. Enplaned passengers are expected to grow from a level of 312,000 in 1983 to 970,000 in 2010, a level 3.1 times the 1983 demand. Air cargo grows from 63,000 tons in 1983 to 191,800 tons in 2010, a three-fold increase. As in Anchorage, changing fleet mix reduces the growth of aircraft operations. At Fairbanks, aircraft operations increase from 186,000 in 1983 to 380,600 in 2010, a two-fold change.

In both Fairbanks and Anchorage, these rapid rates of growth are

TABLE 55

FORECAST AVIATION DEMAND AT FAIRBANKS INTERNATIONAL AIRPORT
WITHOUT THE BARROW ARCH LEASE OFFERING
1983 - 2010

Year	Enplaned Passengers	Air Cargo	Aircraft Operations
1983	312000	63000	186000
1984	325000	65000	193000
1985	343000	68300	200180
1986	355000	71200	207120
1987	372000	74400	215200
1988	389000	77400	223240
1989	408000	80800	231400
1990	432000	84200	240680
1991	442000	87600	246320
1992	467'000	91400	251720
1993	483000	95200	257560
1994	510000	99400	263680
1995	527000	102900	269580
1996	551000	108000	275880
1997	576000	112200	282800
1998	597000	116900	288660
1999	620000	121800	295600
2000	646000	126800	302600
2001	678800	133320	310412
2002	711600	139840	318224
2003	744400	146360	326036
2004	777200	152880	333848
2005	810000	159400	341660
2006	842000	165880	349448
2007	874000	172360	357236
2008	906000	178840	365024
2009	938000	185320	372812
2010	970000	191800	380600

SOURCE: Technical Report 105, Tables 3.14 and 4.17.
(Louis Berger and Associates, Inc., 1983b)

generally accounted for in current master plans for each airport. Consequently, whether or not existing facilities have sufficient capacity for growth through 2010, the State DOT/PF is aware of the magnitude of the problem. Both airports currently have sufficient capacity to handle short range forecast demands and a capital improvements program to deal with longer range requirements.

Overland Transportation

The subject of overland transportation is intended to cover overland pipelines, highways, and rail transportation, to the extent these modes of travel serve the North Slope region. The methodology used to develop these forecasts is based on the assumption that all goods delivered overland to the North Slope are ultimately moved by truck over the Dalton Highway (also referred to as the Haul Road). At present, most of these goods arrive in the State through the ports at Anchorage and Whittier and from these ports move to Fairbanks via existing highways and the Alaska Railroad. A portion of the goods moves directly from the Lower 48 via the Alaska Highway. These current movement patterns are assumed to continue throughout the forecast period. Another aspect of overland transportation is the movement of oil resources from the North Slope to Lower 48 markets. The transportation of these resources is assumed to continue utilizing the Trans-Alaska Pipeline to deliver resources to Valdez, from which large tankers move the product to market. All of these aspects of overland transportation are treated in the following sections.

HIGHWAY TRANSPORTATION

The highway transportation system supporting petroleum exploration and development. on the North Slope includes the Dalton Highway, Parks Highway, and the Alaska l-highway. This system was described in detail in Chapter III. In general, all goods bound for the North Slope collect in Fairbanks or are funneled through Fairbanks because of the transportation infrastructure. For purposes of this analysis, it was assumed the 1981 level of goods movement along the Dalton Highway was a benchmark from which forecasts could be prepared. It was also assumed that a direct correlation exists between the volume of goods moved and non-resident employment levels on the North Slope. No attempt was made to verify this assumption based on observed data since historical highway traffic information is incomplete over time and since so little research has been conducted on the relationship between goods moving on the highway and actual petroleum development events.

Dalton Highway

From an analysis of highway traffic volumes at Mile 186 of the Dalton Highway and information about average truck load weights by commodity category, which appear in Chapter III, it was determined that total heavy truck tonnage for 1981 was approximately 483,600 tons. In order to forecast heavy truck tonnage for subsequent years, a set of growth' factors were developed using ISER's forecast of non-resident employment, which appears in Table 41 earlier in this report. The growth factors represent the percentage increase of a horizon year employment level over the 1981 employment level. By multiplying the 1981 heavy truck tonnage by the respective growth factor for each horizon year, future heavy truck tonnage data was developed. This forecast appears in Table 56. Because North Slope non-resident employment peaks in the early 1990's, declines slightly, and then becomes relatively stable through 2010, the forecast heavy truck tonnage exhibits a similar growth pattern. From a level of about 483,600 tons in 1981, heavy truck tonnage rises to a peak of about 1,206,000 tons by 1992 and declines to a level averaging about 954,200 tons throughout the period 1995 - 2010.

Forecast tonnage data was then converted to an annual number of heavy trucks operating on the highway. Heavy truck traffic on the Dalton Highway is composed of both loaded and empty trucks. The heavy truck tonnage in Table 56 represents loaded trucks. From the Western and Arctic Alaska Transportation Study (Louis Berger & Associates, Inc., et al, 1979), the ratio between empty and loaded trucks ranged between about 0.54 and 0.74 depending on the season. In this analysis the ratio was assumed to be 0.685. The conversion also required an assumption about the average heavy truck load, which for this analysis was 21.12

TABLE 56

DALTON HIGHWAY TRAFFIC VOLUME FORECAST
WITHOUT THE BARROW ARCH LEASE OFFERING
1981 - 2010

Year	Growth Factors(1)	Total Heavy Truck Tonnage(2)	Annual Number of Heavy Trucks(3)	Total Number of Vehicles on Dalton Highway (4)	AADT on Dalton Highway(5)	Highest Hourly Volume(6)	Highest. Daily Volume(7)
1981	1.00	483600	33400	50600	139	46	251
1982	1.18	568300	39300	59500	163	54	296
1983	1.42	684900	47300	71700	196	65	356
1984	1.28	617200	42700	64700	177	59	321
1985	1.50	726900	50300	76200	209	69	378
1986	1.60	774900	53600	81200	222	74	403
1987	1.73	836200	57800	87600	240	79	435
1988	1.81	876400	60600	91800	252	83	456
1989	1.91	921900	63700	96500	264	88	479
1990	2.35	11357'00	78500	118900	326	108	591
1991	2.05	992100	68600	103900	285	94	516
1992	2.49	1206000	83400	126400	346	115	628
1993	2.16	1046100	72300	109500	300	99	544
1994	2.42	1172000	81000	122700	336	111	609
1995	2.08	1006400	69600	105500	289	96	524
1996	2.04	986100	68200	103300	283	94	513
1997	2.02	978800	67700	102600	281	93	510
1998	1.94	939700	65000	98500	270	89	489
1999	1.94	936200	64700	98000	268	89	487
2000	1.94	938300	64900	98300	269	89	488
2001	1.93	933300	64500	97700	268	89	485
2002	1.92	926800	64100	97100	266	88	482
2003	1.96	948500	65600	99400	272	90	494
2004	1.96	950000	65700	99500	273	90	494
2005	1.98	957700	66200	100300	275	91	498
2006	2.00	965200	66700	101100	277	92	502
2007	1.99	960300	66400	100600	276	91	500
2008	1.99	960000	66400	100600	276	91	500
2009	1.94	936400	64700	98000	268	89	487
2010	1.94	938600	64900	98300	269	89	488

NOTES: (1) Derived from Table 41, column labled "Total Non-Resident Employment".
(2) Obtained by multiplying 1981 total truck tonnage by respective growth factor.
(3) Equals total truck tonnage divided by average heavy truck load of 21.12 tons. Also assumes loaded heavy trucks are 68.5 percent of all heavy trucks.
(4) Assumes heavy trucks are 66 percent of the highway vehicle mix.
(5) Total annual vehicle volume divided by 365 days per year.
(6) Highest hourly volume equals 33.1 percent of AADT.
(7) Highest daily volume equals 181.3 percent of AADT.

SOURCES: ERE Systems, Ltd., except State of Alaska, Department of Transportation and Public Facilities, 1982b, for assumptions regarding highest hourly and daily volumes, average heavy truck load, and highway vehicle mix.

tons or 42,240 pounds based on data provided in the WAATS study. Applying these two conversion factors to the heavy truck tonnage data produced an estimate of the annual number of heavy trucks, as shown in Table 56. In general, heavy truck volumes double along the Dalton Highway reaching in 1992 a peak level 1.49 times the estimated 1981 traffic levels, or approximately 83,400 vehicles.

The WAATS study also provided an estimate of the relationship between heavy trucks and other traffic on the Dalton Highway. Measurements in 1981 lead to an estimate that heavy trucks constitute approximately 66 percent of the vehicle mix on the Dalton Highway. Using this value, the volume of heavy trucks was converted to an estimate of the total number of vehicles on the highway and subsequently converted to annual average daily traffic (AADT) and certain hourly and daily peaking characteristics. All of these conversions are summarized in Table 56. Because of the methodology used, the relative change over time in each of these categories is identical to that described earlier for tonnage and truck volume. To obtain AADT, the total number of annual vehicles is divided by 365 days. The highest hourly volume was established as 33.1 percent of AADT and highest daily volume as 181.3 percent of AADT, based on data reported by the Alaska Department of Transportation and Public Facilities in their 1981 annual traffic volume report (State of Alaska, Dept. of Transportation and Public Facilities, 1982b). It was assumed these peaking relationships would remain constant over the

30-year forecast period, although that is highly unlikely.

Based on the assessment of highway capacity presented in Chapter III, the Dalton Highway can handle between 86 and 234 vehicles per hour at level of service "c", the range corresponding to changes in the terrain. From this data it could be concluded that the highway geometric design is generally capable of handling forecast traffic volumes, since the highest hourly volume is estimated at about 115 vehicles. On short sections of the road in mountainous terrain, the road may not be able to sustain this level of service. Level of service is likely to fall to level "D" or "E". This conclusion disregards the physical ability of the road itself to be able to sustain the large truck traffic volume without breaking down structurally and disregards the effects of ice, blowing snow and other environmental factors. However, should DOT/PF not maintain the road at a level sufficient to support these truck traffic volumes, capacity limitations could occur as the result of washouts or similar hazards which constrict the effective roadway width. In addition, if the actual number of trucks is higher than the estimate or if total traffic volume is higher than the estimate, the level of maintenance must be increased or the likelihood of a structural breakdown is increased.

It should be noted that the model represented in Table 56 is highly sensitive to the assumption about average truck load weight. In the analysis of Diapir Field impacts, Technical Report 105 (Louis Berger & Associates, Inc., 1983b), the average truck load was assumed to be 28 tons. That assumption is 32.6 percent larger than the 21.12 ton average truck load used in this study. Applying the 28 ton load in this model produces AADT levels that are about 25 percent below those shown in Table 56. None of the historic data reviewed for this study supports the higher average load.

Parks Highway and Alaska Highway

Since a portion of the tonnage moved over the Dalton Highway is also moved over other highways in the state, an estimate of that impact was also attempted. The methodology first defines tonnage likely to move on the Alaska Railroad, then assumes the remainder moves by truck over other highways. As discussed later in this chapter, approximately 30 percent of the tonnage was assumed to move via rail leaving 70 percent via truck.

The resultant truck tonnage and traffic volumes are summarized in Table 57. The average load per truck was assumed to be 21.12 tons with loaded trucks constituting 68.5 percent of all heavy trucks, the same assumptions as used above. The additional AADT developed from these manipulations was then distributed along the Alaska Highway and Parks Highway. The distribution was based on averaging three years of relative traffic volumes (1979 - 1981) and assumes trucks constitute a

TABLE 57

DALTON HIGHWAY TONNAGE ON OTHER HIGHWAYS
WITHOUT THE BARROW ARCH LEASE OFFERING
1981 - 2010

Year	Tonnage Moving on Other Highways(1)	Number of Large Trucks on Other Highways (2)	Additional AADT on Other Highways(3)	Distribution of AADT on: The Alaska Highway (4)	The Parks Highway (4)
1981	338500	23400	64	12	53
1982	397800	27500	75	14	62
1983	479400	33100	91	16	74
1984	432000	29900	82	15	67
1985	508800	35200	96	17	79
1986	542400	37500	103	18	84
1987	585300	40500	111	20	91
1988	613500	42400	116	21	95
1989	645300	44600	122	22	100
1990	795000	55000	151	27	124
1991	694500	48000	132	24	108
1992	844200	58400	160	29	131
1993	732300	50600	139	25	114
1994	820400	56700	155	28	127
1995	704500	48700	133	24	109
1996	690300	47700	131	24	107
1997	6.95200	47400	130	23	106
1998	657800	45500	125	22	102
1999	6553(50	45300	124	22	102
2000	656800	45400	124	22	102
2001	653300	45200	124	22	102
2002	648800	44900	123	22	101
2003	663900	45900	126	23	103
2004	665000	46000	126	23	103
2005	670400	46300	127	23	104
2006	675600	46700	128	23	105
2007	672200	46500	127	23	104
2008	672000	46500	127	23	104
2009	655500	45300	124	22	102
2010	657000	45400	124	22	102

NOTES : (1) It was assumed that 70 percent of the heavy truck tonnage bound for the North Slope is moved from entry ports via other highways or directly from the Lower 48 via the Alaska Highway.
(2) Average truck weight was assumed to be 21.12 tons, and loaded trucks are 68.5 percent of all heavy trucks".
(3) Derived by dividing the annual number of trucks by 365 days.
(4) Assumes 18 percent of the additional truck traffic moves on the Alaska Highway and 82 percent moves on the Parks Highway.

SOURCE : ERE Systems, Ltd.

fixed percentage of the highway mix. The resultant split channeled 18 percent of the AADT to the Alaska Highway and 82 percent to the Parks Highway. By 1992, the expected growth in North Slope tonnage translates as an increase of about 29 heavy truck vehicles per day along the Alaska Highway and 131 heavy truck vehicles along the Parks Highway. On the surface these increases appear to be small, except. that these routes are the main tourist routes in the state. The combination of additional trucks and additional tourist traffic can be expected to adversely effect currently conjested urban areas, particularly at main intersections, and will further reduce available capacity in mountainous areas where trucks slow down.

SUPPORTING MARINE TRANSPORTATION

Although marine transportation issues were presented earlier, that discussion focused on North Slope communities adjacent to the lease sale area. The issues addressed here focus on the southcentral ports at Anchorage, Whittier, and Valdez. The first two are expected to continue as the principal ports of entry for goods bound overland for the North Slope, the latter port is expected to continue as the only outbound port for export of petroleum resources to Lower 48 markets.

Anchorage and Whittier

A relationship between the ports at Anchorage and Whittier was established from a summary of port activities presented in Table 6, Chapter III. Using data for the period 1970 - 1978, during which these two ports exhibited a remarkably consistent relationship despite construction of the Trans-Alaska Pipeline, Anchorage attracted an average of 81.856 percent and Whittier attracted an average of 18.144 percent of the tonnage moving through these ports. The tonnage to be distributed among these ports consists of the Parks Highway tonnage (82 percent of the 70 percent tonnage assumed to go by truck) and the tonnage assumed to be shipped by rail. Collectively, this amounts to about 87.4 percent of the total tonnage shipped along the Dalton Highway. Applying these rates to the total heavy truck tonnage of Table 56 produces the distribution among these ports shown in Table 58. Since these percentages were assumed constant over the forecast period, the rise and fall of the additional tonnage year to year at each port reflects the same patterns discussed earlier.

At Anchorage, the tonnage is concentrated in containers and trailers, while at Whittier the tonnage is concentrated in rail cars, only some of which have containers or trailers (see later discussion). In 1981, the tonnage distributions shown in Table 58 constitute about 13 percent and 19 percent of annual tonnage levels at these ports respectively. Since growth at these ports has averaged a little over six percent per year,

TABLE 58

DALTON HIGHWAY TONNAGE DISTRIBUTED BY PORT
WITHOUT THE BARROW ARCH LEASE OFFERING
1981 -2010

Year	Total Inbound Tonnage (1)	Distribution by Port (2) Anchorage	Whittier
1981	422700	346000	76700
1982	496700	406600	90100
1983	598600	490000	108600
1984	539400	441500	97900
1985	635300	520000	115300
1986	677300	554400	122900
1987	730800	598200	132600
1988	766000	627000	139000
1989	805700	659500	146200
1990	992600	812500	180100
1991	867100	709800	157300
1992	1054000	862800	191200
1993	914300	748400	165900
1994	1024300	838500	185800
1995	879600	720000	159600
1996	861900	705500	156400
1997	855500	700300	155200
1998	821300	672300	149000
1999	818200	669700	148500
2000	820100	671300	148800
2001	815700	667700	148000
2002	810000	663000	147000
2003	829000	678600	150400
2004	830300	679600	150700
2005	837000	685100	151900
2006	843600	690500	153100
2007	839300	687000	152300
2008	839000	686800	152200
2009	818400	669900	148500
2010	820300	671500	148800

NOTES : (1) Includes 30 percent of Dalton Highway Tonnage on the Alaska Railroad and 57.4 percent (0.70 x 0.82) of Dalton Highway tonnage on the Parks Highway.
(2) Anchorage is assumed to handle 81.856 percent and Whittier 18.144 percent of inbound marine tonnage.

