COAL TO METHANOL FEASIBILITY STUDY BELUGA METHANOL PROJECT

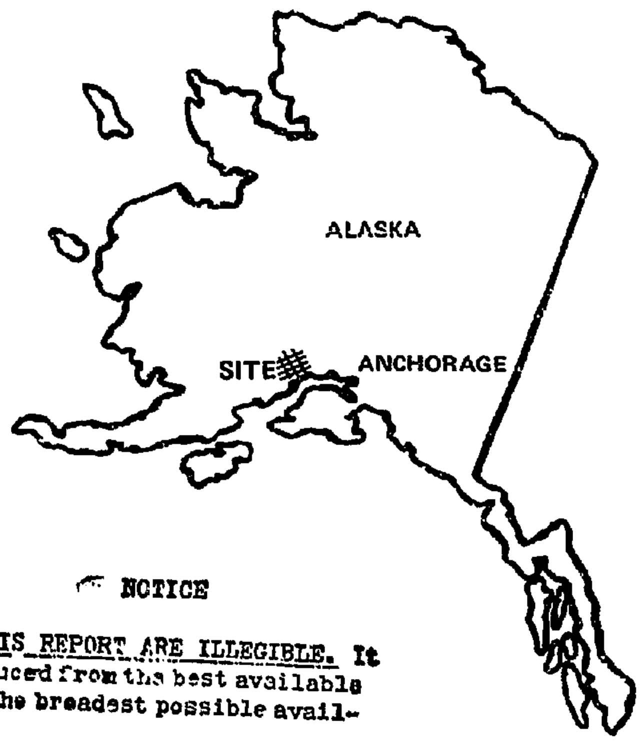
DOE GRANT DE-FG01-80RA-50299

FINAL REPORT

VOLUME IV
ENVIRONMENTAL

DOE/RA/50299--1119 Vol. 4

DE82 006057



NOTICE

PORTIONS OF THIS REPORT ARE ILLEGIBLE. It has been reproduced from the best available copy to permit the broadest possible availability.

COOK INLET REGION, INC.
AND
PLACER AMEX INC.

SEPTEMBER 1981

BELUGA COAL TO METHANOL PROJECT

This submission to the Department of Energy consists of six volumes, namely,

- An Executive Review of the project as of September, 1981, and
- A five volume report presenting the findings of the Phase I Feasibility Study.

The contents of the above volumes are indicated by main headings from their Tables of Content, as listed below:

EXECUTIVE REVIEW

Executive Letter
Table of Contents
Technical Viability
Plan for Phase II
Summary of Study
Appendix

VOLUME I MINING

Introduction
Geology
Coal Quality
Capps Mine
Chuitna West Mine
Tables
Ancilliary Facilities
Exhibits

VOLUME II COAL TO METHANOL PLANT

Introduction
Conceptual Design
Coal Preparation
Gasification
Syngas Upgrading
Synthesis and Distillation
Oxygen - Nitrogen - Air
Utilities
Wastewater, Treatment
Emergency and Safety Systems
Buildings and Vehicles
Dust Control
Drawing List

VOLUME III GEOTECHNICAL, INFRASTRUCTURE

Introduction
Geotechnical
Railroad
Barge Dock
Bus System
Camp, Town, Airstrip
Product Transportation

VOLUME IV ENVIRONMENT AND SOCIOECONOMIC

Introduction
Baseline Data
Environmental Effects
Safety and Risk
Site Evaluation
Bibliography
Participants

VOLUME V COMMERCIAL

Introduction
Marketing
Capital Cost
Financial
Trade-Off Studies

TABLE OF CONTENTS

BELUGA METHANOL PROJECT
ENVIRONMENTAL, HEALTH, SAFETY & SOCIOECONOMIC ASSESSMENTS

INTRODUCTION

		Page No.
1.0	PURPOSE OF REPORT	1-1
	PROJECT LOCATION	1-2
	PROJECT DESCRIPTION	1-2
2.0	SUMMARY OF THE STUDY	2-1
	METHODOLOGY	2-1
	General	2-1
	Field Programs	2-2
	SUMMARY OF MAJOR ISSUES	2-7
	Fisheries	2-7
	Water Sources	2-8
	Wetlands	2-8
	Erosion and Sedimentation	2-9
	Tyonek Village	2-9
	Air Quality	2-9
	ENVIRONMENTAL ACCEPTABILITY OF THE PROJECT	2-10

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Table of Contents
Continued

AFFECTED ENVIRONMENTAL (BASELINE DATA)	Page No.
3.0 GEOTECHNICAL	3-1
THE COOK INLET REGION	3-1
Geologic History	3-1
Formation of Coal Bearing Units	3-4
SURFICIAL SOILS	3-7
THE BELUGA AREA	3-8
Topography	3-8
Geology	3-10
SITE CHARACTERIZATION	3-14
Methanol Plant Site	3-14
° Topography	3-14
° Subsurface Conditions	3-16
° Groundwater	3-22
° Plant Site Conditions	3-22
Town Site	3-26
° Topography	3-26
° Subsurface Conditions	3-26
° Groundwater	3-28
° Construction Feasibility	3-28
Dock Site	3-31
° Topography	3-31
° Subsurface Conditions	3-32
° Dock Construction	3-32
Transportation Corridor and Mine Areas	3-36
° Topography of Mine Areas	3-36

Table of Contents

Continued

		Page No.
	° Surficial Conditions at Mine Areas	3-36
	° Transportation Corridor	3-36
	° Trafficability	3-38
	Construction Materials	3-38
	° Surficial Geology	3-38
	° Concrete Aggregates	3-43
	° Asphalt Concrete Aggregates	3-48
	° Crushed Base Course	3-49
	° Railroad Ballast	3-50
	GEOLOGIC HAZARDS	3-52
	Seismicity	3-52
	° Aleutian Megathrust	3-52
	° Castle Mountain Fault	3-55
	° Bruin Bay Fault	3-55
	° Lake Clark-Lone Ridge Fault	3-56
	° Border Ranges Fault	3-56
	° Seismic Design Considerations	3-57
	Ground Failure	3-60
	Landslides	3-60
	Volcanos	3-61
	Tsunamis	3-62
	Permafrost	3-63
	Additional Geologic Hazards	3-63
4.0	HYDROLOGY	4-1
	GROUNDWATER	4-1
	Introduction	4-1
	Available Supply	4-3

Table of Contents
Continued

		Page No.
	° Nikolai Creek Flats	4-3
	° Plant Site	4-5
	Existing Uses	4-9
	SURFACE WATER	4-9
	Existing Sources	4-9
	° Lakes	4-9
	° Streams and Rivers	4-14
	Possible Use of Surface Waters	4-31
5.0	ECOSYSTEMS	5-1
	FRESHWATER AQUATIC ECOLOGY	5-2
	Existing Habitats (Populations)	5-2
	° Habitat Characterization	5-2
	- Beluga Drainage	5-2
	- Chuitna Drainage	5-9
	- Nikolai Drainage	5-18
	- Congahbuna Drainage	5-21
	° Fishes	5-22
	° Invertebrates	5-28
	TERRESTRIAL ECOLOGY	5-28
	Existing Vegetation	5-28
	Wetlands	5-38
	Existing Mammal Populations	5-40
	° Brown Bear Denning	5-43
	° Brown Bear Movement and Activity Patterns	5-46
	° Black Bears	5-47
	° Moose	5-48

Table of Contents
Continued

		Page No.
	° Other Mammals	5-49
	° General Sensitivity to Changed Conditions	5-53
	Existing Avian Populations	5-54
	Amphibians	5-55
	MARINE ECOLOGY	5-61
	Inter-tidal and Shallow Subtidal Habitats	5-61
	° Mud Flats	5-61
	Gravel and Cobble Substrate	5-63
	Granite Point Intertidal and Shallow Subtidal	5-66
	Marine Species	5-66
	° Fisheries	5-66
	- Commercial Fisheries	5-75
	- Sport Fishery	5-78
	- Subsistence Fishery	5-79
	° Birds	5-80
	° Mammals	5-83
	° Trading Bay State Game Refuge	5-89
6.0	CLIMATOLOGY AND AIR QUALITY	6-1
	CLIMATIC CONDITIONS	6-1
	EXISTING AMBIENT AIR QUALITY	6-6
	ATMOSPHERIC EMISSION SOURCES	6-7

Table of Contents
Continued

		Page No.
7.0	OCEANOGRAPHY	7-1
	PHYSICAL OCEANOGRAPHY OF COOK INLET	7-1
	Tides and Currents	7-3
	CIRCULATION	7-4
	Upper Cook Inlet	7-4
	Middle Cook Inlet	7-6
	Lower Cook Inlet	7-6
	WATER CHEMISTRY	7-6
	Salinity	7-7
	Temperature	7-7
	Suspended Sediments	7-7
	Nutrient	7-8
	SEA ICE	7-11
	PORTS	7-13
8.0	ARCHAEOLOGIC & HISTORIC SITES	8-1
	ETHNOHISTORY AND SETTLEMENT PATTERNS	8-1
	Settlement Patterns	8-1
	Dwellings	8-2
	Caches	8-3
	Burial	8-4
	Material Culture	8-4
	European Contact and Trade	8-6
	Historic and Prehistoric Sites	8-8
	ARCHAEOLOGIC SITES	8-10

Table of Contents
Continued

		Page No.
9.0	OTHER FRAGILE LANDS	9-1
	FRAGILE OR HISTORIC LANDS	9-1
	NATURAL HAZARD LANDS	9-2
	RENEWABLE RESOURCE LANDS	9-3
	LAND PLANNING	9-3
10.0	EXISTING SOCIAL AND ECONOMIC ENVIRONMENT	10-1
	WEST COOK INLET DEVELOPMENT	10-1
	Employment Activities and Population	10-1
	Land Ownership, Status and Use Restrictions	10-2
	Land Ownership and Status	10-3
	° State of Alaska	10-3
	° Resource Management Lands	10-5
	° Industrial Lands	10-6
	° Reserved Use Lands	10-6
	° Material Lands	10-6
	° Cook Inlet Region Inc.	10-7
	° Tyonek Native Corporation	10-7
	° Kenai Peninsula Borough	10-8
	Land Development Planning Authority	10-8
	° Governor's Coal Policy Group	10-9
	° Beluga Interagency Task Force	10-9
	° Kenai Peninsula Borough	10-9
	° Tyonek Village Council	10-10
	Transportation and Power Infrastructure	10-11

Table of Contents
Continued

	Page No.
° Existing Roads and Easements	10-11
° Airports	10-13
° Docks	10-14
° Power	10-15
Kenai Peninsula Borough Services	10-15
Other West Cook Inlet Coal Development	10-16
TYONEK VILLAGE	10-17
Background	10-17
Community Facilities and Infrastructure	10-19
° Housing and Utilities	10-19
° Education	10-20
° Public Safety	10-21
Employment	10-22
Community Attitudes Towards Development	10-24
CONSTRUCTION AND OPERATIONS REQUIREMENTS	10-25
Background	10-25
Direct Labor Force Requirements	10-25
Indirect Employment and Total Population	10-26
OVERALL PROJECT DEVELOPMENT	10-26
Construction Camp	10-28
° Concept	10-28
° Camp Facilities	10-30
° Housing and Support Facilities	10-30
° Utilities	10-33
Airport	10-35
° Concept	10-35
° Facilities	10-35
Permanent New Town	10-38

Table of Contents
Continued

		Page No.
	° Concept	10-38
	° Housing, Education and Commercial Facilities	10-39
	° Transportation	10-41
	° Utilities	10-42
11.0	ACOUSTIC ENVIRONMENT	11-1
	INTRODUCTION	11-1
	GENERAL OVERVIEW	11-3
	NOISE SENSITIVE LAND USES	11-3
	ENVIRONMENTAL IMPACT	
12.0	GEOLOGY AND SOILS	12-1
	CONSTRUCTION EFFECTS	12-1
	LONG-TERM EFFECTS	12-1
	MAJOR REGULATORY REQUIREMENTS	12-3
	ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION	12-3
13.0	HYDROLOGY	13-1
	CONSTRUCTION EFFECTS	13-1

