FERC/EIS—0002F

Western LNG Project

DEPARTMENT OF ENERGY · FEDERAL ENERGY REGULATORY COMMISSION

VOL. I-CP 75-140

Final Environmental Impact Statement

FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF PIPELINE
AND PRODUCER REGULATION

FERC/EIS-0002F

FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF PIPELINE AND PRODUCER REGULATION
WASHINGTON, D.C. 20426

WESTERN LNG PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

VOLUME I

CONSTRUCTION AND OPERATION
OF AN LNG LIQUEFACTION TERMINAL
AT
NIKISKI, ALASKA

Pacific Alaska LNG Associates
Docket No. CP75-140

October 1978

FOREWORD

The Federal Energy Regulatory Commission, pursuant to the Natural Gas Act, is authorized to issue certificates of public convenience and necessity for the construction and operation of natural gas facilities subject to its jurisdiction, on the conditions that:

> [a] certificate shall be issued to any qualified applicant therefor, authorizing the whole or any part of the operation, sale, service, construction, extension, or acquisition covered by the application, if it is found that the applicant is able and willing properly to do the acts and to perform the service proposed and to conform to the provisions of the Act and the requirements, rules, and regulations of the Commission thereunder, and that the proposed service, sale, operation, construction, extension, or acquisition, to the extent authorized by the certificate, is or will be required by the present or future public convenience and necessity; otherwise such application shall be denied.

15 U.S.C. 717

The Commission shall have the power to attach to the issuance of the certificate and to the exercise of the rights granted thereunder such reasonable terms and conditions as the public convenience and necessity may require.

Section 1.6 of the Commission's Rules of Practice and Procedure allows any person alleging applicant's non-compliance with such conditions to file a complaint noting the basis for such objection for the Commission's consideration. 18 C.F.R. §1.6 (1972).

Section 2.82(c) of the Commission's General Rules allows any person to file a petition to intervene on the basis of the staff draft environmental impact statement.

STATEMENT OF GENERAL POLICY TO IMPLEMENT PROCEDURES FOR COMPLIANCE WITH THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

§ 2.80 Detailed Environmental Statement.

(a) It shall be the general policy of the Federal Power Commission to adopt and to adhere to the objectives and aims of the National Environmental Policy Act of 1969 (Act) in its regulation under the Federal Power Act and the Natural Gas Act. The National Environmental Policy Act of 1969 requires, among other things, all Federal agencies to include a detailed environmental statement in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment.

(b) Therefore, in compliance with the National Environmental Policy Act of 1969 the Commission staff shall make a detailed environmental statement when the regulatory action taken by us under the Federal Power Act and Natural Gas Act will have a significant environmental impact. A "detailed statement" prepared in compliance with the requirements of §§ 2.81 through 2.82 of this Part shall fully develop the five factors listed hereinafter in the context of such considerations as the proposed activity's direct and indirect effect on the air and water environment of the project or natural gas pipeline facility; on the land, air, and water biota; on established park and recreational areas; and on sites of natural, historic, and scenic values and resources of the area. The statement shall discuss the extent of the conformity of the proposed activity with all applicable environmental standards. The statement shall also fully deal with alternative courses of action to the proposal and, to the maximum extent practicable, the environmental effects of each alternative. Further, it shall specifically discuss plans for future development related to the application under consideration.

The above factors are listed to merely illustrate the kinds of values that must be considered in the statement. In no respect is this listing to be construed as covering all relevant factors.

The five factors which must be specifically discussed in the detailed statement are:

(1) the environmental impact of the proposed action,

(2) any adverse environmental effects which cannot be avoided should the proposal be implemented;

(3) alternatives to the proposed action,

(4) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(5) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

(c) (i) To the maximum extent practicable no final administrative action is to be taken sooner than ninety days after a draft environmental statement has been circulated for comment or thirty days after the final text of an environmental statement has been made available to the Council on Environmental Quality and the public.

(c) (ii) Upon a finding that it is necessary and appropriate in the public interest, the Commission may dispense with any time period specified in §§ 2.80-2.82.

§ 2.81 Compliance with the National Environmental Policy Act of 1969 under Part I of the Federal Power Act

(a) All applications for major projects (those in excess of 2,000 horsepower) or for reservoirs only providing regulatory flows to downstream (major) hydroelectric projects under Part I of the Federal Power Act for license or relicense, shall be accompanied by Exhibit W, the applicant's detailed report of the environmental factors specified in § 2.80 and 4.41. All applications for surrender or amendment of a license proposing construction, or operating change of a project shall be accompanied by the applicant's detailed report of the environmental factors specified in § 2.80. Notice of all such applications shall continue to be made as prescribed by law.

(b) The staff shall make an initial review of the applicant's report and, if necessary, require applicant to correct deficiencies in the report. If the proposed action is determined to be a major Federal action significantly affecting the quality of the human environment, the staff shall conduct a detailed independent analysis of the action and prepare a draft environmental impact statement which shall be made available to the Council on Environmental Quality, the Environmental Protection Agency, other appropriate governmental bodies, and to the public, for comment. The statement shall also be served on all parties to the proceeding. The Secretary of the Federal Power Commission shall cause prompt publication in the Federal Register of notice of the availability of the staff's draft environmental statement. Written comments shall be made within 45 days of the date the notice of availability appears in the Federal Register. If any governmental entity, Federal, state, or local, or any member of the public, fails to comment within the time provided, it shall be assumed, absent a request for a specific extension of time, that such entity or person has no comment to make. Extensions of time shall be granted only for good cause shown. All entities filing comments with the Commission will submit ten copies of such comments to the Council on Environmental Quality. Upon expiration of the time for comment the staff shall consider all comments received and revise as necessary and finalize its environmental impact statement which, together with the comments received, shall accompany the proposal through the agency review and decision-making process and shall be made available to the parties to the proceeding, the Council on Environmental Quality, and the public. In the event the proposal is the subject of a hearing the staff's environmental statement will be placed in evidence at that hearing.

(c) Any person may file a petition to intervene on the basis of the staff draft environmental statement. All interveners taking a position on environmental matters shall file timely comments, in accordance with paragraph (b) of this section, on the draft statement with the Commission including, but not limited to, an analysis of their environmental position in the context of the factors enumerated in 2.80, and specifying any differences with staff's position upon which intervener wishes to be heard. Nothing herein shall preclude an intervener from filing a detailed environmental impact statement.

(d) In the case of each contested application, the applicant, staff, and all interveners taking a position on environmental matters shall offer evidence for the record in support of their environmental position. The applicant and all such interveners shall specify any differences with the staff's position, and shall include, among other relevant factors, a discussion of their position in the context of the factors enumerated in §2.80.

(e) In the case of each contested application, the initial and reply briefs filed by the applicant, the staff and all interveners taking a position on environmental matters must specifically analyze and evaluate the evidence in the light of the environmental criteria enumerated in § 2.80. Furthermore, the Initial Decision of the Presiding Administrative Law Judge in such cases, and the final order of the Commission dealing with the application on the merits in all cases, shall include an evaluation of the environmental factors enumerated in § 2.80 and the views and comments expressed in conjunction therewith by the applicant and all those making formal comment pursuant to the provisions of this section.

§ 2.82 Compliance with the National Environmental Policy Act of 1969 Under the Natural Gas Act.

(a) All certificate applications filed under Section 7(c) of the Natural Gas Act (15 U.S.C. 717f(c)) for the construction of pipeline facilities, except abbreviated applications filed pursuant to Sections 157.7(b), (c) and (d) of Commission Regulations and producer applications for the sale of gas filed pursuant to Sections 157.23-29 of Commission Regulations, shall be accompanied by the applicant's detailed report of the environmental factors specified in § 2.80. Notice of all such applications shall continue to be made as prescribed by law.

(b) The staff shall make an initial review of the applicant's report and, if necessary, require applicant to correct deficiencies in the report. If the proposed action is determined to be a major Federal action significantly affecting the quality of the human environment, the staff shall conduct a detailed independent analysis of the action and prepare a draft environmental impact statement which shall be made available to the Council on Environmental Quality, the Environmental Protection Agency, other appropriate governmental bodies, and to the public, for comment. The statement shall also be served on all parties to the proceeding. The Secretary of the Federal Power Commission shall cause prompt publication in the Federal Register of notice of the availability of the staff's draft environmental statement. Written comments shall be made within 45 days of the date the notice of availability appears in the Federal Register. If any governmental entity, Federal, state, or local, or any member of the public, fails to comment within the time provided, it shall be assumed, absent a request for a specific extension of time, that such entity or person has no comment to make. Extensions of time shall be granted only for good cause shown. All entities filing comments with the Commission shall submit ten copies of such comments to the Council on Environmental Quality. Upon expiration of the time for comment the staff shall consider all comments received and revise as necessary and finalize its environmental impact statement which, together with the comments received, shall accompany the proposal through the agency review and decision-making process and shall be made available to the parties to the proceeding, the Council on Environmental Quality, and the public. In the event the proposal is the subject of a hearing, the staff's environmental statement will be placed in evidence at that hearing.

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FEDERAL POWER COMMISSION
RULES OF PRACTICE AND PROCEDURE
18 CFR 1.8 Intervention

"(a) Initiation of intervention. Participation in a proceeding as an intervener may be initiated as follows:

(1) By the filing of a notice of intervention by a State Commission, including any regulatory body of the State or municipality having jurisdiction to regulate rates and charges for the sale of electric energy, or natural gas, as the case may be, to consumers within the intervening State or municipality.

(2) By order of the Commission upon petition to intervene.

(b) Who may petition. A petition to intervene may be filed by any person claiming a right to intervene or an interest of such nature that intervention is necessary or appropriate to the administration of the statute under which the proceeding is brought. Such right or interest may be:

(1) A right conferred by statute of the United States;

(2) An interest which may be directly affected and which is not adequately represented by existing parties and as to which petitioners may be bound by the Commission's action in the proceeding (the following may have such an interest; consumers served by the applicant, defendant, or respondent; holders of securities of the applicant, defendant, or respondent; and competitors of the applicant, defendant, or respondent).

(3) Any other interest of such nature that petitioner's participation may be in the public interest.

(c) Form and contents of petitions. Petitions to intervene shall set out clearly and concisely the facts from which the nature of the petitioner's alleged right or interest can be determined, the grounds of the proposed intervention, and the position of the petitioner in the proceeding, so as fully and completely to advise the parties and the Commission as to the specific issues of fact or law to be raised or controverted, by admitting, denying or otherwise answering specifically and in detail, each material allegation of fact or law asserted in the proceeding, and citing by appropriate reference the statutory provisions or other authority relied on: Provided, that where the purpose of the proposed intervention is to obtain an allocation of natural gas for sale and distribution by a person or municipality engaged or legally authorized to engage in the local distribution of natural or artificial gas to the public, the petition shall comply with the requirements of Part 156 of this chapter (i.e., Regulations Under the Natural Gas Act). Such petitions shall in other respects comply with the requirements of §§1.15 to 1.17, inclusive.

(d) Filing and service of petitions. Petitions to intervene and notices of intervention may be filed at any time following the filing of a notice of rate or tariff change, or of an application, petition, complaint, or other document seeking Commission action, but in no event later than the date fixed for the filing of petitions to intervene in any order or notice with respect to the proceedings issued by the Commission or its Secretary, unless, in extraordinary circumstances for good cause shown, the Commission authorizes a late filing. Service shall be made as provided in §1.17. Where a person has been permitted to intervene notwithstanding his failure to file his petition within the time prescribed in this paragraph, the Commission or officer designated to preside may where the circumstances warrant, permit the waiver of the requirements of §1.26(c)(5) with respect to copies of exhibits for such intervener.

(e) Answers to petitions. Any party to the proceeding or staff counsel may file an answer to a petition to intervene, and in default thereof, may be deemed to have waived any objection to the granting of such petition. If made, answers shall be filed within 10 days after the date of service of the petition, but not later than 5 days prior to the date set for the commencement of the hearing, if any, unless for cause the Commission with or without motion shall perscribe a different time. They shall in all other respects conform to the requirements of §§1.15 to 1.17, inclusive.

(f) Notice and action on petitions

(1) Notice and service. Petitions to intervene, when tendered to the Commission for filing, shall show service thereof upon all participants to the proceeding in conformity with §1.17(b).

(2) Action on petitions. As soon as practicable after the expiration of the time for filing answers to such petitions or default thereof, as provided in paragraph (e) of this section, the Commission will grant or deny such petition in whole or in part or may, if found to be appropriate, authorize limited participation. No petitions to intervene may be filed or will be acted upon during a hearing unless permitted by the Commission after opportunity for all parties to object thereto. Only to avoid detriment to the public interest will any presiding officer tentatively permit participation in a hearing in advance of, and then only subject to, the granting by the Commission of a petition to intervene.

(g) Limitation in hearings. Where there are two or more interveners having substantially like interests and positions, the Commission or presiding officer may, in order to expedite the hearing, arrange appropriate limitations on the number of attorneys who will be permitted to cross-examine and make and argue motions and objections on behalf of such interveners."

FEDERAL ENERGY REGULATORY COMMISSION

OFFICE OF PIPELINE AND PRODUCER REGULATION

FINAL ENVIRONMENTAL IMPACT STATEMENT
SUMMARY SHEET

Docket Nos.:	CP75-83-2	- Western LNG Terminal Company
		- Pacific Gas LNG Terminal Company
		- Western LNG Terminal Associates
	CP75-140	- Pacific Alaska LNG Company
		- Alaska California LNG Company
		- Pacific Alaska LNG Associates

1. This Final Environmental Impact Statement (FEIS), prepared by the staff of the Federal Energy Regulatory Commission, is related to an administrative action.

2. The administrative action here involved arises from applications filed by Pacific Alaska LNG Company, Alaska California LNG Company, and Pacific Alaska LNG Associates, in Docket No. CP75-140, for a certificate of public convenience and necessity authorizing, pursuant to Section 7(c) of the Natural Gas Act, the construction and operation of facilities to collect and liquefy natural gas; the transportation of liquefied natural gas (LNG) in interstate commerce; and the sale of natural gas to Southern California Gas Company (SoCal) and Pacific Gas and Electric Company. Natural gas would be purchased from gas fields in the Cook Inlet region of Alaska and transported through a proposed 6- through 24-inch diameter 291.6-mile pipeline network to a proposed LNG plant in the Nikiski industrial complex, 9 miles north of Kenai, Alaska. The proposed LNG plant would consist of two gas liquefaction trains, two 550,000-barrel LNG storage tanks, a marine terminal, a construction dock and haul road, and other appurtenant facilities. Two 130,000-cubic meter LNG vessels would be constructed to carry LNG by sea from Nikiski to the Western LNG Terminal Company, Pacific Gas LNG Terminal Company, and Western LNG Terminal Associates' proposed receiving terminal at Point Conception, California. The receiving terminal is proposed in Docket No. CP75-83-2. The applicants seek a certificate of public convenience and necessity authorizing, pursuant to Section 7(c) of the Natural Gas Act, the construction and operation of an LNG terminal facility, which would unload, store, revaporize, and send out LNG delivered by oceangoing tankers to Point Conception from Pacific Alaska LNG Company's proposed liquefaction and storage facility near

Kenai, Alaska, as well as tankers from the Republic of Indonesia for Pacific Indonesia LNG Company. Western Terminal proposes to construct and operate two 550,000-barrel LNG storage tanks, nine seawater vaporizers, three gas-fired peaking vaporizers, a marine terminal capable of berthing and unloading LNG tankers with a capacity up to 130,000 cubic meters, and other appurtenant facilities. The proposed Point Conception facility would revaporize LNG at an average plant output of 900 million cfd with additional peaking capacity of 300 million cfd. Revaporized gas would be transported through a proposed 112.4-mile long, 34-inch diameter pipeline to Gosford, near Bakersfield, where the pipeline would join with existing gas transmission facilities owned and operated by Pacific Gas and Electric Company.

3. Environmental impact would occur to humans, land use, vegetation, soils, wildlife, water quality, air quality, and noise levels.

4. Alternative sites for the LNG terminal and pipeline as well as alternate sources of energy and the alternative of not constructing the proposed facilities are considered herein.

5. It should be noted that Volume II of this environmental impact statement complements the environmental impact statement that was prepared by the California Public Utilities Commission and the alternative site selection material prepared by the California Coastal Commission. These materials were utilized to prepare various sections of this FEIS.

6. At the end of the 45-day review period for the Draft Environmental Impact Statement (DEIS) dated April 21, 1978, the administrative law judge extended the review period to July 1, 1978. At the end of this review period, 57 letters of comment had been received. They are reprinted in Volume III of the FEIS, along with staff responses to each specific comment. All comments have been carefully reviewed and analyzed by the staff, and, where appropriate, the substance of the DEIS has been modified to reflect the comments. A list of all reports, studies, technical papers, etc. which were attached to various letters of comment but which are not reprinted in the FEIS is also included in Volume III.

7. Copies of this FEIS are being made available to the public and all parties to the proceedings on or about October 31, 1978, and to the following:

A. Federal:

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army
Department of Commerce
Department of Defense
Department of Energy
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Labor
Department of State
Department of Transportation
Energy Resources Council
Environmental Protection Agency
Federal Trade Commission
Interstate Commerce Commission
Nuclear Regulatory Commission

B. State of Alaska:

1. State

Alaska Power Administration
Alaska Public Services Commission
Bureau of Outdoor Recreation
Department of Commerce and Economic Development
Department of Community and Regional Affairs
Department of Environmental Conservation
Department of Fish and Game
Department of Highways
Department of Natural Resources
Department of Revenue
Joint Federal-State Land Use Planning Commission for Alaska
Office of the Attorney General
Office of the Governor
University of Alaska

2. Regional and Local

City of Anchorage
City of Cordova
City of Homer

City of Kenai
City of Seward
City of Soldatna
Cordova Library
Fairbanks Library
Fairbanks North Star Borough (2 Cities)
Greater Anchorage Area Borough
Greater Anchorage Chamber of Commerce
J. J. Loussai Library
Kenai-Cook Inlet Borough (9 Cities)
Matanuska-Susitna Borough (15 Cities)

C. State of California

1. State

Assembly Resources Land Use and Energy
California Air Resources Board
California Coastal Commission
California Public Utilities Commission
California State Division of Industrial Safety
California State Energy Commission
California State University Library at Fullerton
California State University Library at Long Beach
California State University Library at Los Angeles
California State University Library at Northridge
Department of Conservation
Department of Fish and Game
Department of Food and Agriculture
Department of Health
Department of Navigation and Ocean Development
Department of Parks and Recreation
Department of Transportation
Department of Water Resources
Office of the Attorney General
Office of the Governor
Office of Historic Preservation
Office of Planning and Research
Soil Conservation Service
State Lands Commission
The Resources Agency of California
University of California at Los Angeles
University of California at Santa Barbara

2. Regional and Local

California Institute of Technology
California Lutheran College Library
California Polytechnic University Library
City of Hanford
City of Los Angeles
City of San Luis Obispo
City of Santa Barbara
City of Ventura
Claremont University Center Library
County of Santa Barbara
Hanford Public Library
Kern County Council of Governments
Los Angeles City Library
Los Angeles County Air Pollution Control District
Los Angeles County Fire Department
Los Angeles County Flood Control
Los Angeles Harbor Department
Los Angeles Office of Economic Development
Los Angeles Regional Water Quality Control Board
Metropolitan Water District of Southern California
Moorpark College Library
Oxnard City Planning Department
Oxnard College Library
Oxnard Harbor District
San Luis Obispo City County Library
San Luis Obispo City Planning Commission
San Luis Obispo County Planning Commission
Santa Barbara City College Library
Santa Barbara County Department of Environmental Resources
Santa Barbara Public Library
South Central Coast Regional Commission
Southern California Air Pollution Control Board
Ventura City Government
Ventura County Air Pollution Control District
Ventura County Association of Governments
Ventura County Building and Safety Department
Ventura County Fire Department
Ventura County Flood Control
Ventura County Planning Department
Westmont College Library

3. Conservation Groups and Citizens Groups

American Right of Way Association, Inc.
California Academy of Sciences
California Association of Resource Conservation Districts
California Committee of Two Million
California Conservation Council
California Historical Society
California Roadside Council, Inc.
California Tomorrow
Candelaria American Indian Council
Center for Environmental Action
Central Coast Indian Council
Conservation Foundation
Council for Planning and Conservation
Desert Protective Council, Inc.
Ecology Center
Endangered Species Productions, Inc.
Environmental Center of San Luis Obispo County
Environmental Defense Fund, Inc.
Federation of Western Outdoor Clubs
Friends of the Earth
Goleta Valley Historical Society
Historical Society of Southern California
Izaak Walton League of America, Inc.
Kern County Historical Society
Lompoc Valley Historical Society
Native American Heritage Commission
Natural Resources Defense Council, Inc.
Pacific Coast Archaeological Society
People Action Union
Planning and Conservation League
Quabajai Chumash Association
San Luis Obispo County Historical Society
San Luis Obispo League of Women Voters
Santa Barbara Historical Society
Santa Barbara Indian Center
Santa Barbara Trust for Historic Preservation
Santa Maria Valley Historical Society
Santa Ynez Indian Reservation
Santa Ynez Valley Historical Society
The Nature Conservancy
United New Conservationists
Ventura Environmental Coalition
Wildlife Conservation Coalition, Inc.

D. National Citizens Groups:

American Conservation Association, Inc.
Conservation and Research Foundation, Inc.
Conservation Foundation
Environmental Action
Environmental Defense Fund
Iroquois Research Institute
National Association of Conservation Districts
National Audubon Society
National Resources Council of America
National Wildlife Federation
North American Wildlife Foundation
Sierra Club
The Wilderness Society
Wildlife Society

E. Private Individuals (329)

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ABBREVIATIONS AND ACRONYMS

ABS--American Bureau of Shipping
ADEC--Alaska Department of Environmental Conservation
ADFG--Alaska Department of Fish and Game
BACT--best available control technology
BOD--biological oxygen demand
Btu--British thermal unit
cfd--cubic feet per day
cfsm--cubic feet per second per square mile
cm--centimeter
CO--carbon monoxide
CO_2--carbon dioxide
Collier--Collier Carbon and Chemical Company
dBA--decibels on the A-weighted scale
DEIS--draft environmental impact statement
DO--dissolved oxygen
DOT--U.S. Department of Transportation
El Paso--El Paso Alaska Company
EPA--Environmental Protection Agency
°F--degrees Fahrenheit
FEIS--final environmental impact statement
FERC--Federal Energy Regulatory Commission
FPC--Federal Power Commission
g--gravity
GMU--game management unit
gpd--gallons per day
gpm--gallons per minute
gr/scf--grains per standard cubic foot
HC--hydrocarbons
HEA--Homer Electric Association
hp--horsepower
km--kilometer
kn--knot
kw--kilowatt
lb/hr--pounds per hour
L_{eq}--equivalent sound level
L_{dn}--day-night sound level
LFL--lower flammable limit
LNG--liquefied natural gas
loran--long range navigation
m^3--cubic meter
mg/l--milligrams per liter
mgpd--million gallons per day
ml--milliliter
MLLW--mean lower low water
MP--milepost
mph--miles per hour
MSL--mean sea level
MTL--mean tidal level
mwhr/yr.--megawatt hours per year
Nikiski--Nikiski industrial complex
nmi--nautical mile
NO_2--nitrogen dioxide
NO_x--nitrogen oxides
Northwest Alaskan--Northwest Alaskan Pipeline Company
Northwest--Northwest Pipeline Corporation
OIW--Oceanographic Institute of Washington
PA--Pacific Marine Association
Pacific Alaska--Pacific Alaska LNG Company
PG and E--Pacific Gas and Electric Company
PLM--Pacific Lighting Marine Company
PM--particulate matter
ppm--parts per million
ppt--parts per thousand
PSD--prevention of significant deterioration
psf--pounds per square foot
psi--pounds per square inch
psig--pounds per square inch, gauge
ROW--right-of-way
SHP--shaft horsepower
SoCal--Southern California Gas Company
SO_2--sulfur dioxide
SO_x--sulfur oxides
staff--environmental staff
TDS--total dissolved solids
$\mu g/m^3$--micrograms per cubic meter
Union--Union Oil Company of America
USCG--United States Coast Guard
USGS--U.S. Geological Survey
USPHS--U.S. Public Health Service
VHF--very high frequency
Western--Western LNG Terminal Company

A. DESCRIPTION OF THE PROPOSED ACTION

1. Introduction, Purpose, Location

On November 11, 1974, Pacific Alaska LNG Company 1/ (Pacific Alaska) filed an application in Docket No. CP75-140 for a certificate of public convenience and necessity authorizing the construction and operation of facilities to collect and liquefy natural gas; the transportation of liquefied natural gas (LNG) in interstate commerce; and the sale of natural gas to Pacific Gas and Electric Company (PG and E) and to Southern California Gas Company (SoCal). Natural gas would be purchased from gas fields in the Cook Inlet region of Alaska and transported through a proposed 6- through 24-inch diameter 104.5-mile pipeline network to a proposed LNG plant in the Nikiski industrial complex (Nikiski), 9 miles north of Kenai, Alaska. The proposed LNG plant would consist of two gas liquefaction trains, two 550,000-barrel LNG storage tanks, a marine terminal and other appurtenant facilities. Two 130,000-cubic meter (m^3) LNG vessels would be constructed to carry LNG by sea from Nikiski to Western LNG Terminal Company's (Western) proposed receiving terminal at Los Angeles Harbor, California, at which point LNG would be offloaded, stored, regasified, and delivered to PG and E and SoCal. PG and E and SoCal would each purchase one-half of the gas volumes. The estimated project cost for the pipeline, the Nikiski LNG plant, and the two LNG vessels would be approximately $1.2 billion.

On April 11, 1975, Pacific Alaska filed an amendment to its application requesting authorization to construct and operate an additional 12.4 miles of 10-inch diameter pipeline to transport natural gas from the Beaver Creek Gas Field located in the Kenai Peninsula of Alaska to Pacific Alaska's proposed liquefaction facility in Nikiski.

On December 8, 1975, Pacific Alaska submitted additional information indicating that portions of the liquefaction facility would be constructed as modules in the contiguous United States and then transported to Nikiski on barges. A construction dock and haul road would be constructed south of the proposed marine terminal in order to unload and deliver the modules to the plant site for assembly.

1/ By notice of amendment filed May 17, 1976, Pacific Alaska LNG Company (a subsidiary of Pacific Lighting Corporation) and Alaska California LNG Company (a subsidiary of Pacific Gas and Electric Company) would cosponsor the Pacific Alaska project as the applicants under a contemplated partnership, Pacific Alaska LNG Associates.

On March 3, 1975, Western filed, in Docket No. CP75-83-2, a supplement to its original application in Docket No. CP75-83 (filed September 17, 1974) for a certificate of public convenience and necessity requesting authorization to construct and operate an LNG receiving facility at Los Angeles Harbor, California.

On September 3, 1976, the staff of the Federal Power Commission circulated a draft environmental impact statement (DEIS) on the applicant's proposals pursuant to the requirements of the National Environmental Policy Act of 1969 and Section 2.82(b) of Title 18, Code of Federal Regulations, Chapter 1 - Federal Power Commission. The staff received comments on the DEIS and used this information in the preparation of a final environmental impact statement (FEIS).

On October 1, 1977, pursuant to the Department of Energy Organization Act, the Federal Energy Regulatory Commission was vested with most of the functions of the Federal Power Commission.

On November 15, 1977, Western filed an amendment to its application requesting authorization to construct and operate four 100 million cubic foot per day (cfd) seawater vaporizers and associated seawater pumps and secondary LNG pumps at Point Conception, California. The applicant filed the amendment because it believes that the California Natural Gas Terminal Act of 1977 would make the Los Angeles Harbor site unavailable for use as an LNG terminal site. In Docket No. CP74-160 et al., Pacific Indonesia LNG Company proposed to construct and operate an LNG receiving facility at Point Conception, California. The environmental impact of these projects is evaluated in Volume II of this DEIS.

On November 15, 1977, Pacific Alaska submitted additional information indicating that it had revised the pipeline network that was proposed in its November 11, 1974, and April 11, 1975, filings. Natural gas would now be transported from the gas fields in the Cook Inlet region through a proposed 6- through 24-inch diameter 291.6-mile pipeline network to the proposed LNG plant at Nikiski.

The November 15, 1977, amendment and supplemental filings made significant modifications to the applicant's proposals and required the staff to prepare a new DEIS for the California and Alaska proposals. Information provided in the comments on the September 3, 1976, DEIS has been used for the preparation of the subject DEIS.

The purpose of the proposed project is to purchase 431.4 million cfd of gas from a number of gas fields, including the North Fork, Anchor Point, Falls Creek, Sterling, Kenai Loop, Birch Hill, Swanson River, West Fork, Beaver Creek, Susitna Basin, Lewis River, Stump Lake, Ivan River, Beluga River, Coffee Creek, Tyonek, Nicolai Creek, McArthur River, and West Foreland Fields, located in the Cook Inlet region of south-central Alaska, and to deliver these volumes to a proposed liquefaction plant at Nikiski.1/ After losses due to liquefaction and storage, an LNG equivalent of 403.5 million cfd of gas would be loaded onto LNG vessels and transported to Western's proposed facility at Point Conception. Cargo weathering losses and LNG retained to maintain cryogenic temperatures on the return voyage would reduce the amount of LNG delivered to California to the equivalent of 400.2 million cfd. After storage and regasification, 400 million cfd of gas would be delivered for sale to markets in southern California.

Pacific Alaska has proposed a two-phase approach to the project because adequate gas supplies to support the ultimate delivery of 400 million cfd are not presently under contract. Phase I would encompass the facilities necessary to collect, liquefy, and transport 200 million cfd of gas to SoCal and PG and E. Facilities constructed under Phase II and placed in service approximately 1 year after Phase I would increase the deliverability of gas by 200 million cfd for a project total of 400 million cfd. Pacific Alaska has proposed that authorization of Phase II construction and sales be conditioned on acquiring the additional gas supplies required to support Phase II. Table 1 indicates the gas supply volumes that are expected to be produced from the Cook Inlet Gas Fields.

2. Proposed Facilities

a) Liquefaction Plant

Pacific Alaska's proposed LNG facility would occupy a 59.3-acre tract in the Nikiski industrial complex located 9 miles northwest of Kenai, Alaska, and 65 miles southwest of Anchorage, Alaska, as shown in Figure 1. The proposed site is bounded by Cook Inlet on the west, the Collier Carbon and Chemical Company plant on the north, the North Kenai Road on the east, and a forested area on the south. Figure 2 is an aerial photograph showing the location of the proposed site and construction camp.

1/ The Susitna Basin, Stump Lake, Coffee Creek, Tyonek, Kenai Loop, and Anchor Point Gas Fields are potential fields which have not been drilled and therefore their reserves are unproven. The remaining gas fields are existing fields with proven gas reserves. Both existing and potential fields are identified in the text as "gas fields."

TABLE 1

SUPPLY VOLUMES FROM NATURAL GAS FIELDS
IN COOK INLET
(million cfd)

Field		Phase I	Phase II
Birch Hill		2.7	2.7
Swanson River		-	20.5
West Fork		3.4	10.1
Beaver Creek		15.3	18.6
Sterling		13.7	27.4
Kenai Loop		6.8	6.8
Falls Creek		12.4	24.8
Anchor Point		-	13.7
North Fork		-	2.6
West Foreland		16.4	16.4
McArthur River		6.8	6.8
Nicolai Creek		6.8	6.8
Tyonek		10.3	34.3
Beluga River		90.1	103.8
Ivan River		13.7	13.7
Stump Lake		6.8	13.7
Lewis River		3.0	6.0
Coffee Creek		-	20.5
Susitna Basin		-	82.2
	Total	208.2	431.4

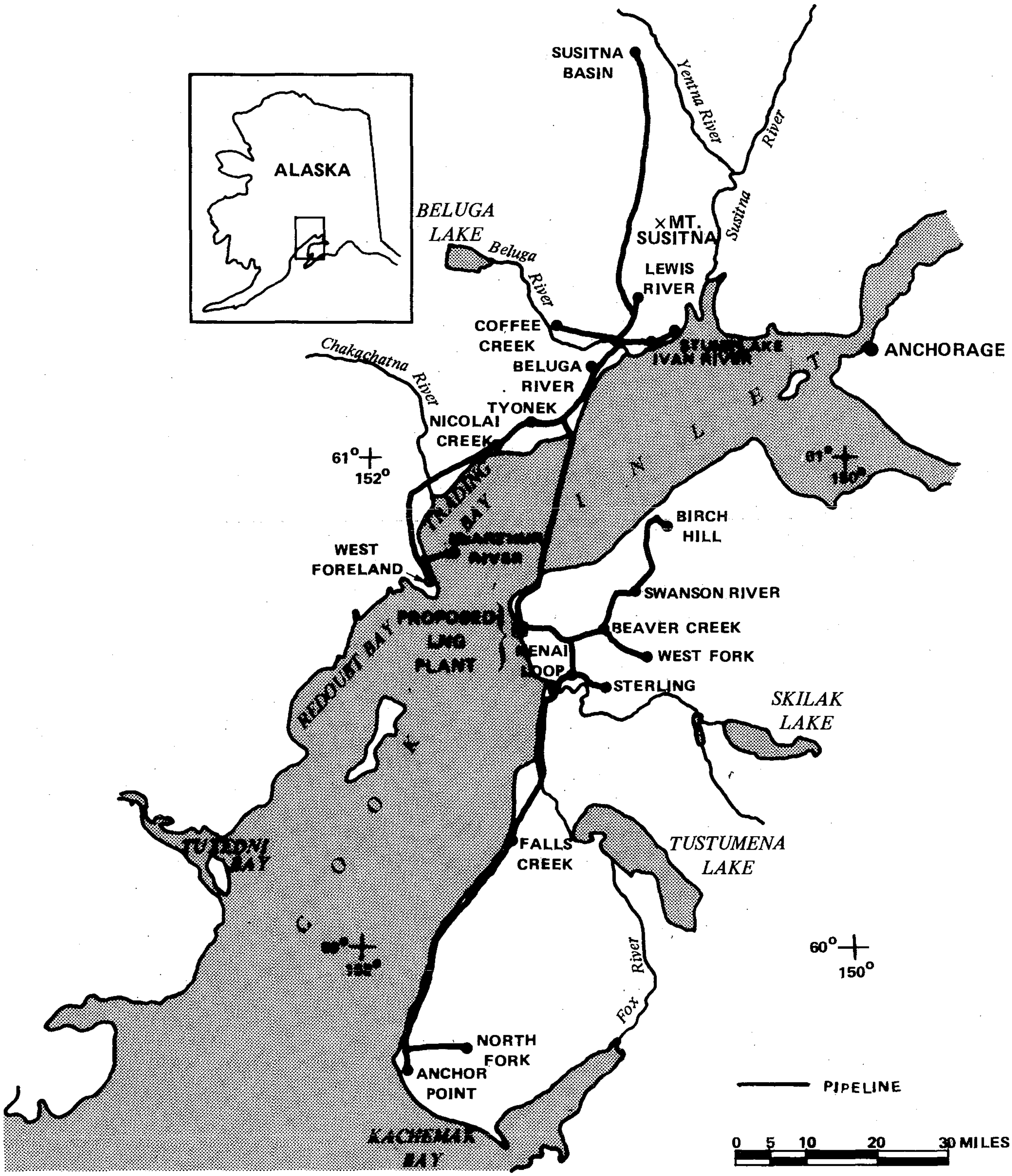


Figure 1. Location Map

Scale 11mm = 1000 ft.

A - Proposed Plant Site
B - Proposed Construction Camp

Figure 2. Aerial Photograph of the Proposed Nikiski Site
(Taken 11/17/68)

A ship berthing and loading dock would be located 2,200 feet offshore in Cook Inlet. The plot plan in Figures 3 and 4 illustrate the location of the major plant facilities. The estimated cost of the LNG plant would be $466.3 million for Phase I and $140.1 million for Phase II, for a total plant cost of $606.4 million.

The two identical liquefaction trains would each liquefy an average of about 200 million cfd of gas on an annual basis. The major components of a liquefaction train are presented in Figure 5. Before entering the liquefaction train, the incoming gas would pass through a knock-out drum and a series of filters to remove pipeline scale and dirt. The first stage of the liquefaction process would involve treating the gas in an amine bed to reduce the carbon dioxide content of the gas to about 50 parts per million (ppm). Molecular sieves would then be used to reduce the water content to less than 1 ppm. Higher concentrations of carbon dioxide and water could plug or foul equipment at cryogenic temperatures.

The liquefaction process would utilize a combined propane cascade and mixed refrigerant cycle. The dried feed gas would be compressed and air-cooled before entering the propane precooling section, at which point three stages of propane evaporation would further cool the gas. Propane vapors would be condensed in air-cooled heat exchangers.

The main cryogenic heat exchanger would be a two-stage unit using a mixed refrigerant composed of nitrogen, methane, ethylene, and propane. Between stages, the gas would be throttled to an intermediate pressure through a valve. After leaving the final stage, the liquefied gas would be throttled by another valve to further reduce the pressure.

Four gas turbine-driven centrifugal compressors having a total of 101,260 horsepower (hp) would be used in each liquefaction train for refrigerant and feed gas compression. Waste heat from the refrigeration cycle would be discharged to the atmosphere by air-cooled heat exchangers.

Nitrogen gas for purging requirements and refrigerant make-up would be liquefied by an onsite air separation unit and stored in a 238.1-barrel insulated double-walled tank. Ethylene would be purchased and stored in a 2,500-barrel double-walled cylindrical tank. Commercial grade propane would be purchased and passed through a distillation column to remove ethane and butanes, producing a propane distillate suitable for refrigerant use. Raw and refrigerant quality propane would be stored in individual 4,000-barrel spherical tanks. The four tanks of refrigerants would be installed aboveground in the areas noted in Figure 3.

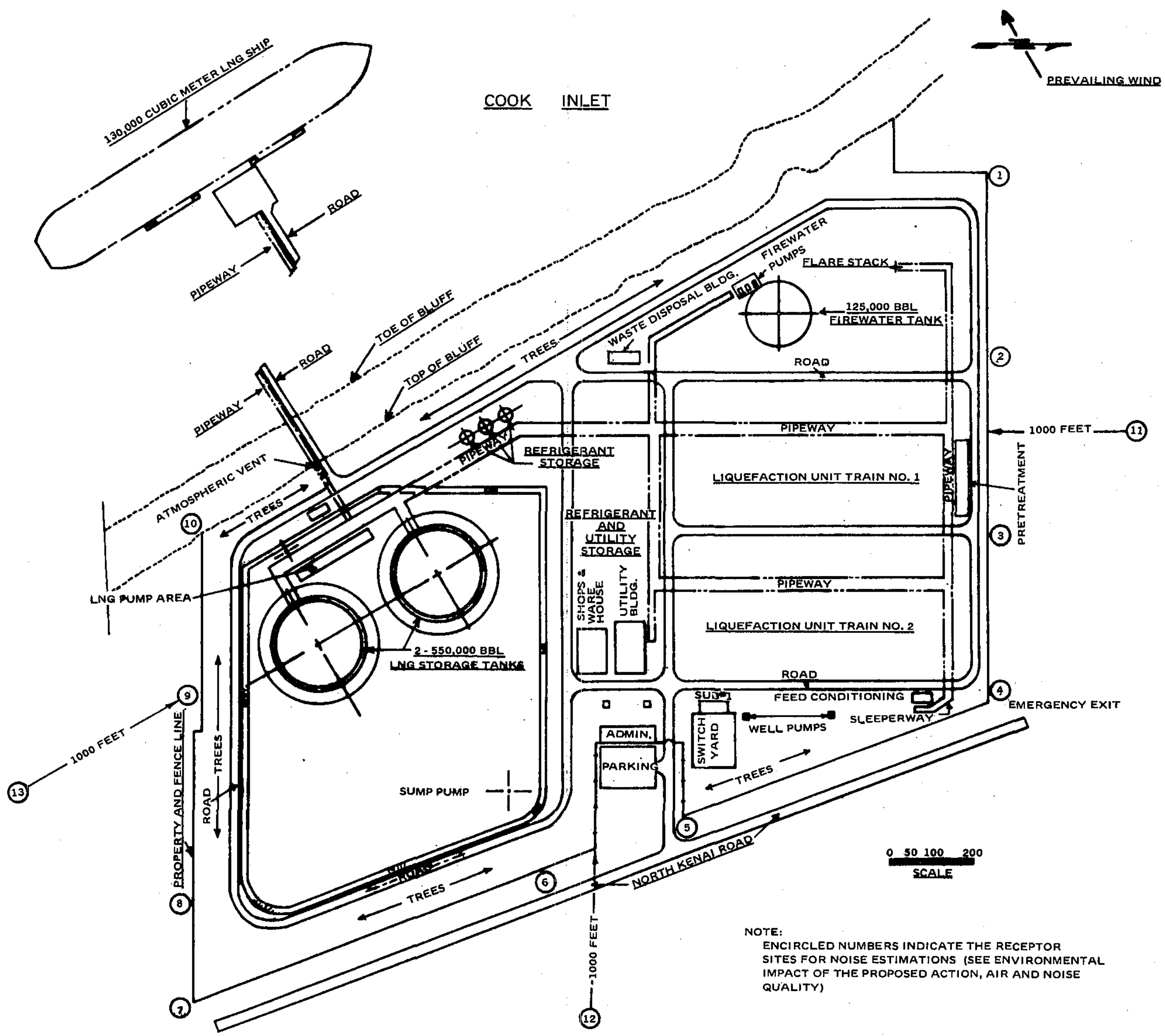


Figure 3. Proposed Nikiski Liquefaction Plant Plot Plan

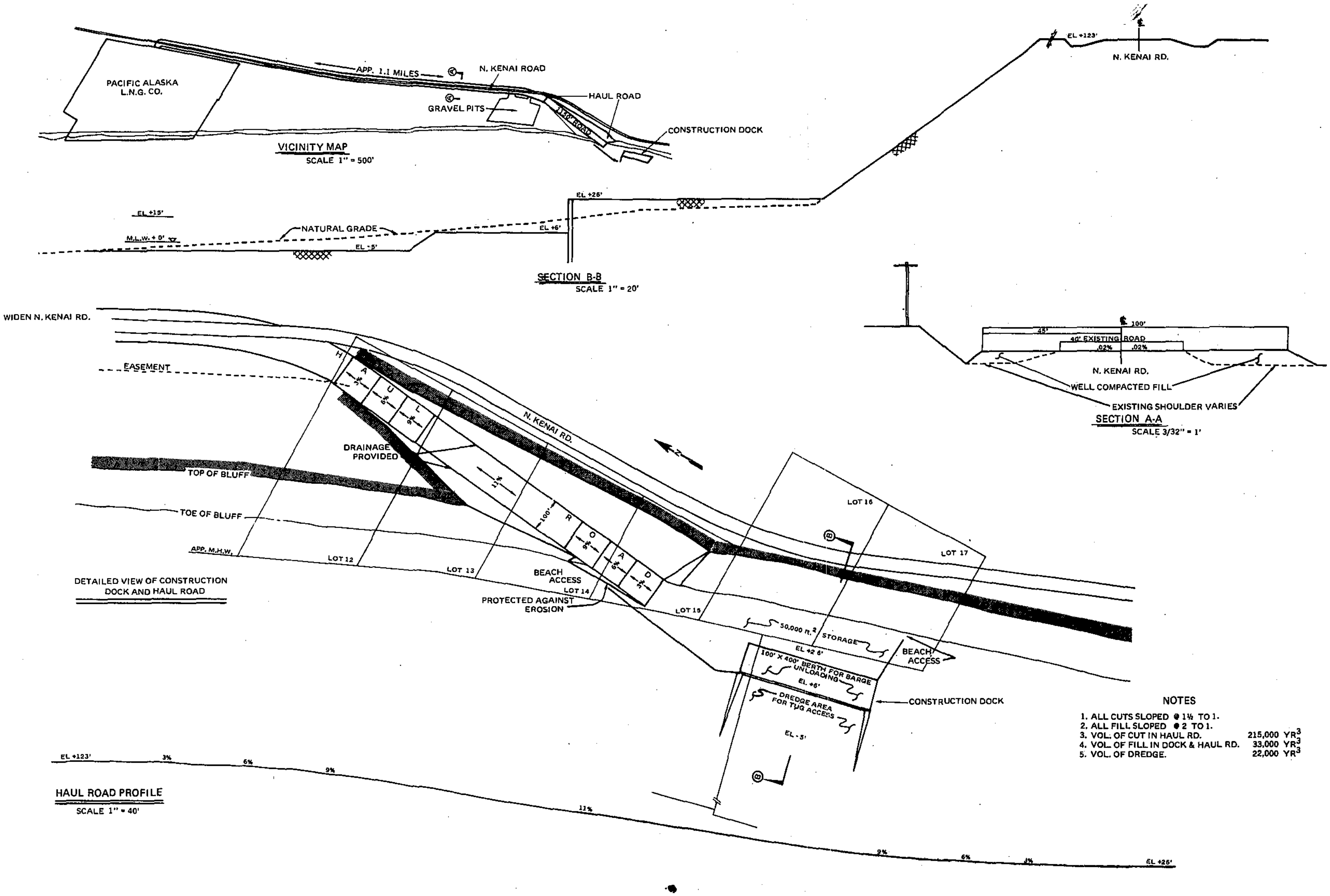


Figure 4. Proposed Construction Dock and Haul Road at Nikiski, Alaska

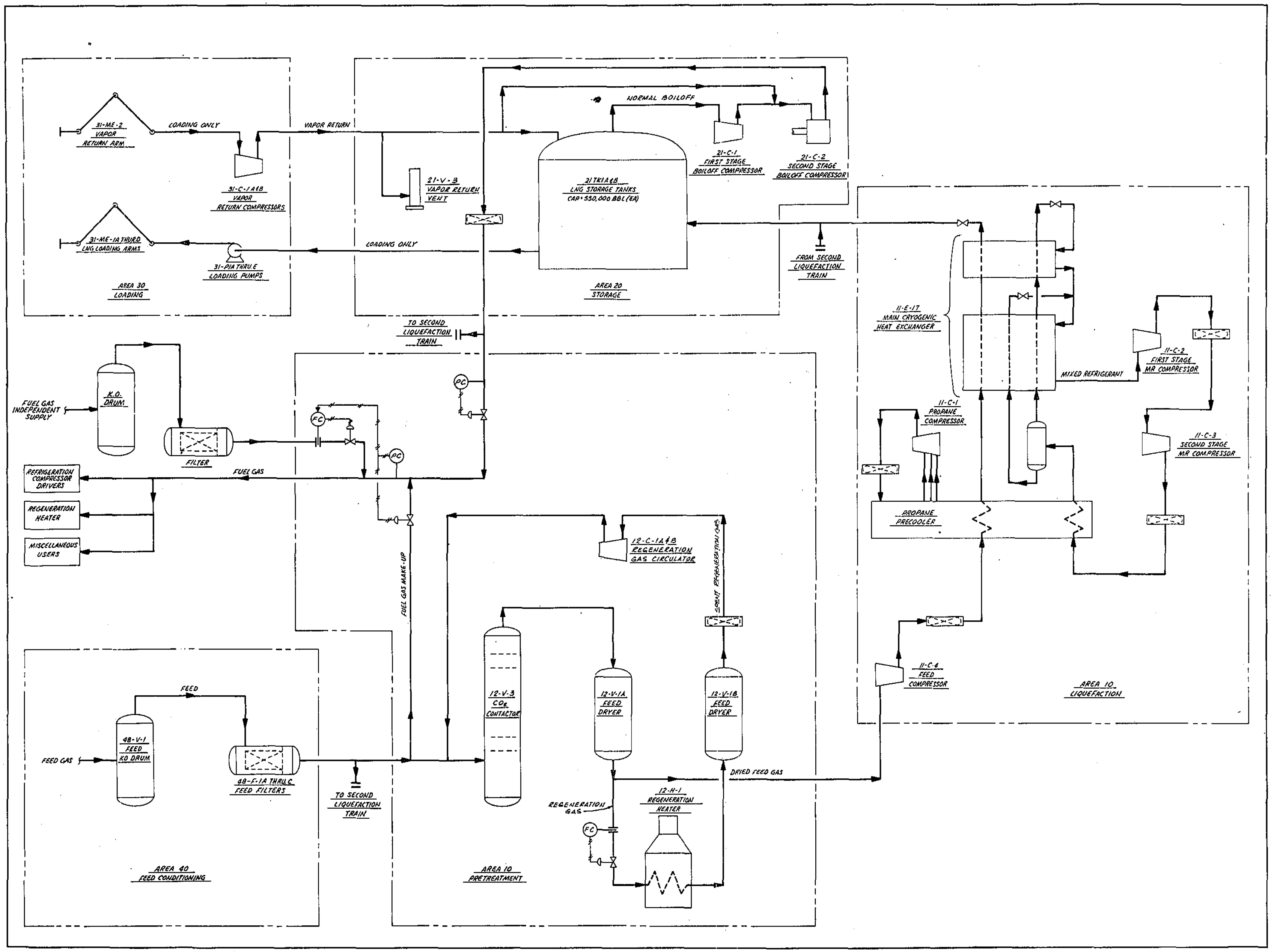


Figure 5. SIMPLIFIED PROCESS FLOW DIAGRAM PROPOSED NIKISKI LIQUEFACTION PLANT

A pressure relief system would collect and direct high pressure hydrocarbon releases for incineration and release through a 50-inch diameter 300-foot tall relief stack. Low pressure releases of methane from the LNG storage tanks would be emitted directly to the atmosphere since the design pressure is too low to discharge into the relief system. A portion of the flash gas from cargo filling operations would be vented to the atmosphere through a 14-inch diameter 75-foot tall stack at the plant site.

LNG from the liquefaction trains would be stored in two 550,000-barrel storage tanks. As shown in Figure 6, each tank would employ the cylindrical, double-wall, suspended inner deck design and would have the following approximate dimensions: diameter - 225 feet, shell height - 98 feet, and overall height - 146 feet.

The storage tanks would be designed, constructed, and tested in accordance with Title 49 CFR, Part 192, Amendment 192-10, Minimum Federal Safety Standards, Liquefied Natural Gas Systems. The inner tank wall would be constructed of 9-percent nickel steel, an alloy that retains its strength and ductility at cryogenic temperatures. The outer tank wall and domed roof would be carbon steel. The annular space between the tank walls would contain perlite, a nonflammable expanded volcanic glass insulator. A resilient fiberglass blanket separating the perlite insulation from the inner tank wall would absorb differential movements between the inner and outer tank walls which could cause compaction of the perlite. The flat bottom tank floor would be insulated with blocks of foamglass, a nonflammable load-bearing insulation. An electrically heated foundation would prevent soil freezing beneath the tank and consequent frost heaving. A layer of mineral wool insulation would be placed on the upper surface of the suspended inner roof.

Two 20-inch diameter LNG fill lines would enter each tank through the outer tank wall and pass through the suspended deck roof to separate top and bottom fill nozzles designed to provide mixing of incoming and stored LNG. LNG would be withdrawn from storage through each tank's floor by two 24-inch diameter lines connected to the suction side of the four loading pumps.

Normal boil-off gas from storage, approximately 0.05 percent per day, would be compressed and used to supplement plant fuel requirements. Each storage tank would use six combination pressure/vacuum relief valves and six pressure (only) relief valves to prevent tank damage due to either high pressure or vacuum within the tank. The valves would be activated by either 2 pounds per square inch gauge (psig) for pressure relief or 2 inches of water for vacuum relief, with a maximum pressure flow rate of 792,000 pounds per hour.

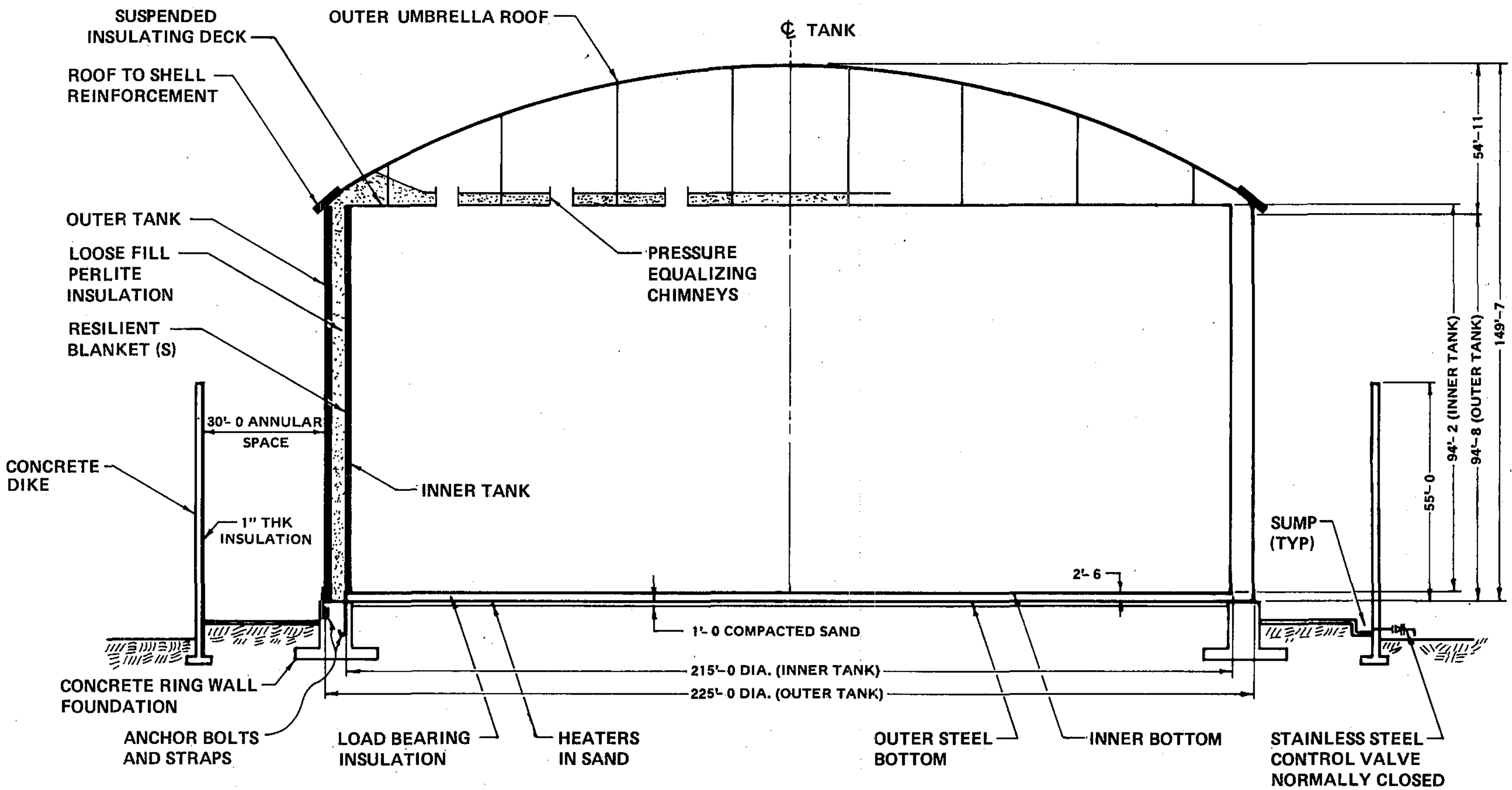


Figure 6. LNG Storage Tank Profile

The tanks would be designed to withstand instantaneous wind gusts up to 117 mph. Each storage tank would be surrounded by a concrete dike 55 feet high, 1.5 feet thick, and 285 feet in diameter. In the event of a storage tank failure, the dike could hold in excess of 620,000 barrels of LNG. The inner dike walls would be insulated to reduce the rate of vapor generation should LNG spill into the diked area.

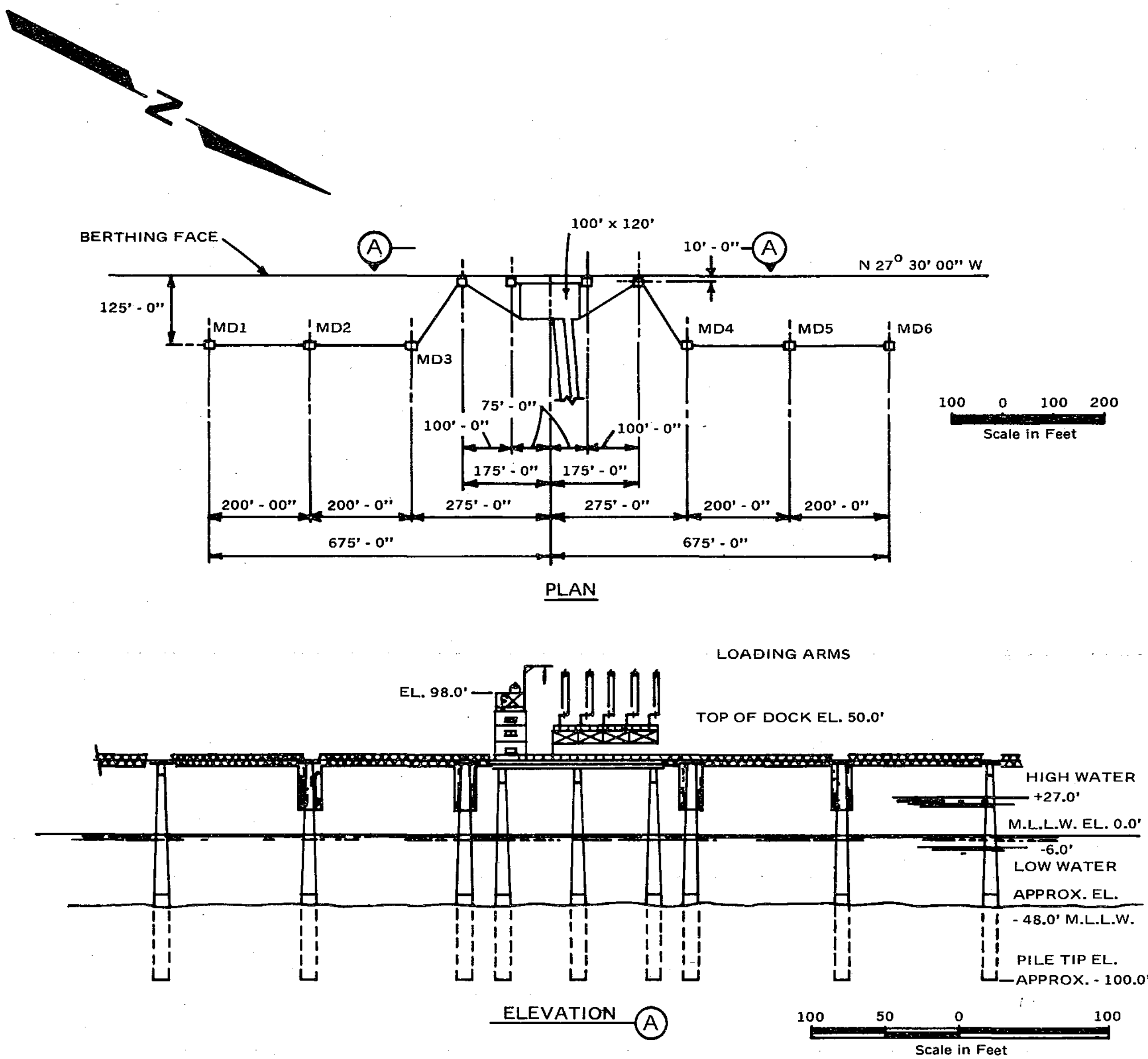
A 2,200-foot pier and trestle would support facilities used to transfer LNG from storage to the marine terminal for loading onto the LNG ships. The trestle would accommodate a 36-inch diameter insulated LNG transfer line, a 24-inch diameter insulated vapor return line, a 4-inch nitrogen purge line, a 10-inch fire-control water line, an insulated and heated sanitary waste discharge line, and a concrete roadway 12 feet wide.

A 100- by 130-foot loading platform, located at the end of the trestle, would be 50 feet above mean lower low water (MLLW) and would be located at a water depth of 48 feet below MLLW. The platform would support four 16-inch LNG loading arms, one 16-inch vapor return arm, a nitrogen surge drum, a 48-foot high control tower, and a compressor building enclosing two vapor return compressors. Six mooring dolphins and four berthing dolphins would be equipped with quick-release mooring hooks and powered capstans. Figures 7 and 8 show the planned locations of the major equipment on the proposed loading dock.

The facility's daily electrical power requirements of 6,400 kilowatts (kw) during Phase I and 10,000 kw during Phase II would be purchased from the Homer Electrical Association, Inc. A 2,500-kw engine-driven generator would be available for emergency power generation.

Fuel requirements for the refrigeration compressors, regeneration heater, and miscellaneous equipment would be 18.3 million cfd during Phase I operations and 37.1 million cfd for Phase II. Pacific Alaska has entered into an agreement with Union Oil Company of California (Union) for the purchase of 11.4 million cfd of natural gas to be used solely as plant fuel. This gas would be delivered from Union's McArthur River Gas Field by means of existing pipelines. The remaining fuel requirements would be supplied by incoming feed gas, storage tank boil-off, and flash gas from the filling of the LNG vessels.

The maximum requirement for potable water at the facility is expected to be 6,000 gallons per day (gpd). Two onsite 100- to 150-foot deep wells would provide freshwater requirements. An extended aeration waste treatment facility would process the plant's 3,000 gpd of domestic waste water prior to discharge into Cook Inlet.



DATUM: M.L.L.W. = 0.0'

PLAN AND ELEVATION OF DOCK

LEGEND:
- EL - ELEVATION
- M.L.L.W. - MEAN LOWER LOW WATER
- MD - MOORING DOLPHIN

Figure 7. Proposed Dock at Nikiski

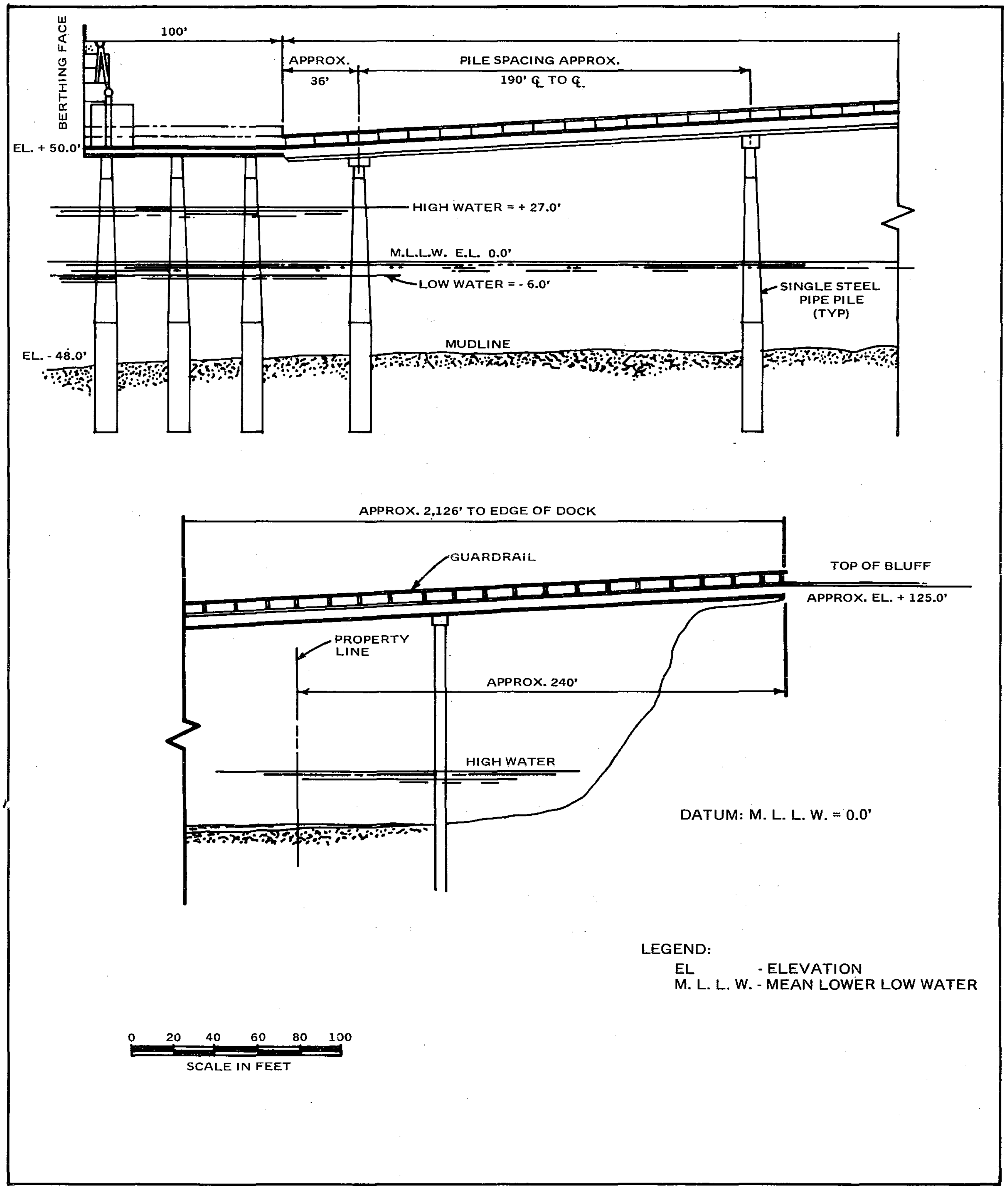


Figure 8. Proposed Trestle and Dock at Nikiski
Side View

During Phase II, the plant would generate a daily maximum of about 600 pounds of combined rubbish, refuse, and garbage, and about 60 pounds of sewage sludge from the waste treatment facility. These wastes would be incinerated at the plant site in a proposed double chamber incinerator. The proposed unit would also be capable of incinerating waste oils from the plant at a maximum rate of 20 gallons per hour.

Additional facilities at the site would include an administration building, shop and warehouse buildings, and a gatehouse. The roads and parking areas would be paved with asphalt, and the remaining ground area would be covered with gravel found at the site. The site would be bounded on the east, south, and west sides by a border of trees about 50 feet wide.

b) Pipeline

Construction of the gas pipelines connecting various gas fields in Cook Inlet to the proposed LNG facility in Nikiski would occur in two phases. The pipeline route for both project phases is shown in Figure 1.

Figure 9 identifies the diameter and length of each segment of pipeline. During Phase I, 52.0 miles of offshore and 148.9 miles of onshore pipeline would be constructed for a total of 200.9 miles of pipeline. In Phase II, 90.7 miles of onshore pipeline would be constructed resulting in a total of 291.6 miles for the proposed project.

Onshore construction and operation of the proposed pipeline from the gas fields in Cook Inlet to Nikiski would occur within a 50-foot wide right-of-way requiring approximately 1,450 acres. Additional clearing beyond the 50-foot wide right-of-way would be required for stockpiling excavated materials, pipe preparation, and access around stream crossings. The amount of acreage for these activities is not known. Pipeline costs are estimated at $167.7 million for Phase I and $32.3 million for Phase II, for a total pipeline cost of $200.0 million.

All pipeline routes would be in Class I locations. 1/ The designed maximum allowable operating pressure of the pipeline system is 1,000 psig. All diameter pipe would conform to the

---

1/ Class I locations contain 10 or less dwelling units per mile of pipeline corridor extending 220 yards on either side of the pipe centerline. Source: Title 49 CFR, Part 192, U.S. Department of Transportation, Pipeline Safety Standards, Section 192.5, Definition of Class Locations.

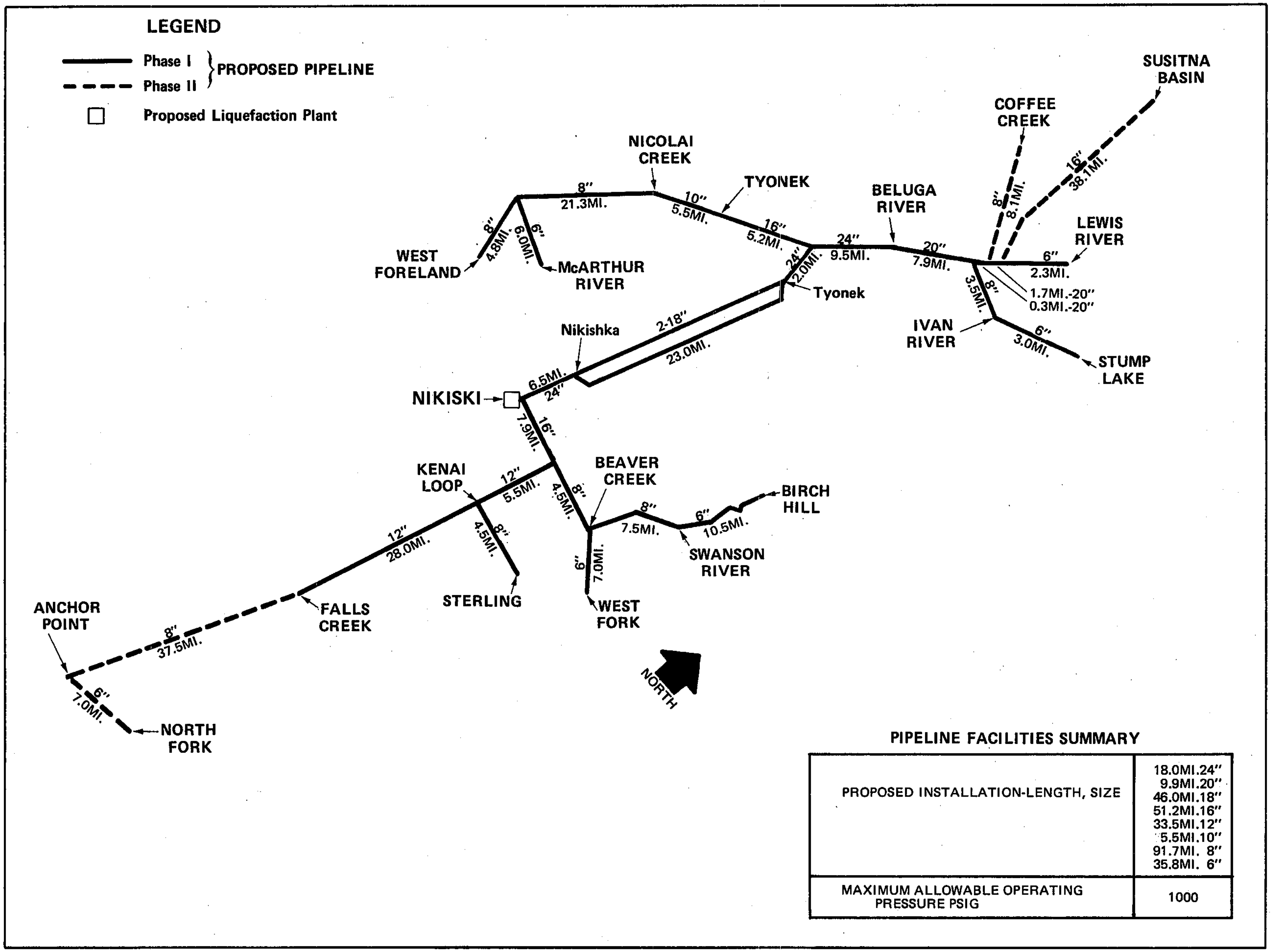


Figure 9. Proposed Pipeline Facilities

provisions of API Standard 5LX for High Test pipe. The 18-inch diameter pipelines for the Cook Inlet crossing would be coated with a 3.75-inch layer of reinforced concrete for protection and negative buoyancy. Table 2 provides the pipe grade and wall thickness of the pipeline system.

TABLE 2

PIPE SPECIFICATIONS

Location	Diameter	Grade	Wall Thickness
Onshore	24	X-65	.281
	20	X-65	.25
	16	X-52	.25
	12	X-42	.25
	10	X-42	.25
	8	X-42	.25
	6	X-42	.25
Offshore	18	X-52	.75
	6	X-52	.50

Mainline block valves would be installed on each end of the pipeline crossing Cook Inlet and at maximum intervals of 20 miles for the remaining sections. The valves would automatically close within a few minutes in the event of a major pipeline failure and seal off the ruptured portion.

c) LNG Vessels

On November 8, 1974, Pacific Alaska entered into an agreement with Pacific Lighting Marine Company (PLM) whereby PLM would supply and operate two oceangoing vessels for transporting LNG from Pacific Alaska's proposed Nikiski liquefaction plant to Western's proposed Point Conception receiving facility. On November 14, 1977, the shipping agreement was amended. Pacific Marine Associates (PA), successor to PLM, would supply, own, and operate two oceangoing vessels for transporting LNG from Pacific Alaska's proposed Nikiski liquefaction plant to Western's proposed California terminal facilities. One tanker would be required for Phase I operations, with both tankers in use during Phase II. The estimated cost for both vessels would be $393.6 million. Each ship would have a cargo capacity of 130,000 m^3 of LNG and be constructed to the specifications listed in Table 3.

Each vessel would be fitted with five membrane storage tanks of the Gaztransport/McDonnell Douglas design contained within a double-hull structure. The inner and outer hulls would be separated by a distance of 6 feet on the side, 8 feet 6 inches on the bottom, and 6 feet at the top. The inner hull structure would be insulated from the cargo by 12 inches of polyurethane foam which would act as the membrane support medium and fully redundant secondary cryogenic containment system.

The rate of boil-off from the tanks would be less than 0.14 percent of the cargo capacity per day. While at sea, the boil-off gas would not be vented to the atmosphere but instead would be consumed in the main boilers as a supplement to the Bunker-C fuel oil. In port during cargo transfer operations, boil-off gas would be burned in the ships' boilers, and the excess vapor produced would be sent to the shore facilities. If steam demand were low, the excess steam produced by burning the boil-off gas would be condensed in the auxiliary and two main condensors, with the waste heat dissipated into the harbor waters. Under emergency conditions, boil-off gas could be vented directly to the atmosphere.

Two water-tube boilers, fired by Bunker-C fuel oil and supplemented by natural gas, would have a total steam output of 169,300 pounds per hour at 955°F to supply steam for the two 30,000-hp propulsion turbines. A 3,000-hp reversible bow thruster would provide additional low-speed maneuverability. Three 2,500-kw steam turbine-driven generators would provide the ship's electric power needs. A 300-kw diesel-driven generator would be available for emergency power generation.

Navigational equipment would include two radar units, a collision avoidance system, an automatic gyrocompass system, loran (to assist in determining the ship's position), a radio direction finder, depth sounders, and a satellite navigation system. Communication equipment would include a radio telegraph system, a VHF radio telephone, an emergency position-indicating radio beacon, and a 40-station dial telephone system for communications within the ship.

TABLE 3

PRINCIPAL CHARACTERISTICS OF THE 130,000-m^3 LNG VESSEL

Length, overall	960 feet
Length, between perpendiculars	902 feet
Beam	136 feet
Depth	94 feet
Design draft	38 feet 3 inches
Total displacement	95,600 tons
Cargo deadweight	57,310 tons
Fuel	6,385 tons
Number of propellers	2
Shaft horsepower (SHP), normal	24,000 each
Shaft horsepower, maximum	30,000 each
Service speed (@ design draft)	20 knots
Cruising range (@ 100,000 SHP, fuel oil only)	13,000 nautical miles
Bow thruster horsepower	3,000
LNG cargo tank capacity (100% @ -260°F)	130,000 cubic meters
Number of cargo tanks	5
Cargo boil-off rate	0.14 percent per day
Number of cargo pumps	10
Cargo pump capacity (gallons per minute)	6,200 each
Crew	28

Fire detecting and extinguishing equipment would be located throughout the vessels. The fire detection system, which would include ionization, ultraviolet, heat-rise, and smoke detectors, would activate alarms and pinpoint the location of a fire on display boards located in the engine control room, the wheelhouse, and the cargo control room. The fire protection system would include chemical dry powder units using compressed nitrogen gas as a propellant, carbon dioxide units, fixed foam systems, and a saltwater firemain throughout the ship. Three 1,000-gallon per minute (gpm) pumps could supply numerous hydrants, fog applicators, swivel gun-type fire monitors, and cooling water sprays with saltwater.

3. Construction Procedures

a) Liquefaction Plant

The applicant has proposed to fabricate substantial portions of the liquefaction plant in the contiguous United States and to deliver these modular components to the Nikiski site on barges towed by tugboats. This procedure would allow fabrication to occur in a controlled working environment which would permit higher levels of quality control. Additionally, manpower requirements would be reduced in the project area. The major items to be constructed as modules are listed in Table 4.

Module fabrication would probably occur in Seattle, Washington, an area with a well-developed industrial base. Fabrication would require approximately 577 man-years of labor over a 3-year period, with a peak labor force requirement of 475 men.

A fleet of four barges, each 100 feet wide by 400 feet long, would be used to transport modules and miscellaneous supplies from Seattle to Nikiski. A round trip would require about 5 to 6 weeks. It is estimated that 25 trips would be made in the first year (April through October), 20 in the second year (April through October) and 5 in the third year (April and May).

A construction dock and a haul road would be required to unload and transport the modules and other materials to the site. A 100-foot by 400-foot berth and construction dock would be located south of the plant site, as shown in Figure 4. The berthing face of the construction dock would be about 80 feet from the toe of the bluff at an elevation of 26 feet above MLLW. About 22,000 cubic yards of material would be dredged in front of the dock to accommodate the barges. The dredged material could be used to partially supply the construction dock and haul road fill requirements (33,000 cubic yards) or, if unsuitable for that purpose, would be disposed of in Cook Inlet. Construction of the

TABLE 4

MODULE CONSTRUCTION FOR LIQUEFACTION PLANT

Item	Number of Modules
Pipeway	26
Refrigerant Equipment	1
Vapor Return Equipment	1
Loading Dock	2
Loading Dock Trestle	12
Building Modules	11
Power Distribution Buildings	5
Electrical Substations	5
Refrigerant Propane Storage Tank	1
Raw Propane Storage Tank	1
Propane Condenser	2

dock would require 3 to 4 months. After construction of the LNG plant, the temporary dock would be removed and the shoreline restored to natural conditions.

The construction of a 100-foot wide haul road having a 3- to 11-percent incline from the proposed construction dock to the plant site would require the excavation of approximately 215,000 cubic yards of material. In addition, a segment of North Kenai road, about 1.1 miles long, would be widened from 40 feet to 100 feet.

Construction and module installation at the Nikiski site would occur during a 48-month period from April 1979 through January 1983, as shown in the construction schedule in Figure 10. This construction would require a peak labor force of 800 men during the second summer construction season. Housing would be provided for nonresident workers in a temporary construction camp to be located on a 10-acre parcel directly across North Kenai Road from the plant site, as shown in Figure 2. Ten-acre pipeline construction camps would also be located at Nikiski, McArthur River, Ivan River, and Falls Creek for work on the pipelines. Pipe storage yards and staging areas for pipeline construction would be established at Tyonek and Nikiski.