SOURCE : ERE Systems, Ltd.

the 1992 annual tonnage levels are expected to be about 5,033,000 tons at Anchorage and 754,200 tons at Whittier. In 1992, the additional North Slope tonnage peaks at about 862,800 tons in Anchorage and 191,200 tons in Whittier. The additional tonnage in 1992 due to expected North Slope development without the Barrow Arch Lease Sale constitutes about 17 percent of forecast tonnage at Anchorage and 25 percent of forecast tonnage at Whittier. These expected tonnages are within existing or planned capabilities of each port and do not represent a negative impact.

Valdez

No additional capacity for the Trans-Alaska Pipeline is assumed for this analysis of conditions without the Barrow Arch Lease Sale. Consequently, oil flowing into the Alyeska Terminal in Valdez remains at approximately the same 1.6 million barrels per day level. Oil tanker activities are, therefore, expected to remain at the current level of about 11 tankers per week.

RAIL TRANSPORTATION

A portion of the tonnage carried over the Dalton Highway is expected to be moved on the Alaska Railroad. After reviewing trends in revenue tonnage for major commodities handled by the railroad, including container and trailer traffic, it was determined that approximately 30 percent of the Dalton Highway tonnage is carried by the railroad in different forms. Applying this percentage to total heavy truck tonnage in Table 56 produces the forecast of railroad tonnage in Table 59. Due to the constant percentage over the forecast period, the changes year-to-year are the same as described for the total highway tonnage earlier in this section. Generally, because of the large volume of excess capacity currently available on the Alaska Railroad, the additional tonnage suggested by this analysis should not pose a problem for the railroad.

However, an estimate was also made of the volume of trailer and container traffic on flat cars (TOFC/COFC), since this is a low volume, premium rate commodity to the railroad. The volume of tonnage not sent by trailer or container also serves as an indicator of the level of reloading that must take place in Fairbanks as part of the transportation mode change (rail to truck). Using 1978 through 1981 revenue tonnage data' for the railroad, it was determined that TOFC/COFC tonnage constitutes about 35 percent of revenue tonnage destined for the North Slope. Applying this assumed rate to the railroad tonnage data in Table 59 and converting the resulting tonnage to truck or container loads produces the remaining information presented in Table 59. The average weight of the load in a trailer or container was assumed to be 21.12 tons. This analysis ignors any tradeoffs associated with the movement of trailers or containers by rail as opposed to their movement

TABLE 59

DALTON HIGHWAY TONNAGE ON THE ALASKA RAILROAD WITHOUT THE BARROW ARCH LEASE OFFERING 1981 - 2010

Year	North Slope Tonnage on the Alaska Railroad (1)	TOFC/COFC Tonnage on the Alaska Railroad (2)	Number of Truck Loads on the Alaska Railroad (3)
1981	145100	50800	2400
1982	170500	59700	2800
1983	205500	71900	3400
1984	185200	64800	3100
1985	218100	76300	3600
1986	232500	81400	3900
1987	250900	87800	4200
1988	26"?900	92000	4400
1989	276600	96800	4600
1990	340700	119200	5600
1991	297600	104200	4900
1992	361800	126600	6000
1993	313800	109800	5200
1994	351600	123100	5800
1995	301900	105700	5000
1996	295800	103500	4900
1997	293600,	102800	4900
1998	281900	98700	4700
1999	280900	98300	4700
2000	281 500	98500	4700
2001	280000	98000	4600
2002	278000	97300	4600
2003	284500	99600	4700
2004	285000	99700	4700
2005	287300	100600	4800
2006	289600	101400	4800
2007	288100	100800	4800
2008	288000	100800	4800
2009	280900	98300	4700
2010	281600	98600	4700

NOTES:
(1) It was assumed that 30 percent of the heavy truck tonnage bound for the North Slope was moved from entry ports via the Alaska Railroad.
(2) Trailers on Flat Cars (TOFC) and Containers on Flat Cars (COFC) were assumed to be 35 percent of North Slope bound rail tonnage.
(3) Derived by dividing TOFC/COFC tonnage by average truck weight of 21.12 tons.

SOURCE: ERE Systems, Ltd.

over the highways. Depending on highway traffic conditions and the Railroad's pricing policy on trailers and containers, the 70-30 highway-rail split assumed in this analysis could be significantly altered, particularly in light of the State's ownership of the railroad. At present, it is difficult to determine the sensitivity of this analysis to such changes, since the likely range of these changes is impossible to determine.

PIPELINE TRANSPORTATION

As noted in Chapter III, the pipeline of interest in this analysis is the Trans-Alaska Pipeline (TAPS). This analysis attempts to determine what portion of pipeline capacity will be available in future-years to satisfy North Slope production requirements without the Barrow Arch sale. Related to this question is determination of North Slope production requirements. The current demands of Prudhoe Bay production are sizable. Production requirements from other finds on the North Slope and immediately offshore are growing as new discoveries are made. At present, TAPS is transporting approximately 1.6 MBBL of crude oil per day. The pipeline was designed to operate at 2.0 MBBL per day with additional Intermediate pump stations. This analysis assumes these intermediate pump stations will not be built in the foreseeable future and that the capacity of the line will be its current operating level.

Table 60 provides an estimate of TAPS pipeline demands for the period through 2010. The estimate of North Slope production was originally made in 1978 as part of an earlier study (see Dames & Moore, 1978). The estimate includes petroleum production from Prudhoe Bay, Flaxman Island/Point Thompson, Camden-Canning, Cape Halkett, and an estimate for offshore production. Both a high and low estimate were made and both are presented in Table 60. Actual production reflects national and world petroleum demands, as well as the capability of the different fields to produce required demands. Both national and world petroleum demands have been generally declining since 1978, consequently, the low estimate would seem to better state expected pipeline requirements.

Excess capacity is measured against the 1.6 MBBL per day operational level. If the low case estimate is correct, there will be excess capacity in all years except 1994 and 1997. If the high case estimate is correct, during the period from 1991 through 1997 the pipeline will operate at the 1.6 MBBL capacity level and some demands will not be met. At the time the original estimate was made, an alternative suggestion to the high case was that production schedules could be adjusted to boost production up to the 2.0 MBBL per day level early in the production phase, thereby justifying the additional pump stations. However, this required long term maintenance of high flow rates to justify the additional infrastructure costs. This has not happened, in large part., we presume, because of falling world oil demand.

TABLE 60

TRANS-ALASKA PIPELINE DEMANDS WITHOUT THE BARROW ARCH LEASE OFFERING
(Thousands of Barrels per Day)

Year	High Case North Slope Demand(1)	High Case Excess Capacity (2)	Low Case North Slope Demand(1)	Low Case Excess Capacity (2)
1986	1,575	25	1,575	25
1987	1,415	185	1,415	185
1988	1,474	126	1,390	210
1989	1,515	85	1,263	337
1990	1,578	22	1,219	381
1991	1,772	-172	1,307	293
1992	1,893	-293	1,416	184
1993	1,996	-396	1,538	62
1994	1,886	-286	1,603	-3
1995	1,801	-201	1,533	67
1996	1,678	-78	1,511	89
1997	1,745	-145	1,659	-59
1998	1,378	222	1,346	254
1999	1,227	373	1,224	376
2000	1,060	540	1,067	533
2001	951	649	961	639
2002	840	760	860	740
2003	739	861	756	844
2004	611	989	630	970
2005	350	1250	370	1230
2006	196	1404	214	1386
2007	73	1527	84	1516
2008	54	1546	63	1537
2009	31	1569	37	1563
2010	16	1584	17	1583

NOTES: (1) Includes Prudhoe Bay, Flaxman Island/Point Thompson, Camden-tanning, Cape Halkett, and an estimate for offshore production.
(2) Operating Capacity was assumed to be 1.6 MBBL per day.

SOURCE : Dames & Moore, 1978

V

FORECAST CONDITIONS WITH THE BARROW ARCH LEASE SALE

This chapter presents transportation demand and requirements forecast data for a "Mean Case" scenario of petroleum development events associated with the Barrow Arch Lease Sale (February 1985). The focus is on a forecast of conditions likely to occur with the proposed Barrow Arch offering. This is in contrast to the forecast of conditions without the proposed Barrow Arch Lease Sale, which appeared in Chapter IV. The forecast consists of four major components: expected economic conditions, marine transportation, air transportation, and land transportation. The latter component includes overland pipelines, highways, and rail transportation.

Expected Economic Conditions

The principal changes in economic conditions from those described in Chapter IV are the activities in the Barrow Arch Planning Area following the February 1985 sale of petroleum development leases. These activities have a direct, as well as, secondary effect on various segments of the North Slope Borough's economy and the State as a whole. This section of the report sets out the general characteristics of expected new OCS petroleum development and discusses the differences from economic conditions expected to occur without the lease offering.

BARROW ARCH SCENARIO

The hypothesized petroleum development events for the Barrow Arch lease area are summarized in Tables 61 and 62, which present the timing and magnitude of assumed development activities. The horizon year for these forecasts is 2010, although petroleum development events in the Barrow Arch Planning Area extend beyond this time period.

Generally, exploratory drilling begins in the second year of the lease (1986); employment opportunities peak in the 10th year of the lease (1994); and production begins in the 11th year of the lease (1995) and peaks in the 16th year (2000). This development scenario is based on the discovery of 2.1 billion barrels of recoverable oil in the planning area. This amount of oil represents the mean case within the statistical range of possible discoveries in the planning area. Although natural gas is expected to be discovered along with the oil, recovery of the gas is not considered to be economical and is therefore excluded. For purposes of this analysis 2.1 billion barrels of oil are assumed to constitute an economically recoverable quantity of oil. The amount of economically recoverable oil needed in the area would be decreased if oil were discovered in the western part. of the North Slope, in the National Petroleum Reserve - Alaska (NPR-A), in the western part of the Diapir Field Planning Area, or in areas as far south as Norton

DRILLING RIGS AND NUMBERS OF WELLS BY TYPE
BARROW ARCH LEASE OFFERING MEAN CASE

Year	Exploration Wells		Delineation Wells				Production and Service Wells			
			Oil		Gas		Oil		Gas	
	Number of Wells	Number of Rigs	Number of Wells	Number of Rigs	Number of Wells	Number of Rigs	Number of Wells	Number of Rigs	Number of Wells	Number of Rigs
1985										
1986	2	2								
1987	3	2								
1988	3	2	1	1						
1989	3	2	2	2						
1990	3	2	3	2	1	1				
1991	3	2	2	2	1	1				
1992	3	2	1	1	1	1				
1993	2	2					16	2		
1994							32	4		
1995							38	5	16	2
1996							22	3	11	2
1997							6	1		
1998										
1999										
2000										
2001										
2002										
2003										
2004										
2005										
2006										
2007										
2008										
2009										
2010										

SOURCE: U.S. m of the Interior, Minerals Management Service, 1983c.

TABLE 62

SCHEDULE OF PLATFORMS, PIPELINES, SUPPORT FACILITIES, AND PRODUCTION REQUIREMENTS
BARROW ARCH LEASE OFFERING MEAN CASE

Year	Oil Platform and Equipment Starts	Trunk Pipeline Miles: Offshore	Trunk Pipeline Miles: Onshore	Percent Completion: Onshore Oil Terminal	Percent Completion: Service Base Dock	Percent Completion: Onshore Pump Station	Oil Production in MMBL
1985							
1986				0.30 (2)			
1987				0.70			
1988							
1989							
1990							
1991	1						
1992	1		(1)	0.30			
1993	1	50	132	0.40	0.40		
1994		50	132	0.30	0.60	2.00	
1995		50					19
1996		50					61
1997							117
1998							157
1999							173
2000							175
2001							172
2002							164
2003							150
2004							133
2005							118
2006							104
2007							93
2008							83
2009							73
2010							67 (3)

NOTES: 1) A private road would be constructed at least one year before construction begins on the pipeline.
2) During exploration terminal support may consist of anchored barges or ships.
3) Production continues beyond 2010.

SOURCE: U.S. Department of the Interior, Minerals Management Service, 1983c.

Sound or the Hope Basin.

The activities presented in Tables 61 and 62 are explained below organized by phase of activity: exploration, development, production. Production activities are expected to continue beyond the year 2010, although the tables show development activities through only that year. The information in these tables, and discussed below, is taken from a document entitled "Barrow Arch (February 1985 Offering], Exploration and Development Report" (undated, but approximately October 1983), prepared by the Minerals Management Service, Alaska OCS Region, Department of the Interior. Additional details about specific development assumptions are contained in the forecasts presented later in the report.

Exploration

The petroleum industry is expected to begin exploration of leased tracts during the summer season of 1986, following the sale of Barrow Arch leases in February 1985. The drilling of exploratory wells is expected to continue through the 9thyear of the lease (1993) and drilling of delineation wells through the 8th year (1992). During the first few years of the exploration period, ice-strengthened drillships are expected to be used to drill exploration and delineation wells. These ships are self contained and carry sufficient. supplies of pipe and drilling materials to complete at least one well. Although ice strengthened, these ships will be able to operate only during the most ice free period. This length of time is estimated to be about 90 days, which allows completion of only one well per drilling season. By the third or fourth year of the lease, specially constructed drilling units are expected to be used. These have the capability of withstanding greater ice forces and therefore can extend the drilling season from breakup to freezeup. A single drilling unit will be able to drill and test more than one well per year even with seasonal drilling restrictions and downtime due to storms, sea ice conditions, or mechanical problems.

Artificial islands may be employed as exploratory drilling units in waters less than 15 to 20 meters (49 to 66 feet) deep. Generally, however, the use of such islands is limited by the bathymetry, coastal geomorphology, and landfast ice conditions in the lease area. Since most of the seafloor shallower than 15 meters (49 feet) lies inside the three geographical (nautical) mile offshore boundary between federal and state areas of jurisdiction, the use of artificial islands is more likely to be in State of Alaska waters. Except for a planned lease sale during 1987 in an area between Icy Cape and Cape Beaufort, the State has no plans, at present, for other sales in this geographical area. If the State of Alaska were to include a lease sale of state owned land within the timeframes of the federal sale, the possibility of using artificial islands in the planning area would be increased. No State lease sales adjacent to the Barrow Arch Planning Area are assumed in this scenario.

The Minerals Management Service considered several other alternative drilling systems including ice-breaking drillships and monotone or concrete/steel islands. The advantages of each of these systems is that drilling can be conducted year round, the units are reusable, and they can be constructed and outfitted in more temperate climates. Although none of these systems currently exist, the scenario assumes such systems will be developed and used within several years after the leases are offered.

Support for the drillship operations during the first two or three years is assumed to come from barges or large ships used as a floating warehouse and supply center. The barges or ships would be loaded in Seattle just prior to beginning of the drilling season and move directly to the lease area. The barges would substitute for the lack of port facilities in the lease area. Either' type vessel could be anchored offshore and support. the drilling operation directly or be anchored nearshore and support the operation more indirectly. The dynamic ice and storm conditions in the lease area (see Chapter III), consideration for worker safety, and the desire to reduced the risk of interrupting drilling activities argues for the nearshore indirect approach, if barges are used. Large ships with ice strengthened hulls might serve better in a direct support role in deeper water. At the end of the drilling season the support vessels and drillships would be returned to

Seattle or sent elsewhere. If oil is discovered during the second or third year of the lease, as expected, a temporary shore base would be developed soon afterward and the barge or ship support system would be phased out.

Two work/supply boats are assigned to each drillship or drilling unit. These boats provide the hauling service between the supporting vessels and the drilling activities. At least one of these supply boats would need ice breaking capability to assist the drillships at the beginning and end of the drilling season. The ice breaking capability of these boats must be sized to the type of drilling unit being supported and expected ice conditions. The longer the allowed drilling period, the greater is the need for increased ice breaking capacity of the support boats. Consequently, the use of year-round drilling units requires extended marine support for personnel and equipment. While some of this support can be accomplished with helicopters, icebreaking work/supply boats or perhaps air-cushioned vehicles will also be required.

Aviation support during the exploration period is expected to be provided through the state operated airport at Barrow and the North Slope Borough operated airport at Wainwright. Commercial flights from Anchorage and Fairbanks initially provide worker transportation to Barrow and on to Wainwright. From Wainwright, helicopters ferry personnel and some freight to and from offshore locations. Two helicopters are expected to be assigned to service each drilling unit.

Development

The first discovery of oil is estimated to occur in the second or third year of the lease. Three and possibly four production platforms must be constructed and installed. More platforms might be needed depending on the depth and structure of the discovery. This development phase would also include construction of a resource transportation system and various permanent support facilities.

The construction and outfitting of the platforms is expected to occur in one or more of the ice--free harbors that border the northern part of the Pacific Ocean. From these sites the platforms would be towed to the lease area, positioned, and installed. During positioning and installation of the production platforms, each platform would be supported by three supply boats and two helicopters.

An offshore pipeline system would link the platforms to a shore terminal in the vicinity of Point Belcher. From the Point Belcher terminal an onshore pipeline transports resources to the Trans-Alaska Pipeline System (TAPS). The shore terminal at Point Belcher would also be used as a support. base during development drilling and pipeline laying. An 1,800 to 1,900 meter (5,906 to 6,234 feet) airstrip would be constructed to service the facility. Construction of the Point Belcher service base is expected to begin in 1988. The full range of the service base functions would not be developed immediately, but beginning about 1987 or 1988, construction would proceed at a measured pace corresponding to determining the commercial value of the find. The shore base/terminal would be upgraded to its ultimate design condition prior to startup of production (about 1994 or 1995).