Table of Contents
Continued

		Page No.
	Groundwater	13-1
	° Construction Water Source	13-1
	° Effects on Water Table	13-1
	° Appropriation of Water Rights	13-1
	Surface Water	13-2
	° Siltation During Construction	13-2
	° Accidental Petroleum and Hazardous Substance Spills	13-3
	° As a Water Source for Construction	13-4
	LONG-TERM EFFECTS	13-4
	Groundwater	13-4
	° Plant Water Source	13-4
	° Effects on Water Table and Marshes	13-5
	° Appropriation of Water Rights	13-6
	Surface Water	13-6
	° Wastewater Discharges and Treatment	13-6
	° Projected Effluent Characteristics	13-21
	° Effects to Surface Waters	13-23
	MAJOR REGULATORY REQUIREMENTS	13-27
	ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION	13-27
14.0	ECOSYSTEMS	14-1
	CONSTRUCTION AND LONG-TERM EFFECTS	14-1
	MAJOR REGULATORY REQUIREMENTS	14-9
	ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION	14-10

Table of Contents
Continued

		Page No.
15.0	AIR QUALITY	15-1
	CONSTRUCTION EFFECTS	15-2
	EMISSIONS AND LONG-TERM EFFECTS	15-3
	Process Plant Area Emissions	15-3
	° Coal Preparation	15-3
	° Process Coal	15-4
	° Coal Gasification	15-4
	° Fugitive Emissions	15-5
	Power Plant	15-5
	° Start-up and Shutdown	15-6
	° Emergencies	15-7
	Mining Area Emissions	15-7
	Air Emission Effects	15-8
	Models Used	15-9
	MAJOR REGULATORY REQUIREMENTS	15-15
	ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION	15-16
16.0	OCEANOGRAPHY	16-1
	CONSTRUCTION EFFECTS	16-1
	LONG-TERM EFFECTS	16-1
	MAJOR REGULATORY REQUIREMENTS	16-2
	ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION	16-3

Table of Contents

Continued

	Page No.
17.0 ARCHAEOLOGIC AND HISTORIC SITES	17-1
CONSTRUCTION EFFECTS	17-1
LONG-TERM EFFECTS	17-1
MAJOR REGULATORY REQUIREMENTS	17-2
ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION	17-2
18.0 SOLID WASTE	18-1
CONSTRUCTION EFFECTS	18-1
Clearing Debris	18-1
Construction Refuse	18-1
LONG-TERM EFFECTS	18-2
Ash and Sludge	18-2
Methanol Process Solid Waste	18-4
Hazardous Substances	18-5
Fugitive Coal Dust	18-5
Refuse	18-5
Sanitary Waste Solids	18-6
MAJOR REGULATORY REQUIREMENTS	18-6
RCRA of 1976 (Federal)	18-6
18 ACC 60 (State of Alaska)	18-7
ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION	18-7

Table of Contents
Continued

		Page No.
19.0	SHORT- AND LONG-TERM SOCIOECONOMIC EFFECTS	19-1
	COOK INLET IMPACTS	19-1
	Population and Employment	19-1
	Growth-Inducing Effects	19-2
	Land Use, Transportation and Ownership Changes	19-3
	° State Lands	19-4
	° Borough Lands	19-6
	° Cook Inlet Region Inc. (CIRI) Lands	19-6
	° Tyonek Native Corporation Lands	19-7
	Borough Services Impacts	19-7
	° Options for Town Management and Governance	19-8
	° Borough Planning of the Town Site	19-9
	° Impacts if Growth Occurs in the Kenai Peninsula	19-9
	TYONEK VILLAGE IMPACTS	19-10
	Village Impacts	19-11
	Culture and Life-style Changes	19-11
	Economic Impacts	19-13
20.0	ACOUSTIC ENVIRONMENT	20-1
	CONSTRUCTION EFFECTS	20-1
	Construction Activities	20-1
	Vehicular Traffic	20-1
	LONG-TERM EFFECTS	20-2
	MAJOR REGULATORY REQUIREMENTS	20-3
	ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION	20-3

Table of Contents

Continued

Page No.

21.0 METHANOL IN THE ENVIRONMENT (SUMMARY) 21-1

METHANOL IN THE ENVIRONMENT (GENERAL) 21-1

Environmental Hazards, Aquatic and Marine 21-1

Marine and Estuarine 21-1

Comparison of Marine Environmental Impact Costs: Methanol/Oil 21-4

Fresh Water 21-8

Terrestrial - Direct Exposure 21-12

Emissions 21-14

METHANOL IN THE ENVIRONMENT (SPECIFIC) 21-15

Introduction 21-15

Fish 21-16

Crustaceans 21-17

Molluscs 21-18

Birds and Mammals 21-19

Summary 21-20

SAFETY AND RISK

22.0 SAFETY AND RISK ANALYSIS 22-1

INTRODUCTION 22-1

ASSESSMENT PROCEDURES 22-1

Program Characteristics 22-1

Regulatory Assessment 22-3

SAFETY OVERVIEW 22-4

Health Effects 22-4

Table of Contents
Continued

	Page No.
° Process Down Time	22-5
° Start-up	22-7
° On-stream Operation	22-8
° Shutdowns	22-9
PROCESS HAZARDS	22-9
Coal Storage	22-9
Coal Preparation	22-10
Coal Feeding	22-10
Methanol Distillation	22-13
Gasification	22-11
Ash Removal and Disposal	22-11
Venturi Scrubber	22-12
Shift Conversion	22-12
Acid Gas Removal	22-12
Methanol Synthesis	22-12
Utilities	22-13
MONITORING THE PROCESS ENVIRONMENT	22-13
Industrial Hygiene	22-13
Monitoring	22-13
Medical	22-14
Education and Training	22-14
Compliance	22-15
Regulated Areas	22-15
Emergency Procedures	22-15
FIRE SAFETY	22-15
Conclusion	22-16

Table of Contents

Continued

SITE EVALUATION SUMMARY | Page No.

23.0 SITE SELECTION 23-1

INTRODUCTION 23-1

Level 1 - Screening Analysis 23-2

- Granite Point on Cook Inlet 23-2
- Capps Coal Field Area 23-2
- Chuitna Coal Field Area 23-3
- Remote Location 23-4
- Comparison of Alternatives 23-4

Level II - Preliminary Site Selection 23-6

- Near Tidewater 23-6
- Upland Location 23-7

Level III - Final Site Selection 23-8

BIBLIOGRAPHY

PARTICIPANTS

LIST OF TABLES

		Page No.
2.1	Beluga Field Program, Summary of Principal Activities, 1980-81	2-3
2.2	Beluga Field Program, Agencies Contacted or Briefed by DOWL in 1981	2-6
3.1	Fine Concrete Aggregates, #4 Minus	3-45
3.2	Typical Asphalt Concrete Surface Course	3-48
3.3	Typical Base Course	3-51
3.4	Typical Railroad Ballast	3-51
4.1	Test Well #1, Summary of Driller's Log	4-4
4.2	Test Well #2, Summary of Driller's Log	4-7
4.3	Lakes of the Beluga Region	4-11
4.4	Selected Data on Stream and River Systems	4-16
4.5	Stream Flow Data (Selected Stations)	4-18
4.6	Selected Discharge Data	4-21
4.7	Summary Data on Suspended Solids	4-22
4.8	Selected Water Quality Data, November 1980	4-25
4.9	Selected Water Quality Data, May 1981	4-26
4.10	Selected Water Quality Data, June 1981	4-27
4.11	Selected Water Quality Data, July 1981	4-28
4.12	Water Quality Comparison, Groundwater & Chuitna River	4-33
4.13	Sediment Sample Analyses	4-34
5.1	Life History Data for Five Species of Pacific Salmon	5-25
5.2	Selected Fish Trapping Data, Nikolai Drainage (June 1981)	5-26
5.3	Checklist of Freshwater Fish of Beluga Area	5-27
5.4	Chinook Salmon Aerial Survey	5-30
5.5	Benthic Invertebrate Community	5-31
5.6	Moose/Bear Observations (Aerial) June 1-4, 1981	5-50
5.7	1980 Moose Survey	5-51

LIST OF TABLES
(Continued)

		Page No.
5.8	Terrestrial Birds	5-56
5.9	Pacific Salmon of Alaska - Life Features	5-69
5.10	General Salmon Timing Information for Northern Cook Inlet Streams	5-70
5.11	Cook Inlet Fisheries, 1973-1977	5-76
5.12	Waterfowl, Shorebirds and Seabirds	5-84
7.1	Cook Inlet Tidal Ranges	7-3
10.1	Anticipated Construction and Operation Work Forces, Beluga Methanol Project	10-27
12.1	Preliminary List of Construction Activities Associated with Development in the Beluga Region	12-2
13.1	Summary of Estimated Flows & Characteristics of Process-Related and Sanitary Wastewater Discharges	13-9
13.2	Summary of Coal Area Wastewater Characteristics	13-14
13.3	Summary of Boiler Cleaning Wastewater Characteristics	13-16
13.4	Estimated Contaminated Process Area Runoff Characteristics	13-17
13.5	Summary of Projected Effluent Characteristics	13-22
13.6	Possible Interaction of Project Activities with Surface Water	13-26
14.1	Outline of Potential Environmental Impacts and Relevant Pollutants Resulting from Site Preparation and Construction Practices	14-2
15.1	New Source Performance Standards & Anticipated Emission Rates	15-10
15.2	Accepted & Anticipated Emission Levels	15-12
15.3	Emission Inventory	15-13

LIST OF TABLES
(Continued)

		Page No.
18.1	Construction Refuse	18-1
18.2	Combined Solid Waste	18-3
18.3	Expected Lives of Catalysts	18-4
21.1	Cost Comparison of Selected Crude Oil, Diesel Fuel, and Methanol Spills	21-7
21.2	Freshwater Organisms -- Methanol Toxicology	21-9
21.3	Organismic Recolonization of Surface Saturated Soils -- Methanol Toxicology	21-13
23.1	Qualitative Comparison of Sites	23-5

LIST OF FIGURES

		Page No.
1.1	General Location - Beluga Methanol Plant	1-3
1.2	Project Location Map (Beluga Methanol Plant)	1-4
1.3	Simplified Block Flow Diagram of a Typical Coal to Methanol Plant	1-6
2.1	Field Program Participants	2-5
3.1	Stratigraphic Column, Upper Cook Inlet Basin	3-2
3.2	Proposed Stratigraphic Nomenclature for Kenai Group	3-6
3.3	Generalized Physiography and Geology of the Beluga Area, Alaska	3-11
3.4	Preliminary Geologic Map of the Congahbuna Area, Cook Inlet Region, Alaska	3-12
3.5	Vicinity Map, CIRI/Placer-Amex, Methanol Plant	3-15
3.6	Soil Samples and Well Locations, CIRI/Placer-Amex, Methanol Project	3-17
3.7	Locations of Soils Test (CIRI/Placer-Amex Plant Site)	3-18
3.8	Idealized Peat Distribution Methanol Plant Area	3-19
3 9	Log of Test Hole, Plant Site Area	3-20
3.10	Log of Test Pit, Plant Site Area	3-21
3.11	Grain Size Distribution - Gradation Curve	3-23
3.12	Locations of Soil Test (CIRI/Placer-Amex Townsite)	3-27
3.13	Log of Test Hole, Town Site Area	3-29
3.14	Log of Test Pit, Town Site Area	3-30
3.15	Dock Site Test Hole Locations	3-33
3.16	Idealized Soil Profile, Dock Site Area Dock Site Idealized Soil Profile	3-34
3.17	Log of Test Hole, Dock Site Area	3-35
3.18	Typical Soil Profile of Capps Area, Alaska	3-37
3.19	Typical Soil Profile of Chuitna Area	3-39
3.20	Grain Size Distribution - Gradation Curve	3-42
3.21	Abrasion Test Results	3-44

LIST OF FIGURES
(Continued)

		Page No.
3.22	Major Faults in Southcentral Alaska	3-53
3.23	Cumulative Magnitude/Frequency Relationship, Anchorage Region	3-58
4.1	Well Locations, Granite Point Area	4-2
4.2	Groundwater Quality	4-6
4.3	Granite Point Area, Bedrock Outcrops and Depth to Bedrock in Wells	4-8
4.4	Pump Test of Well #2	4-10
4.5	Lakes of Beluga Area	4-13
4.6	Staff Gauge Locations - Beluga Region	4-16
4.7	Rating Curve for Nikolai Creek (Bridge)	4-29
4-8	Typical Data Recovered From DATAPOD Experiment (Nikolai Creek)	4-30
4-9	Typical Surface Water Quality Analysis	4-32
5.1	General Location Sampled by Trapping and by Angling (May-Aug. '81)	5-3
5.2	Species Distribution and Spawning Areas	5-23
5.3	Areas Where Adult King Salmon Were Observed (July - August '81)	5-29
5.4	General Vegetation Map	5-33
5.5	Preliminary Photo Interpretation Vegetation Map	5-37
5.6	Preliminary Determination of Wetlands	5-39
5.7	Seasonal Concentrations of Moose	5-41
5.8	Bear Feeding and Denning Areas	5-42
5.9	Known Nesting Sites (Active, 1981)	5-60
5.10	Habitat Types, Cook Inlet Shoreline	5-62
5.11	Distribution of Organisms in Mud Flats	5-64
5.12	Generalized Food Web for Mud Flat	5-65
5.13	Granite Point Intertidal and Shallow Subtidal Species Assemblages	5-67