Grading of the proposed LNG facility would not be extensive, since the site is relatively flat. Materials excavated beneath structure foundations would be used as backfill or be regraded on the site.

The dredging of approximately 70,000 cubic yards of material from Cook Inlet would be required to deepen the southern approach to the dock facility. This material would be disposed of in the deeper waters of Cook Inlet. Underwater blasting, if necessary to remove large amounts of rock, would be conducted after obtaining the required permits from the Alaska Department of Fish and Game.

Plant construction would require the following materials: 2,000 tons of nickel steel plate, 3,000 tons of carbon steel plate, 70,000 cubic yards of concrete, and other miscellaneous materials.

Both 550,000-barrel LNG storage tanks would be tested prior to use. Inner tank welds would be checked by a combination of x-ray, dye penetrant, vacuum box, and solution film test methods. Hydrostatic and pressure tests would subject each tank to 125 percent of the maximum product weight and 125 percent of the maximum design vapor pressure. The hydrostatic tests would utilize 14 to 15 million gallons of well water for each tank. After completion of the tests, the water would be released into Cook Inlet.

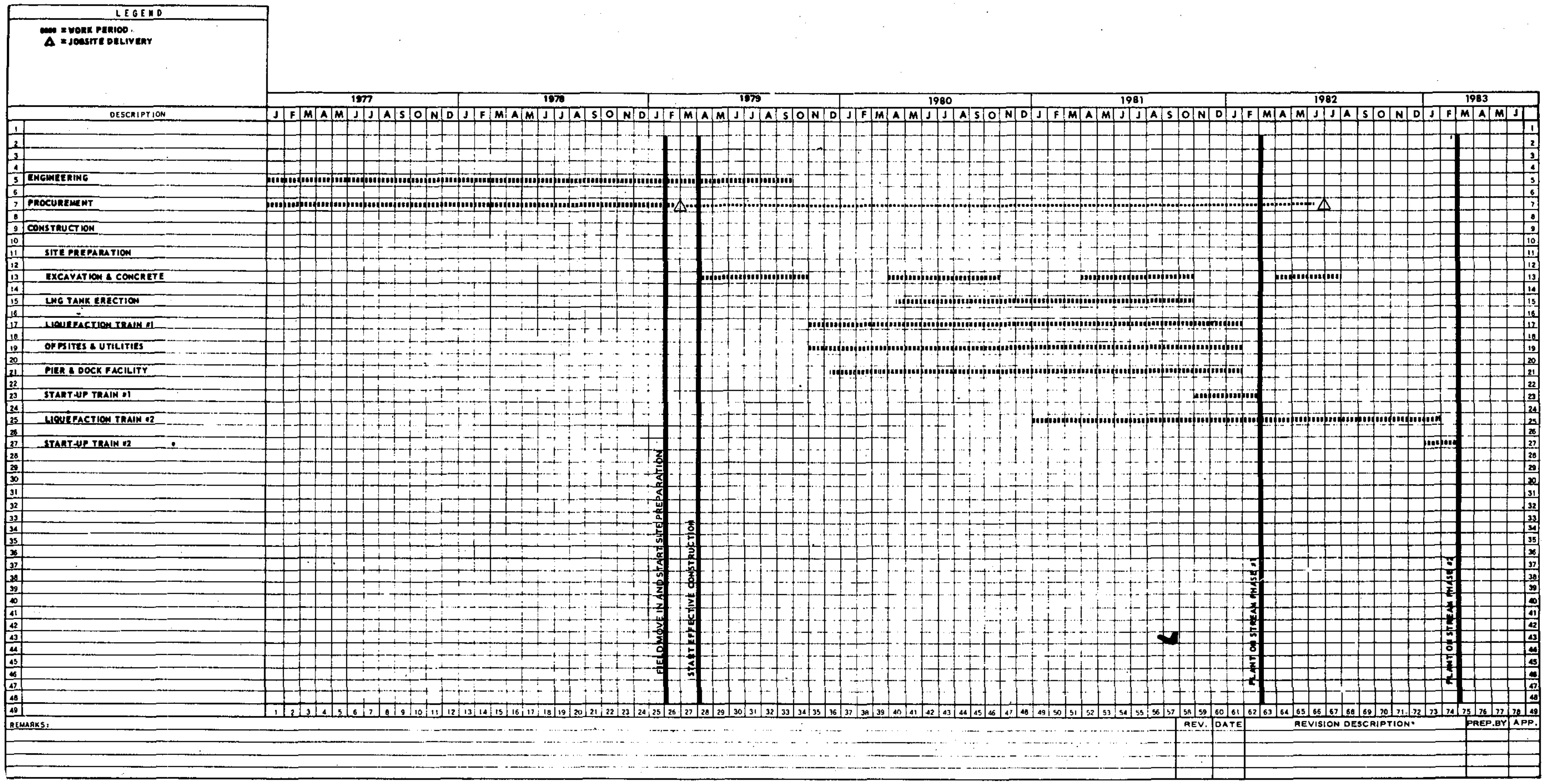


Figure 10

Proposed Project Schedule For 400 Million Scfd Liquefaction Plant at Nikiski

b) Pipeline

The proposed pipeline would traverse numerous areas containing peat, a highly compressible material composed of organic matter and water which, except when frozen, has little support strength. A special construction technique would be required to minimize the impact on these sensitive areas and to provide adequate support for construction equipment. Construction would begin in early winter by removing the snow cover on both sides of the right-of-way and forming a snow berm in the center where the pipeline trench would be excavated. The areas cleared of snow would develop a thicker layer of frost to provide increased support for heavy construction equipment, while the insulating effect of the snow berm would reduce the depth of frost penetration to facilitate trench excavation. Ditching operations would immediately follow the removal of the snow berm. The pipeline would be assembled on the frozen sides adjacent to the trench, lowered in place, and then covered with material excavated from the trench. The minimum depth of cover over the pipeline would be 3 feet.

The applicant has stated that pipeline crossings of rivers would be made in winter by first pumping water over river ice to increase the ice thickness to 2 or 3 feet in order to create a pad to support equipment. The trench would then be excavated in the river bottom through a slot in the ice. The pipe would then be emplaced directly through the slot, and have a minimum cover of 5 feet or as required by government regulations. Normal streamflow transported sediments usually backfill the excavation in the stream.

The pipelines would be hydrostatically tested to pressures required by the Office of Pipeline Safety Operation's regulations. Test water would be withdrawn from local freshwater rivers and streams and returned after the completion of the tests.

Pipeline construction would require the following materials: 40,600 tons of steel pipe, 42,000 tons of concrete, 2,800 tons of steel valves and fittings, and 1,600 tons of miscellaneous materials.

c) LNG Vessels

The LNG vessels would be constructed at the Sun Shipbuilding and Dry Dock Company in Chester, Pennsylvania. Each vessel would require a total of 35,000 tons of material, the major portion being steel. About 200 tons of 36-percent nickel steel (Invar) would be used for constructing the cargo containment system.

4. Operation, Maintenance, and Emergency Procedures

The proposed gas pipeline network would deliver an average volume of 431.4 million cfd of natural gas to the proposed Nikiski liquefaction plant during Phase II operations. An additional 11.4 million cfd of natural gas would be delivered to the plant by Union for fuel usage. Of these volumes, approximately 37.1 million cfd would be utilized for plant fuel requirements. Of the 442.8 million cfd of gas received by the plant, 409.3 million cfd would be liquefied into 18,400 m^3 of LNG 1/ each day and sent to storage. Allowing for storage tank losses through boil-off, estimated to be 135 m^3 of LNG per day, about 4.8 days would be required to fill one of the two 550,000-barrel (87,500 m^3) storage tanks.

With both 130,000-m^3 LNG tankers operational, about 52 arrivals annually would be made at Nikiski. The contents of about 1.45 storage tanks would be loaded onto a tanker at an average rate of 13,000 m^3 per hour. A portion of the flash gas generated during ship loading would be returned to the plant. The remainder, 2.2 million cfd, would be vented to the atmosphere through a 14-inch diameter 75-foot tall stack located at the plant. Approximately 10 to 12 hours would be required to complete the loading operations, during which time about 20,000 gpm of ballast water would be discharged into Cook Inlet. About 7 days would be required to refill the storage tanks.

The round trip between Nikiski and Point Conception would require approximately 12 days. Vessel densities in Cook Inlet are rather low compared to other U.S. waterways, and mandatory shipping lanes have not been established. However, vessels are required to have a licensed pilot on board. Pilots come aboard and leave at Anchor Point, which is near Homer, Alaska. Standard navigation aids pinpoint dangerous areas, and lighted offshore oil drilling platforms serve as reference points for nighttime navigation.

From the mouth of Cook Inlet, the ships would proceed on a heading of 141° and pass through the Gulf of Alaska and the northeastern Pacific Ocean enroute to the California coastline. This portion of the route has no established shipping lanes. At Point Conception, California, the ships would dock and offload their cargo. An average volume of LNG equivalent to 400.2 million cfd of natural gas would be delivered to Western's proposed receiving facility. A small amount of LNG would be left in the

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1/ Assuming 630 cubic feet of gas at standard temperature (60°F) and pressure (14.696 psig) equals the volume of 1 cubic foot of LNG at the boiling point (-260°F).

ship's cargo tanks to maintain cryogenic temperatures on its return voyage.

The Nikiski liquefaction plant has been designed to operate 345 days per year and would require a full-time staff of about 60 persons. Twenty days per year would be available for performing routine scheduled maintenance and unscheduled downtime. A periodic preventative maintenance program would be in effect for all plant equipment. Most of the baseload equipment would consist of multiple units installed for parallel operation to enable the inspection or maintenance of individual units while the other units remained in operation. Essential equipment not consisting of multiple units would have spare, standby units available. Intermittently-operated equipment associated with LNG ship loading and transfer could be maintained between scheduled periods of operation.

Fire detection and extinguishing equipment would be installed throughout the plant and marine facilities. Gas sensors, ultra-violet sensors, high temperature, and rate of temperature rise sensors would indicate the presence of potentially combustible mixtures or fires. Low temperature sensors would be located in the pump area, in the insulation of the LNG storage tanks, and at other locations where leaks could occur.

The fire protection system would include manual and automatic dry-chemical extinguishers, a firetruck, a dry-chemical firetruck, a fire-control water system and a seawater backup fire water system. A 125,000-barrel heated freshwater tank would supply a 12-inch diameter mainline surrounding the plant and a 10-inch diameter water line to the dock area. Three 2,500-gpm pumps, two operating and one spare, would supply fire-control water to numerous hydrants and water deluge systems in the plant. A 35,000-gpm diesel engine-driven pump would be at the dock to pump saltwater to the land-based fire control water system.

LNG pipelines would be equipped with emergency block and check valves designed to automatically close in the event of a pipeline leak or rupture. An emergency shutdown system at the loading dock would sequentially shut down pumps and transfer lines under abnormal conditions.

A work force of 40 persons would operate and maintain the entire pipeline system. The onshore pipeline routes would be inspected monthly by fixed-wing aircraft for evidence of damage to the pipeline. Pipeline river crossings would be inspected during the first period of high waterflow after construction and thereafter at any time that abnormally high river flows or other hazardous conditions exist. The offshore pipelines crossings would be inspected during the first summer following their installation. Areas of maximum scour would be reinspected at less than 1-year intervals.

5. Future Plans and Abandonment

The proposed facility is projected to have a 20-year economic life; however, the supply of gas is the major factor affecting the operational life. Should additional gas supplies become available, the planned use and life of the facilities could be extended; however, additional gas pipelines may be required. There are no plans at this time to increase the liquefaction plant's capacity beyond approximately 400 million cfd.

Upon completion of the construction phase of the proposed liquefaction plant, the haul road could provide access to the beach for recreational or commercial purposes. The construction dock would be removed and the shoreline would be restored to natural conditions.

Upon project termination, the liquefaction plant facilities could be dismantled and the site would be either devoted to other industrial uses or graded to natural contours and reforested. The gas pipelines would probably be abandoned in place and the above-ground facilities dismantled, allowing the right-of-way to return to its prior use.

B. DESCRIPTION OF THE EXISTING ENVIRONMENT

1. Climate

The Cook Inlet Basin is in a transitional climate zone between the maritime influence of the Gulf of Alaska and the continental influences of interior Alaska. The Kenai-Chugach Mountain Range to the southeast of Cook Inlet extends through the Kenai Peninsula, forming a barrier to the relatively warm moist air masses in the gulf. Southeasterly winds from the gulf force the moisture-laden air directly over the mountains where lifting causes a cooling of the air mass and subsequent condensation and precipitation as either rain or snow. The result is that annual precipitation levels of 60 to 100 inches on the gulf side of the mountains are reduced to 15 to 30 inches on the basin side.

The Alaskan Mountain Range to the west and north of Cook Inlet forms a barrier to the large temperature variations and semi-arid climate of the Alaskan continental interior. During winter months, cold high-pressure systems can cause temperatures of -50°F to -60°F over the interior region. However, the mountain range reduces the severity of the climate in the basin, where temperatures may reach only -15°F to -25°F.

The four seasons are distinct in the project area. Winter prevails from mid-October to mid-April and is characterized by the freezeup of the lakes and streams. Ice also forms in Cook Inlet north of the Forelands; however, the strong current and tidal fluctuations prevent large ice sheets from forming. During this period, cold, clear weather alternates with cloudy, milder conditions. Spring is the period immediately following the ice breakup and is characterized by warm pleasant days and chilly nights. Summer is, in fact, two seasons of approximately equal length, extending from June through early September. The first part of summer is very dry (until mid-July); the second is very wet, accounting for about 40 percent of the region's annual precipitation. Autumn occurs from mid-September to mid-October. In Anchorage, the growing season averages 124 days, and the mean daily temperature exceeds 32°F from about April 8 through October 23. The maximum length of daily sunlight ranges from up to 19.5 hours in summer to 5.5 hours at midwinter. 1/

1/ National Oceanic and Atmospheric Administration, Local Climatological Data Annual Summary, Anchorage, Alaska 1972, U.S. Department of Commerce.

Annual temperature variations within the basin are shown in Figure 11, which illustrates mean monthly temperatures for three weather stations--Homer, Kenai, and Anchorage. Both Kenai and Homer are located on the inlet's eastern coast. The temperature range is less at Homer than at the other locations. Temperature profiles for the western coast are not available. However, a summary of temperature, precipitation, and snowfall data at Tyonek for the period 1899 to 1907 can be found in Appendix A, Figures A-1 and A-2.

The closest weather station in the vicinity of the project area is located at Kenai Municipal Airport, approximately 8 miles south of Nikiski. Temperatures at Kenai are characteristic of the basin's middle coastal region where there are prevailing strong northerly winds. More detailed data of mean and extreme monthly temperature ranges for Kenai may be found in Appendix A, Table A-1.

Precipitation levels in the basin generally decrease from the mouth of the inlet to its head. Average annual precipitation ranges from 27.85 inches at Homer to 19.9 inches at Kenai and 14.7 inches at Anchorage. Precipitation is fairly constant throughout the year, with the exception of the late summer and autumn when the highest monthly precipitation occurs. Figure 12 illustrates the mean monthly precipitation levels for the three stations.

Snowfall accounts for about half of the total precipitation and is reported on 25 percent of winter days, although most occurs in relatively small daily amounts. Annual average snowfall in the basin ranges from about 60 to 100 inches, with Homer recording an annual average of 101.5 inches. Snowfall at Kenai averages 68.7 inches annually. Appendix A, Table A-1, presents average monthly levels of total precipitation and snowfall for Kenai.

The prevailing wind direction in the project area is from the north and northeast for 9 months of the year. During the summer the prevailing wind shifts to the south-southwest. Hourly wind speeds average 6 to 7 knots throughout most of the year. The maximum hourly wind speed ever recorded at Kenai was 47 knots. However, individual wind gusts can be much stronger. Storm systems, occurring almost every winter, cause high wind gusts of up 50 to 75 knots and frequently reach 75 to 100 knots over open bodies of water. In the late summer or fall, strong southerly post-frontal winds follow the movement of storms from the southern Bering Sea or Bristol Bay, northeastward across the Alaskan interior. Portions of Cook Inlet located near the northwestern slopes of the Chugach Mountains occasionally experience the southeasterly "Chugach" winds with gusts estimated at 70 to 90 knots. Average monthly wind speeds and directions at Kenai

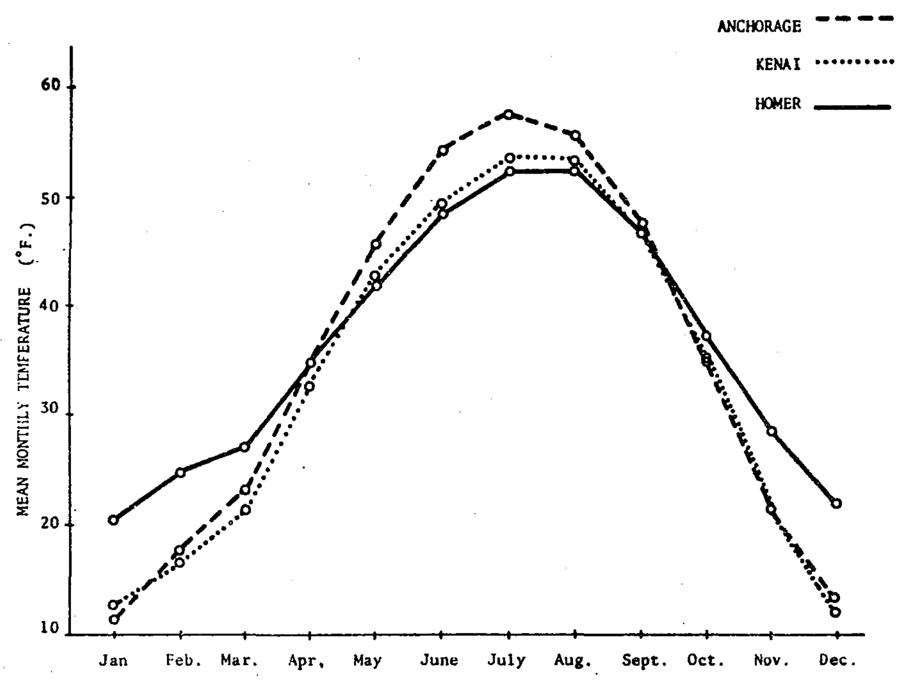

Figure 11- Mean Monthly Temperatures 1/

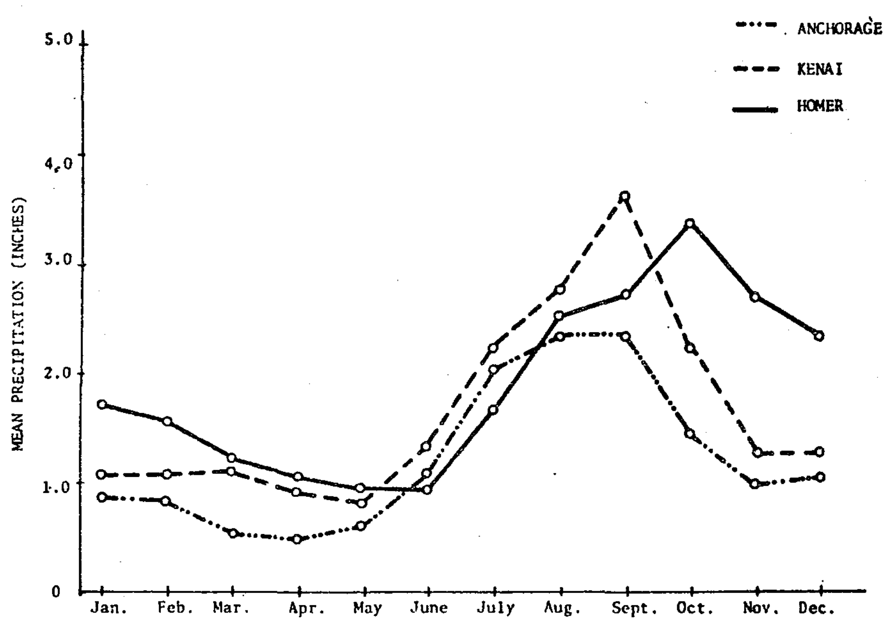

Figure 12 - Mean Monthly Precipitation 1/

1/ Source: Final Environmental Impact Statement, Offshore Oil and Gas Development in Cook Inlet, Alaska; Alaska District, Corps of Engineers, Anchorage, Alaska, September 1974 may be found in Appendix A, Table A-1, while more detailed annual wind speed and direction data may be found in Appendix A, Table A-2.

The combination of cold weather and low level ground moisture causes heavy fog in the northern portion of the inlet during the winter months. Fewer occurrences of fog are found in the middle and lower regions of Cook Inlet. Kenai reports visibility less than one-quarter mile and/or a ceiling less than 100 feet an average of only 0.2 percent annually. Individual monthly frequencies of visibility reduction may be found in Appendix A, Table A-1.

The climatology of a region has a major role in determining the way pollutants disperse in the atmosphere. The Pasquil Stability Classification is commonly used to categorize an atmosphere's ability to disperse pollutants both vertically and horizontally. Based on net radiation and ground level wind speed, the local atmosphere's dispersion potential is categorized in one of six classes ranging from Class A, highly unstable and permitting excellent plume dispersal, to Class F, highly stable and poor for plume dispersal.

Table 5 presents the relative frequency of stability Classes A through E 1/ at Kenai based on eight daily observations for the period January 1966 through December 1970. Stable conditions, Class E, occur 27.3 percent of the time annually. Class D, neutral stability, occurs 62 percent of the time. The winter months have the highest frequency of stable conditions, since the short days and low solar altitude reduce net solar radiation and the associated atomospheric turbulence to a minimum. Conversely, the most favorable conditions for dispersal occur in the summer.

1/ The frequency of occurrence of Class F stability is rare except in more isolated rural areas. In this particular study, the frequency of Class E includes both E and F stability data.

TABLE 5

RELATIVE FREQUENCY OF PASQUIL STABILITY CLASSES
(Kenai, Alaska)

Season	Stability Class (percent occurrence)				
	A	B	C	D	E
Dec., Jan., Feb.	0	.3	3.8	56.4	39.4
Mar., Apr., May	0	1.7	12.0	62.6	23.6
June, July, Aug.	0	2.0	15.0	69.1	13.9
Sept., Oct., Nov.	0	0.8	6.9	59.7	32.6
Annual	0	1.2	9.5	62.0	27.3

Class A - Extremely unstable

Class B - Unstable

Class C - Slightly unstable

Class D - Neutral

Class E - Slightly stable

Source: "Seasonal and Annual Wind Distribution by Pasquil Stability Classes(s) Star Program," National Climatic Center, Asheville, N.C., Oct. 19, 1972.

2. Topography

The proposed Nikiski LNG terminal site is located in the Cook Inlet-Susitna Lowland, a physiographic subprovince of the Pacific Mountain System which extends from the Aleutian Islands through coastal Canada and California. As shown on Figure 13, this lowland is bordered by the Kodiak-Kenai-Chugach Mountains on the south and east, the Aleutian-Alaska Range on the west and north, and the Talkeetna Mountains on the northeast.

The lowland may be subdivided into four units. The Kenai Lowland is located on the east side of the inlet. The proposed plant site and pipelines on the Kenai Peninsula would be located within this unit. On the northern end of the inlet, from west to east, are the Kustatan Lowland, the Susitna Lowland, and the Lower Matanuska Lowland. The proposed pipeline routes pass through all but the Lower Matanuska Lowland.

The Kenai Lowland is comprised of a broad, low shelf of some 3,600 square miles. Most of the land surface is less than 400 feet above sea level, and relief is generally low. The topography is typical of recently glaciated regions with poor drainage, bogs and swamps, and a hummocky land surface developed on morainal material.

The land surface of the proposed site slopes slightly to the south and west at an elevation of approximately 120 feet above mean sea level (MSL). Bordering the site on the west is a 100-foot high bluff which slopes at about 40^{o} to a shingle beach.

Off the beach, the submarine topography slopes fairly uniformly at a ratio of about 1 foot vertical to 50 feet horizontal. Pockets and ridges do occur off the southern end of the proposed trestle site. The -45 foot contour (mean lower low water) occurs about 2,000 feet offshore. See Figure 14 for more detailed bathymetry.

The proposed pipeline routes connecting the Birch Creek, Swanson River, West Fork, and Beaver Creek Fields to the Nikiski site cross the hummocky morainal topography of the Kenai Lowland. Relief, the difference in elevation between highest and lowest points, on these routes is 300 feet or less. Between Nikiski and the Cook Inlet crossing at Nikiski Bay, the relief is about 200 feet, most of this occurring at the bluff overlooking the inlet.

Maximum slope on the Nikishka Bay route is about 1:1, since the pipeline must scale the sea bluff. But on top of the shelf, the maximum slope is on the order of 100 feet per mile.

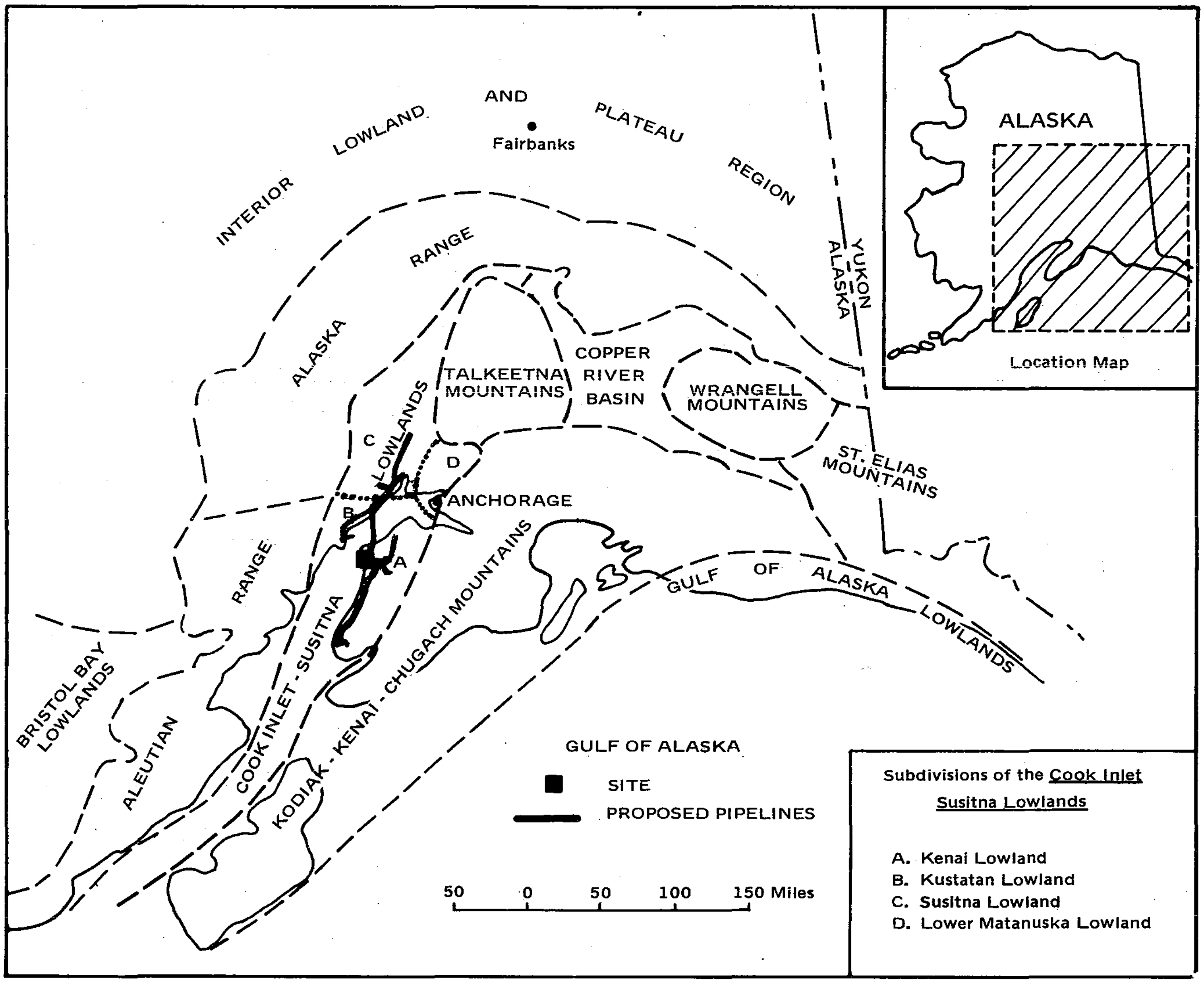

Figure 13. Sketch Map of Major Physiographic Provinces of South-Central Alaska

Source: Karlstrom, 1964

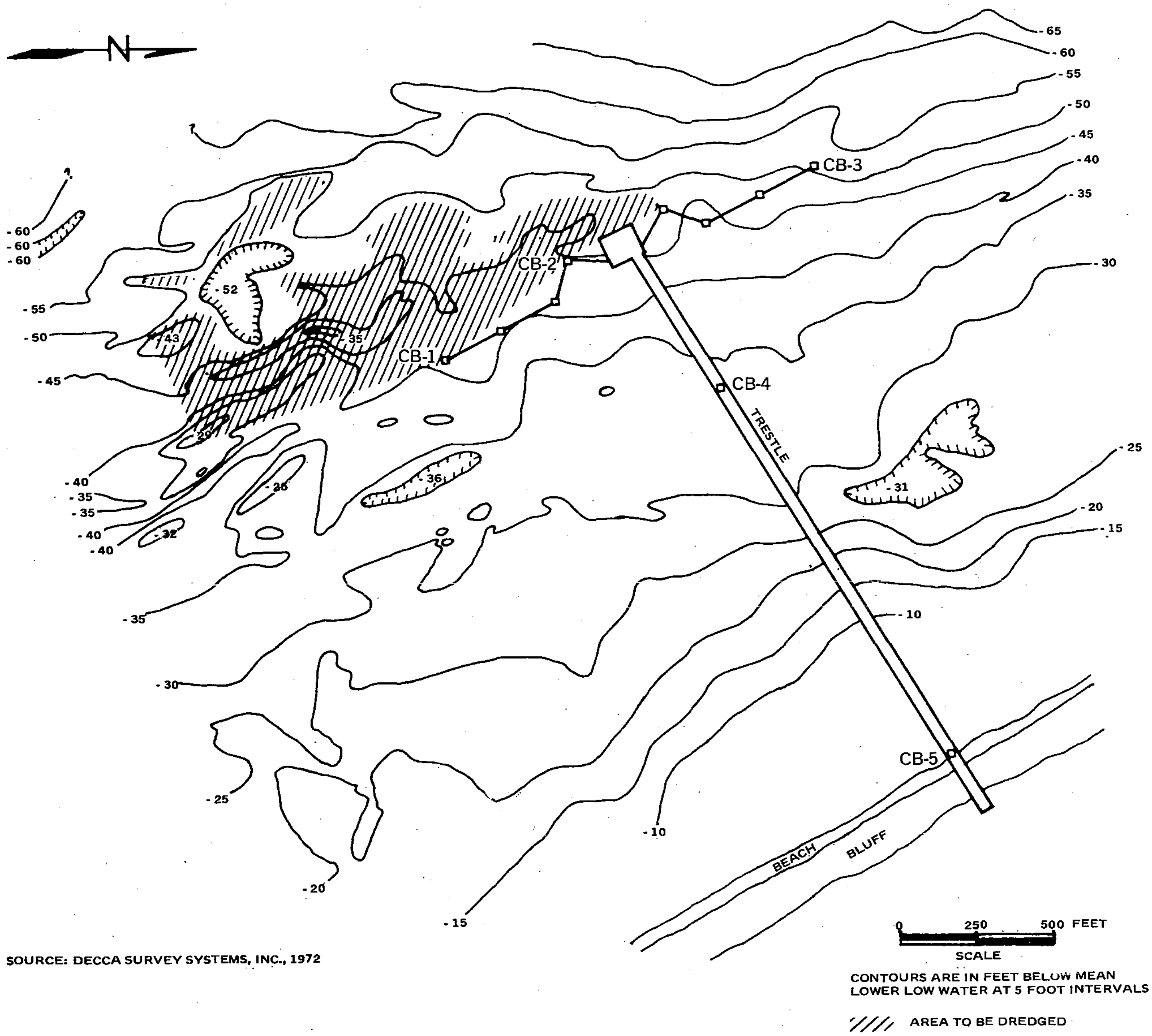

Figure 14. Offshore Bathymetry of the Proposed Nikiski LNG Terminal.

Along the Anchor Point to North Fork Field lateral, a maximum elevation of 750 feet is reached; however, the proposed pipeline from Nikiski to Anchor Point traverses elevations ranging from near sea level at river crossings to only about 300 feet between Clam Gulch and the Kasilof River. This latter route may be divided into four sections of relatively constant elevations of 200,300, 50 and 100 feet, with boundaries at Anchor Point, Clam Gulch, Kasilof River, Kenai River, and Nikiski, respectively. Maximum slope is about 500 feet per mile adjacent to some stream crossings but generally the slope is negligible.

The Nikishka Bay to North Foreland route extends through water depths in excess of 180 feet. However, most of the route is in water less than 120 feet deep and on slopes of less than about 25 feet per mile. The maximum slope is less than 50 feet per mile.

Total relief of the main pipeline alignment between North Foreland and Lewis River on the west side of the inlet is about 150 feet. The terrain is similar to that on the Kenai Lowland. The average slope is no more than 10 feet per mile, with a maximum of about 300 feet per mile in the North Foreland area.

Between West Foreland and North Foreland the proposed pipeline crosses hummocky morainal topography with approximately 300 feet of relief. South and west of McArthur River the maximum elevation is about 170 feet while an elevation of 350 feet is reached east of the river near Old Tyonek Creek. The crossing of the McArthur River floodplain is at an elevation of about 25 feet. Maximum slope along the route is about 400 feet per mile although the average slope is about 100 feet per mile.

The pipeline connecting the Coffee Creek Field to the main pipeline near Beluga River exhibits 600 feet of relief with elevations near 650 feet at the field. Maximum slope is about 3,200 feet per mile in the hills near the Coffee Creek Field but, in general, the average slope is less than 400 feet per mile.

Approximately 1,900 feet of relief occurs along the Susitna Basin to Lewis River route which traverses the pass between Little Mt. Susitna and Mt. Susitna. From an elevation of about 150 feet near the Yentna River, the route heads south, enters the northern slopes of Little Mt. Susitna near Wolverine Creek and slowly ascends the gentle slopes at no more than 500 feet per mile to an elevation of 2,000 feet on the southern slope of the mountain. From this point, the route heads directly downslope at about 500 feet per mile to an elevation of about 100 feet which is maintained for the remaining distance to Lewis River. The maximum slope on the route south of the mountain is about 1,600 feet per mile.

3. Geology

The inlet and adjacent Kenai Lowlands are developed upon a structural basin of Tertiary age. The axis of this basin trends approximately northeast, and the structure overlies the older sedimentary trough of the Matanuska geosyncline.

The inlet region resembles a graben 1/ with normal faults on the northwest and southeast margins. However, the internal structure is apparently dominated by northeast trending anticlines which would not easily fit the tectonic framework required by graben formation. Bounding faults on the north and west are the Castle Mountain and Bruin Bay faults, while the Eagle River and Border Ranges faults pass to the east and south of the Kenai Lowland.

Very little has been published about the subsurface structure within the Kenai Lowland. The thick sequence of glacial debris which mantles the area makes it difficult to obtain subsurface data. Data obtained from drilling in the Middle Ground Shoal, Kenai Gas Field, and the Swanson River Field (see Figure 30) indicate that several anticlinal features trend to the northeast. East-west trending normal faults are common within the onshore fields but are not known to extend to within 4,000 feet of the surface. Beikman (1974) shows an inferred major fault within the Kenai Lowland at a distance of about 10 miles from the Border Ranges fault (Chugach fault of Kelly, 1966) which it roughly parallels. Foster and Karlstrom (1967) indicate that it is likely that their "zone of extensive ground breakage" caused by the 1964 earthquake is associated with a subsurface fault. This zone extends from Chickaloon Bay to Kalifonsky--the queried "fault" in Figure 15.

Late Triassic to early Tertiary rocks have been identified in the basin. The youngest of these formations is the Kenai Formation of Eocene age. 2/ This formation is comprised of interbedded conglomerate, sandstone, siltstone, and shale with

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1/ A depression formed by the downward vertical movement of a portion of the earth's crust between two faults.

2/ T. N. V. Karlstrom, "Quaternary Geology of the Kenai Lowland and Glacial History of the Cook Inlet Region, Alaska," USGS Professional Paper 443, 1964.

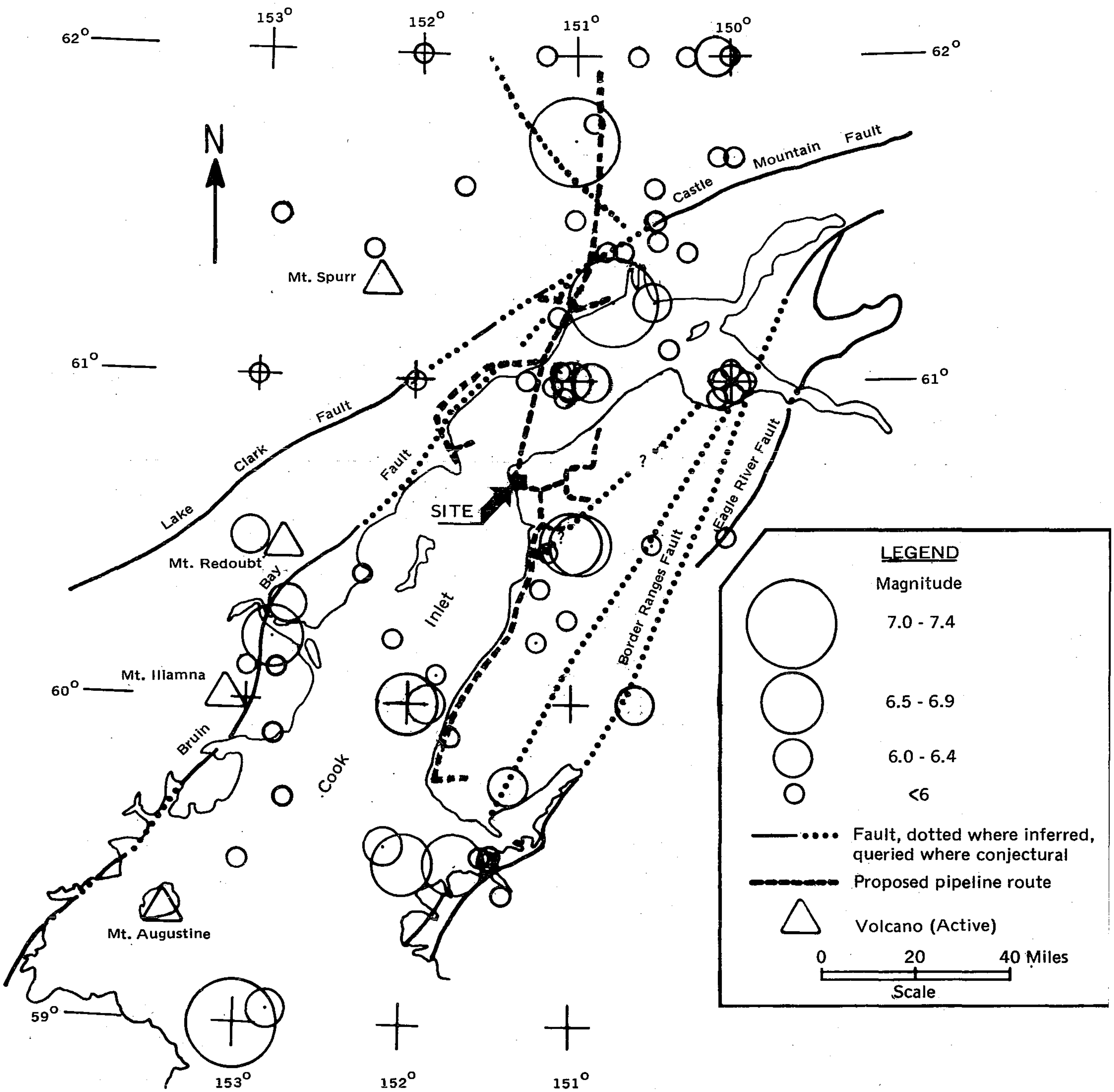

Figure 15. Epicenter Map of the Cook Inlet Region Showing the Approximate Locations of the Proposed Site and Pipelines

Source:

numerous coal beds. It varies in degree of induration, commonly being only semi-consolidated. At the proposed LNG plant site, which lies near the axis of the basin, the Kenai Formation is over 18,000 feet thick.

The unconsolidated Pleistocene glacial deposits which overlie the Kenai Formation are over 250 feet thick at the proposed site and may be as much as 4,000 feet thick. Deposits displayed in the bluff near the site have been dated at 37,000 B.C.

Subsurface conditions at the proposed LNG facility site originally consisted of a surface layer of peat and decaying matter 2.5 to 3.5 feet thick, underlain by 55 to 60 feet of medium-dense to dense, interbedded gravelly fine to coarse sand and sandy fine to coarse gravel. 1/ However, the surface layer of peat and decaying vegetation has been entirely removed. Lignite occurs within the subsurface material at a depth of about 45 feet underneath the proposed location of the LNG tanks. The next 50 to 60 feet are similar except that the sands and gravels are interlayered with hard silt up to 22 feet thick. The last material encounteted is dense to very dense clean and silty sand which extends to the depth explored, which was about 120 feet below the surface.

A study by Fugro Gulf, Inc. (1975) indicated the following sequence of strata below the proposed marine terminal. Approximately 16 feet of medium dense, gray, sandy silt and sand on the surface is underlain by 11 feet of hard, gray, sandy clay. From 27 to 42 feet below the mudline, medium dense, gray, silty fine sand occurs, underlain by about 58 feet of hard, gray, sandy clay and an unknown thickness of dense gravel and coarse gray sand. See Figure 16 for more detail.

Depositional patterns are difficult to describe in detail due to the complexity and force of the currents in the inlet. The trend of sediment movement in the site area is to the north. A general treatment of current and sediment distribution in the inlet may be found within the "Hydrology" section of this report.

It appears that bedrock does not extend to within 60 feet of the floor of the inlet at the proposed marine terminal. However, the shoals in the southern part of the area shown in Figure 14 are inferred to be sedimentary rock, 2/ presumably the Kenai Formation. These ridges are quite common along the navigational approach to the proposed terminal.

1/ Dames and Moore, Report of Foundation Investigation and Seismic Studies, Proposed LNG Liquefaction Plant, Nikiski, Alaska, 1974.

2/ Decca Survey Systems, Inc., Report of Survey, Proposed Dock Structure, Kenai Peninsula, Kenai, Alaska, 1972, p. 9.

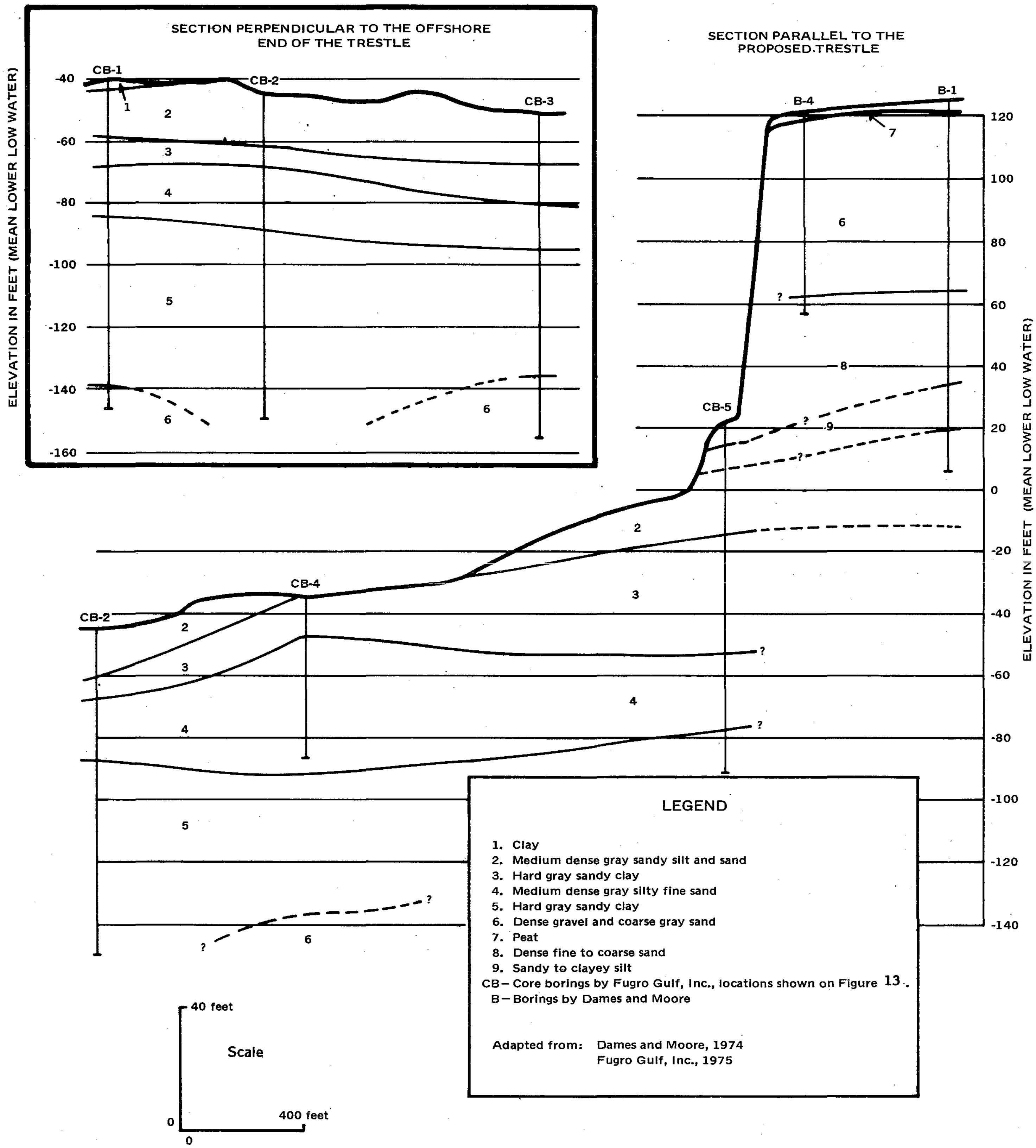

Figure 16. Subsurface Cross-Sections at the Proposed Nikiski LNG Terminal

The proposed crossing of the inlet could encounter three types of bottom sediments with sand and gravel predominating. Areas covered by cobbles and boulders have been mapped adjacent to the proposed route, 1/ and bedrock outcrops exist but apparently comprise only about 1 percent of the route. Most of the proposed marine pipeline within the inlet would be laid on top of a mixture of sand, gravel, and cobbles.

The high velocity tidal currents form sand and gravel waves which may reach amplitudes of 40 feet. However, amplitudes greater than 10 feet were not reported to exist within the proposed pipeline corridor during the aforementioned mapping. Ten percent of the corridor was mapped within sand waves.

Several major earthquakes have been recorded in or near south-central Alaska within the last 200 years. The most notable of these were the 1899 Yakutat Bay and the 1964 Prince William Sound earthquakes--both of which were at least of Richter magnitude 8.3. Earthquakes of magnitude 7.3 or less, including significant events associated with volcanic activity, have been recorded in the project region. See Figure 15 for epicentral locations, and Table A-3 in Appendix A for a comprehensive list of earthquakes.

As a result of the 1964 earthquake, the portion of the Kenai Lowland near the proposed site lost 1 foot of elevation. 2/ Severe ground cracking due to compaction or lateral movement of unconsolidated sediments was common in the Kenai Lowland. In addition, Foster and Karlstrom 2/ indicate that the linear band of surface disruption which passed about 16 miles southeast of the proposed site could have been due to motion on a buried fault. It is unclear how much, if any, horizontal movement of the site area took place. Dames and Moore 3/ state that "the intensity of earthquake shaking probably was about Modified Mercalli VIII . . ." 4/ at the proposed site. The maximum projected

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1/ Dames and Moore, Detailed Environmental Analysis Concerning a Proposed Liquefied Natural Gas Project for Pacific Alaska LNG Company, 1974, Pipeline Plate 2.1.2-7.

2/ H. L. Foster and T. N. V. Karlstrom, Ground Breakage and Associated Effects in the Cook Inlet Area, Alaska, Resulting from the March 27, 1964 Earthquake, USGS Professional Paper 543-F, 1967.

3/ Dames and Moore, Detailed Environmental Analysis . . . , pp. 2-48.

4/ See Table A-4 in Appendix A.

intensity in the area of the proposed site is IX based on historical events. 1/ The entire project is within a region of maximum projected intensity VIII or greater, with isolated areas of IX near Nikiski and Cape Starichkof. The North Foreland to Susitna Basin route is within regions of projected intensity IX and X.

The Cook Inlet Basin has experienced nine earthquakes of magnitude greater than or equal to 6.5 from 1899 through 1975. On the basis of historic events through 1975, recurrence intervals may be determined for earthquakes within the Cook Inlet Region. In the following table, these intervals are compared with the corresponding values for Prince William Sound, the region in which the 1964 earthquake took place.

	Recurrence (years)	
Magnitude	Cook Inlet	Prince William Sound
6.5	8.8	--
7.0	22	9.1
7.5	230	26
8.0	2,130	72
8.5	19,600	196

From this information, there is no reason to expect that the proposed project would not be subject to at least a magnitude 6.5 event during an economic life of 20 years. See further discussion of seismic design in Volume I, Section C.3 of the DEIS.

Possible impacts of such events on the proposed facilties, including indirect effects such as landslides, subsidence, and tsunamis, will be discussed in Section C.3 in Volume I of this report.

1/ H. Meyers, R. J. Brazee, J. L. Coffman, and S. R. Lessig, An Analysis of Earthquake Intensities and Recurrence Rates in and Near Alaska, NOAA Technical Memorandum EDS NGSDC-3, NOAA NGSTDC, Boulder, 1976.

Other possible geologic hazards include nonearthquake-induced landsliding, erosion, volcanic activity, flooding, expansive and collapsing soils, and frozen soils. Except for the first three phenomena, these would only impact the proposed pipeline, not the LNG plant site. These hazards will also be considered in the impact section.

4. Soils

Detailed soil surveys are available from the U.S. Department of Agriculture for the proposed site and most of the proposed pipeline corridors on the Kenai Lowland. 1/ 2/ However, no such published material exists for the area involved with the remainder of the proposal.

The soils of the Cook Inlet region are formed on a complex sequence of unconsolidated sediments deposited over bedrock during the several episodes of glaciation that have influenced this area since the beginning of the Pleistocene epoch. Sediments comprising this morainal material are described in the "Geology" section and are at least several hundred feet thick under all the proposed onshore facilities. Above the coarser subsurface material is generally a layer of loess of varying thickness upon which the soils form. Most of these soils are varying combinations and thicknesses of silt loam and organic matter or peat.

On the Kenai Lowland, the proposed facilities would lie within the Soldatna, Tustumena, Kenai, and Salamatof soil areas of Rieger, *et al*. and would probably cross the Naptowne soil area. South of Clam Gulch the Anchor Point route is within the Cohoe soil area (Cohoe-Salamatof association of Hinton) except for a portion of the North Fork spur which crosses the Mutnala-Salamatof association.

The Soldatna soils are predominant north of Kenai and a large portion of the pipelines connecting gas fields north of the Kenai River may be expected to pass through them. Although published soil surveys do not cover much of the area north and east of Kenai, the pipelines in this area would probably cross all soil areas except the Cohoe soil area. South of the Kenai River all of the soil areas and associations listed are crossed except the Soldatna and Naptowne soil areas.

The proposed LNG plant site was located within the Soldatna series, specifically the Soldatna silt loam. The typical profile consists of gray to olive silt loam which becomes increasingly blocky with depth and is underlain by gravelly sand at depths of 2 to 3.5 feet. However, all of this material has been removed.

1/ S. Rieger, *et al*., *Soil Survey of Kenai-Kasilof Area, Alaska*, USDA Soil Survey Series 1958, No. 20, 1962.

2/ R. B. Hinton, *Soil Survey of Homer-Ninilchik Area, Alaska*, USDA Soil Survey, 1971.

The following soil area descriptions are adapted from Reiger, et al. or Hinton.

The Soldatna soils occur on broad, nearly level plains with lakes and muskeg. The soils are well-drained, moderately deep, silty deposits covering a gravel or coarse sandy substrate.

Tustumena soils also occur on broad, nearly level plains but principally near rivers and streams. Soils of this area are generally well-drained except those which occupy shallow depressions, drainageways, and floodplains. Where well-drained the soils consist of moderately deep silt deposited on gravel or coarse sand.

The Kenai soil area encompasses hilly areas of variable slope. Although these soils are also wind-transported silts, the substrate is a firm, slowly permeable clay.

The Salamatof soil area consists of muskegs or bogs. Mineral soils do occur as isolated patches within this area which may be covered with as much as 10 feet of peat. These soils are very poorly drained.

The Naptowne soil area consists of rolling to steep, low-lying hills. However, as is common on much of the lowland, much essentially level land is present. There are also many small lakes, muskegs, and secondary drainageways. Naptowne soils are well-drained and resemble the Soldatna soils except that the substrate is firmer and of a finer texture.

The Cohoe-Salamatof association, comprised of 45 percent Cohoe soils, 35 percent Salamatof soils, and 20 percent other soils, is described as deep, nearly level to moderately sloping, well-drained silt loams on uplands and very poorly drained peat soils within the low-lying muskegs. Mineral soils are silts lying upon sediments ranging in texture from gravel to clay.

The composition of the Mutnala-Salamatof association is similar to the Cohoe-Salamatof association. The primary differences are the shallowness of the upper soil layers and the predominance of gravelly glacial till in the substrate of the mineral soils. In addition, the Mutnala soils may be found on steep slopes. The association consists of 40 percent Mutnala, 25 percent Salamatof, and 35 percent other soils.

The soils of all the soil areas to be crossed on the lowlands are fairly acid at the surface (pH = 4.0-6.5), with the loams generally approaching neutrality below a depth of 2 feet (pH = 6.0-6.5). Peats tend to remain at a pH less than 5.0 in the southern part of the lowland and less than 6.0 in the north, up to a depth of about 5 feet. Except for the Kenai silt loam, which is moderate to high, the mineral soils have moderate to low shrink-swell potential. The Salamatof peat has a high potential for shrinkage. All the mineral soils are susceptible to wind and water erosion.

Within the Susitna Valley area, the proposed pipeline corridor would be expected to cross the following soil associations: Nancy-Delyndia, Clunie-Tidal Marsh, Salamatof-Jacobsen, and Susitna-Shrock. These associations include the major types of soils which are to be expected within the proposed right-of-way on the west side of Cook Inlet. They do not differ markedly from those found in the Kenai Lowland.

The four associations are described as follows: 1/

> Nancy-Delyndia association: Dominantly nearly level to steep, well-drained, and somewhat excessively drained silt loams that are moderately deep and shallow over sand or gravelly sand; on uplands.
>
> Susitna-Shrock association: Dominantly nearly level, well-drained, stratified fine sandy loams and silt loams that are deep over sand or gravelly sand; on alluvial plains.
>
> Clunie-Tidal Marsh association: Dominantly nearly level, very poorly drained, fibrous peats and poorly drained, clayey sediment; on tidal plains.
>
> Salamatof-Jacobsen association: Dominantly nearly level, very poorly drained, very stony silt loams along the edges of muskegs.

The erosion hazard for the soils of the Susitna Valley is minimal due to the generally low slopes. If slopes are between 3 to 12 percent, the potential is moderate, and over 12 percent, it is severe. All unvegetated dry areas exhibit at least a

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1/ Schoephorster and Hinton, Soil Survey of Susitna Valley Area, Alaska, USDA Soil Survey, 1973.

moderate potential for wind erosion. The shrink-swell potential of most of the inorganic soils is low, while the peats, Salamatof and Clunie, have a high potential for shrinkage. The only exceptions are the Clunie and Wasilla silty clay loams which have a moderate potential for shrink-swell.

Most of these soils are acidic, as is expected due to the high content of organic matter. The range in pH is from 4.0 to 7.3. However, most soils which would be encountered along the route are between pH 4.5 and 5.5.

5. Water Resources

a) General Description

The Cook Inlet Drainage Basin is made up of over 50 separate drainage systems covering a total area of approximately 38,000 square miles. The largest is the Susitna River Basin, which accounts for about 19,600 square miles. Other major systems are the Matanuska, Kenai, Knik, and Chakachatha River Basins. (See Appendix B for hydrologic maps and data identifying the project area.)

The proposed liquefaction plant site is located on the eastern shore of Cook Inlet, about 3 miles south of East Foreland (Figure 17). Proposed rights-of-way extend to the north, east, and south.

North and east of the proposed plant site, right-of-way corridors traverse drainage basins characterized by complex, largely modified morainal land forms, extensive muskeg, swamp, and lake areas, and a peculiar pattern of broad, largely abandoned, and poorly integrated drainage channels. Except for the Swanson River, streams are generally small, slow flowing, and meandering.

South of the Beaver Creek Lateral, the proposed pipeline would cross the flat coastal plain of the Kenai River, which is characterized by extensive muskeg deposits, and then enter the Ninilchik Lowland to the south of the Kasilof River. Basins in this portion of the Kenai Lowland are similar to those found to the north and host numerous broad muskeg-floored northeast-southewest trending channelways, in part occupied and in part crossed by drainage lines. The most obvious

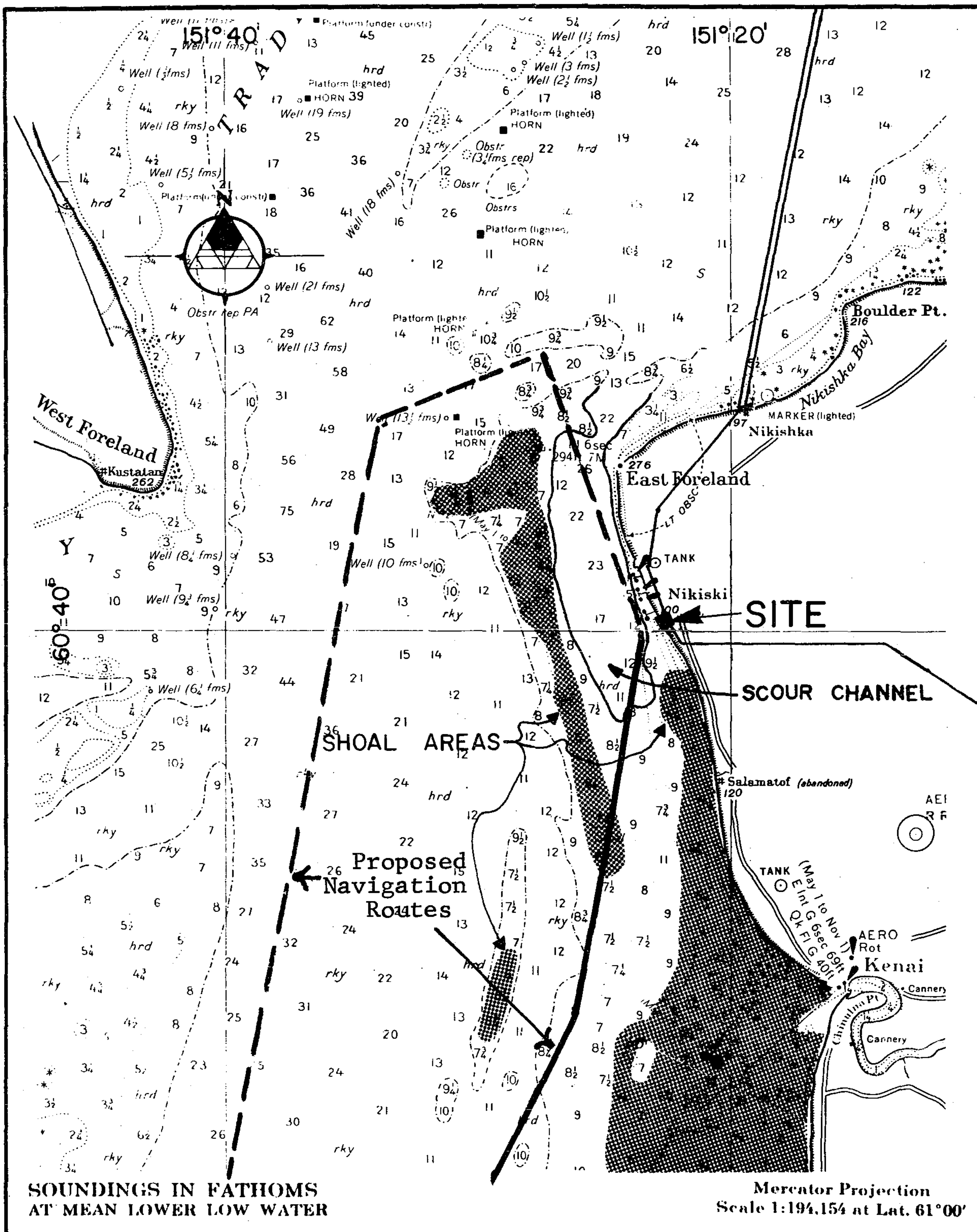

Figure 17

SITE AREA BATHYMETRIC FEATURES

NOTE:
THE SHOAL AREAS SHOWN HAVE LESS THAN 7 FATHOMS BELOW MLLW AND ARE ALONG POTENTIAL LNG SHIP APPROACHES TO THE NIKISKI SITE.

differences between drainage basins in this portion of the peninsula and those in the north are higher elevations and fewer lakes.

The mean annual runoff from drainages in the Kenai Peninsula project area ranges from approximately 0.5 to 1.0 cubic foot per second per square mile (cfsm). During high-flow periods, mean annual peak runoffs average 5 to 10 cfsm. As a result, certain areas along all of the proposed rights-of-way may experience moderate flooding, particularly during spring snowmelt and heavy summer rainfall. Throughout the remainder of the year, much of the surface water which would normally constitute runoff is retained as near-surface groundwater in the extensive muskeg and swamp areas. During low-flow periods, which typically occur in late winter, mean annual low runoffs may fall to 0.3 cfsm as smaller streams freeze solid.

The proposed pipeline rights-of-way on the west side of the inlet traverse areas similar to the project areas on the Kenai Peninsula. Mean annual peak runoff rates of 1 to 5 cfsm can be expected in the lowland areas having swamps or lakes, while rates of 25 to 50 cfsm can be expected in high, steep areas. High-flow periods generally occur during the spring ice breakup and the late summer-early fall rainstorms. Mean annual runoff rates during the low-flow periods of winter average between 0.3 and 0.5 cfsm. It is probable that some smaller basins freeze solid during the winter, thus contributing to runoff. Low flows may also occur during especially dry summers in lowland basins having extensive lakes and swamps.

b) Surface Waters

i. General

Figures B-1, B-2, and B-4 in Appendix B present the known drainage basins in the areas proposed to be crossed by pipeline rights-of-way on the Kenai Peninsula and the west side of Cook Inlet. Unnamed basins in Figures B-1 and B-2 generally consist of small coastal drainages.

On the Kenai Peninsula, the applicant's preferred route would cross 28 streams 31 times. On the west side of the inlet, the preferred route would make 63 crossings of 37 watercourses. A listing of streams proposed to be crossed is presented in Appendix B, Table B-2. Tables 6 and 7 summarize hydrologic conditions at many of the proposed stream crossings on the Kenai Peninsula and the west side of Cook Inlet, respectively. Streamflow data, available for the streams with asterisks in Tables 6 and 7, are presented in Appendix B.

Of the 65 streams proposed to be crossed, 5 may have major hydrologic significance -- the McArthur-Chakachatna System and the Beluga River on the west side of the inlet and the Kenai and Kasilof Rivers on the Kenai Peninsula.

Approximately 15 miles of the proposed pipeline right-of-way would cross the broad, flat McArthur-Chakachatna River Delta. Streamflow characteristics on the delta are complex. Individually, the McArthur and Chakachatna Rivers have drainage areas of approximately 350 and 1,620 square miles, respectively. Both are glacial, deriving most of their discharge from the snowfields of the extensively glaciated Tordrillo and Chigmit Mountains. Streambed materials in the vicinity of the proposed crossings are reported to be sand and sand and gravel, respectively.

The Beluga River Basin has an approximate drainage area of 930 square miles. Streambed materials in the vicinity of the proposed crossing are reportedly tidal silts, possibly intermixed with alluvial sands and gravels. Flow velocities vary because of tidal influences.

TABLE 6

HYDROLOGIC CONDITIONS AT SELECTED PIPELINE STREAM CROSSINGS, KENAI PENINSULA

	Channel Conditions					Floodplain Conditions		
Stream	General	Width(ft)	Depth(ft)	Velocities (fps)	Bed Materials	General	Width (ft)	Surficial Soils
Swanson River	Swift, meandering, and nonglacial	20-30	Unknown; 1-3 (est)	Unknown; 1-3 (est)	Unknown; probably sand, gravel, and some boulders	Low, flat, wet and well-defined floodplain	200-500	Organics over silt, sand, and gravel
* Beaver Creek (East Fork)	Sluggish, meandering, and nonglacial	10-20	Unknown; 2-3 (est)	1/2-1 (est)	Sand, with some gravel	Low, flat, wet and well-defined floodplain	Varies 100-600	Organics over gravelly sand
* Beaver Creek (West Fork)	Sluggish, meandering, and nonglacial	10-20	Unknown; 2-3 (est)	1/2-1 (est)	Sand, with some gravel	Low, flat, wet and well-defined floodplain	350-400	Organics over gravelly sand
* Beaver Creek (Lower Crossing)	Moderately swift, meandering, and nonglacial	30-40	Unknown; 1-3 (est)	Unknown; 1-2 (est)	Sand and gravel	Low, flat, wet and poorly defined floodplain	600-800 (est.)	Organics and silts over sand and gravel
* Kenai River	Swift, meandering, glacial, and tidally influenced	Varies with tides; 800-1100	Varies with tides; 5-15	Varies with tides	Sands and gravels	Wide, flat and well-defined floodplain	8,000-9,000	Silts, sands, and gravels
Coal Creek	Swift, meandering, and nonglacial	10-15	Unknown; 1-3 (est)	Unknown 1-3 (est)	Sands and gravels	Narrow, incised in surrounding topography and well-defined	100-200	Silts, sands, and gravels
* Kasilof River	Swift, meandering, and glacial	200-250	Unknown; 5-10 (est)	Unknown; 4-6 (est)	Sands, gravels, and boulders	Narrow and incised in surrounding topography	300-500	Organic over sands and gravels
Crooked Creek	Moderately swift, meandering, and nonglacial	15-35	Unknown; 1-4 (est)	Unknown; 1-4 (est)	Unknown; probably silts, sands, and gravels	Low, wet and well-defined	300-400	Organics over silts, sands, gravels
* Ninilchik River	Swift, meandering, and nonglacial	30-40	2-3, with deeper pools	1-3	Sand, gravel, cobbles, and boulders	Incised in surrounding topography and well-defined	300-400	Silt, sand, gravel, cobbles, and boulders
Deep Creek	Swift, meandering, and nonglacial	60-100	2-3, with deeper pools	1-3	Sand, gravel, cobbles, and boulders	Incised in surrounding topography and well-defined	600-1,000	Silt, sand, gravel, cobbles, and boulders
* Stariski Creek	Swift, meandering, and nonglacial	10-20	1-2	1-3	Sand, gravel, and cobbles	Incised in surrounding topography and well-defined floodplain	400-600	Silt, sand, and gravel with organics
North Fork of Anchor River (Upper Crossing)	Swift, meandering, and nonglacial	30-50	1-3, with some deep ponds	1-3	Sand, gravel, cobbles, and some boulders	Incised in surrounding topography and well-defined floodplain	600-800	Silt, sand, and gravel
North Fork of Anchor River (Lower Crossing)	Swift, meandering, and nonglacial	40-50	1-3, with some deep ponds	1-3	Sand, gravel, cobbles, and some boulders	Incised in surrounding topography and well-defined floodplain	200-400	Silt, sand, and gravel

* Streamflow data available in Appendix B.

TABLE 7

HYDROLOGIC CONDITIONS AT SELECTED PIPELINE STREAM CROSSINGS, WEST SIDE OF COOK INLET

	Channel Conditions					Floodplain Conditions		
Stream	General	Width(ft)	Depth(ft)	Velocities(fps)	Bed Materials	General	Width(ft)	Surficial Soils
McArthur River	Swift, meandering, and glacial	600-650	Unknown; 10-15 (est.)	2-4 (est.)	Sand	Low, flat, poorly defined floodplain	5,200 (est.)	Sand and silt with some organics
* Chakachatna River	Swift, braided, and glacial	500-700	5-10 (est.)	1-3 (est.)	Sand and gravel	Low, flat, poorly defined floodplain	2,500-2,700	Sands with some organics and gravels (est.)
Middle River	Swift, meandering, and glacial	200-300	5-10 (est.)	2-4 (est.)	Sand and gravel	Low, flat, moderately well-defined floodplain	1,500-1,600	Organics with some sand and gravel
Nicolai Creek	Moderately swift, meandering, nonglacial, and tidally influenced	Varies with tides; 60-80 at low tide	Varies with tides; 2-3 at low tide (est.)	Varies with tides; 1-3 at low tide (est.)	Tidal silts	Low, flat, poorly defined floodplain	400-600	Tidal silts and organics
Old Tyonek Creek	Swift, meandering, and nonglacial	10-20	1-4 (est.)	1-3	Sand and gravel	Incised in surrounding topography	300-400	Sand and gravel with some silts
Tyonek Creek	Swift, meandering, and nonglacial	20-30	1-5 (est.)	1-3	Silts, sand, and gravel	Incised in surrounding hilly terrain; floodplain poorly defined	Varies; 200-800 (est.)	Silts, sand, and gravel with pockets of organics
* Chuitna Creek	Moderately swift, meandering, nonglacial, and tidally influenced	Varies with tides; 50-100 (est.)	Varies with tides; 2-6 (est.)	Varies with tides; 2-3 (est.)	Sand, gravel, and some cobbles	Flat and incised in surrounding topography	1,800-2,900	Tidal silts over sands and gravels
Three Mile Creek	Moderately swift, meandering, nonglacial, and tidally influenced	Varies with tides; 20-30 avg.	Varies with tides; 1-6	Varies with tides; 2-3 max. (est.)	Sand, gravel, and some cobbles	Flat and incised in surrounding topography	50-100	Tidal silts over sands and gravels
Beluga River	Meandering, glacial, and tidally influenced	Varies with tides; 500-600 at low tide	Varies with tides; 15-25 (est.)	Varies with tides; 3-5 at low tide (est.)	Tidal silts with possible sands and gravels	Low and poorly defined floodplain in tidal flats	2,100-2,300 (est.)	Tidal silts and organics over silts and sands
Pretty Creek	Sluggish, meandering, and nonglacial	20-40	Unknown; 1-3 (est.)	Unknown; 1-2 (est.)	Unknown; probably silts and sands	Low, flat, well-defined floodplain	500-1,000	Unknown; probably organics over sand and gravel
Olsen Creek	Swift, meandering, and nonglacial	10-20	Unknown; 1-2 (est.)	Unknown; 2-4 (est.)	Unknown, expect sand, gravels and cobbles	Narrow, well-defined floodplain	400-500	Silts over sands and gravels
Theodore River (Lower Crossing)	Meandering, nonglacial, and strong tidal influence	Varies with tides; 100 at low tide	Varies with tides	Varies with tides	Tidal silts	Low, flat, and adjacent pipeline in tidal floodplain	N/A	Tidal silts
Theodore River (Upper Crossing)	Swift, meandering, and nonglacial	40-60	1-3 with 10 in pools	1-3; less in pools	Sand, gravel, cobbles, and some boulders	Incised in surrounding topography	5,200-5,800 (est.)	Fine sand to coarse sand and gravel. Some silts and organics.
Lewis River (Lower Crossing)	Meandering, nonglacial, and strong tidal influence	Varies with tides; 120-180 at low tide	Varies with tides	Varies with tides	Tidal silts	Low, flat, and adjacent pipeline in tidal floodplain	N/A	Tidal silts
Lewis River (Upper Crossing)	Swift, meandering, and nonglacial	20-40	1-3 with 6-10 in pools	1-2; less in pools	Sand, gravel, and cobbles	Incised in surrounding topography	500-600	Fine to medium sand over medium to coarse sand. Some organics
Ivan River	Sluggish, meandering, nonglacial, and strong tidal influence	Varies with tides; 200-300 at low tide	Varies with tides	Varies with tides	Tidal silts	Low, flat, and adjacent pipeline in tidal floodplain	N/A	Tidal silts
Lower Sucker Creek	Moderately swift, meandering, and nonglacial	20-40	Unknown; 1-3 (est.)	Unknown; 1-3 (est.)	Sand and gravel	Low, flat, and moderately well-defined	400-500	Sand and gravel with some silt and organics
Alexander Creek	Moderately, swift, meandering, and nonglacial	30-70	Unknown; 2-4 (est.)	Unknown; 1-3 (est.)	Sand, with some gravel	Low, flat, and moderately well-defined	2,000-2,100	Sand, with some silts and gravel

* Streamflow data available in Appendix B.

The Kenai River Basin encompasses 2,010 square miles at Soldotna, some 19 river miles upstream from the proposed crossing. This river is the largest on the Kenai Peninsula, having a mean discharge of 5,958 cfs at Soldotna in 1971. Further streamflow data are presented in Appendix B, Table B-4. The headwaters of the river lie in the heavily glaciated Kenai Mountains, and it is therefore susceptible to outburst floods. Other flood events may occur as the result of tidal influences (felt up to 11.5 miles above the mouth on an annual basis) and ice jamming. Streambed materials in the vicinity of the proposed corssing are reported to be sands and gravels, with flow velocities between 2 and 4 feet per second, depending on the tide.

The only other proposed crossing of hydrologic significance would be that of the Kasilof River Basin. This basin is approximately 740 square miles and had an average flow near Kasilof of 2,385 cfs during a 21-year record period ending in 1970. While the Kasilof River's headwaters lie in the Kenai Mountains and drain several small glacier dammed lakes, the presence of Lake Tustumena is expected to effectively mitigate the impact of any outburst releases. Available streamflow data for the Kasilof River are presented in Appendix B, Table B-4.

ii. Water Characteristics

Surface waters in the Kenai Peninsula project area are generally of the dilute calcium bicarbonate type, at times exhibiting sodium and magnesium bicarbonate characteristics. Temperatures vary vetween 32°F. and 62°F., the low occurring in March and the high in August. Waters are generally soft. Larger rivers such as the Kenai and the Kasilof differ from the smaller drainages because they are glacial in origin, a factor which results in generally softer water and lower concentrations of iron and total dissolved solids (TDS). A typical analysis of surface waters in the proposed project area is presented in Appendix B, Table B-9.

Surface waters on the west side of Cook Inlet generally appear to be of the calcium bicarbonate type, but sodium bicarbonate and chloride types occur occasionally. Waters are soft, TDS levels are low, and temperatures range from 32°F. to about 54°F.

iii. Upper Cook Inlet

The areas of the proposed marine pipeline crossing in Upper Cook Inlet, above the Forelands, can be described as a relatively "high-energy" environment -- that is, a system experiencing extreme current velocities, wide total fluctuations, and excessive suspended sediment loads. The total freshwater inflow ranges from approximately 1,400 cfs during March to approximately 123,500 cfs during July. 1/

The primary sources of sediment in the estuary are the major rivers which drain the surrounding watersheds. During the high inflow months of May through September, an average of 206,000 tons of sediment is discharged into the Cook Inlet estuary each day. Essentially, all of this enters at its head. 2/ Figure B-3 in Appendix B illustrates the bathymetric features in the area of upper Cook Inlet proposed to be crossed. Specific water quality parameters for the upper and lower inlet areas are discussed in "Physical Oceanography."

iv. Hydrologic Hazards

Hydrologic hazards associated with crossing the McArthur-Chakachatna Delta include outburst and tidal flooding, as well as riverbed scour, lateral erosion,

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1/ G.D. Sharma and D.C. Burrell, "Sedimentary Environment and Sediments of Cook Inlet, Alaska," American Association of Petroleum Geologists Bulletin (April 1970), p. 648.

2/ U.S. Army Corps of Engineers, Alaska District, FEIS on Offshore Oil and Gas Development in Cook Inlet, Alaska (Anchorage 1974), p.31.

and subsequent channel shifting and migration. Nearly all of these phenomena are related to flood events which occur predominately during the nonwinter (April through October) months.

Blockade Lake is dammed by Blockade Glacier at the head of the McArthur River. While its outburst history is unrecorded, the lake is reported to drain subglacially every 2 to 4 years, posing an extreme flood hazard along the McArthur lowlands. 1/ Streamflow data for the McArthur River are unavailable.

The Chakachatna River has two potential flood sources in its headwater region -- Chakachamna Lake and two glacier-sheathed volcanoes. Chakachamna Lake is dammed by Barrier Glacier. Changes in the stage/discharge relationships monitored during recent years suggest a very low outburst flood hazard from the lake. However, eruptions of Mount Spurr and the resulting glacial melt may present serious flood hazards on the Chakachatna River. 2/ Estimated annual runoff from the Chakachatna Basin is 3 million acre-feet per year, with a mean discharge of 4,658 cubic feet per second. 3/ Available streamflow data for the Chakachatna River are presented in Appendix B, Table B-8.

1/ A. Post and L. R. Mayo, "Glacier Dammed Lakes and Outburst Floods in Alaska," U.S. Geological Survey, Hydrologic Investigation Atlas HA-455 (1971).

2/ A. Post and L. R. Mayo, "Glacier Dammed Lakes . . . '

3/ It should be noted that these values were recorded at the U.S. Geological Survey (USGS) gauging station at Barrier Glacier, some 36 miles upstream of the river's discharge point, during water year 1971.

The McArthur, Chakachatna, and Middle Rivers are expected to be subject to scour on the order of 10 feet. Studies have indicated that lateral erosion rates of 5 to 10 feet per year are not uncommon in some alluvial streams in Alaska. Meandering streams are particularly susceptible to such erosion.

The headwaters of the Beluga River originate in the highly glaciated Tordrillo Mountains. Strandline Lake is dammed by the Triumvirate Glacier above Beluga Lake. Waters from Strandline Lake periodically cut an ice gorge along the margin of the glacier posing an extreme flood hazard on the glacial outwash plain and Beluga River lowlands below.