A harbor may be developed at Peard Bay. The depths and size of the bay are sufficient to hold shallow draft barges and work boats that support offshore operations. The entrance to the bay is shallower and must be deepened and dredged each year to maintain its usefulness. If Peard Bay cannot be dredged because of permafrost, a causeway may be constructed. The causeway would extend offshore as far as one to three kilometers (0.62 to 1.87 miles) and could be used to bring the pipeline onshore.

The offshore portion of the pipeline, including various major gathering lines, is about 320 kilometers (199 miles) long. The pipe would be manufactured and coated outside the lease area then shipped by barge directly to the construction site. Several construction methods could be employed including the bottom tow and cut and cover methods. The pipeline might also be constructed during the winter through trenches cut in the ice. However, the latter approach is limited to the mid-winter season when the ice is solid and to the nearshore landfast ice areas. The pipeline was assumed to be constructed using lay and bury barges, even though the amount of time for the barges to operate is limited. It is assumed pipeline construction takes place during the open water season, although it may be possible to do some nearshore construction from the landfast ice mass. The pipeline would be laid in a trench and covered with fill material to protect the line from collisions with the keels of drifting ice masses. This will require the use of dredges and hopper barges to move and place the fill.

The onshore portion of the pipeline is about 425 kilometers (264 miles) long. In one alternative, the pipeline trends south-southeast and connects with TAPS at Pump Station Two. This route would vary if production within NPR-A could be facilitated with a different alignment, possibly connecting with TAPS at Prudhoe Bay (Pump Station One). This pipeline would utilize the same technology as TAPS. Construction of the onshore portion of the pipeline will necessitate construction of a parallel private roadway. The road would initially be used to distribute construction material and equipment along the route and after construction would be used to inspect and maintain the pipeline. The road itself would need to be constructed at least one year prior to beginning construction on the pipeline in order to be available when pipeline construction materials are distributed.

An alternative to the TAPS pipeline connection is the use of shuttle tankers operating between the Barrow Arch field and a proposed Aleutian

Transshipment Terminal located in the Aleutian Islands. These shuttle tankers would have a capacity of about 75,000 dwt and ice-breaking capabilities enabling them to operate year-round. However, current North Slope Borough policies prohibit onshore development to accommodate petroleum transportation via marine tankers (Alaska Consultants, Inc. et al., 1984). This prohibition effects the design of all shore based facilities and could alter any economic advantages of one approach over the other. It seems unlikely the tanker alternative would be employed unless the discovery was far offshore, thereby changing pipeline economic conditions. Under such circumstances, a separate offshore -loading facility may be needed in addition to the production platforms.

Production

When production begins, oil resources from the Barrow Arch area will flow to and through TAPS to Valdez, from where the resources are tankered to Lower 48 markets. No additional capacity is assumed for TAPS, consequently the level of VLCC tanker support in Valdez is not affected. During the production phase, one supply boat and one helicopter would be dedicated to each platform plus an additional supply boat and helicopter would be maintained at Point Belcher for back-up. Aviation services are expected to continue as in prior phases at a level commensurate with production activities.

EFFECT ON NORTH SLOPE ECONOMY

The most important economic aspect of these various petroleum development activities is the increased number of jobs that would be located in the North Slope Borough in the years following the Barrow Arch lease sale. Table 63 provides a summary of the additional petroleum related jobs through the year 2010. Jobs are shown in three major categories: Petroleum Mining; Petroleum Construction; and Transportation, the latter of which is further divided into air and marine segments.

Construction activities, important during the early years of field development, end abruptly in 1994 with completion of the onshore pipeline and the terminal/service base. Mining employment increases slowly during the first five years following the sale, then jumps almost three fold in 1991 and almost doubles again by 1995, reaching 1,302 jobs. The decline in well drilling activities after 1996 is reflected in the decline in mining jobs through 2010. The number of transportation related jobs grows more rapidly during the early years, particularly in aviation, although the total number of jobs are fewer then other categories. Marine transportation employment exhibit a similar pattern as mining.

Table 63 also presents these additional jobs by general location:

TABLE 63

EMPLOYMENT IN PETROLEUM DEVELOPMENT ACTIVITIES
BARROW ARCH LEASE OFFERING MEAN CASE
1986 -2010

Year	Employment By Industry: Petroleum Mining	Employment By Industry: Petroleum Construction	Employment By Industry: Transportation: Air	Employment By Industry: Transportation: Marine	Total Lease Area Jobs	Employment By Location: Onshore	Employment By Location: Offshore
1986	101	20	13	20	154	47	107
1987	144	47	20	30	241	83	158
1988	185	33	27	40	285	78	207
1989	238	33	33	50	354	97	257
1990	280		40	60	380	72	308
1991	738		42	177	957	99	858
1992	696	90	35	167	988	181	807
1993	1041	920	25	164	2150	1040	1110
1994	760	2090	4	17	2871	2170	701
1995	1302		14	61	1377	368	1009
1996	1148		24	105	1277	371	906
1997	902		30	132	1064	356	708
1998	858		30	132	1020	344	676
1999	938		30	132	1100	344	756
2000	960		30	132	1122	344	778
2001	880		30	132	1042	344	698
2002	805		30	132	967	344	6 2 3
2003	889		30	132	1051	344	707
2004	889		30	132	1051	344	707
2005	713		20	88	821	310	511
2006	713		20	88	821	310	511
2007	713		20	88	821	310	511
2008	713		20	88	821	310	511
2009	674		20	88	782	310	472
2010	674		20	88	782	310	472

SOURCE: U.S. Department of the Interior, Minerals Management Service, 1983c.

onshore and offshore. Except during 1994, the majority of the jobs are located offshore. In 1994, during the final stages of onshore pipeline construction, the ratio temporarily shifts the other way. The total number of jobs attributed to Barrow Arch development peak in 1993 and 1994. This peaking characteristic is marked by a doubling of jobs between 1992 and 1993 and then a decline by half between 1994 and 1995. Due to the magnitude of these changes this peaking is expected to have a significant affect on transportation demands over the period 1993 - 1995.

Despite the intensity of new job creation resulting from the Barrow Arch lease sale, the general effect on Native and Non-Native resident employment is expected to be small. The reasons for this are principally two fold: 1) cultural characteristics point to a preference not to take oil related jobs because of employer attitudes toward time off for traditional hunting and other cultural pursuits; and 2) despite the potential for increased revenue to the North Slope Borough, the State-imposed restrictions on the extent to which property taxes can support operating revenues limits the Borough's capital improvements program, thereby limiting related employment. As noted in Chapter III, this trend could be altered if the petroleum industry changed, or was forced to change, its standards; or if new generations of Native workers are willing to trade certain aspects of their cultural heritage for the economic advantages created by full time employment in high paying jobs.

Based on ISER's employment forecast (Table 63), the net result of current trends is no recognizable increase in resident employment between what is expected without the Barrow Arch lease offering and what is expected with it (see Table 41, Chapter IV). The lack of change in resident employment is also reflected in the population levels. No recognizable change is expected in population (see Table 42, Chapter IV).

Thus the net result of economic changes attributable to the Barrow Arch Lease Sale is that virtually all of the increases in transportation demand can be attributed directly to petroleum development activities. No additional transportation demands are expected from incremental secondary economic changes in the local economy since few local changes are anticipated.

Marine Transportation

The change in economic activities following the Barrow Arch Lease Sale will create increased demands for marine transportation services. This section of the report explores the range of these increased demands and the affects they have on conditions expected without the lease sale.

TONNAGE DEMANDS

The more significant increase in marine transportation demands comes from the movement of drilling materials, pipeline construction equipment and materials, and possibly from the movement of recovered petroleum resources by ship, if the pipeline is not a feasible alternative. The marine tonnage demands of these various industrial requirements are discussed in the following paragraphs.

Drilling materials include tubular goods, drilling mud, cement, fresh water, fuel, and miscellaneous other consumables. The quantity of these materials varies with the number, type, and depth of the wells being drilled. In the Barrow Arch Planning Area the average depth of swell is assumed to be 4,572 meters (15,000 feet), although production and service wells tend to be shallower than exploration wells. Table 64 illustrates the drilling material requirements for a single exploration, production, or workover type well at this average depth. These per-well quantities are then multiplied by the number of wells of each type (see Table61)to get an estimate of total drilling material tonnage, which is shown in Table 65. No adjustments are made for the shallower production or service wells. The greatest demands for movement of drilling materials occurs over the period 1993 - 1996, when a large number of production and service wellsare expected to be drilled. As shown in Table 65, this is the same time period for expected movement of

TABLE 64

DRILLING MATERIEL REQUIREMENTS PER WELL (1)
BARROW ARCH LEASE. OFFERING MEAN CASE

Materiel Categories	Exploration Well	Production Well	Workover Well
Tubular Goods	455	477	2
Drilling Mud (2)	985	403	41
Cement	363	274	25
Fresh Water (3)	5,415	4,269	2,166
Fuel for Drilling (4)	464	499	280
Miscellaneous Consumables (5)	10	10	4
	7,690	5,932	2,518

NOTES: (1) All values are in torts. Amounts shown are for a 4,572 m (15,000 ft) well.

(2) Drilling mud can be reused from well to well on a given platform. Amount shown assumes mud is used in four wells.

(3) Tonnage based on 1 gallon water = 8.33 pounds.

(4) Tonnage basedon 1 ton = 7.15 barrels. Excludes supply boat fuel.

(5) Includes tools and parts.

SOURCES: Technical Report 58, St. George Basin Petroleum Development Scenarios Transportation Systems Analysis, (PMM&Co and ERE Systems, Ltd., 1981).

TABLE 65

MARINE TONNAGE DEMANDS
DRILLING AND PIPELINE MATERIALS
BARROW AR H LEASE OFFERING MEAN CASE

Year	Tubular G	Drilling Mud (1)	Cement	Fresh Water (2)	Drilling Fuel (3)	Miscellaneous Consumables(4	Offshore P·peline(5)	Onshore Pipeline(6
1985								
1986	910	1600	726	10830	928	20		
1987	1365	2400	1089	16245	1392	30		
1988	1820	984	1452	21660	1856	40		
1989	2275	1230	1815	27075	2320	50		
1990	3185	1722	2541	37905	3248	70		
1991	2730	1476	2178	32490	2784	60		
1992	2275	1230	1815	27075	2320	50		
1993	8542	3212	5110	79134	8912	180	84500	132000
1994	15264	3224	8768	136608	15968	320	84500	132000
1995	25758	5441	4796	230526	26946	540	84500	
1996	15741	3325	9042	140877	16467	330	84500	
1997	2862	605	1644	25614	2994	60		
1998								
1999								
2000								

NOTES:
1) Drill·ng mud is dry weight and assumes mud is reusable in up to four wells.
2) Based on 1 gallon water = 8.33 lbs.
3) Based on 1 ton fuel = 7.15 bbls. Excludes fuel required for supply boats.
4) Inc d tools and repair parts.
5) Assumes 32 inch steel pipe coated for an underwater application. Average weight is assumed to be about 1,690 tons/mile.
6 Assumes 32 inch steel pipe with appropriate insulat·on materials for an above ground application. Average weight is assumed to be about 1,000 tons/mile, including pylons and insulation materials.

SOURCE: ERE Systems, Ltd.

pipeline materials.

Quantities of pipeline material are based on an average weight per mile of pipe. The average weight is, in part, based on the type of pipe used, pipe diameter, and the coating placed on the pipe to provide the weight necessary to overcome buoyancy. A 81.3 centimeter (32 inch) diameter steel pipe, coated for underwater use, with an average weight of 1,690 tons per mile was assumed for the offshore pipeline; and a similar sized steel pipe, coated with insulation materials for above ground use, with an average weight of 1,000 tons per mile was assumed for the onshore pipeline. Multiplying these weights by the miles of pipeline (see Table 62) produce the pipeline tonnage estimates in Table 65.

It is highly likely that the onshore pipeline materials would begin to be moved at least a year earlier than needs indicate because of the time required to distribute the materials along the proposed route. For analysis purposes, it was assumed the eastern half of the onshore pipeline was moved through the port at Whittier, by rail to Fairbanks, and by truck from Fairbanks to locations west of Pump Station 2. The analysis of these movements is presented in the section on overland transportation. The western half of the onshore pipeline materials were assumed to be barged to the service base at Point Belcher. Both movements were assumed to be made a year earlier than construction needs indicate. The offshore pipeline materials were assumed to be assembled on barges and sent directly to the construction site in the year needed. This reduces the amount of handling required in lightering the pipe onshore and then offshore again during the short construction season, and is a tradeoff with the increased risk of damage or loss of pipeline materials due to storms or ice conditions,

Operational Requirements

This section attempts to forecast the vessel requirements and operating environment. Vessel requirements were calculated for line haul barge trips (typically from Seattle to the lease area), supply boat trips, and resource tankers (an alternative to the proposed pipeline). Supply boat trips were calculated for three different use categories: used as lighters between line haul barges and the service base; used in support of drilling activities on the rigs and day to day operations on the platforms; and used in support of pipelaying operations.

Fresh water could be manufactured chemically from sea water except that during the open water season, this water and fuel for drilling is more likely to be obtained at Prudhoe Bay (see later discussion). Other drilling materials including tubular goods, muds, cement, and pipeline materials, as well as modules of major onshore facilities (gas separation units, pump stations, etc.), are expected to be moved to the lease area on barges coming directly from Lower 48 ports. The number of line haul barges needed to transport these various materials is calculated in Table 66. Historically, module tonnage has been approximately equal to drilling material tonnage and that relationship is assumed here (see discussion in Technical Report 105, Louis Berger and Associates, Inc., 1983b). Average barge capacity is 4,820 tons based on the average tons per barge experienced during the years 1979 to 1983.

Additional barges are needed to support various construction activities. These barges provide special support such as heavy lifting capabilities or accommodations and are not line haul barges per se. The number of these barges are also estimated in Table 66. From 1986 to 1996, two barges where assumed to be needed each year for general construction " activities. From 1991 to 1993, four barges were assumed to be needed each year to support offshore platform installation. Two additional barges are needed during the period 1993 - 1994 for dock construction and between 1992 and 1994 four barges are needed each year to support offshore pipelaying. During those years when the major facilities are under construction (1993 to 19969 line haul and special support barge requirements jump tenfold from a level of about 8 in 1992 to a level of 82 in 1993. Once the major facilities are constructed, barge demands are expected to drop off. In this analysis it was assumed a constant level of about ten barges per year would be needed throughout the remainder of the forecast period.

TABLE 66

LINE HAUL BARGE REQUIREMENTS
BARROW ARCH LEASE OFFERING MEAN CASE
1986 - 1997 .

Year	Drilling Supplies (1)	Modules (2)	Construction (3) General	Construction (3) Marine	Construction (3) Pipeline	TOTALS
1986	1	1	2			3
1987	1	1	2			4
1988	1	1	2			4
1989	1	1	2			4
1990	2	2	2			5
1991	1	1	2	4		9
1992	1	1	2	4		8
1993	35	35	2	6	4	82
1994	37	37	2	2	4	82
1995	27	27	2		4	60
1996	23	23	2		4	53
1997	1	1	2			4

NOTES: (1) Incl udes tubul ar goods, ing mud, cement, Infsce'11 aneous consumables, offshore pipe, and one-half of the onshore pipe as presented in Table 65. Barge capacity is 4,820 tons.

(2) Assumes a one-to-one rel ationship between dril 1 ing suppl ies tonnage (defined in Note 1 above) and modular tonnage.

(3) Assumes :

- 1986-1996: two barges needed each year for general construction activities and offshore accommodations.
- 1991-1993: four barges needed each year to support offshore platform installation and two added barges for dock construction during period 1993- 1994.
- 1992-1994: four barges needed each year to support offshore pipelaying.

SOURCE: ERE Systems, Ltd.

Not included in the line haul barge calculations are the movement of fuels and fresh water needed for drilling. In the early years of exploration when drillships are used, diesel fuel would be supplied along with the pipe, cement, and other drilling materials. Later, when production platforms are installed, power would come from electricity generated in combustion turbines by burning natural gas present in the crude oil. With respect to fresh water, the rigs and platforms have water manufacturing plants, although, for drilling activities, these tend to be augmented by a shore-based supply. Any supplemental water for drilling is assumed to be transported to the rigs/platforms by supply/work boats, or barges, from an onshore source.

Table 67 summarizes the marine vessel requirements and trip making for the Barrow Arch Mean Case scenario. Line haul round trips by barge repeat the totals from Table 66. It is assumed that these barges move as a convoy during the summer open water season maximizing the use of tug or tow boats. If the barges were assumed to travel independently, the number of tugs required would be greater and the cost of the service would go Up. Typically, one tug will tow two barges.