LIST OF FIGURES
(Continued)

		Page No.
5.14	Life Cycle of King Salmon	5-71
5.15	Life Cycle of Silver Salmon	5-72
5.16	Resource Use in the Cook Inlet Area	5-81
5.17	Trading Bay State Game Refuge	5-90
6.1	Representative Climatic Conditions for Project Area	6-3
6.2	Locations of Weather Monitoring Stations	6-4
6.3	Wind Rose	6-5
7.1	Division of Cook Inlet	7-2
7.2	Net Surface Circulation	7-5
7.3	Bottom Sediments in Cook Inlet	7-9
8.1	Archaeologic and Historic Sites	8-9
10.1	Existing Land Status	10-4
10.2	Existing Roads and Easements	10-12
10.3	Overall Site Plan	10-29
10.4	Camp Siting Considerations	10-31
10.5	Camp Plan	10-32
10.6	Airport Siting Considerations	10-36
10.7	Airport Plan	10-37
10.8	Town Land Use Plan	10-40
11.1	Levels of Noise in Terms of a Weighted Sound Levels, dB(A)	11-2
14.1	A Possible Perturbation Matrix for Considering Enviornmental Impacts of the Methanol Project	14-6
20.1	Levels of Noise, dB(A) - Beluga Methanol Plant	20-4

GLOSSARY OF ENVIRONMENTAL TERMS

AGENCIES

ACMP	-	Alaska Coastal Management Program
AEIDC	-	Artic Environmental Information and Data Center
CEQ	-	Council on Environmental Quality
COE	-	U.S. Army Corps of Engineers
DEC	-	Department of Environmental Conservation (Alaska)
DF&G	-	Department of Fish & Game (Alaska)
DNR	-	Department of Natural Resources (Alaska)
DOE	-	U.S. Department of Energy
DOSH	-	Division of Occupational Safety and Health (Alaska)
DPDP	-	Division of Policy Development and Planning (Alaska)
EPA	-	U.S. Environmental Protection Agency (unless designated as state agency)
FAA	-	Federal Aviation Administration
FWS	-	Fish and Wildlife Services (Federal)
MSHA	-	Mine Safety and Health Administration
NRDC	-	National Resource Defense Council
OSHA	-	Occupational Safety and Health Administration
OSM	-	Office of Surface Mining
USGS	-	United States Geological Service

REGULATIONS/ACTS

AAC	-	Alaska Administrative Code
ANCSA	-	Alaska Native Claims and Settlement Act
CAAA	-	Clean Air Act Amendments of 1977
CFR	-	Code of Federal Regulations
CWA	-	Clean Water Act of 1977
EA	-	Environmental Assessment

EIS	-	Environmental Impact Statement
DEIS	-	Draft Environmental Impact Statement
FEIS	-	Final Environmental Impact Statement
FR	-	Federal Register
FWPCA	-	Federal Water Pollution Control Act
MSHA	-	Mine Safety and Health Act of 1977
NAAQS	-	National Ambient Air Quality Standards
NEPA	-	National Environmental Policy Act of 1969
OSHA	-	Occupational Safety and Health Act of 1970
RCRA	-	Resource Conservation and Recovery Act of 1976
SMCRA	-	Surface Mining Control and Reclamation Act of 1977
TSCA	-	Toxic Substances Control Act of 1976

REGULATIONS/ENGINEERING

BACT	-	Best Available Control Technology
BAT	-	Best Available Technology: Economically Achievable
BMP	-	Best Management Practices
GEP	-	Good Engineering Practice
LAER	-	Lowest Achievable Emission Rate
NPDES	-	National Pollutant Discharge Elimination System
NSPS	-	New Source Performance Standards
PSD	-	Prevention of Significant Deterioration
SPCC	-	Spill Prevention Control and Countermeasure Plans
UNAMAP	-	User's Network for Applied Modeling of Air Pollution (series of meteorological models developed by the U.S. EPA)
PTMAX	-	Single stack meteorological model in EPA UNAMAP series
VALLEY	-	Meteorological model used by USEPA to calculate concentrations on elevated terrain

INTRODUCTION

1.0 PURPOSE OF THE REPORT

The objectives of the environmental, health, safety and socioeconomic assessment tasks of this feasibility study were to define the major environmental issues relevant to development of a coal gasification and methanol fuels production facility and related coal mining activities and transportation systems in the west Cook Inlet area, Alaska. To achieve this, extensive review into existing information on the Beluga region of west Cook Inlet was conducted and updated with the findings of current and on-going land resource projects. Specific field activities then were initiated to expand the environmental data base in areas relevant to this project where there was a paucity of information. Based on these findings the project was reviewed in detail to identify significant environmental issues and to outline the state and federal permit requirements to ensure that these elements are an integral component of all subsequent project planning and management decisions.

While the format of this report is similar to that of an environmental assessment, this document is not a formal environmental assessment. The initial scope of work was to provide for the assemblage of sufficient information to develop a more detailed scope of work for the initiation of the requisite permitting procedures and for the preparation of an Environmental Impact Statement. Therefore, data gaps may be identified but not necessarily addressed beyond the level necessary to identify or define the issue of concern. This document includes the results of the literature review and substantial contributions from the 1981 field program. The report also incorporates input from various state and federal agencies, from other consultants participating in the feasibility study, and from the staffs of both CIRI and Placer Amex.

PROJECT LOCATION

The proposed project is located on the west side of middle Cook Inlet approximately 75 air miles southwest of Anchorage. A general location map is shown in Figure 1.1. The overall project area is bordered on the north and south by the Beluga River and Nikolai Creek and on the east and west by the Cook Inlet and the terminus of the Capps Glacier and the Chichanta River. A project location map is shown in Figure 1.2.

PROJECT DESCRIPTION

The proposed project consists of several components: The methanol plant site, a dock site, a new town site, a construction camp site, and a transportation corridor, as well as the coal mine areas.

The plant site would occupy some 400 acres located about two miles inland from the Granite Point shoreline of Cook Inlet. About half the area would be occupied by methanol processing facilities and the remainder would be for coal handling and general plant grounds.

The transportation corridor is a 300-foot-wide unspecified alignment easement 27½ miles long between the Capps coal field and Cook Inlet. A preferred route has been selected which has a maximum gradient of 2%. A heavy duty railroad line capable of transporting approximately 42,000 tons of coal daily would be constructed to transport coal from the mines in 100-ton cars. Ash would be returned to the Chuitna West mine site in special 80-ton ash handling cars. A 40-foot-wide access road would generally parallel the railroad route within the same easement corridor.

The construction camp site is located about one mile north of the proposed plant site. It would be used to house construction personnel in four quadrants of dormitory style barracks.