Two unnamed lakes high in the Kenai Mountains pose outburst flood hazards. One above the Snow River, a tributary of the Kenai drains every 2 to 3 years, resulting in an extreme flood hazard on the Snow River lowlands. While Kenai and Skilak Lakes, which lie between the glacier and the proposed crossing area, would mitigate this outburst, a moderate flood hazard still exists on the Kenai River. The other unnamed lake is blocked by Skilak Glacier. In January 1969, this lake drained subglacially, releasing a flow which would have been minor had it occurred during the summer. However, ice jams plugging the channel resulted in flooding and severe damage at Soldotna.

v. Ice Regime

The ice regime in the proposed project area may be expected to span 6 to 8 months per year. Freezeup begins in the marshes and ponds, progressing to the larger lakes, smaller streams, and finally larger rivers. Although there are no records for the timing of these events, the process can be expected to begin in September and, depending on the year, be completed by November or December. Ice thickness may reach an estimated 3 to 4 feet on the lowland lakes and 1 to 3 feet on the rivers and streams. Along tidal reaches of the Kenai and Kasilof Rivers, freezeup may be delayed until almost January. While data are unavailable for most rivers in the proposed project area, ice freezeup and breakup dates tabulated by the U.S. Coast Guard and Geodetic Survey for these two rivers are presented below.

TABLE 8

Summary of Freezeup Statistics

Stream	Years of Record	Dates		
		Earliest	Latest	Average
Kenai River	6	11/23/51	12/26/37	12/10
Kasilof River	10	11/13/45	12/24/48	12/3

Summary of Breakup Statistics

Stream	Years of Record	Dates		
		Earliest	Latest	Average
Kenai River	6	3/18/52	4/14/51	4/2
Kasilof River	10	3/27/41	4/29/46	4/13

c) Groundwater

The principal water-bearing formations in the Kenai Peninsula project area are surficial glacial outwash-plain deposits in which groundwater occurs under free water table or unconfined conditions and subsurface abaondon-channel deposits containing water under confined or artesian conditions. These deeper aquifers are thought to occur along the courses of old glacial meltwater channels. Subsurface soils in the area of the proposed liquefaction plant site consist primarily of glacial outwash. Because information concerning these deposits is limited, the occurrence and distribution of productive aquifers is generally unpredictable.

Wells tapping shallow unconfined aquifers in the North Kenai area typically develop modest amounts of water, while artesian deposits reportedly yield 200 to 1,400 gallons per minute (gpm). Recharge to the aquifers, both confined and unconfined, is accomplished primarily by percolation of rainwater supplemented by snowmelt and seepage from the numerous lakes and streams in the area. A certain amount of leakage from the confined to the unconfined deposits probably auguments present normal recharge of the unconfined aquifers. Mean annual recharge to the North Kenai groundwater system has been estimated to be greater than 6.5 million gpd. 2/

Borings and probes made by the applicant during late summer at the proposed liquefaction plant site encountered the groundwater table some 68 to 79 feet below the existing grade. Data indicated that the water table surface sloped downward from east to west across the site towards the sea cliff. Near the base of the cliff, numerous seeps and iron-stained soils were noted. 3/

1/ G. S. Anderson and S. H. Jones, Water Resources of the Kenai-Soldatna Area, Alaska, USGS, Alaska District, Open File Report, 1972, p. 4.

2/ Anderson and Jones, p. 45.

3/ Dames & Moore, Report of Foundation Investigation . . ., p. 9.

Groundwater conditions along the proposed right-of-way corridors north, east, and south of the proposed liquefaction plant site are expected to be similar to those described previously. Both confined and unconfined aquifers have been confirmed in the Kenai area and can be expected below most, if not all, of the proposed routes.

Little information on groundwater conditions in the project area on the west side of Cook Inlet exists. Where the terrain is extremely flat and covered by numerous lakes and ponds, the water table is expected to be at or very near the ground surface. Muskeg areas are likely to have perched or near-surface water tables. In the vicinity of the proposed rights-of-way between the Ivan River and Nikilai Creek, conditions may vary considerably with terrain and subsurface conditions. South of Nikilai Creek, the proposed route would cross the broad McArthur-Chakachatna River Delta, where groundwater is at or within several feet of the ground surface. In the West Foreland area, soils appear to be generally well drained, suggesting a deeper groundwater level.

Groundwater quality in the Kenai Peninsula project area varies considerably, both by area and by aquifer type. Unconfined deposits yield calcium magnesium bicarbonate waters with carbonate hardness. Samples are typically low in dissolved solids but high in iron, particularly near swampy areas. Temperatures range from 37°F. to 43°F. Wells in the North Kenai area tapping shallow water table aquifers generally yield mineralized water with a high iron content.

Confined aquifers in the Kenai Peninsula project area lying 60 to 300 feet below the land surface commonly yield the best quality water. Samples are principally of the calcium magnesium bicarbonate types, but may include sodium bicarbonate or sodium chloride types.

In some areas, including those adjacent to the mouth of the Kenai River and along the coast north to Nikiski, artesian sources at depths from 100 to 450 feet yield water of generally unsatisfactory quality. Most of these samples are of the sodium bicarbonate or sodium chloride type.

Groundwater quality data for the west side of Cook Inlet are sparse. The USGS sampled the Standard camp well at Beluga in 1975 and found soft water of the sodium bicarbonate type. The water was chemically acceptable from a health standpoint, but contained iron and manganese concentrations in excess of U.S. Public Health Service (USPHS) recommended limits. Samples collected for the applicant from wells in the village of Tyonek were generally within USPHS drinking water standards except for iron, hardness, taste, and odor, which represent aesthetic rather than health hazards. Samples collected in 1975 by the USGS at the Trading Bay Well (Lat. 60° 48' 46", Long. 151° 46' 58") had acceptable chemical quality, were hard, and of the sodium bicarbonate type.

d) Present Water Use

Total water use on the Kenai Peninsula is estimated to be from 5 to 5.5 million gallons per day (mgpd). 1/ Existing industrial, commercial, and residential users in the vicinity of the proposed liquefaction plant provide their own supplies by using individual wells. The industrial installations at Nikiski have developed the groundwater resource extensively, extracting some 3 mgpd from both water table and artesian sources. Directly north of the proposed liquefaction plant site, the Collier Carbon and Chemical Company plant uses the largest quantity of water in the area in producing fertilizer. Domestic

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1/ A. J. Fuelner, J. M. Childers, and V.W. Norman, "Water Resources of Alaska," USGS, Alaska District, Open File Report, Anchorage, 1971, pp. 48 and 49.

use of groundwater in the Kenai-Soldotna area is about 1 mgpd. Major water uses along the proposed route on the lower Kenai Peninsula are domestic and recreational, primarily supplied by groundwater sources.

On the west side of the inlet in the vicinity of the proposed project, water use is limited to the village of Tyonek, isolated cabin dwellers, petroleum exploration and scientific crews, and recreational users. Tyonek extracts about 50,000 gpd from subsurface sources.

e) Physical Oceanography

The Cook Inlet estuary consists of an approximately 180-mile long northeast-southwest trending indentation in the south-central Alaskan coastline. The estuary is formed by the confluence of the Knik and Turnagain Arms at its northern end near Anchorage and opens at its southern end into the Gulf of Alaska just east of the base of the Alaskan Peninsula. A topographical constriction formed by the East and West Forelands naturally divides the inlet into an upper and lower section. The environment can be characterized as high-energy, with tidal fluctuations in excess of 30 feet and current velocities over 6 knots.

i. Bathymetry

Cook Inlet is an open-ended basin varying from near 10 to over 30 miles in width. Relief exceeds 500 feet, ranging from tidal flats prevalent in the upper inlet to deeply scoured submarine channels.

The upper inlet is generally relatively shallow and siltladen. In the northern reaches of the upper inlet near Anchorage, channel depths average 60 feet.

Erosion by high-energy tidal currents appears to be the mechanism behind the scoured submarine channels. This phenomenon occurs in areas of restricted flow such as between the Forelands, where channel depths average 120 feet, or adjacent to bedrock outcrops and near-surface bedrock subcrops.

Asymmetrical sand waves occur in some areas where tidal currents are sufficiently strong. Sediment wave amplitudes in excess of 40 feet have been measured. Most sediment waves occur close to the scour channels.

A deep submarine channel lies approximately 4,500 feet from the east shore and is roughly parallel to the beach adjacent to the proposed liquefaction plant site. It is deeper than 130 feet, but water in excess of 60 feet below Mean Lower Low Water (MLLW) can be found less than 3,000 feet from shore. Water depths less than 15 feet below MLLW lie in a shoal area immediately west of the plant site about 3 miles offshore. Bathymetric features in the vicinity of the proposed plant site are presented in Figure 17. Bathymetry of the proposed marine pipeline crossing area is presented in Appendix B, Figure B-3.

ii. Tides and Currents

Tides in Cook Inlet are essentially diurnal but, as is common on the Pacific Coast, exhibit elements of a mixed tidal scheme, i.e., an inequality between the level of the consecutive high and low tides. The funneling effect generated by the Forelands subjects tidal amplitudes to considerable amplification as the tide moves up Cook Inlet. Figure 18 presents tidal range data from selected points within the inlet. The lag time between crests at the mouth and Anchorage is about 4.5 hours. 1/

1/ U.S. Army Corps of Engineers, FEIS on Offshore Oil . . ., p. 26.

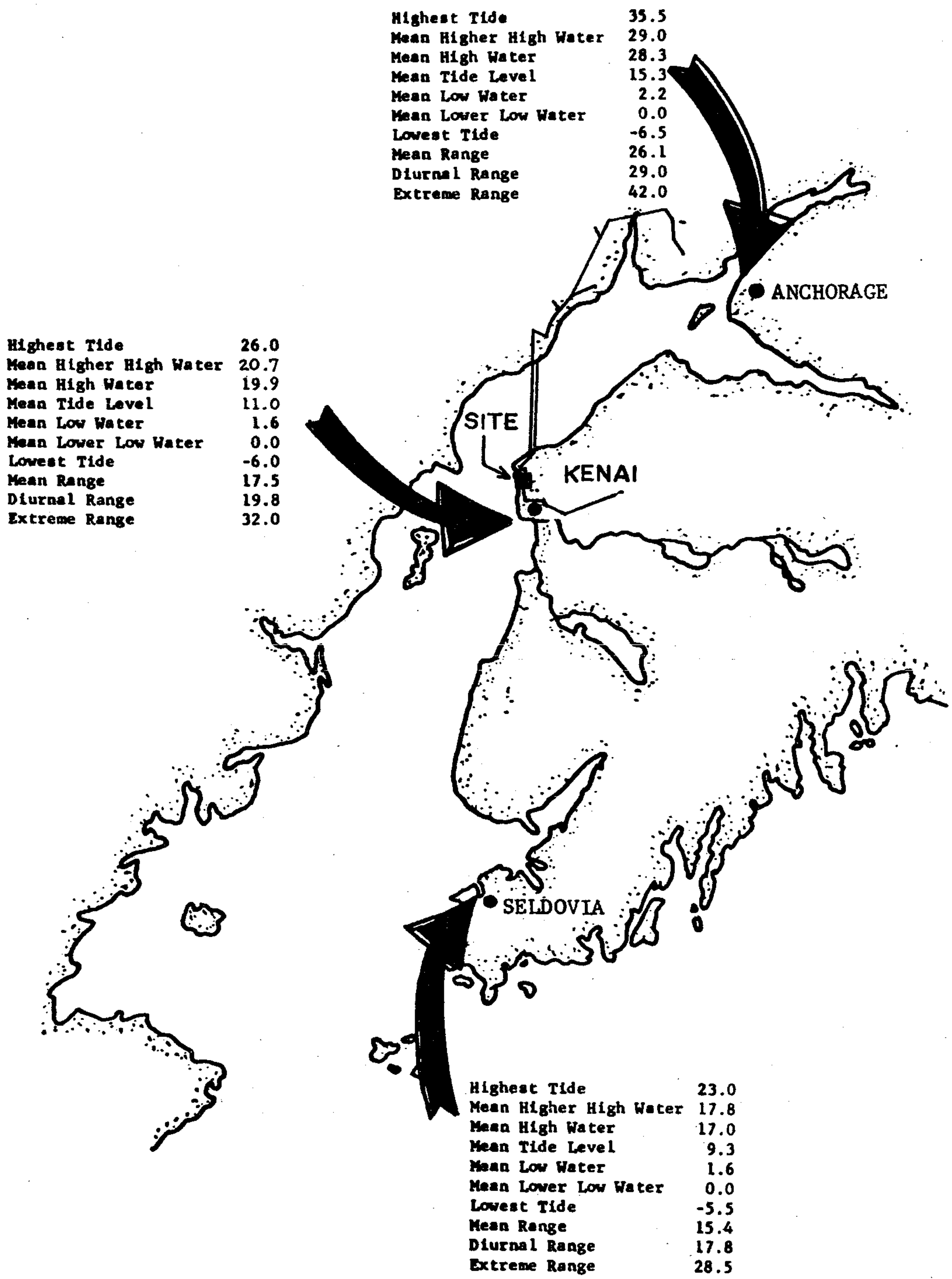

FIGURE 18

COOK INLET TIDES (IN FEET)

Source: U.S. Army Corps of Engineers, FEIS on Offshore Oil., p.27, and National Oceanographic and Atmospheric Administration, 1974, National Ocean Survey Chart No. 16660, Cook Inlet-Northern Part, Washington, D.C.

The Coriolis force, in conjunction with the inlet geometry and tidal currents, produces strong cross-currents and considerable turbulence during both ebb and flood tides. In the lower inlet, floodtides hug the eastern shoreline, while ebbtides are most severe on the western shore as a direct result of the Coriolis force. Another manifestation of this force is tidal ranges. The mean diurnal range on the eastern shore is 19.1 feet, while directly across the inlet the mean diurnal range is 16.6 feet. 1/

Tidal currents, which roughly follow land forms and bathymetric contours, are most severe at the Forelands. This constriction promotes a mean maximum velocity of 3.8 knots, with peaks greater than 6.5 knots during the monthly tidal extremes. 2/ Local tidal currents near 11 knots have been reported. Velocity magnitudes vary with the tidal range and stage, but maximums usually occur 2 to 3 hours behind the high and low tides. Tidal currents are, in general, strongest at midchannel and middepth.

Turnagain Arm is frequently subject to tidal bores up to 10 feet high, attributed to the river inflow and to the very shallow depth within the arm.

Adjacent to the proposed liquefaction plant site, the mean tidal range is 17.9 feet, with a diurnal range of 20.7 feet. Current velocities up to 3.8 knots can be expected during a mean tidal range, with velocities up to 6 to 7 knots during extreme ranges. Average velocities of the maximum flood and ebb tidal currents for the East Foreland vicinity are presented in Table 9. Peak velocities as high as 5.7 knots on the floodtides and 6.6 knots on the ebbtides were predicted for 1977 in the Nikiski and West Foreland areas. 3/

1/ D. L. Peterson and Associates, Water Resources Management for the Cook Inlet Basin/Kenai Peninsula Region, Vol. II (May 1971), 6-5.

2/ U.S. Army Corps of Engineers, FEIS on Offshore Oil . . ., p. 26.

3/ National Oceanic and Atmospheric Administration, Tidal Current Tables, 1977; Pacific Coast of North America and Asia, National Ocean Survey (Rockville, Md., 1976).

TABLE 9

AVERAGE VELOCITY OF MAXIMUM TIDAL CURRENTS, EAST FORELAND VICINITY

Station	Latitude	Longitude	Maximum Currents			
			Flood		Ebb	
			Velocity (Knots)	Direction (True)	Velocity (Knots)	Direction (True)
Kenai, 6 mi. SW	60°29'N	151°26'W	2.4	20°	2.6	195°
Kenai Packers Cannery Wharf	60°33'N	151°14'W	0.7	115°	1.4	285°
Kenai City Wharf	60°33'N	151°14'W	0.5	130°	1.4	300°
Nikiski	60°41'N	151°24'W	3.8	0°	2.6	180°
Nikiski, 0.8 mi. W	60°41'N	151°25'W	3.8	345°	3.6	175°
West Foreland, midchannel	60°45'N	151°32'W	3.8	25°	3.8	205°

Source: National Oceanic and Atmospheric Administration. Tidal Current Tables, 1977. Pacific Coast of North America and Asia, 1976. National Ocean Survey. Rockville, MD.

Other factors important in the dynamics of the inlet are surface wind currents and wind-generated waves. Given sufficient fetch (length of the water body) and duration, a wind speed of 33 knots could hypothetically induce a surface drift current of approximately 1 knot. Wind speeds of this magnitude have been recorded less than 0.1 percent of the time in the Kenai area. 1/

A related phenomenon is wind-generated waves. As with wind currents, the development of wind waves is a function of wind speed, wind duration, and fetch. The proposed marine terminal area is protected from wind-generated waves from the north, east, and south-southeast. Winds in these directions, taken together with periods of calm, occur about 70 percent of the time. 1/ The most severe conditions can be expected to develop during winds from the south-southwest -- i.e., along the longitudinal axis of the inlet. In this direction, the fetch approaches 250 miles. Available information indicates that maximum wave heights of 10 to 12 feet occur about three times per year.

While the proposed pipeline route across the broad McArthur-Chakachatna River Delta would be exposed to wind-generated waves throughout an approximately 135° arc from the northeast to the south, inundation of the route by wind waves would not be expected to represent a significant hazard once the pipeline was emplaced.

Detailed studies of the tides, tidal currents, and salinity-temperature-depth profiles have recently (1973-1975) been conducted in Cook Inlet by the National Ocean Survey, U.S. Department of Commerce. In addition, the National Ocean Survey is currently preparing a numerical model of the inlet tidal dynamics.

1/ National Oceanic and Atmospheric Administration, "Revised Uniform Summary of Surface Weather Observations, Kenai Alaska, Aug. 1948-July 1967" (Ashville, N.C., 1972).

iii. Circulation and Sediments

Many of the freshwater sources discharging into Cook Inlet have high suspended sediment loads. Table 10 lists the major sources of sediment in the inlet and the sediment loads during the high runoff. An average of 206,000 tons of sediment per day is transferred and deposited in the inlet during seasonal periods of high runoff. Materials range from coarse gravels and cobble-sized aggregates to fine sands, silts, and clays. During the remainder of the year, only the smaller grain sizes are delivered.

Bathymetry, freshwater influx,and tidal effects result in a distinctive divisioning of the inlet into three circulatory environments. These environments roughly correspond to three depositional environments (based on the bottom sediment grain-size distributions; see Figure 19). The depositional boundaries of these environments are distinct and well-defined.

Waters in the upper environment are well-mixed in all dimensions by the basin configuration and large tidal ranges. During the summer when freshwater contributions are high, a net seaward mass movement of up to 1 mile occurs during each tidal cycle. In winter, however, when glacial meltwater flow is reduced and precipitation is stored up as snow, almost no net outflow takes place, and water simply shifts back and forth with the tides. Bottom sediments found in the upper depositional environment are predominantly sand.

Some of the highest tidal velocities in the region occur in the constriction between the Forelands in the middle circulatory environment. Such velocities result in turbulence sufficient to produce thorough vertical mixing. Lateral mixing, however, is inhibited by the strong Coriolis force. Inflow consists of saline

TABLE 10

MAJOR SOURCES OF SEDIMENT IN COOK INLET

Region	River	Sediment (May-Sept.) ton/day		
		Mean	Maximum	Minimum
Lower	Ninilchik R.	12	204	2
	Kenai R.	170	320	53
Upper	Susitna R. *	84,000	207,000	2,870
Knik Arm	Ship Creek	11	13	9
	Eagle R.	1,725	12,000	2
	Knik R.	58,100	518,000	150
	Matanuska R.	52,440	190,000	10

Bathymetry, freshwater influx, and tidal effects result in a distinctive divisioning of the inlet into three circulatory environments. These environments roughly correspond to three

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* Note: Values multiplied by 3.19, which is the ratio of the total watershed area to the area tributary to gauge location.

Source: D. L. Peterson & Associates, Water Resources Management for the Cook Inlet Basin/Kenai Peninsula Region, Vol. II (May 1971), p. G-7.

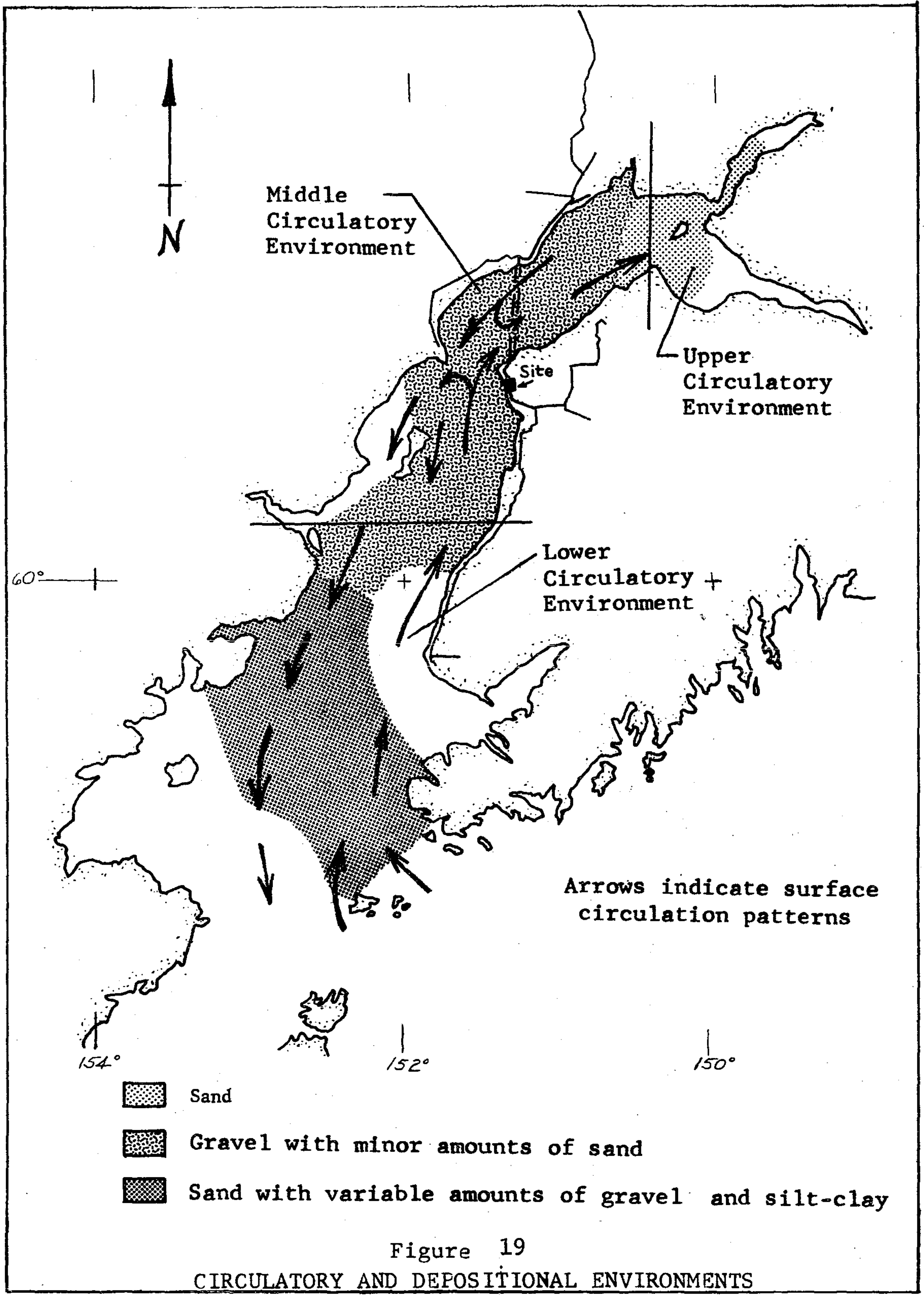

Figure 19

CIRCULATORY AND DEPOSITIONAL ENVIRONMENTS

Source: G.D. Sharma and D.C. Burrell, "Sedimentary Environment and Sediments of Cook Inlet, Alaska," American Association of Petroleum Geologists Bulletin (April 1970), p. 647, and U.S. Army Corps of Engineers, Alaska District, FEIS on Offshore Oil and Gas Development in Cook Inlet, Alaska (Anchorage, 1974), pp. 248-9.

oceanic waters which hug the eastern shoreline. The outflow is highly diluted by fresh runoff water from the Susitna and Knik Arm Rivers and closely follows the western shore. This lateral division is further illustrated by the surface salinity distributions shown in Figure 20. Bottom sediments in the middle depositional environment are primarily gravel (50 to 100 percent), with minor amounts of sand. 1/

Water masses in the lower circulatory environment appear stratified according to their salinities. Vertical stratification develops on the western side of the inlet between the colder, more saline oceanic waters and the warmer, less saline inlet waters. Around the latitude where the lower and the middle circulatory environments meet (see Figure 19), mixing is accomplished on floodtides as the incoming oceanic waters are forced toward the surface by the rising basin bottom. Sediments in the lower depositional environment are primarily sand with variable amounts of gravel and silt-clay.

Cook Inlet is flushed primarily by freshwater influx which creates a net advective flow or flushing rate. The following estimates of the net advective flow have been made by dividing the inlet into sections and calculating the volumes of water in each section at the Mean Tidal Level (MTL) (Figure 21). 2/

	Section	Mean Upstream Inflow 2/ (10^6 ft^3/day)	Volume at MTL 2/ (10^9 ft^3)	Mean Residence Time (days)	Net Advective Flow (mi/day)
Knik Arm	1	1,430	85	59	0.678
Turnagain Arm	2	57	68	1,193	0.042
Upper Cook Inlet	3	7,137	1,470	206	0.267
Central Cook Inlet	4	8,237	4,160	505	0.129

1/ Sharma and Burrell, p. 653.

2/ Peterson & Associates, p. G-12.

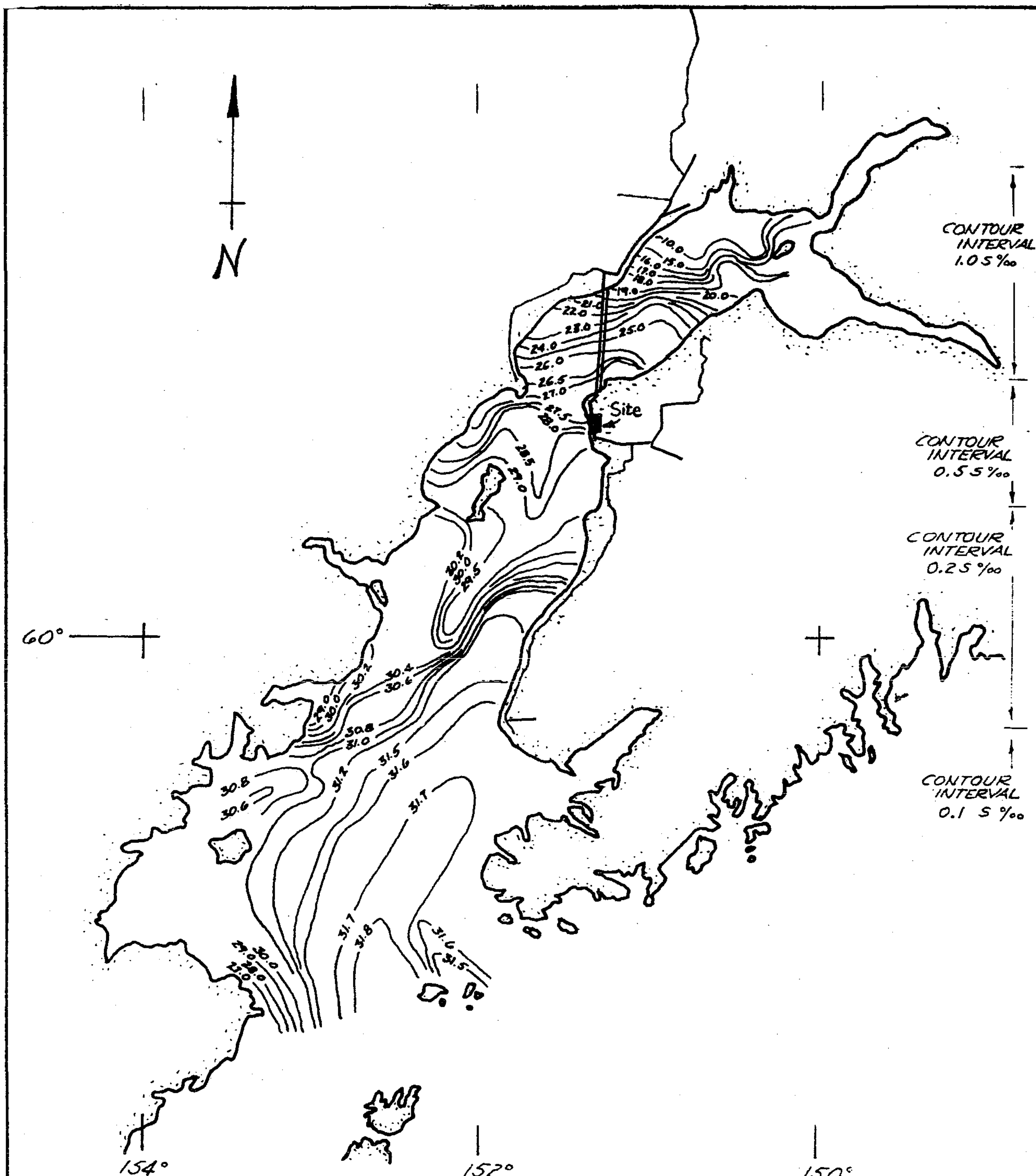

FIGURE 20

SURFACE SALINITY DISTRIBUTION

Source: U.S. Army Corps of Engineers, FEIS on Offshore Oil..., p. 250.

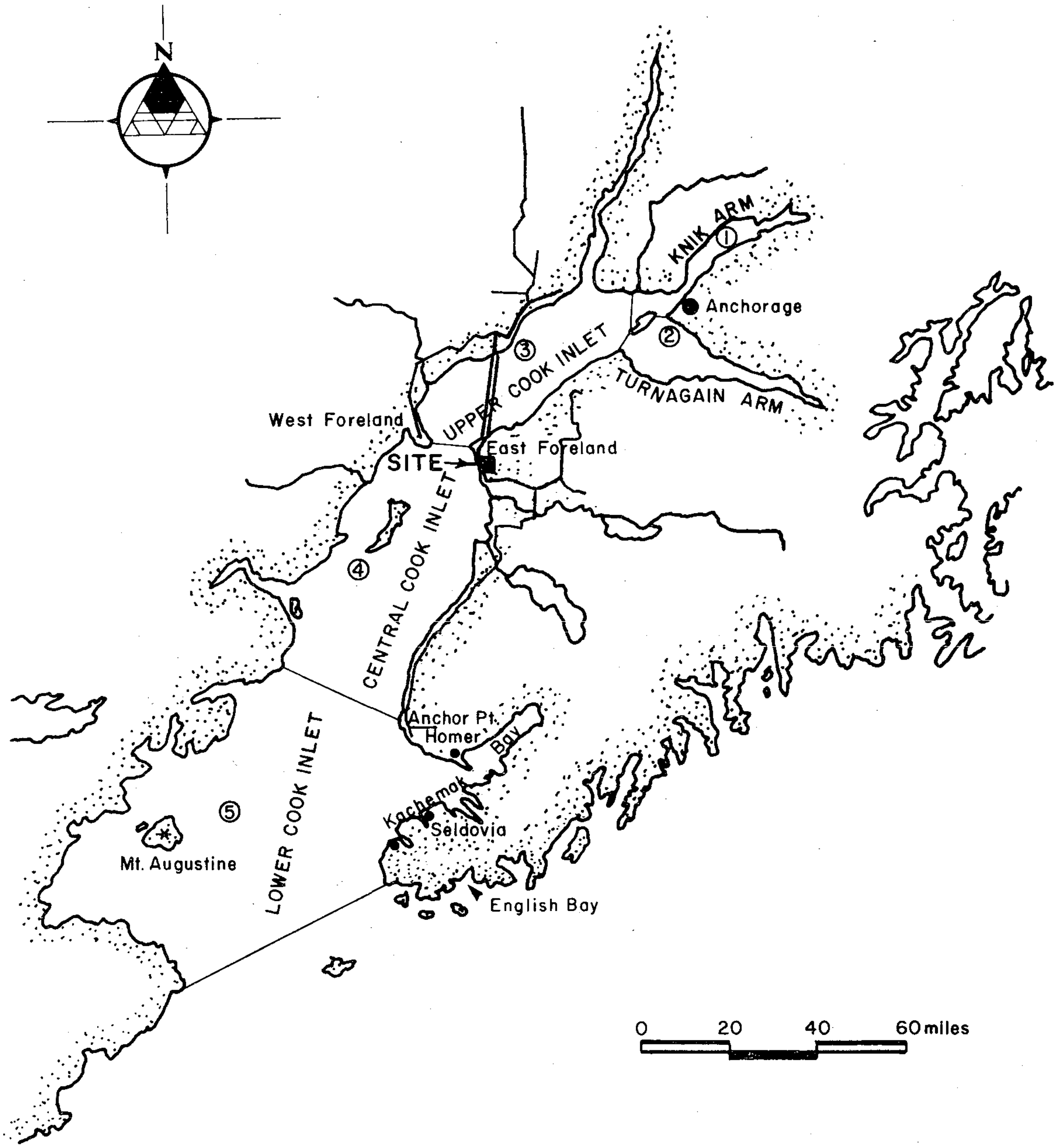

FIGURE 21

DIVISIONS OF COOK INLET

These data indicate that a complete exchange of water in the inlet above Anchor Point (except for the waters in Turnagain Arm) will occur about every 500 days. The greater portion of this exchange can be expected to occur during the summer.

iv. Water Characteristics and Quality

Baseline water quality data were obtained from the applicant and from literature published by the Institute of Water Resources at the University of Alaska. Table 11 presents a summary of the physical and chemical parameters measured at sampling stations presented in Figure 22.

Temperatures -- Water temperature is seasonal, from above 59°F. in the summer to below 32°F. during the winter. In areas influenced by large river flows, warmer water can sometimes be found during the winter. Indications of thermal stratification in the upper inlet are absent because measurements taken at the surface, middepth, and bottom generally vary less than 0.18°F. 1/

Suspended Sediments -- The waters of Cook Inlet have a heavy suspended sediment load. The amount of suspended material present varies according to location, depth, tidal phase, and season. Extreme ranges reportedly extend from near 0 mg/l at the mouth of the inlet to over 3,000 mg/l in Knik Arm. Near Nikiski, suspended sediments values ranged from 26 mg/l to 840 mg/l, with 100 mg/l to 300 mg/l being average.

Salinity -- Salinity values for water in Cook Inlet vary considerably, both by season and by area. At the mouth of the inlet, values remain at or very near 32 parts per thousand (ppt) all year long. Near Anchorage,

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1/ R. S. Murphy, R. F. Carlson, D. Nyguist, and R. P. Britch, Effect of Waste Discharges into a Silt-Laden Estuary; A Case Study of Cook Inlet, Alaska, Institute of Water Resources, University of Alaska, Report IWR-26 (1972), p. 15.

TABLE 11

SUMMARY OF PHYSICAL AND CHEMICAL OCEANOGRAPHIC PARAMETERS[1]

MONTH	J	F	M	A	M	J	J	A	S	O	N	D
					SALINITY (ppt)							
# Casts	2	6	6	10	14	14	22	14	4	19	1	0
Minimum	25.4	27.7	27.2	27.6	27.9	24.4	21.2	19.4	25.2	23.7	26.7	N/A
Average	27.8	29.3	28.5	28.7	29.4	28.0	24.6	23.8	26.1	25.5	27.4	N/A
Maximum	29.0	31.1	30.0	29.9	30.0	29.1	27.3	27.3	27.3	27.1	27.8	N/A
					WATER TEMPERATURE (°C)							
# Casts	1	6	2	9	10	10	18	12	2	17	2	0
Minimum	-2.1	-1.8	-1.6	-0.8	2.9	8.4	11.4	12.3	11.0	6.0	1.8	N/A
Average	-1.8	-1.3	-1.2	-015	3.3	8.8	12.6	13.8	11.2	7.9	2.3	N/A
Maximum	-1.4	-1.0	-0.6	0.4	3.5	9.1	14.3	15.2	11.3	11.6	3.3	N/A
					SUSPENDED SEDIMENTS (mg/l)							
# Casts	2	6	6	10	14	14	24	0	0	0	2	0
Minimum	34	37	147	170	86	33	26	N/A	N/A	N/A	111	N/A
Average	101	204	280	465	209	131	126	N/A	N/A	N/A	152	N/A
Maximum	212	444	530	840	333	256	312	N/A	N/A	N/A	188	N/A
					NITRITE (μg/l NO_2-N)							
# Casts	2	6	6	10	14	14	20	12	2	10	2	0
Minimum	2.4	0.6	0.7	1.3	2.2	1.8	2.0	1.3	2.8	0.6	2.8	N/A
Average	3.6	1.7	2.7	2.2	3.2	3.4	3.4	2.8	3.6	1.1	3.6	N/A
Maximum	5.3	4.8	9.4	4.9	5.9	6.7	6.3	4.3	4.9	2.9	4.9	N/A
					NITRATE (μg/l NO_3-N)							
# Casts	2	2	6	10	14	14	20	12	2	10	2	0
Minimum	189	196	204	203	150	87	41	66	102	151	174	N/A
Average	196	197	223	216	210	192	126	120	118	164	178	N/A
Maximum	203	200	238	225	227	218	218	185	172	364	182	N/A
					AMMONIA (μg/l NH_3-N)							
# Casts	0	4	4	10	14	14	20	12	2	10	0	0
Minimum	N/A	7.0	11.2	1.4	0.0	1.4	1.4	8.4	9.8	16.8	N/A	N/A
Average	N/A	15.4	16.8	5.6	8.4	5.6	11.2	18.2	16.8	25.2	N/A	N/A
Maximum	N/A	30.8	28.0	25.2	32.2	15.4	28.0	49.0	49.0	37.8	N/A	N/A

[1]Summary includes data from Stations 1-5 and 7-8, Figure

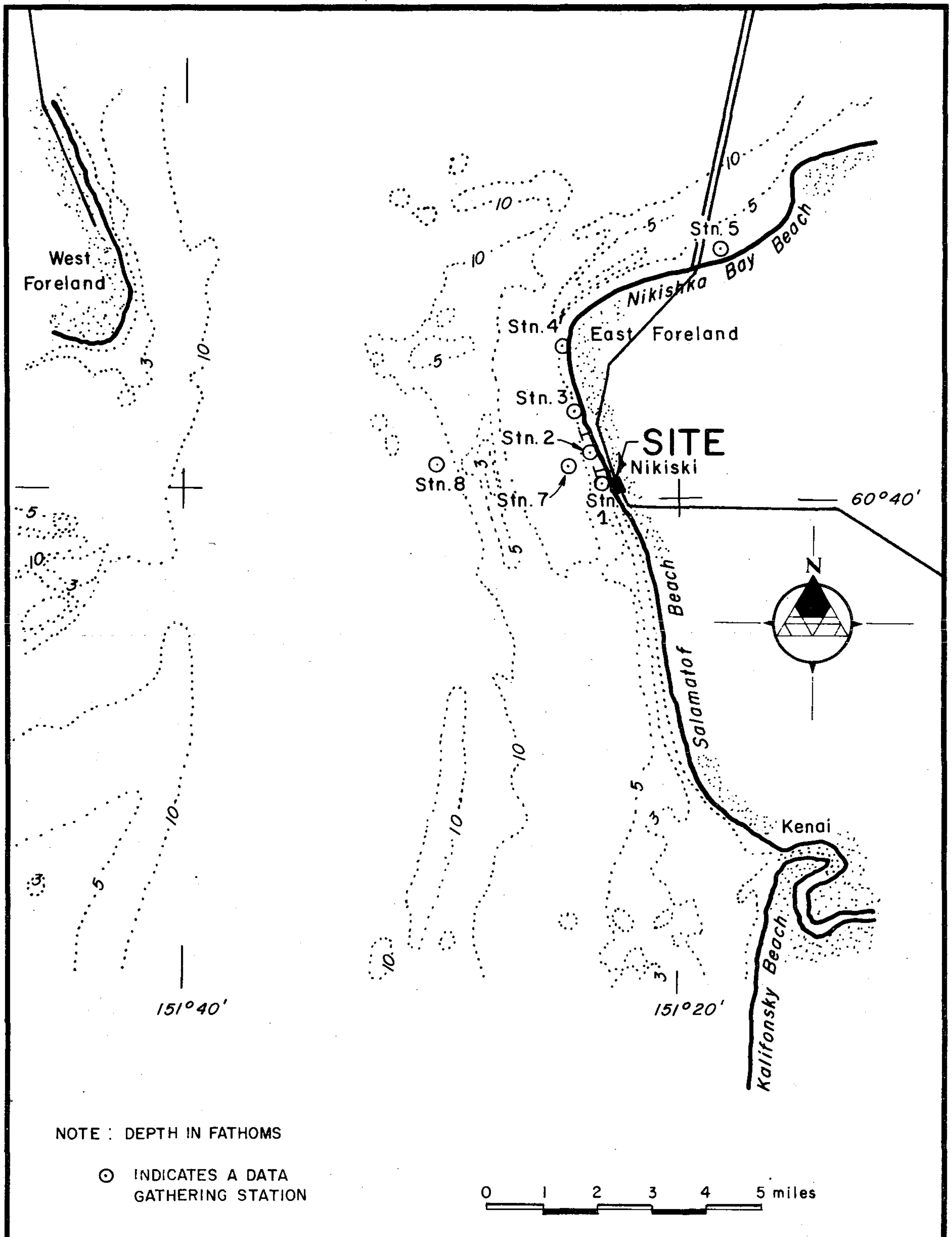

FIGURE 22
OCEANOGRAPHIC SAMPLING STATIONS

the salinity fluctuates from slightly over 20 ppt during the winter to as low as 6 ppt in the summer. 1/ Measurements near East Foreland range from 31 ppt in February to 19 ppt during August.

In the upper inlet, limited vertical stratification occurs where freshwater streams feed the estuary in the absence of strong turbulence. In general, variations of less than 1 ppt from top to bottom are detected, while concentrations vary with latitude.

pH -- Measurements taken in June 1967 indicated a pH range extending from 7.7 to 8.4, increasing toward the mouth of the inlet. In the Knik Arm, reported values range from 7.7 in May to just over 8.3 in August. Little variation was detected in the Knik Arm, either by area or by depth.

Dissolved Oxygen -- In Cook Inlet, the predominately low temperature and high turbulence maintains dissolved oxygen (DO) at or near saturation levels. A slight decrease can be expected when ice covers parts of the inlet during the winter. Biological consumption of DO is minimal during these periods, however, and relative levels remain high because of depressed water temperatures.

Nutrients -- Total nutrient concentrations gradually increase toward the mouth of Cook Inlet. Nitrate is the sole parameter which significantly deviates from this trend.

Trace Metals -- No data are available on the occurrence and distribution of trace metals in Cook Inlet.

Hydrocarbons -- Analysis of water, suspended sediment, and bottom sediment samples for low and high molecular weight hydrocarbons indicates a lack of gross pollution by accumulated hydrocarbons.

1/ Murphy, *et al*., p. 15.

Discharged Wastes -- Wastes discharged into Cook Inlet are primarily from three sources: domestic sewage, fishery industries waste, and oil and petrochemical industrial waste. Table 12 presents a list of significant discharges and their sources.

An estimated 12.5 mgpd of domestic sewage is discharged into Cook Inlet, the vast majority of which enters at Anchorage. Secondary treatment facilities are either in operation or planned for all other large communities discharging into the inlet.

Discharges from fishery industries occur between April and September. During their operation, some 2.4 mgpd of wastewater are discharged into the inlet. This flow contains in excess of 7 million pounds of canning processing wastes which create localized problems such as DO depletion during the season and for a short period afterward.

Oil and petrochemical industry discharges into the inlet are estimated at 33.3 mgpd. The portion contributed by each drilling platform averages 1.5 to 2.5 mgpd. Water withdrawn for cooling purposes is usually processed through oil separators before being discharged into Cook Inlet. Secondary treatment facilities are used both on and offshore for sanitary wastes if the wastes are discharged into the inlet. Ballast waters are generally subjected to oil separation techniques prior to discharge.

A number of accidental discharges, primarily involving oil, have occurred in recent years. The majority of spills of known causes involve drilling platforms, but the largest volume of spills result from tanker accidents or marine oil pipeline breaks. A list of spill incidents tabulated by the Corps of Engineers from 1962 trhough 1974 can be found in Table A-18 of its Final Environmental Impact Statement on Offshore Oil and Gas Development in Cook Inlet, Alaska.

v. Ice Conditions

Sea ice usually covers Cook Inlet above the Forelands from late November through March, April, or May. During

TABLE 12

WASTE DISCHARGES INTO COOK INLET

Domestic	Type of Treatment	Average Flow (mgpd)
Palmer	Secondary	0.25
Eagle River	Secondary	0.22
Fort Richardson	None	1.11
Anchorage	Primary	10.0 (est.)
Kenai	Secondary	0.50
Soldotna	Secondary	0.25
Homer	Secondary	0.10
Seldovia	None	0.03
Drilling Platforms	Secondary	0.03
Others	Varies	0.03
	Subtotal:	12.52
Fisheries Industry		
Columbia Ward, Kenai Packers } at Kenai	None	0.75 (est.)
Alaska Seafood at Homer	Chlorination	0.16
Others	None	1.50 (est.)
	Subtotal:	2.41
Oil and Petrochemical Industry		
Tesoro at Nikiski	Secondary	0.12
Standard at Nikiski	Oil Separation	0.75
Phillips at Nikiski	Secondary	0.06
Collier at Nikiski	Special	0.70
Marathon at Trading Bay	Oil Separation	0.53
Cook Inlet Pipeline Co. at Drift River	Oil Separation	1.10
Drilling Platforms	Oil Separation	30.00 (est.)
	Subtotal:	33.26
	Cook Inlet Total:	48.19

this season, large tidal fluctuations, strong currents, and the diurnal influx of oceanic waters keep the upper inlet ice shattered into small individual floes pushed together by the wind and currents. Although the net mass movement during ebbtides is toward the sea, the topographic constriction at the Forelands retards the movement of ice south from the northern part of the inlet. This results in a concentration of the floes above this narrow neck until the floodtide fragments the mass as it moves it back towards the north. However, ice floes -- some up to 2 miles in diameter -- have travelled about 25 miles per tidal period. 1/ Ultimately, some floes escape the upper inlet and can be carried as far south as Anchor Point before melting in the warmer water. The formation of large concentrations of ice in the lower inlet is limited to occasions when the air temperature is extremely low for prolonged periods.

Since temperature controls ice growth in the upper inlet, ice thickness can be forecast on the basis of frost degree days. A frost degree day is equal to each 1°F. (daily mean temperature) below a base of 32°F. Table 13 presents the cumulative frost degree days for eight recent winters (1964-1971) at Anchorage. While the climate of the inlet is cold enough to create an ice cover 3.5 feet thick, 1/ thicknesses up to 20 feet have been reported. Ice averages about 2.5 feet thick. 2/

Successive freezing of water in the intertidal zone produces shorefast ice. Although these formations generally result in ice thicknesses of 15 to 20 feet, theoretical thicknesses are limited only by the maximum tidal range at a particular site. Shorefast ice may be expected to occur over portions of the proposed pipeline route in the vicinity of the Ivan River and Stamp Lake Fields, since the flat, low-lying coastal topography is particularly subject to tidal flooding up to several

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1/ H. R. Peyton, Sea Ice Strength, Geophysical Institute, University of Alaska, Report UAG R-182 (1966), p. 136.

2/ U.S. Army Corps of Engineers, FEIS on Offshore Oil . . ., p. 280.

TABLE 13

CUMULATIVE FROST DEGREE DAYS AT ANCHORAGE, ALASKA

YEAR	By Nov. 30	By Dec. 31	By Jan. 31	By Feb. 28
1964-65	313	1,270	1,948	2,554
1965-66	338	918	1,068	2,086
1966-67	429	1,080	1,848	2,335
1967-68	133	626	1,228	1,480
1968-69	290	1,083	1,929	2,317
1969-70	265	369	1,078	1,157
1970-71	362	895	1,814	2,153
1971-72	409	897	1,688	2,225

SOURCE: R. J. Hutcheon, Sea Ice Conditions in Cook Inlet, Alaska During the 1971-72 Winter, NOAA Technical Memorandum NWS AR-8 (1973), p. 11.

miles inland. Other large piles of ice called stamukhi are formed on the inlet's tidal flats. During high tides, ice floes are deposited higher up on the flats or on top of beach ice, forming piles which assume essentially vertical sides as the tides recede and the overhanging portions break away. Unusually high tides may then cause these piles, sometimes greater than 40 feet thick, 1/ to go adrift.

Records of the cumulative distribution of frost degree days have been kept since the winter of 1923-24. Using the ice season of 1970-71 as a base, some idea of expected ice conditions within the inlet can be obtained. Figure 23 compares the cumulative distribution of frost degree days for the coldest winter on record (1955-56), the warmest winter (1930-31), and the winter of 1970-71.

During the 1970-71 ice season, Hutcheon recorded the first ice sighting on the 17th of October. The inlet was not ice-free until the 20th of May. The worst period appears to have occurred at the end of January, when ice extended as far south as Cape Douglas on the western side of the inlet and as far as Anchor Point on the eastern side, with shorefast ice extending up to 3 miles off the northern shore of Kachemak Bay. Ice floes were estimated to thicken at the rate of about 1 inch per day. 2/

Although ice frequently causes some difficulties to shipping during the winter, controversy exists as to the severity of the problem. A review of the existing literature concerning ice conditions and navigation in Cook Inlet suggests that by taking advantage of the floodtide currents and other available knowledge concerning ice conditions, schedules allowing for minor down-time periods may be maintained for most locations in the inlet. For example, Sea-Land ships have reportedly made scheduled trips to Anchorage at least once a week for the last 10 years without undue ice delay. 3/

1/ R. J. Hutcheon, Sea Ice Conditions in Cook Inlet, Alaska During the 1970-71 Winter, NOAA Technical Memorandum AR 7 (1972), p. 6.

2/ Hutcheon, Sea Ice Conditions . . ., p. 5.

3/ Soros Associates International, Inc., "Preliminary Design for Coal Loading Marine Facilities at Cook Inlet, Alaska" (June 1975), p. 15.

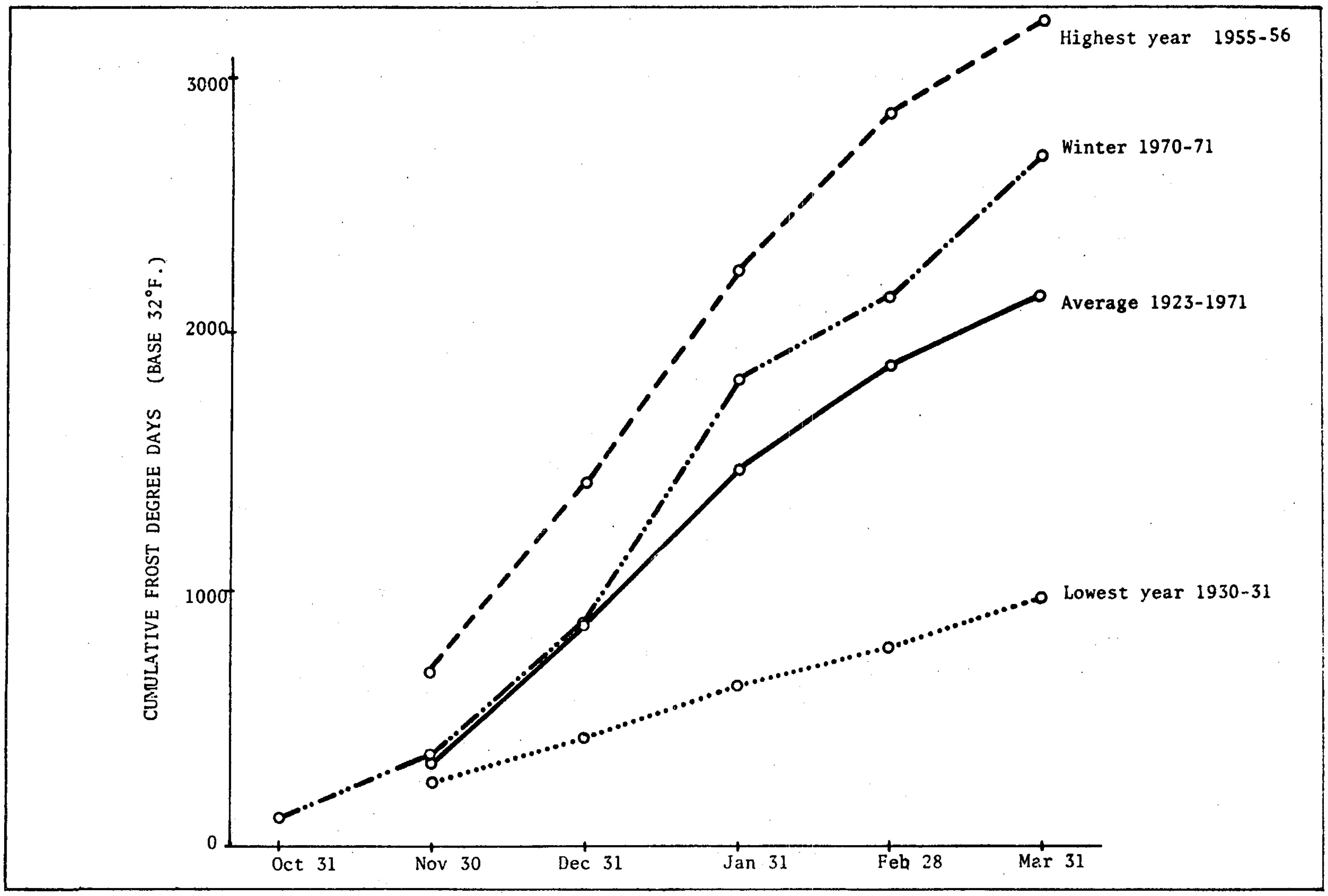


Figure 23

<u>Total Frost Degree Days - Anchorage, Alaska</u>

Source: U.S. Army Corps of Engineers, <u>FEIS on Offshore Oil...</u>, p. 28.

Note: Data for 1925-26, 1926-27, and 1928-29 missing.

During certain periods of the winter, berth securing for the extended time required to load a typical LNG transfer vessel (10 to 12 hours) is somewhat less certain. In the course of tidal changes, the force of current-motivated ice floes against a ship can effectively prevent its docking or, if previously docked, can be sufficient to virtually tear the vessel away from its moorings. A similar problem occurs when ice builds up between docked ships and the shore, again placing mooring lines and loading arms under sufficient stress to cause failure. The response to such stresses and impending failure typically is an emergency disconnect or controlled breakaway. Such incidents have been documented in recent years (see Table 14) for the existing marine facilities at Nikiski.

In designing oil platforms, the forces exerted by winds, waves, or earthquakes are generally considered minimal compared to ice forces. In upper Cook Inlet, however, ice forces are the overriding factor in structural design by four times. 1/

Available reports indicate that the most severe ice conditions in Cook Inlet occur during January, February, and March. Other difficulties caused by sea ice include vessels being frozen fast (Drift River terminal, January 1971) and damage occurring during collisions with stamukhi and partially submerged floe ice. Sea ice occasionally pulls dock pilings free, as it did at Anchorage during the 1967-78 winter. 2/

The proposed liquefaction plant site at Nikiski is partially protected from ice problems during the ebbtides by the East Foreland and dominant circulation patterns which shift ebbtide flows toward the western shoreline. Ice conditions for a particular area, however, change quite rapidly in response to shifting wind direction and magnitude.

1/ U.S. Army Corps of Engineers, FEIS on Offshore Oil . . ., p. 29.

2/ R. J. Hutcheon, Sea Ice Conditions in Cook Inlet, Alaska During the 1969-70 Winter, NOAA Technical Paper AR-6 (1972), p. 1.

TABLE 14

ICE- AND CURRENT-RELATED INCIDENTS
FOR THE PORT OF NIKISKI AND COOK INLET
1971-1975

DATE	LOCATION	DESCRIPTION
* 1-12-71 1-13-71	Phillips-Marathon Terminal	Loading of LNG ship slowed or stopped for a total of 5 hours due to ice. One mooring line broken during docking.
1-23-71	Cook Inlet	Ice damage to tug rudder.
* 2-2-71	Near Kasilof	LNG ship approaching Nikiski forced to turn back when ice plugged main condenser.
2-5-71	Between Anchor Point and Drift River	Tanker collided with ice.
* 2-23-71	Phillips-Marathon Terminal	Saltwater system of LNG ship plugged repeatedly by ice while loading at dock. Some pressure exerted on ship by ice wedged between shore and ship.
* 3-14-71	Phillips-Marathon Terminal	Ice wedged between shore and LNG ship, breaking two mooring lines and forcing pilot to abandon docking.
* 3-15-71	Phillips-Marathon Terminal	Critical ice pressure curtailed loading of LNG. Vessel was unable to resume loading position until next flood tide.
1-14-72	Drift River	Tanker emergency disconnect due to ice flow; spilled ½ bbl crude.
1-25-72	Cook Inlet enroute to Drift River	Tanker collided with ice.
1-27-72	Cook Inlet off Kasilof	Tug collided with ice.
1-27-72	Kachemak Bay	Vessel pushed ice through stern while mooring.
2-4-72	5 miles south Cape Ninilchik	Rig pusher and barge collided in ice.
2-10-72	Anchorage Port	Vessel collided with dock.
3-7-72	Cook Inlet enroute Homer to Drift River	Vessel collided with ice.
* 3-14-72	Phillips-Marathon	LNG vessel unable to dock due to heave ice concentrations and strong currents resulting from 26.4-foot tidal change.
* 3-15-72	Phillips-Marathon	Mooring line of LNG ship broken due to ice pressure and winch problem. Extreme ice conditions coupled with 27.8-foot tidal change caused delay in loading LNG.
* 3-16-72	Phillips-Marathon Terminal	Repeated ice problems occurred while LNG ship was attempting to load LNG. Emergency disconnect required.
3-16-72	Collier Carbon and Chemical Terminal	Barge collided with ice; caused by ice flow.
* 3-18-72	Phillips-Marathon Terminal	Extreme ice conditions and tidal change of 27.5 feet halted loading of LNG and later required emergency unmooring.
3-21-72	Cook Inlet	Tanker collided with ice.
* 3-22-72	Phillips-Marathon Terminal	Loading of LNG delayed twice due to ice conditions.
3-24-72	Near Platform "Baker"	Rig tender collided with ice and fixed object.
4-4-72	Collier Carbon and Chemical Terminal	Vessel collided with ice and dock.
2-14-73	Drift River	Tanker emergency disconnect due to ice flow; spilled 10 bbls. crude.
* 2-19-73	Collier Carbon and Chemical Terminal	Vessel attempting to load broke away from dock due to ice conditions. LNG ship advised to delay approaching Nikiski as a result.
3-23-73	Cook Inlet	Ice damaged vessel fuel tank; spilled 350-400 gal. diesel.
* 2-20-74	Phillips-Marathon Terminal	Loading of fuel oil aboard LNG vessel delayed because of severe ice conditions.
3-10-74	Cook Inlet	Oil tanker required emergency disconnect due to ice conditions; spilled 8-10 bbls crude.
* 1-8-75	Standard Oil Terminal	Oil tanker broke loose from dock, narrowly missing collision with LNG ship moored at Phillips-Marathon Terminal.
* 3-25-75	Standard Oil Terminal	Oil tanker was unable to dock during ebb tide because of strong currents. LNG vessel crew at Phillips-Marathon Terminal placed on standby in case oil tanker drifted toward the LNG vessel.

Source: U.S. Army Corps of Engineers, Alaska District, FEIS on Offshore Oil and Gas Development in Cook Inlet, Alaska (Anchorage, 1974), p. 30, and J. B. Hayes, Rear Admiral, U.S. Coast Guard, Letter to the Federal Power Commission dated November 14, 1975.

* Material contributed by U.S. Coast Guard.

Under the influence of a southwesterly wind, ice could be routed directly toward the proposed marine terminal area. Ice conditions are most severe at Nikiski during the last 2 or 3 hours of a floodtide, particularly a high floodtide, in conjunction with a southwesterly wind. When conditions such as these occur, they frequently result in docking and berth securing problems.

Table 14 lists ice- and current-related incidents which occurred in Cook Inlet from 1971 through 1975. This presentation, originally taken from the U.S. Army Corps of Engineers, has been updated with information related solely to the port of Nikiski provided by the U.S. Coast Guard. 1/

vi. Tsunamis

Historic records of tsunami activity in Cook Inlet prior to 1938 are few and unreliable because the area is relatively undeveloped and unpopulated. The record is believed to be complete since 1938, during which time only one significant tsunami has been recorded. This occurred in response to the so-called Great Alaskan or Prince William Sound earthquake of March 1964, which generated several local and one major tsunami. The major wave originated in the Gulf of Alaska and resulted in considerable damage to waterfront and boats along the Kenai Peninsula. The maximum runup height (amplitude) of the wave as measured at Seldovia, some 90 miles south of the proposed liquefaction plant site, was 4 feet. 2/

The largest tsunami ever recorded in the inlet occurred in response to an eruption of Mt. Augustine in October 1883. Although no observations were made during this phenomenon, the wave runup height was recorded at Port Graham on English Bay, some 100 miles south of the proposed plant site, as 25 to 29 feet. 2/

1/ Rear Admiral J. B. Hayes, Letter to the Secretary of the Federal Power Commission dated November 14, 1975. (See Appendix F.)

2/ D. C. Cox and G. Pararas-Carayannis, Catalog of Tsunamis in Alaska, U.S. Coast and Geodetic Survey (1969), p. 26.

The bathymetry and orientation of Cook Inlet, in conjunction with its turbulent tides and currents, are unfavorable for the entrance and propagation of tsunamis generated outside the inlet itself. The protected location and topography at the inlet mouth, including the shoaling effects of the Barren Islands, would reflect and dampen some of the tsunami energy. The result would be waves of shorter period and lower amplitude entering the inlet. Seismic disturbances occurring within the inlet or a major eruption of Mt. Augustine could produce a wave similar to the one observed on English Bay. The result could cause significant damage to vessels and low-lying coastal facilities. However, the 100-foot seabluff at the proposed liquefaction plant site is expected to protect the plant and associated facilities.

6. Vegetation

The proposed 59.3-acre LNG plant site located on the northwestern coast of the Kenai Peninsula was vegetated until recently with 40 acres of spruce-hardwood forest. The remainder of the site had been cleared by a previous owner. Since the DEIS was issued, it has come to the attention of the environmental staff that the site has been completely cleared and surfaced with gravel. Only a smattering of spruce trees remains around the periphery of the site.

A steep 100-foot bluff, upon which a few small shrubs and grasses grow, forms the western boundary of the site. The northern site boundary is the property line of the Collier ammonia and urea plant; the eastern boundary is the North Kenai Road; and the southern boundary is forested with vegetation similar to that which previously occurred on the site.

The proposed haul road leading up the bluff from the construction dock south of the plant site would pass through the same type of vegetation as that which occurred on the plant site. About 3 to 4 acres of trees would be removed during the construction of the haul road.

Nine different terrestrial vegetative communities are recognized in this area of Alaska. These communities are: coastal Sitka spruce forest, bottomland spruce-poplar forest, upland spruce-hardwood forest, lowland spruce-hardwood forest, high bush, bog and muskeg, moist tundra, wet tundra, and alpine tundra (Figure 24).

A mixture of upland spruce-hardwood and lowland spruce-hardwood forest types dominate the wooded portions of the proposed haul road, Nikiski to Nikiski Bay pipeline corridor, and the Nikiski to West Fork, Beaver Creek, Swanson River, and Birch Hill laterals. Upland spruce-hardwood forest also dominated the LNG site until it was cleared. The common tree species of these two forest types are white spruce, black spruce, Alaska paperbirch, quaking aspen, balsam poplar, and black cottonwood. Common shrubs are willow, alder, dwarf arctic birch, high bush cranberry, blueberry, raspberry, crowberry, bearberry, and Labrador tea. The herbaceous layers of these two forest types are composed of cottongrass, various ferns, lichens, mosses, liverworts,

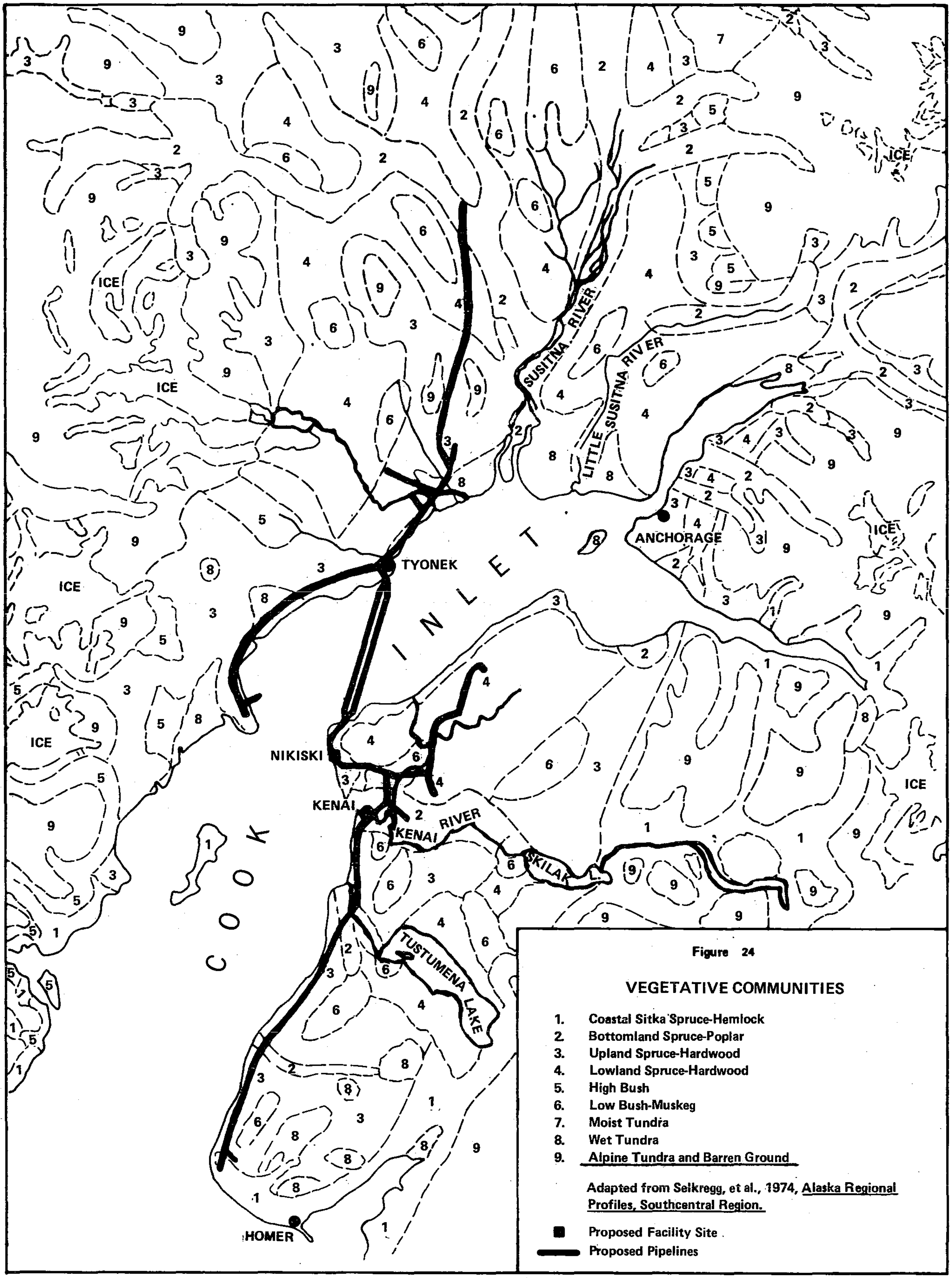


Figure 24

VEGETATIVE COMMUNITIES

Adapted from Selkregg, et al., 1974, Alaska Regional Profiles, Southcentral Region.

and mushrooms. Much of this area is dotted with numerous lakes. The shrub species of these forest types provide good habitat for moose, while the more open areas vegetated with lichens provide good caribou winter range.

Much of this northern Kenai Peninsula area has been burned in forest fires since the turn of the century, the most recent being the Swanson River fire of 1969. The present vegetative cover of this area is patchy, with areas of the naturally occurring climax vegetation interspersed with areas of post-fire successional vegetation. Areas with clumps of mature spruce stands indicate an absence of fire in recent history. Areas displaying pure or mixed stands of young aspen, blackcottonwood, and balsam poplar suggest a history of fire and serve as good moose habitat. In areas such as this, it takes nearly 20 years for an area to regain climax vegetation.

The West Fork, Beaver Creek, Swanson River, and Birch Hill laterals would also cross expanses of low bush-muskeg community found in wet, flat basin areas. This community type includes dwarf-sized black spruce, western hemlock, and Alaska cedar in an area interspersed with standing ponds. Common shrubs include willow, blueberry, bog cranberry, and resin birch. The ground cover of this vegetation type is largely composed of sedges, mosses, and lichens. The wetter areas are dotted with white patches of cottongrass.

Several other vegetative types would be crossed as the proposed pipeline route on the Kenai Peninsula headed south from the Beaver Creek lateral along the Kenai Loop Field lateral and then south along the Sterling Highway to an eventual terminus near the Anchor Point Field. The Kenai Loop Field lateral and a section of the route just south of the Kenai River crossing would pass through extensive areas of muskeg characterized by vegetation just described. The valley floors of the Kenai, Kasilof, and Ninilchik Rivers and Stariski Creek, which would be crossed by this section of the proposed pipeline route, are vegetated with bottomland spruce-poplar forest. This community type is located along level floodplains or low river terraces and consists largely of white spruce, black cottonwood, and balsam poplar. Alders, willow, high bush cranberry, blueberry, bearberry, and raspberry are the chief shrub species. The remaining sections of this route, except for the extreme southern terminus, would pass through extensive areas of upland spruce-hardwood forest.

The southern portion of the pipeline route along the Sterling Highway just north of the Anchor Point Field would pass through an area of coastal Sitka spruce-hemlock forest. This forest type includes primarily Sitka spruce and western and mountain hemlock. Associated balsam poplar and black cottonwood are found primarily on stream floodplains. Sitka alder, salmonberry, willow, and Pacific red elder are a sampling of the associated shrubs of the community, while bluejoint grass, lichens, mosses, and liverworts are the associated ground cover. Along the proposed North Fork lateral, the pipeline would cross extensive areas of muskeg interspersed with patches of spruce-hardwood forest.

On the western side of the inlet, the pipeline route would pass through many of the vegetation types on the Kenai Peninsula. The pipeline right-of-way between the West Foreland Field and the town of Tyonek would cross through upland spruce-hardwood forest for most of its length. The area in the vicinity of McArthur River Flats, however, is vegetated with a community type identified as wet tundra, which occupies tidal flats and areas of low topographic relief near sea level. The wet tundra lacks tall trees, so small species of willows and dwarf arctic birch produce the most conspicuous foliage. Other shrubs and grasses found in the wet tundra are similar to those of the low bush-muskeg community, with cottongrass and sedges common. This area is important waterfowl habitat.

From Tyonek north to and including the Ivan River and Lewis River laterals, the proposed pipeline routes would pass alternatively through upland spruce-hardwood forest in the higher elevations to wet tundra vegetation in the areas near sea level. The upland spruce-hardwood areas are also interspersed with low bush-muskeg type vegetation, especially along the Coffee Creek and Lewis River laterals. The wetland areas in the vicinity of the Beluga River also serve as good waterfowl habitat.

The remainder of the proposed pipeline route--i.e., the Susitna Basin lateral--would initially pass through upland spruce-hardwood forest and then proceed in a northerly direction into lowland spruce-hardwood forest and bottomland spruce-poplar forest as it approached the Yentna River basin.

The applicant has itemized the extent to which the proposed pipeline routes would pass through the various vegetative types discussed. See Figure 42 and Table 35.

The freshwater environment of the Kenai Peninsula and northwestern coastal area of Cook Inlet supports a number of floral species and individuals. A large variety of algae, mosses, rushes, sedges, grasses, water lilies, and other aquatic plants inhabit the lakes, ponds, streams, and marshes of south-central Alaska. 1/

The marine biological environment of the upper inlet strongly reflects the harshness of the physical environment. Many of the species found in the estuarine waters in the vicinity of Pacific Alaska's proposed inlet crossing and marine terminal facilities in Cook Inlet appear only briefly or in small numbers. The marine phytoplankton community is relatively small compared to such communities found in the waters of the lower inlet; apparently the high level of suspended sediment in the local waters decreases light penetration to the point that the lack of light becomes a limiting factor. The upper inlet also lacks the kelp and large masses of attached marine vegetation common in the estuary farther south. A combination of highly mobile substrates, rapid currents, abrasive ice movements, and reduced light penetration may account for this lack of attached plant forms.

7. Wildlife

a) Terrestrial Biota

The most abundant large land animal in the project area is the moose. On the Kenai Peninsula, the region lying generally north of Tustumena Lake and west of the Kenai Mountains [Alaska Department of Fish and Game (ADFG) Game Management Subunits 15 (A) and 15 (B)] had an estimated moose population of 3,782 ± 605 individuals in 1976. (See Figure 25.) A year round moose concentration range is located in an area south of a line from the town of Kenai

1/ State of Alaska, Office of the Governor, Alaska Regional Profiles, Southcentral Region (Salt Lake City, 1974), p. 132.

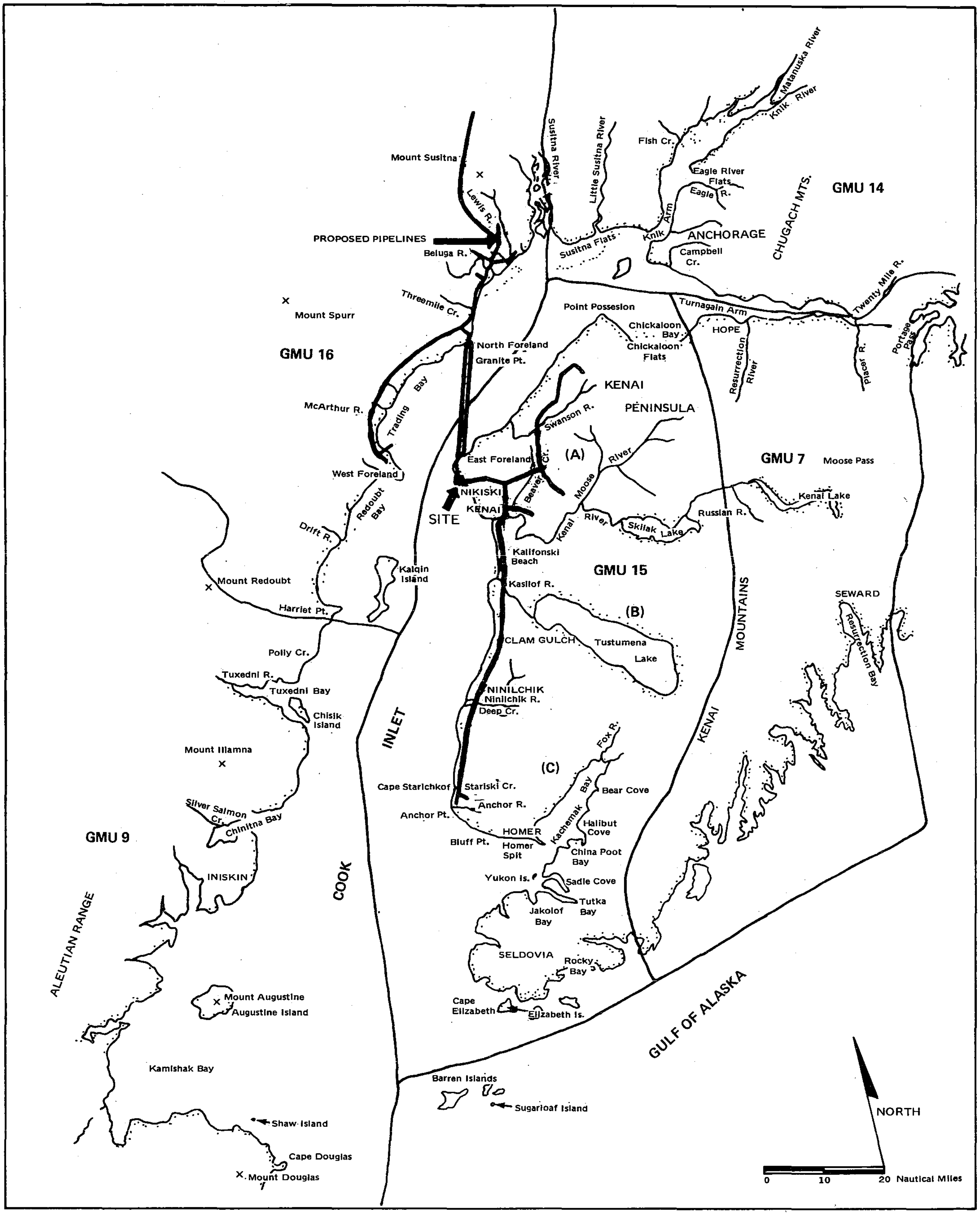


Figure 25
ALASKA DEPARTMENT OF FISH AND GAME
GAME MANAGEMENT UNITS (GMU'S) IN THE COOK INLET AREA

to the headwaters of the Swanson River and north of a line from Clam Gulch to the shores of Skilak Lake. Additional areas of moose winter range are located in the lowland areas of the Ninilchik and Anchor Rivers. On the west side of Cook Inlet, summer and winter moose concentration areas extend along the Susitna River Basin and then southwest along the coastal area of the inlet to Threemile Creek. Areas of moose wintering concentrations are also found in the Middle River and McArthur River areas. The southern sector of the Susitna Basin lateral would pass through summer and winter moose habitat in the lower elevations of the coastal area near the Lewis River. This lateral would then pass into moose fall range in the higher elevations of the Mt. Susitna area. The northern section of the Susitna Basin lateral would pass through moose summer and winter concentration areas in the Yentna River Basin.

The large moose population on the northern part of the Kenai Peninsula may be attributed in part to the administration of much of the region as part of the Kenai National Moose Range. The area's major advantage to moose has been the growth of successional plant species (preferred by moose) following a major forest fire in 1947. Indications are, however, that the value of the 1947 burn area as moose habitat is decreasing rapidly. Predation by wolves and severe winters appear to add to the effects of habitat degradation. The ADFG indicates that the 1969 burn area should begin to produce significant quantities of forage in the next year or two, thereby partially offsetting the loss of the 1947 burn area. Despite recent setbacks and declining moose populations, Game Management Unit (GMU) 15 on the western half of the Kenai Peninsula and GMU 16 on the west side of Cook Inlet together produced one-fifth of Alaska's reported moose harvest in 1974.