Supply/work boats by the very nature of their task produce the greatest level of ship activity. In the early years of exploration, when most of the offshore work is conducted during the open water summer season, ice

TABLE 67

MARINE TRANSPORTATION REQUIREMENTS
BARROW ARCH LEASE OFFERING MEAN CASE
1986-2010

Year	Line Haul Trips: Barges (1)	Line Haul Trips: Tugs (2)	Supply Boat Trips: As Lighters to Shore (3)	Supply Boat Trips: Support of Rigs and Platforms (4)	Supply Boat Trips: Support of Pipelaying Operations (5)	Supply Boat Trips: Total Supply Boat Trips	Resource Tankers Trips: VLCC Tankers (6)	Resource Tankers Trips: Shuttle Tankers (7)
1986	3	2						
1987	4	2						
1988	4	2	11	390		401		
1989	4	2	13	520		533		
1990	5	3	19	650		669		
1991	9	5	16	710		726		
1992	8	4	13	640		653		
1993	82	41	208	590	300	1098		
1994	82	41	234	480	300	1014		
1995	60	30	116	705	300	1121	11	35
1996	53	27	71	555	300	926	34	114
1997	4	2	13	255		268	65	218
1998	10	5		180		180	88	293
1999	10	5		180		180	97	323
2000	10	5		180		180	98	326
2001	10	5		180		180	96	321
2002	m	5		180		180	92	306
2003	10	5		180		180	84	280
2004	10	5		180		180	74	248
2005	10	5		180		180	66	220
2006	10	5		60		60	58	194
2007	10	5		60		60	52	173
2008	10	5		60		60	46	155
2009	10	5		60		60	41	136
2010	10	5		60		60	37	125

NOTES:
1) Summarized from Table 66. After 1997 assumes a constant level of demand of ten barges per year.
2) Each tug is assumed to pull 2 line haul barges.
3) During exploration, materials are unloaded directly from the line haul barges to drillships. After the shore base dock is completed, supply boats are used as lighters between line haul barges and shorebase. As lighters, supply boat capacity is assumed to be 400 short tons.
4) During platform installation 24 trips per platform; during exploratory" drilling 26 trips per platform; during development 15 trips per platform.
5) Assumed to be 75 trips per lay barge; 25 trips per bury barge. No distinction is made for other pipelaying techniques.
6) Represents tanker trips from Valdez attributable directly to the Barrow Arch production. VLCC capacity is assumed to be 250,000 dwt. Activities continue beyond 2010.
7) If shuttle tankers are employed in lieu of a pipeline connection to TAPS, these tankers operate between the Barrow Arch field and the Aleutian Transshipment Terminal. Shuttle tanker capacity is 75,000 dwt. Activities continue beyond 2010.

SOURCE: ERE Systems, Ltd.

strengthened supply/work boats are expected to be adequate. However, when activities year-round are begun ice breaking work boats will be required. Certain activities can only be accomplished during the summer months, and this analysis does not attempt to define seasonal differences in supply/work boat trip making. With certainty, the number of trips during the summer months will be higher than during winter. During winter months the helicopter may offer a better alternative than supply/work boats for many routine tasks, not because the helicopter is inherently the better choice, but because environmental conditions dictate modifications in equipment utilization. Another factor to consider in winter use of the supply/work boats is the likely effect on the environment. Although environmental considerations are beyond the scope of this analysis, restrictions in the lease may prevent or reduce supply/work boat movements during whale migrations or during other environmentally sensitive periods. The data presented in Table 67 does not incorporate any of these considerations.

Supply boats may be used in different ways, one of which is to offload line haul barges. Operating in this mode the capacity of a supply/work boat was assumed to be 400 short tons. During early years of exploration these boats operate between the line haul barge and the drillship(s) as needed. Once the dock is completed, possibly as early as 1988 for a temporary structure, the supply/work boats operate as a lighter between the line haul barges and the dock. These activities peak in 1993. The level of activity of these lighters could be reduced if the line haul barges could be delivered directly to the dock. Shallow water conditions appear to prevent this unless the barge is partially unloaded or the dock is sufficiently long enough to reach deeper water.

Another, more traditional, use for supply/work boats is in support of rigs and platforms. This support work involves moving the drill pipe, mud, cement, consumables, fresh water, and fuel from the support base to the various rigs and platforms. Since the mix of cargo on any one trip is virtually impossible to forecast, this analysis relys on some empirical data gathered for MMS and reported in Technical Report 55, "Monitoring Oil Exploration Activities in the Lower Cook Inlet," (Northern Resource Management, 1980). This report developed an estimate of the average number of supply/work boat trips per month per rig/platform during the different phases of development,. These are presented in footnote 4 of Table 67. Using these assumptions, trip demands for supply/work boats supporting the rigs/platforms peak first in 1991 at about 710 trips and again in 1995 at 705 trips. Since the platforms continue to function throughout the forecast period, supply/work boat activities continue through 2010 at a declining annual level of activity.

Supply/work boats are also used to support subsea pipelaying operations.

For purposes of developing a forecast, it was assumed the lay and bury barge technique would be used to construct the pipeline. Supply/work boats were assumed to make 75 trips for each lay barge per month and 25 trips for each bury barge (Kramer, L.S., Clark, V.C. & Cannelos, G.J., 1978). The net result is about 300 round trips per year for the period 1993 to 1996. If offshore pipeline construction is speeded up by the introduction of additional lay and bury barges, additional supply/work boat support will be required during those years. The use of other pipelaying methods, such as trenching through the ice or bottom tow require a lower level of supply/work boat support with different seasonal considerations.

Taking all supply/work boat functions together, the peak activity period is expected to be 1993 to 1996. At the height of this period in 1995, supply/work boat activities reach 1,121 round trips per year. This level of activity represents a doubling of the number of annual round trips from the early years of exploration.

The transportation of resources recovered from the Barrow Arch fields are anticipated to be by pipeline, as described earlier in this report. The oil would travel across the North Slope and south via TAPS to Valdez. At Valdez the oil is loaded into VLCC (very large crude carriers) tankers and shipped to Lower 48 markets. The capacity of TAPS can be increased to 2.0 million barrels per day from the existing level of about 1.6 million barrels per day. However, the additional capacity comes at the expense of reduced efficiency, which translates as higher operating costs. Also, additional capital expenditures would be required for several new intermediate pump stations and improvements at Valdez. This additional effort is not reflected in the MMS scenario for the Barrow Arch Sale and is assumed not to be an economic requirement for development of the Barrow Arch field.

Since the capacity of TAPS is not expected to be increased, it is assumed the current flow rate will be maintained. Therefore, the rate at which tankers visit and leave Valdez will also remain the same, about 11 trips per week. The VLCC tanker analysis in Table 67 attempts to define the level of tanker trip making at Valdez that can be attributed to Barrow Arch lease activities. The forecast number of VLCC tankers is based on vessels with an average capacity of 250,000 dwt and expected Barrow Arch oil production levels, as defined earlier in Table 62. The resulting forecast shows a peak activity period between 1998 and 2003 with the highest level occuring in 2000.

Also shown in Table 67 is the expected impact of using shuttle tankers if the TAPS pipeline connection is not constructed. The concept utilizes ice-breaking shuttle tankers to move oil resources from the Barrow Arch field to a proposed Aleutian Transshipment Terminal. This latter terminal, to be located on the south side of the Aleutian

Islands, was proposed as a means to consolidate oil shipments from several Bering Sea oil fields, including the St. George Basin, Navarin Basin, North Aleutian Shelf, and possibly the Norton Basin. The average size of the shuttle tankers is expected to be 75,000 dwt (Dames & Moore, et.al., 1982a). Using these smaller ships results in a high level of ship activity, as shown in the table. During 2000, the peak production year, 326 round trips are required by these shuttle tankers to move the resource to the Aleutian terminal.

The use of shuttle tankers can also be expected to boost supply/work boat and tug boat activity, although these requirements are not addressed specifically in Table 67. At a minimum, at least two tug boat round trips will be required for each tanker round trip to assist in docking and subsequently undocking the tanker. If the tanker takes on supplies, or is used to move small consumables into or from the planning area, a supply/work boat may be dispatched to meet it. A supply/work boat supporting the shuttle tankers would make 685 additional round trips in 2000, based on 2.1 round trips per tanker round trip. The peak year for supply/work boat activity would shift from 1995 to 1996, but more importantly, the high level of supply boat activity, associated with construction during the years 1993 to 1996, would continue beyond 1996 to 2005 driven by shuttle tanker support activities.

Air Transportation

The economic size of the Barrow Arch discovery is such that a significant number of new jobs are created in the North Slope Borough. As noted earlier, few of these new jobs will be filled by residents of the North Slope Borough, meaning that most of the labor force must be imported. The transient nature of most of these jobs, in combination with the lack of intra-regional roads, a remote location, and harsh environmental conditions, argue for a highly mobile work force; a work force dependent on aviation support for most if not all of its movements from place to place. In this section of the report we have attempted to forecast the more general movements of this work force: to and from resident locations, and from places onshore to places offshore. Air transportation will also be required to move OCS related freight. Although freight enplaned on commercial scheduled carriers can be forecast, the larger movements of equipment and supplies by private contractors lack sufficient information to develop a forecast.

AIR TRANSPORTATION DEMANDS

The begining point for this analysis is the employment model used by MMS to develop a forecast of employment by major petroleum development task, by year, by major employment category, and by location onshore or offshore. The details of this model can be obtained from MMS and are not further explained in this report. However, Appendix A to this report includes a summary of annual employment by place of residence, for 21 major tasks and several related subtasks identified by MMS. Those tasks missing from Appendix A have been deemed by MMS as having zero employment levels for purposes of the model. The most important aspect of Appendix A is the distribution of employment by place of permanent residence. Non-Alaska residents are assumed to be 79 percent of total employment and the remaining 21 percent are all Alaska residents living in different parts of the State. The model assumes for this analysis that Alaska residents are distributed: 8.2 percent to the North Slope Borough; 22.4 percent to the Fairbanks area (depicted as the Fairbanks Census Division); 51.2 percent to the Anchorage area (depicted as the Anchorage Census Area); and 18.2 percent to South Central Alaska, which for the most part is the Kenai Peninsula.

The employment distribution in Appendix A was converted to peak month trips using a tripmaking factor that reflects the nature of each work category. The results of this analysis are presented in Appendix B. The trip information in Appendix B is presented as round trips by origin/destination point (place of permanent residence), by year, and by major task and subtask. The general formula for air trips in the peak month is:

$$\frac{30.4167 \text{ days per average month}}{\text{Number of days Onsite} + \text{Number of days Offsite}}$$

Assumptions pertaining to the number of days onsite and offsite, and the resultant trip generation factors are summarized in Appendix B for each task. 'This detailed trip table serves as the basis for developing the onshore and offshore trip summaries found respectively in Tables 68 and 69. Table 68 summarizes trips for all offshore tasks in Appendix B; Table 69 summarizes trips for all onshore tasks in Appendix B. A composite of all trips is presented in Table 70, which sums the results shown in Tables 68 and 69. The information in these three tables was used to develop changes to operations levels for the major aviation terminal facilities at Wainwright, Barrow, the new shorebase airfield at Point Belcher, and the Anchorage and Fairbanks International Airports.

In order to develop an estimate of aircraft operations at the major air terminals, the data in Table 70 must be converted to passenger trips between the different terminal pairs and from that to aircraft operations between terminal pairs. The conversion of the trip data in Table 70 to a set of passenger round trips between major air terminals is presented in Table 71, and covers the period 1986 to 1992. Travel patterns during the first two years after the Barrow Arch lease sale are expected to continue to revolve about Barrow. This pattern is illustrated in Figure 23, which is keyed to Table 71. Workers destined

TABLE 68

OFFSHORE EMPLOYMENT PEAK MONTH AIR TRAVEL DEMANDS
BARROW ARCH LEASE OFFERING MEAN CASE
1986 - 2010

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	240	6	17	39	14
1987	356	9	25	57	20
1988	471	12	33	76	27
1989	587	15	41	95	34
1990	703	18	50	113	40
1991	1221	24	65	148	53
1992	471	12	33	76	27
1993	1386		64	147	52
1994	769	[illegible]	39	89	32
1995	915	29	78	179	64
1996	708	35	97	221	78
1997	250	40	109	250	89
1998	176	43	118	270	96
1999	198	49	133	304	108
2000	202	50	135	310	110
2001	180	44	121	276	98
2002	161	40	108	247	88
2003	183	45	123	282	100
2004	183	45	123	282	100
2005	134	33	90	205	73
2006	134	33	90	205	73
2007	134	33	90	205	73
2008	134	33	90	205	73
2009	123	30	83	189	67
2010	123	30	83	189	67

NOTES : (1) Summed from offshore tasks in Appendix B.

SOURCE : ERE Systems, Ltd.

TABLE 69

ONSHORE EMPLOYMENT PEAK MONTH AIR TRAVEL DEMANDS
BARROW ARCH LEASE OFFERING MEAN CASE
1986 - 2010

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	47	2	7	15	5
1987	74	4	10	23	8
1988	84	5	13	29	10
1989	106	6	16	37	13
1990	107	7	18	41	15
1991	101	7	20	47	17
1992	117	9	25	58	21
1993	673	25	69	158	56
1994	855	45	124	283	101
1995	59	22	59	134	48
1996	66	2 0	56	127	45
1997	65	17	47	107	38
1998	65	16	44	100	35
1999	65	16	44	100	35
2000	65	16	44	100	35
2001	65	16	44	100	35
2002	65	16	44	100	35
2003	65	16	44	100	35
2004	65	16	44	100	35
2005	58	14	39	89	32
2006	58	14	39	89	32
2007	58	14	39	89	32
2008	58	14	39	89	32
2009	58	14	39	89	32
2010	58	14	39	89	32

NOTES: (1) Summed from onshore tasks in Appendix B.

SOURCE: ERE Systems, Ltd.

TABLE 70

TOTAL INDUSTRY EMPLOYMENT PEAK MONTH AIR TRAVEL DEMANDS
BARROW ARCH LEASE OFFERING MEAN CASE
1986 - 2010

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
	Peak Month Trip Distribution by Origin/Destination (1)				
1986	287	9	24	54	19
1987	430	13	35	81	29
1988	555	17	46	105	37
1989	693	21	57	131	47
1990	809	25	68	154	55
1991	1322	31	85	195	69
1992	588	21	59	134	48
1993	2059	49	133	305	108
1994	1624	60	163	372	132
1995	973	50	137	313	111
1996	774	56	152	348	124
1997	315	57	156	357	127
1998	241	59	162	370	132
1999	263	65	177	404	143
2000	267	66	179	409	146
2001	245	60	164	376	134
2002	226	56	152	347	123
2003	248	61	167	382	136
2004	248	61	167	382	136
2005	191	47	129	294	105
2006	191	47	129	294	105
2007	191	47	129	294	105
2008	191	47	129	294	105
2009	181	44	122	278	99
2010	181	44	122	278	99

NOTES: (1) Summed from Tables 68 and 69.

SOURCE: ERE Systems, Ltd.

for offshore locations would be transported by commercial air carrier first to Barrow then to Wainwright for a helicopter trip to an, offshore location. Workers going to onshore locations would be transported to Wainwright and drive or fly via helicopter to their work site. Once oil is discovered {approximately year three of the leases), direct flights are begun to the new runway at Wainwright, and are assumed to bypass Barrow.

In Table 71 and Figure 23, round trips are shown for eight location pairs: Wainwright/Offshore, Wainwright/Barrow, Barrow/Fairbanks, Wainwright/Fairbanks, Wainwright/Anchorage, Fairbanks/Seattle, Fairbanks/Anchorage, and Anchorage/Seattle. In general, the peak year for this set of travel patterns is 1991. Due to the channeling of trips through Barrow during the first two years, peak month trip demands between Wainwright and Barrow are very high in 1986 and 1987. The continuation of trips between these locations after 1987 reflect the assumption that as many as 70 percent of North Slope Borough residents have either a destination at Barrow or must pass through Barrow enroute to other North Slope destinations.