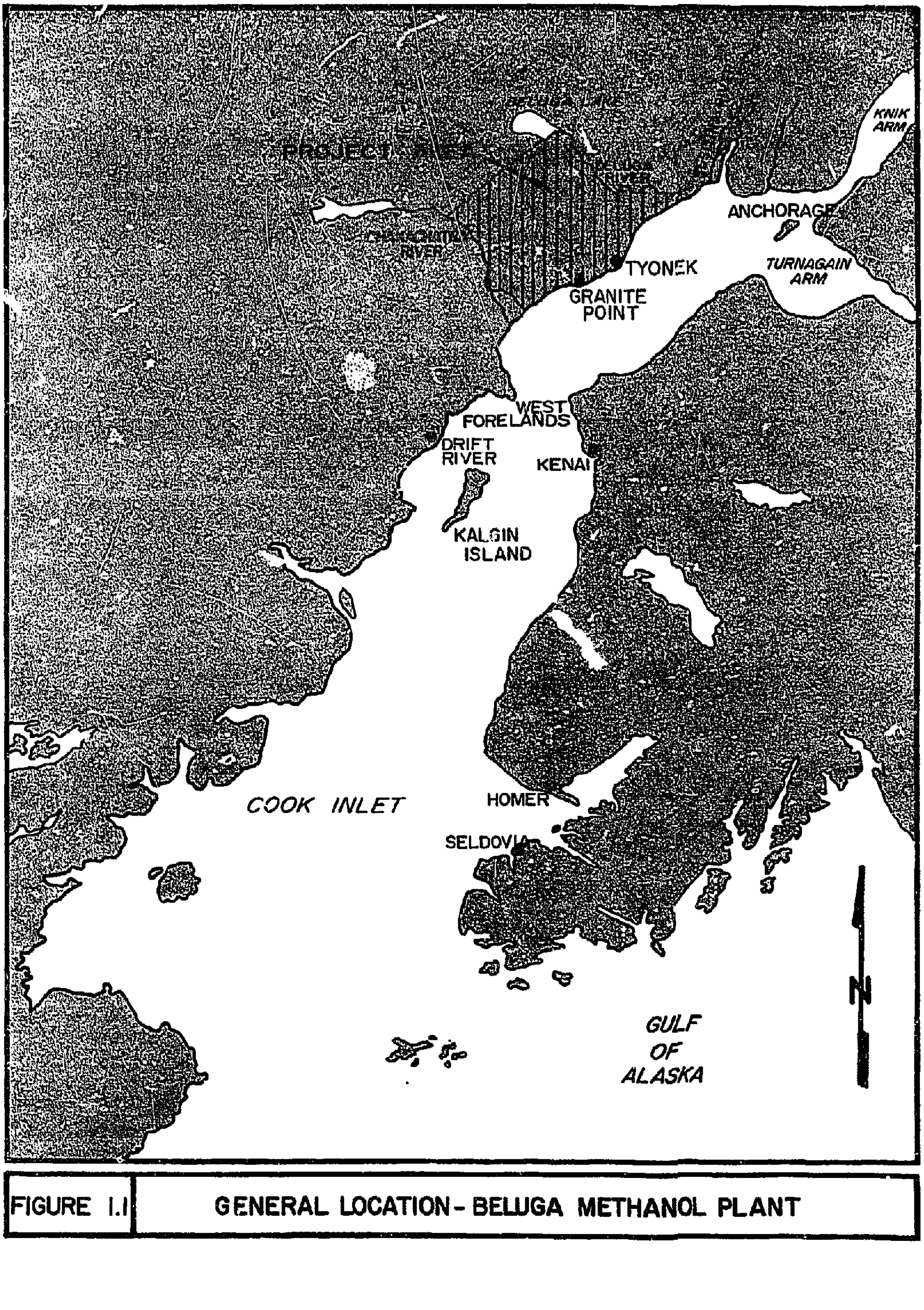


FIGURE I.I GENERAL LOCATION - BELUGA METHANOL PLANT

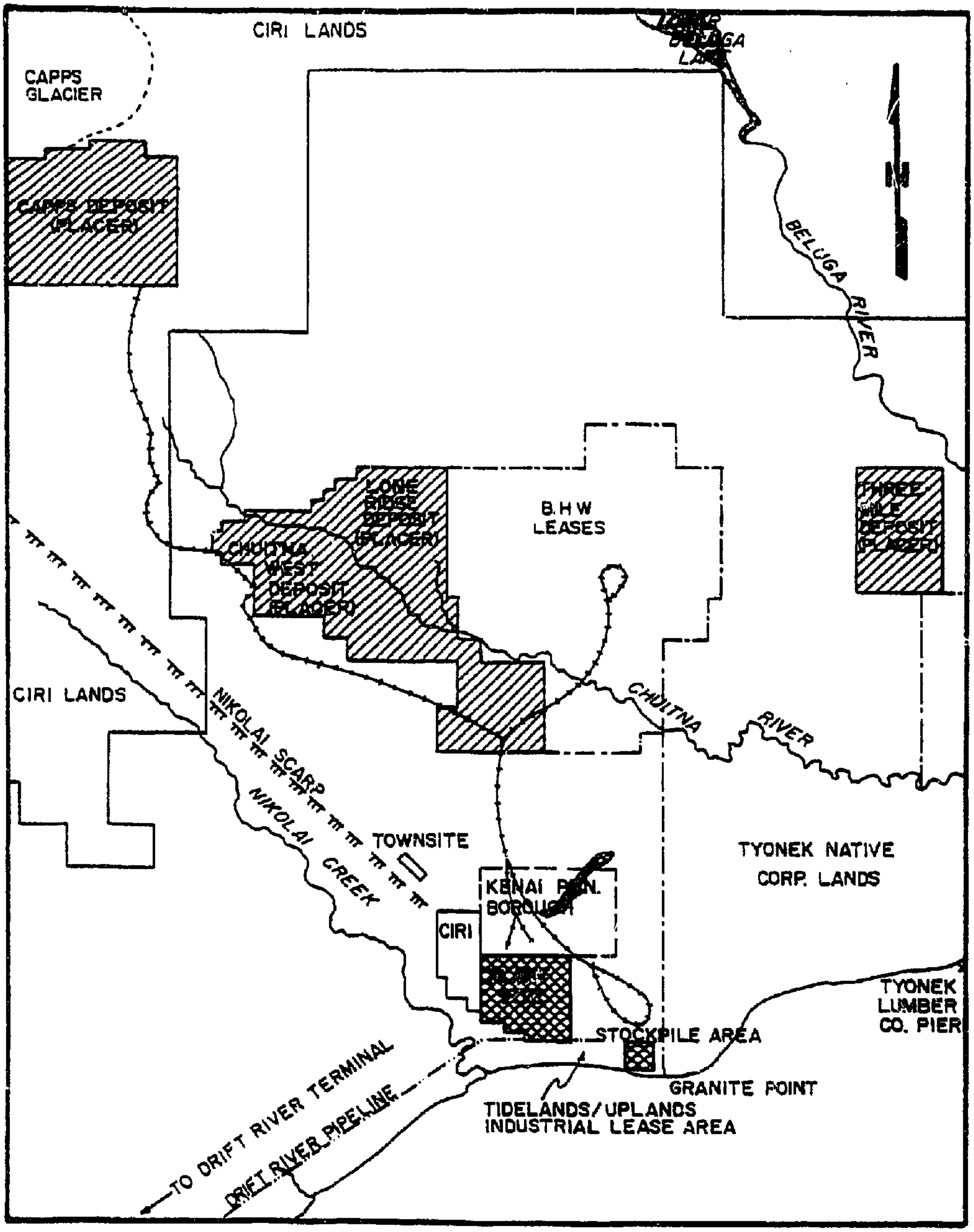


FIGURE 1.2 PROJECT LOCATION MAP (BELUGA METHANOL PLANT)

The town site is an area about three miles northwest of the proposed plant site, which has tentatively been selected for development of a permanent new community in which plant and mine employees and their families could live. It is envisioned that this community would eventually contain all the amenities of a self-sufficient town.

The dock site is an area near Granite Point on Cook Inlet where a permanent dock structure is proposed. The dock's initial use would be to receive equipment and construction materials during the development phase of this project.

Presently mineable coal reserves of the area exceed one billion tons, all within 25 miles of the proposed plant site and deep water in Cook Inlet. The coal is characterized as sub-bituminous (6,500 - 7,500 Btu/lb.), with low sulfur (0.2%), high moisture (25 - 28%), and high ash content (14 - 25%). The rate of coal consumption by the methanol plant would be less than 10 million tons per year. The coal feedstock for this project would be extracted from both the Chuitna Center Ridge mine area and the Capps lease. The coal would be mined open pit with shovels and/or draglines, would pass through a crushing process at the mine and would be transported via railroad a distance of 15 to 25 miles to the coal receiving station at the methanol plant near Cook Inlet.

Following preparation the coal would be gasified utilizing the Winkler procedure followed by the remaining two major processing steps in the production of methanol: syngas upgrading and methanol synthesis (see Figure 1.3). These are commercially proven processing systems currently in operation in various parts of the world. Approximately 80% of the commercial plants now in operation use the methanol synthesis technology proposed for this project. The basic design philosophy has been to select process steps in widespread use with proven reliability which would maximize the possibility for future increases in production with limited additional capital investment. The resulting production of the plant would be approximately 54,000

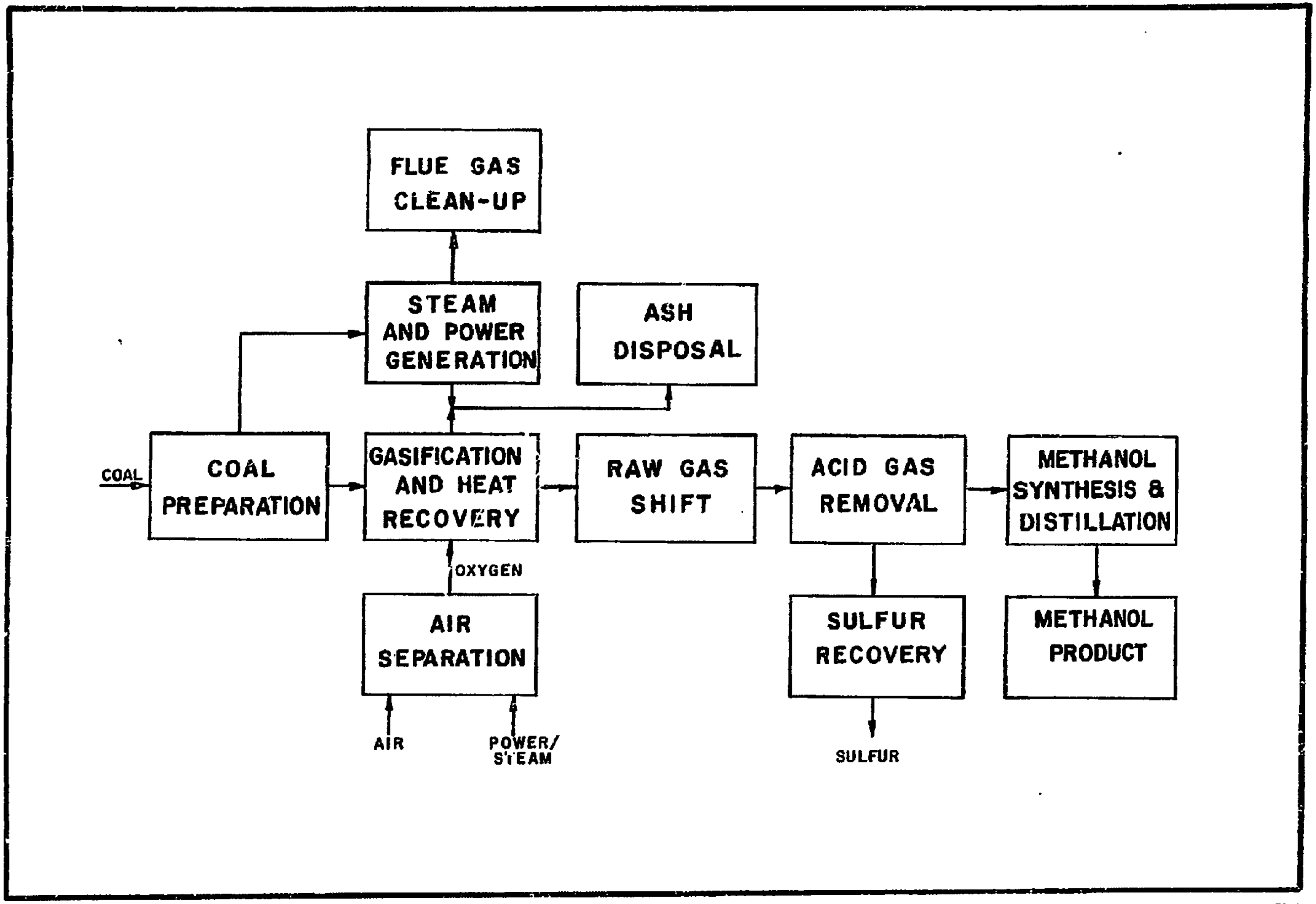


FIGURE I.3	SIMPLIFIED BLOCK FLOW DIAGRAM OF A TYPICAL COAL TO METHANOL PLANT

barrels per day of fuel grade methanol targeted primarily for power plant consumption on the west coast of the United States. The methanol would be batched at the plant and transported approximately 40 miles south via the existing Cook Inlet pipeline to the existing Drift River Terminal currently operated by the Cook Inlet Pipe Line Company. The Drift River marine terminal is a single-berth, fixed-platform, offshore loading facility capable of accommodating tankers up to 70,000 DWT. The methanol would be loaded at this dock and transported by tanker to market.

2.0 SUMMARY OF THE STUDY

METHODOLOGY

General

To achieve the objectives stated in the purpose of the report, a five-step process was utilized:

a. Review all existing data and published environmental and socio-economic information relative to the project area.

b. Supplement the published information with the findings of recent and ongoing land resource projects (conducted primarily by state and federal agencies).

c. Identify specific areas where the environmental data base is insufficient to make meaningful appraisals of the environmental effects and permit requirements of this project. Following this identification, develop, plan and conduct specific field investigations in the highest priority areas.

d. Review the total project design and consider its effect on each major environmental attribute.

e. Summarize the issues and make preliminary findings relative to permit requirements, general environmental acceptability of the project, and environmental factors (data gaps) material to the next stage of planning and development.

Participation by and input from concerned state and federal agencies was encouraged during the course of this work. Briefing meetings were conducted on numerous occasions with the various agencies at both the state and federal levels. Representatives of the U.S. Army Corps of Engineers (COE), Alaska Department of Fish and Game

(DF&G), and federal Fish and Wildlife Service (FWS), Environmental Protection Agency (EPA) and Department of Energy (DOE) visited the project site to review the general project concept and observe the environmental field activities. It has been the intention during the course of this study to encourage as broad a participation as possible and to present the findings in a systematic format that would be compatible with the National Environmental Policy Act outline for an Environmental Impact Statement (EIS). The goal was to produce the data base in a form that could be utilized efficiently to prepare the scope of work for the preparation of an EIS, which would be the next major step in the orderly progression of project permitting. DOWL staff members and consultants as well as personnel from CIRI/Placer Amex also participated in an Adaptive Environmental Assessment program sponsored by the FWS in Anchorage in late July 1981 which focused on the broader aspects of coal development in the Beluga region. Although this study generally addresses the entire project area from the inlet to the coal mine areas, the emphasis of the investigation and field program was on the proposed methanol plant site.

Field Programs

The field program was initiated in the fall of 1980 with a reconnaissance survey of aquatic and terrestrial habitats. In the early spring of 1981, aerial reconnaissance of the general area was undertaken to determine the onset of spring "break-up" and the migratory patterns of moose and emerging bear populations. Following scoping meetings with representatives of CIRI/Placer Amex and Davy McKee, the spring-summer field program was initiated in early May. A summary of the highlights of the activities and the participants is shown in Table 2.1. The field program was designed to address specific gaps in available background information under three general categories:

- Geotechnical (soils)
- Hydrologic (groundwater)
- General Environmental

Table 2.1

BELUGA FIELD PROGRAM
SUMMARY OF PRINCIPAL ACTIVITIES, 1980-81

Dates	Activities	Participants
November 3-7, 1980	Reconnaissance of aquatic and terrestrial habitats	DOWL Engineers, Arctic Environmental Information & Data Center (AEIDC)
May 4 - June 8, 1981	Soils and groundwater investigations including the drilling of 2 water wells and 1 observation well	DOWL Engineers, Alaska Testlab with support of Exploration Services and M-W Drilling
May 2-6, June 1-5, July 13-17, & August 3-7, 1981	Field programs in hydrology, fisheries, wildlife, habitat evaluation of aquatic, terrestrial & marine habitats	DOWL Engineers, with support from AEIDC, Radian Corp. and individual consultants. Included site visits by personnel representing the state DF&G, and the federal FWS, EPA and COE

Under the general environmental program, preliminary work was undertaken to perform reconnaissance surveys of aquatic habitats and determine the presence or absence of fish in the numerous streams in the area; perform reconnaissance surveys of big game distribution (moose and bear); and conduct a reconnaissance survey of the intertidal habitat near the proposed dock location. Other tasks also fell under this general category: vegetation mapping, wetlands determination, socioeconomics, etc.