The barren ground caribou is another inhabitant of the project area. Transplanted to the Kenai Peninsula in 1965 and 1966, this species had a population of about 400 individuals in 1975. The largest group is resident in the Northern Kenai Mountains south of Hope, between the headwaters of Resurrection Creek and the Chickaloon River. A small herd of 41 to 50 caribou was observed wintering on the Moose River Flats by ADFG personnel in February 1974. Based on an observation of this smaller herd in the spring of 1975, the ADFG estimated the herd size at 75 to 100 animals. The Moose River Flats have been reported to be a winter concentration area for this small herd, while the summer and calving grounds for this herd were described as lying in the lowlands generally north of the Kenai Airport. 1/ Apparently the larger herd south of Hope utilizes the same range in summer and winter. 2/ The first harvest of barren ground caribou on the Kenai Peninsula was allowed in GMU 7 in 1972 in an effort to keep caribou numbers within the limits of the GMU's carrying capacity. During the fall of 1975, hunting was allowed in GMU 7, with the goal of reducing the peninsula's herd by 140 to 150 individuals to a desired winter carryover level of approximately 250 individuals. Hunting is not allowed in GMU 15. Caribou are not found on the west side of Cook Inlet in the vicinity of the proposed project.

The black bear is reportedly numerous on the Kenai Peninsula, and a large concentration of black bears occurs north of the Kenai River and east of Beaver Creek. Concentration areas on the west side of the inlet occur along the coastal flats from the Lewis River to the Little Susitna River. Bear harvests generally fluctuate from year to year with little cause other than the number of bear-human interactions. In 1975 the ADFG received reports of increased nuisance bears in GMU's 15 and 16; likewise, there was a larger bear harvest that year. It is suspected that normal food for the bears was low in 1975; therefore, bears foraged near human habitation to supplement their diets, making them more available to hunters. The ban on black bear hunting the same day a hunter flies into an area has undoubtedly contributed to the reduction in black bear harvests since 1973.

The western portion of the Kenai Peninsula is not an important habitat for the brown/grizzly bear, although it is felt that the population is expanding. Brown bear are more numerous on the west side of the inlet, where concentrations of bear engaged in fishing are found on the inland reaches of Alexander Creek and the Lewis, Theodore, and Chinitna Rivers. Suspected denning areas for this bear are located on the slopes of Mount Susitna and the southern shore of Beluga Lake.

1/ Alaska's Wildlife and Habitat, p. 93.

2/ ADFG, Annual Report of Survey - Inventory Activities, Vol. III, part III, p. 2.

Wolves were long absent from the Kenai Peninsula, but they returned to the area in the 1960's. An ADFG aerial survey in 1974 identified 10 packs totaling 51 to 56 wolves. The estimated spring breeding population for the entire Kenai Peninsula in 1975 was 100 to 130 wolves, or about the same density as in the rest of south-central Alaska. ADFG field reports indicate that wolf abundance has been stable or perhaps increasing in GMU 16. Wolf harvest data in the Cook Inlet area have fluctuated widely since 1962-63, depending of course on local abundance, as well as differing harvest recording methods and hunting techniques.

Other predators in the project area include wolverine, red fox, lynx, coyote, marten, and short-tailed weasel. Other prey species include red squirrels, flying squirrels, ground squirrels, snowshoe hares, northern bog lemmings, and meadow voles.

The Kenai Peninsula and northwestern coastal area of Cook Inlet have a large avian population, many species of which live there seasonally or appear even more briefly during spring and fall migrations. The spruce grouse, the great horned owl, and the common raven are typical year-round residents, while the willow ptarmigan, the snowy owl, and the snow bunting are winter visitors only. The osprey, the northern bald eagle, and most of the passerine species, such as swallows, thrushes, warblers, and sparrows, nest in the area but migrate south for the winter. The Arctic and American peregrine falcons are present only when they pass through during migrations. The Peales peregrine falcon, which is neither threatened nor endangered, may have nested in the Cook Inlet area in the past.

b) Freshwater Biota

The freshwater invertebrates of the south-central Alaska area include protozoa, rotifers, flatworms, aquatic earthworms, small crustaceans, numerous species of insects, and mollusks. These organisms support large populations of fish and waterfowl.

A large number of fish species, some of them anadromous, are found in the lakes and streams of the area. The Kenai River has runs of chinook, sockeye, pink, and coho salmon.

Various species of salmon are also found in Ninilchik, Kasilof, and Anchor Rivers and Deep and Stariski Creeks. Dolly Varden char, rainbow trout, and steelhead trout are found in the Kenai River and its tributaries, in Deep and Stariski Creeks, in the Ninilchik River, and in the north fork of the Anchor River. The area between Kenai River and Anchor Point is intensively utilized by recreational anglers seeking razor clams, king, silver, pink, and red salmon, Dolly Varden, rainbow trout, steelhead, and smelt. Located northeast of the proposed LNG plant site, the Swanson River system is fished for sockeye, coho, and pink salmon, Dolly Varden char, and rainbow trout. Beaver Creek supports chinook and coho salmon and rainbow trout. Bishop Creek is also listed as an anadromous fish stream.

On the west side of Cook Inlet, upper Alexander Creek supports chinook, sockeye, coho, and chum salmon as well as Dolly Varden and grayling. A major sport fishing area exists at the area of the proposed pipeline crossing. Upper Sucker Creek, a tributary of Alexander, has runs of chinook and sockeye salmon and harbors Dolly Varden and rainbow trout. Wolverine Creek supports rainbow trout and king salmon. Chinook, chum, sockeye, pink, and coho salmon occur in the Susitna and Little Susitna Rivers, while the Ivan River has runs of pink salmon. The Lewis River has runs of chinook, pink, and coho salmon, the Theodore River has runs of chinook and pink salmon, and Threemile Creek has runs of sockeye salmon. Pretty Creek produces chinook, sockeye, coho, and pink salmon with the latter spawning in the vicinity of the proposed pipeline crossing. Olsen Creek supports king salmon. The Beluga and Chuitna Rivers also support salmon populations. Tyonek and Old Tyonek Creeks support pink salmon, while Nicolai Creek supports chinook, coho, and pink salmon, Dolly Varden and rainbow trout. Spawning runs of all five salmon occur in the McArthur River while a tributary, the Chakachatna River, supports sockeye runs. The Middle River supports coho salmon.

Shilak and Tustumena Lakes are inhabited by lake trout. A state fish hatchery is located just south of Johnson Lake at Beaver Creek. Other fishes found in local bodies of freshwater are eulachon, sculpins, Arctic grayling, broad whitefish, threespine sticklebacks, burbots, and northern pike.

Waterfowl are important members of the aquatic community in the Kenai and Susitna lowlands. Peak concentrations of waterfowl in this area (GMU's 14, 15, and 16) occur during spring and fall migtations--April to May and late August to October, respectively. The tidal flats of the larger rivers entering Cook Inlet are important resting and feeding sites for migratory waterfowl and shorebirds. During migrations, the 2,400 square miles of waterfowl habitat near the project area are heavily utilized for resting and feeding by ducks, geese, and swans.

Breeding densities in GMU 14 and 15 average about 12 ducks per square mile of waterfowl habitat, and that figure almost triples for GMU 16. The Trading Bay area located in GMU 16 is an important waterfowl and shorebird area, with duck breeding densities of 60 per square mile in the coastal marsh. Waterfowl species commonly breeding in the project area include lesser scaup, mallard, pintail green-winged teal, American widgeon, shoveler, and others. Small numbers of white-fronted and Canada geese, and sandhill cranes also breed within GMU 14. The trumpeter swan is an important species found in GMU 15 and is relatively abundant in upland ponds in that area. This organism nests at sites on the Kenai Peninsula near Mink Creek Lake, Beaver Lake, Cow Lake, and east of Stormy Lake. Numerous shorebirds are also known to breed or occur in the subregion.

The beaver and muskrat are the major aquatic mammals found in the local freshwater environment. Beaver prefer to build their lodges near supplies of food trees, mainly aspen, cottonwood, and willow. Muskrat prefer a marsh habitat. Other mammals seldom found far from water are the river otter and the mink.

c) Marine Biota

The animal populations dependent upon the primary producers in the project area of Cook Inlet are reduced in number compared to those in the lower inlet. Zooplankton organisms are scarce in the upper inlet and may actually be members of transient populations carried up the estuary from the more productive southern regions. Macroinvertebrate populations probably suffer from both the paucity of the lower trophic level populations and the extremes of the physical environment. Virtually all the commercially important crustaceans taken in Cook Inlet come from south of Anchor Point, over 60 miles south of Nikiski, although king crabs, tanner crabs, dungeness crabs, and several commercial species of shrimps are known to exist in the Central Fishing Management District (Central District) of the inlet (Figure 26). The razor clam (Siliqua patula) is the only invertebrate of major importance in the Central District, and its distribution on the east side of the inlet lies generally south of the mouth of the Kasilof River, which is about 20 miles south of Nikiski. Since 1973, however, razor clam fishing has decreased, and a 3-mile area of Polly Creek is the only place razor clams may be harvested commercially for human consumption. The remainder of the commercial razor clam fishery is used only for bait. Greatest digger effort and noncommercial harvest of this organism occurs at Clam Gulch.

Barnacles, usually the most visible and abundant of intertidal organisms, are not numerous at the beach in the proposed project area. Certain burrowing forms of mollusks, annelids, and crustaceans probably find sufficient protection from the elements offshore, but the sampling methods used to date have not been very successful in recovering specimens

Many of the marine fishes found in the inlet are migratory species. Pacific herring ascend the Alaskan estuaries in vast numbers from April to June to attach their eggs to vegetation and other objects in the intertidal zone. The adult and juvenile herring remain near shore until late fall, then most migrate into much deeper waters in the Pacific Ocean. A substantial fishery for herring roe in Cook Inlet exists in the Kamishak Bay and Southern Districts (Figure 26). In 1977, there was a limited bait fishery in the Central District, while the Eastern and Outer Districts were closed for the season. The eastern beaches of the Central and Northern Districts support subsistence fishing for herring.

Eulachon, known as smelt or candlefish, also spend much of their lives at sea, but enter the inlet each spring and summer and ascend some of the local streams to their spawning grounds. The Kenai River is one of these streams. There is no major fishery in the Cook Inlet region for eulachon, although they have been utilized by the Natives in a subsistence fishery.

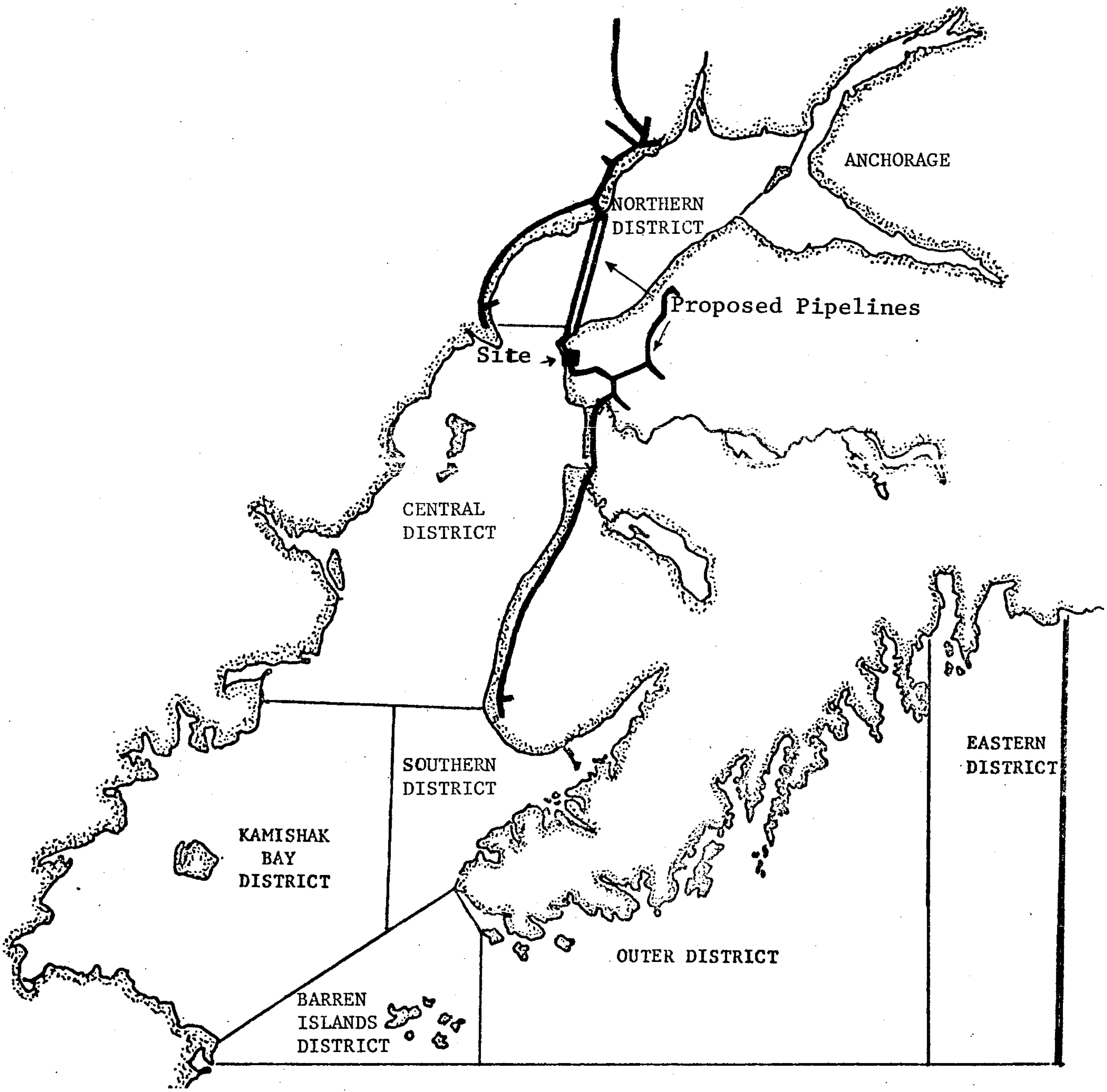


Figure 26

Alaska Department of Fish and Game
Division of Commercial Fisheries
Cook Inlet - Resurrection Bay Area
Fisheries Management Districts

Five species of salmon leave the ocean each year and migrate up the inlet to enter their spawning streams during the period from late spring to late fall. In the order of their relative abundance in the catches from the Central and Northern Districts, these species are the sockeye or red salmon, the pink or humpback salmon, the chum or dog salmon, the coho or silver salmon, and the chinook or king salmon. The average numbers of each species caught in Cook Inlet and in the Central and Northern Districts each year are given in Table 15. It may be seen from this table that nearly 80 percent of the commercial catch in Cook Inlet came from these two districts from 1954 to 1973. Most of the fishing effort and catch is concentrated in the Central District, especially in the areas south of the mouths of the Kenai and Kasilof Rivers. A recent annual management report from the Division of Commercial Fisheries of ADFG indicates that the trends in salmon species abundance and fishing area preferences have continued through the 1973-1977 fishing seasons. There are presently 677 set gillnet permits for the Upper Cook Inlet area (Northern and Central Districts), which account for 43 percent of the total salmon harvest, while 545 drift gillnet permits account for the remaining 53 percent of the commercial catch.

Other fish that might occur in the inlet waters near Pacific Alaska's proposed project area are Dolly Varden char, steelhead trout, sticklebacks, sculpins, starry flounders, and Pacific halibut. The Dolly Varden char and steelhead are anadromous forms which have nonmigratory counterparts in Cook Inlet streams. The sticklebacks and sculpins inhabit both estuarine and freshwater environments. The halibut occur mainly south of Kalgin Island in the inlet, although they have been reported in the Tyonek area.

Large numbers of seabirds and shorebirds are found in the Cook Inlet region, especially during the warmer parts of the year. Seabird colonies have been identified in the southern portion of the inlet at Tuxedni Bay, Chisik Island, Duck Island, Augustine Island, Gull Island, and Glacier Spit. All these colonies are well over 50 miles from Nikiski.

The marine mammals most likely to occur near the project area are the harbor seal and the beluga whale. Although common on the entire west side of the inlet and even more numerous at the mouth of the Susitna River, harbor seals

TABLE 15

AVERAGE ANNUAL COOK INLET COMMERCIAL SALMON CATCH, 1954-1973[1]

	SPECIES					
	Chinooks	Sockeyes	Cohoes	Pinks	Chums	Total
Numbers Taken in Entire Cook Inlet	22,910	1,021,306	222,021	1,486,864	714,652	3,467,753
Numbers Taken in Northern District	7,959	95,322	75,667	191,374	64,138	434,460
Numbers Taken in Central District	14,735	891,419	141,214	765,703	521,421	2,334,492
Combined Percentage of Cook Inlet Catch Taken in Northern and Central Districts	99.0	96.6	97.7	64.4	82.0	79.8

1/ ADFG, Division of Commercial Fisheries, Annual Management Report, Cook Inlet Management Area, (1973), pp. 28, 29.

are seldom seen on the eastern side of the inlet north of Kachemak Bay. The beluga travel as far up the inlet as the mouths of the Susitna River and Ship Creek and may be seen in the mouth of the Kenai River during salmon runs. In the lower inlet, sea otters, Steller sea lions, Dall porpoises, harbor porpoises, and killer whales are also seen. Some of the large baleen whales commonly enter the lower inlet. All of the marine mammals in Cook Inlet are subject to protection under the Marine Mammal Protection Act of 1972.

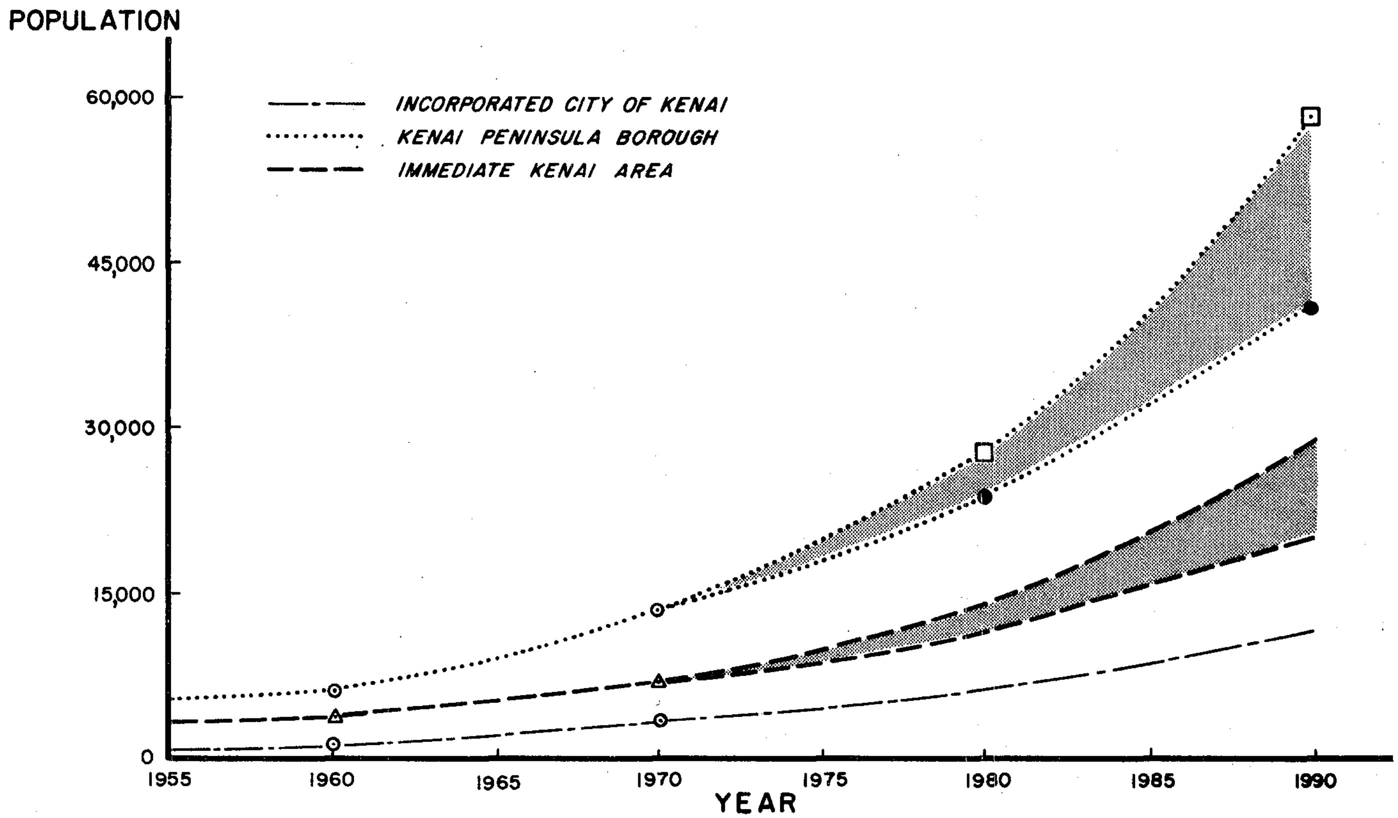
8. Socioeconomics

Alaska presents many socioeconomic characteristics which no longer exist elsewhere in the United States. There is a relatively large Native population with persistent Native cultural patterns. The land itself possesses an undeveloped "frontier" quality and is, in many places, subject to disputed ownership. The severe winter climate places seasonal restrictions on outdoor economic activity. Finally, all these considerations must be coupled with the effects of recent oil and gas discoveries at a time when energy shortages trouble the industrialized world.

a) Population and Employment

The proposed project would traverse portions of the Kenai Peninsula Borough and the Matanuska-Susitna Borough, both of which encompass extensive regions of land in a near-wilderness condition. However, the focus of the project at the Kenai-Nikiski plant site is within a relatively developed area with good transportation access, available commercial services, and relatively high population density.

As seen in Figure 27, populations in the general project area are expected to increase. Recent population, employment, and economic statistics for specific cities affected by the proposal are given in Tables 16 and 17. The Anchorage area has a population of about 175,697, while the Kenai-Cook Inlet region, excluding Seward, has about 14,000 inhabitants.



LEGEND

O Official U.S. Census. figures

☐ Porter, Armstrong, Ripa & Assoc., population projection included in Turnagain Arm Crossing Study for the Alaska Dept. of Highways, 1968

● Alaska State Housing Authority, Interim Population Projection, Kenai Peninsula Borough

△ Alaska Dept. of Highways, Reconnaissance Study – Kenai River Crossing (at Kenai), 1969

Figure 27

KENAI AREA POPULATION DATA

Source: Dames & Moore

TABLE 16

COOK INLET NONAGRICULTURAL WAGE PAYMENTS, 1970-1974

Industrial Classification	Total Payroll 1970	1971	1972	1973	1974	Percent Change 1970-1974	Percent of State Wide Payroll 1970	1974
Total - Nonagricultural*	521,007,967	584,144,170	655,846,957	704,137,752	921,746,504	76.9	52.3	49.7
Mining	28,801,678	25,621,131	25,607,481	26,189,870	34,735,131	20.6	55.4	51.6
Contract Construction	63,236,510	77,941,909	88,739,014	83,435,095	147,378,318	133.1	50.3	38.2
Manufacturing	18,303,956	20,402,590	21,359,172	24,081,619	30,460,691	66.4	21.8	23.3
Transportation-Communication and Utilities	56,512,628	62,966,438	68,467,222	73,575,884	104,703,450	85.3	50.7	51.5
Wholesale and Retail Trade	85,530,677	93,474,436	105,013,593	113,290,307	144,061,159	68.4	64.8	65.3
Finance-Insurance and Real Estate	19,607,516	22,358,752	27,245,846	33,131,766	39,165,808	99.8	71.0	69.8
Services	55,343,278	62,750,554	75,137,309	85,211,211	122,355,261	121.1	62.2	63.3
Government	186,430,182	215,828,555	239,801,231	259,108,274	293,564,573	57.4	50.0	50.6
Federal	109,420,137	118,060,795	122,269,440	130,777,478	145,228,484	32.7	59.6	60.0
State and Local	77,010,045	97,767,760	117,531,791	128,330,796	148,336,089	92.6	40.8	43.9
Miscellaneous	875,643	511,690	1,691,282	3,767,991	3,523,972	302.4	35.2	19.1

* Sector wage payments do not add to total; wage payment estimates for industry divisions in some labor areas are withheld to comply with disclosure regulations.

Source: Bureau of Land Management, U.S. Department of the Interior, Lower Cook Inlet. DEIS on Proposed Oil and Gas Lease Sale No. CI. Vol. I (1976).

TABLE 17

KENAI PENINSULA BOROUGH COMMUNITY PROFILES 1/

Kenai-Cook Inlet Labor Market Area

	Homer	Kenai	Seldovia	Soldotna
Population				
Greater Area	4,000	6,215	700	2,000
Within City	1,538	5,161	450	1,800
Estimated Area Employment				
Agriculture (& Fishing)	120	688	142	23
Construction	80	180	10	138
Finance	41	50	0	92
Government	109	738	22	138
Mining/Oil	0	480	0	92
Manufacting/Processing (ave.)	80	386	104	58
Service	84	402	8	138
Trade	160	312	22	46
Transportation, Comm.	50	195	5	46
Other	35	70	0	N/A
Total Estimated Area Employment	759	3,501	313	771

Source: U.S. Department of the Interior, Bureau of Land Management, Alaska OCS Office, Lower Cook Inlet Draft Environmental Impact Statement.

1/ There are no sizable communities affected by the project within the Matanuska-Susitna Borough.

Immigrating job seekers and the unskilled, undereducated, Alaskan Native population have contributed to a severe chronic unemployment problem. For south-central Alaska in 1972, the average unemployment rate was 10.2 percent, with a seasonal range from 8.5 to 11.9 percent. 1/ Because this area includes most of the urbanized development within the entire state, these unemployment levels are somewhat less than in the more isolated hinterlands with predominantly Native populations. The Kenai Peninsula Borough, which includes both urban and rural areas, had an average rate of unemployment during 1974 of 15.7 percent out of a total labor force of 6,170. More stable economic components of the urbanized areas include government and a growing sector of year-round commercial services. (See Tables 16 and 17.) However, vast regions that lack ground transport systems find ordinary commerce to be difficult and costly. Economic activity is restricted by bad weather and rugged topography, with frigid temperatures curtailing logging, construction, and recreation. Another seasonal economic sector is the fishing industry, where salmon runs are the basis for local employment fluctuations. All of these factors influence "underemployment" (seasonal employment) which is especially prevalent among the Natives. (See Figure 28.) During periods of unemployment, many Native people return to their age-old patterns of subsistence from the natural environment.

b) Transportation, Housing, and Services

Although south-central Alaska has better highway service than other regions of the state, there is a continuing need for more highway development. The direct highway routes between major population centers are: Anchorage-Fairbanks, Alaska Highway No. 3; Anchorage-Kenai Peninsula, Seward Highway; Palmer to points east, Glenn Highway. It is especially noteworthy that there is only one highway which connects the Kenai Peninsula with the rest of the state. The city of Kenai is located on the Sterling Highway, which branches off this single main highway between Anchorage and Seward. Nearly all industrial, commercial, and residential development is concentrated along the relatively few highway corridors. The highways must serve continuous commercial and often heavy recreational traffic.

1/ State of Alaska, Alaska Regional Profiles, Southcentral Region (July 1974), p. 186.

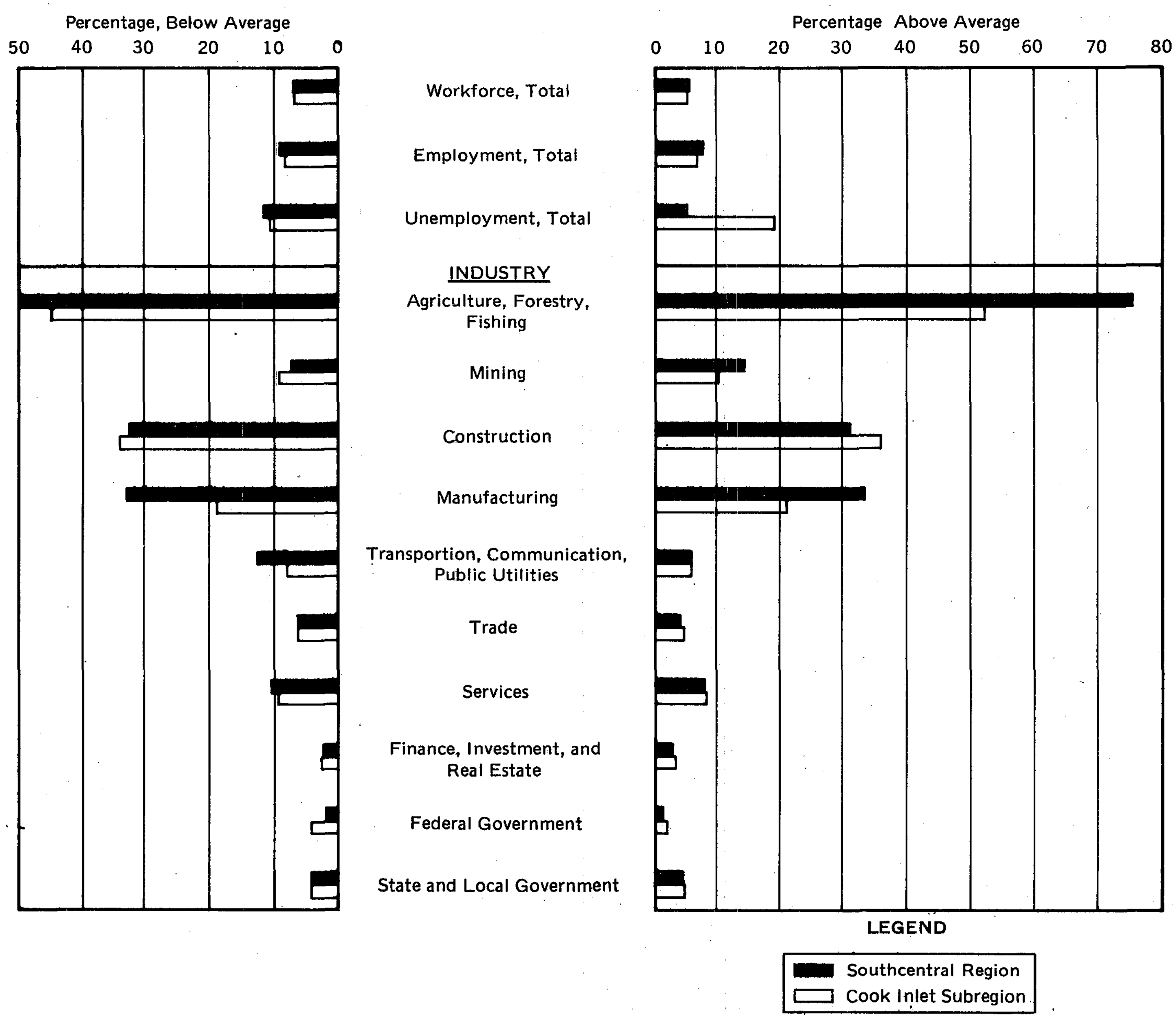


Figure 28 Seasonal Variation in Quarterly Workforce, Employment and Unemployment, 1972

Source: State of Alaska, Department of Labor

Topography is an important constraint inhibiting highway expansion. Existing routes are often circuitous and inefficient. For example, the highway connection between Anchorage and Kenai is over twice as long as the direct-line air route. Among the highway improvements planned as the state's financial status improves is a bridge over Turnagain Arm to shorten this important route. There is no developed highway access to the portion of the Matanuska-Susitna Borough affected by the proposed project.

Seagoing transportation in the project area is concentrated in Anchorage, which is an important international center of transportation and supply for the entire northern Pacific. 1/ Other smaller seaports include Homer, Seward, and Seldovia. Kenai, the largest city on the peninsula, does not have containerized shipping facilities. (See Table 18.)

Air transportation in Alaska is particularly important. Small aircraft add accessibility to otherwise isolated settlements. Seaplanes are especially versatile in lake country where airstrips may not exist. Helicopters are crucial in the opening of rugged, poorly known areas for exploration and resource development. In addition to the air facilities shown in Figures 29 and 31, several small airstrips are located on the west side of Cook Inlet, the largest of which is located southwest of the Beluga River. The Kenai-Nikiski area possesses a complete public education system from elementary school through the community college level. The North Kenai Elementary School is located 2.5 miles north of the proposed plant site. Fluctuations in school attendance have occurred periodically as employment conditions in the Kenai area have varied. During a petrochemical construction "boom" in 1969, area school enrollments reached a maximum of 3,096. Present school enrollments in the Kenai area schools are shown following. Soldotna Elementary and Soldotna Junior High, with enrollments of 530 and 314, respectively, are within easy commuting distance of this proposed project. Construction is presently underway to add eight classrooms, a media center, and a swimming pool to the Kenai High School. There are also plans to construct

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1/ U.S. Forest Service, Alaska Region, Final Environmental Impact Statement, Land Use Plan, Chugach National Forest (July 1974), p. C-27.

TABLE 18

MAJOR PORTS IN COOK INLET[1/]

Port Name	General Cargo	Oil & Gas	Fish Processing	Timber Processing	Ferry Terminal
Anchorage	X	X	X		
Nikiski		X			
Kenai			X		
Drift River		X			
Homer	X	X*	X		X
Seldovia	X		X	X	X

* No major shipments through the port, but tankers lie in the roadstead at times awaiting improvements in ice conditions or weather.

1/ Information adapted from U.S. Army Corps of Engineers, Alaska District, Final Environmental Impact Statement for Offshore Oil and Gas Development in Cook Inlet, Alaska (Anchorage, September 1974), p. 69.

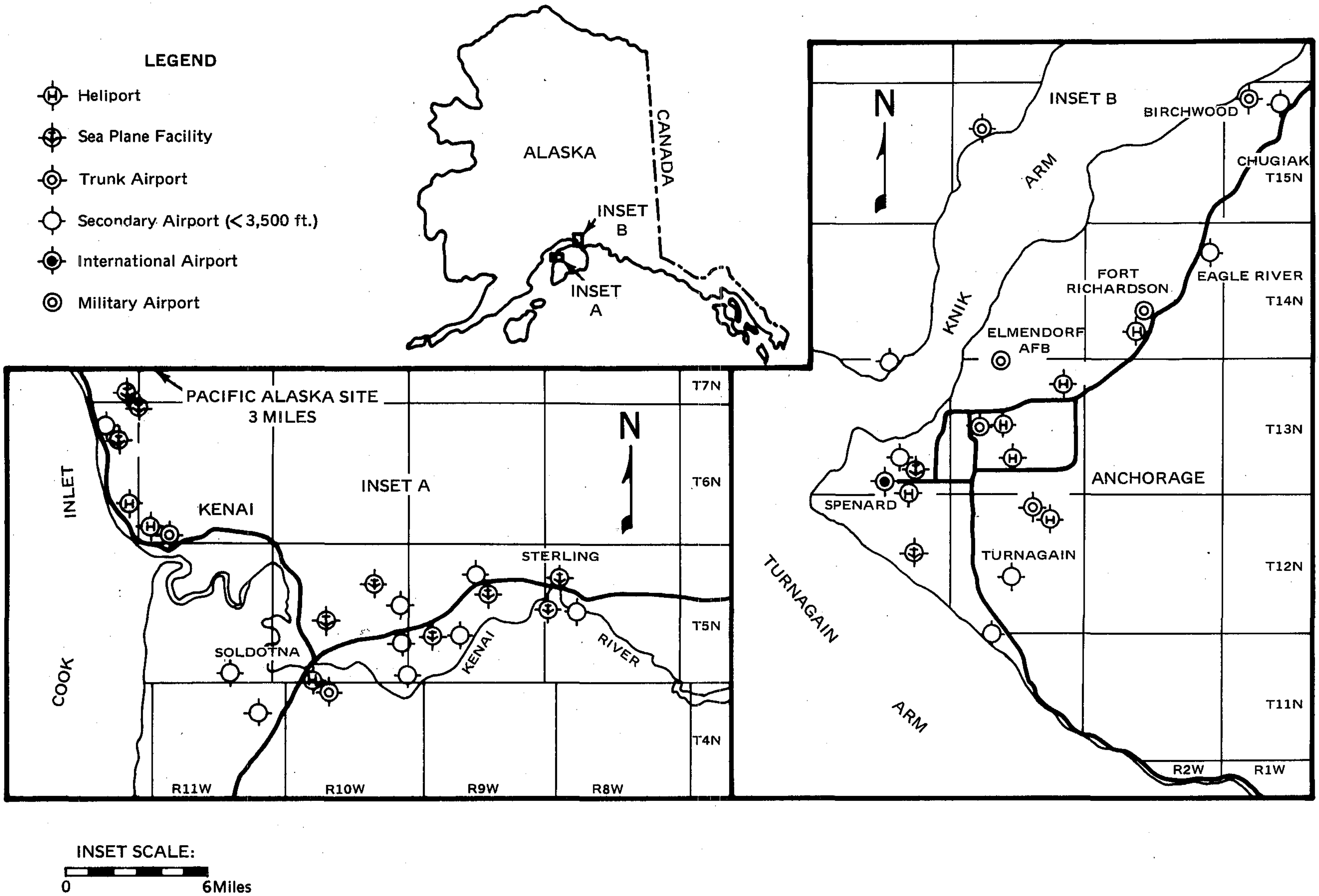

Figure 29 Airport Facilities

Source: Alaska Regional Profiles

eight more classrooms for the Soldotna Elementary School, a new classroom building for the community college, a new high school in Soldotna, and a new junior high school in North Kenai. The city of Kenai also maintains a public library, and five radio and three television stations are received in the area.

School	November 15, 1976	Capacity
Kenai Central High	664	755
Kenai Elementary	273	500
Kenai Junior High	491	625
North Kenai Elementary	336	475
Sears Elementary	315	550
Total	2,079	

Housing in the Kenai area and throughout Alaska is an important constraint in providing for large temporary labor forces. Housing vacancy rates fluctuate widely because of the "boom and bust" nature of the local economy. However, mobile homes and trailer sites are generally available at all times. Also, new housing construction in the Kenai area is expanding and should enhance the housing available in the future.

South-central Alaska contains about 60 percent of the state's electrical generation capacity divided among small local cooperatives, commercial, and military power networks. 1/ Oil and gas are the primary fuels, especially in and around Anchorage where inexpensive natural gas is available from nearby producing areas. Gas resources in the Cook Inlet

1/ U.S. Department of the Interior, Alaska Power Administration, Alaska Electric Power Statistics, 1960-1973, (December 1974).

region are believed sufficient to support the proposed LNG project without jeopardizing availability of gas supplies for future local requirements. In any event, Pacific Alaska has agreed to give priority to the satisfaction of local gas demand before and during exportation of LNG to out-of-state markets.

Oil- and gas-related activities provide a major revenue source for local and state governments. The 10 largest taxpayers in the Kenai Peninsula Borough are oil or pipeline companies. In 1975, assets of these companies comprised 49 percent of the assessed valuation in the Borough. The total tax liability may increase even further when a 10-year tax moratorium on a portion of the hydrocarbon industry expires in 1979. 1/

The State of Alaska and numerous Alaskan Native Regional Corporations and Native villages are entitled to substantial conveyances of land pursuant to the Alaskan Native Settlement Claims Act (1971). Once land titles and rights are completely transferred, large areas will become available for possible sale, taxation, and leasing for mineral exploration. This will contribute to significant new cash flows into Alaskan governmental budgets.

Electric power for the Kenai-Nikiski area is supplied by gas turbine generators at the Chugach Electric Association facility near Bernice Lake. This power is distributed by the Homer Electric Association (HEA) grid-system. The proposed LNG facility would have an electrical demand of 10,000 kw per day, which would require some system upgrading by HEA. The cost of upgrading the system would be borne by Pacific Alaska.

Water and waste disposal requirements would be served by onsite wells and sewage treatment facilities with little or no demand on local utilities.

1/ U. S. Department of the Interior, Bureau of Land Management, Alaska OCS Office, Lower Cook Inlet Draft Environmental Impact Statement, Proposed Oil and Gas Lease Sale No. CI, Vol. I, (Anchorage 1976).

9. Land Use

Land use trends in the Cook Inlet Region, as throughout Alaska, exhibit great variety. Vast reaches of essentially untouched wilderness include zones and corridors of rapid development. The Kenai Peninsula, Anchorage, and surrounding geographical areas, by merit of population, highway networks, and broadening commercial-industrial activity, lie at the heart of the Alaskan economy.

The essence of Alaska's land-use heritage lies in the ongoing development of natural resources. Prior to the late 18th century and the Russian presence in Cook Inlet, a sparse Alaskan Native population subsisted upon the local wildlife and fisheries. The Russians later developed a fur-trading economy before selling what is now Alaska to the United States in 1867 for $7,200,000, approximately 2 cents per acre of land.

By 1880, fewer than 300 whites, most of whom lived in Sitka, Alaska, complemented the Native population, and until 40 years ago, the Native Alaskans still outnumbered the non-Native immigrants. Eventually there came coastal settlers (both Russian and American), whalers, fishermen, trappers, and late 19th century gold-seekers. Other permanent settlers came to Alaska during and after World War II. With prospects for the economic development of Alaska's resources, the influx of non-Native settlers increased and set Alaska on the course toward statehood in 1958. 1/

Land development in the Kenai vicinity was greatly accelerated by the discovery of oil and gas deposits in 1957. Until the discovery of oil and gas on the Arctic North Slope in 1968, Cook Inlet was the only significant hydrocarbon-producing area in Alaska. Several petrochemical facilities have been located at Nikiski with the encouragement of local authorities. (See Figures 30 and 31.) This industrial expansion has enlarged the local tax base and has dampened the seasonal fluctuation in local employment. This has also allowed Kenai to expand municipal services

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1/ Federal Field Committee for Development Planning in Alaska, Alaska Natives and the Land (Anchorage, October 1968), pp. 429-437.

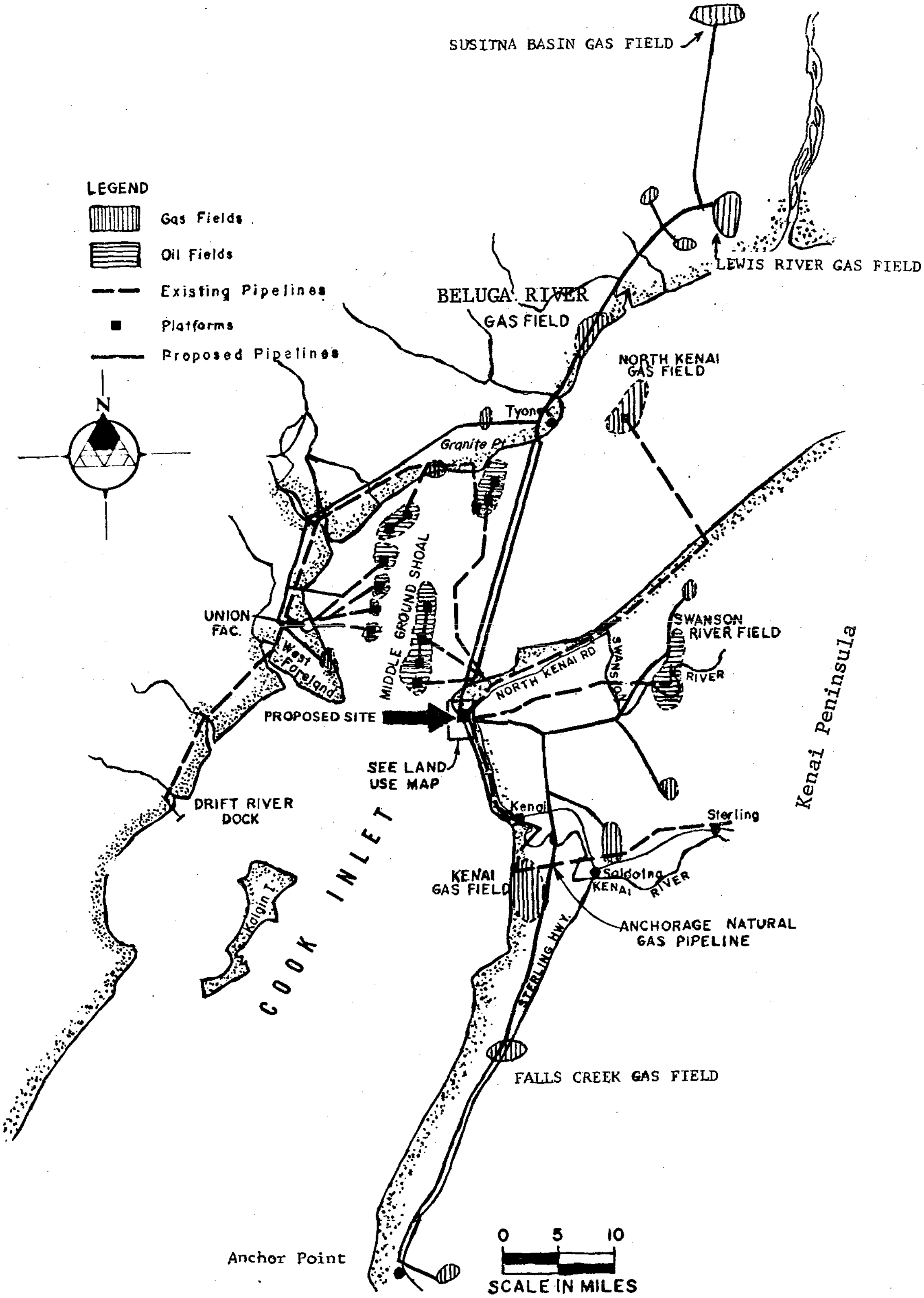

Figure 30

COOK INLET PETROLEUM DEVELOPMENT

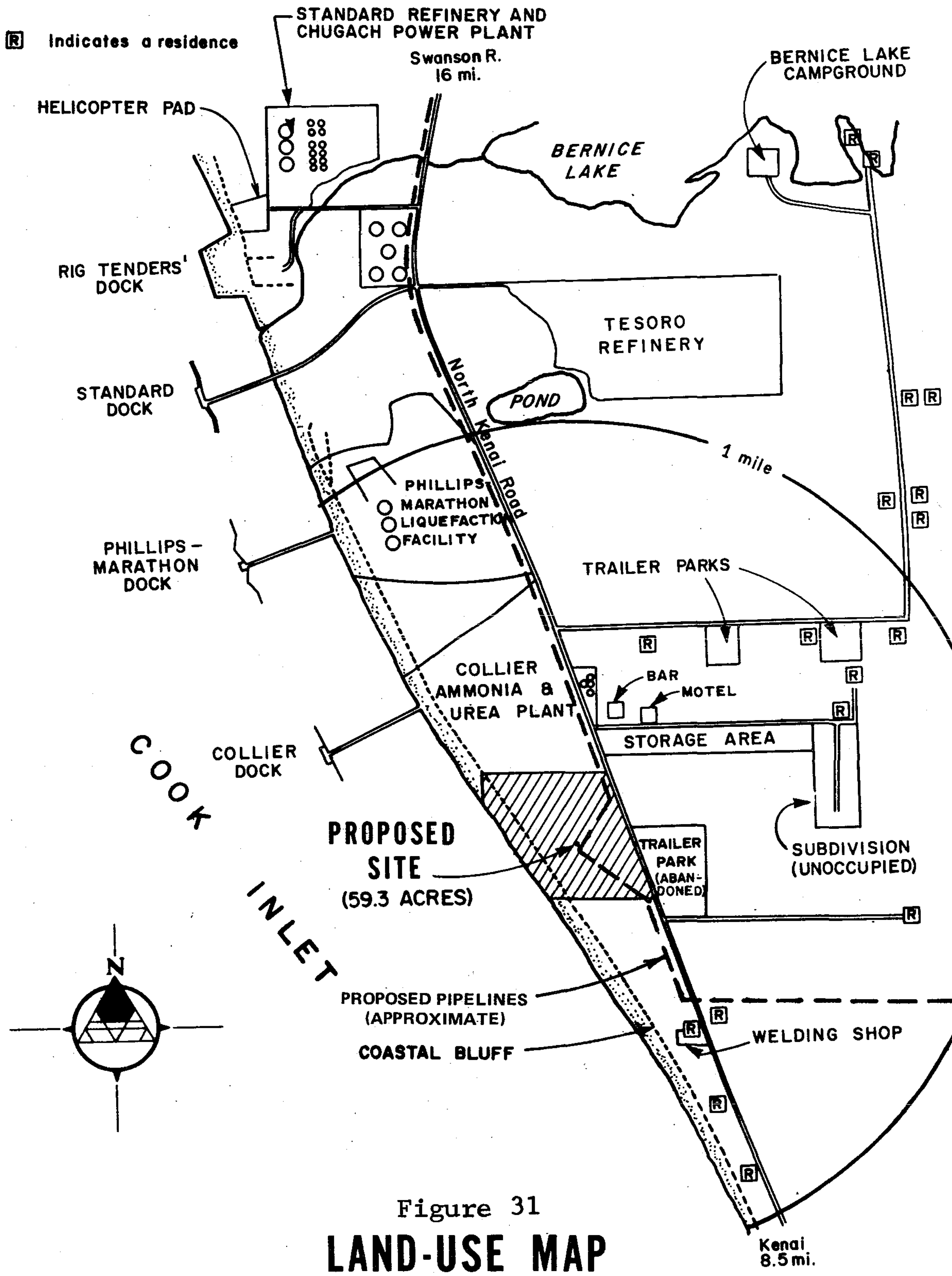

Figure 31

LAND-USE MAP

PREPARED FROM AERIAL PHOTOGRAPH KMA 3-14, 10-17-68, BY AIR-PHOTO TECH., ANCHORAGE, ALASKA for the overall benefit of the local populace. Other important developments include two salmon canneries. Several historic areas within the city have been preserved, including an old Russian Orthodox church and the restored original American settlement at Fort Kenay. Agriculture in the Kenai area is limited to small, noncommercial plots.

South of the Kenai-Nikiski area, toward Anchor Point and Homer, land use is more strongly oriented towards recreation, tourism, and commercial fishing. However, planned Outer Continental Shelf oil and gas exploration activities in the lower Cook Inlet could give some impetus to industrial growth in this area. The proposed pipeline routes in this area would closely follow existing highway or transmission line rights-of-way. Local businesses tend to concentrate near the highway access corridors. Air service facilities include the Kenai and Soldotna airports and a helicopter pad near the Chugach Electric Association's Bernice Lake Station. (See Figure 31.) There are no railway facilities directly serving the Kenai vicinity or the areas located to the south toward Anchor Point and Homer.

Except for some land under private ownership within several miles of the North Kenai Road, the area surrounding the proposed plant site for many hundreds of square miles can be characterized as "open space," primarily used for undeveloped recreation. Most of the land is either in the public domain or subject to ownership determinations under the Alaskan Native Claims Settlement Act. The proposed 59.3-acre site is owned in part by Pacific Alaska, with the remainder under lease from the state. The nearest permanent residence is 0.4 miles from the proposed storage tank area.

About 7 miles to the east, away from the coastal roads and developments, much of the range also contains areas with extensive oil and gas exploration, development, and production. The land has a genuine wilderness character. In this vicinity, the Kenai National Moose Range, an area of 2,700 square miles, is popular for canoeing, fishing, and wilderness camping. Most outdoor recreation activities on the Kenai Peninsula are heavily concentrated along the relatively few highway corridors.

The network of gas supply pipelines proposed by Pacific Alaska would extend to the west side of Cook Inlet, an area accessible only by ship or aircraft. The applicant's proposed pipeline route would occasionally follow several existing pipeline and electric transmission line rights-of-way. Two small Native settlements, Tyonek and Alexander, may lie within 0.12 mile of the proposed pipeline route, depending on the final right-of-way selection. Although long-term plans call for eventual highway connection of these villages to the Anchorage area, present land use on the west side of the inlet is limited to hunting and fishing, some logging, and scattered oil and gas development.

Land use along the coastal areas of Cook Inlet includes the commercial seaports of Anchorage, Drift River, Kenai, Nikiski, Homer, and Seldovia. Present shipping traffic in the inlet is not congested enough to require special traffic control efforts, such as narrowly defined shipping lanes. Several ports are specialized and may serve only a single industrial purpose. Table 18 lists and classifies ports according to those commodities that make up a significant part of their total cargo.

The first commercial Cook Inlet oil and gas discoveries in 1957 preceded those on the Alaskan North Slope by about a decade. The exploitation of these reserves has developed a healthy industrial-economic sector in the Cook Inlet area. The areas surrounding both Kenai and Nikiski, in particular, have benefited from this recent industrial growth. Immediately after World War II, this area's primary economic activities were related to government, national defense, and fisheries. Cook Inlet petrochemical development contributed to a proliferation of local businesses, an increase in population, and a more diversified local economy. Expensive petrochemical facilities have also enhanced the local tax base, thereby allowing for the expansion and improvement of public services. Today, Kenai is the regional economic center for the peninsula, largely due to industrial oil and gas development.

The discovery of vast oil and gas deposits on the Alaskan North Slope has accelerated the state's overall economic activity dramatically. This activity is manifested in the Anchorage-Kenai Peninsula area by increased materials movements and by an influx of job seekers and tourists. Although the North Slope pipeline projects have no direct relationship to oil and gas development in the Cook Inlet Basin, the socioeconomic effects statewide are difficult to separate. For additional discussion on various socioeconomic considerations in Alaska, particularly as related to North

Slope oil and gas development, see the Federal Power Commission's Final Environmental Impact Statement, Volume I, for the Alaska Natural Gas Transportation Systems, CP75-96 *et al.*, 1976.

10. Archaeology and History

Although non-Natives first entered the Kenai area in the late 18th century, the Indian population continued to outnumber the immigrating settlers until about 1935. From that time on, the military presence in Alaska, the growth of Anchorage as an economic center, and the discovery of petrochemical resources in Cook Inlet irrevocably altered the patterns of past centuries.

It is not known how long man has inhabited the Cook Inlet area; however, nearby archaeological remains on Kokiak and Afognak Islands indicate a human history of at least 6,000 years. The known cultural history of Cook Inlet spans approximately 3,000 years. The human population represented the fusion of various cultures mixing at geographic boundaries. It appears that Pacific Eskimos were the first inhabitants of all portions of Cook Inlet and the Kenai Peninsula, yielding territory which was subsequently occupied by Tanaina Athapaskan Indians. The transition from Eskimo to Indian occupancy is not well understood. A major problem in interpreting the archaeological record for the area is the difficulty in clearly distinguishing Tanaina artifacts from those of Eskimo manufacture. However, the Eskimo culture receded, and the Tanaina held dominance until Russian intervention in the 18th century. 1/ The Kenai Peninsula and the city of Kenai take their names from the Kenaitze Indians, who as members of the Tanaina culture, became well-adapted to survival in coastal environments. In 1805, the Indian population in the Cook Inlet region is estimated to have been 3,000 persons. 2/

1/ U.S. Department of the Interior, Bureau of Land Management, Alaska OCS Office, Lower Cook Inlet Draft Environmental Impact Statement, Proposed Oil and Gas Lease Sale No. CI. Vol. I. (Anchorage 1976), p. 334.

2/ Federal Field Committee for Development Planning in Alaska, Alaska Natives and the Land (Anchorage 1968), p. 253.

Because of the protracted Native presence, archaeological sites are abundant throughout the general project area. Known archaeological and historical sites, including house pits, ancient villages, churches, and trading posts have been identified in a consultant study for the FPC by the Iroquois Research Institute. 1/ Descriptions of these sites are presented in Table 19. The Holy Assumption Russian Orthodox Church in Kenai (KEN 036 in Table 19) is listed in the National Register of Historic Places. Tyonek (TYO 005) and Alexander (TYO 013) are the only sizeable settlements on the west side of Cook Inlet and in 1970 had predominantly Native populations of 232 and 100, respectively.

At present, no archaeological or historical sites have been noted in the proposed plant area or within the proposed pipeline corridors which could not be avoided by relatively minor realignments of the pipeline route. However, because most of these lands are undisturbed, there is a good chance that uncataloged archaeological sites may be discovered during construction.

11. Recreation and Aesthetics

The Kenai Peninsula ranks high among the important recreational areas within the state of Alaska. The relatively large population in Anchorage lives in proximity to the peninsula's superlative scenery and wildlife. An apparent paradox exists, however, in that, while overcrowding frequently occurs in some areas, vast regions are seldom visited. This results from the limited highway access prevalent throughout the state. Although the Kenai Peninsula is well-served by Alaskan highway s tandards, there is only one highway link from Anchorage to the south, and many desirable road connections are inhibited by the rugged topography. Presently, all commercial highway traffic to and from the Kenai Peninsula must pass through the Chugach National Forest along the Seward Highway (Alaska Rt. 9). This road must serve both commercial and recreational needs. Figure 32 shows the regional recreation centers and highway routes on the Kenai Peninsula.

1/ Robert L. Humphrey, Jr. et al., A Study of Archaeological and Historic Potential Along the Trans-Alaskan Natural Gas Pipeline Routes, (Falls Church, Virginia, 1975).

TABLE 19

KNOWN ARCHAEOLOGICAL AND HISTORICAL SITES IN THE VICINITY OF THE PACIFIC ALASKA LNG PROJECT 1/

West of Cook Inlet

TYO 013.2/ HISTORIC. The site of Alexander is at the mouth of Alexander Creek, on both sides of the stream. On the left bank there are pits and a house depression with bone, glass, nails, and trade beads. There is also a graveyard where one wooden cross of the Russian Orthodox type remains. Several artifacts are reported from this Tanaina Indian site which dates back to late-contact period. There is some erosion damage due to the river and private buildings.

TYO 005. HISTORIC. Tyonek. Although Tyonek is the site of a modern Indian village, it is also the site of an historic fur-purchasing post and Indian village. Location is on the northwest shore of Cook Inlet. 3/

TYO 007. HISTORIC. St. Nicholas Church. This site is a Russian Orthodox Church building founded in 1891 at Tyonek.

TYO 002. HISTORIC. Ladd. A former trading post and fishing station on the northwest shore of Cook Inlet at the mouth of the Chuitna River, this Native settlement is on or near the site of an Indian village called Chuitna. It has been called Ladd since 1895, after the operator of the trading post.

1/ Excerpted from Robert L. Humphrey, Jr. et al., Iroquois Research Institute, A Study of Archaeological and Historic Potential Along the Trans-Alaskan Natural Gas Pipeline Routes (Falls Church, Va., 1975), pp. 34, 164, 172, 173, 174.

2/ These six character address codes indicate sites referenced in the Alaska Heritage Resource Survey Index.

3/ "Old Tyonek," an archaeological area, was the town's original location before floodtides in 1931 forced the local residents to relocate.

East of Cook Inlet

KEN 029. HISTORIC. Kenay. This reconstruction of a for barracks building and six deteriorated log cabins was built in 1868, abandoned in 1870, and reconstructed in 1967. It is a significant example of U.S. Army government of south central Alaska.

KEN 027. ARCHAEOLOGICAL. According to local sources in the Kenai area, material, possibly cultural in nature, has been collected at "Boulder Point," a site located north of Kenai.

KEN 040. HISTORIC. Redoubt St. Nicholas. This fur purchasing post and Russian Orthodox mission at the mouth of Kenai River, eastern shore of Cook Inlet, dates to 1791.

KEN 028. Mr. Daniels, a resident of Kenai, is reported to have possession of some copper artifacts he recovered while working his field next to Daniels Lake.

KEN 036. HISTORIC. Holy Assumption Russian Orthodox Church. Built in 1896, this church is the finest and best preserved 19th century Russian Orthodox Church. Originally erected as a log chapel by the Russians in 1841, it was expanded to a log church in 1849 and then rebuilt in stone in 1896. It is located in Kenai.

KEN 015. HISTORIC. There is a house pit in the backyard of a homestead on Daniels Creek, midway between Daniels Lake and Bishop Creek. This site remains unexcavated.

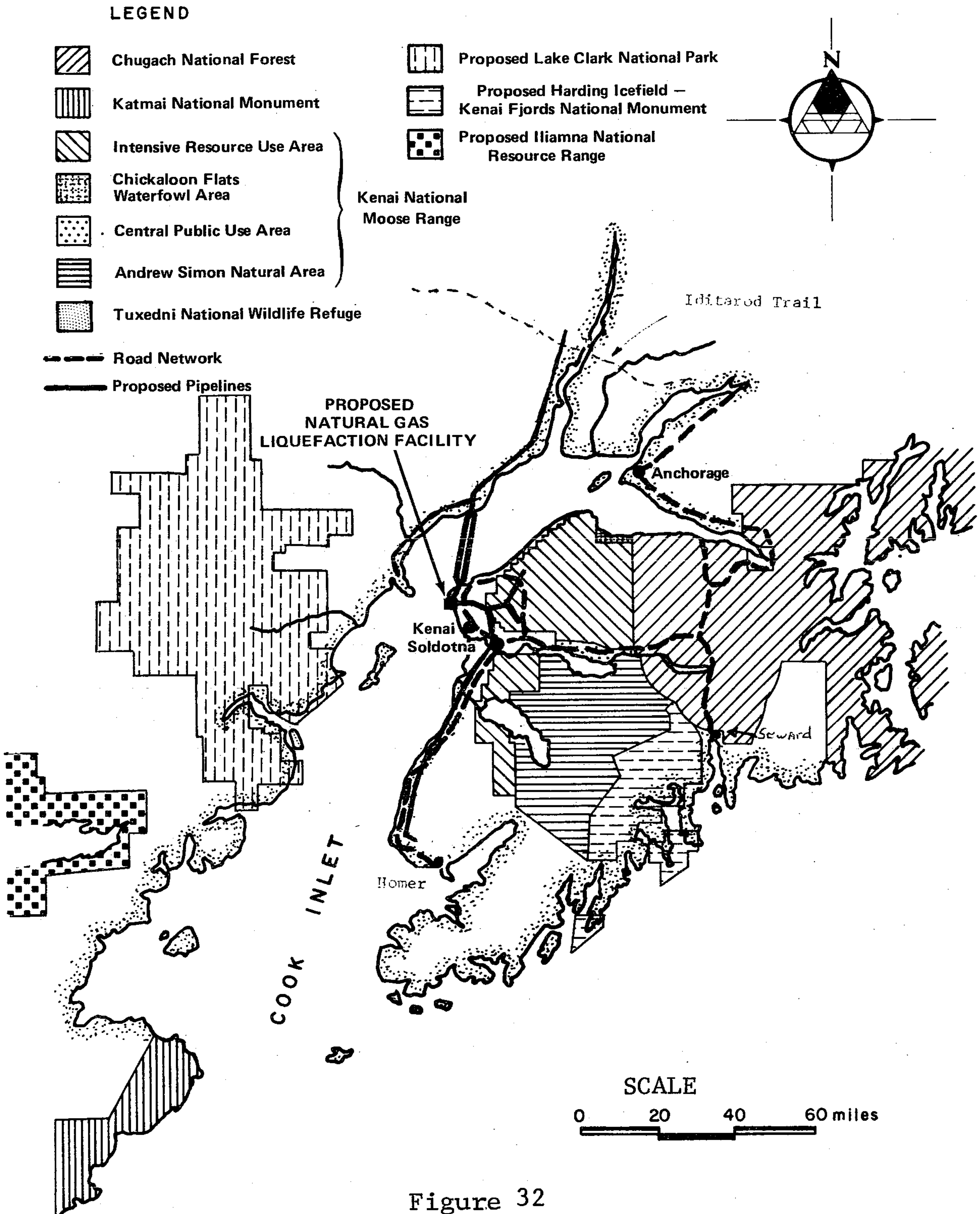

Figure 32

REGIONAL RECREATIONAL AREAS

It has been estimated that almost 2.1 million recreation days were spent on Kenai Peninsula in 1973, using a 12-hour recreation day. The principal attractions of the Kenai Peninsula are the opportunities for canoeing, sport fishing, hiking, camping and wildlife observations, and hunting. Most activity occurs during peak summer days which coincide with long holiday weekends, low tide for clam digging, and peak salmon runs. This summer influx into the area is a big boost to the local economy. Probably the largest single recreation expenditure is for sport fishing; sport fishermen spent over $2 million in 1972 pursuing salmon in the Cook Inlet area. Overall, demand for recreation on the Kenai Peninsula appears to be sustained by the high quality of recreation that has prevailed through the years.

Various estimates for the growth rate of recreation and tourism on the Kenai Peninsula have been made. The Joint Federal-State Land Use Planning Commission for Alaska projected an 8-percent growth rate in 1972, which is somewhat less than the state's estimate. Applying an 8-percent growth rate to a base of 350,000 visitors in 1973 means that there will be approximately 2.5 million visitors by the year 2000. It appears doubtful that recreation on the Kenai Peninsula will contribute a lesser percentage to the economy in the future than it currently does. This is true for several reasons. There is a fairly strong feeling in Anchorage that the Kenai Peninsula should be maintained as a recreation center; most of the industrial development that occurs in south-central Alaska is expected to take place in the Anchorage area, since it is close to a large labor market and capital, housing, and transportation facilities are more readily available there. Industrial activity on the Kenai Peninsula is currently limited to the North Kenai area. The area actually occupied by the industry is limited and therefore provides few barriers to recreation and tourism. As mentioned, the relative ease of access enhances recreation opportunities in the area. 1/

A Kenai National Recreation Area has been proposed to include 1,300,000 acres of the Chugach National Forest. This

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1/ U.S. Department of the Interior, Bureau of Land Management, Alaska OCS Office. Lower Cook Inlet Draft Environmental Impact Statement, Proposed Oil and Gas Lease Sale No. CI. Vol. I. (Anchorage 1976), pp. 308-310.

proposal, if implemented, would involve new scenic roads, developed campsites, and wilderness trails. Some of this additional recreational development can be expected regardless of the administrative status of the land. A new Harding Icefield-Kenai Fjords National Monument to encompass approximately 305,000 acres on the south coast of the Kenai Peninsula has been proposed by the U.S. Department of the Interior. The proposal would add to the variety of recreation opportunities and could possibly accelerate recreation growth on the Kenai Peninsula. The monument would permit scenic boat tours into the coastal fjords and would establish observation stations for scenic viewing of the Harding Icefields. There would be little new road development as a result of this proposal, although there could be increased traffic on the existing highway from Anchorage to the Kenai Peninsula.

Perhaps the most important recreational resource serving local citizens and out-of-state vacationers is the Kenai National Moose Range east of the proposed plant site. This hummocky forested lowland has an abundance of wildlife, fish, and inter-lake passages for canoeists. Approximately 27.3 miles of Pacific Alaska's proposed pipeline would extend into the range. Most of this pipeline route would utilize existing rights-of-way and also would traverse vegetation areas damaged by fire 8 years ago. Table 20 shows public use of the Kenai National Moose Range.

The nearest recreational development to the proposed plant site is a small 7-acre state-run campground-wayside at Bernice Lake. This area is only 1.5 miles from the proposed site and is served by the North Kenai Road. About 10 miles to the northeast of the proposed site is the 3,620-acre Captain Cook Recreation Area which also has camping and picnicking facilities operated by the State of Alaska. The pipeline routes would not cross these or any other developed camping-recreation areas.

The land on the west side of the inlet is sparsely inhabited and essentially undeveloped. The only year-round access is by ship or aircraft. The primary land uses are oil and gas development, hunting, fishing, and a small Japanese timber operation near North Foreland. The Iditarod Trail, which would be crossed by the applicant's proposed Susitna Basin pipeline, was recently proposed for inclusion in the National Historic Trails System. It is a popular route for winter dogsledding. Proposals have been formulated

TABLE 20

KENAI NATIONAL MOOSE RANGE PUBLIC USE DATA

	1973		1974		1975	
	Visits	Act. Hrs.	Visits	Act. Hrs.	Visits	Act. Hrs.
Interpretation	1,240	620	1,600	800	2,400	1,100
Environmental Education	2,200	28,400	800	4,700	800	2,600
Hunting - Resident Game	23,500	615,500	30,700	215,600	15,000	150,000
Hunting - Migratory Birds	2,300	17,400	1,500	12,200	1,800	12,000
Fishing	45,300	603,400	71,400	436,400	49,800	536,700
Other Consumptive Activity	1,050	8,400	500	1,300	1,600	3,400
Trapping	10,000	90,000	8,000	30,000	7,000	21,000
Wildlife/Wildland - Non-Consumptive	68,500	1,120,400	166,000	6,679,000	141,000	2,250,000
Recreation Non Wildlife/ Wildland	47,100	3,584,000	10,300	180,900	5,500	110,900
Total Activity Visits	201,190		271,000		224,900	
Total Visits	140,300		156,300		102,000	

Areal Distribution of Activity

A.	Swanson River Rec. Area	30%
B.	Skilak Loop Rec. Area	55%
C.	Tustumena Lake Rec. Area	10%
D.	Mystery Creek Road	2%
E.	All Other	3%

Note: Due to changes in sampling techniques, statistical validity may vary from year to year.

Source: U.S. Department of the Interior, Bureau of Land Management, *Lower Cook Inlet*.

by the U.S. Department of the Interior to establish a Lake Clark National Park and a Iliamna National Resource Range inland from the southwestern Cook Inlet area. (See Figure 32.) Such proposals would increase recreation opportunities in the general area. There are plans to eventually connect this area to Anchorage by highway; however, this is not likely to occur in the near future. Table 21 provides statistics on wildlife and hunting pressure in Alaska's national forests. The Department of the Interior has indicated that additional information on aesthetics and land use is available from the Federal-State Land Use Planning Commission.

12. Air and Noise Quality

a) Air Quality

The proposed project area is located within the Cook Inlet Air Quality Control Region of Alaska. Air sampling of the six major air pollutants--total suspended particulate (TSP), sulfur dioxide (SO_2), photochemical oxidants, carbon monoxide, nitrogen dioxide, and hydrocarbons--was conducted in Anchorage to determine the extent of air pollution in the region. TSP levels were found to exceed the Federal primary standard, while concentrations of the remaining five pollutants were found to be below their respective Federal secondary standards. Therefore, the region received a Priority I designation for TSP and a Priority III designation for the remaining pollutants. 1/ Although the priorities reflect the regional air quality, specific areas within the region may not experience the same air pollution levels.

1/ A Priority I designation indicates that air pollution concentrations exceed the Federal primary standard and that a significant reduction in emissions of that pollutant is required. Priority II indicates the pollution levels are greater than the Federal secondary standard, but below the primary standard. Priority III indicates pollution concentrations are below the Federal secondary standard.

TABLE 21

ALASKA NATIONAL FORESTS - WILDLIFE RESOURCE
ESTIMATED PRESENT AND FUTURE SUPPLY AND DEMAND

Species or Group	1962			1976			2000		
	Total Supply #	Usable Surplus #	Harvest Demand #	Total Supply #	Usable Surplus #	Harvest Demand #	Total Supply #	Usable Surplus #	Harvest Demand #
Big Game:									
Sitka Deer	200,000	50,000	13,000	210,000	52,000	25,000	220,000	55,000	40,000
Moose	4,000	1,000	500	4,000	1,000	950	4,000	1,000	1,600
Roosevelt Elk	1,200	300	120	1,400	350	200	1,800	450	400
Mountain Goat	12,700	3,000	400	12,700	3,000	800	12,700	3,000	1,500
Dall Sheep	900	200	15	900	200	50	900	200	100
Black Bear	5,800	1,160	200	6,000	1,200	400	6,000	1,200	700
Glacier Bear	300	60	5	300	60	20	300	60	40
Brown Bear	6,900	690	150	6,700	670	300	6,500	650	500
Timber Wolves	2,000	500	80	1,900	475	160	1,800	450	250
Wolverine	1,000	250	20	900	180	40	800	160	70
Waterfowl	Not possible to assess	Exceeds demand	40,000	Same numbers as 1962	Will exceed demand	80,000	Possible reduction	Not possible to assess	150,000
Salmon (commercial & sport)	--	26MM	26MM	--	48MM	48MM	--	57MM	57MM
Trout, Char & Grayling	Not possible to assess	Exceeds demand; local shortages	Less than surplus	Same numbers as 1962	Exceeds demand; local shortages	Less than surplus	Same numbers as 1962	Exceeds demand; local shortages	Less than surplus
Furbearers	Abundant	Not known	Less than surplus	Abundant	Not known	Less than surplus	Abundant	Not known	Less than surplus
Grouse & Ptarmigan	--	--	Less than surplus	--	--	Less than surplus	--	--	Less than surplus

Source: U. S. Forest Service, Alaska Region, Final Environmental Impact Statement, Land Use Plan, Chugach National Forest (July 1974) p. 400-J-1

The national primary and secondary standards for the criteria air pollutants are presented in Table 22. The primary standards are the levels necessary to protect public health. The secondary standards are generally more stringent than the primary standards and are designed to protect the public welfare from any known or anticipated adverse effects of a pollutant. The ambient air quality standards for the state of Alaska are also included in this table.

Ambient air quality data for the project area are limited to TSP sampled at the Phillips Marathon LNG plant, located within 1 mile of the proposed LNG plant site. Data for 1970 through the first 9 months of 1977 are summarized in Table 23. Although annual TSP levels are within the Federal and state standards, a trend toward increasing concentrations is evident from Table 23. The national secondary and Alaskan 24-hour standards, 150 mg/m^3, were exceeded three times in 1976, once in 1975, and once during the first 9 months of 1977. The national primary 24-hour standard was exceeded once in both 1975 and 1976. The Alaska Department of Environmental Conservation (ADEC) has attributed these high TSP levels primarily to fugitive dust, not industrial activity.

Air sampling for the remaining five pollutants has not been conducted at the Nikiski station or elsewhere in the project area. However, it is unlikely that this area would experience elevated concentrations of these pollutants. The Environmental Protection Agency (EPA) has designated the Kenai area as an attainment area for all criteria pollutants, indicating that ambient levels of these pollutants are within their respective standards.

Table 24 presents a 1975 emission inventory for the major point sources in the Nikiski industrial complex identified in Figure 31. The Collier Carbon and Chemical Corporation (Collier) located immediately north of the proposed LNG site represents the major source of particulate matter (PM) and SO_2 in the area. Table 24 also includes the total projected emissions from both continuous and noncontinuous sources for the Collier plant's expansion of its amonia and urea production facilities, scheduled to begin operation in 1978. The plant expansion is estimated to increase PM emissions by 31 percent and SO_2 emissions by 61 percent. EPA Region X reviewed the Collier proposal and on June 7, 1977, issued a "Negative Declaration," indicating that significant environmental impacts are not anticipated and that an EIS would not be prepared. EPA's analysis found

TABLE 22

NATIONAL AND ALASKA AMBIENT AIR QUALITY STANDARDS

(Concentrations in $\mu g/m^3$ unless otherwise noted)

Pollutant	National Primary Standard	National Secondary Standard	Alaska Standard
1) Total Suspended Particulates			
Annual Geometric Mean	75	60	60
24-Hour Maximum 1/	260	150	150
2) Sulfur Dioxide			
Annual Arithmetic Mean	80	---	60
24-Hour Maximum 1/	365	---	260
3-Hour Maximum 1/	---	1,300	1,300
3) Carbon Monoxide			
8-Hour Maximum 1/	10 mg/m^3	Same as Primary	10 mg/m^3
1-Hour Maximum 1/	40 mg/m^3	Same as Primary	40 mg/m^3
4) Nitrogen Dioxide			
Annual Arithmetic Mean	100	Same as Primary	100
5) Photochemical Oxidants			
1-Hour Maximum 1/	160	Same as Primary	160
6) Hydrocarbons (Non-Methane)			
3-Hour (6 to 9 a.m.) 1/	160	Same as Primary	160

1/ Not to be exceeded more than once per year.

TABLE 23

TOTAL SUSPENDED PARTICULATE ($\mu g/m^3$) MEASURED AT PHILLIPS MARATHON LNG PLANT AIR MONITORING STATION AT NIKISKI, ALASKA 1/

Averaging Time	1970	1971	1972	1973	1974	1975	1976	1977 2/
Annual Geometric Mean	16	12	15	17	14	36	43 3/	32 3/
24-Hour Maximum	68	34	147	50	96	346	476	158
24-Hour Second High	40	32	106	37	58	123	199	134
Number of Samples	38	44	34	25	41	37	51	41

1/ Source: 1970-1974 Data - Greater Anchorage Area Borough, Department of Environmental Quality, Anchorage, Alaska.

1975-1977 Data - State of Alaska, Department of Environmental Conservation, Juneau, Alaska.

2/ Based on 9 months of data, January thru September 1977.

3/ Calculated from numbers reported by the sampling agency.

TABLE 24

1975 EMISSION INVENTORY FOR NIKISKI INDUSTRIAL COMPLEX, ALASKA

Source 1/	Emissions (Tons/Yr.) PM	SO_2
Chugach Electric - Bernice Lake Power Station	21	1
Phillips Marathon LNG Plant	55	2
Standard Oil - Alaska Refinery	3	1
Tesoro - Alaska Petroleum Refinery	18	½
Collier Carbon and Chemical Corporation 2/		
a) Current emissions	755	184
b) Projected 1978 emissions - Combined existing and plant expansion	992	296

1/ Source: Except where otherwise noted--State of Alaska, Department of Environmental Conservation, Juneau, Alaska.

2/ Source: Negative Declaration, Collier Carbon and Chemical Corporation, U.S. Environmental Protection Agency, Region X, Seattle, Washington, June 7, 1977.

that both TSP and SO_2 levels would increase but not exceed the ambient air quality standards. The ADEC analysis found that the SO_2 standard would not be violated except under highly unusual circumstances. Although Federal regulations for the prevention of significant deterioration of air quality (PSD) do not apply to this plant, EPA estimated that the plant expansion emissions would contribute 2 $\mu g/m^3$ to the annual TSP increment and 12 $\mu g/m^3$ to the 24-hour TSP increment.

b) Noise Quality

A noise survey was conducted at six locations in the vicinity of the project area by Dames and Moore on October 10, 11, and 12, 1972. Figure 33 shows the locations of the sampling sites. Ten-minute noise samples were recorded on tape approximately once each hour during midday, late evening, and early morning hours. Sample recordings were later analyzed in the laboratory.

The study found that noise from the Collier facility controlled the ambient noise levels within a 3-mile radius of the plant. Pacific Alaska's proposed plant site is located adjacent to the Collier facility and within its range of influence. L_{50} levels 1/ of 64 to 69 decibels on the A-weighted scale (dBA) were recorded at sampling site 3. This site is located near the northeast corner of the proposed site and approximately 1,000 feet from the Collier plant. Noise levels of 51 to 59 dBA were measured at site 4, which is located near the southeast corner of the proposed site, about 3,500 feet from the Collier plant.

Site 1 characterizes the noise environment at the nearest residences to the plant site. Noise levels ranged from 40 to 53 dBA at this site. The location of other nearby residences are identified in Figure 31.

Ambient noise levels generally decreased with increasing distance from the Nikiski industrial complex. Site 6, approximately 5 miles away, exhibited essentially rural noise levels of 32 and 39 dBA. The range of L_{50} levels for each sampling site is indicated in parentheses on the map in Figure 33.

1/ Medium sound level, exceeded 50 percent of the time.