In 1993, with completion of the service base airfield, direct flights shift from Wainwright to this new facility. The travel demands for the period 1993 to 2010 are summarized-in Table 72 and the change in air travel patterns is illustrated in Figure 24, which is keyedto the

TABLE 71

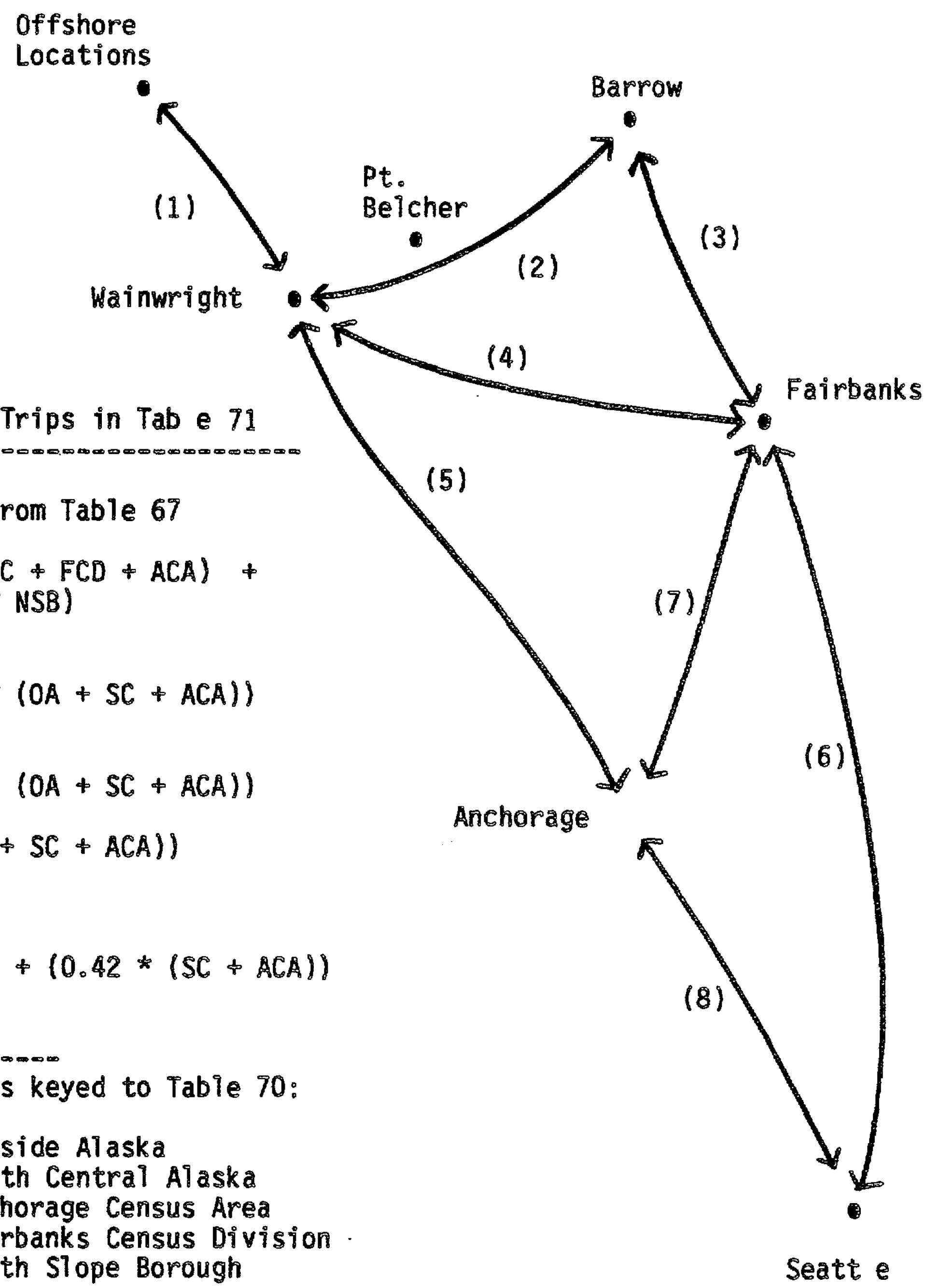
INDUSTRY AIR TRAVEL DEMANDS BY ROUTE PAIR
BARROW ARCH LEASE OFFERING MEAN CASE
1986 - 1992

Passenger Round Trips Between

Year	Wainwright/ Offshore (1)	Wainwright/ Barrow (2)	Barrow/ Fairbanks (3)	Wainwright/ Fairbanks (4)	Wainwright/ Anchorage (5)	Fairbanks/ Seattle (6)	Fairbanks/ Anchorage (7)	Anchorage/ Seattle (8)
1986	316	390	301			36	66	251
1987	467	584	450			54	99	376
1988	619	2		339	404	70	128	485
1989	772	5		423	505	87	160	606
1990	924	18		496	590	102	188	707
1991	1511	22		751	920	167	274	1155
1992	619	15		382	447	74	149	514

NOTES:
1) Wainwright serves as the air terminal for offshore helicopter trips until the service base is completed in 1993. These are derived from Table 68, which shows all offshore trips by O/D pair.
2) During the first two years aviation services to Wainwright are provided through Barrow. After oil is discovered, services are provided directly to Wainwright. It is assumed that 70 % of the total trips with an origin/destination in the North Slope Borough travel first to Barrow.
3) The Barrow-Fairbanks link shown is for only Barrow Arch trips. These trips end with the start of direct flights to Wainwright. Incorporates 100 % of Fairbanks trips and 42 % of the trips to South Central, Anchorage, and Outside Alaska from Table 70.
4) Represents direct flights between Wainwright and Fairbanks. Incorporates 100 % of Fairbanks trips and 42 % of the trips to South Central, Anchorage, and Outside Alaska from Table 70.
5) Represents direct flights between Wainwright and Anchorage. Incorporates 58 % of trips to South Central, Anchorage, and Outside Alaska from Table 70.
6) Incorporates 12.6 % of trips to Outside Alaska from Table 70.
7) Incorporates 29.4 % of trips to Outside Alaska and 42 % of trips to South Central and Anchorage from Table 70.
8) Incorporates 87.4 % of trips to Outside Alaska from Table 70.

SOURCE: ERE Systems, Ltd.



Composition of Trips in Tab e 71

(1) All Offshore
Trips From Table 67

(2) (1 * (OA + SC + FCD + ACA) +
(0.70 * NSB)

(3) (1 * FCD) +
(0.42 * (OA + SC + ACA))

(4) (1 * FCD) +
(0.42 * (OA + SC + ACA))

(5) (0.58 * (OA + SC + ACA))

(6 (0.126 * OA)

(7) (0.294 * OA) + (0.42 * (SC + ACA))

(8) (0.874 * OA)

NOTE: abreviations keyed to Table 70:

OA = Outside Alaska
SC = South Central Alaska
ACA = Anchorage Census Area
FCD = Fairbanks Census Division
NSB = North Slope Borough

FIGURE 23

ILLUSTRATION OF INDUSTRY AIR TRAVEL DEMANDS BY ROUTE PAIR
WITH THE BARROW ARCH LEASE OFFERING MEAN CASE
1986 - 1992

TABLE 72

INDUSTRY AIR TRAVEL DEMANDS BY ROUTE PAIR
BARROW ARCH LEASE OFFERING MEAN CASE
1993 -2010

	Passenger Round Trips Between						
Year	Shore Base/ Offshore (1)	Shore Base/ Fairbanks (2)	Shore Base/ Anchorage (3)	Fairbanks Seattle (4)	Fairbanks/ Anchorage (5)	Anchorage/ Seattle (6)	Wainwright/ Barrow (7)
1993	1672	1171	1434	259	428	1800	34
1994	943	1057	1234	205	412	1419	42
1995	1265	724	810	123	298	850	35
1996	1139	675	723	98	294	676	39
1997	738	492	463	40	242	275	40
1998	703	474	431	30	241	211	41
1999	792	517	470	33	262	230	46
2000	807	524	477	34	266	233	46
2001	719	481	438	31	244	214	42
2002	644	444	404	28	225	198	39
2003	733	489	4 4 4	31	248	217	43
2004	733	489	444	31	248	217	43
2005	535	377	342	24	191	167	33
2006	535	377	342	24	191	167	33
2007	535	377	342	24	191	%67	33
2008	535	377	342	24	191	167	33
2009	492	356	324	23	181	158	31
2010	492	356	324	23	181	158	31

NOTES :
1) The shore base serves as the air terminal for offshore helicopter trips after 1992. These are derived from Table 68, which shows all offshore trips by O/D pair.
2) Represents direct flights between Shore Base and Fairbanks. Incorporates 100 % of Fairbanks trips and 42 % of the trips to South Central, Anchorage, and Outside Alaska from Table 70.
3) Represents direct flights between Shore Base and Anchorage. Incorporates 58 % of the trips to Central, Anchorage, and Outside Alaska from Table 70.
4) Incorporates. 12.6 % of trips to Outside Alaska from Table 70.
5) Incorporates 29.4 % of trips to Outside Alaska and 42 % of trips to South Central and Anchorage from Table 70.
6) Incorporates 87.4 % of trips to Outside Alaska from Table 70.
7) It is assumed that 70 % of the total trips with an origin/destination on the North Slope travel first to Barrow.

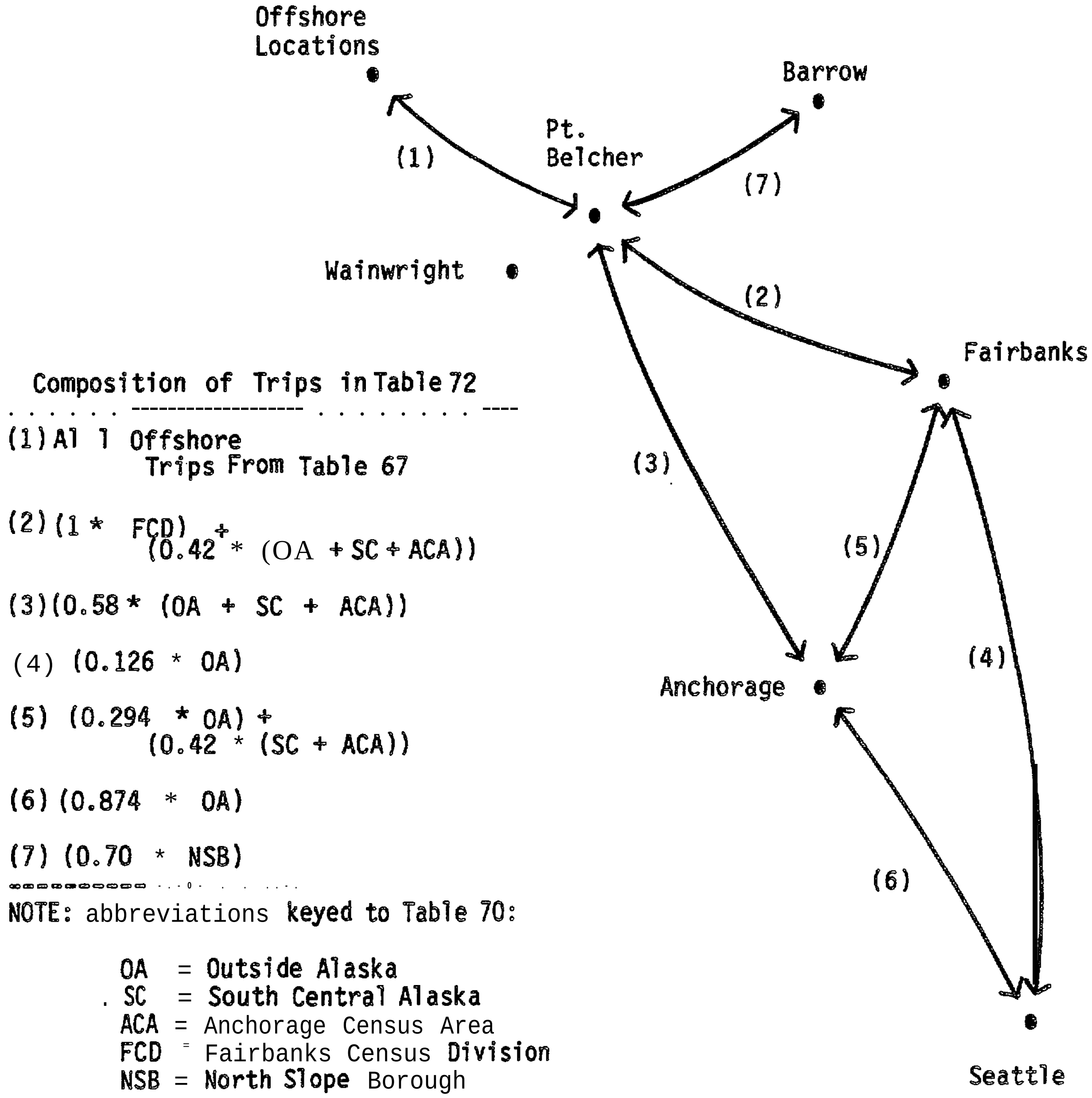


FIGURE 24

ILLUSTRATION OF INDUSTRY AIR TRAVEL DEMANDS BY ROUTE PAIR
WITH THE BARROW ARCH LEASE OFFERING MEAN CASE
1993 - 2010

table. In Table 72 and Figure 24, round trips are shown for seven location pairs: Shore Base/Offshore, Shore Base/Fairbanks, Shore Base/Anchorage, Fairbanks/Seattle, Fairbanks/Anchorage, Anchorage/Seattle, and Wainwright/Barrow. The peak demand period is generally 1993-1994, except that trip demands offshore continue at a high level through 1996 and peak again slightly in 2000. The effects of these changing travel patterns are discussed further in the next section on aircraft operations.

AIRCRAFT OPERATIONS

An aircraft operations forecast can be developed from the information presented in Tables 71 and 72. The resultant conversion is-presented in Tables 73 and 74. Operations are derived by placing expected trip demands on expected types of aircraft. In this analysis, aircraft types are illustrated by an average number of seats and an assumed load factor. Different aircraft types operate between different location pairs. Typically, the type of aircraft is based upon expected demand levels and landing facilities and services, among a number of factors. Aircraft size in this analysis was based on an assessment of seats currently available between these location pairs and the total number of scheduled aircraft operations (see Chapter III). The result was an average number of seats per operation. These averages were used in Tables 73 and 74 and are noted in the respective footnotes. The load

TABLE 73

INDUSTRY EMPLOYMENT GENERATED AIRCRAFT OPERAT ONS
BARROW ARCH LEASE OFFERING MEAN CASE
1986 - 1992

Add t onal Peak Month Aircraft Operations B tw

Year	Wa nwright/ Offshore (1)	Wainwright/ Barrow (2)	Barrow/ Fairbanks (3)	Wainwright/ Fairbanks (3)	Wainwright/ Anchorage (3)	Fairbanks/ Seattle (4)	Fairbanks/ Anchorage (5)	Anchorage/ Seattle (4)
1986	19	27	6			1	1	2
1987	27	40	9			1	1	2
1988	36	1		7	8	1	1	3
1989	45	1		8	10	1	1	4
1990	54	1		10	12	1	2	4
1991	89	2		15	18	1	2	7
1992	36	1		7	9	1	1	3

NOTES: (1) Assumes 20 seat helicopter, operating at 85 % load factor, applied to related data in Table 71.
(2) Assumes 17 seat aircraft, operating at 85 % load factor, applied to related data in Table 71.
(3) Assumes 60 seat aircraft, operating at 85 % load factor, applied to related data in Table 71.
(4) Assumes 189 seat aircraft, operating at 85 % load factor, applied to related data in Table 71.
(5) Assumes 130 seat aircraft, operating at 85 % load factor, applied to related data in Table 71.

SOURCE: ERE Systems, Ltd.

TABLE 74

INDUSTRY EMPLOYMENT GENERATED AIRCRAFT OPERATIONS
BARROW ARCH LEASE OFFERING MEAN CASE
1993 - 2(UO

Additional Peak Month Aircraft Operations Between

Year	Shore Base/ Offshore (1)	Shore Base/ Fairbanks (2)	Shore Base/ Anchorage (2)	Fairbanks/ Seattle (3)	Fairbanks/ Anchorage (4)	Anchorage/ Seattle (3)	Shore Base/ Barrow (5)
1993	98	23	28	2	4	11	2
1994	55	21	24	1	4	9	2
1995	74	14	16	1	3	5	1
1996	67	13	14	1	3	4	1
1997	43	10	9	1	2	2	1
1998	41	9	8	1	2	1	1
1999	47	10	9	1	2	1	1
2000	47	10	9	1	2	1	1
2001	42	9	9	1	2	1	1
2002	38	9	8	1	2	1	1
2003	43	10	9	1	2	1	1
2004	43	10	9	1	2	1	1
2005	31	7	7	1	2	1	0
2006	31	7	7	1	2	1	0
2007	31	7	7	1	2	1	0
2008	31	7	7	1	2	1	0
2009	29	7	6	1	2	1	0
2010	29	7	6	1	2	1	0

NOTES: (1) Assumes 20 seat helicopter, operating at 85 % load factor, applied to related data in Table 72.
(2) Assumes 17 seat aircraft, operating at 85 % load factor, applied to related data in Table 72.
(3) Assumes 60 seat aircraft, operating at 85 % load factor, applied to related data in Table 72.
(4) Assumes 189 seat aircraft, operating at 85 % load factor, applied to related data in Table 72.
(5) Assumes 130 seat aircraft, operating at 85 % load factor, applied to related data in Table 72.

SOURCE : ERE Systems, Ltd.

factor was assumed to be constant at 85 percent. Generally, the patterns of change from one year to the next in Tables 73 and 74 reflect those of Tables 71 and 72.

How these travel demands and aircraft requirements affect the major air terminals is discussed in the following subsections.

Changes at Barrow

Expected changes in aircraft operations at Barrow are illustrated in Table 75. The forecast level of operations without the Barrow Arch lease offering are presented in the first data column. This information is taken from Table 50, Chapter IV. An estimate of the additional aircraft operations at Barrow was made by selecting and adding relevant location pair data from the routings in Tables 73 and 74. This estimate of additional operations appears in the second data column of Table 75, together with an analysis of the percentage change from conditions without the offering. The peak year is 1987 when about 946 additional operations might be expected. In that year, these added operations constitute about a 5.6 percent change. Total and peak daily operations for that year accelerate demands at the airport by about two years, which is not significant. This determination is made by comparing total and peak daily figures in Table 75 to those developed in Table 50, Chapter IV.