In this report, the perspective of the current field program must always be considered. The areas of ecological concern for a project of this magnitude varies with the specific activity and the resource concerned. It will only be when the assemblage of baseline data is more complete that the functional relationships of these ecosystems can be understood and habitat values established.

The hydrology and geotechnical programs included drilling two test water wells and an observation well; drilling six test holes; digging 32 test pits; and collecting six grab samples from existing road cuts.

Personnel and/or organizations involved in the field program are shown in Figure 2.1. In addition, contributions from Benno Patsch of Placer Amex and John Ramsey of the Bass-Hunt-Wilson leaseholder group provided valuable insight into the geology and groundwater conditions of the general area. Details as to field methodologies, sample sizes and handling techniques, nature of laboratory tests, and general operational procedures have not been provided as part of the various overviews and summary sections. Numerous state and federal agencies (Table 2.2) were briefed as to the intent and scope of the program, and valuable input was received from many of these agencies.

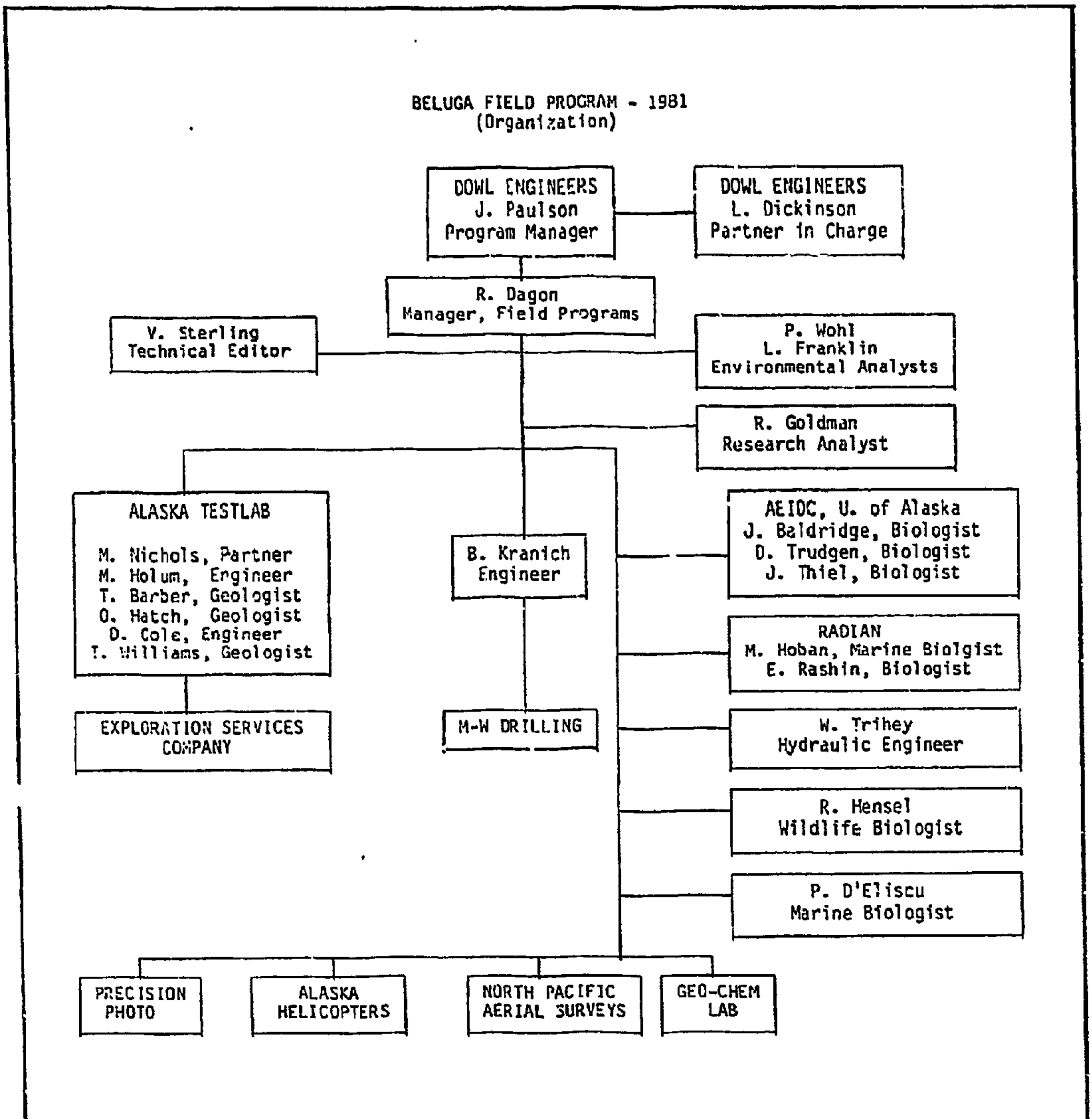


FIGURE 2.1 FIELD PROGRAM PARTICIPANTS

Table 2.2

BELUGA FIELD PROGRAM

AGENCIES CONTACTED OR BRIEFED BY DOWL IN 1981

U.S. GOVERNMENT	
Department of the Army, Corps of Engineers (COE)	- Alaska District, Regulatory Functions Branch
Department of the Interior, Fish and Wildlife Service (FWS)	- Land & Water Resources Development; Biological Services; Environmental Contaminant Evaluation
Department of the Interior, Geological Survey (USGS)	- Water Resources Branch
Environmental Protection Agency (EPA)	- Region 10, Environmental Evaluations Branch
Department of Agriculture, Soil Conservation Service (SCS)	- Susitna Task Force
Department of Agriculture, Forest Service (USFS)	- Forestry Science Laboratory, Susitna Task Force
Department of Energy (DOE)	- Region 10 Representative
STATE OF ALASKA	
Department of Fish & Game (DF&G)	- Habitat; Game Management; Sport Fish; Office of the Commissioner
Department of Community & Regional Affairs (DCRA)	- Division of Community Planning
Department of Commerce & Economic Development (DCED)	- Office of the Commissioner; Director of Industrial Development
Department of Environmental Conservation (DEC)	- Southcentral Region; Division of Environmental Quality; Office of the Commissioner
Department of Natural Resources (DNR)	- Lands; Research; Geological Survey; Water Resources; Office of the Commissioner
Governor's Commission	- Coal Task Force

SUMMARY OF MAJOR ISSUES

Fisheries

The Beluga area, although not one of the major salmon fisheries in Alaska, has three principal drainage systems containing relatively productive fish habitat: Nikolai Creek and its tributaries to the immediate south of the project area; the Beluga River system to the north; and the Chuitna River and its extensive tributary system in between, which flows through major portions of the overall project area. Prior to the 1981 environmental baseline field work conducted for this study, relatively few details were known about the salmon populations in these systems. The system best known is the Chuitna River which supports four species of Pacific salmon (pink, chum, coho and king). Other species of fish (i.e., rainbow trout and Dolly Varden) are also present in these systems. A key environmental issue concerns the fish populations in each of these three areas, primarily the Chuitna River system due to its immediate proximity to the Chuitna mine area. Any water discharges to this river system or development activities near it would involve particularly close scrutiny by the Alaska departments of Fish and Game and Environmental Conservation. Alaska Statute 16.05.870 "Protection of Fish and Game" defines the requirements of one of the major permits that would be necessary to get approval for development activities near a fishery. Principal impacts to the fisheries resource would result from disruption or elimination of habitat in the feeder streams of the principal creeks and the possible disruption of the groundwater that supplies these habitats. Consequently one of the major unknowns that will require extensive exploration is the nature and operation of the ground water regime. There are two major groundwater considerations. It is potentially an operational problem to the mining activities and it has a potential impact on the flows in adjacent streams. A reasonable determination will probably have to be made as to whether alteration of mine area groundwater flows will reduce or deplete flows in important streams and if so how you re-establish the water source. At this time, fisheries are considered one of the key environmental issues relative to opening the coal mine portion of the proposed project. The methanol plant and proposed town site would have no affect on the Chuitna or Beluga river systems but could potentially impact the lower reaches of Nikolai Creek.

Water Source

Operation of a methanol plant requires large volumes of water. The plant process and cooling concept requires approximately 15,000 gpm. Present freshwater surface sources have been ruled out as insufficient, and desalination of Cook Inlet water to fill the freshwater requirement was considered unfeasible due to the extraordinary power requirements. This study confirmed that deep groundwater is available in limited quantities, but even with storage it would be far too inadequate to provide the anticipated supply. An infiltration gallery system in the lower reaches of Nikolai Creek appears to be the most viable alternative for large volumes of fresh water. It appears that this could be done with an acceptable impact on the water flows in Nikolai Creek. The lack of alternate sources, however, and the possible affects on the Nikolai drainage system remain significant development issues to be further defined.

Wetlands

Although wetland areas constitute major portions of the general Beluga area, the plant site area avoids standing bodies of water and appears relatively dry. There is a fairly high water table and the plant site supports types of vegetation representative of a wetland, and for this reason a major portion of the plant site may be considered a wetland by definition. A preliminary determination by the Corps of Engineers, however, indicates that plant development in this area may fall under the jurisdiction of the Corps of Engineers nationwide permit procedure thereby possibly simplifying future permit requirements.

Erosion and Sedimentation

The potential sedimentation from mining activities and runoff during the construction and operation phases of the plant remain an issue of major concern, relative to fisheries. The potential discharge of sediment laden wastewaters may be one of the factors that would prompt the Environmental Protection Agency to require an environmental impact statement for this project. New Source Performance Standards exist for a point wastewater (drainage) discharge from a coal mine, and these discharges would require a National Pollution Discharge Elimination System (NPDES) Permit under the Clean Water Act. An industry which would create potential discharges for which there are New Source Performance Standards can be required to file environmental impact statements. One of the principal concerns, primarily in mining activities, will be sedimentation and its potential impact on existing fishery habitat.

Tyonek Village

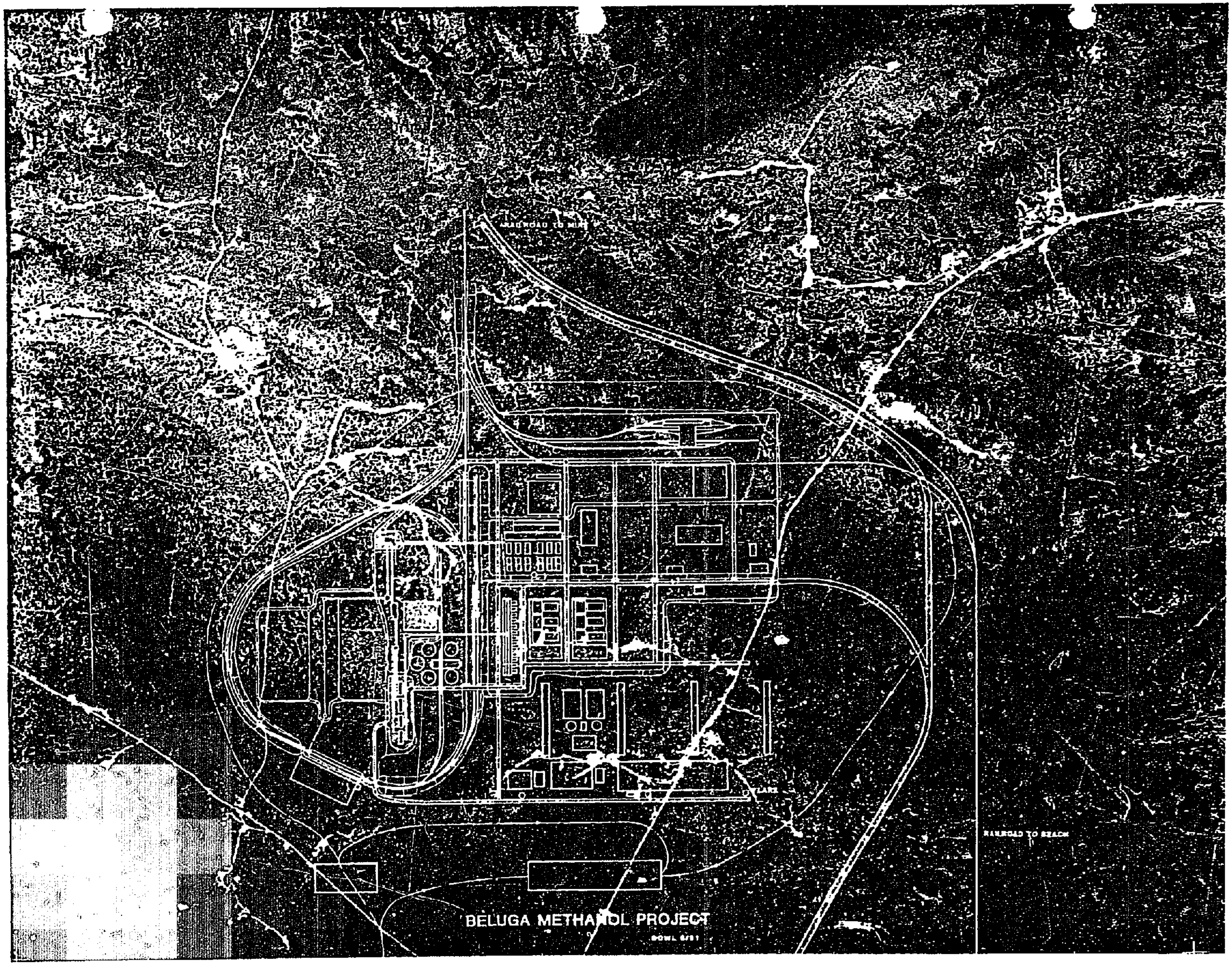
Due primarily to likely cultural changes and the changes to the present subsistence life-style, the neighboring Village of Tyonek generally does not welcome the inevitable growth that would accompany development of one the the state's major energy resources in the Beluga area. Special consideration should be given to the potential socioeconomic conflicts with village residents. Coal development would probably mean that for the first time in their long history, the Tyonek residents would be in the minority in their own region.