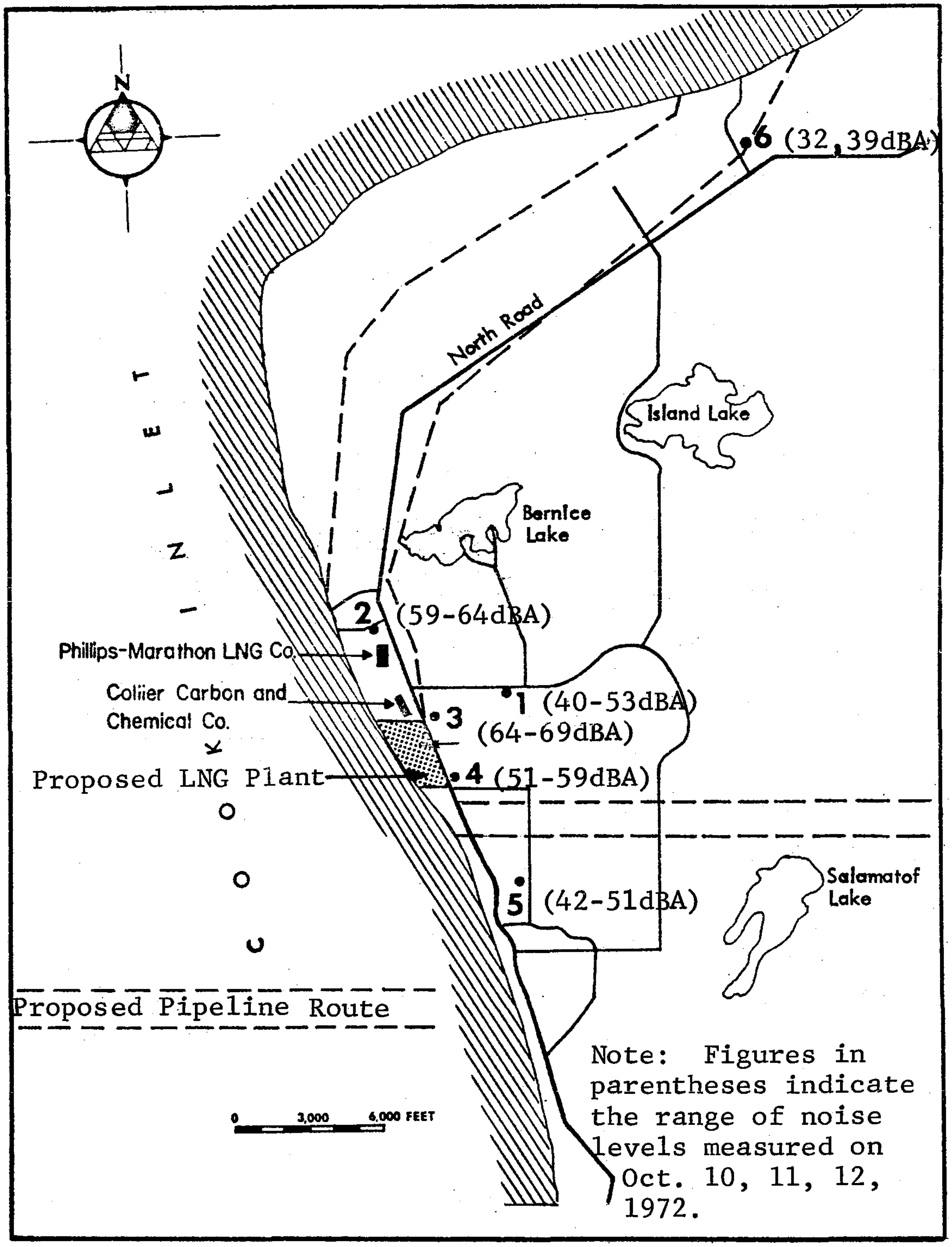

Figure 33
Ambient Noise Measurements
and Sampling Locations
Nikiski, Alaska

The expansion of the Collier plant, identified in the previous section, could further increase ambient noise levels in the Nikiski area. A worst-case analysis presented in EPA's "Negative Declaration" estimated that ambient sound levels would increase by approximately 3 dB at location 3 and 2 dB at locations 2 and 4. The resulting sound level at location 1 would be 56 dBA. However, the use of proper mufflers on steam vents and acoustic insulation over machinery noise sources would reduce sound levels from the Collier plant and result in a minimal impact on ambient noise levels.

C. ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

1. Climate

The construction and operation of the project should have an insignificant impact on the climatology of the region. Water vapor emissions from the gas turbine exhausts and condensors may occasionally cause local fogging, but this is expected to be minor and restricted within the site boundary. Minor spills or leaks would have an insignificant impact on the climate.

2. Topography

The permanent impact of the proposed project upon the topography would be limited to those areas where grading, cut-and-fill, borrow, or dredging operations are required. Most of these operations would be connected with the construction of the LNG plant and marine terminal. Impact of the pipeline installation or topography would be temporary, because the material excavated from the trench would be used as backfill. However, there would be a 6- to 12-inch crown over the backfilled trench which should disappear as compaction takes place. Any excess material would be spread over the right-of-way. The trench depth would be governed by the Department of Transportation regulations listed in Part 192 Title 49 CFR and would be a minimum of 5.5 or 6.0 feet deep depending on location, as defined in those regulations. At most river crossings, the trench depth would be a minimum of 7 feet, except for the crossing of the Beluga River, where the minimum trenching might be 12 feet. The depth of placement is also subject to state regulation. Grading and terracing might be needed at the points where the pipeline would enter Cook Inlet. Impact from borrow activity is discussed in the following "Geology" section.

Because the slope of the proposed site is minimal and because the site has already been cleared and leveled, grading would be necessary only to excavate the foundation areas. After completion of the facilities, the final site elevation would range from about 113 to 118 feet above mean sea level, compared to the present range of 112 to 120 feet.

Construction of the proposed haul road would have more impact on the topography than any other portion of the proposal and represents a significant impact of the project. (See Figure 4.) Excavation of some 215,000 cubic yards of material would leave a permanent breach in the top of the bluff over 750 feet wide. The haul road would have a maximum incline of 11 percent, a width of 100 feet, and would occupy the bottom of an ever-widening cut (side slope of 1.5 to 1, horizontal to vertical) terminating at the construction dock. A total surface area of about 4 acres would be excavated, all of it outside of the proposed plant site. The excavated material would cover the equivalent of about 10 football fields to a depth of 13 feet and would, therefore, require a substantial disposal site. No sites have yet been proposed.

Dredging off the end of the marine trestle and in the southern tanker approach channel would change the bathymetry of the inlet. Pacific Alaska has indicated that about 70,000 cubic yards of rock and bottom sediment would be removed from the channel. They suggest that if significant quantities of rock are encountered, then blasting may be necessary, but they do not anticipate the need for such activity. Dredge depth would be 48 feet below mean lower low water at the dock and on the approach. Present water depth at the dock site is 42 feet or more. (See Figure 14.)

The proposed construction dock would require about 33,000 cubic yards of fill. It is not expected that any of this could be provided from material dredged as part of the dock construction program. The entire 33,000 cubic yards would come from onshore borrow areas, perhaps from excavation for the haul road. Since all of the dredged material would be unsuitable for use as fill, it would increase the amount of dredge spoil to be dumped within the inlet from this project by 30 percent, to a total of about 92,000 cubic yards. The area involved in dredging for the construction dock would be approximately 300 feet by 400 feet. The average thickness of material to be removed from within this area would be 5 feet, resulting in a depth of 5 feet mean low water. (See Figure 4.)

Dredge spoil would be dumped within the inlet, at latitude 60° 40' 00" North, longitude 151° 36' 00" West, in approximately 120 feet of water. The bottom is rocky, and it is likely that currents would distribute the spoil around the inlet with no appreciable permanent bathymetric effect.

Impact on the topography caused by erosion will be treated in the following section.

3. Geology

The major impact on the geologic environment would be increased erosion. Most of the land crossed by the proposed facilities is of low relief and not generally susceptible to erosion. In addition, the generally high permeability of the soils below the organic mat would inhibit surface runoff and erosion.

Where there is significant relief, especially at the bluff bordering the site and where the proposed pipeline would enter Cook Inlet, there would be a potential for erosion by surface runoff or by slumping, because the stability of the slope would be altered by cut-and-fill activities. Increased infiltration of water at the top of the bluff due to removal of the layer of peat could also promote slumping by increasing the water content of the bluff material.

Disturbance of streambanks and streambeds would increase the potential for bank erosion and bed scour. Until these areas were restabililized, there would be increased sediment load in the streams and increased siltation downstream and within the inlet. The increase in turbidity within the inlet would not be significant due to the normally high sediment levels in that body of water.

In addition to changing the topography, borrow activity--the excavation of natural fill or construction materials--would tend to increase siltation and erosion. Most borrow material needed at the plant site would be obtained from foundation excavation on the site. If more material were needed, either at the site or during pipeline construction, Pacific Alaska would obtain it from the closest source--location(s) not specified.

Sediment distribution patterns would be altered by the construction and operation of the marine facilities and the construction dock. During construction and dredging operations, the amount of sediment in suspension would be increased. Soon after construction operations were completed, the swift inlet currents could be expected to restabilize bottom contours so that the degree of turbidity would return to preconstruction levels. Operation of the LNG tankers and maintenance dredging would increase turbidity to some extent; however, such dredging operations would occur infrequently.

Construction of the proposed facility would not be expected to deplete any natural resources. Borrow material which might be needed is readily and abundantly available. Future utilization of mineral resources would not be significantly hindered by the existence of the facility. Aside from gold, aggregate, coal, and hydrocarbons, there are no known economically significant accumulations of mineral resources in this area. Placer gold deposits do occur near the proposed Susitna Basin pipeline lateral along the Lewis River, and near the proposed Anchor Point pipeline in the vicinity of Ninilchik and Anchor Point. However, no significant impact to utilization of these resources is likely.

There are several hazards to the proposed facilities due to potential earthquake activity. These hazards include ground shaking, ground rupture, tectonic subsidence, landsliding, liquefaction, and tsunamis.

There is no evidence of surficial faulting at or within a few miles of the proposed site. Bedrock faults oriented east-west are known from oil and gas fields to the south and east of the site, but they appear to be related to the formation of the reservoir structures. Faulting at the site is unlikely.

Cracking of the ground surface due to lurching or compaction of unconsolidated sediments was common within the Kenai Lowland during the 1964 earthquake. The nearest reported cracking occurred about 2 miles south of the proposed LNG facility. Most of this type of disturbance is restricted to a relatively thin surface layer and would have little or no effect upon the facility. Future differential compactions would probably be reduced in magnitude due to effects of the 1964 event; however, it is not known whether any compaction of this sort occurred on the proposed site. Ground rupture of any kind is not considered to be a significant hazard at the proposed LNG plant site.

Several geologic faults would be crossed by the proposed pipelines. The Bruin Bay fault would be crossed twice by the West Foreland to North Foreland pipeline and once by the Coffee Creek Field lateral. The pipeline from the Susitna Basin Field to the Lewis River would cross the Beluga Mountain fault and the Lake Clark portion of the Castle Mountain fault system. Of these faults, only the Castle Mountain fault has been found to display evidence of Holocene activity. It should be considered a potential hazard to this pipeline.

On the Kenai Peninsula the Beaver Creek Field to West Fork Field pipeline lateral, the Kenai Loop Field to Sterling Field pipeline lateral, and the portion of the Anchor Point pipeline between Kenai Loop Field and Kasilof are all within the area which experienced significant ground rupture during the 1964 earthquake. It is possible that recurrence of such an event could damage the proposed pipelines.

It is not unlikely that the proposed LNG facilities would be subjected to ground accelerations similar to those experienced in 1964. The probability is 14 percent that this will occur in 30 years. The probability of at least a magnitude 6.5 event occurring within the Cook Inlet Basin is 97 percent over the same period of time, although the probability of reaching or exceeding 0.5g bedrock accelerations at the facilities due to this event is only about 10 percent.

Given the estimates of seismic ground acceleration at Nikiski in 1964, the seismicity of the Cook Inlet area, and the unique tectonic framework of southern Alaska compared to the lower 48 states, it is the staff's opinion that critical portions of the proposed Nikiski facility should be designed for a combination of the effects of a local magnitude 6.5 earthquake (peak bedrock acceleration 0.5g) and a distal magnitude 8.5 earthquake (peak bedrock acceleration 0.3g). This does not mean to imply that these two events are expected to occur simultaneously. It means that the characteristics of the bedrock motion, and presumably the resultant ground motion, would be so dissimilar that certain facilities designed to a response spectrum based upon only one of these earthquakes might not fare as well if the other earthquake occurred. For example, the LNG tanks would tend to respond more strongly to the higher frequency shaking during the magnitude 6.5 event while the marine trestle would tend to respond more to low frequency shaking resulting from the larger, more distant earthquake.

These design assumptions utilize the same philosophy that has been used at other proposed LNG facilities where several earthquake sources may be expected. In these instances, similar LNG facilities--the proposed terminal at Point Conception (see Volume II) and the previously proposed Oxnard and Los Angeles LNG terminals--are designed to earthquakes of magnitude 8.25 on the San Andreas fault and earthquakes of magnitude 6.5 to 7.5 from closer sources.

It should be understood that since these accelerations are design bedrock values, the facilities would be designed to accommodate different values depending on soil column response, foundation-soil interaction, and properties of the structures to be built. The latter two considerations are strongly related to individual structures, and consequently the design values for the LNG tanks may not be the same as those for equipment at the loading dock, for example. Analysis of the soil properties at the proposed terminal site shows that peak accelerations of 0.5g from a local magnitude 6.5 earthquake are not likely to be transmitted to the surface. The design ground surface accelerations are 0.32g for the remote earthquake and 0.35g for the local earthquake. Utilization of these design values would result in conservative design for the proposed facilities.

As previously mentioned, tectonic subsidence in the project area of the Kenai Lowland was on the order of 1 foot during the 1964 event. Apparently no subsidence took place along the route on the west side of the inlet. Such regional subsidence would have little effect on the facilities.

Landsliding is a potential hazard wherever the facilities would be near the sea bluff or other areas of significant slope. Earthquake-induced landsliding in 1964 occurred in Anchorage and at Homer on the southern tip of the Kenai Lowland. Slumping of the bluff occurred at two locations on the North Forelands. The pipeline would pass within 100 yards of these areas. If the 1964 level of shaking is not exceeded, there should be little effect on the pipeline if it is buried below the level of slippage. At the site, landsliding is not expected to be a significant hazard, since structures would be set back from the bluff a minimum of 100 feet and the subsurface materials are not prone to deep-seated slippage. 1/ If properly anchored, the trestle and transfer pipelines should not be affected.

Liquefaction occurs when a soil behaves as a liquid and loses its ability to support objects. This may occur when a water-saturated soil is shaken and may result in the

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1/ Dames and Moore, Detailed Environmental Analysis Concerning a Proposed Liquefied Natural Gas Project for Pacific Alaska LNG Company, 1974, p. 2-74.

soil flowing down very gentle slopes. Liquefaction should not be a problem at the plant site. The soils are not particularly susceptible to this phenomenon, and the ground water table is deep. 2/

Liquefaction could occur in the saturated bottom sediments of the inlet with resulting loss of support for the pipeline, which might then sink into the sediments. Increased stress could result in rupture. This same phenomenon could occur in relatively fine-grained saturated sediments in or near river channels, floodplains, or tidal flats. Additional longitudinal stresses would result if the soil around the pipeline began to slide downhill.

Seismic sea waves (tsunamis) are generally caused by displacement of the ocean floor. Waves with less far-reaching impact may result from a landslide into a body of water. There have only been two reported tsunamis in Cook Inlet since 1883. In that year the eruption of Mt. Augustine resulted in a 25- to 29-foot high wave at English Bay, while the 1964 Prince William Sound earthquake initiated only a 4-foot high wave at Seldovia. These locations are about 100 miles south of the proposed site. Apparently, it is unlikely that waves generated outside of the southern Alaska region would travel up the inlet. Tsunamis generated within the inlet might have an impact upon the marine facilities.

Tsunamis should have no effect upon the onland facilities, due to their elevation and/or buried condition. A repetition of the 1883 episode would not occur without warning, since Mt. Augustine's activity is continuously monitored. In such an event, a berthed LNG tanker could be removed from the docking area to avoid damage to the vessel or the docking facilities. The same is not necessarily true for waves generated due to faulting in the inlet, but there is no evidence that such waves have occurred to date.

Geologic hazards not necessarily related to earthquake activity include subsidence, landsliding, erosion, flooding, expansive soils, frozen soils, organic soils, and volcanic activity.

2/ Dames and Moore, Detailed Environmental Analysis..., pp. 2-71 and 2-75.

Subsidence may be caused by withdrawal of subsurface fluids or compaction of unconsolidated deposits as well as the aforementioned tectonic activity. Compaction due to loading by the facilities would be no more than a few inches and would be accommodated by foundation design. 1/ Withdrawal of groundwater is not expected to be great and should not result in subsidence. Extraction of oil and gas from local fields is at a depth that should minimize surface effects. In addition, the distance of these fields from the site would preclude subsidence from this source as a significant hazard.

Because most of the proposed pipeline would be routed through terrain of minimal slope, landsliding should not generally be a problem. Where the bluff which borders the inlet would be approached or crossed, there would be a potential for mass movement and rupture of the pipeline.

The generally low slope throughout the project area would also minimize the hazard of erosion. However, pipeline crossings of rivers or Cook Inlet would be subject to scour, as would the supports for the marine terminal. Within the inlet, shifting bottom material associated with sand and gravel waves could undermine the pipeline and result in unsupported portions rupturing. Shifting material on the inlet floor has damaged oil pipelines in the past and could be hazardous to the proposed gas pipeline. The proposed crossing of the inlet would avoid mapped areas of boulders and cobbles and high-amplitude sand waves. While this would not eliminate the potential for damage, it should reduce that potential considerably. At river crossings, depth of burial would be used which would protect the pipeline from the maximum expected scour.

At the terminal site, the maximum rate of sea bluff retreat from erosion is 1 foot per year. The minimum setback of 100 feet for the facilities should provide an adequate safety margin.

Flooding could cause excessive scour of pipeline river crossings. In addition to a seasonal flood hazard, there is a potential for outburst floods caused by the release of water trapped within or behind glaciers. Within the Kenai Lowlands pipeline crossings of the Kenai and Kasilof Rivers could be

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1/ Dames and Moore, Report--Foundation Investigation and Seismic Studies, Proposed LNG Liquefaction Plant Nikiski, Alaska, 1974, p. 18.

subjected to flooding. To the north of the inlet, the Beluga, Yentna, McArthur, and Chakachatna Rivers are inferred to have experienced outburst floods and could experience them again. 1/

No expansive soils have been encountered in subsurface exploration at the site or nearby facilities. 2/ It is possible that such soils exist along the proposed corridor, but they are not expected to present a significant hazard to the pipeline.

Frozen soils should be no problem at the proposed site, and permafrost is nonexistent in the project area. Although the depth of winter frost penetration is 10 to 12 feet, the site is underlain by porous, well-drained soil and should not be susceptible to frost heave and associated problems. The pipeline would inhibit frost formation in its vicinity since the gas temperature would be above 32°F. Since this region contains no permafrost, the thermal impact to the soil would be insignificant.

Organic soils are not thick at the plant site and would be removed prior to construction. However, approximately 10 percent of the proposed pipeline route crosses peat deposits, notably the West Foreland to North Foreland pipeline and the pipelines near the Susitna Basin, Beluga, and Kenai Loop Fields. Some of these deposits are over 15 feet thick, so that the pipeline would be surrounded by peat. Within this saturated material, the pipeline would be buoyant and would tend to rise to the surface unless weighted. Conversely, if it were weighted excessively, it would tend to sink. The proposed use of soil anchors would eliminate most of this hazard.

The western side of Cook Inlet is the site of several active volcanoes. These are shown on Figure 15. It is unlikely that eruption of any of these volcanoes would adversely affect the proposed pipeline due to their distance from the proposed facilities. The plant site could be subjected to dense ash-falls, but this should not be particularly hazardous. It is possible, although unlikely, that operations could be impeded by such an occurrence, but no risk to the public would result.

1/ R. Post and L.R. Mayo, Glacier Dammed Lakes and Outburst Floods in Alaska, USGS Map, Hydrologic Investigations Atlas HA-455, 1971.

2/ Dames and Moore, Detailed Environmental Analysis . . ., p. 2-77.

The recent major activity of Mt. Augustine, the southernmost volcano on Figure 15, resulted in the destruction of measuring instruments on the island. However, impacts on the eastern side of the inlet were limited to ash-falls. Approximately one-sixteenth of an inch fell in Anchorage about 170 miles away. There was no significant hazard to navigation within the inlet due to this activity, but it is possible that future activity could temporarily impair visibility, and there is a potential for tsunami generation. However, ample warning could be supplied by the monitoring system operated by the Alaskan Geophysical Institute.

4. Soils

Impact of the proposed construction upon area soils should be relatively minor. Due to the soil types and terrain, erosion impact should be negligible except at crossings of the inlet and rivers or where the slope is more than approximately 10 percent. If erosion due to construction activities were not controlled in these areas, the entire soil profile could be washed away. Erosion impacts were treated in detail in the "Geology" impacts section; the impacts which remain to be discussed concern soil fertility.

Soils which contain appreciable amounts of clay may be compacted during construction activities. As a result of decreased permeability, drainage and therefore fertility is impaired. However, clayey soils are not common in this area. Muskeg areas are not generally fertile. The high water table in these areas makes agriculture impractical.

Mixing of the soil profile, a result of normal trenching operations, commonly has an adverse effect on soil fertility. Where peat or organic matter is encountered to depths in excess of the trench depth, no effect is anticipated, since mixed organic material is no more or less fertile than the unmixed material. Elsewhere, the thin soil generated above coarse morainal deposits would be destroyed by mixing with the underlying material. This is true whether or not this soil is covered with an organic mat. Impact is expected to be greatest on the Kenai Lowland where the water table is generally farther from the surface than it is on the west side of the inlet.

In the event of LNG spillage, the soil would be temporarily frozen to varying depths, depending upon its water content and the magnitude of the spill. However, there would be no lasting impact upon the soil since the LNG evaporates quickly, allowing the soil to return to its previous temperature.

5. Hydrology and Water Quality

No streams traverse the proposed plant site, nor are any lakes, ponds, or marshes present within its bounds. During construction, approximately 2½ feet of organic-rich material overlying the site would be removed, except for a 50-foot wide strip around the southerly half of the perimeter, exposing the more permeable soils below. These soils, composed of sandy gravel, would significantly enhance percolation. Consequently, very little runoff would be anticipated. The essentially flat nature of the site would also limit runoff. During periods of particularly heavy precipitation, runoff would follow the present topography, sloping slightly to the south and west. A small ditch in the southwestern corner of the site would direct any runoff to a discharge point at the top of the sea bluff. This point would be monitored for erosion until the permanent plant drainage system was operational, and if required, restored by installing a pipe to carry runoff to the bottom of the bluff. Unless the applicant amends the proposed drainage plan to incorporate a settling pond or other such sediment-control device near the top of the bluff, site drainage may contain sediments washed from exposed construction areas. Discharges from the top of the bluff would almost certainly erode the sea bluff itself. Sediments carried by these flows, however, would be expected to have very little impact on ambient inlet water quality.

During construction of the proposed pipeline and LNG facility, various chemicals such as gasoline, fuel and crankcase oils, primers, and paints might be accidentally spilled. The applicant plans to control minor spills by placing metal pans or buckets under the valves, storage tank and transfer hose connections, and underneath oil and lubricant containers. Paints and primers would also be stored and mixed on metal pans. These techniques would probably be effective for controlling small spills, seeps, and drips.

Even if a spill could not be contained by the measures proposed above, surface and/or groundwater contamination in the area of the LNG plant site would be unlikely, since the proposed site has no surface water, and groundwater lies approximately 70 feet below the surface. Soils which soaked up small spills would be removed and transported to an approved chemical landfill where leaching could be controlled. The staff is unaware of any formal controls proposed by the applicant which would effectively deter hazardous substances from being carried to the southwest corner of the site and over the bluff into Cook Inlet during a heavy rain. While the applicant asserts that only small spills of oils or lubricants would be expected during plant construction, the possibility that a hazardous substance, oil, for instance, could find its way into the inlet still exists. The impact associated with such an occurrence would depend on the concentration of the substance and the volume actually entering the inlet. However, given the inlet's dilution capacity, the minor volumes of hazardous substances expected to be present during construction, and the relatively few aquatic organisms which inhabit the inlet near the proposed plant site, the resulting impact on water quality would be localized and probably insignificant.

The permanent liquefaction plant drainage system would divert stormwater runoff to a low point in the tank area, from which it would be pumped along the loading trestle and discharged into Cook Inlet. This discharge is expected to be free of industrial pollutants and as such would have no significant impact on the estuary water quality.

Embankment cuts made adjacent to the proposed haul road between the beachfront construction dock and the plant site would be held to a slope no greater than 1.5:1 (horizontal to vertical), the same as the existing sea bluff. Despite this slope rate and the granular nature of the underlying soils, erosional gullying could be a problem prior to implementation of a control program or the introduction of slope-stabilizing vegetation.

It is anticipated that the spoil created by the excavation of the proposed haul road (see Section C.2) would have some impact on local water quality in the vicinity of the disposal site. At this time, however, the applicant has indicated only that "a state-approved, environmentally acceptable disposal area" would be used and that the excavated spoils would consist of "clean organics and mineral soils characteristic of the general area."

Two temporary construction camps are proposed to be located in the Nikiski area. The camp proposed to house workers constructing the LNG plant itself would be located on a site just east of that proposed for the LNG plant. Existing drainage to adjacent roadway ditches would be expected to serve this camp, resulting in a negligible impact to local water quality since this area has been previously graded. Surface runoff from the proposed pipeline construction camp at Nikiski would be controled by site grading, and erosion control structures and culverts where needed. Water would be collected and discharged into Cook Inlet or existing drainage channels. Runoff directed into the inlet would result in an insignificant impact under normal circumstances and only localized degradation in a worst-case situation due to the inlet dynamics. However, locations for the pipeline construction camps have yet to be determined, and without site-specific information, it is impossible to predict where "existing drainage channels" might direct runoff from the Nikiski construction camp, and to determine what impact might result.

The proposed pipeline rights-of-way cross areas having substantially more topographic relief than the plant site. Furthermore, much of the route would traverse areas of muskeg soil material containing a large percentage of water and would be relatively close to ponds, lakes, streams, and rivers. Therefore, if a major spill occurred along the rights-of-way or at one of the other proposed temporary pipeline construction camps, significant damage to the aquaous environment could be sustained. Spilled petroleum products could result in reduced light penetration into stream waters as well as depletion of dissolved oxygen levels as the petroleum oxidized. Additionally, the lighter fractions of petroleum would go into solution in the water column. The biological impact of such an event is discussed in Section C.7.

Construction of the proposed pipeline, for the most part, would be scheduled during the winter. Although the ground would be devoid of vegetative cover, runoff would be minimal since much of the precipitation would be in the form of snow. Construction, however, would cause additional sediment to be carried into Cook Inlet and into the streams along the pipeline routes until these areas are revegetated. Backfill would be mounded over the pipeline 6 to 12 inches above preconstruction levels to allow for settling. In extensive marsh or muskeg areas, this berm could significantly alter background drainage patterns. Alternately, if sufficient material is not crowned over the pipeline, natural consolidation could result in the formation of artificial channels along the right-of-way. This would both increase the potential for erosion and modify existing background drainage. The principal impact of construction on the hydrologic regime, however, is expected to be limited to the proposed river crossings.

The proposed pipeline would make approximately 68 crossing of 39 identifiable (named) watercourses (crossings of unnamed streams which are tributaries of identifiable streams were counted as multiple crossings of the named watercourse) and 26 crossings of 26 unidentified watercourses. Where dry construction techniques could not be used, operations would temporarily increase suspended sediment concentrations and turbidity in the affected waterways. The degree to which this impact would be expected is primarily related to the streamflow velocity and the characteristics of the streambed sediments. Increased suspended sediment concentrations would be experienced farther downstream in a fast-flowing stream than in a slow-flowing stream. A streambed composed of silt would produce more turbidity than one comprised of larger, heavier sands and gravels. Although no generalized statement can be made concerning composition of the bed materials at the proposed crossings, all major crossings would be scheduled during the winter months when flows are minimal and, in many cases, would occur within the tidal reaches of the rivers. Under winter low-flow conditions, turbidity and the potential for riverbank damage would be lessened. The most serious potential impact would result from increases in riverbed erosion and scouring. Impacts of this nature would probably take place at crossings where the riverbed is normally protected by an armor of coarser-grained sediments covering erosion-susceptible materials. Removal of this protective armor could enhance local scouring. A listing of the proposed crossings and affected streams is presented in Appendix B, Table B-9.

Overall impact to the aquatic environment resulting from the proposed temporary pipeline construction camps should be minimal. By avoiding sites which would require extensive grading and by implementing standard engineering practices to stablilize exposed soil surfaces and control runoff, erosion and subsequent turbidity and stream siltation could be effectively controlled. If mechanical control devices such as ditch liners, letdown structures, stilling basins, levees, and terraces are deemed necessary by the applicant on a site-specific basis and included in the overall sediment-and-erosion-control plan, it is expected that these devices would become a permanent part of the environment. While such devices might be considered aesthetically displeasing in the "natural" environment, they should create positive benefits for the aquatic environment.

Failure to implement and maintain an effective sediment- and erosion-control plan would result in erosion of exposed soil surfaces and degradation of the aquatic environment between the point where runoff is allowed to enter the stream and the stream's confluence with Cook Inlet. It is expected, however, that the deleterious effects which siltation imposed upon rivers and streams would have little or no impact upon inlet water quality. Materials other than silt washed from temporary pipeline construction camp locations could also contribute substantially to the degradation of stream water quality, depending upon the material.

The applicant proposes to dispose of solid wastes at state-approved sanitary landfill sites. This practice should result in no significant long-term impact, as long as hazardous or toxic materials are segregated for disposal at an approved chemical landfill and standard engineering practices are followed. Conversations with the Alaska Department of Environmental Conservation (ADEC) have indicated that while approved landfill operations do exist, capacities are limited. The ADEC suggests that all solid wastes amenable to incineration be incinerated, reserving sanitary landfills for incinerator residues whenever possible.

Sanitary wastes would probably be stabilized in a package waste-treatment unit incorporating an extended aeration or a physical-chemcial process. Either of these schemes could provide the necessary secondary level of treatment. However, successful disposal of the treated effluent by discharging it into a flow-control management structure for ultimate percolation into the ground would depend heavily on site-specific conditions. Since stringent state and Federal requirements have been established for sewage disposal, the staff expects that both the State of Alaska and the EPA would impose adequate controls once the applicant proposes specific locations for the temporary pipeline construction camp flow management control structures.

After removal of the pipeline construction camps, all disturbed surfaces would be revegetated. By applying standard stabilization techniques in conjunction with mechanical erosion-control devices where necessary, long-term deleterious alterations to the aquatic environment could be avoided. Establishment of adequate vegetative cover may require only a few growing seasons. This recovery period, however, would strongly depend upon climatic conditions, with severe weather contributing to a potential long-term problem. The results of an unsuccessful revegetation/soil stabilization program would be similar to but greater than those discussed above because more soil surface area would be exposed.

The applicant proposes to remove some 70,000 cubic yards of bottom material by dredging from the southern approach channel and loading trestle areas. Another 22,000 cubic yards of material would be dredged from the construction dock area. It is anticipated that this operation would be performed by a clamshell-type bucket dredge. Current plans call for disposal of the material dredged from the construction dock area at approved locations in Cook Inlet. It is proposed that material dredged from the approach channel and loading trestle areas be transported by one or more bottom-drop disposal barges to a proposed mid-inlet disposal site, some 7 to 8 miles west of the liquefaction plant site, and then dropped in approximately 100 feet of water.

Dredging and offshore disposal operations would impact estuarine water quality by temporarily increasing suspended sediments, temporarily decreasing light penetration, and temporarily depressing dissolved oxygen levels. The existing background suspended sediment concentrations in Cook Inlet are normally quite high. Thus, a temporary increase in suspended sediment levels would not be expected to result in significant degradation of the existing water quality. For the same reasons, the ensuing temporary reduction in light penetration would not be expected to result in substantial adverse impact. Dissolved oxygen levels, being somewhat influenced by suspended sediments, would be depressed slightly, but rapid dispersion of the affected waters coupled with the high ambient dissolved oxygen concentrations and the high aeration factor present in the inlet would tend to minimize this impact. The applicant would be required to obtain permits covering both the dredge and the disposal operations from the U.S. Army Corps of Engineers. A more site-specific impact analysis would be made by the Corps at that time.

The proposed marine pipelines between the West Foreland and the McArthur River Field, and between Nikishka Bay and the North Foreland would be buried across intertidal zones in water depths of less than 12 feet below MLLW. The trenching operation associated with these buried sections would impact water quality in a manner similar to the dredging operations discussed above, i.e., increase suspended sediments, decrease light penetration, and depress dissolved oxygen levels. The applicant, however, proposes to schedule offshore pipeline construction during the summer months, which coincides with the peak period of sediment transport and deposition in Cook Inlet. Since waters in the offshore construction areas would already be extremely turbid due to suspended sediments, this activity would not significantly degrade ambient water quality. Trenching operations would also modify local bathymetric contours, but the high-energy marine environment would be expected to rapidly restabilize the impacted areas.

During routine operation of the proposed LNG plant facilities, average potable water requirements are anticipated to be around 1,500 gpd or 1 gallon per minute (gpm). The maximum anticipated requirements would be 6,000 gpd or 4.0 gpm.

Water would be obtained from two wells drilled on the plant site. Although the principal aquifer tapped would be an unconfined type, withdrawal of such quantities would not be expected to significantly affect multiple use of the aquifer or disrupt its flow characteristics. However, due to the erratic nature of groundwater aquifers in the area and their generally unpredictable characteristics, the applicant would have to run pumping tests on the proposed wells (with observation wells) to verify the above suppositions.

During the construction stage, a temporary third well would be installed on the east side of the site to provide potable water to the temporary LNG plant construction camp. During peak construction periods, the total requirements anticipated from the one temporary and two permanent wells would be approximately 21 gpm.

Some 14-15 million gallons of water would be required to hydrostatically test each of the proposed LNG tanks. Due to scheduling difficulties, the applicant anticipates that the same water would not be used to test both tanks. Even with the existing minimum capacity of 260 gpm that the applicant hopes to develop from the three above-mentioned wells, additional temporary wells would probably be required to provide the 400 gpm fill rate proposed by the applicant. These additional wells would be installed on the east side of the site and would tap the same aquifer as the permanent and construction camp wells. Following hydrostatic testing, the test water would be discharged into Cook Inlet through a temporary line running down the sea bluff.

Due to the variability of local aquifer characteristics, it would be impossible to predict, in the absence of data provided by professionally supervised field tests, what impact would result from this withdrawal, or even if the proposed rate of withdrawal could be attained and maintained long enough to accumulate the 14-15 million gallons required to test each tank. If, however, the applicant were able to tap a source adequate to supply the proposed quantities, it seems reasonable to postulate that since both withdrawals would occur over relatively short periods about 26 days for each test, no long-term impact would occur to local users of the groundwater resource or to the aquifer itself. This conclusion is further supported by the estimated recharge factor to the North Kenai groundwater system of 6.5 million gpd. The pumping tests proposed by the applicant could indicate the extent to which the withdrawal of such quantities would affect other local groundwater users. No adverse impact would result from the discharged test waters, because no antifreeze compounds or other contaminants, except for minor amounts of dirt and mill scale, would be contained in the water. The overall discharge plan would be subject to approval by local regulatory agencies.

Hydrostatic testing of the proposed gas supply pipelines would be accomplished with freshwater obtained from local rivers and streams along the right-of-way. To protect the local aquatic enironments, the rate at which water would be withdrawn from such surface sources and conditions governing its final discharge would be specified by permitting agencies. Test water would be cascaded from section to section to minimize overall requirements. Since the pipelines will be tested when temperatures are above freezing, no inhibitors or antifreezes would be used. The minor traces of grease, lubricants, and weld material washed from the inside of the pipe by the test water would be expected to have an insignificant impact on local aquatic systems.

During construction of the proposed liquefaction plant, the applicant intends to install and operate temporary sewage treatment facilities in the LNG plant construction camp. The treatment scheme would involve a package waste treatment plant utilizing physical/chemical methods, preceded by an extended aeration unit to aid in the stabilization of the soluble biological oxygen demand (BOD) and reduce chemical requirements. Liquid effluent would be disinfected and discharged from the package plant into an onsite drainage field, while sludge would be stored for periodic incineration. Prior to construction and operation of these facilities, the applican would be required to obtain permits from the ADEC. All necessary public health and effluent discharge standards would have to be met prior to the issuance of such permits.

The liquefaction plant itself would be served by a prefabricated extended aeration treatment facility utilizing physical/biological methods for the neutralization of sanitary wastes. Material introduced into this system would be charged with biologically "activated" sludge and aerated to promote oxidation of biodegradable organic materials. The flow would then pass into a clarifying unit where the solids would be allowed to separate from the liquid and where froth would be removed. The liquid would then be chlorinated and ultimately discharged through an insulated, heat-traced line at the end of the marine pier. The outfall would be located to permit effluent to drop to the surface of Cook Inlet, thus avoiding ice problems during the winter. Again, the necessary permits would have to be granted by ADEC for the protection of public health and quality of state waters. Waste sludge generated in the process would be accumulated in a storage compartment for periodic incineration along with other dry solid or oily wastes. The treatment facility itself would be housed in a heated building so that processes could continue undisturbed by cold weather. Plant washwater, used primarily to wash the inside of buildings on an intermittent basis, would be cycled through an oil-water separator prior to discharge into the treatment facility. Any oil obtained from this washwater would be incinerated.

The LNG tankers would process sanitary and other liquid wastes, including bilge wastes, at sea in accordance with U.S. Coast Guard standards. Ballast water, taken in as the vessels unload at Point Conception and stored in tanks used solely for ballast, would be discharged into Cook Inlet as the vessels load at Nikiski. No pollutants (other than those present at Point Conception) would be present in this water.

A daily discharge of approximately 5,000 gallons of high salinity backwash from the two desalination units aboard each LNG tanker would be expected to have salinity concentrations of approximately 100 parts per thousand. Due to the rapid dilution and dispersion factors inherent in Cook Inlet, the low level of biological activity in the waters, and the fact that the elements contained in the backwash are normally found in natural seawater, no adverse impact to the ambient water quality would be expected. All solid wastes would be incinerated on the high seas. Any residue would be retained for in-port offloading.

Cooling water from the vessel's condenser facilities would be discharged at sea during transit and while loading at the dock. During transit, it is anticipated that the heat input to the surrounding environment would rapidly dissipate. While docked and loading, normal dispersion factors would be expected to easily dissipate the local increases in surface water temperature near the marine pier. A minor LNG spill in the plant site or marine terminal area would probably have a negligible effect on the ambient water quality. While such a spill would generate the potential for ice formation at the LNG-water interface, the phenomenon would be short-lived.

6. Vegetation

When this project was initially proposed, there were about 36 acres of mixed spruce-hardwood forest on the proposed 59.3-acre LNG terminal site. However, since the DEIS was published, the environmental staff has visited the site and has discovered that the applicant has already completely cleared, leveled, and gravelled it. Only a smattering of trees remains along the periphery of the site, and this will not screen a passerby's view of the site. Even if the applicant replants a 50-feet wide screen of trees along the edge of the site to replace the trees which have already been removed, the benefit of such a screen will not be felt for numerous years since this northern climate slows and stunts vegetation growth.

Approximately 4 acres of mixed evergreen-deciduous forest would be cleared for the construction of the proposed haul road south of the LNG plant site. Since much of the road would be excavated from the side of the bluff, this portion of forest habitat would probably be lost permanently.

Although the exact locations of the 50-foot wide rights-of-way for the proposed pipelines are as yet undetermined, roughly 836 acres of evergreen, deciduous, and mixed evergreen-deciduous forest, 123 acres of willow-birch, and alder scrub, 440 acres of muskeg, 80 acres of non-natural vegetation, and 142 acres of successional vegetation in recently burned areas would be cleared during the construction of the proposed pipelines. A considerable portion of onshore pipeline would parallel existing rights-of-way, thus reducing the width of clear-cutting necessary along those portions of the route. An additional 40 acres of land would be impacted for use in four construction work camps.

Besides the direct impact of clear-cutting, the operation of construction equipment would affect terrestrial plants by compacting the soil along much of the 50-foot wide right-of-way. Soil compaction would decrease the permeability of the surface layers, thereby altering both aboveground and subsurface moisture conditions. Vegetative changes would result, making the paths taken by vehicles visibly different from the surrounding area for many years.

Prompt debris disposal along the pipeline route would be of major importance to the forest ecosystem. The spruce bark beetle could breed prolifically in any leftover slash from clear-cutting, then attack living spruce trees nearby when its population reached epidemic proportions. The applicant has proposed to dispose of the slash in existing landfills wherever possible and to burn the remainder according to the stipulations of the local fire wardens. While such measures would help eliminate the beetle problem, the burning of debris would impair local air quality and increase the risk of forest fires. However, it would benefit the environment by returning nitrogen to the soil and stimulating the return of browse plants. 1/

Other impacts to the vegetative communities would include the effects of maintenance clearing along the right-of-way, damage by vehicles engaged in emergency repairs to the pipeline, and wind damage to trees along the edge of the cleared pipeline route. Once the pipeline was constructed, occasional cutting back of the larger successional plant species might be necessary to prevent deep root systems from encroaching upon the pipeline. Periodic aerial surveys of the rights-of way would check the pipeline for possible problems. Should a pipeline break occur, some vegetation in the vicinity of the gas leak would be killed, but the most damaging impact associated with the leak would be caused by the activities of the repair equipment brought in along the right-of-way. Vegetation would be cleared if access were required to repair the pipeline. This would generally affect vegetation in the immediate area and would probably involve only minor clearing. However, significant damage to the environment, beyond even that caused by the original pipeline construction, could take place if such repairs had to be done when the ground was not frozed particularly in areas of wet tundra or muskeg. Maintenance clearing on the right-of-way would include the disposal of dead trees. Trees adjacent to rights-of-way are particularly vulnerable to destruction, primarily because of exposure to winds, but also because soil compaction and increased sunlight penetration may deprive their root systems of adequate moisture.

Marine vegetation in Cook Inlet, because of its scarcity in the project area, would not suffer a significant impact from the construction of the proposed terminal, construction dock, and pipelines. Freshwater vegetation, however, would be destroyed or injured by the actions of machinery operating within any marshes, lakes or streams crossed by the pipeline routes. Turbidity produced by the suspension of solids during trenching activities in bodies of water would temporarily reduce light penetration and thus reduce the productivity of

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1/ U.S. Department of Agriculture, U.S. Forest Service. Environmental Analysis Report--Trans-Alaska Gas Project, Chugach National Forest, Alaska Region (1974), p. 62.

submerged aquatic plants temporarily. The release of hydrostatic test waters would also produce a certain amount of increased turbidity.

Trenching and soil compaction caused by the operation of construction equipment could have effects upon existing runoff patterns and could therefore affect the vegetation of ponds and marshes. Because only the upper soil layers would be affected, however, the impact on all but the most superficial groundwater movements would probably be insignificant.

Contact with LNG released during a spill on land or sea would result in various degrees of injury depending upon the nature of the vegetation and the period of contact.

7. Wildlife

Bird populations in the area of the haul road, as well as along the pipeline route, would lose nesting and feeding habitats in direct proportion to the amount of vegetation removed in such habitats. Any bird nesting habitat on the proposed plant site has already been destroyed. The construction of the plant and the haul road would also eliminate possible swallow nesting habitats along the bluff overlooking Cook Inlet. Except for birds highly tolerant of human activities, the plant site would be removed from use as an avian habitat for the life of the project. The areas cleared for pipeline construction would be temporarily unsuitable for use by birds, but some species would quickly make use of rights-of-way for foraging, and later on for nesting. These species would probably be different from those normally frequenting the area because the vegetation would revert to a much earlier successional level. Woodpeckers, for instance, would be excluded from the right-of-way when the trees were removed, but they would be replaced by songbirds which feed on the seeds of the successional grasses and herbs.

Any diversion of existing waterflow patterns caused by trenching or soil compaction could have an impact on vegetation and bodies of water, especially ponds and marshes. Waterfowl and other avian species dependent upon such habitats would be affected in proportion to the effects of water gain or loss on their environment.

Relatively few birds would be directly disturbed by construction activities because the pipeline system would be installed primarily during the winter when many species are absent. A few gray jays and great horned owls nest as early as February in this part of Alaska, but nearly all other species nest during the warmer months. Plant construction during the spring, summer, and fall on the Kenai Peninsula would have little impact on waterfowl, since it would be done in areas away from nesting concentrations.

The operation of the proposed LNG plant would probably have only a slight impact on birds not living at or near the site itself. Because of the industrial character of the surroundings, many of the species present in the Nikiski area may be presumed to be fairly tolerant of human activities. Noise and gaseous discharges from the proposed facilities would be disturbing factors, but would probably be overshadowed by the outputs of the nearby Collier Carbon and Chemical Plant. Nevertheless, installation of another industrial complex would remove additional natural wildlife habitat.

The operation of the pipelines would have little impact on birdlife except during maintenance and repair operations on the rights-of-way. Low-flying surveillance aircraft used to check for pipeline damage would, however, pose a threat to nesting waterfowl. Some species, particularly the trumpeter swan, are very sensitive to such disturbance and have been known to abandon their nests permanently if disturbed by aircraft.

The clearing of the proposed haul road and pipeline routes would represent a direct loss of habitat for many terrestrial mammals. The animals which have abandoned the plant site area have probably done so permanently, but some species would gradually repopulate the pipeline rights-of-way. Those animals displaced permanently might be unable to find equivalent habitats and would thus be lost to the regional population. Successional changes in the vegetative communities would determine the new inhabitants of the disturbed area. Moose would benefit from clear-cutting mature forests if the right-of-way (except directly over the pipeline) was scarified following construction to initiate browse species revegetation. Caribou, on the other hand, prefer certain mature vegetative communities and would be less likely to use a right-of-way for foraging, although they are known to use such cleared routes as convenient paths and will forage on sedge when their preferred lichen species are not available.

Some small burrowing animals might be killed during clearing and digging activities at the proposed plant site and along the pipeline routes. Most animals would avoid these areas during construction, but a few might remain. Bears are notorious camp followers and could endanger construction personnel and equipment to the point that the bears might have to be driven away or even killed. Moose are frequent casualties on Alaskan roads, sometimes remaining in the paths of oncoming vehicles, and could be injured or killed by construction equipment. It has already been noted that caribou could occur on the pipeline rights-of-way.

Because nearly all of the onshore pipeline would be constructed during the winter, many mammals in the project area would be dormant and less subject to construction impact than at other times. Most mammals give birth in the spring or summer, so winter construction would not interfere with this critical phase of animal life cycles. Bears, which give birth in midwinter, are not known to den near the proposed facilities. Winter construction could have considerable impact on some individuals, however, if they were crushed, turned out of their dens, or excluded from certain areas. For instance, moose, which trample yarding areas when snows are deep, would, if driven from those yards, be more easily preyed upon by wolves. In general, many animals are heavily stressed during the winter and lack the resilience to recover from an impact not significant during the rest of the year.

Plant operations probably would have little effect on the terrestrial mammal population because the local existing biota are relatively acclimated to an industrial environment. Small rodents would probably continue to venture within the LNG plant's boundaries, and even moose have been known to approach the fence surrounding the Collier Carbon and Chemical Plant. The operation of the pipeline would also have little impact, except for the effects of maintenance, repair, and aerial surveillance operations. Aerial surveillance operations might disturb the calving of moose and caribou. Moose might also be particularly sensitive to low-level aerial surveillance in winter since these animals, if frightened, might expend more energy fleeing than could be easily replaced by the meager forage available, further deteriorating their already weakened conditions.

The construction and operation of the proposed facilities would probably have little, if any, impact upon any endangered terrestrial species. Two endangered subspecies of peregrine falcon would be present only during migrations, and most of the pipeline construction where these birds are found would not coincide with their migration periods.

The major impact of the proposed project upon marine animals would probably result from dredging operations associated with channel construction near the LNG tanker terminal and construction dock and with the installation of the pipeline loops across Cook Inlet. Dredging would affect some benthic organisms by crushing, burying, and/or displacing them and their habitats. Poisonous or biologically active substances in the sediments suspended as a result of dredging could temporarily increase local toxicities or lower the level of dissolved oxygen in the water. Increased suspended sediment levels in the vicinity of dredging activities would interfere with the respiratory functions of marine fauna. Another impact associated with dredging could be blasting and dumping of dredge spoils, although the applicant states no blasting is presently anticipated. Blasting could kill or injure marine organisms at varying distances from the dredging site, depending upon the type and amount of explosive used. Fish eggs have been shown to be particularly susceptible to blast damage. The dumping of dredge spoils would have an impact similar to that of dredging, primarily through the suspension of sediment and the burying of organisms.

The operation of the proposed LNG ships in Cook Inlet would also have a minor effect on the marine environment. Minute organisms would be entrained in the ships' engine cooling water and killed by mechanical action and rapid temperature changes. The heated effluents from these cooling systems are potentially harmful but would probably be diluted too quickly once they left the ships to cause any significant thermal effects in Cook Inlet. The ballast water expelled from the ships as the LNG would be pumped aboard would probably contain a number of chemical contaminants and organisms foreign to the Nikiski area. The impact of the chemical substances would probably be minor because of their rapid dilution in the waters of Cook Inlet, while the potential for establishing organisms from southern California (the source of the ballast water) in Alaskan waters could be possible. The ADFG has voiced a concern that salmon-infecting bacteria could be transported from California to Nikiski via ballast water. The applicant, however, indicates it is not aware of any problems with fish diseases in that area of California. The applicant has stated that "regulations are not known to exist that require the treatment of clean ballast water prior to discharge in port." It has also indicated that "the ADFG currently requires no treatment of clear ballast water from [the] LNG ships [loading LNG at the Phillips Marathon plant]." This matter will apparently require further investigation and negotiation between the applicant and the ADFG before ballast water can discharged. A third impact created by LNG ship operations would be the discharge of 5,000 gallons per day of high salinity brackwash water from the ship's desalination units. Although the water released would have a salinity of over three times the normal salinity found near Nikiski, dilution would probably take place before there was any significant damage to the biota.

Spills of LNG, fuel oil, or other petroleum-based products could have very damaging effects upon the marine environment. Any organisms in contact with LNG for even a brief period would be killed or seriously injured. However, due to the rapid evaporation of LNG and its low solubility in water, impact caused by the spillage of LNG would be extremely short-lived. Because of its volatility at ordinary temperatures, LNG is not classified by EPA and the Coast Guard as a hazardous polluting substance that affects water quality. The impacts of oil and oil products spills, while not as immediately dramatic as those of an LNG spill, are potentially more long-lasting and damaging. Seabirds and sea otters in contact with oil on the water would be affected by ingesting oil and by losing the insulative protection of their feathers or fur. Soluble fractions from the oil would be toxic to fish and lower life forms, and heavy oils and tars would coat benthic and tidal habitats. The natural decomposition of spilled oil in cold Alaskan waters might be so slow that the effects would linger for months.

The 3,000 gallons per day of treated sewage from the proposed plant facilities would produce a certain amount of enrichment in the waters near Nikiski, but the ever-present dilution factor of the Cook Inlet tidal flows would considerably reduce the impact associated with such effluents. This impact normally includes the phenomenon of eutrophication with associated decreases in oxygen levels, but the levels of turbidity at Nikiski would prevent an extensive plankton bloom even if the currents did not disperse the treated effluent.

The impact of the proposed action on the freshwater environment would be similar in nature to that described for the marine environment. Runoff from the plant and pipeline construction areas would increase the turbidity of the streams marshes, ponds, and lakes into which it drained. Trenching of streambeds for pipeline crossings would affect the freshwater biota in much the same way as similar operations would affect marine life. Any salmon spawning areas at or downstream from the pipeline crossing would be very susceptible to damage during the winter months when pipelaying is scheduled to take place. Direct mechanical injury, siltation, and decreased oxygen levels would be potential dangers to salmon eggs and fry as a result of trenching. Because of the stress of trenching-related siltation on salmon eggs located downstram from pipeline crossings, the ADFG has indicated that it will require crossings of selected salmon spawning streams during the warm season between fry emergence and the next spawning activity, thereby minimizing siltation impact on these fish.

Fuels, lubricants, and other chemicals spilled during the construction of the plant site and pipelines could eventually find their way into local bodies of water, affecting the water quality and aquatic organisms. Leachates from disturbed soils and decaying vegetation would contribute to the potential impact of the runoff. These contaminants could be immediately toxic to aquatic life or could change the ecological balance by affecting the pH and dissolved oxygen levels of the water. Most of this impact would be temporary.

The withdrawal of water for hydrostatic testing of the LNG storage tanks could affect the water table near the proposed plant site, but the amount withdrawn would probably not change the water levels in local waterways enough to significantly affect the aquatic biota. Withdrawing water from rivers to test segments of the pipeline could have a more serious impact if the volumes were withdrawn fast enough to greatly affect water levels, particularly during the salmon spawning season. The release of hydrostatic test waters into local streams could also significantly increase the turbidity of those streams if the release velocity were too great.

Pipeline construction could alter drainage patterns enough to permanently change the water levels of some ponds or marshes. Surface water flows could be intercepted on the uphill side of a pipeline right-of-way, thus changing existing runoff routes. Whole biotic communities, both aquatic and terrestrial, might be changed as a result.

No rare or endangered aquatic species would likely be affected significantly by the construction or operation of the proposed facilities. Of the protected marine mammals, however, two species, the sea otter and the beluga whale, could be affected by oil spills or blasting in the project area.

8. Socioeconomics

a) Population and Employment

A number of both temporary and permanent jobs would be created as a result of the construction and operation of the proposed project. The peak employment during construction would be about 800 workers at the Nikiski plant site during the second summer construction season. Although pipeline construction would involve as many as 485 additional personnel, the current schedule is such that there would be little overlap between the pipeline and terminal peak construction periods. Table 25 indicates the workforce requirements and construction schedule for the proposed pipeline and terminal facilities. A full-time operation and maintenance staff of about 100 employees would be needed after all facilities are completed.

TABLE 25

SEASONAL WORKFORCE REQUIREMENTS

LNG Plant Construction:

Construction Year	Season	Peak Manpower For Season
1	Spring, Summer, Fall	450
2	Winter	250
2	Spring, Summer, Fall	800
(The peak of 800 is estimated during July thru September.)		
3	Winter	450
3	Spring, Summer	550
3	Fall	250
4	Winter	150
4	Spring, Summer, Fall	150

Pipeline Construction:

Construction Year	Season	Peak Manpower For Season
4	Winter, Spring (Phase I on-land construction)	325
4	Spring (Construction across Cook Inlet by lay barge)	160
5	Winter (Phase II on-land construction	325

Four temporary construction workcamps would be available to provide room and board for all nonlocal construction personnel at the employee's option. Since vacant housing may be relatively scarce in the project area, it is expected that most nonlocal workers would choose to live in the workcamps. The payroll over the 4-year phased construction period beginning in early 1979 would amount to $74 million for the LNG terminal and $14.5 million for the pipeline system. The applicant's policy would be to hire local workers whenever practical. Among the types of positions that might be filled are: laborers, truck drivers, heavy equipment operators, concrete workers, painters, welding assistants, landscapers, and workcamp services personnel (janitors, cooks,etc.). Also, some construction workers in the Kenai area may posses specialized skills gained from past experience with previous gas and oil pipeline and LNG facility construction on the Kenai Peninsula. Additional temporary job opportunities may become available at local area businesses in response to the increased economic activity and circulation of the construction payroll dollars through the local economy.

The proposed facilities would provide nearly $7 million in additional annual property tax revenues for local governments. This amount of revenue may be compared with the total 1973-1974 property tax revenues of about $2.5 million for the entire Kenai Peninsula Borough. A considerable portion of the Phase I and II pipelines would be located in the Matanuska-Susitna Borough on the northwest side of Cook Inlet. The tax revenues from these pipelines would be a relatively small percentage of the total project tax revenues, but could be significant to the Matanuska-Susitna Borough's tax base which is also relatively small. The Alaska state government would benefit financially from royalty payments on the gas sold out-of-state and by income tax revenues generated from worker's salaries during facility construction and operation.

The construction of the LNG terminal would require the purchase of certain construction materials, particularly concrete, sand, and gravel, from Kenai area suppliers. The money spent on these materials would be an additional direct cash flow into the area economy. Figure 34 is a qualitative diagram of some important cash flows into the Kenai area economy resulting from the applicant's proposal.

The construction of the two proposed LNG tankers would have a socioeconomic impact on the Philadelphia, Pennsylvania, metropolitan area in the form of increased employment and business for local commercial and industrial contractors. This effect, however, would not be readily visible against the

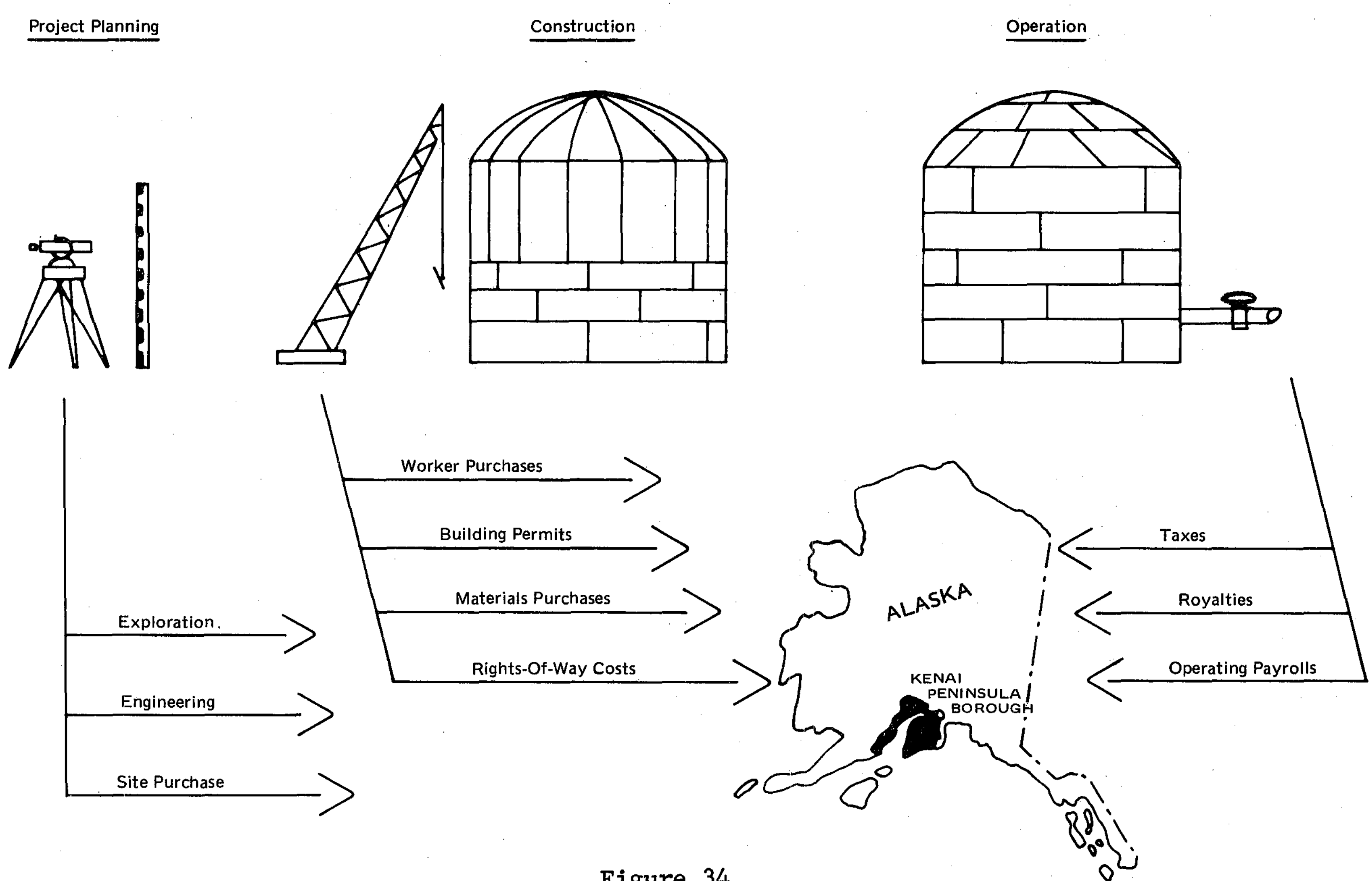

Figure 34

Cash Flows Into The Cook Inlet Region

economic background of the urban megalopolis. Any additional demands on housing and on public services would be readily absorbed by the existing economic structure in the area.

Construction of modular plant components in Seattle, Washington, would result in additional local socioeconomic impact. The gross direct payroll for module fabrication would be about $16 million and would involve a peak labor force of 475 personnel. Similar to the impact on Philadelphia, this level of socioeconomic change would be readily incorporated into the existing economy. Construction by the use of modular plant components is estimated to save $19,800,000 over conventional onsite construction methods.

b) Social Impact, Transportation, Housing, and Services

Economic expansion in the Kenai-Nikiski area could result in socioeconomic problems adversely affecting the "quality of life." Area businesses and certain community functions, (such as providing law enforcement, educational, and recreational services), may have difficulty adjusting to the presence and needs of immigrating project employees. Workers involved with pipeline construction would generally be located at isolated locations, and of necessity, would be independent of, and would not affect, community social life and services. However, the workers employed at the Nikiski terminal site, and to a lesser degree at the Falls Creek pipeline workcamp, would be in a position to interact with local communities. These workers could contribute to a considerable increase in local business, particularly in the nearby bars and restaurants. Higher populations in the general area could result in some increase in the incidence of crime and could require additional patrols by local police forces.

The applicant would emphasize local hiring and the use of local contractors whenever practical. It is believed that relatively few nonlocal workers would attempt to relocate their families to the project area. While a variety of social impacts are possible, it is expected that the region's relatively broad economic base, coupled with the past experience with "boom and bust" economic growth induced by oil and gas development, would result in no serious socioeconomic problems.

Some disruption of Native lifestyle patterns could occur as a result of the proposed project, particularly on the west side of Cook Inlet. However, Natives in the project area are more accustomed than those peoples from some interior Alaskan villages to cash economies and outside visitors. Subsistence lifestyles in the general project area have already been substantially altered by tourism, recreational hunting, oil and gas development, and commercial fishery operations. The influence of modern values and commodities on traditional Native cultural patterns has already greatly affected the Native villages in the inlet area.

Increased materials supply traffic on the existing transport systems could constitute an adverse socioeconomic impact. Congestion on highways could occur even at a considerable distance from the site because of the "funneling" imposed by the limited road system. Within the Chugach National Forest and the Kenai National Moose Range, congestion could detract from recreational highway use and would have an adverse economic impact on recreation-oriented businesses. Table 26 illustrates the present traffic loads on the important south-central Alaskan highways.

The loss of gas to markets outside Alaska would not seriously affect future Alaskan energy supplies because the great volume of present reserves exceeds estimated future requirements. The population in the Cook Inlet area, although concentrated by Alaskan standards, is small enough to have relatively limited and manageable energy needs. Without an out-of-state gas market, much of Alaska's vast energy reserves might never be developed.

Concern for the safe operation of the proposed facility could create anxiety among local residents. However, this impact would be reduced following a period of safe, incident-free terminal operation. Safety precautions undertaken to control potential hazards along with efforts to inform the public of such precautions would lessen any concern for safety. A minor LNG spill or leak could produce short-term disruptions of activities adjacent to the proposed facilities.

9. Land Use

Construction of the proposed LNG terminal and pipeline system would alter a total of approximately 1,570 acres of land for the duration of the project. 1/ Following the

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1/ This 1,570 acres includes about 11 acres for the haul road spoil disposal area, 4 acres for the haul road itself, 59 acres for the plant site, 1,452 acres for the pipeline right-of-way, 40 acres for the construction workcamps, and 4 acres for river-crossing construction sites and pipe storage yards.

TABLE 26

ESTIMATED MAXIMUM DESIGN CAPACITY AND USE OF EXISTING PRIMARY ROADS IN THE COOK INLET AREA: 1974

Road	Length (miles)	Max. Design Capacity in ADT†	ADT for the Busiest Road Segment	Current Use of Busiest Segment as a % of Capacity
Sterling	100	10,000	3,030	30%
Cohoe Road	16	250-400	230	71% *
Kalifonsky	22	5000-7000	1,400	23% *
Kenai Spur	39			
1. Jct. with Sterling Highway to Jct. with Beaver Loop Rd.	11	10,000	5,230	52%
2. Jct. with Beaver Loop Rd. to Jct. with Beach Spur	16	7,000	6,600	94%
3. Jct. with Beach Spur to end of route	12	250-400	820	252% *
Sterling Spur	39	5000-7000	1,670	28% *
Seward/Glennallen				
1. Seward to Potter	116	5,000	2,665	53%
2. Potter to start of four lane	-	10,000	14,800	148%
3. Four-lane highway	-	50,000	37,400	75%
Hope Road	18	250-400	145	45%.*

* Where the estimate of maximum design capacity is given as a range, the median value was used to calculate the percentage. †ADT = Average Daily Vechicle Traffic.

Source: Bureau of Land Management, U.S. Department of the Interior, Lower Cook Inlet. DEIS on Proposed Oil and Gas Lease Sale No. CI. Vol. I (1976).

conclusion of terminal operations, after a planned 20-year facility lifespan, most of these lands could be restored to their present condition or modified for other industrial use. The construction haul road, however, can be considered a permenant alteration to the landscape because of the large volume of materials removed. Along the 50-foot pipeline right-of-way, trees would be cleared from forested portions, and only low-profile vegetation would be permitted. At the plant site, only about 4.1 of the total 59.3 acres would be allowed to remain forested as an aesthetic "green belt" along the North Kenai Road and southern boundary of the site. The construction workcamps would affect a total of about 40 acres and could be restored to their original condition.

It may be possible to utilize several gravel pits in the area for haul road spoil disposal; however, no arrangements have been finalized. Dump truck activity during haul road construction would disrupt traffic, especially along the North Kenai Road. Disposal would be done in accordance with the governing local regulations. The area required for disposal of the haul road spoil could be converted to some other use following terminal construction.

During peak construction, approximately 6,400 to 8,000 lb/day of Class 1, 2 and 3 solid wastes would be generated at the Nikiski-area workcamp and burned in an incinerator. The incinerator would be designed and operated to comply with Alaska state particulate emission standards of 0.2 grains per standard cubic foot of exhaust gas (gr/scf). The small amounts of ash generated would be taken to an existing landfill. No new landfill sites would be required for this ash. It is estimated that 10 to 20 pounds per person per day of solid waste would be generated in the proposed pipeline workcamps. This solid waste would be disposed of in approved landfills operating with an air permit by the Alaska Department of Environmental Conservation.

Pipeline construction alongside or across roads would require temporary detours by traffic but would not require any road closures. Disruptions to normal traffic flow from this construction would not occur at any given location for longer than 2 or 3 days.

The limited highway development from Anchorage and Seward to the Kenai-Nikiski area could result in highway congestion from additional overland supply traffic during plant construction. This impact is not expected to be as significant as the spoil disposal truck traffic.

An increase in shipping activity would occur during the construction and operation of the LNG terminal and related facilities. Shipping lanes would not be expected to become congested during construction, although about 50 barge arrivals over a three-summer period would be necessary to deliver project modules. The anticipated expansion of existing ports in Cook Inlet and a new port facility proposed for North Foreland are likely to increase vessel traffic in shipping lanes south of Nikiski by as many as 100 vessel trips annually over the next several years. Modifications to the existing marine facilities in the Nikiski Port complex are expected to result in fewer but larger and more specialized ships visiting this port area. Large vessel arrivals (greater than 1,000 dwt) at Nikiski are estimated to decrease from 373 in 1974 to about 350 in 1980, including approximately 52 tanker arrivals per year to the proposed LNG terminal. At present, LNG tankers are required by the U.S. Coast Guard to have a licensed pilot on board when navigating inland waters. Standard navigational aids such as lights, whistles, horns, and bells are used in Cook Inlet to pinpoint particularly dangerous areas. Although the increase in shipping would make inlet navigation incrementally more complex, the construction and operation of the proposed facility would not disrupt present regional shipping services nor limit future regional shipping development. By comparison with other inland waters in the United States, the Cook Inlet is very sparsely traveled.

The beaches near the proposed terminal site are utilized by local fishermen for set-net emplacement. Although some interference with such fishing would occur during construction, access to the beach would be kept clear at all times, and there would be no long-term effect on fishing. Beach access could be improved by eventual public use of the proposed haul road. However, the construction dock would be removed after unloading operations are completed and would not be available for future use.

The lands affected by the Pacific Alaska project are owned in large part by the State of Alaska. Exceptions are those lands along the proposed pipeline route which lie within the Kenai National Moose Range, lands subject to Native village claims, and lands along the Nikiski-Anchor Point pipeline route, some of which are privately owned. A portion of the 59.3-acre terminal site is owned by Pacific Alaska, with the remainder under lease from the State. Patterns of industrial development at Kenai-Nikiski and of oil and gas development on the west side of Cook Inlet have already been well established. No significant deviation in the character of local land use would result from the applicant's project. The expected land use impact would be incremental as the initial growth in population and economic activity eventually stabilizes. The long-term impact of the project would be the encouragement of community growth with attendant increased economic stability. Any long-term limitations of such land use development must result from local governmental policy and from the expressed desires of the local populace.

10. Archaeological and Historical Resources

A literature survey of archaeological and historical sites, as shown in Table 19, indicates that 10 known sites would lie within the proposed pipeline corridors. All of these sites could be avoided by minor realignments of the proposed pipelines. However, a report by the Iroquois Research Institute 1/ estimates that only 6 percent of the total number of archaeological and historical sites in Alaska are, in fact, known and cataloged, leaving open the possibility that undiscovered sites might be impacted during construction activities. An on-the-ground survey would be necessary to determine the actual location and significance of any unknown archaeological and historical resources along the right-of-way. The chance of finding and disrupting such sites would be reduced somewhat by the expected use of existing rights-of-way over about 62 percent of the pipeline route. Also, the performance of an archaeological survey prior to the staking of a final pipeline alignment would further help to avoid site disturbances. There is no guarantee, however, that the impact on archaeological resources would be reduced to zero, because some artifacts might not be discovered until pipeline trenching reveals their presence.

1/ Robert L. Humphrey, Jr., A Study of Archaeological and Historic Potential Along the Trans-Alaskan Natural Gas Pipeline Routes, Iroquois Research Institute (Falls Church, Virginia, 1975).

The general nature of construction impact can be both direct and indirect. Direct impacts would arise from the actual construction of the pipeline, LNG and terminal facilities, construction camps, and haul roads. The proposed right-of-way would be 50 feet wide with a normal ditch for the pipe of about 6 feet in depth and 4 feet in width. The activities associated with the construction of these facilities would include trenching, land clearing, and grading and would, in many instances, destroy any archaeological remains in the affected areas. Indirect impact would arise from activities outside the actual construction areas. Foremost among these would be the greater likelihood of archaeological site disturbance by souvenir hunters because hitherto remote sites would be exposed to human intrusion. Other indirect impact could come about through erosion or chemical alteration of soils which could affect the integrity of archaeological sites. Where archaeological and historical sites are located in wooded areas, the land clearing of the pipeline right-of-way would produce a permanent visual intrusion and alteration in the surrounding aesthetic environment. Other effects might include the draining of small ponds and the diversion of streams. Such disturbances to natural land features could mislead any future attempts to discover archaeological materials by obscuring the geographical clues that researchers use to predict likely site locations.

11. Recreation and Aesthetics

The aesthetic condition of the Cook Inlet region differs from other areas in Alaska in that extensive oil- and gas-related activities, and the relatively large human populations, have changed the character of the land from that of an undisturbed wilderness. Nevertheless, the area holds much to excite the recreational interests of outdoorsmen, including hunters, fishermen, canoeists, hikers, skiers, snowmobilers, sightseers, and photographers. The impact of the applicant's proposal would be an incremental increase over similar disturbances in the existing aesthetic and recreational environment.

Pipeline rights-of-way and cleared seismic exploration lines may provide "off-road" access to otherwise isolated areas, particularly in the winter when the ground surface is frozen. In this sense, oil and gas development has increased recreational opportunities while at the same time creating an aesthetic and recreational impact. Unregulated use of cleared pipeline rights-of-way by off-road vehicles can cause significant damage by scarring the landscape, damaging vegetation, compacting soils, facilitating erosion, and harassing wildlife. Pipeline construction caused increased noise and dust because of the operation of heavy equipment. Construction workers involved in project development also place some additional recreational pressure on the area during their leisure time; however, this impact would not be significant, given the abundance and continued growth in recreation opportunties in the region. The visual impact of a cleared pipeline right-of-way persists for many years and may be seen from great distances when viewed from the air.

Industrial facilities, such as the proposed LNG terminal, tend to reduce recreational use of adjacent areas and have an adverse aesthetic impact. The visual character of the inlet shoreline has been decidedly changed by the existing docking and storage facilities, particularly at Nikiski, and would be incrementally affected by the Pacific Alaska project. Also, during the facility's construction and operation, shipping would be more noticeable in the inlet. However, cleared areas around the Nikiski facilities do provide views of distant scenery which are otherwise obscured from the North Kenai Road by the thick forest.

During the LNG terminal construction period, materials movements and the removal of haul road spoil could lead to highway congestion between Anchorage and Seward to Nikiski and along North Kenai Road. Within the Chugach National Forest and the Kenai National Moose Range (Moose Range), any such highway congestion could interfere with sightseeing and other highway-oriented recreation. The worst effects would probably be suffered by the state-run Bernice Lake Campground, only 1.5 miles north of the proposed terminal area. This locality could also be subjected to dust and noise arising from the nearby construction project. However, once the LNG facility is operational, these impacts would cease.

The proposed haul road and construction dock would also create adverse aesthetic impact, both by alteration of the natural bluff along the shoreline and by creation of a large spoil disposal area at some presently undetermined location. The approximately 215,000 cubic yards of cut materials would require a disposal area of about 11 acres, assuming an average spoil depth of 12 feet. The excavated materials would not readily compact and would require extensive fertilization and revegetation to avoid possible erosion and degradation of nearby water resources. Similarly, the embankments along the haul road would also be erosion-susceptible unless carefully revegetated. In other areas of the country, large landfills have eventually provided recreational playing fields and open spaces, if properly planned and managed. A beneficial impact of the haul road would be the increased beach access it could provide to the public after the proposed LNG terminal construction is completed.

On the Kenai Peninsula, pipeline construction would cause aesthetic impact within the Moose Range and along the Sterling Highway, which is used by large numbers of recreationalists. The impact would be lessened by the use of existing rights-of-way in many areas and by winter construction which would avoid the peak summer recreational highway usage.

12. Air and Noise Quality

a) Air Quality

During construction of the proposed project, the main sources of air pollutants would be the exhausts from the gasoline- and diesel-powered construction equipment and fugitive dust from general construction activities. Nitrogen oxides (NO_x), carbon monoxide (CO), and hydrocarbons (HC) are the primary pollutants emitted from construction equipment. The applicant has estimated the average fuel usage for construction equipment at the LNG plant to be 175 gpd of gasoline and 540 gpd of diesel fuel for an 8-hour workday. While equipment use and emissions would vary throughout the 4-year construction period, average daily emissions based on fuel consumption projections and average emission factors (Appendix J, Table J-1) would be approximately 220 pounds of NO_x, 420 pounds of CO, 50 pounds of HC, 15 pounds of sulfur dioxide (SO_2), and 9 pounds of particulate matter (PM). During unfavorable meteorological conditions, construction emissions would cause a localized increase in ambient pollutant concentrations. However, these emissions would have a negligible impact on regional air quality. Pipeline construction would cause only temporary air quality impact in any particular location.

An additional source of particulate emissions would be fugitive dust resulting from vehicle traffic on unpaved roads, excavation and grading, and materials stockpiling. The extent of dust generation would depend on the level of construction activity and soil composition and dryness. Because of their relatively large diameter, dust particles tend to settle out of the atmosphere rapidly, confining the dust to the vicinity of the construction site. However, dry and windy weather could create a nuisance if proper dust suppression techniques are not implemented.

The applicant proposes to dispose of the land clearing wastes from the 59.2-acre plant site by open burning. According to the Alaska Air Pollution Regulations, Section 50.030, open burning is prohibited during an air quality advisory, which is declared when meteorological conditions can be expected to prevent adequate pollutant dispersal. The open burning of oils, oily wastes, asphalt and tars, and similar waste materials is prohibited without a permit from the Alaska Department of Environmental Conservation. Open burning, if conducted during periods of good atmospheric ventilation, should cause only a minor impact on the local air quality.

The main sources of air pollutant emissions directly related to the operation of the proposed project are listed in Table 27. Additional sources of plant emissions would include minor plant fuel uses, the plant incinerator, occasional gas and refrigerant leaks, and the venting of LNG vapors during ship loading operations.

The major source of plant emissions would be the eight gas-fired turbines (194,900 hp total) used in the two liquefaction trains. The turbines would be of the regenerative cycle type, and together would account for over 96 percent of the plant's fuel use. New source performance standards (NSPS) for stationary gas turbines larger than 1,000 horsepower, proposed by the EPA on October 3, 1977, would limit NO_x and SO_2 emissions to 75 ppm and 150 ppm, respectively. The NO_x emission limit would be adjusted upward for turbines with efficiencies greater than 25 percent. The gas turbines proposed for liquefaction train number 1 would emit approximately 210 ppm NO_x, while the gas turbines proposed for train 2 would be designed to meet the proposed NSPS and emit about 100 ppm NO_x. Section 50.050 of the Alaska Air Pollution Regulations limits visible emissions to 20 percent capacity and emissions of PM and SO_2 to 0.05 gr/scf and 500 ppm, respectively. The proposed turbines particulate emission rate of 0.002 gr/scf and the typically low visible emissions from natural gas combustion should permit compliance with these regulations.

The other major source of project emissions would be two LNG tankers, which together would make about 52 annual arrivals at Nikiski. The primary fuel used in the LNG tankers would be Bunker-C fuel oil having a sulfur content of 2 percent or less. Boil-off gas would supplement fuel-oil combustion in transit and would supply about one third of the ship's fuel requirements on the ballast voyage and about two thirds for the loaded voyage. Table 27 lists estimated tanker emissions for the design service speed, docking maneuvers, receiving cargo, and hoteling. Cargo loading would occur over a 10- to 12-hour period, while the total in-port time would be on the order of 24 hours. No Federal regulations apply to ship emissions; however, Section 50.100 of the Alaska regulations limits visible emissions from marine vessels to 40 percent capacity while the vessel is within 3 miles of the Alaskan coastline.