TABLE 75

AIRCRAFT OPERATIONS FORECAST - BARROW, ALASKA
WITH THE BARROW ARCH LEASE OFFERING - MEAN CASE
1986 - 2010

Year	Aircraft Operations Without Lease Sale (1)	Additional Aircraft Operations With Sale: Number (2)	Additional Aircraft Operations With Sale: Percent (3)	Total Aircraft Operations (4)	Peak Daily Aircraft Operations (5)
1986	16456	632	3.84	17088	70
1987	16822	946	5.62	17768	73
1988	17173	16	0.09	17189	71
1989	17513	20	0.11	17533	72
1990	17862	23	0.13	17885	74
1991	18202	29	0.16	18231	75
1992	18545	20	0.11	18565	76
1993	18890	37	0.20	18927	78
1994	19230	32	0.17	19262	79
1995	19587	21	0.11	19608	81
1996	19939	19	0.09	19958	82
1997	20291	12	0.06	20303	83
1998	20662	11	0.05	20673	85
1999	21023	12	0.06	21035	86
2000	21399	12	0.06	21411	88
2001	21775	11	0.05	21786	90
2002	22165	11	0.05	22176	91
2003	22551	12	0.05	22563	93
2004	22952	12	0.05	22964	94
2005	23353	9	0.04	23362	96
2006	23773	9	0.04	23782	98
2007	24198	9	0.04	24207	99
2008	24629	9	0.04	24638	101
2009	24922	8	0.03	24930	102
2010	25063	8	0.03	25071	103

NOTES :
(1) From Table 50, Chapter IV.
(2) Derived from Table 73, columns labeled Wainwright/Barrow and Barrow/Fairbanks; and from Table 74, column labeled Shore Base/Barrow. The peak month is assumed to be 125 % of the average month. Round trips are doubled to get landings and takeoffs.
(3) Percentage shown is percent of operations without lease sale.
(4) Sums operations without and additional operations.
(5) Derived as 1.5 times the annual daily average.

SOURCE : ERE Systems, Ltd.

Perhaps a more important question to ask is what might happen if Barrow Arch related flights continue to be funneled through Barrow after 1987, instead of switching to Wainwright or to the Point Belcher service base. The sensitivity of this hypothesis was tested in the model by routing selected flights through Barrow. This information is not represented in any tables, but is summarized in this discussion. For t-he period 1986 through 1992, flights from Wainwright to Offshore, Wainwright to Fairbanks, Wainwright to Barrow, and Wainwright to Anchorage, were switched through Barrow. For the period 1993 through 2010, all trips from or to the new shore base were switched through Barrow. The peak year for industrial activity at Barrow then changes to 1993, when approximately 2,906 operations are added to operations' without the lease sale, a 15.4 percent jump for that year. Total operations during that peak year reach about 21,800 and peak daily operations about 90. Except for 1992, annual increases exceed 10 percent per year for the period 1991 through 1995. Comparing these values to those of Table 50, indicates that if operations were routed through Barrow, instead of Wainwright or the new service base airfield, this would produce about a five to six year acceleration in demands. By 2010, and under these conditions, the annual change is reduced to about 820 operations, a 3.3 percent increase for that year.

Changes at Wainwright

Because of the current low level of operations at Wainwright, the addition of Barrow Arch related aircraft operations is more significant. The details are summarized in Table 76. The peak year is 1991, when approximately 2,364 operations from Barrow Arch activities are added to activities forecast without the lease offering. These added operations constitute a 140 percent change over conditions without the lease offering. Comparing the results for 1991 to those developed in Table 51 for conditions without the planned lease offering, indicates that this level of operations accelerates expected growth by about 15 years. Although this is a significant change, the level of operations can be easily accommodated on the new runway. The more important aspect of this growth, however, will be the need for passenger handling facilities and a temporary terminal or temporary add-on to the North Slope Borough's planned terminal. Only a temporary facility is needed for Barrow Arch movements because in 1993 operations are assumed to shift to the service base.

Helicopter and jet traffic added to the present level of propeller driven aircraft poke some special planning problems. During the first two years of the lease helicopters are assumed to be maintained at Barrow. Although the helicopters could be maintained at Wainwright, it is likely that because Wainwright is an interim solution to a more permanent facility, maintenance services would be retained at Barrow and

TABLE 76

AIRCRAFT OPERATIONS FORECAST - WAINWRIGHT, ALASKA WITH THE BARROW ARCH LEASE OFFERING - MEAN CASE 1986 - 2010

Year	Aircraft Operations Without Lease Sale (1)	Additional Aircraft Operations With Sale: Number (2)	Additional Aircraft Operations With Sale: Percent (3)	Total Aircraft Operations (4)	Peak Daily Aircraft Operations (5)
1986	1487	875	58.88	2362	10
1987	1525	1304	85.48	2829	12
1988	1562	995	63.68	2557	11
1989	1600	1241	77.55	2841	12
1990	1641	1476	89.93	3117	13
1991	1679	2364	140.83	4043	17
1992	1720	1031	59.93	2751	11
1993	1762	0	0000	1762	7
1994	1804	0	0.00	1804	7
1995	1849	0	0.00	1849	8
1996	1891	0	0.00	1891	8
1997	1936	0	0.00	1936	8
1998	1985	0	0.00	1985	8
1999	2030	0	Cl.oo	2030	8
2000	2079	0	0.00	2079	9
2001	2128	0	0.00	2128	9
2002	2181	0	0.00	2181	9
2003	2234	0	0.00	2234	9
2004	2287	0	0.00	2287	9
2005	2340	0	0.00	2340	10
2006	2397	0	0.00	2397	10
2007	2454	0	0.00	2454	10
2008	2514	0	0.00	2514	10
2009	2559	0	0.00	2559	11
2010	2590	0	0.00	2590	11

NOTES :
1) From Table 51, Chapter IV.
2) Derived from Table 73, columns labeled Wainwright/Offshore, Wainwright/Barrow, Wainwright/Fairbanks, and Wainwright/Anchorage. Round trips are doubled to get landings and takeoffs. The peak month is assumed to be 125 % of the average month.
3) Percentage shown is percent of operations without the lease sale.
4) Sums operations without and additional operations.
5) Derived as 1.5 times the annual daily average.

SOURCE : ERE Systems, Ltd.

transferred directly to the new service base when it becomes operational. Due to the significantly increased level of helicopter operations, the FAA will need to certify that these operations can be safely handled at this facility. This may require an investigation of current airspace utilization leading to a possible change in aircraft operating procedures. Since jet aircraft will use the airfield, crash, fire and rescue equipment and other facilities and services at the airport will need to be upgraded. Here too, consideration must be made for the fact that such improvements are temporary. Large investments may not be recovered in the time period during which the facility operates at the higher levels and subsequent years of maintenance without revenue traffic may be a significant financial drain.

The analysis of Wainwright also looked at possible use of the Wainwright airfield as a substitute for the Point Belcher service base. In this situation, operations at Wainwright continue beyond 1993 and throughout the forecast period. Under these circumstances the peak year shifts to 1993, when about 4,668 additional operations create a jump of almost 165 percent over expected conditions without the lease offering. While these operations can be handled on the existing runway, the impacts to longer range planning for terminal facilities and other equipment will be more significant. With the prospect of longer range, high level demands, the cost recovery period is greater and more permanent improvements could be installed. However, under these conditions an alternative means must be found to get equipment and personnel to the service base. This will most likely necessitate construction of a road between the airport and the service base. The construction and maintenance of this road may be an expensive undertaking and, if accomplished by the North Slope Borough, these activities could negate any financial benefits that accrue to the community from an improved airport. In all likelyhood, the road will ultimately exist (if it doesn't already) even as a broad path due to the movements of local villagers

Changes at Industry Service Base

The Point Belcher service *base* and airport is a brand new facility when it opens in 1993. The runway planned for the support base is expected to range in length from 1,800 to 1,900 meters (5,900 to 6,200 feet). This length runway will adequately serve the petroleum industry's demands. An estimate of passenger movement aircraft. operations at the service base is shown in Table 77. Total aircraft operations, which includes freight and other type activities, can be expected to be about twice the levels shown. This higher level of operations can easily be handled at this type airfield. Presumedly as part of the airport's design, FAA will perform the necessary investigations to determine airport needs prior to its use as a commercial airfield.

It may be that both the Wainwright airfield and the proposed Point

TABLE 77

AIRCRAFT OPERATIONS FORECAST - INDUSTRY SHORE BASE
WITH THE BARROW ARCH LEASE OFFERING -MEAN CASE
1993 - 2010

Year	Total Aircraft Operations 1)	Peak Daily Aircraft Operations(2)
1993	2906	12
1994	1960	8
1995	2027	8
1996	1832	8
1997	1205	5
1998	1146	5
1999	1278	5
2000	1301	5
2001	1169	5
2002	1057	4
2003	1191	5
2004	1191	5
2005	884	4
2006	884	4
2007	884	4
2008	884	4
2009	820	3
2010	820	3

NOTES: 1) Derived from Table 74, columns labeled Shore Base/Offshore, Shore Base/Fairbanks, Shore Base/Anchorage, and Shore Base/Barrow. The peak month is assumed to be 125 % of the average month. Round trips are doubled to get landings and takeoffs.
2) Derived as 1.5 times the annual daily average.

SOURCE : ERE Systems, Ltd.

Belcher airfield are used simultaneously. The service base would handle mostly cargo flights while Wainwright would handle passengers. This set up would require transport services for those workers moving to and from the support base. Such services could be provided by overland means (e.g. a shuttle bus on the roadway) or by air. The forecast of commercial flights in Table 77 is indicicative of the range of impact suggested by this change. In Wainwright, the worst set of conditions resulting by operating from both airports is that described earlier for extending operations beyond 1992.

Changes at Anchorage International Airport

Anchorage International Airport will be affected by both direct and indirect increases in air travel as a result of the Barrow Arch Lease Sale. The direct effects occur from Barrow Arch employees and freight. The indirect effects occur from the incremental increase in population at Anchorage and in the state as a whole, which results in increased air travel. The direct effects of increased tripmaking through Anchorage International Airport are shown in Table 78. During the early years following the sale the changes at Anchorage are moderate, averaging about one extra operation per day. By 1993, the additional aircraft operations reach about 2.3 per day, an increase of little more than one-tenth of a percent. The indirect affects are expected to be less than the direct effects, but were not calculated.

TABLE 78

AIRCRAFT OPERATIONS FORECAST - ANCHORAGE, ALASKA
WITH THE BARROW ARCH LEASE OFFERING - MEAN CASE
1986 - 2010

Year	Aircraft Operations Without Lease Sale (1)	Additional Aircraft Operations With Sale: Number (2)	Additional Aircraft Operations With Sale: Percent. (3)	Total Aircraft Operations (4)
1986	544760	41	0.01	544801
1987	553020	62	0.01	553082
1988	563460	232	0.04	563692
1989	575560	290	0.05	575850
1990	587840	339	0.06	588179
1991	597440	532	0.09	597972
1992	613180	255	0.04	613435
1993	626340	829	0.13	627169
1994	641920	706	0.11	642626
1995	655720	458	0.07	656178
1996	671160	404	0.06	671564
1997	686540	249	0.04	686789
1998	702060	229	0.03	702289
1999	717860	250	0.03	718110
2000	733860	254	0.03	734114
2001	752600	233	0.03	752833
2002	771340	215	0.03	771555
2003	790080	236	0.03	790316
2004	808820	236	0.03	809056
2005	827560	182	0.02	827742
2006	846188	182	0.02	846370
2007	864816	182	0.02	864998
2008	883444	182	0.02	883626
2009	902072	172	0.02	902244
2010	920700	172	0.02	920872

NOTES :
(1) From Table 54, Chapter IV.
(2) Derived from Table 73, columns labeled Wainwright/Anchorage, Fairbanks/Anchorage, and Anchorage/Seattle; and from Table 74, columns labeled Shore Base/Anchorage, Fairbanks/Anchorage, and Anchorage/Seattle. The peak month is assumed to be 125 % of the average month. Round trips are doubled to get landings and takeoffs.
(3) Percentage shown is percent of operations without the lease sale.
(4) Sums operations without the sale and additional operations with the sale.

SOURCE : ERE Systems, Ltd.

Changes at Fairbanks International Airport

Fairbanks International Airport serves as an intermediate hub and like Anchorage will be affected by the direct and indirect influence of Barrow Arch activities. The direct effects of added air travel at Fairbanks are shown in Table 79. During 1993, approximately 546 additional operations can be attributed to Barrow Arch activities. These constitute an increase of about two-tenths percent over conditions expected without the lease sale. This level of increase is considerably less than the one percent increase expected year to year. Given the low percentage increase arising from direct effects, the indirect effects were not calculated.

Overland Transportation

HIGHWAY AND RAIL TRANSPORTATION

As explained earlier it was assumed that all pipeline materials and equipment for the eastern portion of the onshore pipeline link to TAPS would be channeled through Whittier and move by rail and truck to distribution points along the eastern part of the new pipeline right-of-way. Materials and equipment for the western portion of the onshore pipeline arrive by barge at the Point Belcher service base and are trucked from the base to distribution points along the western right-of-way. If construction is scheduled for 1993 and 1994, portions

TABLE 79

AIRCRAFT OPERATIONS FORECAST - FAIRBANKS, ALASKA
WITH THE BARROW ARCH LEASE OFFERING - MEAN CASE
1986 - 2010

Year	Aircraft Operations Without Lease Sale (1)	Additional Aircraft Operations With Sale: Number (2)	Additional Aircraft Operations With Sale: Percent (3)	Total Aircraft Operations (4)
1986	207120	144	0.07	207264
1987	215200	206	0.10	215406
1988	223240	169	0.08	223409
1989	231400	206	0.09	231606
1990	240680	238	0.10	240918
1991	246320	350	0.14	246670
1992	251720	189	0.08	251909
1993	257560	546	0.21	258106
1994	263680	494	0.19	264174
1995	269580	343	0.13	269923
1996	275880	324	0.12	276204
1997	282800	246	0.09	283046
1998	288660	239.	0.08	288899
1999	295600	259	0.09	295859
2000	302600	263	0.09	302863
2001	310412	243	0.08	310655
2002	318224	226	0.07	318450
2003	326036	246	0.08	326282
2004	333848	246	0.07	334094
2005	341660	194	0006	341854
2006	349448	194	0.06	349642
2007	357236	194	0.05	357430
2008	365024	194	0.05	365218
2009	372812	185	0.05	372997
2010	380600	185	0.05	380785

NOTES: (1) From Table 55, Chapter IV.
(2) Derived from Table 73, columns labeled Barrow/Fairbanks, Wainwright/Fairbanks, Fairbanks/Seattle, and Fairbanks/Anchorage; and from Table 74, columns labeled Shore Base/Fairbanks, Fairbanks/Seattle, and Fairbanks/Anchorage. The peak month is assumed to be 125 % of the average month. Round trips are doubled to get landings and takeoffs.
(3) Percentage shown is percent of operations without the lease sale.
(4) Sums operations without the sale and additional operations with the sale.

SOURCE : ERE Systems, Ltd.

of the pipeline must. begin moving toward forward distribution points during 1992. For this analysis, it was assumed most of the materials would be transported during 1992 and 1993. Most, if not all, of the construction equipment is assumed to be moved from mostly in-state locations during 1991 and 1992. Part of 1991 would be dedicated to construction of the various camps and facilities needed along the pipeline, while much of 1992 would likely be dedicated to construction of the roadway parallel to the pipeline. The general quantity of materials to be shipped was given earlier in Table 65.

Based on the quantities in Table 65, approximately 66,000 short tons of " pipeline materials arrive in Southcentral Alaskan ports in both 1992 and 1993. Based on an assumed average truck load weight of 21.12 short tons (see Chapter IV), this annual quantity is transported in about 3,125 truck loads. If the pipeline materials are assumed to be moved by trucks on the Alaska Railroad from southcentral Alaska ports, these trucks on the railroad constitute about a 50 percent increase over the forecast for 1992 in Table 59. This increased level of activity should not adversely effect the railroad. In moving from Whittier to Fairbanks by rail, these trucks would be transported on about 1,563 rail cars, assuming two trucks to a rail car, which is typical.

At Fairbanks the trucks would be offloaded and driven north on the Dalton Highway. The suggested volume of trucks is an additional AADT of about 9 vehicles. This constitutes about a 3 percent increase for the years 1992 and 1993. This is derived from a comparison to Table 56. Three additional trucks are added to the highest hourly volume under these circumstances. This is not a significant impact given that activities are limited to a three or four year period.

If these trucks are moved over the Parks Highway to Fairbanks, rather than by train, the impact is more significant. The 9 additional trucks constitute an increase of about 8 percent in 1992. The mix of trucks and tourist vehicles continue to be the predominant problem, slowing traffic in the two-lane mountainous areas.