Air Quality

The primary air pollutant emitted from the mining operation would be suspended particulates, and from the plant operation it would be products of combustion. The existing air quality of the Beluga area is considered virtually pristine, being relatively unaffected by industrial activities in the Kenai area. Because this project would constitute an introduction of air emissions into a clean air shed, there would be air quality impacts. However, these all should be well within the limits of the air quality regulations under the Clean Air Act.

ENVIRONMENTAL ACCEPTABILITY OF THE PROJECT

Based on the present level of environmental knowledge in the project area and current environmental law and regulations, Cook Inlet Region, Inc./Placer Amex, Inc. should be able to obtain permits for this project and mitigate major environmental concerns with prudent construction and operation practices. The information gathered in the field, previous assessments of the issues in the Beluga area and the periodic involvement and comments of state and federal agency personnel during the course of the on-going environmental studies revealed no single environmental or permit issue which could preclude proceeding with this project. There would be environmental impacts, as with any large project involving land or water resources. However, it appears that if managed properly, an acceptable balance between orderly industrial and social growth and the preservation and enhancement of environmental values can be achieved.


RAILROAD TO BEACH
BELUGA METHANOL PROJECT

AFFECTED ENVIRONMENT (BASELINE DATA)

3.0 GEOTECHNICAL

THE COOK INLET REGION

To understand the geology of the Beluga area, it is necessary to consider a much larger geographic area, and to discuss the geologic events that have occurred in the area over a broad time frame.

Geologic History

The Cook Inlet area has been described as a topographic, structural and sedimentary basin containing 60,000-70,000 cumulative feet of marine and non-marine sedimentary and volcanic rocks ranging in age from Late Paleozoic to Recent (Barnes, 1966). Rocks of Triassic to Recent age outcrop in the Cook Inlet Basin, while older rocks are overlain by an estimated 40,000 feet of sediments. Figure 3.1 shows the sequence or general correlation of sediments occurring in the Cook Inlet Basin.

During Paleozoic and early Mesozoic eras, sediments were deposited in a linear depression occurring in Southeastern Alaska. Volcanic islands and other land masses served as the source of these sediments and reef limestone depositions. Sediments which were deposited at this time include bedded cherts, tuffaceous silts, shales and carbonates. The Triassic (early Mesozoic) rocks outcrop on the southeastern rim of the Cook Inlet Basin near Seldovia. These rocks include limestone, tuff, and banded chert underlain by ellipsoidal lava, slate and graywacke. The thickness of the Triassic rocks in the Cook Inlet Basin is estimated to exceed 2,000 feet.

Jurassic rocks of southern Alaska represent the most complete sequence of this age in North America. During the middle Jurassic,

Figure 3.1

STRATIGRAPHIC COLUMN
UPPER COOK INLET BASIN

ERA	PERIOD	EPOCH	GROUP	FORMATION	THICKNESS (Feet)
CENOZOIC	TERTIARY	Pliocene	KENAI GROUP	Sterling Formation	6,000
		Miocene		Beluga Formation	5,000
		Oligocene		Tyonek Formation	7,000
				Hemlock Conglomerate	1,500
		Eocene Paleocene		West Foreland Formation	3,300
MESOZOIC	CRETACEOUS			Matanuska Formation	8,500
				Matanuska Formation	2,400
				Nelchina Limestone	700
	JURASSIC			Naknek Formation Chinitina Formation	7,200 2,300
			Tuxedni Group		9,700
				Talkeetna Formation	8,400
	TRIASSIC			Unnamed Rocks	1,300

the sediments within the Southcentral Alaska area were tilted, uplifted and/or depressed to form anticlinal and synclinal belts - large linear ridges and troughs. Volcanic activity increased during this time and large batholiths and other intrusions of igneous rocks took shape.

The rocks of Jurassic time comprise the Talkeetna Formation, Tuxedni Group, and Chinitna and Naknek formations, and are widely distributed along the western shores of Cook Inlet and the Matanuska Valley. These formations contain rocks predominantly consisting of tuff and volcanic agglomerates in lower, older sections. The Talkeetna Formation is composed of volcanic detritus containing fossil plants and marine invertebrates, and is estimated to be several thousand feet thick. The middle Jurassic Tuxedni Group consists of sandstone, shale, conglomerate, and arkose with an estimated thickness of up to 7,000 to 10,000 feet.

The Chinitna Formation, composed of several thousand feet of red and dark argillaceous marine shales, is dated upper Jurassic and lies conformably on the Tuxedni Group. The Chinitna Formation is comformably overlain by the Naknek Formation. The Naknek Formation is the uppermost of the Jurassic system and consists of a basal conglomerate overlain by shales, arkose, and sandstone. The formation ranges in thickness from 2,000 to more than 7,000 feet.

During the early Cretaceous era the seas of the Jurassic era shallowed and the land rose. This emergence of land masses caused increased erosion in some areas and less deposition in other areas, causing a linear structural belt. The rock formations associated with the Cretaceous era include a limestone unit referred to as the Nelchina Formation; the Matanuska Formation which consists of shales, siltstone and sandstone sequences; and the Arkose Ridge Formation, consisting of well indurated arkose and conglomerate.

The rocks which comprise the Kenai and Chugach mountains probably also were formed during the late Cretaceous era. The strata consists primarily of slate and graywacke which has been intensely deformed and metamorphosed. Considerable volcanics and ultra-basic intrusions also are present, but these are considered to be late additions to the area. More than 30,000 feet of sediments were deposited from the time of the late Paleozoic era to the early Mesozoic era. This period of deposition was followed by a period of uplift, erosion and mountain building. The Alaska range was also formed during this period of mountain building, by large-scale batholithic intrusions.

In early Tertiary time a change occurred in Southcentral Alaska. As the Chugach and Kenai mountain ranges began to emerge, the seas were closed off and a fresh-to-brackish water basin was created. It was within this basin that the extensive formations of the Tertiary were laid down.

Formation of Coal Bearing Units

During early Tertiary time a narrow, deep basin, some 200 miles long and 70 miles wide, formed in the area now known as Cook Inlet. It was in this basin that more than 26,000 feet of non-marine sediments were deposited during repetitive cycles of clastic sedimentation alternating with coal swamps. In addition, considerable igneous activity occurred in the northern part of the basin.

The formations deposited in the Cook Inlet Basin vary within the basin. In the Matanuska Valley, the northern part of the basin, the Tertiary sequences include three formations: The Chickaloon, Wishbone and Tsadaka. The Chickaloon Formation, deposited in the Paleocene epoch, consists of more than 5,000 feet of non-marine clastic sediments including many beds of bituminous coal, and random intrusions of igneous stocks, sills, and dikes. The Chickaloon Formation is conformably overlain by the Wishbone Formation. This late Paleocene/early Eocene formation consists of a sequence of coarse clastic, non-marine sedimentary rocks, and is about 3,000 feet thick. The Tsadaka Formation, a sandstone and conglomerate of more than 1,000 feet thick, rests with angular unconformity on the Wishbone and Chickaloon formations.

Outside the Matanuska Valley and in the southern portions of the Cook Inlet Basin including the Beluga area, the Kenai Group is the primary sequence of sediments. The Kenai Group is a mixture of conglomerates, sandstone, siltstone, claystone and coal deposits and has been divided into five formations: The West Foreland, Hemlock Conglomerate, Tyonek, Beluga and Sterling formations. Of these, three are significant with respect to energy resources. All of the oil, gas and proposed coal production within the Cook Inlet Basin originates from the Kenai Group. Oil production comes from the Hemlock and lower Tyonek formations, gas production from the Beluga Formation (minor amounts from the Sterling Formation), and proposed coal extraction would be primarily from the Tyonek Formation. Figure 3.2 illustrates the stratigraphic sequence of the Kenai Group as proposed by Calderwood and Fackler (1972).

The lowest member of the Kenai Group is the West Foreland Formation, a tuffaceous siltstone and claystone. There are also scattered lenticular beds of sandstone and conglomerates within this formation. The West Foreland Formation rests unconformably on older Tertiary, Cretaceous and Jurassic rocks, and varies in thickness from a few hundred feet to more than 1,000 feet.

The Hemlock Formation is the principal oil horizon in the basin. It is composed of poorly to moderately sorted sandstone and conglomerate, with interbedded carbonaceous siltstone, shale and coal. The Hemlock Formation varies in thickness from a few hundred feet to about 1,000 feet.

The middle member of the Kenai Group is the Tyonek Formation. It is a massive unit varying in thickness between 4,000 feet and 8,000

Figure 3.2

PROPOSED STRATIGRAPHIC NOMENCLATURE FOR KENAI GROUP

ERA	PERIOD	GROUP	FORMATION	DESCRIPTION
CENOZOIC	QUAT.		Alluvium and Glacial Deposits	
	TERTIARY	KENAI GROUP	Sterling Formation	Massive sandstone and conglomerate beds with occasional thin lignite beds and gray clay
			Beluga Formation	Claystone, siltstone and thin sandstone beds, thin sub-bituminous coal beds
			Tyonek Formation	Sandstone, claystone & siltstone interbeds and massive sub-bituminous coal beds.
			Hemlock Conglomerate	Sandstond and conglomerate.
			West Foreland Formation	Tuffaceous siltstone & claystone. Scattered sandstone & conglomerate beds.
		Rests unconformably on older Tertiary, Cretaceous and Jurrasic rocks		

Source: Calderwood and Fackler, 1972

feet, and is composed of alternating lenticular beds of sandstone, siltstone and claystone, with massive sub-bituminous coal beds. Overlying the Tyonek Formation is the Beluga Formation. It varies in thickness to a maximum of about 6,000 feet and is primarily claystone and siltstone interbedded with thin sandstone beds and sub-bituminous coal.

The upper unit of the Kenai Group is the Sterling Formation which varies in thickness to about 11,000 feet. It consists primarily of massive, fine to medium grain, unconsolidated sandstone and conglomerate with occasional thin beds of coal and gray claystone.

SURFICIAL SOILS

The landscape in the Beluga coal fields and proposed methanol plant area is dotted with unconsolidated Quaternary deposits which mask the underlying structures and bedrock. These deposits include glacial morainal and outwash deposits; alluvium in stream valleys; and talus and landslide masses. The thickness of Quaternary deposits varies to a maximum of 300 feet. This variation in thickness is due primarily to irregular deposition on a surface of considerable relief, and post glacial erosion.

Shallow discontinuous glacial debris consisting of gravel, sand, and silt was deposited over the bedrock of the Kenai Group during the Quaternary. These deposits include a complex system of lateral and ground moraines deposited by the numerous glaciers which have scoured the area. Lateral moraines are parallel to the Nikolai escarpment and then broaden into kames and ground moraines. The glaciers which deposited these sediments extended southeastward across Cook Inlet almost to Boulder Point on the Kenai Peninsula. Isolated eskers also dot the area.