A portion of the LNG vapors generated while filling the ship's cargo tanks would be returned to the storage tanks to make up the displaced volume. The remainder of the gas, about 324 tons for a 10- to 12-hour loading period,

TABLE 27

AIR POLLUTION EMISSIONS - OPERATIONAL PHASE
(Phase II - 400 million cfd)

Source	Maximum Firing Rate	Emissions at Maximum Firing Rate (lb/hr.)[1] PM	SO_2	NO_x	HC	CO	Average Operation
Major Plant Emissions:							
Liquefaction Trains (8-turbines)	1.65×10^9 Btu/hr.	24	neg	918	30	60	345 days/yr.
Gas-Fired Heaters (5)	111.25×10^6 Btu/hr.	.6	neg	16	.4	2	345 days/yr.
130,000 m^3 LNG Tanker 2/:							52 arrivals/yr.
Approaching	1.25 - oil 3/ 0.49 - gas	6	110	19	1	1	1.6 hours/trip
Berthing	1.25 - oil 1.06 - gas	10	110	24	1	2	1.5 hours/trip
Loading	1.25 - oil 1.42 - gas	12	110	27	1	3	12.0 hours/trip
Hoteling	1.25 - oil 0.85 - gas	8	110	22	1	2	7.3 hours/trip
Deberthing	1.25 - oil 1.02 - gas	9	110	24	1	2	0.5 hours/trip
Departing	1.74 - oil 3.42 - gas	35	153	60	4	7	1.1 hours/trip
Service Speed (18 knots)	2.51 - oil 3.42 - gas	53	221	87	4	9	

	Annual Emissions (ton/yr.) PM	SO_2	NO_x	HC	CO	
Plant Emissions	101.8	neg	3866.8	125.9	256.7	
130,000 m^3 LNG Tanker 4/	4.9	45.5	11.1	.7	1.0	
Total	106.7	45.5	3877.9	126.6	257.7	
Offsite Utility	15.5	5.7	457.2	46.5	127.3	87,600 mwh/yr.

1/ Emission factors are presented in Appendix J.

2/ Emissions reflect winter operations. Emissions would be lower in summer.

3/ Fuel comsumption in metric tons per hours (1 metric ton = 2204.6 pounds)

4/ Emissions for tanker at berth and docking maneuvers.

would be vented to the atmosphere through a 75-foot high stack. Methane and ethane would comprise about 98.9 percent of the gas by volume and would have a negligible contribution to photochemical oxidant formation. Of the remaining components, about 0.37 percent would be propane, a hydrocarbon having low photochemical reactivity, and 0.7 percent would be nitrogen.

Emergency releases of LNG vapors from the storage tanks would vent directly to the atmosphere from pressure relief vents on the tank roof. High pressure releases of propane and mixed refrigerant would be incinerated and exhausted through a 300-foot flare stack.

Solid and liquid wastes generated at the plant would be burned in a modified Consumat Model C-120P incinerator equipped with a sludge injector system. This unit is designed to incinerate trash, rubbish, refuse, and garbage at a maximum rate of 435 to 560 pounds per hour (lbs/hr), sewage sludge at 130 lbs/hr, and waste oils at 20 to 40 gallons per hour. During Phase II, the unit would incinerate a maximum of about 600 pounds of combined rubbish, refuse, and garbage and 60 pounds of sewage sludge each day. The emissions from the incinerator would be less than 0.08 gr/scf corrected to 12 percent CO_2, or about 1 pound of PM per hour of operation. 1/

Under Section 50.040, part (a), of the Alaska Air Pollution Regulations, visible emissions from incinerators installed after July 1, 1972, may not cause a reduction in visibility greater than 20 percent. Part (b) limits the maximum PM emission to 0.2 gr/scf for incinerators having a maximum rated capacity greater than 200 lbs/hr but less than 1,000 lbs/hr. The proper use of the proposed incinerator should insure compliance with both standards.

Table 28 lists projected maximum ambient concentrations of total suspended particulates (TSP), nitrogen dioxide (NO_x), and SO_2 for the major sources of project emissions--the gas-fired turbines and the LNG tanker at dock. Maximum 1-hour concentrations were estimated for Pasquil stability classes A through F. 2/ Estimates are also presented for

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1/ The actual emission rate is corrected to a standard exhaust gas concentration of 12 percent CO_2.

2/ A description of atmospheric stability classes and the frequency of each class in the project area may be found in Table 3.

TABLE 28

MAXIMUM AMBIENT CONCENTRATION INCREASES
(ug/m^3)

Source	Stability Class	Windspeed (m/sec)	Distance to max. (km)	1-Hour Max.			3-Hour Max.	24-Hour Max.		Annual		
				TSP	SO_2	NO_2	SO_2	TSP	SO_2	TSP	SO_2	NO_2
Liquefaction Trains	A	3.0	0.8	4	neg	142	neg	1	neg			
	D	20.0	2.5	2	neg	63	neg	1	neg			
	E	2.0	14.2	2	neg	73	neg	1	neg			
	Fumigation	2.5	11.0	7	neg	274	neg	-	-			
	All	All	10.0	-	-	-	-	-	-	neg	neg	2
LNG Tanker	C	3.0	0.7	14	253	44	201	9	77			
	D	5.0	0.7	18	321	55	263	12	100			
	F	2.0	3.2	11	200	35	162	7	61			
	Fumigation	2.5	2.4	16	298	51	215	-	-			
	All	All	0.7	-	-	-	-	-	-	0.1	1	0.3

Note:

1. Stack parameters are listed in Appendix J, Table J-3.
2. Maximum 1-hour concentrations for stability classes A through F were computed by EPA's PTMAX program.
3. Fumigation and annual concentrations were calculated according to Guidelines For Air Quality Maintenance Planning and Analysis Volume 10 (Revised), EPA, October 1977.
4. Multiplying factors of 0.9 and 0.4 were used to calculate 3-hour and 24-hour concentrations from the 1-hour maximums listed in the PTMAX output. 3-hour maximum concentrations for fumigation are based on 1-hour fumigation followed by 2 hours at D stability.

fumigation, a condition where high short-period concentrations can occur when a plume, originally emitted into a stable atmosphere, is later mixed rapidly downward by an unstable atmosphere. The maximum 3-hour and 24-hour concentrations corresponding to the appropriate Federal and state ambient air quality standards (Table 22) were estimated from 1-hour concentrations.

Ambient concentrations for the eight gas turbines used in the liquefaction trains were analyzed by assuming that the combined emissions originate from a single stack. Stack parameters were based on turbine d (Appendix J), which was found to yield the highest ground level concentrations. It is estimated that this source would increase annual NO_2 levels by a maximum of 2 $\mu g/m^3$, assuming that all NO_x emissions would be converted to NO_2 at ground level. This source would have a negligible impact on other ambient pollutant levels.

The impact of LNG tanker emissions on ambient air quality was analyzed for receptors located on the nearby bluff, about 125 feet above sea level, by subtracting the receptor height from the plume height. The maximum 1-hour concentration represents the tanker approaching the marine terminal, since emissions and stack parameters for this condition yielded the highest short-period concentrations. Three-hour concentrations are based on tanker approach followed by hoteling; 24-hour levels are based on approaching, hoteling and loading conditions. The lowest plume rise (hoteling in summer) and annual average emission rates were used to estimate annual pollutant concentrations. As shown in Table 28, LNG tanker emissions would have a slight impact on annual ambient standards and be within the appropriate short-period ambient standards. Tanker emissions would also contribute to regional air quality during inbound and outbound transits through Cook Inlet. As a moving source, tankers would have a temporary impact on ambient concentrations in any particular location and would contribute very little to 3-hour or 24-hour concentrations.

In areas where the existing air quality is cleaner than the national standards, EPA's regulations on the prevention of significant deterioration (PSD) specify the maximum pollutant increases for new sources locating in the area. Originally issued in 1974, EPA's PSD regulations have been modified by the Clean Air Act Amendments of 1977 to expand their applicability to a larger number of sources and increase the scope of the review. The final PSD regulations, issued on June 19, 1978, which reflect the requirements of the 1977 Clean Air Act Amendments, would apply to all new or modified sources having a potential to emit more than 250 tons per year of any single pollutant or 100 tons per year of any pollutant if the facility can be identified as one of the 28 major sources specified in the regulations. The proposed LNG plant would emit more than 250 tons per year of NO_x and CO and, on that basis alone, would require PSD review.

The maximum allowable PSD increases for Class II areas are listed in Table 29 for TSP and SO_2, the only pollutants with defined increments. The project area is currently designated Class II, and no proposals exist for redesignation to Class I where the PSD increments are more restrictive. The increments specify the maximum change in air quality from baseline pollutant concentration, based on measured or estimated concentrations for calendar year 1974. Any additional emissions in the area since the base year are assigned to the increments, thereby reducing the available increments for other new sources.

Table 29 presents the results of the applicant's PSD analysis of the proposed LNG project. Short-period ambient concentrations were estimated with EPA's Real-Time Air Quality Model (RAM) and annual averages predicted by EPA's Climatological Dispersion Model. The RAM calculates hourly pollutant concentrations based on local meteorological data--in this case, 1964 data collected at Kenai Airport. The effects of terrain were incorporated by using the half-height method, which assumes that the separation between the plume and ground remains at least one-half the original effective stack height calculated for level terrain. Background pollutant levels were estimated by modeling all existing emission sources within 25 km of the plant site.

The applicant found that the LNG project, both alone and combined with other PSD sources (a major source that began construction after January 6, 1975), would be within the appropriate PSD increments. When the estimated background concentrations are considered, the project would be within all ambient air quality standards except the national secondary and Alaska 24-hour TSP standards. The violation apparently results from the contribution of Collier's prill tower, currently operating under an ADEC variance which requires a 75 percent emission reduction by October 30, 1979. This lower emission rate will reduce 24-hour TSP levels below the standards.

The refined modeling techniques used in the PSD analysis results in lower SO_2 impacts than predicted for individual sources in Table 28. The simplifications incorporated into the screening techniques used to analyze the individual sources--the plume height adjustment to correct for receptors on elevated terrain, and the extrapolation to the time periods

TABLE 29

PSD ANALYSIS - NIKISKI, ALASKA 1/
(concentrations in $\mu g/m^3$)

	SO_2			TSP		NO_x
	3-Hour	24-Hour	Annual	24-Hour	Annual	Annual
LNG Project Only	94	42	0.1	15	1.5	0.9
LNG Project and PSD Sources	110	48.1	1.0	26	0.5	
LNG Project with Background	208	106	5.5	254	11	14
Ambient Air Quality Standards:						
National Primary	-	365	80	260	75	100
National Secondary	1,300	-	-	150	60	100
PSD Increments - Class II	512	91	20	37	19	-
Alaska	1,300	260	60	150	60	100

1/ Pacific Alaska's response to staff deficiency question No. 28 (Sept. 1978) greater than 1-hour--result in conservative estimates of ambient concentrations. While the results of the PSD analysis appear reasonable, they have not yet been verified by the staff. The actual increments assigned to the LNG project and any modeling issues will ultimately be resolved during EPA's PSD review. Should SO_2 levels exceed the available increments, low sulfur fuel-oil could be substituted while the tanker is at dock, as proposed for the Point Conception receiving terminal to bring the facility into compliance. Other issues such as impacts on visibility, soils, vegetation, and preconstruction monitoring requirements will also be addressed during EPA's PSD review.

In addition, the PSD regulations require the application of BACT for reducing pollutants with the potential to exceed 250 tons per year. BACT is determined on a case-by-case basis by the regional administrator, in this case EPA Region X. In general, project emissions with BACT applied must not exceed the applicable NSPS. Therefore the gas turbines in both liquefaction trains would be required to comply with the NSPS for gas turbines. (Final promulgation of NSPS is anticipated for early 1979.) This would reduce the NO_x emissions shown in Table 27 by about 35 percent, or 1,200 tons/yr.

In addition to the pollutants emitted by the liquefaction plant and LNG tankers, the generation of electric power to supply the plant's electric utility requirements would produce additional emissions during plant operations. The plant's Phase II annual electric requirement of 87,600 megawatt hours per year (mwhr/yr.) would be supplied by the Homer Electric Association from the Bernice Lake Generating Plant located in North Kenai. An estimate of the additional emissions which would occur at this plant was made from 1977 data on fuel consumption and power generation. (See Appendix J, Table J-2.) Since the plant's existing gas-turbine generators are fueled by natural gas, the main pollutant would be NO_x, estimated at 457 tons/yr. Emissions of the other pollutants, shown in Table 27, would be much lower

The proposed LNG plant would have an operational staff of about 60 employees. The increased vehicular emissions from commuting employees would not significantly affect ambient air quality.

b) Noise Quality

Both the construction and operation of the proposed project would have an impact on the local noise quality. Although techniques exist for projecting ambient noise levels at nearby locations, few criteria exist for determining the acceptability of environmental noise. According to the Noise Control Act of 1972, state and local governments were assigned the primary responsibility for establishing ambient noise standards with the assistance and guidance of the Federal government. In response to this act, EPA published the "levels document," which evaluates the effects of various levels of environmental noise. 1/ EPA emphasizes that the "identified levels" discussed in the document should not be interpreted as a Federal ambient noise standard since neither cost nor technical feasibility is considered. Rather, they provide information for state and local governments in developing their own ambient noise standards. At this time, relatively few states or local jurisdictions have promulgated ambient noise standards. There exist no state or local ambient noise standards. There exist no state or local ambient noise standards which would apply to the proposed project.

In the absence of ambient noise standards for the project area, estimated noise levels will be compared with the EPA's "identified levels." The levels, as summarized in Table 30, are not ambient standards and are, therefore, not meant to imply acceptability. However, the levels are useful guidelines for impact analyses.

Table 30 expresses noise in terms of the equivalent sound level, L_{eq}, and the day-night sound level, L_{dn}. The L_{eq} represents the sound energy averaged over a 24-hour period, while the L_{dn} represents the L_{eq} with a 10 dBA weighting applied to nighttime sound levels (10 p.m. to 7 a.m.). The level required to prevent hearing loss represents exposure over a long period and should not be identified with short-term or single event noises.

1/ EPA, "Information of Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," March 1974.

TABLE 30

SUMMARY OF NOISE LEVELS IDENTIFIED AS REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

EFFECT	LEVEL	AREA
Hearing Loss	$L_{eq(24)} \leqslant 70$ dBA	All areas
Outdoor activity interference and annoyance	$L_{dn} \leqslant 55$ dBA	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq(24)} \leqslant 55$ dBA	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} \leqslant 45$ dBA	Indoor residential areas
	$L_{eq(24)} \leqslant 45$ dBA	Other indoor areas with human activities such as schools,.etc.

Source: "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adaquate Margin of Safety," EPA, March 1974, Page 3.

Pipeline construction normally causes only temporary impact on the noise quality in a particular area. The major portion of the proposed pipeline would pass through undeveloped land, and construction would cause only minor impact on the noise environment. The remaining areas are sparsely populated, and residents in the immediate vicinity of the work areas could experience temporary annoyance.

Material excavated from the construction haul road would be transported to disposal sites by trucks operating 16 hours per day at an approximate rate of 40 trucks per hour. The additional traffic on North Kenai Road, a 30-percent increase over current volumes, would impact the local noise environment over a 30- to 40-day working period. Noise from passing trucks would be cyclic and would peak at 84 dBA for an observer located 50 feet from the highway. This level roughly corresponds to an L_{eq} of 74 dBA and an L_{dn} of 76 dBA. This noise environment is identified with activity interference.

Construction of the liquefaction plant would occur over 4 years. During this time, noise levels would vary with the type of activity and the equipment actually in use. Estimated mean noise levels at the site boundaries would range from 65 to 73 dBA, with maximum noise levels from 67 to 75 dBA. The noise experienced at nearby residences would be about 10 dBA less than at the site boundaries, but it would represent an increase over existing levels. Without specific construction information, these levels cannot be directly converted to L_{eq} and L_{dn}.

The operation of the pipeline would have only a minor impact on the noise environment. Compressor stations, the major noise sources associated with pipeline operation, would not be located along the proposed pipeline route. Operational noise levels would be limited to monthly airplane surveillance and routine maintenance activities.

The proposed LNG plant operating 24 hours per day would impact the local noise environment for the life of the project. The major continuous noise sources for Phase II operations are listed in Table 31.

The project's impact on the surrounding noise environment was estimated by resolving all plant noise sources into a single point source located at the acoustic center of the plant. (See Figure 35). Noise levels at other locations were predicted using spherical attenuation techniques, i.e. a 6-decibel reduction for each doubling of distance, without considering the shielding effects of vegetation. Plant noise levels are estimated to attenuate to an L_{eq} = 55dBA at 2,800 feet from the acoustic center and to an L_{dn} = 55dBA at 5,800 feet.

The contours of L_{eq} = 55dBA and L_{dn} = 55dBA plotted on Figure 35 represent the additional sound levels resulting from LNG plant operations. Because different noise descriptors were used in the background noise survey, the combined impact cannot be calculated. However, noise levels to the north and east of the plant are presently controlled by the Collier plant, and the impact of the LNG plant would be slight in these areas. Much lower background noise levels were recorded south of the plant site, and residents in this area would experience increased noise levels during plant operations. As identified in Table 30, exposure to L_{dn} greater than 55dBA is associated with activity interference. The staff therefore recommends that the applicant apply the necessary noise reduction techniques to insure that plant operations would not increase the environmental noise levels at nearby residences above an L_{dn} of 55 dBA.

TABLE 31

MAJOR CONTINUOUS PLANT NOISE SOURCES

Noise Source	Quantity	Sound Level at 10 Feet dBA
Gas Turbine Drivers	8	91 - 93
Propane Desuperheaters	2	85
Propane Condensors	4	89
Dryer Reactivation Heaters	2	85
2nd Stage Boil-off Compressor Aftercooler	1	88
Propane Column Coolers	2	89
Heat Medium Heater	1	85

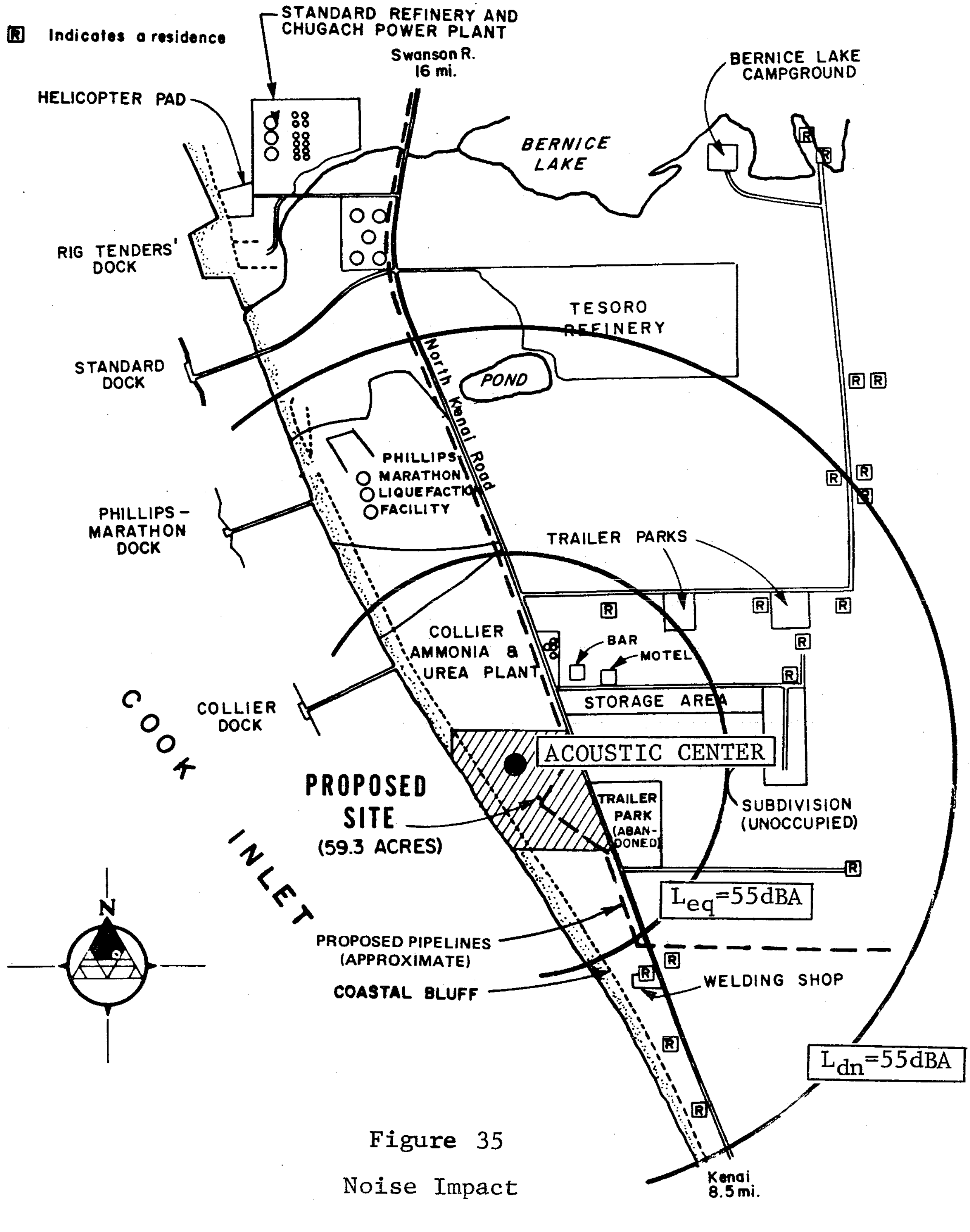

Figure 35

Noise Impact

PREPARED FROM AERIAL PHOTOGRAPH KMA 3-14, 10-17-68, BY AIR-PHOTO TECH., ANCHORAGE, ALASKA

13. Analysis of Public Safety

When analyzing the risks to the public from the proposed LNG terminal at Nikiski, all events which could cause casualties among the general public must be considered. Normally, this analysis focuses on the marine transportation of LNG as the element in the system having the greatest potential for large releases of LNG. The safety features proposed for the process and storage facilities are such that the consequences from an LNG release in these areas would be restricted to the nearby vicinity of the plant. However, an LNG tanker casualty resulting in a spill of LNG on water could form a potentially flammable vapor cloud which could drift into populated areas. 1/ If ignited at the spill site, an intense pool fire could generate hazardous radiation levels and cause fatalities among the nearby population. In evaluating the safety of the proposed project, the probabilities and consequences of these events are quantified and then judged as to their acceptability.

The inherent properties of LNG--flammability, volatility, and extreme cold (-260°F)--necessitate increased safety precautions in transportation and transfer operations for these potential hazards.

(1) As a cryogenic liquid, LNG will rapidly cool materials upon contact, causing extreme thermal stresses on normal containment materials and, in the case of contact with humans, immediately freeze (burn) human skin.

(2) LNG is a liquefied flammable gas which readily vaporizes when exposed to external heat sources (anything at temperatures above -260°F), including water, soil, air, etc., producing approximately 620 to 630 cubic feet of natural gas vapor at ambient temperature for every cubic foot of liquid. Unconfined, the vapor mixed with air is not explosive. In a mixture of 5 to 15 percent vapor and air, it is flammable. Within enclosed spaces, in such concentrations, and in the presence of an ignition source, it can explode. The primary danger present in a large-scale LNG spill is a very intense fire at the spill site. A more remote hazard is that the vapor plume could drift downwind, possibly into enclosed spaces, and

1/ A casualty is defined as an accident involving a ship and should not be construed as a human fatality or injury.

explode or catch fire. Once the air-vapor mixture has been ignited, the fire would probably propagate back to the fuel source.

(3) Methane is colorless, odorless, and tasteless and is classified as a simple asphyxiant, possessing only a slight inhalation hazard. However, methane or revaporized LNG, inhaled in significant quantities and over sufficient time (i.e., exposure to a low oxygen concentration), could result in extreme health hazards including death. Extremely cold methane gas could also cause health hazards, including "freeze burns" and death.

Although there is little actual experience with the extent of hazards to the public from the type of LNG import terminal proposed for Nikiski, there are data concerning LNG spills, analytical techniques for calculating vapor dispersion, and past experience involving the transportation and storage of LNG and other liquefied flammable gases. These data and techniques can be used to analyze the potential hazards associated with LNG transportation and terminal operations. The transportation of LNG by sea has become a feasible commercial operation. The first experimental voyage was undertaken in 1959 when the 5,123-cubic meter capacity Methane Pioneer transported LNG from Lake Charles, Louisiana, to Canvey Island, England. Foreign LNG carriers with capacities up to 125,000 cubic meters are currently available for service, and vessels with up to a 165,000-cubic meter capacity are now being designed.

In the following analysis of public safety (see Attachment A of the EIS), the operation of LNG vessels in and around the Cook Inlet harbor area has received the primary emphasis. The rationale is that shipping accidents are the most likely mechanism for large-scale LNG spills. A land-based storage tank spill would be limited to the confines of the surrounding dike, thereby limiting the vapor cloud and radiation hazards associated with such an unlikely event. For example, for a storage tank failure, the more severe thermal radiation levels (72,000 Btu/hour-ft^2) have been found to remain generally within the LNG plant boundary, and estimated vapor cloud travel distances are less than those calculated for an LNG shipping accident and major spill at the berth. The staff is also conducting additional research work to refine its analytical methods for determining such risks and potential hazards. Small LNG spills, such as flange or piping breaks, would also create hazardous situations, but they would be much less hazardous than those created by a large-scale spill. Large-scale spills could be caused by material or construction defects, seismic forces, or sabotage. Mitigating or preventing the first two have been discussed in "Mitigating Measures." Although the threat of sabotage exists, there are a number of measures which the applicant may take to reduce the probability: employee screening, a perimeter intrusion detection and alarm system, vehicle barriers around the perimeter of the plant, perimeter lighting, plant entry control, and escorts for all visitors. Even if these tanks were sabotaged, causing a massive failure, the spill and possible fire would be contained in a very small area, containing the safety threat within the plant boundaries. Underground tanks may provide increased security, in that they would present a smaller target for potential sabateurs. There is no method of totally eliminating the treat of sabotage; however, with a properly implemented security system, this threat can be minimized, and with properly designed safety features, consequences can be confined within the terminal boundaries. The staff is also currently studying the ability of dikes to contain LNG spilled from a storage tank as a result of a hole in the tank below the liquid level (spigot flow). Preliminary figures indicate that if the distance to the dike wall is equal to or greater than the maximum liquid level in the tank, there is no danger of liquid spigotizing over the dike. The staff is also studying the ability of a dike wall to contain splashing from a large wave of LNG following a massive, instantaneous failure of an LNG tank.

The marine transportation around the Nikiski area would pose a threat to the public if an accident resulted in an LNG spill onto the water. In such a case, the escaping LNG could form a potentially flammable vapor cloud which could endanger the populace within the dispersion limits of the cloud. The direction and the extent of travel of the vapor cloud would depend on the magnitude of the LNG spill, the prevailing meteorological conditions, and the number of nearby ignition sources.

In conducting the study of LNG spill probabilities and accident fatalities, it was necessary to determine a basis for the volumetric size of a large-scale spill. Of considerable importance was a determination of what type of shipping accident could result in a sudden release of large volumes of LNG. This type of damage could occur as a result of collisions (ship to ship), rammings (ship to object), and groundings.

Groundings are considered to be the most likely causes of large-scale LNG release. This study considers the maximum credible event to the instantaneous spill of the contents of one cargo tank. Physical constraints on maximum vessel speeds and maximum depth of collision penetration make the possibility of a sudden LNG release of more than one cargo tank unlikely. This does not imply that the total destruction of a loaded LNG vessel and consequent loss of its entire contents is not possible, but such a catastrophic, noncredible event would require extraordinary circumstances which the staff considers extremely remote.

It should be noted that there are considerable differences in estimates of the maximum downwind distance from a spill site to the LFL predicted by several researchers in the field. For example, for a 25,000-cubic meter spill, the computed distances to the LFL under stable atmospheric conditions are 300,000 feet, over 200,000 feet, or 37,000 feet as predicted by Professor James A. Fay from MIT, Dr. David Burgess from the Bureau of Mines, and the API, respectively. The staff's prediction for a 5-mph wind and neutral stability is 4,265 feet for a 30,000-cubic meter spill. A detailed explanation of each author's model is beyond the scope of this analysis, but the wide variance of plume travel predictions is primarily due to the different assumptions used in each author's models. Some of the primary differences are:

(1) the issue of positive buoyancy--i.e., some models incorporate positive buoyancy of the cloud into the dispersion model, while others do not;

(2) the use of a point source dispersion model versus the use of a line source dispersion model versus the use of an area source dispersion model;

(3) the use of a neutral (D class) atmospheric stability class versus a stable (F or G class) atmospheric stability class;

(4) the use of a gravity spread model to account for the spread of LNG over water, as well as the spread of LNG vapor from negative to neutral buoyancy;

(5) the use of different windspeeds;

(6) the use of peak-to-average ratios other than unity, as suggested in the Bureau of Mines study, to predict downwind concentrations.

While widely varying estimates have been made, the salient point is that the probability of ignition of the cloud approaches unity at a finite distance downwind, regardless of the unignited vapor travel distance calculated by the various models.

Staff analysis found that the tanker casualty rate for the Nikiski area was high, being nearly double the mean casualty rate of 4.4×10^{-3} casualties/trip as predicted by an independent study for seven U.S. harbors. 1/ The most frequent casualty type for the study period was ramming into either docks or ice fields. The harsh winters of 1970-71 and 1971-72 resulted in a large number of rammings with ice fields and ice-related casualties. In most cases, rammings at docks were found to result from severe environmental factors such as ice, strong winds, strong tidal current, or a combination of factors. These external forces were either the cause of the casualty or a contributing factor in all but 2 of the 19 total casualties. Most of the incidents are clustered around the petroleum docks at Nikiski and Drift River and in the inlet's upper region where ice and tidal currents can be most severe. Far fewer casualties were found in the lower regions of Cook Inlet which experience less severe ice problems.

Only one incident of a collision involving a tanker was recorded. In this case, a fishing craft struck a tanker in Kennedy Entrance. The tanker received little damage; however, the fishing craft sank. At this time, collisions appear to be a minor hazard for Cook Inlet because of the low volumes of traffic and wide areas of navigable waters.

A mean single-trip casualty rate of 7.04×10^{-3} casualties/trip was used for this study. When this mean casualty rate is multiplied by the number of proposed transits per year (52), the estimated LNG tanker accidents of any type per year are estimated at 0.366. Further analysis indicated that for the proposed project, the probability of a spill per year in the event of an accident was 2.05×10^{-4}.

1/ Oceanographic Institute of Washington, Offshore Petroleum Transfer System For Washington State, A Feasibility Study, (December 16, 1974), p. V-45.

The probability of immediate ignition following a collision and spill is conservatively estimated to be 90 percent. It was assumed that a vapor cloud not ignited at the spill site would not encounter any ignition sources over water. Over populated areas, the probability of vapor cloud ignition is modified on the assumption that each residence contains one ignition source and that each source has only a 1 percent chance of igniting the cloud. These parameters are chosen to provide an extremely conservative estimate of risk.

The risk consequence analysis was based upon the impact of pool and plume fires and the associated thermal radiation from each. The level of thermal radiation required to cause fatal burns is assumed to be 5,300 Btu/hr.-ft.^{2}. This is the level at which blistering occurs after 5 seconds of exposure. It was further assumed that 20 percent of the people within the area exposed to this level of radiation were fatalities. This is based on surveys that have indicated that the fraction of people outdoors and not otherwise effectively shielded from radiation is 20 percent during the day. The fraction is much smaller at night.

The staff's calculations for a pool fire from a one-tank spill of 30,000 cubic meters yields an area of hazardous radiation extending 3,830 feet radially. The maximum range of flammable vapors for a one-tank spill without ignititon is about 4,265 feet. The configuration of the Cook Inlet harbor and the proposed approach to the terminal is such that the nearest residences are about 3,600 feet from the LNG tanker route.

The staff recognized the considerable controversy over the maximum range of flammable vapors from an LNG spill on water. Therefore, in the interest of conservatism, additional risk estimates were made in Attachment A of Volume III of this EIS, based on vapor cloud distances considerably greater than 4,265 feet, e.g., staff performed risk calculations based on vapor cloud distances up to 27.1 kilometers.

The additional calculations yielded an individual risk of 4.39×10^{-8} fatalities per exposed person per year for the residents of the Nikiski area. These risks are lower than risks from natural events such as tornadoes, hurricanes, and lightning.

The staff's safety study is extremely conservative and should not be construed as an exact science. In the event of an LNG spill, the actual number of people endangered and the extent to which they would be physically affected is highly variable and would depend on (1) the location of the spill and the population of the areas adjacent to this location, (2) the presence of an ignition source within the dispersion limits of the vapor cloud and whether the cloud became ignited, (3) the flammability of the structures and materials encompassed by the vapor cloud or exposed to radiation from a large LNG pool source, and (4) the time required to notify the public and take appropriate mitigation actions. If the vapor cloud were not ignited, people close to the spill could have difficulty breathing, depending on how long they were subject to high concentrations of natural gas. In addition, extremely cold methane gas could also cause "freeze burns" or even death.

The staff's safety analysis does not quantify the possible secondary effects of LNG ignition. To analyze the possible secondary effects of LNG ignition at various industrial plants along the ship's route or in the Nikiski area would be pure conjecture at this point and would result in a never-ending study of the area. The staff would have to attempt to analyze an almost infinite number of structures along and inland from the vessel's route. In essence, a much more rigorous risk analysis would have to be accomplished to entail <u>all</u> possible accidental events. While the staff would agree that more rigorous risk analyses are always possible and desirable, the staff also believes that the risk analysis presented in Attachment A of this environmental impact statement provides a valid assessment of public safety for the proposed project and is adequate in order to assist concerned individuals and decisionmakers in their value judgments.

On October 10, 1975, the FPC sent a letter of inquiry (see Appendix F) to the U.S. Coast Guard in Juneau, Alaska, asking in part what would be the U.S. Coast Guard's official position regarding the development at Nikiski of the LNG terminal proposed by Pacific Alaska LNG Company requiring approximately 60 LNG tanker arrivals per year. The U.S. Coast Guard letter of response, dated November 14, 1975 (see Appendix F), stated that the "the siting of any additional LNG terminals in the Nikiski area poses a significant hazard to the safety of life, property and the environment." Responses from the U.S. Coast Guard to additional FPC and Pacific Alaska LNG Company letters of inquiry (see Appendix F) since November 14, 1975, have, however, reflected a change of the opinion stated in the Coast Guard's November 14, 1975, response. The latest letters of March 9 and 23, 1977, indicate that, with appropriate mitigating measures instituted by the Coast Guard, "safety can be made essentially a moot point" (see Appendix F).

D. MEASURES TO ENHANCE THE ENVIRONMENT OR TO AVOID OR MITIGATE ADVERSE ENVIRONMENTAL EFFECTS

Avoiding or mitigating adverse effects to the environment, the regional economy, and the safety of the public and plant personnel is essential in projects involving LNG. Approval from Federal, state, and local agencies concerning the various aspects of Pacific Alaska's proposed project is required, and their regulations must be followed. These agencies, their jurisdictions, and the statutes and codes defining their authority over the construction and operation of the proposed LNG terminal, gas pipeline, and shipping are listed in Appendix C. Standards applicable to the construction and operation of the proposed LNG terminal are also listed in Appendix C.

LNG spills or fires would pose the greatest potential hazard in operating the proposed LNG terminal. Safety measures which eliminate or mitigate such hazards demand the utmost consideration in the design and operation of the proposed LNG terminal and its related shipping activities. Measures to reduce the impact on the environment and the regional economy from construction and operation of the LNG terminal and pipeline also require attention. This section describes the mitigating measures proposed by Pacific Alaska for this project.

1. LNG Terminal

a) Design

The LNG plant would be designed to the seismic loads specific to the proposed site and would exceed the Uniform Building Code requirements for seismic risk Zone III. The proposed site of the Cook Inlet facility is in a seismically active region with a high probability for a future seismic event. Prior to designing the facility, the applicant contracted Dames and Moore Soils and Foundation Consultants to determine the maximum credible earthquake which could occur at the site. They concluded that it is reasonable to expect shaking with an intensity of VIII (modified Mercalli scale) for a duration of 60 to 90 seconds and a peak bedrock acceleration of 0.3g horizontal and 0.2g vertical, resulting from a recurrence of the 1964 Prince William Sound earthquake. In addition, they considered the effects of a local event with 0.5g bedrock acceleration, as suggested by the staff. Design ground surface accelerations for these events are 0.32g and 0.35g, respectively.

The environmental staff has retained the services of the National Bureau of Standards to assess the validity of assumptions and completeness of the applicant's engineering approach toward seismic safety design of the proposed LNG storage tanks and containment systems and to assess the degree of conservatism of the applicant's design parameters by comparison with the seismic design requirements of the Nuclear Regulatory Commission for nuclear power plants. Upon completion of this contract, the staff may have additional recommendations concerning seismic design.

The two 550,000-barrel LNG storage tanks would be of double-wall, suspended inner-deck design and would be designed to retain their full structural integrity during the earthquakes as previously described. In the absence of preventative measures, horizontal acceleration of tanks using the suspended inner deck could cause the liquid within the tanks to slosh over the inner tank wall and spill into the insulation barrier. However, the tanks would have about 8 feet of freeboard, which is greater than the maximum liquid wave, to prevent spilling should the maximum liquid wave occur. 1/ The tanks would also be designed to withstand severe climatic conditions, including a maximum instantaneous wind gust of 117 mph (100-year recurrence interval) and a snow load of 60 pounds per square foot (psf).

The LNG storage tanks would also meet the requirements of the American Petroleum Institute standard 620, Appendix Q, which governs materials selection, tank design, construction, and testing procedures. The inner tank would be constructed of 9-percent nickel steel, a material that retains its strength and ductility at cryogenic temperatures. During construction, the welds on all vertical seams would be 100-percent X-ray inspected. Welds not 100-percent X-ray inspected would be checked by the liquid penetrant method, as would all attachment welds. The inner tank would be anchored to the concrete ring wall foundation by anchor straps.

The outer tank wall and domed roof would be constructed of carbon steel. The outer tank wall would be attached to the foundation by anchor bolts, which would resist uplift forces from internal pressure, wind, or earthquakes.

The annular space between the tank walls would be filled with expanded perlite, a nonflammable insulator. A resilient fiberglass blanket separating the perlite from the inner tank wall would be designed to absorb differential movements between the inner and outer tank walls which could cause compaction of the perlite. The suspended deck insulation would be mineral wool.

The space between the inner and outer tank floors would be insulated with a 25-inch layer of foamglass, a nonflammable load-bearing insulation. A 1-foot layer of compacted sand would be located beneath the outer tank floor and would contain electrical heating elements.

Each storage tank would have two 20-inch diameter inlet pipelines entering through the outer tank wall. One pipe would terminate at a nozzle just below the suspended deck to allow top-filling of the tank. The second pipe would discharge LNG into the top of a 60-inch diameter stand pipe extending from above the high liquid level to the bottom of the tank. The stand pipe would provide bottom-filling of the tank through evenly spaced perforations near the bottom of the pipe. This arrangement would

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1/ Freeboard is the distance from the maximum liquid level in the tank to the top of the inner tank wall.

permit LNG to be added to the bottom of the storage tank at the same pressure and temperature as the liquid within the tank.

Stratification of the liquid contents in an LNG storage tank can occur when the incoming liquid has a different density than the tank heel, the liquid initially in the tank. If unchecked, stratification can lead to rollover, a sudden high rate of vapor generation. The top- and bottom-filling of the proposed LNG storage tanks would provide for flexible operation and reduce the likelihood of stratification.

Each tank would have a movable vertical temperature probe to monitor the temperature of the LNG throughout the height of the liquid level. Temperature differences between any points would indicate stratification of the LNG. Pumps would then circulate and mix the LNG in the tank, reducing the possibility of rollover.

LNG would be withdrawn from a tank through two 24-inch diameter outlet nozzles on the inner tank floor. These pipelines would pass through the side wall of the outer tank and connect to the suction side of the loading pumps. Each outlet nozzle would be equipped with internal shutoff valves. The valves would have pneumatic controls and would normally be kept open. The valves could close automatically by gravity if the pneumatic controls failed.

The design maximum and minimum pressures of the outer tank would be 2.0 psig and 0 psig, respectively. The normal operating pressure of 0.9 psig would be maintained by adjustments in the speed of the boil-off compressor. Each tank would be equipped with six combination pressure/vacuum relief valves and six pressure-only relief valves. If pressure rose above the normal operating level, a high-pressure alarm would sound, and the vent valve would begin to open to reestablish the operating pressure level. A continued pressure increase would cause the high-high pressure alarm to sound and the vapor inlet and liquid inlet valves to close. If the pressure rose above the design pressure, the 12 pressure relief valves would open and permit a maximum of 792,000 pounds per hour of LNG vapor to be vented to the atmosphere.

A drop in pressure below the normal operating level would sound the low-pressure alarm. A continued drop would activate the low-low pressure alarm and close the boil-off vapor and liquid outlet valves. To prevent a further drop in pressure, gas would be supplied by an independent offsite source. If the pressure dropped to the design pressure level, the vacuum relief valves would open.

The liquid level in the tank would be monitored by one displacement float gauge which could be replaced while the tank was still in service. The temperature probe could also monitor the liquid level. A liquid level switch would sound an alarm at the high-liquid level. A continued rise of liquid would activate the high-high liquid level alarm and close the liquid inlet to the LNG storage tank.

Each LNG storage tank would be surrounded by a concrete dike wall approximately 55 feet high, 285 feet wide (inside diameter) and 18 inches thick. The wall would provide a 30-foot annular space and would have a capacity in excess of the maximum storage tank capacity. The inner face of the wall would be lined with an insulating material. If LNG spilled into the dike, the insulation would limit the rate of vapor generation and, consequently, the downwind distance of potentially flammable vapors. An 8-foot high roadway would be constructed on the perimeter of the LNG storage tank area.

After construction, the inner tank would be hydrostatically tested to 1.25 times the weight of a full tank of LNG. The tank wall would be inspected for leaks and the perimeter of the tank floor checked for subsidence. Measurements of subsidence would be made when the tank contained various levels of test water, and again when empty. Thereafter, the tank elevation would be checked every 3 months until no change was indicated. After that time, the elevation would be checked annually.

About 14 to 15 million gallons of groundwater from onsite wells would be used to hydrostatically test each tank. Scheduling difficulties would prevent the same water from being used to test both tanks. After the tests, the water would be piped down the bluff into Cook Inlet. The discharge plan would be subject to the approval of appropriate state and local regulatory agencies.

Following hydrostatic testing, the outer tank would be pneumatically tested at 1.25 times the maximum design vapor pressure. Pipe connections would be tested for leaks with a soap film solution.

The LNG plant, the process equipment, and the various liquid storage areas would have both active and passive defenses to minimize an LNG release. The design of equipment and selection of materials for cryogenic temperatures and the use of containment areas for LNG spills would provide a passive defense system. Active defenses would include the various fire detection and extinguishing systems.

In addition to the LNG storage tank area, liquid containment would be provided for the three refrigerant storage tanks and each liquefaction train process area. A common impoundment area would serve all three refrigerant storage tanks. Low-level diversion dikes would separate adjacent vessels to protect individual tanks.

Each liquefaction train would be surrounded by a dike to contain spills of LNG or refrigerant. The surface beneath each liquefaction train would be sloped to drain spills away from the equipment and into the corners of the containment area. Drains located at the corners of the impoundment area would carry both rainwater runoff and LNG spills to the LNG storage tank containment area. The materials selected for the drains would withstand cryogenic temperatures.

Storm water runoff from impoundment areas and other locations in the plant would generally be directed to a low point in the LNG storage tank containment area. Storm water would be pumped out of the basin at a rate of 400 gpm, piped along the trestle, and discharged into Cook Inlet.

The LNG transfer system would not have provisions for spill containment beyond the plant roadway surrounding the storage tanks. However, the system would use shutoff valves designed to limit the volume of LNG spilled in the event of a pipeline failure. Shutoff valves would be located at each loading arm of the dock, onshore in the main transfer line, in the transfer lines from each tank, and in each discharge line from the primary loading pumps. The valves would be powered pneumatically and could be controlled either remotely or locally. The pneumatic air supply would have redundant compressors, with one compressor powered by an emergency power source. Each valve could also be manually operated.

The LNG transfer system would be constructed of stainless steel and covered with self-extinguishing polyurethane insulation containing a fire-retardant additive. The entire insulation system would be covered by a 0.010-inch thick stainless steel weather-proofing jacket.

Pressure-relief valves, located throughout the process equipment, would be designed to relieve high pressures before the design load of the equipment is reached. Gas discharges from these valves would enter the flare header system and be directed to the flare stack for incineration. The main header would be 40 inches in diameter to handle the maximum discharge rate of the first-stage, multicomponent refrigerant compressor. The flare stack, 300 feet high and 50 inches in diameter, would contain a fluidic seal to prevent air from entering the relief system. The stack would be located at the northwest corner of the plant site so that releases from the stack would not pose a hazard to the staff or plant equipment. The relief valves on the LNG storage tanks would discharge directly to the atmosphere, since the design pressure would be too low for the pressure-relief system.

Regardless of the safety measures employed, the possibility of an accidental LNG release or a fire must be considered in the plant design. As part of the plant's active defenses, combustible gas detectors, flame detectors, and temperature sensors would be located throughout the plant and process equipment. The activation of a sensor would cause the automatic shutdown of the affected equipment in most cases, sound an alarm, and indicate the exact location of the spill or fire on a graphic panel in the main control room. In the event of a fire, the plant's fire protection systems, consisting of a fire-control water system, dry chemical units, and two firetrucks could then be employed. Figure 36 illustrates the locations of the various detection and extinguishing systems.

Gas sensors at the inlets to ventilated buildings would activate both visible and audible alarms if the gas concentration reached 25 percent of the LFL for natural gas. At this time, the ventilation of the building would be turned off to prevent gas from being forced inside the building.

Gas sensors and flame detectors would be located above the compressors inside the compressor buildings. Visible and audible alarms would be activated if gas concentrations reached 25 percent of the LFL or when fire was detected. These buildings would have two-stage ventilation. The high-speed ventilation would rapidly evacuate gas from the building if the gas concentration reached 25 percent of the LFL. If conditions warranted, the compressor equipment would then be shut down manually. A second level alarm, occurring at a higher gas concentration, would automatically shut down the compressor equipment. Gas sensors would also be located in the transfer pump area, on the dock, and near the heat exchangers and other process equipment. These sensors would also activate at 25-percent LFL.

Ultraviolet sensors would be located inside buildings and throughout the plant for fire detection. Each zone would be covered by at least two sensors. The activation of flame detectors would cause the automatic shutdown of local equipment.

Low-temperature detectors would be located in the pump area, in the insulation of the LNG storage tanks, and at other locations where liquid leaks could occur. Activation of the sensors in the pump area would cause the automatic shutdown of the pumps and close the valves in the loading lines during loading operations. Flame detectors would detect flames at the LNG storage tank relief valves.

The final design of the plant's fire-control water system has not been completed. However, the following basic features should be common to both the current and final designs. The fire-control water system would consist of a main water loop surrounding the plant, with fire hydrants and water monitor nozzles connected at various intervals as shown in Figure 36. The main loop would consist primarily of 8- and 10-inch diameter pipeline, and a segment of 14-inch diameter pipeline connecting the fire-control water pumps to the main loop. A 10-inch diameter pipeline would run along the trestle to monitors on the dock. Branch lines would also be provided to liquefaction trains and plant buildings.

The main water loop would be supplied by a 125,000-gallon freshwater storage tank and would be continuously maintained at a pressure of 75 psig by one circulation pump. The storage tank would be supplied by two onsite wells. A 3,500 gpm seawater pump and 10-inch diameter pipeline would back up the primary firewater system.

The fire-control water system would be designed to provide fire-exposure protection and damage control. It would also help extinguish fires which might originate in the area adjacent to the plant.

The LNG storage tanks would have water deluge systems to protect them against radiation from fires inside the plant. The system would consist of a series of weirs encircling the tank roof at several elevations. The system would be designed to protect the dome-shaped roof from radiation damage and provide uniform distribution of water on the tank's outer shell. The water would be supplied by the main loop at a rate of about 2,600 gpm. It is estimated that this flow rate would be sufficient to protect one tank, since partial radiation shielding would be provided by the 55-foot high concrete dike wall.

The environmental conditions of Cook Inlet require precautionary measures to prevent freezing in the fire-control water system. The fire-control water loop would be buried at a depth of 12 feet below the ground surface in order to be under the frost line. The water lines from the main line to control valves would be heat-traced and normally kept dry. The use of a weir system on the LNG storage tanks instead of spray nozzles would eliminate possible nozzle freezeup. The fire-control water pipeline along the trestle to the dock would be kept empty; therefore, heat tracing or insulation would not be required. The fire-control water storage tank would not be insulated; however, heated water would be circulated in the tank to prevent freezeup. High-expansion foam systems would not be used at the site because it would be difficult to store foam concentrate at subfreezing temperatures.

The dry chemical fire extinguishing systems would include fixed systems with permanent nozzles, fixed systems with hoselines. monitor nozzles, and portable extinguishers. The compressor buildings would use fixed units with hoselines. The transfer pump

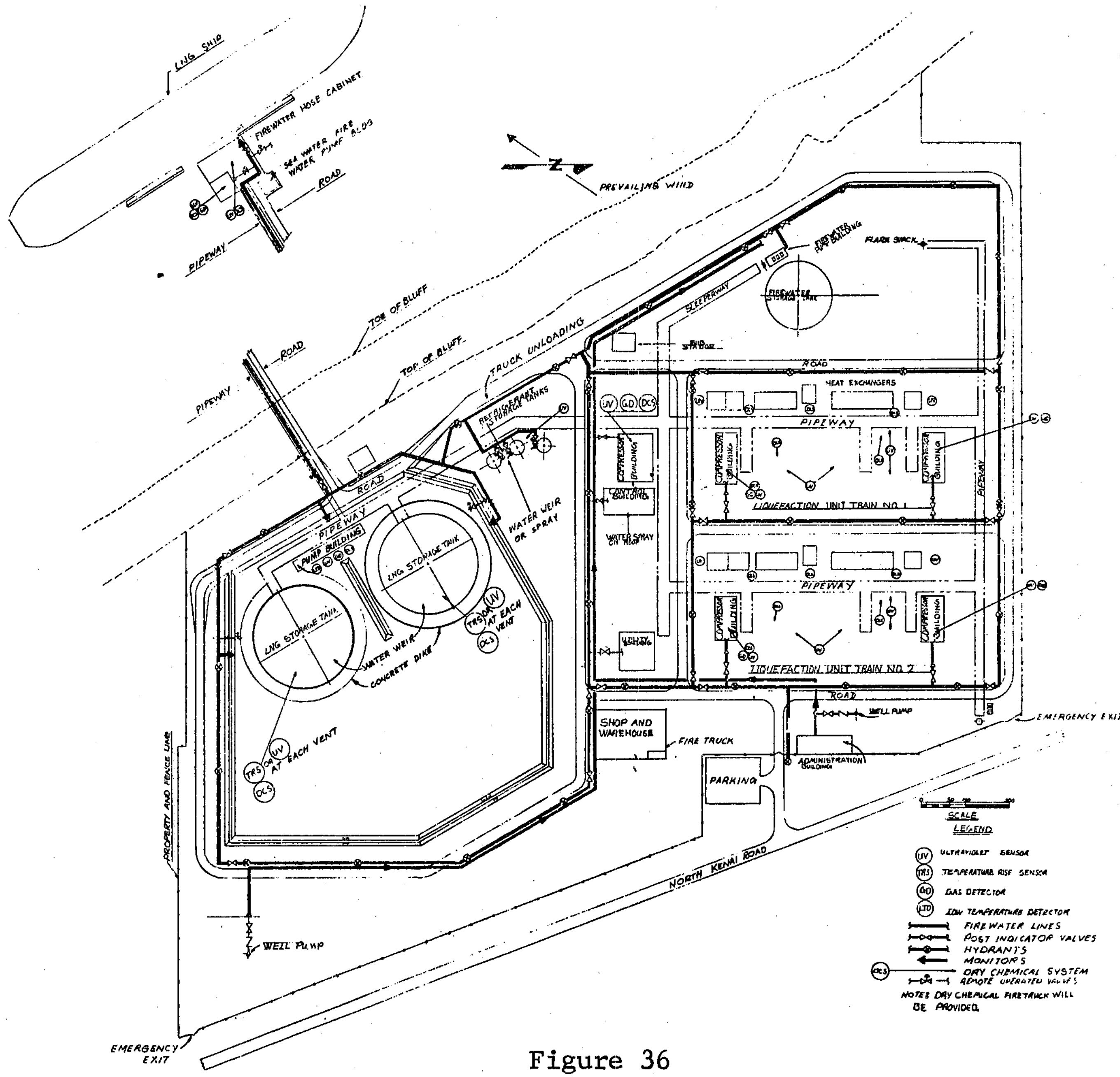

Figure 36

Fire Detection and Extinguishing Systems area would have a fixed system designed to cover the pump area with dry chemical in the event of a fire. The dry chemical systems in the liquefaction trains would include hoselines and monitor nozzles. A dry chemical unit at the dock would have both monitor nozzles and hoselines. A dry chemical system on the storage tank vents would be operated manually from a remote location at grade level or from the control room. The fixed dry chemical units would use sodium bicarbonate or potassium bicarbonate.

Two firetrucks would be available to provide backup fire protection for all plant areas and would serve as primary fire protection for areas not otherwise covered. One truck would contain a dry chemical system with hoselines and a monitor and could attach to any of the fixed dry chemical systems for backup. A second fire-truck would be designed as a water-pumping firetruck.

Electric power for the normal operation of the plant would be supplied by the Homer Electric Association. A 2,500-kw gas turbine/generator would be located at the plant for emergency power generation.

The marine terminal would be designed to the same earthquake criteria as the liquefaction plant. However, additional features would be incorporated into the design of the dock and trestle support structures to withstand the ice and tidal currents of this region in Cook Inlet. Ice and strong currents could also endanger tankers during docking and loading operations. Therefore, the design of the loading dock and dolphins would facilitate rapid undocking of a tanker in an emergency.

The loading platform, the approach trestle, and the berthing and mooring dolphins would be supported by piles driven and/or jetted into the sea bottom. The number of structural members located in the ice zone would be minimized to limit the ice forces on the structure. Vertical piles receiving ice forces would be tapered to minimize the bending moments from ice. They would also be designed to breakup the ice sheet as it moves past the pile.

The LNG loading system would utilize five 16-inch diameter articulated arms, four for liquid loading and one for vapor return. The articulated arms would extend and rotate to accommodate the normal movement of the tanker during loading operations. Each arm would be provided with a shutoff valve designed to prevent LNG spillage during an emergency and would also utilize a check valve to prevent backflow. The loading arms would be connected to the tanker by quick-release hydraulic couplers. The couplers would be manually activated and could be disconnected in about 1 or 2 minutes.

Excessive ship movements would be detected by high rotation or extension of the loading arms, which would activate the first level alarm. Greater ship movement would cause the loading operation to stop. Additionally, a cable connecting the tanker to the dock would also sense excessive movements and terminate loading operations. Automatic shutdown could also be triggered by low storage tank levels, low tank pressure, or detection of an LNG spill.

Provisions would also be made for emergency shutdown of the transfer systems. This could be accomplished either by isolating specific systems or areas for shutdown or by shutting down the entire operation. The emergency shutdown system would be activated at the operator's discretion or, in critical areas, by low-temperature sensors which detected an LNG spill.

Before a tanker could make an emergency departure, the loading arms would first have to be drained, a procedure requiring less than 5 minutes, and the loading arms disconnected. The berthing and mooring dolphins would be equipped with quick-release hooks which could be released under load to permit rapid ship departures. If the loading arms disconnected before the unloading pumps had shut down, a spill of about 7,900 gallons could result. There are currently no plans for shielding to protect the ship from spills at the dock.

In addition to the safety features proposed for the LNG plant, consideration has been given to minimizing the environmental impact of the plant's normal operations. Sanitary wastes generated at the plant would be treated in a prefabricated extended aeration waste water treatment facility. The treatment plant would have a capacity of 7,200 gpd of domestic sewage, which would be adequate to handle the estimated 3,000 gpd from the facility. The reduction of BOD solids would be approximately 90 percent on a 30-day average. In addition to sanitary wastes, the unit would also treat the backwash from the filtration bed of the potable water treatment plant. After being processed, the effluent from the waste treatment plant would be piped through a 2-inch diameter pipe running along the trestle and discharged into Cook Inlet. The pipe would be electrically heat-traced and insulated to prevent freezeup. The sludge from the waste treatment plant would be accumulated in a storage compartment and burned in the proposed plant incinerator approximately once a year.

Accidental spills of oil at the plant site would be channeled through the drainage system to a low point on the site where oil would be confined and skimmed off prior to discharge of the drainage. A separate system would be provided to collect washdown water (or other fluids accidentally spilled) from inside plant buildings and the liquefaction train areas. Flow from this system would be processed through an oil-water separator before being discharged into the plant sewage system. Oil collected by the separator would be incinerated.

The plant's garbage, sewage sludge, and waste oils would be disposed of in an incinerator. The unit would have both a primary and a secondary chamber, each equipped with natural gas-fired burners to maintain the high temperatures necessary for efficient combustion. The unit would have a maximum rated capacity of from 435 to 560 pounds per hour, depending on the type of waste.

The visual impact of the proposed LNG plant would be minimized by a 50-foot wide tree screen on the east, south, and west perimeter of the site. The strip would be composed of existing vegetation and landscaped where required to fill in thin areas. The tree screen would shield most of the facility from view and partially obscure the two LNG storage tanks which would be among the tallest man-made structures in the area. The tanks would be painted to blend with their surroundings and somewhat reduce their visual impact.

b) Construction

Substantial portions of the liquefaction plant would be fabricated in various-sized modules at a location in the contiguous United States, probably the Seattle, Washington, area. As described in Section A.3, the modular components would be delivered to Nikiski on barges and erected at the plant site. The proposed modular construction method is estimated to save $19.8 million over conventional onsite construction techniques. Labor requirements for the Nikiski site would be reduced by about one-third. The peak labor force would also be reduced from 1,000 to 800. As a result, the temporary impact on Kenai caused by the influx of a large labor force would be correspondingly reduced. Additionally, a construction camp would be built on an abandoned trailer park adjacent to the site to house nonlocal workers, thereby reducing the temporary demands on local housing.

Another benefit of the proposed modular construction would be that fabrication would occur in a controlled working environment, permitting higher levels of quality control.

Several mitigating measures would reduce the impact associated with the construction dock and haul road. The banks along the side of the haul road would have a slope not greater than $1\frac{1}{2}$ to 1 (horizontal to vertical), which is the existing slope of the bluff. Severe erosion is not anticipated because of the granular nature of the slopes. The exact location for the disposal of the 215,000 cubic yards of excavated material has not yet been determined. However, local interest may exist for using the excavated topsoil for agriculture and the excavated sand and gravel to fill a nearby gravel pit. After construction of the terminal, the construction dock would be removed and the shoreline restored to natural conditions.

The mitigating measures identified in the following paragraphs have been proposed to reduce adverse environmental impact during the construction period of the plant. The contractors and subcontractors would comply with all Occupational Safety and Health Administration noise control regulations for construction equipment operation and hearing protection for workers. Dust generated by construction vehicles traveling over unpaved roads would be reduced by water sprinkling and soil compaction. The high settling velocities of dust particles and the proposed dust control measures should confine fugitive dust to the construction site.

During construction of the proposed pipeline and LNG facility, the applicant plans to locate metal pans under storage tank connections and valves, buckets under transfer hose connections, and large metal pans under drums and cans of oil and lubricants. Paints and primers would also be stored and mixed on metal pans. The only oils and lubricants to be stored during construction would be those required by construction equipment, since the waste oil would be incinerated. Large spills at the plant site would be handled by removing the contaminated soil and transporting it to an approved chemical land fill where leaching could be controlled.

Chemical toilets would be provided from the beginning of construction until the proposed package waste treatment plant had achieved satisfactory operation, approximately 3 to 4 months later. The treatment plant would be located within the construction work camp, while chemical toilets would be available at the construction site. The sludge generated from the treatment plant would be stored in a sludge storage tank and disposed of in an incinerator.

The proposed LNG plant site is flat and would require little additional grading. Material removed in connection with excavation would be regraded within the site boundaries, eliminating the impact of offsite disposal. Most of the fill material needed during construction would be available at the site, thereby avoiding the impact of extensive borrowing activity elsewhere.

Construction of the marine terminal would affect commercial fishing in the immediate construction area. However, construction would be scheduled to minimize the adverse effects on local fishing, especially during salmon season. The applicant is currently negotiating compensation for local commercial fishermen who would be affected by construction activities.

Dredging operations offshore of the marine terminal would be monitored as specified by local authorities. Parameters measured would include dissolved oxygen and turbidity.

c) Operation

The safe and reliable operation of the LNG terminal would be facilitated by routine plant maintenance and the duplication of key plant equipment. The liquefaction plant has been designed to operate 345 days per year, allowing 20 days for routine maintenance or unscheduled downtime. Maintenance and inspection would be carried out only by trained, authorized personnel. Ignition sources, such as heaters and gas or electric welding equipment, generally would not be used for maintenance.

Duplication of certain equipment would permit continuous operation of the plant even during periods of routine maintenance. Spares would be provided for the LNG loading pumps, storage and loading vapor-handling equipment, the instrument air compressor, instrument air dryers, feed gas filters, a fire-control water pump, refrigerant storage pumps, and the water well. Maintenance of the marine loading equipment could be performed between scheduled periods of operation.

Maintenance of equipment associated with the LNG storage tanks, such as testing relief valves and foundation heater adjustments, could be accomplished without taking the tank out of service. Internal tank equipment could be removed and serviced without emptying the tank. Welding equipment or heaters required for tank maintenance would be used only after conducting tests to insure an atmosphere free of combustible gases. The entire internal area of the storage tank would be kept under an oxygen-free, noncorrosive atmosphere, and therefore would not require corrosion inspection.

Plant personnel would visually inspect all plant equipment, piping, and the LNG storage tanks for signs of minor LNG leaks and insulation failures. Nuisance leaks would be indicated by local concentrations of frost or ice on the exterior surfaces of equipment. The leaks could then be repaired either by switching to spare equipment or by effecting a local shutdown of the equipment.

In addition to the practices for safe plant operation, the applicant would also take measures to minimize the impact on air and noise quality. Prior to the start of plant operations, air quality measurements would be made to determine existing background concentrations of particulates, carbon monoxide, nitrogen oxides, hydrocarbons, and sulfur dioxide. The major air pollution emissions during normal plant operations would come from the eight gas turbine compressors, which together would consume over 96 percent of the plant's fuel requirements. These units would be fueled by natural gas, which is a relatively clean-burning fuel. The quantity of emissions of all air pollutants, with the exception of nitrogen oxides, would be low. However, the 80-foot tall exhaust stacks and the relatively high exit gas velocities should adequately disperse the nitrogen oxides and comply with National Ambient Air Quality Standards.

All condensor heat loads would be discharged to the surrounding air by an air-cooled heat exchanger. This system would eliminate any possible icing or fog problems associated with water cooling towers and reduce freshwater makeup requirements. Also, the plant would not experience the thermal discharge problems common with water-cooled systems.

Noise levels in the plant vicinity would be reduced by controlling the noise at the source. The major compressors would have acoustic insulation on the valves and piping, with an acoustic enclosure around the units. The compressor buildings would be constructed of Thermlock panels, which would provide a sound transmission loss of at least 20 decibels. The gas turbine-driven compressors would be totally enclosed and equipped with intake and exhaust silencers.

2. Pipeline

The environmental impact associated with the gas pipeline gathering system would generally be short-term and limited to the construction period. However, without appropriate mitigating measures, the effects of pipeline construction could remain much longer. These impacts would be minimized by special construction techniques, by scheduling all onshore construction activities during winter months (except for those stream crossings which ADFG requires to be constructed in the early summer following fry emergence and preceding the next season's spawning activity), and by selecting pipeline routes which avoid environmentally sensitive areas. In addition, the applicant would comply with the FPC pipeline construction guidelines as described in Section 2.69 of Title 18 CFR, Chapter 1, Subchapter A--General Rules.

The proposed pipeline route would be located primarily in remote areas and cause little impact on the public during either construction or operation. The proposed pipeline route might pass within one-eighth mile of residential dwellings in the vicinity of the Beluga River Field, Tyonek, East Foreland, Kenai, and the small communities of Clam Gulch, Ninilchik, and Anchor Point. However, most of the pipeline for both Phase I and II would be in sparsely populated Class I locations. 1/

The use of existing rights-of-way would be maximized in order to minimize vegetation removal associated with the clear-cutting of forested areas. The pipeline would be routed to avoid areas with a high potential for landsliding, erosion, or liquefaction.

a) Construction

Prior to construction, an archaeological reconnaissance survey would be conducted along the entire length of the proposed pipeline route. The survey would be conducted by an archaeologist with local expertise and would be designed to reduce the probability of uncovering sites during construction. Should archaeological finds be uncovered, a qualified archaeologist would be requested to evaluate their importance. Construction operations would be suspended if the findings were significant.

All of the onshore pipeline segments would be constructed during winter months. Winter construction would permit the use of conventional pipelaying techniques in the poorly drained and soft peat areas common to the lowlands of the Susitna Flats and the Kenai Peninsula. In cases where the pipeline would cross salmon spawning streams, the ADFG has indicated that summer construction would be required.

The proposed methods of winter pipelaying are described in "Description of the Proposed Action." Since construction equipment would be supported by frozen peat adjacent to the trench, the major disruption to the soil and vegetative cover would be limited to the immediate area of the trench. The pipeline would be laid and weighted with concrete saddles to counter the positive buoyancy of the pipeline

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1/ Class locations are determined by the density of human occupancy within a corridor extending 220 yards on either side of the pipe centerline. Class I locations contain 10 or less buildings intended for human occupancy per mile of corridor. Source: U.S. Department of Transportation, Pipeline Safety Standards, Title 49 CFR, Part 192, Section 192.5: Definition of Class Locations.

and prevent it from floating when the peat had thawed. In areas where the peat is thicker than the normal pipeline depth, the applicant would use soil anchors in lieu of saddles to provide the necessary negative buoyancy and also to prevent the pipeline from sinking.

The frozen backfill would be pushed into the trench using standard techniques. The frozen material would be crushed only if the trenching process did not provide adequate size reduction of the soil. The backfill would be mounded to heights of 6 to 12 inches, which should allow for the settling of those soils having a high water content.

Winter construction would minimize disturbances to nesting birds, especially trumpeter swans and eagles. Possible contact with black bears and disturbance of beaver colonies would also be reduced. Construction through the moose-calving area in the Susitna Flats wetlands and caribou calving grounds north of Kenai would be scheduled to avoid the critical calving period in May and June.

The pipeline routes proposed for winter construction would generally pass through land classified as open space. However, these areas are used extensively for hunting and sport fishing. Winter construction would avoid interference with these recreational pursuits.

At crossings of rivers and streams, the pipeline would be weighted and placed in a trench excavated in the river bottom. Some scouring of materials would occur in the immediate vicinity of the trench, particularly in locations where removing an armor of coarser-grained soils would expose the finer underlying soils to erosion. However, the low river velocities associated with the winter months would minimize the extent of scour, siltation, and sedimentation. Winter construction would reduce potential riverbank damage and subsequent erosion. However, to prevent damage to the juvenile fish, the ADFG will require those streams harboring salmon spawning beds to be crossed in the warmer months, between the time of fry emergence and the next spawning season.

Determination of the specific construction techniques to be used where the proposed pipeline would cross rivers, lakes, or streams awaits detailed site-specific data. General construction methods and temporary structures which are expected to be employed include:

1. Local realignment of the route to minimize costs and avoid environmentally sensitive areas.

2. Disposal or storage of subaqueous trench spoil in suitable onshore areas.

3. Installation of bridges where frequent crossings by construction equipment are planned.

4. Flow diversion structures to permit crossing of a "dry" streambed.

5. Construction during the season of lowest flow or as the ADFG requires.

6. Replacement of natural riverbed armor.

7. Strict compliance with location and timing requirements established by permitting agencies.

8. Environmental training program for construction workers.

Winter construction would avoid impact on adult salmon, which migrate during summer and early fall. Siltation from trenching activities, however, would affect gravel spawning beds downstream. Most river crossings would occur relatively close to the mouths of streams which generally are not suitable spawning habitat, although pink and chum salmon do spawn in these areas. Proposed crossings of each stream would be reviewed by the Alaska Department of Fish and Game, and its specific approval is required to cross salmon spawning streams. Although some spawning habitat might be affected, no long-term impact is expected if proper mitigative measures are taken.

To avoid scour damage, the pipeline would be buried with at least 5 feet of overburden at the proposed river crossings. At the Beluga and Susitna Rivers, minimum depths of 10 and 15 feet, respectively, might be required to avoid scouring. The pipeline river crossings would be checked with a fathometer to determine the bottom profile and the riverbanks inspected visually during the first period of high water following construction. If excess scour occurred, the pipeline would be reburied at a greater depth, or the channel bottom would be stabilized.

The pipeline across the main body of Cook Inlet and the offshore pipeline at McArthur River would not be buried. The pipeline crossing Cook Inlet would be coated with 3.75 inches of reinforced concrete for protection against scouring. A minimum coating of 3 inches would be used on the McArthur River pipeline. The pipeline routes would be selected to avoid areas of shifting sand and gravel waves to minimize scouring. The portions of the pipelines located in intertidal zones at water depths less than 12 feet below MLLW would be buried using conventional techniques. The entire Cook Inlet crossing and the other offshore pipeline would be inspected during the first summer following its installation.

Upon completion of construction, the pipelines would be hydrostatically tested to 1.25 times their maximum design pressure. Test water would be withdrawn from local freshwater streams and rivers at rates specified by permitting agencies. The water would be cascaded from test segment to test segment to minimize water requirements. The used water would be returned to natural water bodies under discharge conditions specified by the permitting agencies.

Land-clearing wastes from the right-of-way and nonmarketable timber would be disposed of in landfills when possible. In areas where it is economically feasible to save marketable timber, trees would be cut, trimmed, stockpiled on the right-of-way, and later transported to market. Otherwise, the debris would be burned after obtaining permits from the local fire marshall. Solid waste from the workcamps would be disposed of in approved sanitary landfills or incinerated. Sanitary wastes generated from the workcamps would be treated in portable waste treatment plants before discharge to local surface waters.

Revegetation would be part of an erosion and sediment control program designed to minimize or avoid short- and long-term terrain disturbance that might result from rights-of-way clearing. All disturbed soil surfaces in areas not subject to further traffic or construction activities would be revegetated as soon as climatic conditions allowed. After removal of the temporary construction camp(s), all disturbed areas would be revegetated. Mulches would be applied in areas subject to the erosive effects of wind and water.

Where revegetation would be impossible or would not totally control erosion, mechanical control measures would be instituted. Examples include inlets and outlets around culverts, ditch checks and liners, let-down structures and stilling basins, levees and terraces, and siltation basins. Because mechanical control measures require more maintenance and are less environmentally acceptable than revegetation, mechanical methods would only be used where necessary. In areas of high vehicular or personnel traffic, gravel pads would be placed to ease traffic movement during inclement weather and to lessen the potential for erosion and subsequent siltation.

The pipeline workforce would be hired from local areas when possible. This would help in temporarily relieving the area's high unemployment rate. Since much of the pipeline construction would occur during the winter months, the season of highest unemployment, local employment fluctuations would tend to even out during the winters of 1981-1982 and 1982-1983. Most of the workforce would be housed in construction camps or support barges, minimizing the impact on local housing.

b) Operation

Operation of the proposed pipeline would have little environmental impact. The use of pipeline compressors is not anticipated in the immediate future. Therefore, these sources of noise and air pollutants would not be present.

No regular ground maintenance along the proposed pipeline rights-of-way is planned. Local vegetation would not be periodically cut back along the rights-of-way, with the possible exception of timber trimming in areas where such growth might pose a long-term hazard (because of deep root systems) to the pipeline or where clearing would be required to permit access for pipeline repair.

Monthly aerial reconnaissance of the rights-of-way would be made from a fixed-wing aircraft, and more frequent inspections would be made if conditions warranted it. Low-flying surveillance should be avoided during trumpeter swan nesting and caribou and moose calving. Offshore pipeline crossings would be inspected at areas of maximum scour at least yearly. The inspection frequency at pipeline river crossings would depend on local stream conditions.

Mainline block valves, designed to close within a few minutes of a major rupture, would be located at both ends of the pipeline crossing of Cook Inlet and at intervals of 20 miles or less for the remainder of the system. In the event of a major pipeline rupture, a maximum of about 1.5 million cubic feet of gas per mile of pipeline could escape. A minor leak would freeze local vegetation, which might catch on fire if an ignition source were in the area. Likewise, local wildlife might suffer some injury and/or loss of life.

3. LNG Tankers

Two 130,000-m^3 LNG tankers would be built for service between Nikiski, Alaska, and Point Conception, California. Sun Shipbuilding and Drydocking Company would construct both tankers at its Chester, Pennsylvania, facility according to the applicant's specifications. The basic design features of the proposed tankers are illustrated in Figure 37 and described in the "Description of the Proposed Action." Table 3 lists the principal characteristics of the tankers.

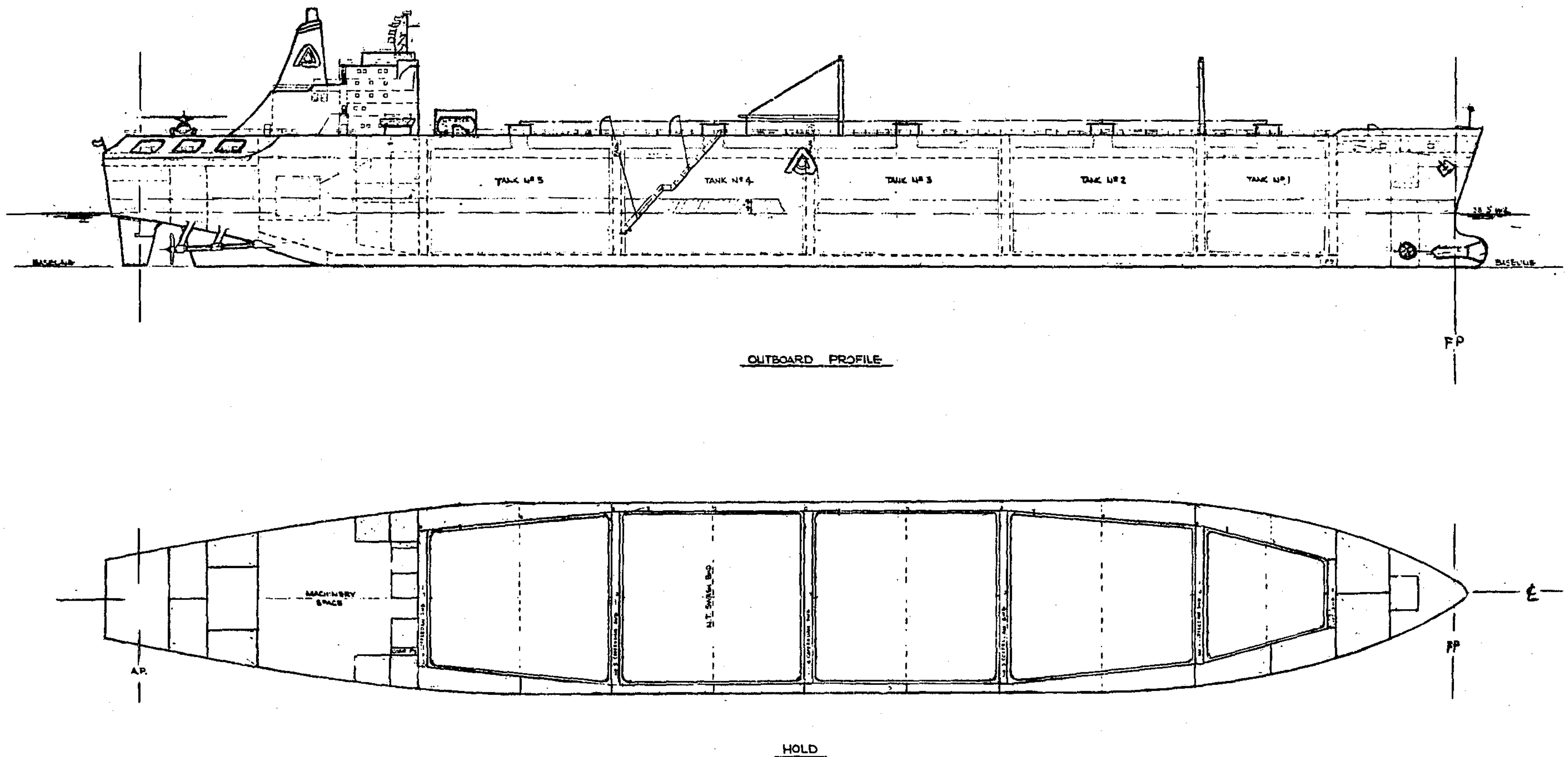

Figure 37

Typical 130,000 m^3-LNG Tanker
- Sun Shipbuilding

The operation of LNG tankers could pose a risk to public safety because of an accident resulting in a cargo spill or an LNG fire. The most likely cause would be a severe LNG tanker casualty, such as a collision with another large ship, a grounding, or a ramming with a fixed object. However, the breakdown of a major component of equipment could leave the tanker without propulsion or controls and therefore vulnerable to an accident. A hazardous situation could also arise following the failure of the cargo containment or related cryogenic systems. In order to minimize these risks, the proposed LNG tankers would employ design and operational features which would reduce the likelihood of a casualty or breakdown and also minimize the extent of damage should a casualty occur.

The proposed LNG tankers have been designed to include waste treatment systems which would reduce the amount of liquid and solid wastes discharged to the marine environment.

a) Design

The LNG tankers would be built to meet the requirements of the American Bureau of Shipping (ABS) and U.S. Coast Guard (USCG) Rules and Regulations. The hulls of an LNG tanker would be designed and constructed of special quality steels in order to withstand the environmental conditions of the southern coast of Alaska and to meet the requirements for cryogenic service. The outer hull would be constructed of special steels for low-temperature areas. The inner hull structure would extend for the length of the cargo space and would provide a separation from the outer hull of 8 feet 6 inches on the bottom and a minimum of 6 feet on the sides. The double-hull design is considered to be effective in minimizing the extent of damage to the cargo tanks in groundings and in low-speed or glancing-type collisions. The double-hull would probably not prevent cargo tank damage in a high-energy right-angle collision, although the extent of damage would be reduced.