PIPELINE TRANSPORTATION

In utilizing the Trans-Alaska Pipeline System (TAPS) to transport recovered resources, there is an implicit assumption that TAPS has sufficient capacity to handle expected Barrow Arch production quantities. An analysis of this assumption is presented for a high and low case in Table 80. An estimate of current production demands on TAPS was discussed in Table 60 (see Chapter IV), and is presented again in Table 80. Oil production from the Barrow Arch field does not begin until 1998, at which time other North Slope production demands are declining. Consequently, the addition of Barrow Arch production to North Slope demands does not adversely affect pipeline capacity for

TABLE 80

TRANS-ALASKA PIPELINE DEMANDS
BARROW ARCH LEASE OFFERING MEAN CASE
(Thousands of Barrels per Day)

	High Case				Low Case			
Year	North Slope Demand(1	Barrow Arch Demand (2	Total Demand	Excess Capacity (3)	North Slope Demand(1	Barrow Arch Demand (2)	Total Demand	Excess Capacity (3)
1986	1575		1575	25	1575		1575	25
1987	1415		1415	185	1415		1415	85
1988	1474		1474	126	1390		1390	210
1989	1515		1515	85	1263		1263	337
1990	1578		1578	22	1219		1219	381
1991	1772		1772	-172	1307		1307	293
1992	1893		1893	-293	1416		1416	184
1993	1996		1996	-396	1538		1538	62
1994	1886		1886	-286	1603		1603	-3
1995	1801		1801	-201	1533		1533	67
1996	1678		1678	-78	1511		1511	89
1997	1745		1745	-145	1659		1659	-59
1998	1378	71	1449	151	1346	71	1417	183
1999	1227	192	1419	181	1224	192	1416	184
2000	1060	299	1359	241	1067	299	1366	234
2001	951	384	1335	265	961	384	1345	255
2002	840	419	1259	341	860	419	1279	321
2003	739	433	1172	428	756	433	1189	411
2004	611	397	1008	592	630	397	1027	573
2005	350	351	701	899	370	351	721	879
2006	196	282	478	1122	214	282	496	1104
2007	73	236	309	1291	84	236	320	1280
2008	54	200	254	1346	63	200	263	1337
2009	31	167	198	1402	37	167	204	1396
2010	16	140	156	1444	17	140	157	1443

NO ES: 1 Includes Prudhoe Bay, F axman Island/Point Thompson, Camden-Canning, Cape Halkett, and Prudhoe Offshore.
2) Production does not begin until 1998.
3) Operating capacity is assumed to be about 1.6 MBBL/day

SOURCES: TAPS Forecast: Dames & Moore, 1978.
Barrow Arch Forecast: Dames & Moore, et al., 982.
Remainder by ERE Systems, Ltd.

either

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APPENDIX A

FORECAST DISTRIBUTION OF
PETROLEUM INDUSTRY EMPLOYMENT
FOR THE BARROW ARCH LEASE OFFERING
BY ORIGIN/DESTINATION AND
BY MAJOR 1NDUSTR% TASK

APPENDIX A

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 1: Drilling of Exploration Wells (Offshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	960	240	758	17	45	103	37
1987	1440	360	1138	25	68	155	55
1988	1920	480	1517	33	90	206	73
1989	2400	600	1896	41	113	258	92
1990	2880	720	2275	50	135	310	110
1991	2400	600	1896	41	113	258	92
1992	1920	480	1517	33	90	206	73
1993	960	240	758	17	45	103	37

NOTES: (1) Average is based on a task duration of 4 months.
(2) Non-Alaska Residents are assumed to be 79 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and resfdence.assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 1A: Drilling of Exploration Wells - Helicopter Support (Onshore)

Year	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Residence (2): Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	160	40	76	7	19	43	15
1987	240	60	114	10	28	65	23
1988	320	80	152	14	38	86	31
1989	400	100	190	17	47	108	38
1990	480	120	228	21	56	129	46
1991	400	100	190	17	47	108	38
1992	320	80	152	14	38	86	31
1993	160	40	76	7	19	43	15

NOTES: (1) Average is based on a task duration of 4 months.
(2) Non-Alaska Residents are assumed to be 47.5 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 1B: Drilling of Exploration Wells - Supply and Anchor Boats (Offshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	240	60	139	8	23	52	18
1987	360	90	209	12	34	77	28
1988	480	120	278	17	45	103	37
1989	600	150	348	21	56	129	46
1990	720	180	418	25	68	155	55
1991	600	150	348	21	56	129	46
1992	480	120	278	17	45	103	37
1993	240	60	139	8	23	52	18

NOTES: (1) Average is based on a task duration of 4 months.
(2) Non-Alaska Residents are assumed to be 58 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 1C: **Drilling of Exploration Wells** - Related Onshore Work (Onshore]

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	48	12	38	1	2	5	2
1987	72	18	57	1	3	8	3
1988	96	24	76	2	5	10	4
1989	120	30	95	2	6	13	5
1990	144	36	114	2	7	15	6
1991	120	30	95	2	6	13	5
1992	96	24	76	2	5	10	4
1993	48	12	38	1	2	5	2

NOTES : (1) Average is based on a task duration of 4 months.
(2) Non-Alaska Residents are assumed to be 79 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough: 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 2: Construction of Exploration Shore Base (Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	240	30	190	4	11	26	9
1987	560	70	442	10	26	60	21
1988	400	50	316	7	19	43	15
1989	400	50	316	7	19	43	15

NOTES: (1) Average is based on a task duration of 8 months.
(2) Non-Alaska Residents are assumed to be 79 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 3: Exploration Base Operations (Onshore)

Year	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Residence (2): Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	120	20	95	2	6	13	5
1987	120	20	95	2	6	13	5
1988	120	20	95	2	6	13	5
1989	240	40	190	4	11	26	9
1990	240	40	190	4	11	26	9
1991	240	40	190	4	11	26	9
1992	240	40	190	4	11	26	9
1993	240	40	190	4	11	26	9

NOTES: (1) Average is based on a task duration of 6 months.

(2] Non-Alaska Residents are assumed to be 79 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 4: Geophysical-Geological Survey (Offshore)

Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	Place of P m Residence (2) North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	90	30	71	2	4	10	3
1987	90	30	71	2	4	10	3
1988	90	30	71	2	4	10	3
1989	90	30	71	2	4	10	3
1990	90	30	71	2	4	10	3
1991	90	30	71	2	4	0	3
1992	90	30	71	2	4	10	3
1993	90	30	71	2	4	10	3

NOTES: (1) Average is based on a task durat on of 3 months.
(2) Non-Alaska Residents are assumed to be 79 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A [Cent.fnued]

FORECAST DISTRIBUTION OF PETROLEUM 1NDUSTR% EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 6: Production Equipment Installation (Offshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	" North Sl ope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	6000	600	5370	52	141	323	115
1992	6000	600	5370	52	141	323	115
1993	6000	600	5370	52	141	323	115

NOTES : (1) Average is based on a task duration of 10 months.
(2) Non-Al aska Residents are assumed to be 89.5 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

A ND X A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 6A: Production Equipment Instal ation - Hel copter Support (Onshore

Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	Place of Permanent Residence (2): North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	100	10	48	4	12	27	10
1992	100	10	48	4	12	27	10
1993	100	10	48	4	12	27	10

NOTES: (1) Average is based on a task duration of 10 months.
(2) Non-Alaska Residents are assumed to be 47.5 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions m Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 6B: Production Equipment Installation - Tugboats (Offshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	750	75	435	26	71	161	57
1992	750	75	435	26	71	61	57
1993	750	75	435	26	71	161	57

NOTES: (1) Average is based on a task duration of 10 months.
(2) Non-Alaska Residents are assumed to be 58 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

A ND A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MA R INDUSTRY TASK

Task 6C: Production Equipment Instal at on - Supply d Anchor Boats Offshore

Year	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Residence 2): Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	450	45	261	15	42	97	34
1992	450	45	261	15	42	97	34
1993	450	45	261	15	42	97	34

NOTES: (1) Average is based on a task duration of 10 months.
(2) Non-Alaska Residents are assumed to be 58 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual mp oyment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

IFORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 6D: Production Equipment Installation - Boat Maintenance (Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	120	12	70	4	11	26	9
1992	120	12	70	4	11	26	9
1993	120	12	70	4	11	26	9

NOTES: (1) Average is based on a task duration of 10 months.
(2) Non-Alaska Residents are assumed to be 58 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 6E: Production Equipment Installation - Longshoring (Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	200	20	0	16	45	102	36
1992	200	20	0	16	45	102	36
1993	200	20	0	16	45	102	36

NOTES: (1) Average is based on a task duration of 10 months.
(2) Non-Alaska Residents are assumed to be zero percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST IDISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 7: Construction of Production Shore Base [Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1992	1080	90	513	46	127	290	103
1993	1440	120	684	62	169	387	138
1994	1080	90	513	46	127	290	103

NOTES : (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 47.5 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 8: Drilling of Production and Service Wells (Offshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	3584	299	2831	62	169	385	137
1994	7168	597	5663	123	337	771	274
1995	8512	709	6724	147	400	915	325
1996	4928	411	3893	85	232	530	188
1997	1344	112	1062	23	63	145	51

NOTES: (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 79 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 8A: Drilling Production and Service Wells - Related Onshore Work (Onshore]

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	384	32	0	31	86	197	70
1994	768	64	0	63	172	393	140
1995	912	76	0	75	204	467	166
1996	528	44	0	43	118	270	96
1997	144	12	0	12	32	74	26

NOTES : (1) Average is based on a task duration of 12 months.

(2] Non-Alaska Residents are assumed to be zero percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9: Laying Offshore Pipe (Offshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	1111	250	994	10	26	60	21
1994	1111	250	994	10	26	60	21
1995	1111	250	994	10	26	60	21
1996	1111	250	994	10	26	60	21

NOTES: (1) Average is based on a task duration of 4.44 months.
(2) Non-Alaska Residents are assumed to be 89.5 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERINGBYORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 9A: Laying Offshore Pipe - Helicopter Support (Onshore)

Year	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Residence (2): Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	44	10	21	2	5	12	4
1994	44	10	21	2	5	12	4
1995	44	10	21	2	5	12	4
1996	44	10	21	2	5	12	4

NOTES: (1) Average is based on a task duration of 4.44 months.
(2) Non-Alaska Residents are assumed to be 47.5 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9B: Laying Offshore Pipe - Tugboats (Offshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	67	15	39	2	6	14	5
1994	67	15	39	2	6	14	5
1995	67	15	39	2	6	14	5
1996	67	15	39	2	6	14	5

NOTES:
1) Average is based on a task duration of 4.44 months.
2) Non-Alaska Residents are assumed to be 58 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9C: Laying Offshore Pipe - Supply and Anchor Boats (Offshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	67	15	39	2	6	14	5
1994	67	15	39	2	6	14	5
1995	67	15	39	2	6	14	5
1996	67	15	39	2	6	14	5

NOTES: (1) Average is based on a task duration of 4.44 months.
(2) Non-Alaska Residents are assumed to be 58 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPEND X A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9D: Laying Offshore Pipe - Boat Maintenance (Onshore

			Place of Permanent Res d 2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	27	6	16	1	3	6	2
1994	27	6	16	1	3	6	2
1995	27	6	16	1	3	6	2
1996	27	6	16	1	3	6	2

NOTES: (1) Average is based on a task duration of 4.44 months.
(2) Non-Alaska Residents are assumed to be 58 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9E: Laying Offshore Pipe - Longshoring [Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	44	10	0	4	10	23	8
1994	44	10	0	4	10	23	8
1995	44	10	0	4	10	23	8
1996	44	10	0	4	10	23	8

NOTES: (1) Average is based on a task duration of 4.44 months.
(2) Non-Alaska Residents are assumed to be zero percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9F: Laying Offshore Pipe - Other Task Related Work (Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	78	18	0	6	17	40	14
1994	78	18	0	6	17	40	14
1995	78	18	0	6	17	40	14
1996	78	18	0	6	17	40	14

NOTES: (1) Average is based on a task duration of 4.44 months.
(2) Non-Alaska Residents are assumed to be zero percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERINGBY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% 'TASK

Task 10: Laying Onshore Pipe [Onshore)

Year	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Residence (2): Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	4800	750	4296	41	113	258	92
1994	4800	750	4296	41	113	258	92

NOTES : (1) Average is based on a task duration of 6.4 months.
(2) Non-Alaska Residents are assumed to be 89.5 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 11: Marine Terminal Construction (Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	4800	400	2280	207	564	1290	459
1994	9600	800	4560	413	1129	2580	917

NOTES: (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 47.5 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; al else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 12: Pump Station Construction (Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks census Division	Anchorage Census Area	south Central Alaska
1994	9600	800	4560	413	1129	2580	917

NOTES: (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 47.5 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 15: Production Platform Operations (Offshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	1920	160	480	118	323	737	262
1996	3840	320	960	236	645	1475	524
1997	5760	480	1440	354	968	2212	786
1998	5760	480	1440	354	968	2212	786
1999	5760	480	1440	354	968	2212	786
2000	5760	480	1440	354	968	2212	786
2001	5760	480	1440	354	968	2212	786
2002	5760	480	1440	354	968	2212	786
2003	5760	480	1440	354	968	2212	786
2004	5760	480	1440	354	968	2212	786
2005	3840	320	960	236	645	1475	524
2006	3840	320	960	236	645	1475	524
2007	3840	320	960	236	645	1475	524
2008	3840	320	960	236	645	1475	524
2009	3840	320	960	236	645	1475	524
2010	3840	320	960	236	645	1475	524
2011	3840	320	960	236	645	1475	524

NOTES: (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 25 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumption from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 15A: Production Platform Operations - He'icopter Support (Onshore)

Year	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Residence (2) Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	120	10	30	7	20	46	16
1996	240	20	60	15	40	92	33
1997	360	30	90	22	60	138	49
1998	360	30	90	22	60	138	49
1999	360	30	90	22	60	138	49
2000	360	30	90	22	60	138	49
2001	360	30	90	22	60	138	49
2002	360	30	90	22	60	138	49
2003	360	30	90	22	60	138	49
2004	360	30	90	22	60	138	49
2005	240	20	60	15	40	92	33
2006	240	20	60	15	40	92	33
2007	240	20	60	15	40	92	33
2008	240	20	60	15	40	92	33
2009	240	20	60	15	40	92	33
2010	240	20	60	15	40	92	33
2011	240	20	60	15	40	92	33

NOTES: 1) Average is based on a task duration of 12 months.
2) Non-Alaska Residents are assumed to be 25 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST D:STRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 15B: Production Platform Operations - S pp y and Anchor Boats (Offshore)

Year	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Residence (2): Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	432	36	108	27	73	166	59
1996	864	72	216	53	145	332	118
1997	1296	108	324	80	218	498	177
1998	1296	108	324	80	218	498	177
1999	1296	108	324	80	218	498	177
2000	1296	108	324	80	218	498	177
2001	1296	108	324	80	218	498	177
2002	1296	108	324	80	218	498	177
2003	1296	108	324	80	218	498	177
2004	1296	108	324	80	218	498	177
2005	864	72	216	53	145	332	118
2006	864	72	216	53	145	332	118
2007	864	72	216	53	145	332	118
2008	864	72	216	53	145	332	118
2009	864	72	216	53	145	332	118
2010	864	72	216	53	145	332	118
2011	864	72	216	53	145	332	118

NOTES: (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 25 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM **INDUSTRY** EMPLOYMENT **FOR THE BARROW** ARCH LEASE OFFERING BY ORIGIN/DESTINATION **AND** BY MAJOR **INDUSTRY** TASK

Task **15C: Production** Platform Operations - **Boat** Maintenance **(Onshore)**

			Place of Permanent Residence (2)				
Year	**Total Annual** Employment	Average Monthly Employment **(1)**	**Outside** Alaska	North Slope Borough	**Fairbanks Census Division**	Anchorage Census Area	South Central Alaska
1995	96	8	24	6	16	37	13
1996	192	16	48	12	32	74	26
1997	288	24	72	18	48	111	39
1998	288	24	72	18	48	111	39
1999	288	24	72	18	48	111	39
2000	288	24	72	18	48	111	39
2001	288	24	72	18	48	111	39
2002	288	24	72	18	48	111	39
2003	288	24	72	18	48	111	39
2004	288	24	72	18	48	111	39
2005	192	16	48	12	32	74	26
2006	192	16	48	12	32	74	26
2007	192	16	48	12	32	74	26
2008	192	16	48	12	32	74	26
2009	192	16	48	12	32	74	26
2010	192	16	48	12	32	74	26
2011	192	16	48	12	32	74	26

NOTES : (1) Average is based on a task duration of 12 months.