Other surficial soils are a result of Holocene marine deposition. It is thought that the Chakachatna River and McArthur River region, south of the Nicholai escarpment and the Chuitna River, is the setting of Recent (Holocene) marine deposition. The most recent and near surface deposits are probably tidal or estuarine shallow water sediments, primarily of fine grain. These sediments include sandy beach deposits, silty/sandy lagoon and outwash deposits, and silt and clay tidal, estuarine, or shallow marine deposits.

Pond and bog deposits of Holocene age dot the post-glacial deposits in discontinuous depressions. These deposits, chiefly peat and other organic debris, also contain silt, clay and fine-grain sands. There are also several thin beds of volcanic ash. The pond and bog deposits can be found in areas of poor drainage where the ground is soft and wet except when frozen in winter.

Landslide deposits are found in several areas within the vicinity of the Beluga coal fields. They are generally comprised of slumped beds of the Kenai Group and occur along the steep slopes of the upper Chuitna Valley and other locations where slopes have been over steepened by erosion or mountain building. A large landslide of approximately six square miles in area is located on the east-facing slope of the valley below the Capps Glacier. Another massive landslide extends for about two miles along the west ridge of the Beluga River near Felt Lake.

THE BELUGA AREA

Topography

The proposed methanol plant site, townsite, construction dock, and transportation corridor areas are located on the west shore of Cook Inlet. The Cook Inlet-Susitna Lowlands form an intermontane province between the Aleutian Range and the Kenai-Chugach mountains of the coast range.

The topography of the western shore of Cook Inlet is generally characterized by high glaciated mountains dropping rapidly to a glacial moraine/outwash plateau which slopes gently to the inlet. The outwash/moraine deposits generally begin at an elevation of 2,500 feet and drop to tidewater in about 30 to 50 miles. The beach area often consists of either a steep (1:2) escarpment which may be 50 to 120 feet high and which is caused by beach erosion of glacial deposits, or it may be composed of extensive mud flats. The upper portion of Cook Inlet is relatively shallow and the submarine topography slopes at only a few degrees.

The proposed development sites are on the Nikolai moraine, which runs southeast from the vicinity of the Tordrillo Mountains and has been mapped as extending across Cook Inlet to the Kenai Peninsula (Schmoll, et al., 1981). A well defined escarpment (Nikolai escarpment) marks the southwestern edge of the moraine, but the northeastern edge (Susitna escarpment) is cut by numerous streams and is not as steep or distinct. The surface of the moraine is generally of low relief, and in the vicinity of the proposed plant there are numerous level areas containing peat bogs. Relief is generally 50 feet or less in this area.

Stream channels are deeply eroded and may be hundreds of feet deep. Slopes along the eroded stream channels and near the mountains often exceed the maximum angle of repose of soil, and numerous landslides have occurred, some of which cover areas of more than five square miles. Bluffs along eroding rivers such as the Chuitna, and along tidewater have also been unstable. However, the proposed methanol plant site is on the upper portion of the moraine and has little slope except near the escarpment. The escarpment is generally stable near the plant site. Maximum slopes are approximately 10°

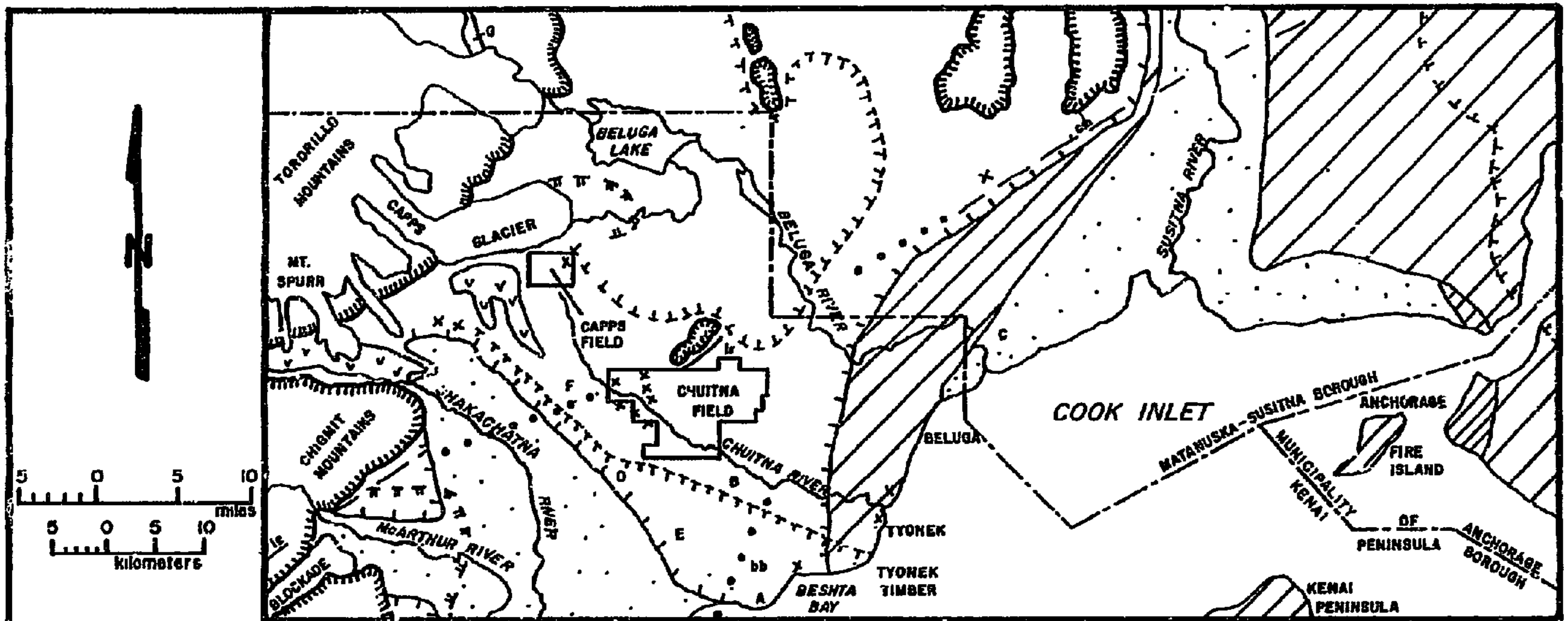
except at small eroded areas and at the base of the escarpment where the slope is about 20°.

Geology

Extensive reconnaissance geologic mapping, most recently by H.R. Schmoll and others (USGS 1980), has resulted in a detailed geologic map in the vicinity of the proposed development, shown on Figures 3.3 and 3.4. The town and plant sites are on the Nikolai moraine, and the construction dock site is on the submarine extension of the moraine. The moraine consists of a complex group of ground and lateral moraines with numerous kames and eskers.

The moraine appears to lie in contact with sedimentary Tertiary rocks, but subsurface conditions have not been extensively investigated. The depth to bedrock is not accurately known, although gas and water wells have been drilled in this area. The age and extent of the moraine are unresolved. It appears to be slightly older than many of the other moraines in Cook Inlet which formed about 10,000 years ago during the last major glacial retreat. No lacustrine or marine deposits are known to underlie the moraine, and hence it may have formed earlier than the extensive lacustrine/marine Bootlegger Cove clay which underlies much of upper Cook Inlet and which has been dated as 10,000 years old. Test Well #2, which was drilled at the plant site during the 1981 field program, indicated some fine sand at depths below 200 feet, but the samples were obtained by wash boring, which may have produced nonrepresentative samples. The log of Test Well #2 appears in Section 4.0 HYDROLOGY.

The Nikolai moraine is bounded on the southwest by the Chakachatna-McArthur embayment, an area containing Recent alluvial and marine deposits of sand and silt. Coarse material is generally found at higher elevations in the embayment, and gray silt is found near tidewater. No soils exploration was conducted in this area, but



Margin of mountains and hills underlain by pre-Tertiary metamorphic rocks and igneous rocks mainly of early Tertiary age.

Margin of plateau underlain by sedimentary rocks of Tertiary age.

Glacial and marine deposits of Pleistocene age; Bootlegger Cove clay present in area of more widely spaced diagonal lines, overlain by gravel, sand, or peat.

Alluvial and tidal sand, silt, and gravel of Holocene age.

Areas underlain by semiconsolidated volcanic debris flows late Tertiary or Quaternary in age.

Outer limit of moraines of early Holocene age.

Outer limit of prominent moraines of late Pleistocene age.

Major fault zones (dotted where less certain): bb, Bruin Bay; cm, Castle Mtn.; lc, Lake Clark; lr, Lone Ridge.

SELECTED LOCALITIES:

- A Granite Point
- B young landslides
- C Beluga River mollusk - shell locality
- D possible area of gravitational spreading
- E surface-exposed volcanic clasts in diamicton (till?) Stedatna Creek area
- F soft ground along access trail
- G Strandline Lake
- x Selected areas of extensive landsliding

FIGURE 3.3 GENERALIZED PHYSIOGRAPHY AND GEOLOGY OF THE BELUGA AREA, ALASKA

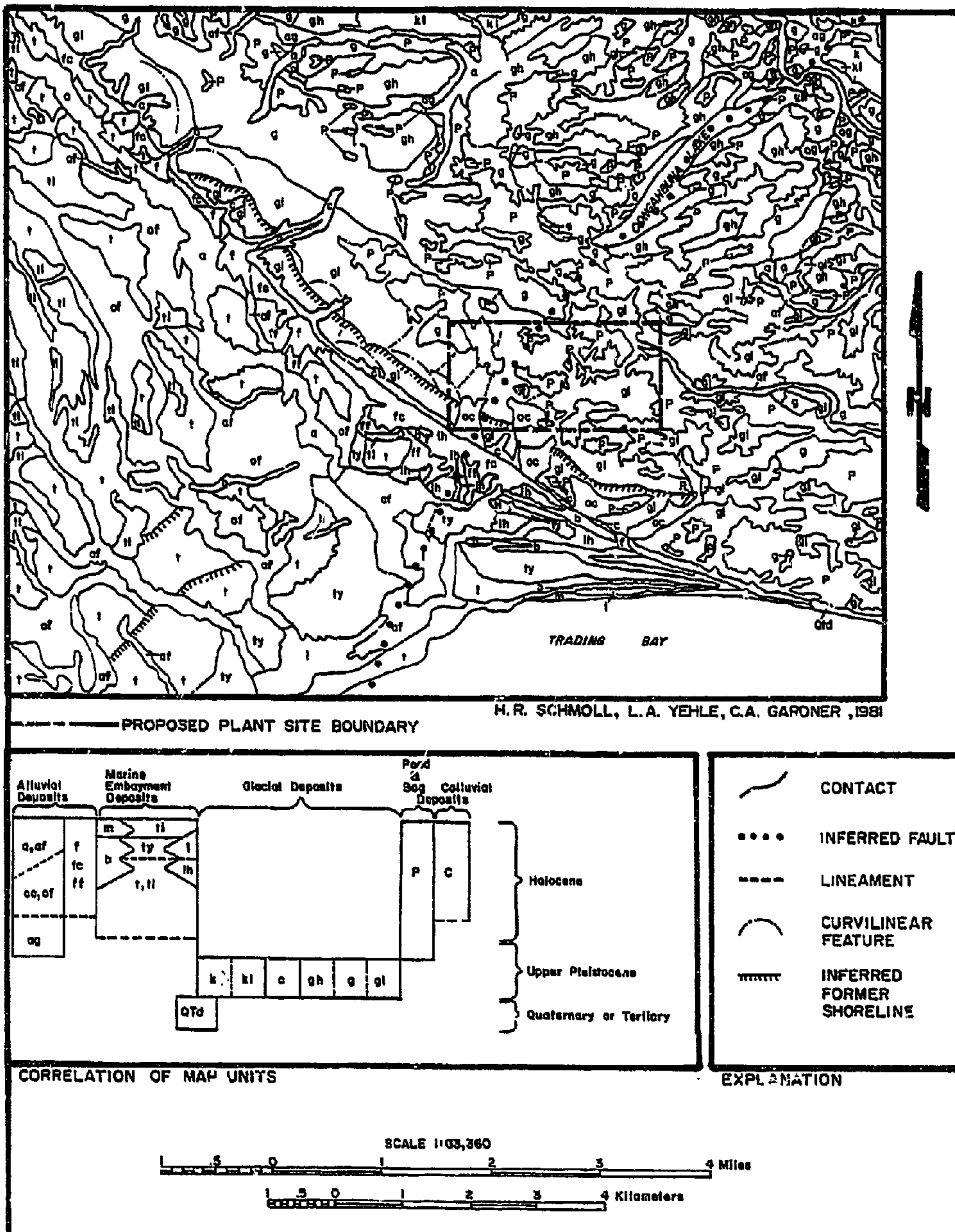


FIGURE 3.4 PRELIMINARY GEOLOGIC MAP OF THE CONGAHBUNA AREA, COOK INLET REGION, ALASKA

water well drillers have indicated that coarse material overlays fine-grain-material near the Nikolai escarpment. The layer of coarse material becomes thinner west of the escarpment. In Test Well #1, which was drilled west of the proposed town site at Nikolai Creek, coarse material was encountered to 85 feet and silt was found below 85 feet.