The space between the two hulls would be used to contain ballast water. The ballast tanks would have no alternate fuel-oil storage connections, so ballast water would not be contaminated by fuel oil. Separate tanks would be provided for Bunker-C fuel oil. Because of the segregated ballast feature, the ballast water could be discharged during cargo loading operations without contaminating the waters around the terminal.

Located within the inner-hull structure would be five individual tanks, each separated from the adjacent tanks by a 6-foot cofferdam. The cargo containment system would be of the Gaz-Transport/McDonnel Douglas design. The primary barrier is an Invar membrane developed by Gaz-Transport of France. The Gaz-Transport design has been in continuous commercial service in the Polar Alaska and Arctic Tokyo LNG tankers since 1969. Between the Invar membrane and the ship's inner hull is an insulation system originally developed by McDonnel Douglas Corporation for cryogenic applications in the U.S. space program. A three dimensional, reinforced, polyurethane foam system provides the cargo tank insulation and also serves as secondary barrier for LNG containment.

The space between the primary barrier and the ship's inner hull would be pressurized with nitrogen gas to maintain an inert atmosphere; this would prevent the formation of potentially flammable concentrations of methane and act as a carrier medium for the gas detection system. If methane were detected in this space, the supply of nitrogen would be increased to maintain the concentration of methane below the hazardous level. Figure 38 illustrates a typical midship section of the proposed LNG tankers.

Liquid nitrogen, stored on the main deck in two 9,000-gallon tanks, would be vaporized as required to maintain pressure in the insulation spaces and to supply other ship needs.. The nitrogen storage tanks would be recharged at every call to the receiving terminal. It is estimated that the tanks would have sufficient capacity for a 40-day round-trip voyage.

The boil-off rate from the cargo tanks would be less than 0.14 percent per day of the total cargo volume when the ship is fully loaded and less than 0.07 percent per day when in ballast. Boil-off gas would normally be consumed in the main boilers and serve as auxiliary fuel for propulsion. During periods of low steam demand, the excess energy generated from the combustion of boil-off gas would be discharged through the two main and one auxiliary condensors.

Under ordinary operating conditions, boil-off gas would not vent to the atmosphere. However, high boil-off rates such as those that might result from the failure of cargo tank insulation could exceed the capacity of the gas combustion system in the main boilers. Under these circumstances, boil-off gas would be vented directly to the atmosphere. The gas would first be heated to increase its buoyancy and thereby enhance its dispersion.

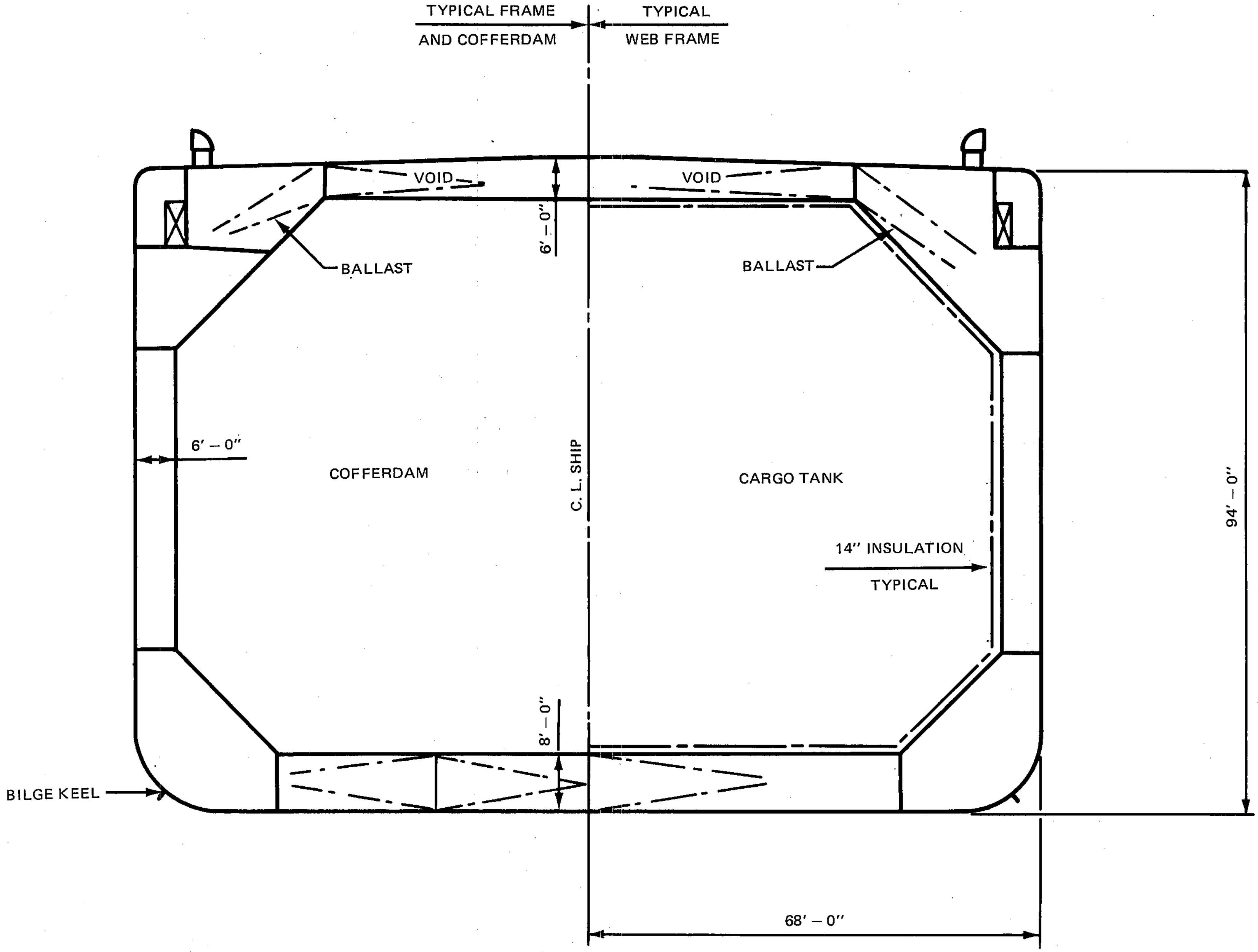

Figure 38

TYPICAL MIDSHIP SECTION
130,000-M^3 LNG TANKER

Propulsion for an LNG tanker would be provided by two steam-driven turbines, each driving a separate propeller. Each of the power trains would be complete in itself, and in the event of a failure to one system, the tanker could operate on the remaining power train. This feature would make the tanker less vulnerable to the total loss of propulsion. The twin propellers would also provide additional maneuverability at low speeds and increase the flexibility of operation at high speeds. The astern turbines used for stopping the tanker would deliver 75 percent of the normal ahead torque and 50 percent of the normal ahead revolutions per minute.

The tanker would use both a 38° rudder and a 3,000-hp reversible bow thruster for steering. The bow thruster would enable the ship to maneuver at low speeds when the rudder would be least effective.

Each of the propulsion plants would have separate and independent boilers, boiler feed, and condensate systems. The two boilers would supply superheated and reheated steam to the two propulsion turbines, superheated steam for the three turbo-generators, and desuperheated steam for the auxiliary turbines and other ship services. Makeup water for the boilers would be supplied in two separate distilling plants, each capable of providing the ship's makeup and potable water requirements. Normally one unit would be on-line, with the other unit as a complete standby. Two reserve distilled water storage tanks and one potable water storage tank would be located below the aft house.

Three 2,500-kw steam turbine-driven generators would provide the ship's electrical power. Two units could supply most power requirements. A 600-kw diesel-driven generator would be available for emergency electrical power generation. The unit would be capable of attaining its full capacity within 20 seconds and would supply emergency lighting, emergency interior communication, and the emergency power load.

The tanker would be equipped with several electronic systems to aid navigation and to reduce the likelihood of a casualty. A loran unit (long-range aid to navigation) would be provided to determine the ship's position in waters with loran coverage. Also available for navigation would be a radio direction finder and a satellite navigation system. An automatic gyrocompass system would provide accurate and constant reference to true north and would also supply information to the ship's automatic steering control system.

The ship would be equipped with two radar units--a 3-cm and a 10-cm wavelength--to show the position of moving objects on the water surface and the location of the nearby shoreline. A separate collision avoidance radar system would monitor the movements of other ships in the area, provide advanced warning of potential collisions, and allow sufficient time to perform avoidance maneuvers. The water depth would be continuously monitored by an echo depth sounder. The presence of shallow water would activate an alarm. A VHF radiotelephone would be provided to communicate with other ships and shore facilities. Also available would be an emergency position-indicating radiobeacon. Doppler speed logs and docking systems would also be installed.

Extensive fire detection and extinguishing systems would be located throughout the tanker. The fire detection system would use smoke detectors, ionization, ultraviolet, and heat-rise sensors depending on the nature of the space to be protected. Sensing devices would be located in all accommodation spaces, store rooms, machinery spaces, working areas, and all areas normally accessible to the crew. The activation of a sensor would automatically sound the ship's fire alarm system and indicate the location on alarm display boards in the wheelhouse and the engine control room.

In the event of an electrical failure, the fire detection system would be powered by the ship's emergency electrical generator. Should that system fail, standby battery power would provide a minimum of 12 hours operation.

The ship's fire extinguishing system would include saltwater, dry powder, carbon dioxide (CO_2), and fixed foam systems. A saltwater firemain circulating through the machinery spaces, crew accommodations, and the upper deck would supply the following units:

1) Five swiveling-type fire monitors located on the upper deck.

2) Water curtains covering the front of the aft house and all sides of the compressor house.

3) A water curtain sprinkling system covering the main cargo piping and cargo manifolds.

4) Numerous fire hydrants equipped with hoses and nozzles.

The dry chemical powder system on the upper deck would use a total of six 3,300-pound capacity units activated by compressed nitrogen gas. Four swivel-mounted monitors located within the cargo tank area would provide coverage of the port and starboard cargo-loading header connections. The two remaining units would be located forward and aft and each fitted with a 100-foot hose for local use. An additional unit would be located in the machinery space to cover the boiler dual-fuel burner location. Spare nitorgen bottles and dry powder would be stored for recharging one-half the units.

A fixed CO_2 system would protect the machinery space, emergency generator room,and the paint lockers. The machinery spaces would be covered by a fixed foam system using a 3-percent solution of concentrate in seawater. Halon 1301 systems would protect the control rooms, and fixed CO_2 extinguishers would protect the machinery spaces.

The tanker would employ several pollution abatement systems to reduce the quantity of effluents during normal operation. A sanitary waste disposal system would be capable of handling about 12,000 gpd of sanitary waste from the urinals, toilets, and the garbage grinder. These wastes could be pumped to shore facilities or retained in a 15,000-gallon capacity holding tank while the tanker is in U.S. waters. Upon reaching the high sea, sanitary wastes would be processed so that the liquid effluent would contain a fecal coliform count of less than 1,000 per 100 ml and then discharged. The remaining solid waste material from the treatment process would be injected into the ship's main boilers when the tanker is underway. An incinerator would be provided for burning all solid trash, garbage, and oil residue from the oily water separator.

Oily bilge water from the machinery spaces would be discharged to a slop tank. Periodically, the tank would be emptied through an oily water separator and discharged overboard or pumped directly to a shore treatment facility. The effluent from the oily water separator would contain less than 50 ppm of oil.

b) Testing

All portions of the tanker, including the structure, fittings, machinery, and auxiliary and cryogenic systems, would be thoroughly tested throughout the construction period and prior to service as required by the applicant and the various regulatory bodies.

Samples of the material to be used in constructing the cargo tanks would be subjected to tensile strength, yield strength, and elongation tests prior to fabrication. During the construction of the cargo tanks, welds would be visually and radiographically tested, and subassemblies leak-tested by vacuum box or other approved methods. The completed tank would be tested by a global leak test. In this test, the space behind the membrane is pressurized and the pressure degradation is monitored over time to determine the extent of any leak. Hydrostatic testing of the containment system would not be done, but hydro testing of the ballast area, and therefore the inner hull structure, would be done. Defects discovered would be repaired, inspected visually and radiographically, and retested.

When the tanker was substantially complete, sea trials would be conducted to test the conventional features of the ship. The contractor would first conduct a 4-hour dock trial to determine as far as practical the seaworthiness of the ship. The sea trials would then be conducted in accordance with the procedures of the Society of Naval Architects and Marine Engineers. The test would include endurance trials, power, speed, and fuel economy trials, and steering, stopping, and backing trials.

Prior to receiving the initial cargo load, all cryogenic systems would be tested at operating conditions. One cargo tank would be subjected to a full cycle of operations--from cool-down through loading and discharge to warmup--using LNG. The final test of the cryogenic system would take place when the tanker received its first cargo. Operation of the boil-off system would be checked during gas trials.

c) Operation

Each tanker would make the round-trip voyage between Nikiski, Alaska, and Point Conception, California, in about 12 days. Therefore, one arrival would occur at each terminal about once every 6 days during Phase II operations.

The Ports and Waterways Safety Act of 1972 gives the USCG responsibility and authority to control marine traffic and extends USCG authority to include setting the standards of design, construction, operation, and maintenance. The USCG would conduct a preloading safety inspection of the LNG tanker and marine terminal at Nikiski prior to each transfer of LNG. No Federal regulations currently exist for vessel movements in Cook Inlet since the volume of ship traffic is low. However, ships greater than 300 gross tons are required to pick up a licensed pilot at Anchor Point when entering the inlet. The waters of Cook Inlet are wide and should provide adequate space for maneuvering and avoiding other vessels. Night navigation is facilitated by numerous lighted oil and gas rigs which serve as reference points throughout the inlet.

Ice and strong currents pose the main hazard to docking operations during winter months. The worst conditions can occur during the last few hours of flood tide in the presence of a southwesterly wind. This combination of conditions can cause ice to build up between a docked ship and the shore, forcing the ship to castoff. Should such conditions occur at the proposed Nikiski terminal, the quick disconnect features of the marine terminal would allow the tanker to castoff quickly, minimizing the chance of an LNG spill.

The applicant is a participating member of the Nikiski Marine Terminal Safety Committee. This group recently issued a booklet, Operations Guide-Nikiski Marine Terminal Complex, to assist ship masters in using the Nikiski Port complex. The guide, appearing in Appendix I, establishes voluntary procedures for ship arrival, mooring, unmooring, and departure, as well as communications systems and emergency procedures. Special winter rules for the safe use of the complex apply when there is free ice floating in Cook Inlet. The actual starting and end dates for winter rules would be established by the Nikiski Marine Terminal Safety Committee. These voluntary procedures require that ships berth so as to stem the worst ice conditions to be expected, maintain sufficient ballast or cargo so that sea suctions and propellers remain below the ice level, and maintain the ship in a ready status that would permit the immediate suspension of cargo operations and casting off, should conditions warrant.

E. UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Construction of the proposed LNG plant would result in unavoidable alterations to the physiography of the site. The site has already been cleared and leveled. Excavation activities in preparation for the construction of plant buildings and LNG tanks would change existing elevations and runoff patterns. Soil compaction caused by the operation of construction machinery and the presence of buildings and paved areas on the site would tend to increase surface runoff, but the exposure of porous subsoils of the site would increase water absorption and decrease surface water runoff. The remaining surface runoff would be collected in a drainage system and diverted into Cook Inlet.

Construction of the proposed haul road would considerably alter the physiography of the coastal bluff. The removal of approximately 215,000 cubic yards of material would impose a significant burden upon existing disposal areas. Slope dewatering measures taken during the excavation of the haul road would decrease the amount of groundwater present locally Despite these dewatering measures, the steep sides of the haul road would experience increased erosion.

Approximately 836 acres of evergreen, mixed evergreen-deciduous and deciduous forest, 440 acres of muskeg, 123 acres of various scrub assemblages, and 80 acres of non-natural vegetation, would be cleared for the construction of the proposed haul road and gas pipeline facilities. In addition, 40 acres of, as yet, unspecified land would be altered for the installation of four pipeline construction work camps. This would result in the loss of habitat for a number of animals and could eventually change the species composition of the areas affected. Soil erosion in the cleared and trenched portions of the pipeline rights-of-way would take place at a faster than normal rate until vegetation grew back and covered the ground again. Soil compaction and trenching would change the surface and subsurface moisture patterns and increase the period of time necessary for complete revegetation. Maintenance clearing along the pipeline routes would prevent the total reforestation of the rights-of-way for the life of the project. Approximately 36 acres of land at the plant site would not revegetate naturally, even if it were allowed by the applicant, since the fertile topsoil has been removed from this area and gravel put down in its place.

The construction of the proposed docking facilities and dredging in the docking areas would kill some individual marine organisms and temporarily impair the local water quality and benthic habitats enough to affect others. The process of laying the proposed pipelines across Cook Inlet would have similar unavoidable environmental effects. The environments of streams crossed by the pipeline could be affected more severely than the marine habitats if critical salmon spawning beds were dug up or covered by silt. Close adherence to local Alaska Department of Fish and Game guidelines would help mitigate such impact in salmon streams, but some temporary effect might still be unavoidable.

The noise, fugitive dust, and exhaust gases from construction equipment would detract from the environmental quality of the area temporarily, driving away sensitive wildlife and disturbing nearby human residents. The operation of the LNG plant and marine terminal would also affect the local noise levels and air and water qualities. While not as aesthetically pleasing as the forested area it would replace, the LNG plant and haul road would be similar to nearby land uses. The new right-of-way would also have some adverse aesthetic impact.

The existence of an LNG facility at Nikiski would limit future recreational and residential development in the immediate area of the site. The surrounding area would be developed in accordance with local zoning requirements. Public concern over the potential hazards associated with LNG could limit the area's use for recreation and the construction of homes. The presence of the proposed facility would serve to perpetuate an existing local trend towards industrialization. The proposed pipeline would produce a similar long-term limiting economic impact because no permanent structures could be constructed above the pipeline rights-of-way.

The proposed LNG tanker operations would cause an increase in large-scale vessel traffic in Cook Inlet. To accommodate the increased traffic at Nikiski, new mandatory loading procedures for all vessels using the port during ice conditions would probably have to be instituted. 1/ In addition, the partial barrier presented by the proposed LNG loading pier would largely preclude boating activities in the offshore tanker mooring area for the project's operational life and would interfere with set net fishermen who have previously utilized the immediate area.

1/ U.S. Coast Guard letter to Federal Power Commission dated March 9, 1977. (See Appendix F.)

F. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The short-term impact of the proposed project is that which would occur during the construction and operation of the proposed facilities. Construction of the LNG plant, haul road, and marine terminal would require or has already required clearing approximately 40 acres of mixed evergreen and deciduous forest. The construction of the proposed 239.6 miles of onshore pipeline would necessitate clearing about 1,452 acres of land, mainly mixed evergreen-deciduous forest and muskeg. Temporary degradation of water quality would occur in the areas of proposed dredging and pipelaying in Cook Inlet and at each stream crossing along the onshore portion of the pipeline. Operation of the proposed facilities would have some adverse effects on air and water quality and on noise levels.

The proposed LNG plant and marine terminal would be located at Nikiski in the Kenai Peninsula Borough, Alaska. Because this area is presently developed for industrial operations, the proposed facility would be consistent with the planned land use of the area. However, the proposed project would not be consistent with possible recreational and residential development in the immediate site vicinity.

The proposed project would allow a small increase in full-time employment in the Nikiski-Kenai area and an increase in local and state tax revenues for the life of the project. It could also decrease future curtailments of gas supply to southern California.

The use of LNG as an energy source is advantageous because natural gas is the cleanest burning of all fossil fuels and is not considered to be an environmental pollutant in either its liquid or gaseous state. However, the handling of LNG does present some risk to the public. In the event of an LNG spill, contact with soil or water would vaporize the LNG and disperse the flammable vapors. Gaseous emissions from combustion would be negligible and should present no threat to ambient air quality.

Most of the mineral resources required for construction of the LNG plant, marine terminal, tankers, and pipeline could be reclaimed at the end of their useful life. After abandonment, the plant and terminal area could be vacated, making it available for a similar or new land use. After abandonment of the pipeline, the maintained right-of-way could slowly revert to its original state, if desired by the landowners. Although several decades may be required to return land cleared of forest vegetation to its natural condition, little extended long-term impact on the productivity of the vegetated areas would be likely to occur as a result of the proposed action.

G. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

No permanent, irreversible change in land use would be expected with the implementation of the proposed project except for the areas disturbed by the haul road construction. About 4 acres would be committed to the haul road itself, and an undetermined amount of land would be altered by the disposal of haul road spoil materials. The estimated 215,000 cubic yards of spoil would, for example, cover about 11 acres if distributed to an average depth of 12 feet. The location of the required landfill area has yet to be determined.

During facility operations, the 59.3-acre terminal site would be unavailable for any alternative development, and the roughly 1,456 acres of pipeline right-of-way and haul road would have limited usefulness for other purposes. Although the erection of the LNG terminal would represent a change from present land use, inasmuch as no industrial facilities are now situated on the proposed site, the project would be consistent with other industrial activities in the adjacent areas. Approximately 62 percent of the 291.6-mile pipeline system would utilize and parallel other existing rights-of-way.

After pipeline abandonment, the rights-of-way would eventually revert to their original condition; however, any revegetation of the LNG plant site would be contingent upon the replacement of topsoil removed during clearing. Immediate revegetation of the haul road banks and the spoil disposal area would be necessary to prevent erosion and potential impact to water resources.

Construction of the LNG terminal and pipeline facilities would involve an irretrievable commitment of fiscal resources and labor of up to 800 workers at the peak of the 48-month construction period. Additional labor would also be required by the LNG tanker and module construction operations. Given current levels of unemployment, particularly in Alaska, labor shortages should not be expected, and no labor-induced delay of other projects should result from this proposal.

Construction of the LNG storage and docking facilities would require the use of some 70,000 cubic yards of concrete, 2,000 tons of 9-percent nickel steel plate, and 3,000 tons of carbon steel plate. The two LNG tankers would each require some 35,000 tons of materials, primarily steel, but including about 200 tons of 36-percent nickel steel. The 291.6-mile pipeline system would utilize approximately 40,000 tons of steel pipe and 42,000 tons of concrete coating. All of the above-described materials could be salvaged after termination of the LNG operation or could be recycled for other purposes. However, the fabrication of these materials would use coal, limestone, and electricity which would be irreversibly consumed.

The dredging of a southern approach channel to the LNG terminal and to the proposed construction dock would alter the bottom configuration of the inlet by removal of some 92,000 cubic yards of materials. The usefulness of the dredged channel would extend beyond the lifespan of the proposed facility. The temporary loss of some benthic organisms during dredging would not constitute any long-term irreversible resource impact.

The primary irreversible and irretrievable project impact would be the development and consumption of important fossil fuel resources. The LNG tankers would require about 6 million tons of fuel oil over the 20-year project period; more important, however, would be the consumption of some 3.2 trillion cubic feet of Alaskan natural gas in southern California. The development and subsequent use of these large gas reserves would constitute a significant depletion of this nation's nonrenewable hydrocarbon resources.

H. ALTERNATIVES TO THE PROPOSED ACTION

This section discusses the alternatives to implementing the proposed project. These alternatives include the following topics:

1) Alternate Plant Sites and Pipeline Routes
2) Alternate Sites for Construction Dock and Haul Road
3) Pipeline Alternatives to the Pacific Alaska Project
4) No Action or Postponement of Action
5) Alternate Modes and Systems
6) Alternate Sources of Energy
7) The Alternative of Energy Conservation

Alternatives 1, 2, 3 and 4 are covered on the following pages. The discussions of alternatives 5, 6, and 7 are adopted by reference from Energy Alternatives: A Comparative Analysis. This document, published in May 1975, was prepared by the Science and Public Policy Program of the University of Oklahoma for the Council on Environmental Quality, the Federal Power Commission, and other Federal agencies in order to avoid duplication of effort in preparing lengthy technological analyses about energy alternatives. Further discussion on the alternative of energy conservation can be found in Volume III of this environmental impact statement.

1. Alternate Plant Sites and Pipeline Routes

a) Introduction

The expanding fuel requirements of the United States have acted as a catalyst in stimulating the rapid development of LNG facility sites that are capable of handling additional supplies of energy. In view of the concerns for human safety, project success, and environmental protection applicable to the proposed Cook Inlet LNG terminal, the staff has undertaken an extensive siting study for potential LNG terminal sites. The staff, with the assistance of a study prepared by the Oceanographic Institute of Washington, conducted a regional analysis of the Cook Inlet area, evaluating locations on the level of a site-specific analysis. The specific sites that were analyzed were chosen on the basis of material submitted by the applicant and OIW.

b) LNG Terminal Siting Criteria

A site which is physically best suited to accommodate a liquefaction facility and loading terminal must meet several requirements.

i. Topographic Conditions

The potential site should satisfy certain topographic requirements to insure the structural and operational integrity of the plant and to minimize preconstruction site preparation.

The slope of the site should be minimal but sufficient to permit adequate site drainage. Construction on poorly drained sites could increase potential disruption of ground-water regimes as well as increase construction costs.

The site should have few topographic irregularities such as hills, valleys, or terraces so that extensive site preparation is unnecessary. Sites which would require excavation into the bases of mountains or leveling of large topographic irregularities would necessitate hauling large quantities of spoil material and the consequent development of spoil disposal sites, which would increase costs as well as increase the potential for additional adverse impact.

ii. Foundation Conditions

Foundation conditions at the site should provide adequate stability during both static and dynamic loading. Soils should be dense and granular to provide strength and resist settlement. The soils should not be susceptible to lique-faction caused by rainfall or subsurface water movement.

If bedrock is present, it should be relatively close to the surface in order to preclude high tension pile loads, but at a sufficient depth to avoid interference with site preparation.

iii. Seismic Considerations

The plant site should not be located on or adjacent to any active fault zones which could jeopardize the structural integrity of the facility through ground movement or other related events which could accompany a major seismic disturbance.

The soils at the site should not be susceptible to liquefaction during seismic events and should retain their foundation stability under dynamic stress. The site should not be located in or near areas where unstable submarine slopes could undergo sliding during seismic events.

The site should not have a potential for extensive shoreline damage from tsunamis. Areas with past histories of shoreline damage could pose a threat to a marine terminal and/or storage facility. The site should be well above the elevation of water levels resulting from major storm tides, river floods, or tsunamis.

iv. Atmospheric Conditions

The plant site should be relatively well sheltered and should permit safe and economical year-round operation with minimum periods of downtime resulting from adverse climatic conditions.

Winds exceeding a velocity of 30 miles per hour at the site should have a low frequency of occurrence and should be of short duration. High winds could hinder LNG carrier maneuvering, and wind loads imposed upon the mooring lines or on the fendering system could require a ship to vacate its berth.

Periods of reduced visibility resulting from fog and/or precipitation should also have a low frequency of occurrence and minimal persistence at the site. Extended or frequent periods of reduced visibility could increase the risk of ship accidents (collisions, groundings, etc.) or require temporary suspension of docking procedures.

v. Oceanographic Conditions

The site should offer as much protection as possible from exposure to waves and currents of magnitudes which could hinder the safe operation of LNG tankers. Open, exposed coastal areas may not be acceptable because wave action could cause excessive ship movement at the berth and increase the potential for hull and berth damage.

vi. Bathymetric Conditions

The minimum acceptable water depth at the berth should be 42 feet at MLLW in areas not susceptible to wave action. This depth should be achievable with minimal initial or maintenance dredging or blasting. Areas exposed to wave action should have additional water depth, 5 to 15 feet, at the berth to accommodate increased vertical ship movements. The distance from the berths to the shore should be as short as possible to reduce costs of construction and operation and revaporization problems that would be associated with a long cryogenic transfer line. Modern technology would allow for a transfer line approximately 2 to 2.5 miles long before revaporization problems would be encountered.

vii. Navigational Suitability

The nature and configuration of the approach channel should be such that difficult navigation conditions would not be encountered. The width of the approach channel should be at least three times the width of the ship if traffic would be limited to one-way movement or six times the width of the ship if two-way traffic would be allowed. Minimum channel depths should be 42 feet at MLLW in areas sheltered from waves and 47 to 57 feet in areas subject to wave action. All turns along the channel should be gradual and should not require any unsafe maneuvers. No obstructions to navigation should be present.

Areas with minimal amounts of vessel traffic congestion would be preferable. In areas where there is a moderate to heavy concentration of vessels, traffic patterns will probably be established by the U.S. Coast Guard to restrict the movement of other ships during harbor transit of the LNG tankers.

The land bordering the areas in which the LNG carriers would maneuver should be well marked or capable of being marked with lighted aids to navigation.

viii. Anchorage Suitability

At least one area suitable for standby anchoring of the LNG carriers should be available in the vicinity of the marine terminal site. The bottom conditions at the anchorage area should be firm to permit secure anchorage, and the water depth should not exceed 200 feet. The anchorage area should also be located away from vessel maneuvering areas or channels and should be of sufficient size to permit the ship to swing with the wind or current.

ix. Ice Conditions

The formation of sheet ice or the passage of ice floes of a magnitude which would prevent the safe and economical year-round operation of the LNG carriers should not be characteristic of the waters in which the ship would travel.

x. Land Use Conflicts

The proposed site should not be located where conflicts would arise between operation of the proposed project and existing, planned, or potential land uses on or near the proposed site, including residential, commercial, recreational, or conservation-oriented activities.

xi. Proximity to Gas Sources

In order to maximize economic feasibility and to reduce the environmental impact of pipeline construction, a potential site should be located as near the source(s) of gas as possible.

To insure the protection of the environment, LNG facility sites must be simultaneously considered for selection on the basis of their ecological and environmental stability. Areas such as tidal marshlands that are highly susceptible to ecological imbalances should be avoided whenever possible. Since waterways are an integral component of LNG facility operations, coastal waters and shorelines are often the areas most likely to suffer environmental damage from the construction and operation of LNG terminals. This damage would be minimized in areas where the natural water depth exceeds 42 feet, lessening the need for initial or subsequent maintenance dredging, and where the shoreline is rocky or consists of a stable, sandy beach.

Human safety factors are often inversely related to the extent of damage that may be imparted to the environment. A site selected in a rural area may generate the greatest environmental impact but would expose the minimum number of people and properties to danger in the event of an accident. Industrial locations would help minimize impact upon the natural environment but would expose more people to danger in the event of an LNG mishap. Industrial areas also pose the problem of the LNG facilities being affected by an industrial accident at a neighboring facility. The use of residential locales generally presents the greatest risk to people and private property.

c) Site-Specific Analysis

The Oceanographic Institute of Washington (OIW) conducted a study of alternative sites in the Cook Inlet/Kenai Peninsula area for the FPC. 1/ The study investigated the Cook Inlet coastal areas for potential LNG sites on both a subregional and a site-specific level. The general procedures in the site selection process are excerpted and attached as Appendix D.

All sites in Resurrection Bay were rejected by the staff because of the overall geologic, climatic, and oceanographic conditions characteristic of the bay. This position was previously taken by the FPC staff in Volume II of Alaska Natural Gas Transportation Systems: Final Environmental Impact Statement, published in April 1976.

1/ On October 1, 1977, the FPC was reorganized under the Department of Energy Organization Act and designated as the Federal Energy Regulatory Commission (FERC) within the Department of Energy.

The locations of the 11 sites not eliminated by OIW or the staff because of navigational unsuitability or their location in Resurrection Bay are shown in Figure 39. The symbols which represent the ratings of the physical characteristics of each site as they relate to the developmental and/or operational requirements of the proposed project are shown in Figure 40.

Of the 11 sites 1/ that were studied, 9 were considered unacceptable for the technical requirements of the project and were rejected from further study. The principal reasons these sites were rejected are explained below.

d) Sites Unacceptable for Technical Requirements

i. East Foreland

The East Foreland site is located approximately 60 miles north of Anchor Point and about 56 miles southwest of Anchorage. The site consists of a nearly level wooded headland with a 276-foot high bluff at the water's edge. East Foreland is presently classified as a lighthouse reserve. LNG terminal development could therefore involve conflicts between the existing conservation-oriented land use and newly introduced industrial uses. The site also lies north of the constriction in Cook Inlet formed by the Forelands and would be subject to severe winter ice conditions which could adversely affect the operation of the marine terminal associated with the proposed project.

ii. Nuka Bay-North Arm; Nuka Bay-Beauty Bay; Nuka Passage

Three sites within the Nuka Bay-Nuka Passage area on the south coast of the Kenai Peninsula were considered as potential sites for terminal development. Each of the three sites is situated on deltaic deposits. River deltas are characteristically susceptible to soil liquefaction, and

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1/ The general site area at Nikiski actually contains three distinct sites, each of which was studied separately. Due to their close proximity, the three Nikiski sites were first considered as a single site in the above discussion. The names of these sites are Phillips-Marathon, Nikiski-North, and Nikiski-South.

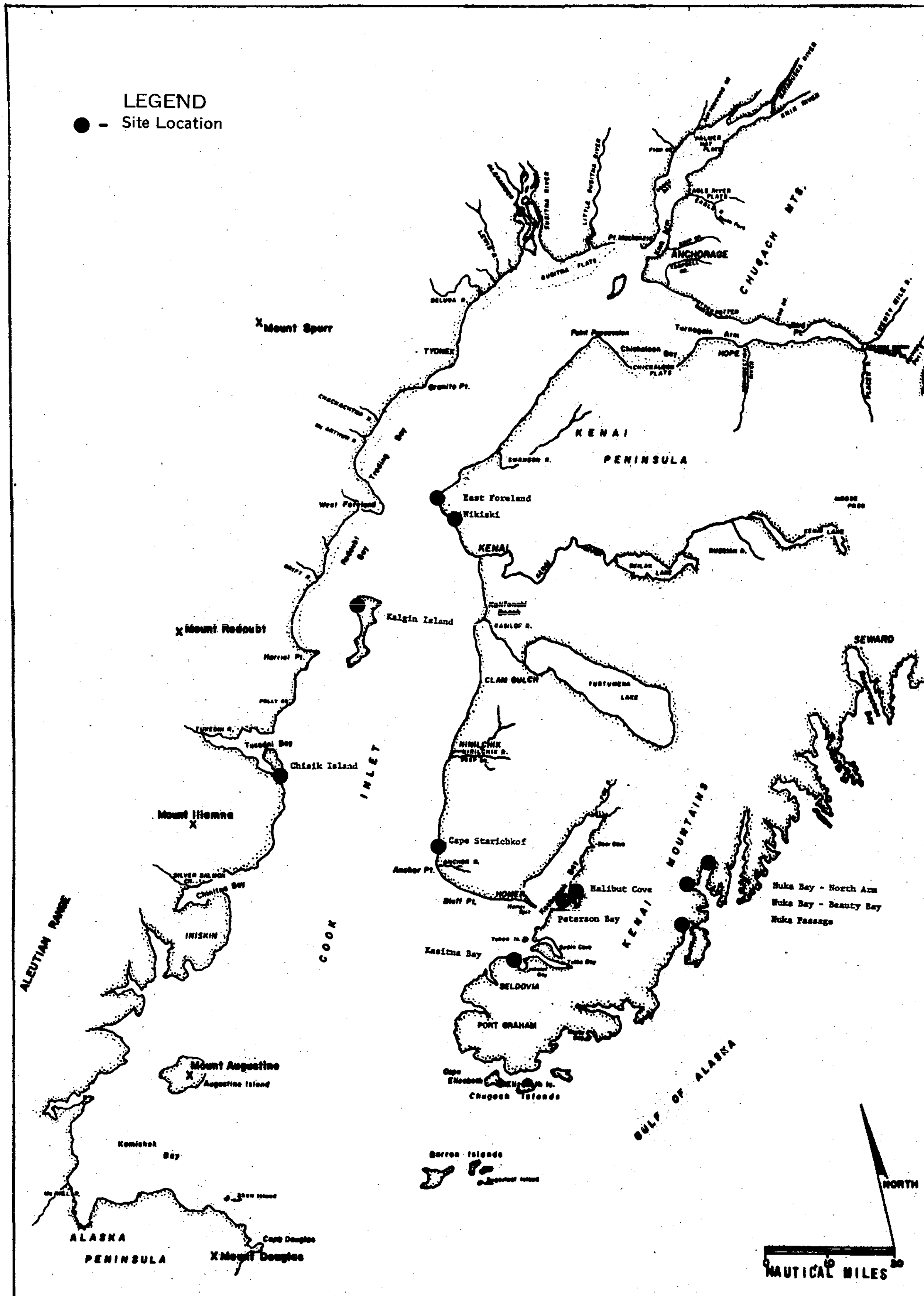

Figure 39. Location of Sites Analyzed in Cook Inlet

Figure 40. Symbolic Ratings - Cook Inlet Subregion

	Topographic Conditions	Geologic or Foundation Stability	Seismic Considerations	Atmospheric Conditions	Oceanographic Conditions	Distance to Deep Water	Navigational Suitability	Anchorage Suitability	Ice Formation	Land Use Conflicts
Cape Starichkoff	◐	○	◐	○	◐	○	○	○	○	◐
Nikiski	○	○	◐	○	◐	○	◐	○	◐	○
East Foreland	◐	○	◐	◐	◐	○	○	○	●	●
Nuka Bay (North Arm)	●	●	●	◐	◐	○	○	○	○	○
Nuka Bay (Beauty Bay)	●	●	●	◐	◐	○	○	◐	○	○
Nuka Passage	●	●	●	◐	◐	○	○	○	○	○
Kasitna Bay	●	○	◐	○	○	○	◐	○	○	○
Peterson Bay	●	○	◐	○	○	○	◐	◐	○	○
Halibut Cove	●	●	◐	○	○	○	○	○	○	○
Kalgin Is. (West Side)		○	◐	○	○	○	◐	○	◐	●
Chisik Is. (Snug Harbor)	●	●	◐	○	○	○	◐	○	○	●

LEGEND

○ - Favorable condition.

◐ - Sub-Favorable condition that could be mitigated with appropriate measures.

● - Unfavorable condition that could not be mitigated or which would present a serious problem or hazard.

historic earthquake occurrences have indicated that deltaic deposits on coastlines also display a high potential for tsunami inundation and subaqueous landsliding during periods of dynamic stress. These geologic considerations, in combination with evidence of the frequent local occurrence of high-speed Venturi winds (williwaws) which could adversely influence safe LNG tanker navigation, would not be conducive to LNG terminal development at any of the three Nuka Bay-Nuka Passage sites.

iii. Kasitna Bay

The Kasitna Bay site is located on the south shore of Kachemak Bay between Nubble Point and Herring Island. The site would require extensive site preparation to compensate for the uneven topography, resulting in excessive amounts of spoil material as well as increased costs incurred from these massive cutting and filling operations. For this reason, the site was rejected from further consideration.

iv. Halibut Cove

This site is located in Kachemak Bay on the eastern shore of Halibut Cove. The site presents two disadvantages which resulted in its removal from further consideration as a potential terminal site: (1) the rugged topography would require extensive site preparation; (2) the site is located within the floodplain of Grewingk Glacier and could be subject to outburst flooding or other adverse effects associated with glacial activities.

v. Peterson Bay

The Peterson Bay site is located on the south shore of Kachemak Bay just west of the Halibut Cove site. Unlike the Halibut Cove site, Peterson Bay would not be subject to adverse effects from Grewingk Glacier, but its uneven topography would similarly require extensive site preparation. The Peterson Bay site was therefore dismissed from further consideration as a potential site for terminal development.

vi. Kalgin Island--West Side

The Kalgin Island site is located on the northwest side of Kalgin Island within Cook Inlet. Vessel maneuvering might be restricted in some directions near the island, but sufficient area is available to accommodate LNG tankers. Much of the site is wet and marshy, which might create problems during site preparation and might adversely affect foundation stability. The widespread marshlands on the island are used extensively as a waterfowl habitat, and present land use of the area is directed toward ecological preservation. The development of an industrial facility on Kalgin Island would be inconsistent with the existing natural conditions of the area and would result in the removal or disruption of waterfowl habitat.

vii. Snug Harbor--Chisik Island

The Snug Harbor site on Chisik Island is at the mouth of Tuxedni Channel on the west side of Cook Inlet. The topographic configuration of the site would require massive cutting and filling operations prior to emplacement of the facilities. The existing status of Chisik Island as a natural wildlife refuge would conflict with industrial development of the magnitude proposed at the site.

e) Site Unacceptable for Other Reasons

i. Phillips-Marathon

The Phillips-Marathon LNG Company liquefaction plant and marine terminal site located approximately 2,000 feet north of the applicant's proposed site at Nikiski was considered by the environmental staff for possible expansion to include Pacific Alaska's project. Because the Phillips-Marathon site is quite close to the proposed site, there seems little reason to suspect that the Phillips-Marathon site would not also fit the technical requirements sought for Pacific Alaska's project. The obvious advantage of combining the Phillips-Marathon and Pacific Alaska facilities would be the elimination of an additional marine terminal at Nikiski.

Closer examination by the staff revealed that the existing Phillips-Marathon facilities would require extensive modification beyond the simple addition of the liquefaction trains, storage tanks, and other facilities necessary to accommodate Pacific Alaska's proposed volumes of LNG. Phillips-Marathon's existing marine terminal is too small to handle Pacific Alaska's proposed 130,000-m^3 LNG ships, and much of the existing liquefaction plant equipment was constructed according to codes and regulations in effect over a decade ago. Considerable redesign and updating of the Phillips-Marathon facilities would therefore be required to make those facilities compatible with Pacific Alaska's proposal. The reconstruction of the Phillips-Marathon marine facilities could require an interruption of undetermined length in that company's service to Japan. Beyond the physical problem of modifying Phillips-Marathon's facilities, there is the legal problem of inducing Phillips-Marathon to amalgamate its facilities with the Pacific Alaska project.

In summary, although it would be technically possible to use the Phillips-Marathon site for the proposed project, it appears that economic and legal impediments would make the site unavailable.

f) Sites Not Eliminated

i. Applicant's Proposed Nikiski Site

Nikiski is located 9 miles northwest of Kenai and 65 miles southwest of Anchorage. Three sites in this general area were considered for the proposed LNG facilities. (See Figure 41.) One of these sites, the Phillips-Marathon site, was discussed in the previous subsection. The applicant's proposed site is the southernmost of the three sites and was originally given the name of Nikiski-South by the applicant. The third site, referred to as Nikiski-North, will be described subsequently.

Although all other factors appear favorable for the use of the applicant's proposed site, sea ice in conjunction with extreme tidal currents creates serious problems for the navigation, docking, and loading of LNG vessels at Nikiski. Both the applicant and OIW (see Appendix E) commented on these problems but concluded that since docking

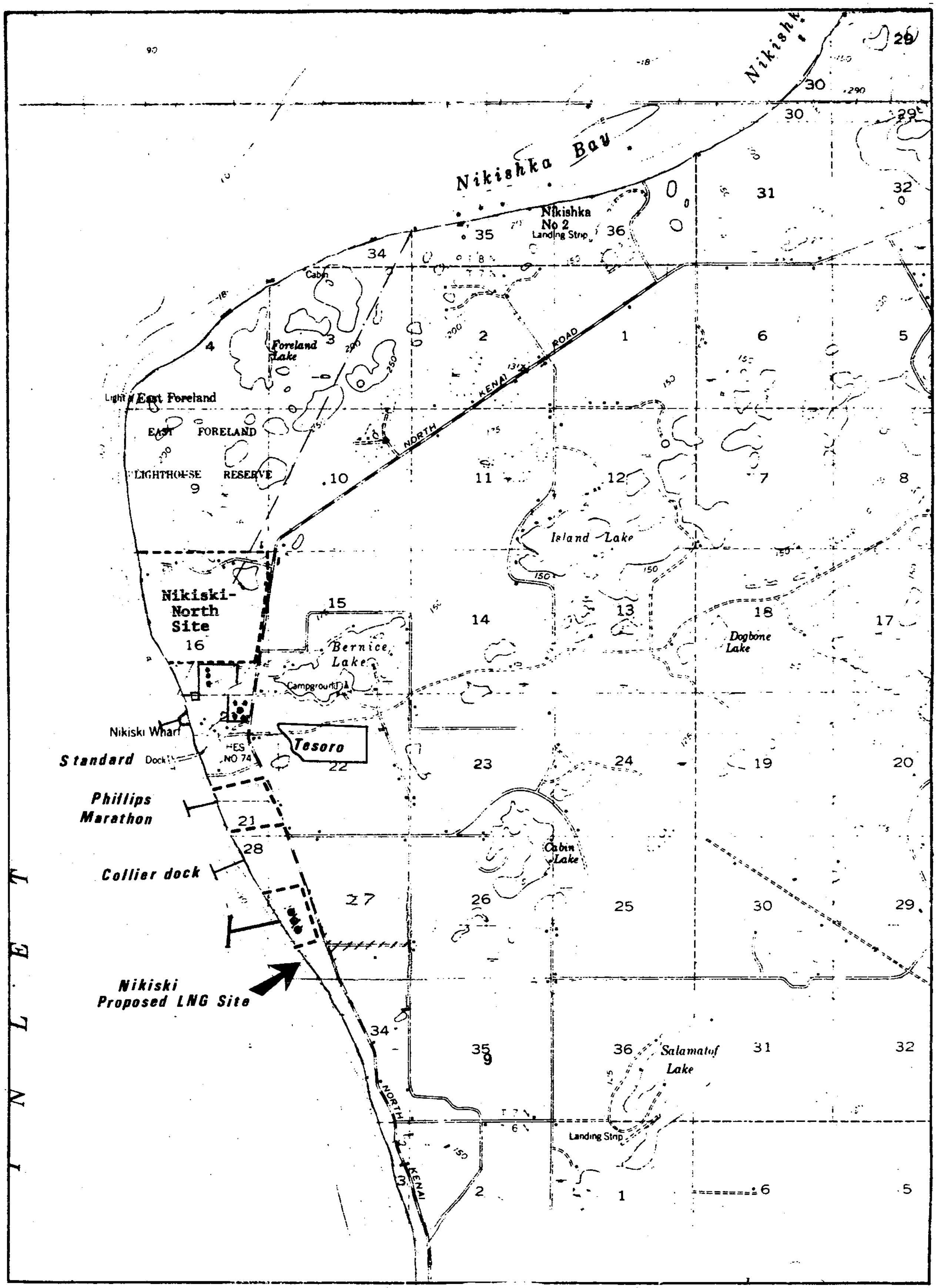

Figure 41. Nikiski Sites, Cook Inlet

has generally been possible year-round at the three existing Nikiski terminal facilities (Standard Oil Company Refinery, Collier Carbon and Chemical Plant, and Phillips-Marathon LNG Liquefaction Plant), hazards of ice action could be overcome. In the course of investigating the severity of this phenomenon, the staff began a lengthy correspondence with the U.S. Coast Guard. (See Table 14 and Appendix F.) A summation of the correspondence can be found in the March 9, 1977, letter from Rear Admiral Hayes, which states that if the appropriate precautionary steps are taken, "present and future Nikiski operations can be conducted safely, though perhaps under conditions of considerable economic burden to the operators." The economic burden could result when periods of severe winter icing conditions require the closing of the port, thus interfering with Pacific Alaska's shipping schedule.

However, the Coast Guard believes operations can be conducted safely. The State of Alaska has also indicated that, "Because of the obvious benefits of the Nikiski site, the State of Alaska supports its selection for the proposed liquefaction plant and terminal . . . ." 1/

ii. Nikiski-North

The Nikiski-North site is located about 2 miles north of the proposed site and about 1 mile south of East Foreland. The environmental aspects of this site so closely resemble the proposed site that the applicant's choice between the Nikiski-North and the proposed site was determined primarily by the greater availability of the land at the latter site. The environmental staff agrees that there is little difference between the sites. Like the proposed site, the Nikiski-North site is subject to potential winter shipping delays that detract from its suitability as a location for an LNG terminal. In addition, some of the Nikiski-North site lies within the East Foreland Lighthouse Reserve. The staff favors the applicant's proposed Nikiski site because it avoids land use conflicts.

1/ Mr. John Halterman, State-Federal Coordinator for the State of Alaska, Letter to the FPC dated November 26, 1976.

iii. Cape Starichkof

The Cape Starichkof site lies on the eastern shore of Cook Inlet some 13 miles south of Ninilchik. (See Figure 42.) Since the OIW study was originally intended to identify sites suitable to accommodate a much larger LNG project than the one proposed by Pacific Alaska, the site identified by that study at Cape Starichkof covers an area of approximately 600 acres and is connected to a marine terminal, with a pier projecting 4,060 feet into the waters of Cook Inlet.

The area required at Cape Starichkof for the Pacific Alaska Project would be substantially smaller (probably no more than 150 acres), and the pier could be shorter, since water depths of 45 feet at MLLW, which would be sufficient for Pacific Alaska's LNG tankers, are found about 0.5 mile offshore.

The climate at Cape Starichkof probably resembles that at Homer and Kasilof, the nearest sources of meteorological data. Table 32 lists average annual weather data compiled at these towns and at Kenai and Anchorage.

Much of the site is nearly level and lies at an elevation of over 200 feet. The northwestern portion of the site, between the Sterling Highway and the shore of Cook Inlet, slopes rapidly towards the beach in a series of heavily vegetated ravines. Other more gradual slopes may be found along a small stream flowing southward through the site and along the southern and eastern borders of the site.

Bedrock at Cape Starichkof is more than 60 feet beneath the surface, and no exposed bedrock is found in the immediate area. There are no active faults at or near the site, and maximum earthquake magnitudes near the site are not expected to exceed 7.5 on the Richter scale. The 1964 Alaskan earthquake in Prince William Sound, which had a Richter magnitude of 8.5, resulted in an estimated subsidence of 0.5 feet at Cape Starichkof and produced 20-foot high waves at Seldovia and Halibut Cove, about 30 miles south and southeast, respectively. The site's elevation should be sufficient to protect the LNG plant from tsunamis. There have been no landslides or other mass movement phenomena at the site, and the potential for soil liquefaction is low. Pacific Alaska

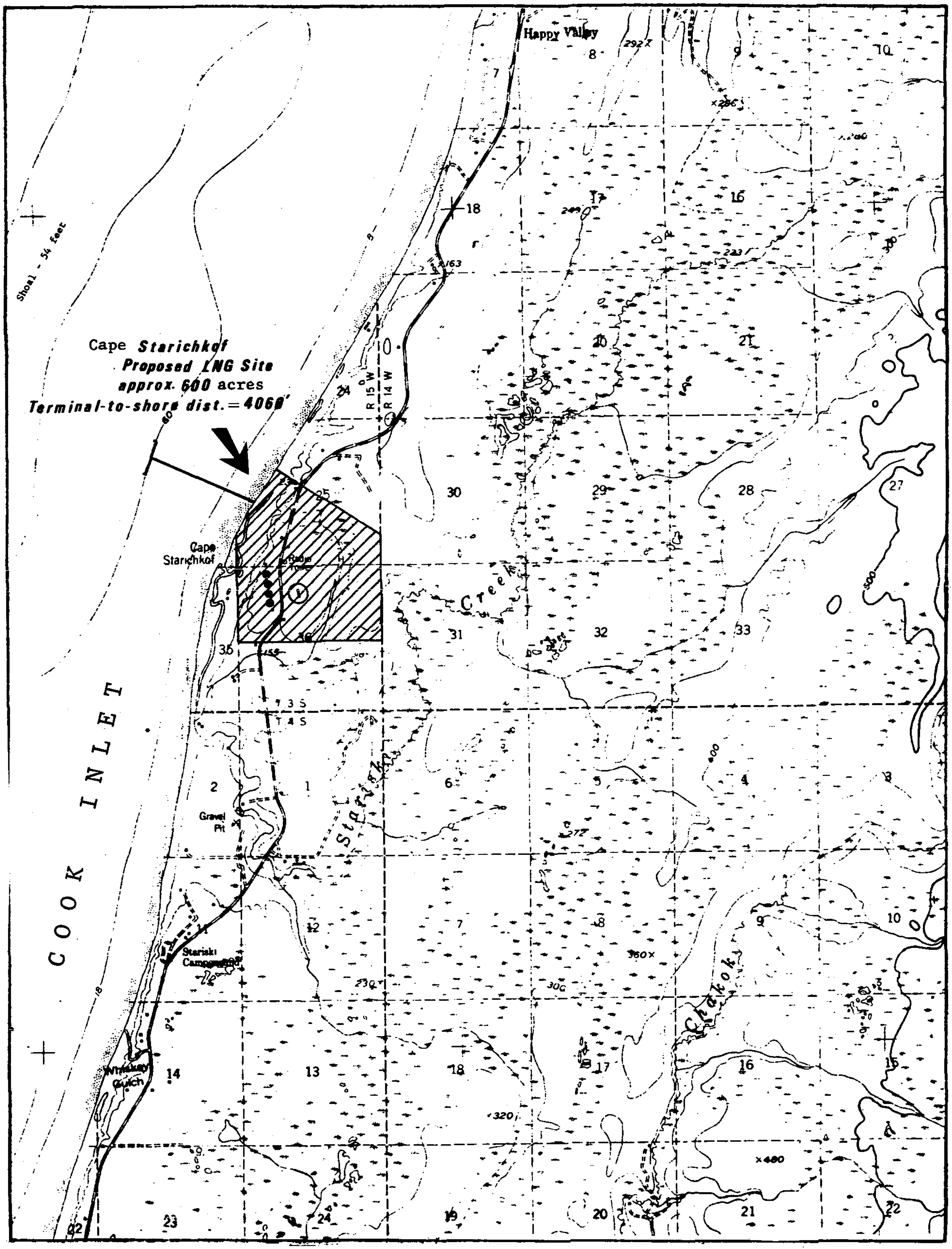

Figure 42. Cape Starichkof Site, Cook Inlet

TABLE 32

AVERAGE ANNUAL WEATHER CONDITIONS KENAI-COOK INLET AREA

Station	Max. Temp. (°F)	Min. Temp. (°F)	Precip. (in.)	Snow (in.)	Wind Speed (mph)	Days of Rain	Days of Snow	Days of Fog
Homer[1]	43.8	29.2	23.06	58.6	6.5	141	24	9 (heavy)
Kasilof[2]	43.6	25.3	17.77	55.6	-	118	-	-
Kenai	41.7[3]	24.5[3]	19.91[3]	68.7[3]	6.7[4]	107[3]	45[5]	93[5] (<7 mi.)
Anchorage[6]	43.4	28.1	14.81	66.0	6.7	114	21	27 (heavy)

1/ National Oceanic and Atmospheric Administration, "Local Climatological Data,Homer, Alaska" (1974).

2/ National Oceanic and Atmospheric Administration, "Kenai Peninsula, Climatic Summaries of Resort Areas" (March 1971), p. 3.

3/ Ibid., p. 4.

4/ ETAC, U.S. Air Force, "Percentage Frequency of Wind Direction and Speed, Kenai, Alaska, FAA, 1948-1967."

5/ ETAC, U.S. Air Force, "Air Weather Service Climatic Brief, Kenai Municipal/FAA, Alaska, 1948-1967."

6/ National Oceanic and Atmospheric Administration, "Local Climatological Data Anchorage, Alaska" (1972).

has testified that coal seams occur beneath the site. 1/ OIW states that the soils consist of peat and various silt-loams overlying 3 to 5 feet of silt and 40 to 50 feet of dense, gravelly materials. It is possible that deposits of subbituminous coal occur beneath that depth. Drainage is generally fair, although a poorly drained marshy area is located in the northeastern portion of the site.

The site is surrounded on three sides by Stariski Creek, and an unnamed stream flowing through the site empties into this creek. The water table lies about 10 feet beneath the ground surface. Surface waters are generally confined to marshes and streams in the vicinity of Cape Starichkof, with few of the shallow lakes common in the Nikiski-Kenai area in evidence.

The 60-foot MLLW depth contour lies less than 0.8 mile offshore. A shoal area with depths of about 54 feet MLLW lies 1.5 to 2.3 miles offshore (see Figure 42), but it appears that LNG tanker access to the terminal area would not be hindered by the shoal. No dredging would be required to provide access to the marine terminal if Pacific Alaska constructed a trestle about 0.5 mile into the inlet.

The diurnal tidal range at Ninilchik, 12 miles north of the site, is 19.1 feet. Average currents at Cape Starichkof are 2.3 knots at floodtide, with a maximum of 3.5 knots; ebb currents are weaker. Maximum wave heights of 10 to 12 feet generally occur about three times a year. The offshore area is generally ice-free, although 10 to 20 percent of the surface may be covered by ice during severe winters. The U.S. Coast Guard has insufficient data to assess the ice hazards at Cape Starichkof in detail, but has indicated that both the amount of ice present and the length of the ice season are probably less severe at Cape Starichkof than at Nikiski. 2/ (See Appendix F.) The U.S. Army Corps of Engineers has indicated that the amount of ice which might occur at Cape Starichkof would not delay LNG ship operations. (See Appendix H.)

1/ K.C. McKinney, hearing testimony in the matter of Pacific Alaska LNG Company, Docket No. CP75-140 *et al.*, June 22, 1976.

2/ A detailed risk analysis of marine transportation at Cape Starichkof is presented in Attachment A, Volume III of this environmental impact statement.

Most sediment movement in this area of Cook Inlet is confined to shifts of the bottom materials, with relatively little suspension of particles. A northerly transport of bottom sediments takes place along the coast. The sands and gravels making up the bottom would be conducive to ship anchoring and channel dredging, but the sediment mobility would require repeated maintenance dredging. Suspended sediment concentrations in this part of the inlet are generally less than 30 ppm, although the outflow from the nearby mouth of Stariski Creek may add more suspended sediments to the local regime during periods of high runoff. Because of the distance from developed communities and industries, the waters off Cape Starichkof are probably relatively free from sewage and other contaminants.

The vegetation at the site consists of mixed upland and lowland spruce-hardwood forest and low brush-muskeg communities similar to those described for the proposed site and route in the "Vegetation" subsection of the "Description of the Existing Environment." The low level of suspended sediments in the marine waters at Cape Starichkof undoubtedly allows the phytoplankton population to exceed that described for Nikiski. Attached marine algae may also be present offshore near the site, since Cape Starichkof lies about 7 miles south of the northernmost reported occurrence of kelp beds in Cook Inlet. 1/

The terrestrial fauna at Cape Starichkof generally resemble those described for Nikiski, although the marshy habitat provided by the poorly drained portion of the site increases the likelihood that wetlands species such as waterfowl and muskrats could be disturbed by construction of the facilities. With the exception of the caribou, all terrestrial species may be more abundant at this site than at Nikiski because the Cape Starichkof area is generally less developed. In particular, there is a moose winter concentration area around the lower reaches of Stariski Creek. 2/

1/ U.S. Department of the Interior, Bureau of Land Management, Alaska OCS Office, Lower Cook Inlet Final Environmental Impact Statement.

2/ Lance L. Trasky, Fisheries Research Biologist, Alaska Department of Fish and Game, Anchorage, Alaska, Letter to the FPC received June 25, 1976.

Stariski Creek is the only anadromous fish stream in the area of the site. An estimated 200 king salmon, 100 pink salmon, and 100 coho salmon spawn in this creek each year. There is a sport fishery in Stariski Creek for pink and coho salmon as well as for Dolly Varden char, rainbow trout, and steelhead. Construction of the LNG plant would almost certainly result in increased sediment loads in the runoff entering Stariski Creek, particularly if the marshy portion of the site and the stream draining through the site were disturbed. Pink salmon spawn near the mouth of the creek and would, therefore, be especially susceptible to construction-related siltation. 1/

There is a saltwater salmon fishery in Cook Inlet offshore from the site, and residents of Ninilchik, Happy Valley, Anchor Point, and the intervening areas also conduct a local subsistence fishery for halibut, salmon, and herring. Beds of razor clams can be found along the shoreline and on sandbars offshore. Some king and tanner crabs are known to spawn at the 60- to 120-foot depths offshore. Crab larvae are present during the spring and summer months and may be settling out to mature in the Cape Starichkof area. Harbor seals, harbor porpoise, and Dall porpoise are found in the nearshore areas, and it is thought that sea otters may be extending their range into this area. Beluga whales migrate farther offshore. 1/

Existing land use at Cape Starichkof is primarily residential. Residences near the site vary from cabins to mobile homes to substandard housing. Seven residences, some of which may be occupied only on a seasonal basis, are found within the boundaries of the 600-acre site. A radio tower also stands within the site, and a new subdivision is being cleared and surveyed on the site. The Sterling Highway passes through the site, and a 69-kv Homer Electric Association, Inc. powerline runs along the site's eastern boundary. A school patent borders the site on the south. The State of Alaska has nearby patents which may be available, but no industrial classification for the area was identified by OIW in its study of the site. A public campground near the Sterling Highway about 2 miles south of the site is the only recreational development in the vicinity, although Stariski Creek is a popular fishing stream, and clam-digging is a frequent pastime on local beaches.

1/ Lance L. Trasky, Fisheries Research Biologist, Alaska Department of Fish and Game, Anchorage, Alaska, Letter to the FPC received June 25, 1976.

Plant construction and operation impacts at Cape Starichkof would be similar to those noted for the Nikiski site. However, because of the less-developed nature of the area and the increased abundance of aquatic species in relation to Nikiski, socioeconomic and aquatic biological impacts would be more significant at Cape Starichkof. In general, Cape Starichkof is an acceptable site, but an LNG plant and marine terminal would appear more conspicuous in the relatively rural setting of Cape Starichkof than in the industrial setting of Nikiski.

g) Comparison of Acceptable Sites

Table 33 compares the major differences between the Cape Starichkof and Nikiski sites. 1/ The sites are similar in earthquake potential, subsidence associated with the 1964 earthquake, weather, depth to bedrock, soils, and tsunami exposure. Cape Starichkof is nearer to the potential lower Cook Inlet gas supplies which the applicant might need to achieve its Phase II goals. The combination of ice, currents, and crowded shipping activities at Nikiski gives Cape Starichkof an advantage. However, the biological and socioeconomic impact associated with the construction of an LNG plant and related facilities would be greater at Cape Starichkof than at Nikiski.

It appears that one must weigh the Coast Guard's reservations about shipping schedule reliability at Nikiski against the impact of introducing industrial development at Cape Starichkof. However, the following factor must be included in the comparison. According to the Department of the Interior's FEIS, Lower Cook Inlet (1976, Lease Sale No. CI) for a proposed oil and gas lease sale, the estimated undiscovered recoverable reserves of the Outer Continental Shelf area in Lower Cook Inlet proposed for development are between 0.6 and 3.3 trillion cubic feet of natural gas and between 0.09 and 2.6 billion barrels of oil.

The FEIS further estimates that if a "high case development scenario" is used to give maximum consideration to environmental impact resulting from the proposed lease sale, one new LNG terminal (equivalent to the applicant's) would be required to handle the peak gas production level of

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1/ Additional comparative data from the State of Alaska's comments on a previous DEIS for this project, issued September 1976, are available for inspection at the FERC's offices.

TABLE 33

COMPARISON OF POTENTIAL SITES

Parameter	Nikiski	Cape Starichkof
Diurnal Tidal Range	20.7 ft.	19.1 ft. at Ninilchik, 13 miles north of site. 17.8 ft. at Seldovia, 31 miles south of site.
Maximum Tidal Currents	6-7 kn	Flood tide - 3.5 kn Ebb tide - less than 3.5 kn
Ice Conditions	Occasionally sufficient to break mooring lines and delay LNG loading.	Less frequent and intense than at Nikiski.
Marine Terminal Trestle Length	2,200 ft.	About 2,640 ft.
Nearby Marine Activities	Three terminals and a barge dock; about 250 vessels used the port in 1974.	No terminals or shipping activities. Some fishing-boat activity.
Dredging	Some dredging needed for approach channel (15,000 cubic yards)	No dredging required.
Length of LNG Ship Route	2,050 nmi to Point Conception	2,000 nmi to Point Conception
Distance to Mt. Augustine	Approximately 112 mi.	Approximately 62 mi.
Drainage	Fair; water table 80 ft. below surface.	Generally fair; water table 10 ft. below surface; some marshy ground but not in area of plant construction.
Aesthetics	Proposed facility would generally be compatible with local industrial background.	Proposed facility would contrast with existing rural background.
Existing Land Use	Industrial area; no structures on site.	Limited residential and industrial development. Radio tower and seven residences on 600-acre site. Highway through site might require burial of LNG transfer line. New subdivision being cleared on site.
Biological Impacts at Site	Relatively light because of existing industrial background and hostile marine environment.	Potentially significant because of less intensive human intrusion, less hostile marine environment, and proximity of clam beds, anadromous fish stream, and moose winter concentration.

465 million cfd if existing LNG facilities do not process this gas. If the Nikiski port could safely handle these gas reserves by expanding existing and proposed facilities, this production level would require an additional 52 arrivals per year by 1986 (if ships similar to the applicant's were used). Such a schedule would not require another LNG terminal in Cook Inlet, but the additional shipping would increase the possibility of navigation and scheduling problems. On the other hand, if such expansion were restricted and the high level of projected reserves were discovered in Lower Cook Inlet, then another LNG facility might be proposed and constructed at another site within Cook Inlet. Such a site would probably be at Cape Starichkof.

Interior's FEIS also considers a "low case development scenario" in which only 0.6 trillion cubic feet of gas would be discovered in the lower Cook Inlet region. This discovery level would result in a peak production level of about 85 million cfd instead of 465 million cfd. The applicant's proposed project would have a Phase II gas supply requirement of 431.4 million cfd. At this time, the applicant has under contract only enough proven reserves to supply its facility with 130 million cfd. Pacific Alaska is presently conducting an onshore drilling program in Upper Cook Inlet to obtain the additional gas supplies it needs. If its exploration is partially or completely unsuccessful, the applicant may be required to obtain some or all of the gas from the Lower Cook Inlet region to fulfill its gas supply requirements for Phase II. If the applicant is unable to obtain enough gas to justify its proposed project, there may be no need for the construction and operation of any LNG facilities in Cook Inlet.

The Nikiski site could not be as easily expanded as the Cape Starichkof site. 1/ However, in view of the uncertainty of exactly how much gas will be produced in the Cook Inlet Basin, it is not clear whether one can justify choosing the Cape Starichkof site because of its expansion capability.

The impact associated with each of the two remaining sites studied in detail is comparable. Therefore, there is no alternative site in or near Cook Inlet significantly superior to the proposed Nikiski site, and the staff agrees with the applicant and the State of Alaska that the proposed LNG facility should be located at Nikiski.

1/ The applicant has indicated that its proposed facility could be expanded into a 600-million cfd facility if additional gas volumes were available.

h) Alternative Pipeline Routes

In the DEIS, the environmental staff examined the pipeline laterals proposed by the applicant and found a large percentage of the proposed routes to be environmentally acceptable. In a few cases, however, the staff felt an alternative was superior to the applicant's proposed route. Since the DEIS was issued, the ADFG has made additional information available to the staff. As a result, two of the route changes initially proposed by the staff--the Birch Hill Lateral and the North Fork Lateral--have been abandoned, and the staff now favors the applicant's preferred routes. This section will discuss only those alternative laterals which the staff still advocates.

The principal considerations used by the environmental staff in recommending alternative routes are:

(1) Use of existing rights-of-way, where practicable.

(2) Minimizing pipeline length, where practicable.

(3) Avoiding critical wildlife habitats and areas highly susceptible to environmental damage during pipeline construction, maintenance, or repair, including avoiding productive wetlands and floodplains where possible, pursuant to Executive Order Nos. 11990 and 11988.

(4) Avoiding unnecessary stream, road, and pipeline crossings.

(5) Avoiding areas with special hazards, such as outburst flooding, severe erosion, or soil instability, which would threaten pipeline integrity.

Figure 43 shows the prime routes proposed by the applicant and the alternate corridors preferred by the environmental staff. Detailed information on the corridors shown in Figure 43 is presented in Table 34 and Appendix B, Figures B-1 through B-4.

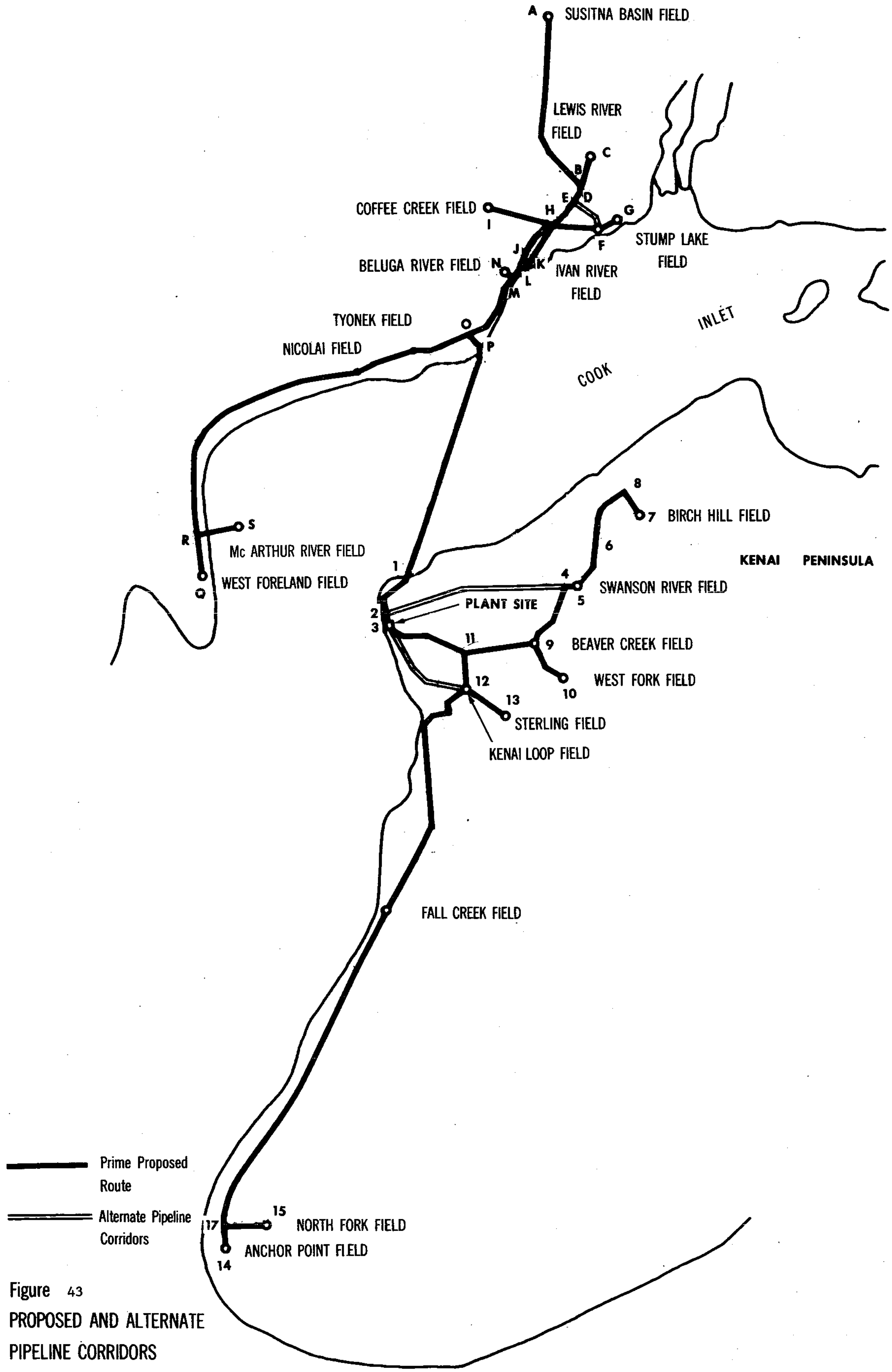

Figure 43
PROPOSED AND ALTERNATE PIPELINE CORRIDORS

TABLE 34

COMPARISON OF PIPELINE CORRIDORS

Corridor	Total Length (miles)	Existing Rights-of-Way (miles paralleled)	Acreages of Vegetation Along Corridors 1/				Total Acreage Disturbed 1/	Number of Stream Crossings
			Forest	Scrub	Muskeg	Non-Natural		
AB 2/	38.1	0	65.9	93.9	72.6		232.4	16
CBD 2/	4.3	4.3	11.0		15.3		26.3	1
DEH 2/	3.1	3.1	16.0		3.0		19.0	2
EF	3.5	3.0	3.2		18.2		21.4	1
FG 2/	3.0	0			18.3		18.3	2
FH 2/	4.5	4.5			26.6		26.6	2
HI 2/	8.1	0	29.9		19.5		49.4	2
HJL	5.4	5.4	20.5		11.4	.8	32.7	1
HKL 2/	5.1	0	9.1		22.0		31.1	1
LM 2/	1.1	1.1				6.8	6.8	0
MN 2/	.5	0	.7		1.5	.8	3.0	0
MOP 2/	9.6	5.6	52.4		4.5	1.5	58.4	2
QRO 2/	36.8	32.0	79.9	6.1	124.4	14.0	224.4	6
RS 2/	6.0	6.0						
1-2 2/	5.1	5.1	28.1	.8		2.3	31.2	0
2-3 2/	1.4	1.4	7.6			.8	8.4	0
2-4	14.5	14.5	62.8	8.2	10.5	6.7	88.2	3
3-11-9 2/	12.8	6.8	49.6	9.2	11.8	4.2	77.8	1
3-12	12.0	9.7	NA		NA		NA	6
5-4-9 2/	9.5	6.2	38.8	12.8	6.7		58.3	3
7-8-6-5 2/	10.5	10.5	36.6		6.7	20.7	64.0	2
9-10 2/	7.0	7.0	36.6		5.5	.6	42.7	0
11-12-13 2/	10.0	1.3	26.2		29.3	5.5	61.0	0
12-17-14 2/	65.5	63.0	323.3		53.7	22.6	399.6	17
15-17 2/	7.0	.5	24.4		18.3		42.7	1

1/ Assumes a 50-foot wide right-of-way

2/ Indicates the applicant's proposed corridor

NA - Not available

i. Ivan River Lateral

Since the DEIS was issued, the applicant has adopted the environmental staff's alternative route as its prime route. This discussion has been retained in the FEIS to clarify which route is preferred by the staff and the applicant.

From the Ivan River Field, the applicant originally proposed to construct a 4.5-mile long pipeline lateral due west through the coastal wetland to an interconnection with the proposed main pipeline just east of the Beluga River crossing. (See Appendix B, Figure B-4.) This spur would have crossed the Lewis and Theodore Rivers, both recognized salmon streams. There is no existing right-of-way along this route.

The lateral examined by the environmental staff, which is now also the applicant's prime route, would lead northwest from the field following an existing road for most of its 3.5 miles before connecting with the proposed main pipeline about 3.2 miles northeast of the Beluga River crossing. From the northern end of the existing roadway to an interconnection with the main pipeline right-of-way, a distance of about one-half mile, this route should follow an existing cleared seismic line, visible in aerial photographs. This lateral would require crossing only the Lewis River before connecting with the main pipeline.

The new prime route would require some forest clear cutting, while none would have been required along the original route. However, the new route would cross less wetland, thereby minimizing the possibility of nonwinter pipeline maintenance and repair in this more sensitive area. The environmental staff finds the new lateral preferable to the applicant's original route because it is shorter, requires fewer stream crossings, and crosses less wetlands while following an existing right-of-way for most of its length. Pertinent factors considered by the staff are compared in the following table.

	Applicant's Original Route	Staff's Preferred Route 1/
Total length, miles	4.5	3.5
Existing ROW paralleled, miles	0	3
Stream crossings	2	1
Clearcut forests, acres 2/	0	3.2
Muskeg crossed, acres 2/	26.6	18.2

ii. Main Pipeline Route Between the Lewis River Field Tie-In and the Beluga River Field Tie-In

Between the Lewis River Field tie-in and the Beluga River Field tie-in, the applicant proposes to follow an existing powerline right-of-way from the Lewis River tie-in to within one-half mile of the Beluga River crossing. At this point, the proposed route would deviate from the powerline right-of-way and cross the Beluga River about 2 miles downstream from the powerline crossing. The proposed route would then parallel the foot of a bluff through an area of wetland until it met a small road about one-half mile south of the Beluga River Power Plant. The proposed route would then follow the road southwest toward Tyonek, picking up gas from the Beluga Field through an 0.8-mile long spur pipeline southeast of the gas field. (See Appendix B, Figure B-4.)

An alternative to the applicant's proposal examined by the environmental staff would follow the powerline right-of-way from the Lewis River tie-in to the Beluga River Power Plant. Almost all of this segment would also follow an existing roadway. The remainder of the route from the Beluga River Field south would follow the applicant's route.

1/ The applicant has now identified the "staff's preferred route" as its prime route.

2/ Assumes a 50-foot wide cleared right-of-way.

According to the applicant, the existing powerline right-of-way crossing of the Beluga River is susceptible to severe flooding. However, high tides and storm surges are also expected to cause flooding at the applicant's crossing, which is farther downstream. The applicant's preferred route would be situated on a peninsula between two meanders and would cross the river where the normal floodplain is almost three times as wide as at the powerline right-of-way crossing. Aerial photographs provide little evidence that the applicant's preferred crossing would be better hydrologically than the more northern crossing. On the contrary, the fact that many old dry meanders and oxbow lakes are visible on the lower Beluga River as well as the river's known history of glacial outburst flooding suggest that the Beluga may eventually cut through the peninsula upon which the applicant proposes to construct its pipeline.

The staff favors the alternate route (shown in Appendix B, Figure B-4), primarily because it would follow existing rights-of-way and its crossing of the Beluga River appears as stable as the applicant's preferred route. Although this alternative is slightly longer than the proposed route, the staff believes that its environmental benefits justify the added length. A brief comparison of the applicant's route and the staff's preferred alternative route between the Beluga River and the Beluga River Field tie-in shows the following differences.

	Applicant's Preferred Route	Staff's Preferred Route
Total length, miles	5.1	5.4
Existing ROW paralleled, miles	0	5.4
Clearcut forest, acres	9.1	20.5 1/

1/ Assumes necessity to clear 50-foot wide right-of-way and does not account for existing cleared area along powerline right-of-way and roadway.

iii. Kenai Loop Lateral

The applicant has proposed a 5.7-mile long pipeline spur which would lead due north from the Kenai Loop Field and tie in to the remainder of the pipeline system at a point on the Beaver Creek Lateral just south of Ivanoff Lake. (See Figure 44 and Appendix B, Figure B-2.) Approximately 2.3 miles of this lateral would pass through the Kenai National Moose Range, and the entire route would pass through the Swanson River Fire burn area. Nearly two-thirds of the route would cross muskeg area. This lateral would bisect an ADFG-recognized caribou summer concentration and calving area. This route would not follow an existing right-of-way.