(2] Non-Alaska Residents are assumed to be 25 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 15D: Production Platform Operations - Other Task Related Work (Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Employment	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	192	16	48	12	32	74	26
1996	384	32	96	24	65	147	52
1997	576	48	144	35	97	221	79
1998	576	48	144	35	97	221	79
1999	576	48	144	35	97	221	79
2000	576	48	144	35	97	221	79
2001	576	48	144	35	97	221	79
2002	576	48	144	35	97	221	79
2003	576	48	144	35	97	221	79
2004	576	48	144	35	97	221	79
2005	384	32	96	24	65	147	52
2006	384	32	96	24	65	147	52
2007	384	32	96	24	65	147	52
2008	384	32	96	24	65	147	52
2009	384	32	96	24	65	147	52
2010	384	32	96	24	65	147	52
2011	384	32	96	24	65	147	52

NOTES: (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 25 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Cont nued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 16: Major Platform Maintenance (Offshore

Year	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Re d (2) Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1997	96	16	24	6	16	37	13
1998	96	16	24	6	16	37	13
1999	96	16	24	6	16	37	13
2000	---	0	0	0	0	0	0
2001	---	0	0	0	0	0	0
2002	58	10	15	4	10	22	8
2003	58	10	15	4	10	22	8
2004	58	10	15	4	10	22	8
2005	58	10	15	4	10	22	8
2006	58	10	15	4	10	22	8
2007	58	10	15	4	10	22	8
2008	58	10	15	4	10	22	8
2009	58	10	15	4	10	22	8
2010	58	10	15	4	10	22	8
2011	58	10	15	4	10	22	8

NOTES: (1) Average is based on a task duration of months.
(2) Non-Alaska Residents are assumed to be 25 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 18: Production and Service Well Workovers (Offshore)

Year	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Residence (2): Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1998	960	80	240	59	161	369	131
1999	1920	160	480	118	323	737	262
2000	2280	190	570	140	383	876	311
2001	1320	110	330	81	222	507	180
2002	360	30	90	22	60	138	49
2003	1368	114	342	84	230	525	187
2004	1368	114	342	84	230	525	187
2005	1368	114	342	84	230	525	187
2006	1368	114	342	84	230	525	187
2007	1368	114	342	84	230	525	187
2008	1368	114	342	84	230	525	187
2009	900	75	225	55	151	346	123
2010	900	75	225	55	151	346	123
2011	900	75	225	55	151	346	123

NOTES: (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 25 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

APPENDIX A (Continued)

FORECAST DISTRIBUTION OF PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE 0FFER1NGB% ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 19: Production Base Operations (Onshore)

Y	Total Annual Employment	Average Monthly Employment (1)	Place of Permanent Residence (2): Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
199	1224	102	306	75	206	470	167
1996	1224	102	306	75	206	470	167
1997	1224	102	306	75	206	470	167
199	1224	102	306	75	206	470	167
1999	1224	102	306	75	206	470	167
2000	1224	102	306	75	206	470	167
2001	1224	102	306	75	206	470	167
2002	1224	102	306	75	206	470	167
2003	1224	102	306	75	206	470	167
2004	1224	102	306	75	206	470	167
2005	1224	102	306	75	206	470	167
2006	1224	102	306	75	206	470	167
2007	1224	102	306	75	206	470	167
2008	1224	102	306	75	206	470	167
2009	1224	102	306	75	206	470	167
2010	1224	102	306	75	206	470	167
2011	1224	102	306	75	206	470	167

NOTES: (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 25 Percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from Minerals Management Service; all else ERE Systems, Ltd.

D A (Continued)

FORECAST DISTRIBUTION O PETROLEUM INDUSTRY EMPLOYMENT FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION ND BY M OR INDUSTRY TASK

Task 20: Oil Terminal Operations (Onshore)

			Place of Permanent Residence (2)				
Year	Total Annual Emp m	Average Monthly Employment (1)	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alask≡
1995	1680	140	420	103	282	645	229
1996	1680	140	420	103	282	645	229
1997	1680	140	420	103	282	645	229
1998	1680	140	420	103	282	645	229
1999	1680	140	420	103	282	645	229
2000	1680	140	420	103	282	645	229
2001	1680	140	420	103	282	645	229
2002	1680	140	420	103	282	645	229
2003	1680	140	420	103	282	645	229
2004	1680	140	420	103	282	645	229
2005	1680	140	420	103	282	645	229
2006	1680	140	420	103	282	645	229
2007	1680	140	420	103	282	645	229
2008	1680	140	420	103	282	645	229
2009	1680	140	420	103	282	645	229
2010	1680	140	420	103	282	645	229
2011	1680	140	420	103	282	645	229

NOTES (1) Average is based on a task duration of 12 months.
(2) Non-Alaska Residents are assumed to be 25 percent of total employment. Alaska Residents are distributed: 8.2 percent North Slope Borough; 22.4 percent Fairbanks Census Division; 51.2 percent Anchorage Census Area; and 18.2 percent Southcentral Alaska.

SOURCES: Annual employment data and residence assumptions from M·nerals Management Service; all else ERE Systems, Ltd.

APPENDIX B

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

APPENDIX B

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERINGBY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 1: Drilling of Exploration Wells (Offshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	206	4	12	28	10
1987	309	7	18	42	15
1988	412	9	25	56	20
1989	515	11	31	70	25
1990	618	13	37	84	30
1991	515	11	31	70	25
1992	412	9	25	56	20
1993	206	4	12	28	10
1993	206	4	12	28	10

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 1A: Drilling of Exploration Wells - Helicopter Support (Onshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	21	2	5	12	4
1987	31	3	8	18	6
1988	41	4	10	23	8
1989	52	5	13	29	10
1990	62	6	15	35	12
1991	52	5	13	29	10
1992	41	4	10	23	8
1993	21	2	5	12	4

NOTES: (1)
task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST' DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 1B: Drilling of Exploration Wells - Supply and Anchor Boats (Offshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	25	1	4	9	3
1987	38	2	6	14	5
1988	50	3	8	19	7
1989	63	4	10	23	8
1990	76	4	12	28	10
1991	63	4	10	23	8
1992	50	3	8	19	7
1993	25	1	4	9	3

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 1C: Drilling of Exploration Wells - Related Onshore Work (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	10	0	1	1	0
1987	15	0	1	2	1
1988	21	0	1	3	1
1989	26	1	2	4	1
1990	31	1	2	4	1
1991	26	1	2	4	1
1992	21	0	1	3	1
1993	10	0	1	1	0

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.086.3. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service was modified to fit onsite/offsite assumptions.

B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 2: Construction of Exploration Shore Base [Onshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	9	0	1	1	0
1987	21	0	1	3	1
1988	15	0	1	2	1
1989	15	0	1	2	1

NOTES: (1) Trips are derived by mul tiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.3802. This trip factor is based on a rotation factor of 2.0, assuming 40 days onsite and 40 days offsite.

SOURCES: ERE Systems, Ltd., " except rotation factor from Wrier'als Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION ANO BY MAJOR INDUSTRY TASK

Task 3: Exploration Base Operations (Onshore)

Peak Month Trip Distribution byOrigin/Destination (1)

Year	Outside Alaska	North Sl ope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	7	0	0	1	0
1987	7	0	0	1	0
1988	7	0	0	1	0
1989	14	0	1	2	1
1990	14	0	1	2	1
1991	14	0	1	2	1
1992	14	0	1	2	1
1993	14	0	1	2	1

NOTES : (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.4345. This trip factor is based on a rotation factor of 2.0, assuming 35 days onsite and 35 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 4: Geophysical-Geological Survey (Offshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1986	9	0	1	1	0
1987	9	0	1	1	0
1988	9	0	1	1	0
1989	9	0	1	1	0
1990	9	0	1	1	0
1991	9	0	1	1	0
1992	9	0	1	1	0
1993	9	0	1	1	0

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.3802. This trip factor is based on a rotation factor of 2.0, assuming 40 days onsite and 40 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BYMAJOR INDUSTRY TASK

Task 6: Production Equipment Installation (Offshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	583	6	15	35	12
1992	583	6	15	35	12
1993	583	6	15	35	12

NOTES : (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 6A: Production Equipment Installation - Helicopter Support (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	5	0	1	3	1
1992	5	0	1	3	1
1993	5	0	1	3	1

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from "Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

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FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 6B: Production Equipment Installation - Tugboats (Offshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	32	2	5	12	4
1992	32	2	5	12	4
1993	32	2	5	12	4

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service'.

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 6C: Production Equipment Installation - Supply and Anchor Boats (Offshore]

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	19	1	3	7	2
1992	19	1	3	7	2
1993	19	1	3	7	2

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task **6D:** Production Equipment Installation - Boat Maintenance (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	5		1	2	1
1992	5		1	2	1
1993	5	0	1	2	1

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service was modified to fit onsite/offsite assumptions.

APPENDIX B [Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 6E: Production Equipment Installation - Longshoring (Onshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1991	0	1	3	7	3
1992	0	1	3	7	3
1993	0	1	3	7	3

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE system, Ltd., except rotation factor from Minerals Management Service was modified to fit onsite/offsite assumptions.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 7: Construction of Production Shore Base (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1992	31	3	8	18	6
1993	41	4	10	23	8
1994	31	3	8	18	6

NOTES : (1) Trips are derived by multiplying correspond ng industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28, days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service was modified to fit onsite/offsite assumptions.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OWERING BY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 8: **Drilling of Production and Service Wells (Offshore)**

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	256	6	15	35	12
1994	513	11	31	70	25
1995	609	13	36	83	29
1996	352	8	21	48	17
1997	96	2	6	13	5

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 8A: Drilling Production and Service Wells - Related Onshore Work (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	0	3	8	18	6
1994	0	6	16	36	13
1995	0	7	18	42	15
1996	0	4	11	24	9
1997	0	1	3	7	2

NOTES: (l) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9: Laying Offshore Pipe (offshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	243	2	6	15	5
1994	243	2	6	15	5
1995	243	2	6	15	5
1996	243	2	6	15	5

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9A: Laying Offshore Pipe - Helicopter Support (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	5	0	1	3	1
1994	5	0	1	3	1
1995	5	0	1	3	1
1996	5		1	3	1

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 9%: Laying Offshore Pipe - Tugboats (Offshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	6	0	1	2	1
1994	6	0	1	2	1
1995	6	0	1	2	1
1996	6	0	1	2	1

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution {from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX 5 (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9C: Laying Offshore Pipe - Supply and Anchor Boats (Offshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	6	0	1	2	1
1994	6	0	1	2	1
1995	6	0	1	2	1
1996	6	0	1	2	1

NOTES : (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14' days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9D: Laying Offshore Pipe - Boat Maintenance (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	3	0	0	1	0
1994	3	0	0	1	0
1995	3	0	0	1	0
1996	3	0	0	1	0

NOTES : (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service was modified to fit onsite/offsite assumptions.

APPENDIX B {Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9E: Laying Offshore Pipe - Longshoring (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	0	1	2	4	1
1994	0	1	2	4	1
1995	0	1	2	4.	1
1996	0	1	2	4	1

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service was modified to fit onsite/offsite assumptions.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 9F: Laying Offshore Pipe - Other Task Related Work (Onshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	0	1	3	7	2
1994	0	1	3	7	2
1995	0	1	3	7	2
1996	0	1	3	7	2

NOTES : (1) Trips are derived by multiplying corresponding task employment distribution (fromAppendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service was modified to fit onsite/offsite assumptions.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 10: Laying Onshore Pipe (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North S1 ope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	486	5	13	29	10
1994	486	5	13	29	10

NOTES: (1) Trips are derived by mul tiplying industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 2.0, assuming 21 days onsite and 21 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor' from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 11: Marine Terminal Construction (Onshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1993	83	7	20	47	17
1994	165	15	41	93	33

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.4345. This trip factor is based on a rotation factor of 2.0, assuming 35 days onsite and 35 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 12: Pump Station Construction (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1994	165	15	41	93	33

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.4345. This trip factor is based on a rotation factor of 2.0, assuming 35 days onsite and 35 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK.

Task 15: Production Platform Operations (Offshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	43	11	29	67	24
1996	87	21	58	133	47
1997	130	32	88	200	71
1998	130	32	88	200	71
1999	130	32	88	200	71
2000	130	32	88	200	71
2001	130	32	88	200	71
2002	130	32	88	200	71
2003	130	32	88	200	71
2004	130	32	88	200	71
2005	87	21	58	133	47
2006	87	21	58	133	47
2007	87	21	58	133	47
2008	87	21	58	133	47
2009	87	21	58	133	47
2010	87	21	58	133	47
2011	87	21	58	133	47

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION IIF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 15A: Production Platform Operations - Helicopter Support (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	3	1	2	4	1
	5	1	4	8	3
1997	8	2	5	13	4
1998	8	2	5	13	4
1999	8	2	5	13	4
2000	8	2	5	13	4
2001	8	2	5	13	4
2002	8	2	5	13	4
2003	8	2	5	13	4
2004	8	2	5	13	4
2005	5	1	4	8	3
2006	5	1	4	8	3
2007	5	1	4	8	3
2008	5	1	4	8	3
2009	5	1	4	8	3
2010	5	1	4	8	3
2011	5	1	4	8	3

NOTES : (1) Trips are derived by multiplying correspond ng industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 15B: Production Platform Operations - Supply and Anchor Boats (Offshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	7	2	4	10	4
1996	13	3	9	20	7
1997	20	5	13	30	11
1998	20	5	13	30	11
1999	20	5	13	30	11
2000	20	5	13	30	11
2001	20	5	13	30	11
2002	20	5	13	30	11
2003	20	5	13	30	11
2004	20	5	13	30	11
2005	13	3	9	20	7
2006	13	3	9	20	7
2007	13	3	9	20	7
2008	13	3	9	20	7
2009	13	3	9	20	7
2010	13	3	9	20	7
2011	13	3	9	20	7

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 1.5, assuming 28 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 15C: Production Platform Operations - Boat Maintenance (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	1	0	1	2	1
1996	3	1	2	4	2
1997	4	1	3	7	2
1998	4	1	3	7	2
1999	4	1	3	7	2
2000	4	1	3	7	2
2001	4	1	3	7	2
2002	4	1	3	7	2
2003	4	1	3	7	2
2004	4	1	3	7	2
2005	3	1	2	4	2
2006	3	1	2	4	2
2007	3	1	2	4	2
2008	3	1	2	4	2
2009	3	1	2	4	2
2010	3	1	2	4	2
2011	3	1	2	4	2

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 2.0, assuming 21 days onsite and 21 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management was modified to fit onsite/offsite assumptions.

APPENDIX B (Continued)

DISTRIBUTION OF PE MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 15D: Production Platform Operations - Other Task Related Work (Onshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	3	1	2	4	2
1996	6	1	4	9	3
1997	9	2	6	13	5
1998	9	2	6	13	5
1999	9	2	6	13	5
2000	9	2	6	13	5
2001	9	2	6	13	5
2002	9	2	6	13	5
2003	9	2	6	13	5
2004	9	2	6	13	5
2005	6	1	4	9	3
2006	6	1	4	9	3
2007	6	1	4	9	3
2008	6	1	4	9	3
2009	6	1	4	9	3
2010	6	1	4	9	3
2011	6	1	4	9	3

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 2.0, assuming 21 days onsite and 21 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 16: Major Platform Maintenance (Offshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1997	4	1	3	7	2
1998	4	1	3	7	2
1999	4	1	3	7	2
2000	0	0	0	0	0
	0	0	0	0	0
2002	3	1	2	4	1
2003	3	1	2	4	1
2004	3	1	2	4	1
2005	3	1	2	4	1
2006	3	1	2	4	1
2007	3	1	2	4	1
2008	3	1	2	4	1
2009	3	1	2	4	1
2010	3	1	2	4	1
2011	3	1	2	4	1

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 18: Production and Service Well Workovers (Offshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1998	22	5	15	33	12
1999	43	11	29	67	24
2000	52	13	35	79	28
2001	30	7	20	46	16
2002	8	2	5	13	4
2003	31	8	21	48	17
2004	31	8	21	48	17
2005	31	8	21	48	17
2006	31	8	21	48	17
2007	31	8	21	48	17
2008	31	8	21	48	17
2009	20	5	14	31	11
2010	20	5	14	31	11
2011	20	5	14	31	11

NOTES : (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 1.0863. This trip factor is based on a rotation factor of 2.0, assuming 14 days onsite and 14 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR 1NDUSTR% TASK

Task 19: Production Base Operations (Onshore)

	Peak Month Trip Distribution by Origin/Destination (1)				
Year	Outside Alaska	North Sl ope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	18	5	12	28	10
1996	18	5	12	28	10
1997	18	5	12	28	10
1998	18	5	12	28	10
1999	18	5	12	28	10
2000	18	5	12	28	10
2001	18	5	12	28	10
2002	18	5	12	28	10
2003	18	5	12	28	10
2004	18	5	12	28	10
2005	18	5	12	28	10
2006	18	5	12	28	10
2007	18	5	12	28	10
2008	18	5	12	28	10
2009	18	5	12	28	10
2010	18	5	12	28	10
2011	18	5	12	28	10

NOTES : (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 2.(), assuming 21 days onsite and 21 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.

APPENDIX B (Continued)

FORECAST DISTRIBUTION OF PEAK MONTH AIR TRAVEL DEMANDS FOR THE BARROW ARCH LEASE OFFERING BY ORIGIN/DESTINATION AND BY MAJOR INDUSTRY TASK

Task 20: Oil Terminal Operations (Onshore)

Peak Month Trip Distribution by Origin/Destination (1)

Year	Outside Alaska	North Slope Borough	Fairbanks Census Division	Anchorage Census Area	South Central Alaska
1995	25	6	17	39	14
1996	25	6	17	39	14
1997	25	6	17	39	14
1998	25	6	17	39	14
1999	25	6	17	39	14
2000	25	6	17	39	14
2001	25	6	17	39	14
2002	25	6	17	39	14
2003	25	6	17	39	14
2004	25	6	17	39	14
2005	25	6	17	39	14
2006	25	6	17	39	14
2007	25	6	17	39	14
2008	25	6	17	39	14
2009	25	6	17	39	14
2010	25	6	17	39	14
2011	25	6	17	39	14

NOTES: (1) Trips are derived by multiplying corresponding industry task employment distribution (from Appendix A) by a trip factor of 0.7242. This trip factor is based on a rotation factor of 2.0, assuming 21 days onsite and 21 days offsite.

SOURCES: ERE Systems, Ltd., except rotation factor from Minerals Management Service.