The environmental staff has examined three possible alternate routes for moving gas from the Kenai Loop Field to Nikiski. These routes, which would avoid the caribou calving grounds located principally in the muskeg area north of the Kenai Airport, would utilize either the corridor of the Kenai Spur Road or the Kenai pipeline right-of-way (owned by Kenai Pipe Line Company) or a combination of the two. Both of these rights-of-way are located along the western coast of the peninsula between Kenai and Nikiski.

The Kenai Spur Road alternate (shown in Figure 44 and designated as Alternative 1 in the following table) would require a pipeline which would proceed north from the Kenai Loop Field for approximately 0.5 mile to intersect with the Kenai Spur Road. From that point, it could follow the road for its entire 12.7-mile long route to the LNG plant at Nikiski. Such a route would eliminate the 5.7-mile long proposed route, thereby avoiding construction of a pipeline directly through the caribou calving grounds and skirting the area instead. The route would completely avoid the Kenai National Moose Range and would pass for approximately 0.5 mile through the Swanson River Fire burn area. This route would also avoid an extensive wetland area crossed by the proposed route. However, it would require six minor creek crossings and would impact the populated areas along the Spur Road.

A second alternative routing (shown in Figure 44 and designated as Alternative 2 in the following table) would involve major use of the existing Kenai pipeline right-of-way which generally follows the route of the Kenai Spur Road

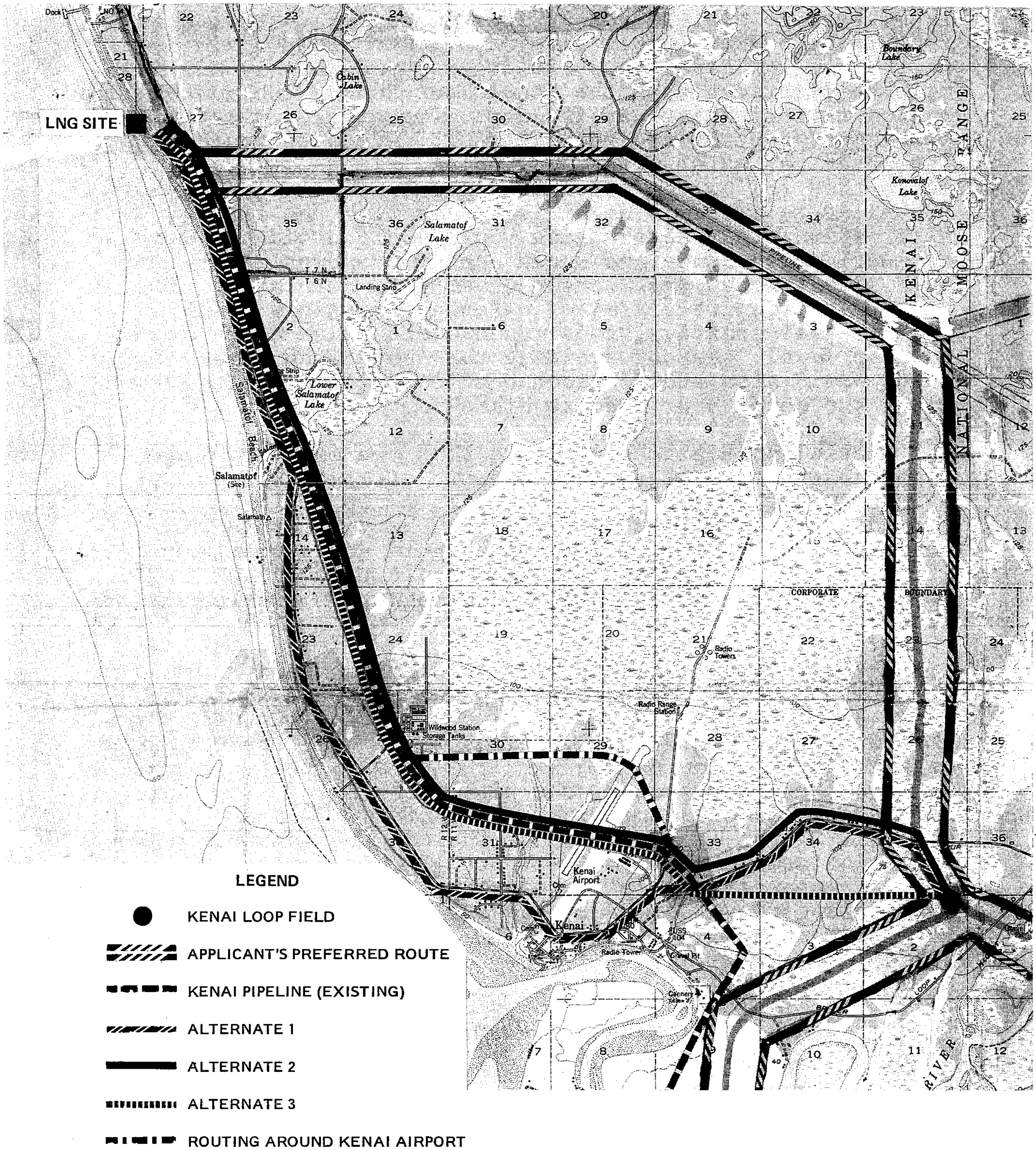

Figure 44 ALTERNATE CORRIDORS FOR KENAI LOOP LATERAL

from Kenai to Nikiski and is located to the east of that road right-of-way. This alternate route would again head north from the Kenai Loop Field for approximately one-half mile to intersect with the Kenai Spur Road. The route would follow this right-of-way for approximately 2.5 miles to a point just east of the Kenai Airport, where it would intersect the existing Kenai pipeline right-of-way. It could then follow the pipeline right-of-way for approximately 9.5 miles to a tie-in at Nikiski. As with the first alternative, this alternative route would avoid the Kenai National Moose Range and would pass for approximately one-half mile through the Swanson River Fire burn area. It would also require six minor waterway crossings. Unlike the first alternative, this route would skirt north of the town of Kenai, thereby avoiding that populated area. This route would also avoid direct conflict with populated areas along the Kenai Spur Road to Nikiski.

Aerial photographs indicate that the existing Kenai pipeline traverses the Kenai Airport directly across the main runway. However, the alternate route could be redirected around the eastern and northern periphery to avoid this congested area. Such a rerouting would add approximately 1 mile to the alternate route and would pass closer to the ADFG-recognized caribou summer concentration area and calving grounds.

A third alternative (shown in Figure 44 and designated as Alternative 3 in the following table) would avoid the Kenai Spur Road. It would involve a routing due west from the Kenai Loop Field for 2.3 miles through a less developed area to an interconnection with the Kenai pipeline right-of-way. From that point, the pipeline could follow the existing Kenai pipeline right-of-way for 9.7 miles to Nikiski. (This length does not include the possible minor rerouting around the Kenai Airport.) This alternative would completely remove the pipeline from any populated areas along the Kenai Spur Road and also completely avoid the caribou calving grounds.

A comparison of these routes shows:

	Applicant's Preferred Route	Alternatives		
		1	2	3
Total length	5.7	13.2	12.5	12
Existing ROW paralleled, miles	0	12.7	12.0	9.2
Kenai Moose Range crossed, miles	2.3	0	0	0
Stream crossings	0	6	6	6
Sensitive habitat crossed	Crosses caribou summer & calving area	Skirts these areas	Skirts these areas	Skirts summer range; avoids calving area

Since the DEIS was published, the applicant has responded to an FERC deficiency question concerning the feasibility of an alternate route to deliver Kenai Loop Field gas. The applicant indicated that it still prefers the 5.7-mile long Kenai Loop Lateral connecting with the Beaver Creek Lateral, as originally proposed, assuming that the Beaver Creek Lateral is also installed as originally proposed. It feels that such a route is most advantageous from environmental, engineering, and economic standpoints. The applicant also stated that "the muskeg area along the proposed route is not as biologically sensitive as bogs or wetlands and therefore will be minimally impacted by pipeline construction. Furthermore, the impact on caribou calving will be negligible due to construction scheduling during the winter months."

If the existing Swanson River pipeline is utilized instead of constructing a Beaver Creek lateral (see following section), the applicant would prefer a Kenai Loop Field alternate route which would extend westerly along the FERC Alternate 3 route from the Kenai Loop Field to the

North Kenai Road (approximately 3.0 miles). This route would then extend along the FERC Alternate 1 route along the North Kenai Road for 10.6 miles to the LNG plant, provided that a right-of-way can be reasonably obtained through the commercial center of Kenai.

The applicant opposed the FERC environmental staff's Alternates 2 and 3 (including the routing around the airport) because these routes would "cut across existing airport runway facilities which would present problems for daily commercial air traffic during construction of such a pipeline." The applicant indicated that the existing runway facilities now extend beyond the boundary identified by the staff. Therefore, the applicant suggested that to avoid the airport runway, a route should be plotted farther east and north than indicated in the DEIS. If this were done, the route would be closer to the caribou calving grounds. Therefore, the applicant feels the route least disruptive to the calving grounds would be one which follows the Kenai Spur Road.

The FERC environmental staff has met with the ADFG since the DEIS was published. At that meeting, ADFG personnel indicated that they saw no problem in crossing the muskeg area of the caribou's spring calving grounds--i.e., along the applicant's preferred route--if wintertime pipeline construction techniques were employed. However, they have also voiced concern over aerial surveillance during calving, which disturbs these animals. In the DEIS, the staff indicated that a route along the presently disturbed coastal area would be environmentally preferable to the applicant's prime route. The staff also maintained that use of the Kenai pipeline right-of-way would minimize impact on any recognized wildlife concentration areas, especially the caribou calving grounds, while avoiding direct conflict with the populated areas along the Kenai Spur Road. However, because it now appears that crossing the airport runways would unduly interrupt the service of a heavily used airport and because circumventing the airport would not alleviate the problem of crossing the caribou calving grounds, the environmental staff agrees with the applicant that the Kenai Spur Road route is preferable for moving gas from the Kenai Loop Field to Nikiski if the existing Swanson River gas pipeline is utilized. If pipeline construction occurs during the winter, if low-level maintenance surveillance is avoided during May and June, and if any intrusions of vehicles or machinery into this area during the summer or spring months is first approved by the ADFG, the staff will not oppose the use of the applicant's Kenai Loop Lateral if the Beaver Creek Lateral is also installed.

iv. Use of the Existing Swanson River Gas Pipeline

The applicant estimates that the gas volumes to be produced from the Birch Hill, Swanson River, Beaver Creek, and West Fork Fields would be 2.7, 20.5, 18.6, and 10.1 million cfd, respectively, a total of 51.9 million cfd. An alternative to building all the laterals proposed by the applicant to move these gas volumes to Nikiski would be to replace some of this proposed construction by using the existing Swanson River gas pipeline. Part of this 16-inch diameter pipeline, owned by the Kenai Pipe Line Company, extends from Nikiski to the Swanson River Oil Field. It has a capacity of 125 million cfd and as of the first quarter of 1977 was transporting only 30 to 40 million cfd. (See Figure 45 and Table 35 for more detail.) The gas in this pipeline presently flows from the Nikiski area to the Swanson River Field and is used for field operations there. An alteration in gas flow and gas displacement arrangements would be needed to utilize this excess pipeline capacity for the proposed Pacific Alaska project.

To utilize this existing pipeline, the proposed Birch Hill and West Fork Laterals would still be constructed. Construction of the proposed pipeline running from the Beaver Creek Field due north to intersect the existing Swanson River pipeline would also be needed. Construction of the section of pipeline proposed to extend along the existing Swanson River pipeline right-of-way would be eliminated, as would construction of the Beaver Creek Field Lateral between the field and Ivanoff Lake. (See Figure 46.)

Gas flow through such a system would proceed according to the following scheme. Gas from the Birch Hill and Swanson River Fields would be delivered to and/or remain at the Swanson River Field to supply the Swanson River Oil Field with part of the gas volumes presently being transported there by the existing pipeline. The remainder of the volumes needed at the oil field would be transported north to the Swanson River Field from the West Fork and Beaver Creek Fields. Gas in excess of that needed at the Swanson River Oil Field coming from the West Fork and Beaver Creek Fields could then be transported west through the existing Swanson River pipeline to Nikiski. The volumes of Pacific Alaska gas that remained at the Swanson River Oil Field would be replaced at Nikiski by the volumes of gas that would have been transported to the Swanson River Oil Field in the existing 16-inch diameter pipeline. (See Figure 46 for a flow diagram.)

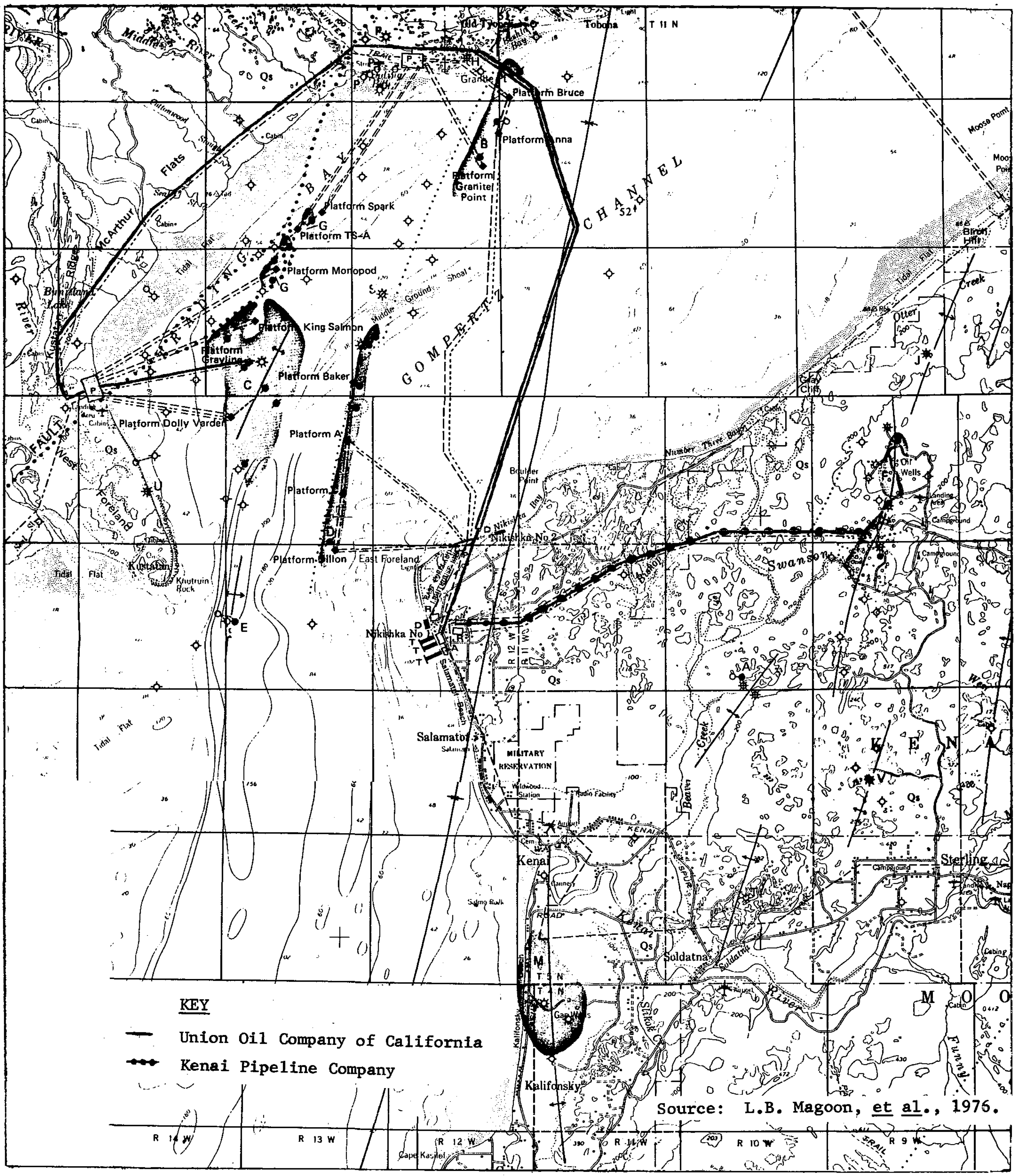

Figure 45 - Existing Gas Pipelines in Cook Inlet Area

TABLE 35

SELECTED GAS PIPELINES IN THE COOK INLET AREA

Owner/ Operator	Origin	Outside Diameter (inches)	Design Capacity	Present Capacity	Destination
Union Oil Co. of Calif.	McArthur River oil field Platform Grayling	10	22 MMcfd	15 MMcfd	Union Trading Bay production facilities
	Trading Bay Production Facilities	16	91 MMcfd	27 MMcfd	Granite Point
	Granite Point	10 3/4	45.5 MMcfd	13.5 MMcfd	Nikishka No. 2
	Granite Point	10 3/4	45.5 MMcfd	13.5 MMcfd	Nikishka No. 2
	Nikishka No. 2	16	91 MMcfd	27 MMcfd	LNG plant, Nikishka No. 1
Kenai Pipe Line Co.	Nikishka No. 1	16	125 MMcfd	30-40 MMcfd	Swanson River Oil Field

Source: L.B. Magoon, *et al.*, USGS Miscellaneous Investigations Series Map I-1019. 1976.

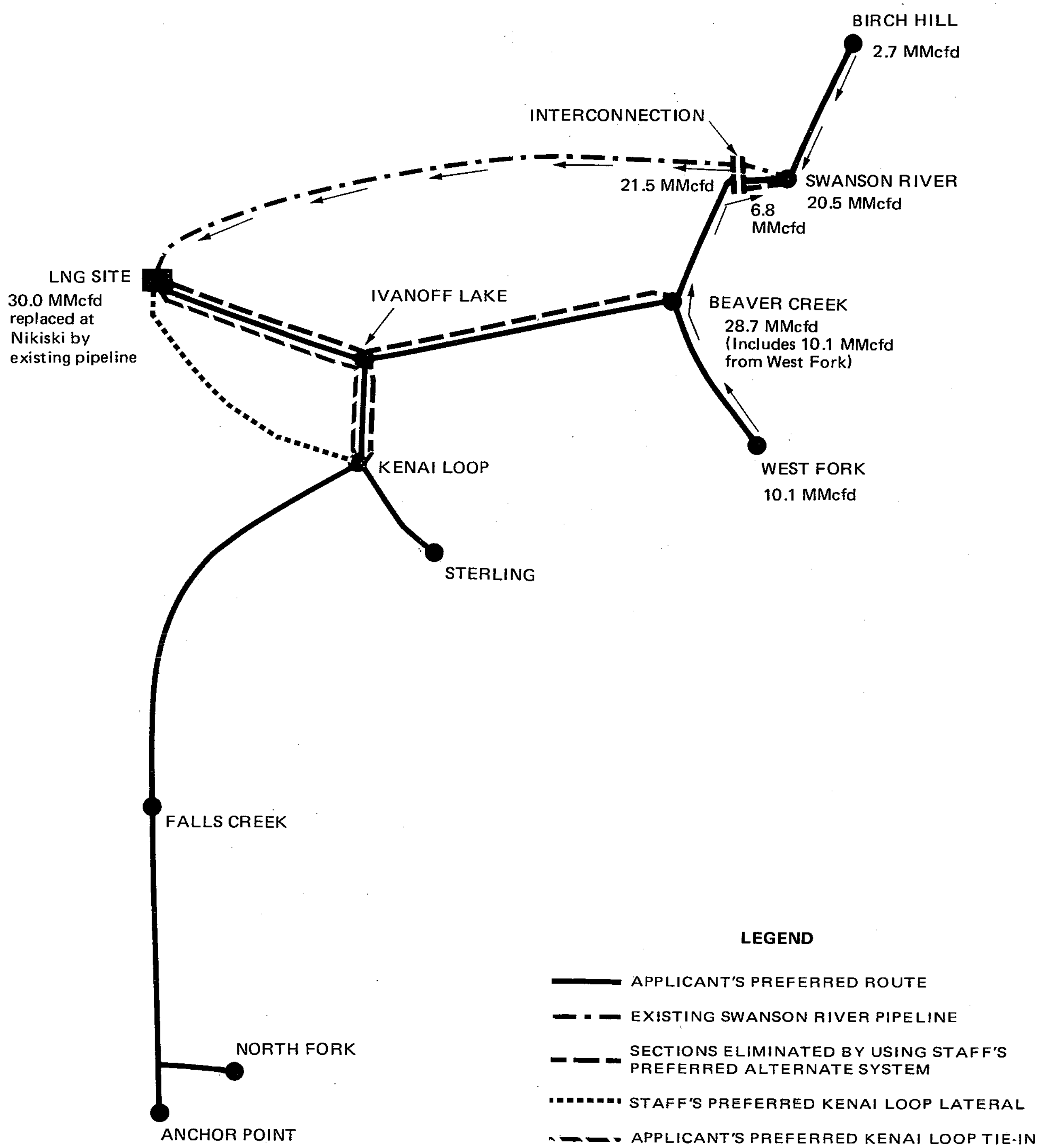

Figure 46 . Gas Flow Utilizing Existing Swanson River Pipeline

Such a system would eliminate the section of the Beaver Creek Lateral heading due west from that field to Ivanoff Lake. However, tie-ins from the southern gas fields (Kenai Loop, Sterling, Falls Creek, North Fork, and Anchor Point) to Nikiski would still be required. Tie-ins to the Kenai Loop Field from points south of there would be made as proposed by the applicant. A tie-in from the Kenai Loop Field to Nikiski would still be required and could be accomplished by one of two principal routes.

The first alternative would be a 5.7-mile route due north from the field to just south of Ivanoff Lake, where the route would head west along the originally proposed Beaver Creek Lateral for 7.9 miles to Nikiski. This overall route, totaling 13.6 miles, is composed of two route segments originally proposed by the applicant. The second alternative for connecting the Kenai Loop Field to Nikiski would be using the Kenai Spur Road right-of-way (or a similar coastal route) discussed in the preceding subsection. This alternative would have an overall length of approximately 12.9 miles. Of these two possibilities, the staff favors the Kenai Spur Road alternate because it would be shorter and avoid the Kenai National Moose Range, the caribou calving grounds, and most of the caribou summer range. It would also follow existing rights-of-way, passing through previously and presently disturbed areas.

The applicant's proposed system compares to the staff's preferred alternative system utilizing the existing Swanson River pipeline and alternate Kenai Loop Lateral as follows:

	Applicant's Preferred System	Staff's Preferred System
Total new pipeline length, miles	50	39.8
Existing ROW paralleled, miles	35	24
Kenai Moose Range crossed, miles	34.7	22.0
Stream crossings	7	11
Sensitive habitat crossed	Crosses caribou calving grounds	Avoids caribou calving grounds

The staff's preferred alternative system utilizing the existing Swanson River pipeline would require a total of 39.8 miles of new pipeline, as opposed to the 50 miles needed for the applicant's prime route. Such an alternative would result in 22 percent fewer miles of new pipeline installation, with an associated decrease in environmental impact, and would make optimum use of existing facilities while conserving natural resources. The staff's alternate system would minimize crossings of sensitive wildlife habitats. The environmental staff prefers the existing Swanson River pipeline system, as discussed, over the proposed system of the applicant.

2. Alternate Sites for Construction Dock and Haul Road

As stated earlier in "Description of the Proposed Action," the applicant proposes to ship much of the LNG plant equipment to Nikiski in modular form. In order to move the modules from their transporting barges to the plant site, the applicant proposes to build a temporary docking facility just south of the plant site and to construct a haul road from the dock to the plant site. Construction of the dock at Nikiski would require the dredging of about 22,000 cubic yards of material, while construction of the haul road would require the excavation of another 215,000 cubic yards of material and the clearing of 3 to 4 acres of trees. Therefore, the direct impact of the construction of these facilities would be considerable from an environmental, economic, and aesthetic standpoint.

An obvious alternative to the applicant's proposal would be to use existing facilities nearby to unload and transport the barge cargo. Investigation showed that existing docks in the area, such as the Rig Tender's Dock at Nikiski and the Nikishka Dock No. 2 on Nikishka Bay, were unsuitable for the project and could not be readily modified for unloading the modules. The use of such docking facilities, even if they were suitable, would require the enlargement of the 25-foot wide North Kenai Road to a width of 100 feet in order to accommodate the modules and their transporters. Therefore, the staff favors the location of the applicant's proposed haul road because it would be built as close as possible to the plant site and would avoid altering extensive portions of the North Kenai Road.

3. Total Project Alternatives

a) Pipeline Alternatives to the Proposed Project

i. Alternative Pipeline Routes

In order to examine all feasible alternatives to the proposed project, the staff has considered the possibility of connecting Cook Inlet gas supplies to the Northwest Alaskan project. 1/ The Northwest Alaskan pipeline system is scheduled to transport Prudhoe Bay gas to the lower 48 states early in 1983.

Basically, there are two alternative pipeline systems which the staff considered and which include the applicant's gathering pipelines as proposed without the LNG terminal at Nikiski. 2/ The Fairbanks Tie-in Alternative Route (Fairbanks Alternative) involves approximately 270 miles, and the Tok Tie-in Alternative Route (Tok Alternative) 340 miles of additional pipeline right-of-way, (see Figure 47) as well as modifications to the Northwest Alaskan pipeline system. These alternative pipeline routes are dictated by the rugged topography of the Alaska Range which governed the location of Alaska's major transportation arteries from the south to the interior.

Fairbanks Alternative

The Fairbanks Alternative would begin at the northern end of the proposed Susitna Basin Lateral in the Susitna Basin and extend approximately 270 miles to a connection with the Northwest Alaskan pipeline system at about MP 445 just north of Fairbanks. Five compressor stations would be

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1/ Northwest Alaskan Pipeline Company, formerly Alcan Pipeline Company, is the firm approved by Congress to transport Alaskan natural gas to the lower 48 states pursuant to the Alaska Natural Gas Transportation Act of 1976.

2/ To distinguish the transmission pipelines for the Tie-in Alternative pipeline systems, either Beluga to Tok or Susitna Basin to Fairbanks, from the pipelines proposed by the applicant, the latter are hereafter referred to as gathering pipelines.

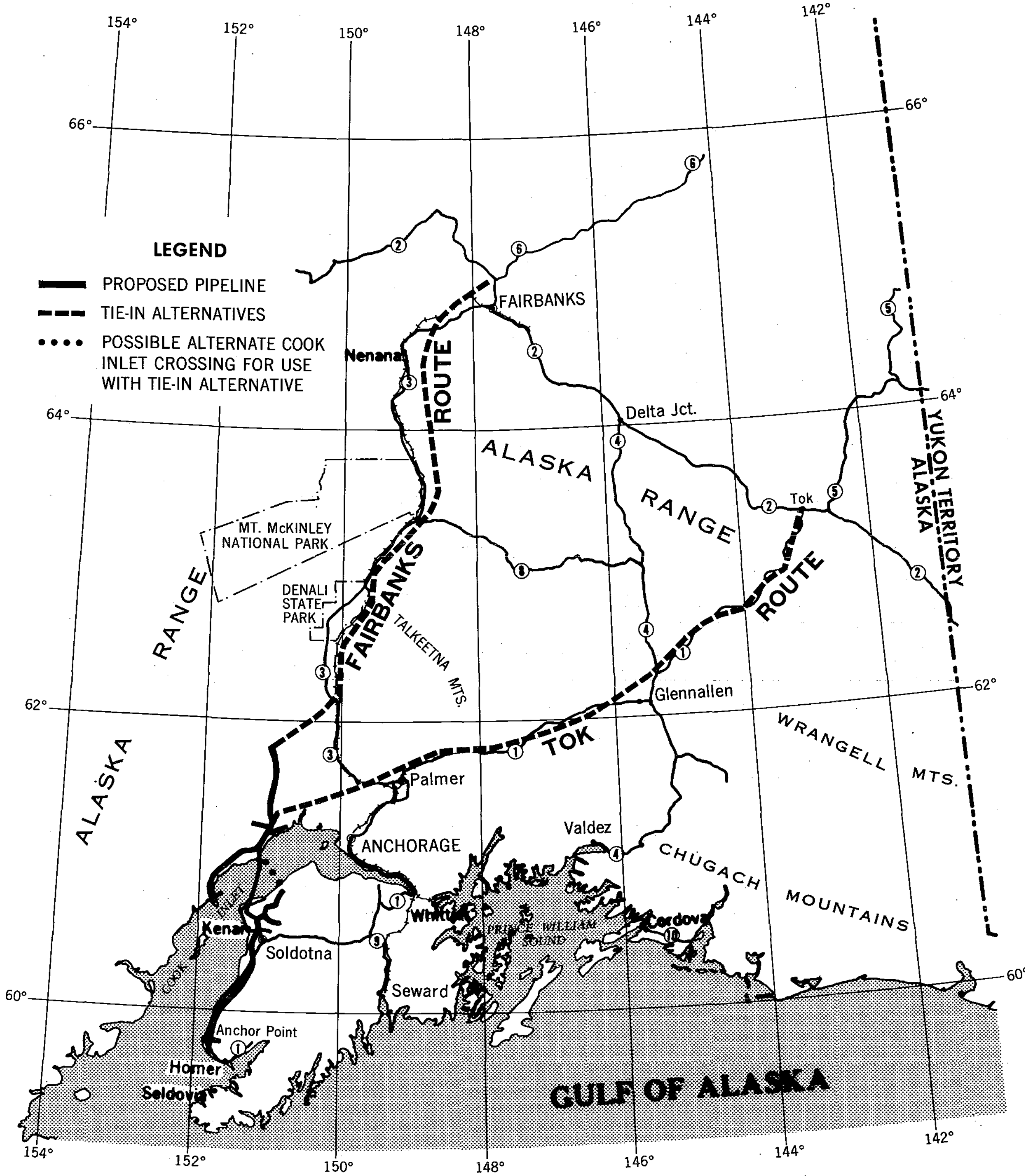

Figure 47. FAIRBANKS AND TOK TIE-IN ALTERNATIVES

required. After crossing the Susitna River near Sunshine, the route would generally follow the corridor occupied by the Alaska Railroad and Alaska Route 3, the Anchorage-to-Fairbanks highway. Deviation from this corridor might be preferable near Mount McKinley National Park, primarily to avoid aesthetic impact to the park.

Geologic hazards along the Fairbanks Alternative include flooding, landsliding, and faulting. The Yentna River and upper portion of the Susitna River are probable glacial outburst flooding watercourses. Two strands of the active Denali fault would be crossed, one near Cantwell and the other east of the village of McKinley Park. The entire route lies within a region of high historical seismicity; i.e., many earthquakes have been reported along the route. The potential for erosion is high on about 30 percent of the route, since it passes through rugged terrain with much exposed bedrock.

Vegetative communities similar to those crossed by the gathering pipelines would be crossed by this alternative. About 223 miles of forest, 37 miles of tundra, and 10 miles of bog and muskeg would be crossed. Impact to these communities would be similar to the impact of the gathering pipelines.

Approximately 50 miles of caribou winter range would be crossed by the pipeline right-of-way, and an additional 108 miles of the route would pass through areas which caribou utilize during their migration at some time during the year. No summer concentration areas or calving grounds would be crossed. Moose are present as migrants along 128 miles of the Fairbanks Alternative. In addition, the route to Fairbanks would cross the following distances through seasonal moose concentration areas: winter, 108 miles; spring-summer, 20 miles; and fall, 64 miles. Because the concentration areas overlap, they only comprise a total of 96 miles of the route. Waterfowl areas would be crossed for 128 miles of the route. Black and brown bear and wolverine are present all along the route. The impact to moose and waterfowl would be similar to that of the gathering pipelines. Pipeline construction, which would remove vegetation from only a small portion of the caribou's range, would not affect a significant amount of caribou habitat. However, construction would occur when the Delta herd is usually in its winter range. Resulting disturbance to the herd might force the animals from the range, causing hardship to them. No significant impact to bears, wolverine, Dall sheep, or mountain goats is expected. The route would cross 104 streams and 14 rivers, with impact to water quality and fish being similar to that expected from the construction of the gathering pipelines. The applicant would have to receive permission from the ADFG for stream crossings and would have to abide by its stipulations.

Air and noise impact would result from compressor station operation and would include the incremental impact of increased compression at Northwest Alaskan pipeline compressor stations. Socioeconomic impact during construction would include traffic congestion, interference with recreational activity, and a probable reduction of workforce available for other tasks. Land use restrictions and aesthetic impact would continue throughout the life of the project. There are not many people along the route, but both Mt. McKinley National Park and Denali State Park would be close to the route.

The Fairbanks Alternative would follow a long-established transportation corridor which contains many historic properties and probably a significant number of archaeological sites. All known cultural resources could be avoided.

More information on the types of impact which would be experienced during pipeline construction may be found in Section C of this volume.

Tok Alternative

The actual pipeline mileage from Beluga to the Lewis River Field to Tok would be 351 miles; however, approximately 13 miles of this pipeline right-of-way would utilize a portion of the gathering pipeline right-of-way.

Therefore, the right-of-way for the Tok Alternative, distinct from the gathering pipelines, would commence at the Lewis River Field and extend approximately 340 miles east and north to Tok where it would connect with the Northwest Alaskan pipeline system at about MP 643. Four compressor stations would be required from Beluga to Tok, with an additional station at Birch Hill. This route would follow the corridor occupied by Route 1, the Glenn Highway, to Tok.

Deviations from this corridor would be necessary. A description of the existing environment along the route to Tok follows. Impacts would be similar to those along the route to Fairbanks, so they will not be discussed in detail until the relative impact between the two alternative pipeline systems is discussed in the following section.

In general, the surficial deposits along the Tok Alternative are similar to those found in the vicinity of the gathering pipelines. The primary deposits are well-sorted floodplain, terrace, and alluvial fan deposits associated with streams and rivers, and glacial moraine and drift which has only been minimally reworked. However, the Tok Alternative, which, unlike the gathering pipeline, would pass through mountainous terrain, would encounter bedrock at or near the surface in some areas. Significant bedrock occurs in the valley of Caribou Creek, along the base of Gunsight Mountain, and in the Slana Road House, Indian Pass, and Mentasta Pass areas. Erosion potential is low to moderate except within the Alaska Range, where it may be high.

In spite of the rugged terrain through which the pipeline would be constructed, the topographic slope along the route would generally be less than 10 percent. However, it would not be desirable or even possible to strictly adhere to the Glenn Highway right-of-way all the way from Tok to Palmer. Side-hill construction on slopes of more than 100 percent would be necessary in several places, primarily in the upper reaches of the Matanuska River drainage, if the road were followed closely. In other places, construction within a river would be necessary. In addition, strict adherence to the road would, in many cases, disturb a relatively large area and/or destroy significant wetland resources, since the road frequently forms the boundary between a steep slope and poorly drained marsh, bog, or riverine areas. In these cases, it might be preferable to leave the road altogether and follow the higher ridges or plateaus which generally border the highway on the north. Specific problem areas are near the Slana River, in the vicinity of Gakona, and between Eureka Summit and Sutton. As a consequence, approximately 25 percent of the Tok Alternative would not be within, or adjacent to, existing rights-of-way.

Several geologic hazards are present along the Tok Alternative, primarily between Palmer and Glennallen. These hazards include glacial outburst flooding, landsliding, and faulting. Landsliding and faulting are particularly prevalent within the 25-mile segment between Chickaloon and Meekins Roadhouse, where the Castle Mountain-Caribou fault lies near the road. Potential for faulting would also be great at the crossing of the Denali fault near Mentasta Pass.

Vegetation along the route to Tok, similar to that along the proposed gathering pipeline, includes bottomland spruce-poplar forest, lowland and upland spruce-hardwood forest, and bog-muskeg communities. Extensive stands of bottomland spruce-poplar forest occur within the Susitna, Matanuska, and Copper River valleys. The principal tree species of this community include white spruce, black cottonwood, and balsam poplar. Alders, willows, high bush cranberry, blueberry, bearberry, and raspberry are the chief shrub species.

The lowland spruce-hardwood forest is found in areas of shallow peat, glacial deposits, outwash plains, and on north-facing slopes. The principal species encountered would be black and white spruce, Alaska paperbirch, quaking aspen, balsam poplar, and black cottonwood. Shrub species are willow and dwarf arctic birch with a ground cover of cottongrass, ferns, lichens, mosses, and liverworts. Willow and other brush species of this forest type provide shelter and browse for moose, while open forest stands with lichens provide excellent winter range for caribou. Areas near the Susitna and Copper Rivers sustain extensive stands of this vegetation type.

The upland spruce-hardwood forest type is also found along the river valleys that would be traversed by the Tok Alternative and occurs at higher elevations than the previous two community types. This forest type is composed of black and white spruce, Alaska paperbirch, quaking aspen, black cottonwood, and balsam poplar. Black spruce occupies north-facing slopes or areas with poor drainage, while combined stands of the remaining species are found on well-drained, south-facing slopes. Extensive stands of this forest type occur along the Susitna and Matanuska Rivers and in the Mentasta Pass area. Areas of bog-muskeg composed of species of dwarf shrubs growing over mats of sedges, mosses, and lichens are interspersed among the other communities in the Susitna and Copper River valleys.

ADFG-identified wildlife areas are generally plentiful along the Tok Alternative. All of the Tok Alternative would pass through areas where moose may be found at some time during the year, with about 200 miles being in areas of seasonal concentration. Within the Matanuska Valley, moose have been abundant because portions of the land have been cleared by development and fires and have revegetated with flora suitable for moose browsing. This valley has been the most consistently productive area for moose in the state. Prime moose habitat may also be found in the Nelchina Basin and along the Tanana River. There is a critical winter habitat for moose in the Tok River Valley between Tok and Mineral Lake, a relatively small area which supports a concentrated moose population for brief periods during late winter.

About 92 miles of winter caribou range would be crossed by the Tok Alternative. This range is inhabited by the Nelchina herd, which many consider to be the state's most important caribou population. Indications are that the winter range for these animals has been quite variable. Although they remain within the general area of Lake Louise, Talkeetna River, Nenana River, Mentasta Pass, and Copper River, the boundaries of their winter range are not precisely known. Therefore, although the herd's general winter range is known, it is not possible to identify the particular portion of the range that might be occupied during any given winter.

Black and brown bear and wolverine are present along the route, but it would cross no areas of seasonal concentration. Dall sheep and mountain goats occupy the higher elevations bordering the route.

Significant quantities--about 308 miles--of waterfowl habitat would be crossed. Noteworthy are trumpeter swans which are present in the Susitna River Flats area and which breed in the vicinity of the Nelchina and Copper Rivers. Another noteworthy avian species is the bald eagle, which winters in the Copper River drainage.

Virtually all of the 138 streams and rivers that would be crossed by the Tok Alternative contain salmon or other game species; however, spawning only occurs near the crossings of 11 of those. Species which spawn at the crossings and the number of streams crossed are coho (3), king (6), chum (3), pink (1), and sockeye (1) salmon. Other species present are rainbow trout, Dolly Varden, steelhead, grayling, white fish, burbot, and northern pike.

Water quality along the route is generally quite good, with over 50 percent of the streams rated as clear water. Approximately 30 percent contain colored water which has relatively high concentrations of organic material, primarily the products of decaying vegetation. Glacial streams containing very high suspended and dissolved mineral concentrations comprise the rest of the streams crossed, about 15 percent.

Air and noise quality are both excellent along the route. Noise levels are typical of rural areas with very low population.

The existing socioeconomic situation, represented by the 90 percent of the route which is outside of the Matanuska Valley, is generally dominated by lack of significant industry, including agriculture. In the Matanuska Valley, probably the most important agricultural region in the state, 20 percent of the workforce is engaged in agricultural activities. Most of the remaining workforce is employed by various governments, utilities, and other service industries. Trade, manufacturing, and construction industries utilize about 25 percent of the workforce.

Land ownership along the route is almost evenly divided among the state, Native villages, and Native regional corporations. The most important land uses include recreation, mining and prospecting, and subsistence. Four large communities (by Alaskan standards) exist along the route--Wasilla, Palmer, Glennallen, and Tok. Their 1976 populations were 1,566, 1,643, 1,070, and 550, respectively. Other communities, numbering about 12, contain considerably fewer than 100 persons each. Among the larger villages are Gulkana and Mentasta Lake, with populations of 75 and 68, respectively.

Many sites of cultural interest are located in the vicinity of the route. The favorable topography and presence of rivers has encouraged travel and settlement along the corridor followed by this route, and consequently archaeological and historical sites are abundant.

Comparison of the Fairbanks Alternative and the Tok Alternative

Based on miles of plant communities and wildlife habitat crossed, it appears that the Fairbanks Alternative would create less construction impact to the biological resources of the area than the Tok Alternative. In addition, the Fairbanks Alternative does not pass through a critical moose wintering area, while the Tok Alternative does. However, most of the advantage of passing through less sensitive habitat would be considerably reduced because much of the Tok Alternative would utilize existing rights-of-way.

The Fairbanks Alternative would pass through generally more rugged terrain which has greater historic seismicity than the Tok Alternative, but the latter would be nearer active geologic faults along more of its length. Other geologic hazards would be similar for both routes.

Compression requirements for either of the routes would be similar, with five compressor stations needed for each. However, air and noise quality impacts would be greater for the Fairbanks Alternative because it would require additions to compression along the Northwest Alaskan pipeline between Fairbanks and Tok.

Adverse socioeconomic impact would be somewhat less along the Fairbanks Alternative, primarily because there would be fewer people nearby. Construction materials for the route to Fairbanks could be supplied by both railroad and highway, whereas the Tok Alternative would have only one major highway to support construction. Land use impact would be less for the Fairbanks Alternative which would not cross as much agricultural land.

Impact to recreation and aesthetic values would be about the same for each route. Although the pipeline right-of-way to Tok would be more visible on the ground, in general it would only appear as a widened highway right-of-way. As such, it would not be as offensive as a new right-of-way striking off by itself into unspoiled terrain. As viewed from the air, the Fairbanks Alternative would create much more impact. Because both routes have been utilized by man over a long period of time, the potential for impact to cultural resources is about the same for each route.

Because an existing right-of-way can be used for much of the Tok Alternative, most of the short-term environmental advantages of the route to Fairbanks are negated. In the long term, the Tok Alternative would involve less environmental impact, primarily because of ready access for routine maintenance and repair. Other considerations also favor the route to Tok. Either alternative pipeline system would require substantial modification of the Northwest Alaskan pipeline system's compression requirements. However, because the Fairbanks Alternative would utilize 200 more miles of that system, it would necessitate greater modification than would the Tok Alternative. Over the lifetime of the project, these modifications could significantly increase transportation costs and reduce gas volumes delivered. Moreover, should looping of the Northwest Alaskan system be required after the Cook Inlet volumes were connected, the Fairbanks Alternative would necessitate more looping than the Tok Alternative. Consequently, the staff favors the Tok Alternative.

ii. Tok Alternative Versus the Proposed Project

Comparing the proposed LNG project with the Tok Alternative is, in some respects, easier than comparing the two tie-in alternatives themselves. Because the gathering pipelines are similar, the comparison is basically between one Alaskan LNG terminal with a modified terminal in California on the one hand and approximately 351 miles of transmission pipeline with modifications to the Northwest Alaskan pipeline system on the other. Table 36 compares some aspects of the two alternative systems. Since few facilities would be required in California to process the Pacific Alaska volumes of gas, only a limited amount of environmental impact to that state must be considered.

LNG Project Facilities and Cost

Facilities required in Alaska for the LNG project include the LNG liquefaction plant, marine terminal, and 292 miles of gathering pipeline. Two 130,000-m^3 LNG tankers would also be required. A more detailed description of these facilities may be found in Section A.2.

TABLE 36

COMPARISON OF PROPOSED PROJECT AND TOK ALTERNATIVE

	Tok Alternative	LNG Project Proposed	LNG Project Without Pacific Indonesia
Pipeline right-of-way (miles)			
Gathering (on-and off-shore)	250	269	269
Transmission	338	-	112
Total onshore	565	240	352
Total offshore	22.5	29	29
Construction acreage			
Pipeline 1/	3500	1450	2810
Compressor stations	75	-	-
LNG terminal 2/	-	60	360
Workcamps	70	50	125
Total	3645	1560	3295
Watercourses crossed			
Streams	225	90	200± 4/
Major Rivers 3/	7	4	5 5/
Salmon spawning streams	34	23	23
Wildlife (miles)			
Caribou			
Calving area	2	2	2
Winter concentrations	92	0	0
Moose			
Winter concentration	265	90	90
Spring concentration	153	92	92
Waterfowl habitat	538	230	230
Vegetation (Alaska, miles of 50 foot ROW)			
Forest			
Bottomland Spruce-Poplar	145	22	22
Upland Spruce-Hardwood	207	133	133
Lowland Spruce-Hardwood	164	42	42
Low Brush Bog and Muskeg	14	15	15
Wet tundra	37	28	28
Vegetation (California, miles of 100 foot ROW)			
Oak woodland	-	-	6
Chaparral	-	-	5
Coastal sage	-	-	27
San Joaquin saltbush	-	-	18
Valley grassland	-	-	15
Agricultural, disturbed/open	-	-	42
Archaeological/historical sites	54	10	53
Seismic considerations	Pipeline, Zone 3	2 LNG terminals, Zone 3	
Capital cost ($billions, 1977)	1.15	1.22	1.60
Cost of service ($/MMBtu, 1977) 1983	4.03	4.06	?
Total primary energy cost 6/ (Trillion Btu)	46.4	41.4	65.8
Gas delivered 7/ (Million cubic feet/day)	354	400	395
Fuel use 7/ (Billion Btu/day)	78	65	65
Delivery Efficiency (percent) 7/	82.1	86.1	86.0

1/ Assumes 50 foot width in Alaska, 100 foot width in California. No allowance for existing right-of-way.

2/ Includes access road easement (California) and construction dock (Alaska).

3/ More than about 600 feet wide.

4/ Over 110 are intermittent.

5/ Includes California Aqueduct.

6/ See Appendix G.

7/ Includes fuel oil and electricity; see Appendix G, Table G-2.

As proposed, the LNG project would require the addition of four 100-million scfd seawater vaporizers and associated facilities to the Point Conception, California, terminal which would receive LNG from Pacific Indonesia LNG Company. No other California facilities would be needed for this project as long as the basic facility proposed for Indonesian LNG were constructed. The following comparison of the proposed LNG project and the Tok Alternative is made on that basis. However, if the Indonesian LNG import scheme does not materialize, the entire California facility, its environmental impact, and its cost must then be ascribed to the Pacific Alaska project alone. This eventuality is discussed in Section H.3.b.

The capital cost of the LNG project--including the Alaskan facilities, two LNG tankers, and the incremental facilities in California--would be $1.27 billion. The level annual cost of service for the LNG project, in 1977 dollars, would be $3.49 per million Btu on an incremental basis. 1/

Tok Alternative Project Facilities and Cost

Facilities required for the Tok Alternative include approximately 351 miles of 24-inch diameter transmission pipeline, 266 miles of gathering pipeline, and five compressor stations. The locations of the onshore gathering pipelines would be similar to those for the LNG project, although approximately 22 miles of the pipeline would have to be resized. Since the Tok Alternative would not include an LNG terminal, it would not be desirable to use the applicant's proposed pipeline crossing of Cook Inlet. Instead, the Tok Alternative would utilize a crossing from Birch Hill Field to Tyonek involving only 16.5 miles of offshore and 2 miles of onshore right-of-way, replacing 23 miles of offshore and 14.4 miles of onshore right-of-way. For this comparison, no other changes have been made in the proposed gathering pipeline rights-of-way. The new inlet crossing would be near the eastern boundary of the area delineated in Figure B-3 of Appendix B. Its location is shown schematically in Figure 47.

1/ Level annual cost is an annuity. The value of the annuity is calculated in present value terms so that it is the equivalent of the sum of the present values of the annual costs of service for the project over the useful life of the project.

The transmission pipeline would extend from the Beluga River Field to the Lewis River Field along the existing powerline right-of-way and/or the right-of-way for the proposed gathering pipeline between those fields. From the Lewis River Field, it would follow the powerline east to Palmer and would then generally follow Alaska Route 1 between Palmer and Tok. This is schematically shown on Figure 47. Compressor stations would be required near the Birch Hill and Beluga River Fields and near the towns of Palmer, Glennallen, and Tok. From Tok, Alaska, to Kingsgate, British Columbia, the Northwest Alaskan pipeline system would have to provide additional compression to support the Tok Alternative. The PGT and PG and E pipeline systems from Kingsgate to Antioch, California, would require modification to looping already proposed in connection with the Northwest Alaskan pipeline system.

Pacific Alaska has indicated that a Tok Alternative would require modifications of existing facilities south of Antioch. The staff assumes these facilities are 128 miles of 34-inch diameter pipeline, which would parallel an existing pipeline between Antioch and Panoche Junction, California. 1/ As discussed in the El Paso Alaska proceeding, FPC Docket No. CP75-96 et al., these facilities would have been utilized to transfer Prudhoe Bay gas from the northern to the southern portions of the PG and E system so that SoCal could receive its Prudhoe Bay gas volumes. It appears to staff that these facilities would not be required if the Pacific Indonesia Project materializes, 2/ because Cook Inlet volumes transported by the Northwest Alaskan pipeline system could be delivered to SoCal via a displacement arrangement with Northwest Pipeline Company, 3/ and because the Pacific Indonesia Project would make sufficient volumes of gas available to the southern PG and E system to allow delivery of SoCal's Prudhoe Bay gas volumes via an exchange of gas.

1/ FPC Docket No. CP74-241, Hearing Exhibit PG-103, p. 7.

2/ If the Pacific Indonesia Project does not materialize, then these facilities might be required.

3/ FPC Docket No. CP74-241, Hearing Exhibit PG-104, pp. 5, 6, and 8.

The applicant estimates the capital cost of a somewhat different Tok Alternative, including all required modifications to the Northwest Alaskan pipeline system, at $1.21 billion. This Tok Alternative, which does not include a crossing of the main part of the inlet, would require two feeder pipelines to the main transmission line at Palmer. On the west side of the inlet, the feeder pipeline would correspond to the transmission pipeline previously described. The eastern feeder pipeline would extend from Soldotna on the Kenai Peninsula to Palmer. It would replace 2 miles of onshore and 16.5 miles of dual offshore pipeline, required for the staff's Tok Alternative, with 108 miles of onshore and 5 miles of dual offshore pipeline. Neither the staff's Tok Alternative nor the applicant's Tok Alternative has a cost advantage. The applicant's capital cost estimate also includes refrigeration of the natural gas and insulation of the entire transmission pipeline. It is probable that neither of these techniques would be necessary for the entire tie-in pipeline, so it may be tentatively concluded that the capital cost for the Tok Alternative could be further reduced.

The incremental level annual cost of service of the Tok Alternative studied by the applicant would be $3.61 per million Btu. This compares with the $3.49 figure for the LNG system. The $3.61 figure includes an additional $0.06 increase in cost of service in anticipation of a 30-percent cost overrun on a portion of the Northwest Alaskan pipeline system instead of a 10 percent overrun. The applicant has also indicated that without the insulation equipment, the cost of the delivered gas in the 1983 cost of service for the Tok Alternative could be reduced by $0.15 per million Btu. Therefore, it would appear that neither the Tok Alternative nor the applicant's proposed project enjoys a significant cost-of-service advantage.

Comparison of Environmental Impact

A summary of those factors of the existing environment which relate to the relative impact of the Tok Alternative and the proposed project, and which lend themselves to quantification, are contained in Table 36.

In order to compare the relative environmental impact of the LNG project and the Tok Alternative, it is not necessary to include the gathering pipelines, not because their impact would be minor, but because they are similar for both systems.

Differences do exist between the gathering pipeline configurations for the two systems, but the difference in impact would be insignificant. Because of this simplification, the following discussion of environmental impact will only compare the Tok Alternative and modifications to the Northwest Alaskan pipeline system on the one hand with the Nikiski LNG terminal, marine transport, and modifications to the Point Conception, California, LNG vaporization facility on the other.

A few topics normally of concern to environmentalists are not considered important in this comparison because impacts from each project, while not necessarily the same, tend to balance in the comparison, thereby nullifying their relative importance. Two such topics are air and noise quality.

Air quality impact from the LNG project would primarily result from emissions from the LNG tankers at both terminals, the trim heaters and gas-fired vaporizers at Point Conception, and the liquefaction trains at Nikiski. The Tok Alternative would produce emissions from compressor stations and a possible increase in pollution in California because the pipeline would not be able to transport as much gas as the LNG project, thereby requiring the use of alternate, and possibly "dirtier" fuels. Noise from the Nikiski LNG terminal would be quite substantial; however, its impact would be largely masked by the presence of a greater noise source to the north, the Collier Chemical Plant. South and east of the site little masking effect would be present, but there are very few residences which could be significantly affected. Compressor stations for the tie-in transmission pipeline probably would not be terribly noisy because they would be relatively small. However, if located near the more populated areas of the route, they could create some impact.

The remaining points of comparison are significant. However, most of those which favor the LNG project involve Tok Alternative impacts which would disappear soon after construction was completed. Such topics include soils, wildlife, water quality, socioeconomics, and recreation and aesthetics.

The topographic impact of the Tok Alternative would be greater. At first glance, it would appear that the Tok Alternative is superior because the Nikiski LNG terminal and associated haul road would produce the most substantial impact of either system. However, utilizing the highway right-of-way for the Tok Alternative would require substantial side-hill construction. In addition, permafrost conditions may require substantial quantities of select fill.

The soil impact of the Tok Alternative would be more extensive than that of the LNG project since the Tok Alternative would involve more land. This type of impact is discussed in Section C.4. Impact at the LNG terminal would involve permanent loss of topsoil wherever excavation would be required.

The applicant has already removed most of the vegetation and topsoil from the proposed 59.3-acre LNG terminal site. The only clearing still required would be about 4 acres for the haul road. The Tok Alternative would require permanent removal of trees from the presently uncleared portion of the right-of-way, a much larger area; however, the return of grasses and shrubs would be encouraged.

Wildlife impact would be much greater for the Tok Alternative than for the LNG project, since virtually no wildlife impact would be associated with the LNG terminal at Nikiski. At Point Conception, a portion of the marine animals killed by entrainment or perhaps by locally lowered water temperatures and unneutralized biocide could be counted in this comparison, but they are relatively unimportant. The Tok Alternative would traverse many miles of caribou, moose, and waterfowl habitat and many fish streams.

The Tok Alternative would result in much more impact to surface water quality because of the number of streams crossed. The LNG project would create only minor marine water quality impact in Alaska. There would be impact to California waters during construction of the marine terminal at Point Conception; during operation, there would be a local reduction in water temperature. Because of the huge volume of water required for hydrostatic testing of the LNG tanks and the limited availability of groundwater at Nikiski, there would be a potential for short-term lowering of the groundwater table.

Adverse socioeconomic impact would be greater for the Tok Alternative. Although the pipeline would not require a high concentration of workers in one location, as would the LNG facility, it would burden the existing support facilities beyond their capabilities. The LNG terminal area, including Kenai, could more easily absorb the impact. However, work-camps for the Tok Alternative could be self-contained, considerably reducing the impact.

Aesthetic impact would be much greater along the Tok Alternative, primarily in the short term. The LNG terminal would be located in an existing industrial area so that the onshore aesthetic impact would be minor. The marine facilities would look the same as the existing facilities immediately to the north; however, the proposed haul road would present a substantial affront to the aesthetic appeal of the coastline. Along the Glenn Highway, comparatively minor development has taken place, and the construction and permanently cleared right-of-way for the Tok Alternative would have a greater relative impact.

Very little recreational activity takes place in the immediate area of the LNG site, so no significant impact would result. By contrast, the Glenn Highway corridor is used extensively for recreation. Since the construction effort for the Tok Alternative would last about 9 months, impact to the use of the highway would be substantial.

Impact to known archaeological and historical sites would be substantially different for the two systems. No archaeological or historical sites are known to exist in the vicinity of the LNG site. About 44 such sites occur in the vicinity of Glenn Highway, and it is possible that more would be discovered during construction. However, all currently known sites should be easy to avoid.

In considering the previous impacts, which are generally short term, it is apparent that the Tok Alternative would have more impact in Alaska. Nevertheless, it must be recognized that impact to soil, vegetation, wildlife, aesthetics, and, to some extent, cultural sites would be substantially reduced by locating most of the Tok Alternative within the existing highway right-of-way.

Geologic hazards and safety are of concern for the lifetime of the facilities, not just during construction. The Tok Alternative would be subject to more geologic hazards than the Alaskan LNG terminal. The former would cross and parallel active geologic faults and cross areas subject to landsliding and flooding, while the latter would be threatened by earthquake ground motion. The hazard from all of these factors except faulting could be substantially reduced by proper design of the facilities. However, the effectiveness of any design in withstanding natural events depends heavily on the quality of materials and workmanship, especially for a complex LNG facility. This is one of the reasons that the staff considers the Tok Alternative to be more reliable than the LNG project, in spite of the fact that it would be subject to more geologic hazards in Alaska. Another reason is that the reliability of the Pacific Alaska project cannot be divorced from the reliability of the LNG receiving facilities, including the Point Conception-to-Gosford pipeline in California. Geologic hazard to that pipeline would be at least as severe as that to the Tok Alternative, and the terminal itself would be in a more hazardous location than the one at Nikiski.

Safety, Efficiency, Reliability, and Flexibility

Natural gas pipelines have been in operation for many years across thousands of miles of land with an excellent safety record. LNG facilities of the size contemplated here are rare and have not established statistically meaningful safety records. The staff has indicated in its analysis of public safety for this project (Volumes I and II) that it believes these LNG facilities can be operated at an acceptable level of risk to the public. Nevertheless, there is no question that a pipeline alternative would involve less risk to the public at large and to those at voluntary risk as company employees. Therefore, the Tok Alternative would be preferred to the proposed project from the safety standpoint.

Because of the importance of fossil fuel energy to the United States, it is desirable to efficiently bring the Alaskan natural gas to market. The last line in Table 36 shows the delivery efficiency of the two systems. These percentages represent the operating energy cost of moving natural gas to California via each system. As more fully described in Appendix G, the computation for the LNG project includes natural gas used as process fuel, fuel oil used by the LNG tankers, and fuel utilized for offsite electrical generation. For the Tok Alternative, the incremental compressor fuel use along various pipeline systems between Tok and Antioch is added to the compressor fuel used on the Beluga to Tok pipeline.

The Tok Alternative, with a delivery efficiency of 83.3 percent, would be less efficient than the LNG project, with its efficiency of 87.4 percent. Although pipelines are generally the more efficient means of transporting natural gas, the pipeline system trails in this case because all of the incremental fuel which would be used to transport Cook Inlet gas has been charged to the Tok Alternative, rather than rolling it in with overall Northwest Alaskan system. See Appendix G.

The energy dependence of this country also requires reliability of supply. From this standpoint, the Tok Alternative would be preferable. A pipeline system involves no complex equipment comparable to that required for an LNG terminal/tanker transport system, and therefore the opportunity for mechanical failure or operational error would be much less. In addition, maintaining the tanker delivery schedule would depend upon the weather. No such problem would exist for a pipeline. Finally, the potential system downtime resulting from extreme natural events such as earthquakes is much longer for an LNG system than for a pipeline system.

The LNG project could not as easily accommodate gas volumes in excess of those currently proposed; in other words, it would not be as flexible as the Tok Alternative. It would rely on expensive vessels of fixed capacity; consequently, additional vessels could be economically justified only if substantial additional volumes of gas became available. On the other hand, the Tok Alternative could accommodate a wider range of additional gas volumes by adding compression or pipeline looping. However, use of the Northwest Alaskan gas pipeline for Cook Inlet volumes would reduce the "as built" flexibility of that pipeline to carry gas from new sources in Alaska and Canada.

Previous Studies

At least three studies have previously addressed the concept of a Tok Alternative. Northwest Pipeline Corporation (Northwest), in a study entitled Alcan Pipeline, Options for Alaska, discussed the facilities needed, capital costs, gas balance, and cost of service for moving Cook Inlet gas by pipeline to the Northwest Alaskan pipeline at Tok on Alaska

Route 2, the Alaska Highway, 208 miles southeast of Fairbanks. Northwest also provided similar information for a Fairbanks-to-Anchorage pipeline that could deliver the state's royalty portion of the Prudhoe Bay gas to the vicinity of Cook Inlet.

The second study, basically environmental, was performed at the FERC environmental staff's request. 1/ It compares the environmental impact of a Cook Inlet-to-Tok or Cook Inlet-to-Fairbanks pipeline with that of the proposed LNG project. The third study is an economic analysis of alternatives similar to those identified in the second study. 2/ None of the studies are entirely applicable to the alternatives devised and analyzed by the environmental staff, since they consider connections to the Cook Inlet gathering system that are substantially different from those considered by the staff. In general, however, they do corroborate the staff's findings.

Summary

It is the staff's conclusion that the environmental impact of the Tok Alternative would be greater than that of the proposed LNG project if California facilities were built for the Pacific Indonesia project and modified to handle the proposed volumes of LNG from Alaska. 3/ In addition, the LNG project would deliver more natural gas to California and would do it more efficiently. On the other hand, safety, flexibility, and reliability all favor the Tok Alternative. Studies by Northwest Pipeline Corporation, SoCal, and PG and E indicate that a Tok Alternative would be competitive with the LNG project.

1/ Dames and Moore, Addendum, Detailed Environmental Analysis Concerning a Proposed Liquefied Natural Gas Project, Cook Inlet Basin Pipelines Supplement, For Pacific Alaska LNG Associates, 1977, unpublished.

2/ PG and E and SoCal, Pipeline Transportation Systems for Cook Inlet Gas, 1978, unpublished.

3/ It should be noted that Volume II of this FEIS finds the Point Conception site to be unacceptable.

The staff believes that either of these systems--LNG or pipeline--would be an acceptable means of transporting Cook Inlet gas to California. Neither system appears to have a clear overall advantage over the other. Therefore, based on the work that has been done by the staff and on the studies it has reviewed, the staff believes that the Tok Alternative is not a superior or preferable alternative to the applicant's proposed LNG project.

b) Comparison of the Tok Alternative to the Pacific Alaska Proposal If There Are No Existing Facilities in California

If the applicant pursued an Alaskan LNG project without an LNG facility assumed to exist at Point Conception, California, the sum of the environmental impact in Alaska and California would have to be compared to the impact resulting from the staff's Tok Alternative. 1/ The environmental impact resulting from construction and operation of the Alaskan and California LNG systems has been addressed in Volumes I and II of this environmental statement, and the impact of the Tok Alternative has been addressed in the previous section.

It appears that the information can be condensed into three general areas of concern: environmental impact; public safety, reliability, and flexibility; and economics. It should be emphasized, however, that the environmental staff has already found that either the Pacific Alaska proposal with a dual-purpose terminal facility in California or the Tok Alternative would be acceptable systems for transporting Cook Inlet gas to California.

i. Environmental Impact

The long-term and short-term environmental impact resulting from the construction and operation of two LNG facilities (Alaska and California) and about 112 miles of pipeline in California must be weighed against the impact resulting from the construction and operation of 350 miles of pipeline in Alaska for the Tok Alternative. The gathering pipelines in Alaska would be similar for each project and will not be discussed further.

1/ The proposed site at Point Conception has been found to be unacceptable. (See Volume II.) Therefore, this comparison is based on the premise that the decisionmakers will not agree that the Point Conception site is unacceptable because of the active faults.

The 350-mile long Tok Alternative used to connect the Cook Inlet gas fields with the Northwest Alaskan pipeline would pass through some areas of discontinuous permafrost and rugged terrain. About 90 miles of the route would not be within or adjacent to existing rights-of-way. The tie-in would not cross any national forests or state parks. The construction phase of a pipeline is usually the period of greatest socioeconomic, biological, and physical impact. The communities near the Alyeska oil pipeline, the proposed Northwest Alaskan gas pipeline, and the highways leading northeast from Anchorage have either already been or will be affected by the stresses created from major construction projects, and this would tend to reduce the socioeconomic impact resulting from the Tok Alternative. After construction has been completed, natural processes can work to restore the disturbed corridor, particularly if aided by effective mitigating measures. The major long-term impact resulting from the tie-in pipeline's presence would be the operation of five additional compressor stations, the restriction imposed on the land use of the right-of-way, and the adverse aesthetic impact resulting from side-hill construction.

The Tok Alternative would eliminate the need for two LNG facilities with their associated marine terminals, LNG shipping, and California transmission pipeline. Both of the transportation systems, LNG and pipeline, would cause significant short-term environmental impact. However, unlike the minimal long-term impact associated with the tie-in alternative, the California LNG facilities would cause significant long-term impact that would continue for the 20-year life of the facilities. The Nikiski LNG facility would be located within an industrial area and would not conflict with the planned use of that region, whereas the Point Conception regasification facility and transmission pipeline would conflict with the existing land use of that region. The regasification facility would substantially change the unspoiled nature of Point Conception. It could serve as a nucleus for an industrial area if associated industries locate near the facility. The construction of a trestle, LNG facility, access road, and possible aboveground electric transmission powerline would cause a major aesthetic impact. The project would have a significant adverse impact on the archaeological resources of the area and would also have an adverse long-term impact on the air quality, topography, and marine biota of the site and surrounding area.

The environmental staff has presented (Table 37) a comparison of some of the quantitative aspects of the two alternative systems. However, it is difficult to quantitatively compare all facets of the LNG and pipeline transportation systems because they are essentially located in two different regions of the United States that have significantly different environments. Both systems would cause serious environmental impact, but the environmental staff believes that the Pacific Alaska proposal would have a significantly greater long-term impact on the human environment than the Tok Alternative.

ii. Public Safety, Reliability, and Flexibility

As discussed in the preceding section, "Pipeline Alternatives to the Proposed Project," considerations of public safety, reliability, and flexibility favor the Tok Alternative over the Pacific Alaska proposal.

iii. Economics

PG and E and SoCal prepared a study entitled "Pipeline Transportation Systems for Cook Inlet Gas." This economic analysis estimated the capital costs, efficiency, and cost of delivered gas for moving Cook Inlet gas to California. The applicant's study examined two pipeline route alternatives, Fairbanks and Tok, for transporting Cook Inlet gas to the Northwest Alaskan pipeline system and found that the pipeline alternative to Tok was the most promising. The applicant's study showed that there is a difference of 12 cents in the incremental level annual cost of service between the Tok Alternative and the Pacific Alaska LNG proposal (3.61 - 3.49), assuming that an existing LNG facility were operating in California. However, the applicant's comparative study does not make any cost adjustment for eliminating unnecessary insulation, the cost of the Gosford pipeline, or for differences in the cost of overruns assumed for each project. Taking these factors into account, neither project appears to have a significant economic advantage. Without an existing LNG facility, the applicant would be forced to increase the capital and operating costs associated with its proposal, i.e., all of the cost for the California regasification facility and Gosford pipeline. Therefore, it appears that, based on information submitted by the applicant, the LNG proposal would have a higher cost of service and would result in the Tok Alternative being more economically attractive.

iv. Summary

Analysis of the three general areas of concern supports the tie-in alternative. Therefore, the environmental staff prefers the Tok Alternative because it is a superior alternative to the Pacific Alaska proposal unless it is assumed that an existing LNG facility is available at Point Conception, California.

4. No Action or Postponement of Action

The actions that are available are: to grant the various permits that are sought; to deny them; or to postpone action pending further study. If action is postponed, this decision will ultimately lead to one of the other two.

Denial of the Pacific Alaska terminal and its associated pipelines could result in: (1) no action on the entire system, (2) action on an equivalent alternative site or system with other associated pipeline construction, or (3) alternative energy sources. The alternative of "no action" means that the proposed volumes of gas would not be transported to the lower 48 states. Inasmuch as there is a need for natural gas, this alternative would appear to be unacceptable. The staff has considered alternate pipeline systems and LNG sites that could be used to deliver the gas. With respect to alternative energy sources, the environmental staff has previously stated that all possible sources of energy supplies must be explored and that no one source of energy will be sufficient to meet all projected demands.

I. CONCLUSIONS AND RECOMMENDATIONS

Information provided by Pacific Alaska and further developed by the staff from field investigation, literature research, local and state agencies, other Federal agencies, and special studies indicates that the environmental impact associated with the construction and normal operations of the proposed Alaskan LNG project would have a limited adverse impact on the environment.

The bulk handling of LNG would involve some risk to the public from potential operational accidents. The risk associated with the operation of a marine terminal could result from the transport of LNG on the ocean by tankers; the operation of large tankers in the offshore area, including docking of the tankers; loading of tankers and storage of LNG in the land-based tanks at the terminal; and the pipeline transport of the gas to the liquefaction plant.

A major accident, such as a tanker collision or ramming and subsequent release of LNG, must be recognized as possible, and the consequences of such an accident must be considered. The risk associated with the operation of the LNG ships and liquefaction facility is discussed and analyzed in the "Analysis of Public Safety" and Attachment A. This analysis concludes that the proposed project is acceptable. In addition, the U.S. Coast Guard has indicated that it can and will continue to insure safe tanker operations at Nikiski. Therefore, the staff concludes that the level of risk to the public inherent in an LNG operation at Nikiski within the Kenai Peninsula Borough is acceptable.

The staff's analysis of sites within the Cook Inlet region indicates that Cape Starichkof and Nikiski would be acceptable sites for the construction and operation of an LNG facility and marine terminal. The staff also found that the impact associated with these sites is comparable and that the Cape Starichkof site is not significantly superior to the proposed Nikiski site. Therefore, if an LNG transportation system is approved by the Commission to transport gas to California, the staff agrees with the applicant and the State of Alaska that the proposed liquefaction facility should be located at Nikiski.

The environmental staff investigated several pipeline alternatives in Alaska to the applicant's proposed LNG system. 1/

1/ Pacific Alaska's proposed LNG system assumes that it would only be required to construct incremental facilities in California because it could utilize an existing LNG facility.

After weighing the environmental and safety aspects, the staff has concluded that the Tok Alternative, a pipeline that could connect the Cook Inlet gas fields to the Northwest Alaskan transportation system at Tok, Alaska, and the applicant's proposed project are both acceptable and that neither system has a clear overall advantage. The Tok Alternative is a more flexible, reliable, and safer transportation system than the LNG proposal. However, it would cause more environmental impact than the proposed LNG project, particularly during construction and right-of-way restoration. Therefore, the environmental staff supports the proposed Alaskan LNG project over the Tok Alternative.

The applicant has indicated that it would pursue its proposed project even if there were no existing facility at Point Conception to receive the delivery of its Alaskan gas. If it were necessary for the applicant to construct all of the facilities at Point Conception in order to transport only the Alaskan gas, then the Tok Alternative would be a significantly superior alternative. It would generally follow existing rights-of-way, whereas the LNG terminal and associated pipeline would disrupt an essentially undisturbed region of California. It should be noted, however, that the staff believes an LNG terminal at Point Conception would be environmentally unacceptable and that an LNG receiving terminal should be constructed and operated at Oxnard, California instead. (See Volume II.) In this event, the Tok Alternative would no longer be a significantly superior alternative to the Oxnard terminal; rather, it would be environmentally comparable, and other factors--such as economics--would determine whether a pipeline or LNG transportation system is acceptable.

To minimize the adverse environmental impact of the proposed Alaskan project and to promote its safe operation, the staff recommends that Pacific Alaska comply with the following stipulations or show good cause why they cannot be accomplished:

1. The applicant shall utilize the following staff-preferred alternate pipeline routes as identified within "Alternatives to the Proposed Action, (g) Alternate Pipeline Routes."

    (a) From the north side of the Beluga River to the vicinity of the Beluga Power Plant, the proposed 20-inch diameter pipeline route shall follow the powerline right-of-way and then continue south along the road heading toward Tyonek.

(b) The excess capacity of the existing Swanson River Oil Field gas pipeline shall be used. To utilize this system, the applicant shall construct the Birch Hill and West Fork laterals and the section of pipeline connecting the Beaver Creek Field to the existing Swanson River gas pipeline. The applicant shall also construct the proposed Kenai Loop lateral along the Kenai Spur Road.

2. Sulfur dioxide emissions from the LNG tankers shall be reduced by substituting boil-off gas for Bunker-C fuel oil to the maximum extent possible during the tanker's approach to the marine terminal and berthing maneuvers and while the tanker is docked at the terminal. Under these operating conditions, only a nominal amount of Bunker-C fuel oil shall be burned as a safety measure in case of flameout of the boil-off gas.

3. The proposed marine terminal, LNG storage tanks, backup containment system, fire control systems, and all other systems or equipment required for the safe shutdown of the facilities shall be designed to maintain an operational capability if seismic shaking equivalent to the near-source Richter Magnitude 6.5 event specified in the applicant's geoseismic study (hearing Exhibit 171) occurs.

   To further analyze the sufficiency of the structural design of the facility, particularly the LNG storage tanks, the staff has contracted with the National Bureau of Standards. The staff recommends that the Commission specifically require that the study resulting from this contract be used in evaluating the adequacy of the final seismic design.

4. Any significant changes in facility design, construction, operations, or operating philosophy from those described in this EIS shall be reported to the FERC on a timely basis.

5. The applicant shall outline procedures to be utilized if the evacuation of nearby areas and the suspension of local highway and shipping traffic is necessitated by a major accident. Such procedures shall contain measures for the immediate notification of nearby inhabitants of any potentially dangerous situation that might arise and notification and mobilization of emergency personnel such as Civil Defense, hospitals, police, and fire departments.

These procedures shall include the volunteer procedures adopted by the Operation Guide--Nikiski Marine Terminal Complex.

6. The applicant shall develop and implement a public information program to educate the public, particularly the frequent users of the LNG offshore project area, of the potential hazards resulting from an LNG spill.

7. The final design plans for the proposed LNG terminal shall be submitted to the Commission for review before construction of the terminal begins.

8. The applicant shall conduct "oral reviews" for the staff on the security measures to be enforced by Pacific Alaska at its Nikiski facility. An initial review shall be conducted when the final design plans for the proposed LNG terminal are submitted to the Commission. (See item 7.) A more extensive review shall be conducted before the first full year of plant operation.

9. If the terminal is approved for operation, the Commission shall require operational reports semiannually, within 45 days after each period ending December 31 and June 30, describing facility operations for the period covered, noting any abnormal operating experiences or behavior. Abnormalities shall include, but not be limited to, rollover, geysering, cold spots on the tank, significant equipment malfunctions or failures, nonscheduled maintenance or repair (and reasons therefor), relative movement of the inner vessel after each cooldown and following local seismic activity, vapor or liquid releases, negative pressures (vacuum) within the storage tank, and higher than predicted boil-off rates. The technical information supplied by the applicant shall be submitted in a form acceptable to the Commission and shall be in sufficient detail to allow a complete understanding of such events consistent with the existing state-of-the-art or knowledge. Such information can provide the Commission with technical data that may be applied to other LNG facilities. If an abnormality is sufficient to endanger the facility or operating personnel, the Commission shall be notifid immediately.

10. The applicant shall conduct studies to determine the hydrodynamic behavior of spilled LNG following a catastrophic failure of a storage tank or other credible spill and the ability of the dikes to contain potential

splashing or overflow from such a failure. Specific measures to reduce or eliminate such dike overflow potential shall be evaluated and implemented. Results shall be submitted with the final design plans.

11. The applicant shall provide additional thermocouples on the tank floor and lower shell of the inner tank to obtain more comprehensive data on the thermal stresses imposed during cooldown. Previous experience with other LNG tanks indicates that at least 12 temperature sensors located in quadrants on the floor or footer plat and on the lower portion of the inner shell are necessary to obtain meaningful data on thermal stresses during tank cooldown.

12. Linear movement indicators between the inner and outer tank shells shall be installed on the proposed LNG storage tanks to provide data on the relative position of the inner and outer shells. The indicators shall be in quadrants at or near the floor of the inner shell and be either direct reading or electronic (linear motion transducer) type.

13. The internal storage tank LNG temperature probe shall be located so that the accuracy of its data sendout will not be thermally influenced by fluid circulation within the tank or by other structural members.

14. The applicant shall install a low liquid level indicator and alarm in addition to the float-type gauge and traversing temperature probe presently proposed.

15. High and low temperature detectors shall be installed on all tank vent valves to indicate the venting of LNG vapor from the storage tank.

16. Primary and backup signal lines installed for all instrumentation and control systems at the LNG terminal shall be routed separately to each system to avoid simultaneous damage in the event of an accident.

17. The applicant shall consult the appropriate natural resource departments, such as local offices of the U.S. Soil Conservation Service and the Alaska Department of Fish and Game, to determine how best to control erosion and promote revegetation of all disturbed areas. If periodic inspections of these areas reveal that revegetation and/or erosion control measures have not been

successful, the measures recommended by the local agencies shall be repeated, or the local agencies shall be consulted again and their further recommendations followed.

18. The applicant shall consult with and follow the recommendations of the Alaska Department of Fish and Game and the U.S. Department of the Interior, as appropriate, throughout preconstruction, construction, and post-construction periods on the following:

    a) Scarifying the restored right-of-way (except for that area directly over the pipeline) to allow the regrowth of browse species for moose.

    b) Scheduling all stream crossings.

    c) Compensating local set net fishermen in the immediate vicinity of the site who have permits from the Alaska Department of Fish and Game and who would no longer be able to fish near the trestle.

    d) Obtaining hydrostatic test water from an acceptable source and releasing such water in an environmentally acceptable manner.

    e) Timing low flying inspection surveillance to avoid nesting swans and calving caribou and moose.

    f) Studying the potential that fish pathogens might be transported from California via the ship ballast water and discharged into Cook Inlet; also examining ways to prevent such a problem.

    g) Preconstruction surveying of areas to be dredged or blasted.

    h) Preconstruction approval of site for gravel removal.

19. In accordance with the requirements of the National Historic Preservation Act of 1966 as amended in 1976,

the National Environmental Policy Act of 1969, and the Archaeological and Historic Preservation Act of 1974, the staff recommends that the applicant be required to conduct a cultural resources program consistent with that outlined in Appendix K to avoid or minimize the possible loss of historic and prehistoric sites during the construction of the proposed LNG terminal and pipeline system.

20. During the life of the project, streambanks shall be maintained to conform to their original contours. Temporary berms left atop the pipeline trench after construction shall incorporate intermittent gaps to allow the passage of water and thus prevent substantial alteration of surface runoff patterns. Later, the level of backfill above the pipeline shall be maintained to prevent the formation of a linear depression that would divert surface runoff and contribute to erosion.

21. Professionally supervised pumping tests shall be performed on all wells from which the applicant would obtain water during construction, hydrostatic testing, and plant operation.

22. The applicant shall make every effort to schedule the hydrostatic testing of the two LNG tanks so that the same water (14 to 15 million gallons) can be used to test both tanks.

23. The applicant shall prepare an oil spill contingency plan for use during construction of the pipeline, particularly for the proposed watercourse crossings. At a minimum, construction crews should have a supply of oil-sorbent pads or rolls on hand, and preferably have immediate access to some boom material.

24. The applicant shall apply the necessary noise reduction techniques to insure that operation of the proposed liquefaction plant would not increase noise levels at nearby residences above an L_{dn} = 55dBA.

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