The Chuitna River approximately follows the northeast boundary of the Nikolai moraine, but this edge is cut with numerous stream channels and forms an indistinct boundary. This area exhibits no evidence of recent glaciation and appears to be a long-established drainage channel for runoff from the Nikolai and adjacent moraines. Hence, the area contains well washed alluvium with a small amount of fines and is generally a good source of aggregate.

The Nikolai moraine has been mapped as extending across Cook Inlet. The area to the south of the moraine, which forms the present beach, consists of a thin deposit of fine sand and silt over very dense moraine type material. The proposed dock area appears to be underlain by a dense soil exhibiting properties similar to that of the onshore moraine.

The Nikolai moraine consists of a complex group of ground and lateral moraines with numerous kames and eskers. It is composed of very dense diamicton including boulders up to 10 feet or more in diameter. The diamicton exhibits well to obscure bedding and contains layers of volcanic clasts, sandstone, siltstone, and at one location east of the site, coal. The diamicton may be generally characterized as a silty sand although numerous inclusions of silty sandy gravel and sandy silt were observed. The very dense diamicton was only observed at ground surface along steep bluffs, but drilling revealed similar soil at several sites on the moraine. Numerous deposits of clean sand and boulders were also found, often in distinctly bedded planes. The upper soils have been mapped as more recent moraine deposits.

Alluvial deposits of sand and gravel are found in broad channels along the moderate slopes near the plant site and consist of material which is less dense and which contains less fines than the surrounding moraines. These areas (OC material in Figure 3.4) may present loose soil conditions. Test Pit 7 was placed in this area.

Peat generally covers the moraine and is usually at least one foot thick except upon eroding surfaces and may be 10 feet thick or more on level, poorly drained areas. Vegetation was observed to have little correlation with peat depth. Large black spruce, cottonwood, and birch were observed to grow on peat which was more than 10 feet thick.

Surface water is relatively high in areas with peat bogs, which includes the top of the moraine and most of the plant site, but many wells in the vicinity of Tyonek and elsewhere on the moraine indicate a water table at depths of 30 to 50 feet or more. Surface water drainage is impeded by the layer of organic material and organic silt immediately below the peat. During soil exploration drilling, water was encountered at depths which varied from 0 to more than 24 feet. The deeper water levels were observed in areas with little or no peat.

SITE CHARACTERIZATION

Methanol Plant Site

Most of the subsurface exploration was performed along the existing road system (Figure 3.5).

- Topography

  The site lies entirely upon the Nikolai moraine and generally slopes to the south at a rate of about 50 feet per mile. The

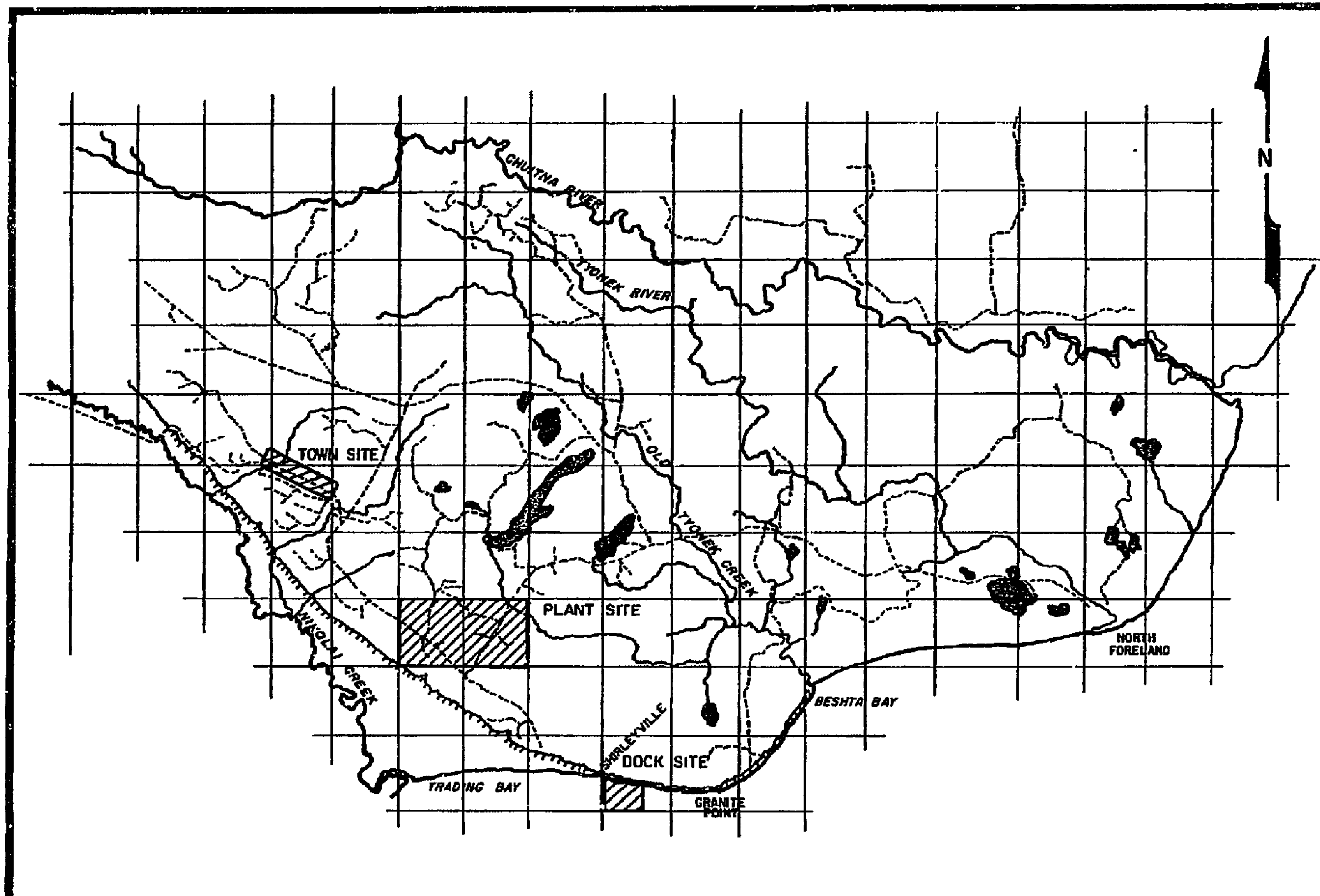


FIGURE 3.5 VICINITY MAP, CIRI/PLACER-AMEX, METHANOL PLANT

maximum elevation is about 350 feet. The southwest section of the site approaches the Nikolai escarpment and has slopes of up to 10% or more.

The topography of the area is characterized by low moraines structures with relief of less than 50 feet set among nearly level peat bogs. This topography changes to one of increasing slope with steeply eroded stream channels along the south and southwest portions of the site.

° Subsurface Conditions

Existing information on subsurface conditions was expanded with a field program that included backhoe excavation of 32 Test Pits (TP1 through TP32); drilling nine Test Holes to depths up to 50 feet (B1 through B9); and taking six grab samples from existing road cuts (G1 through G6). Logs of borings from two test water wells (Well #1 and Well #2) and from one observation well (Well #3), which were drilled during the 1981 field hydrology investigation for this study, also provided data. Locations of test pits, borings, and grab samples are shown on Figures 3.6 and 3.7. These investigations indicate the subsurface conditions at the site consist of an upper layer of peat of varying depth (Figure 3.8) underlain by very dense silty sand and hard sandy silt. One to three feet of organic silt may also be found beneath the peat. Layers of clean sand are present occasionally, and cobbles and boulders are encountered frequently. Logs for a typical test hole and test pit are shown in Figures 3.9 and 3.10. The upper soil contains large amounts of boulders, cobbles, and angular sand and gravel. These angular particles differ from the deeper soil which contains subangular to moderately rounded fragments.

Although both types of material appear to be glacially transported, sources and distance to the sources may differ for each group. The silty sand resembles the diamicton exposed along the steep

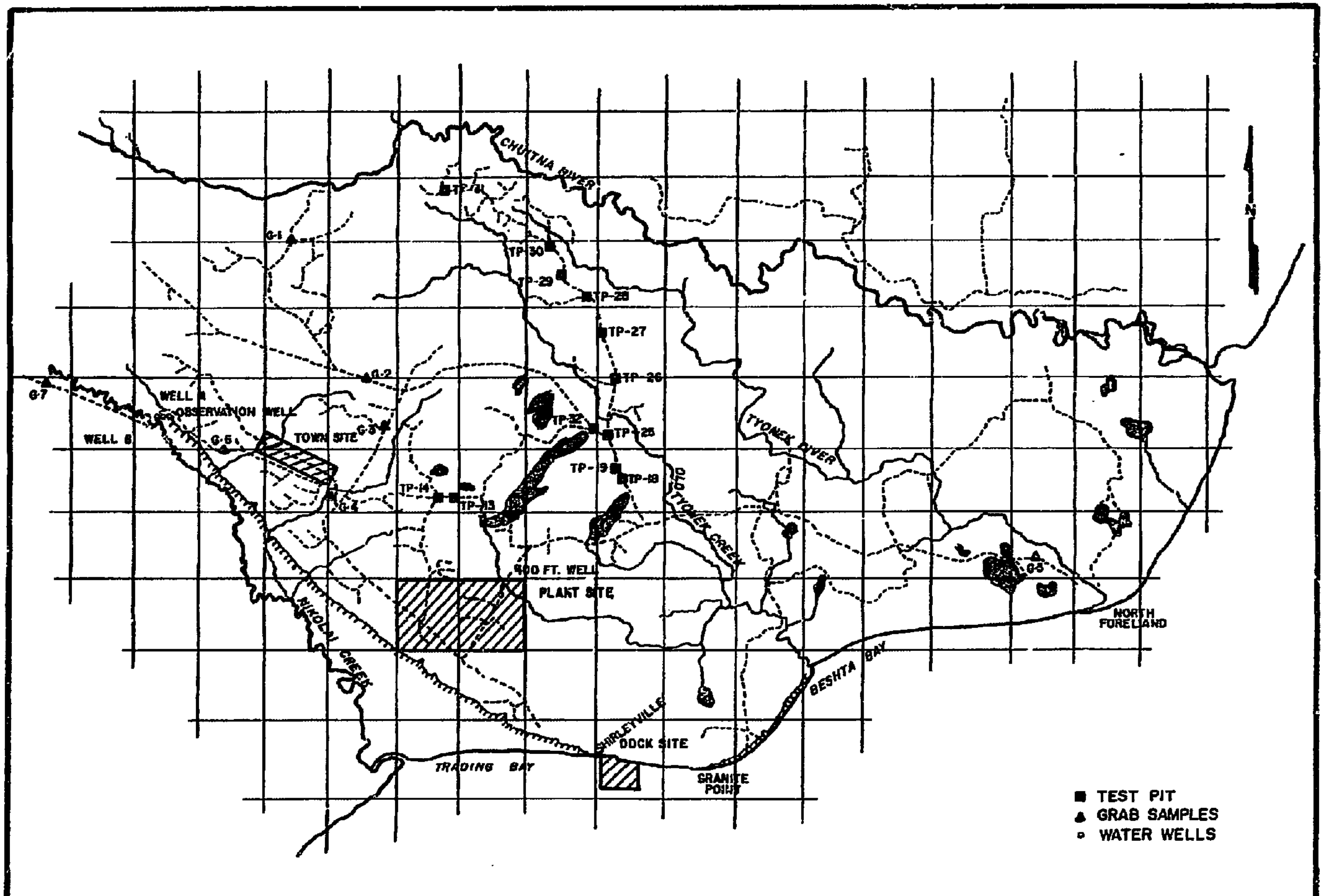


FIGURE 3.6 SOIL SAMPLES AND WELL LOCATIONS, CIRI/PLACER-AMEX, METHANOL PROJECT

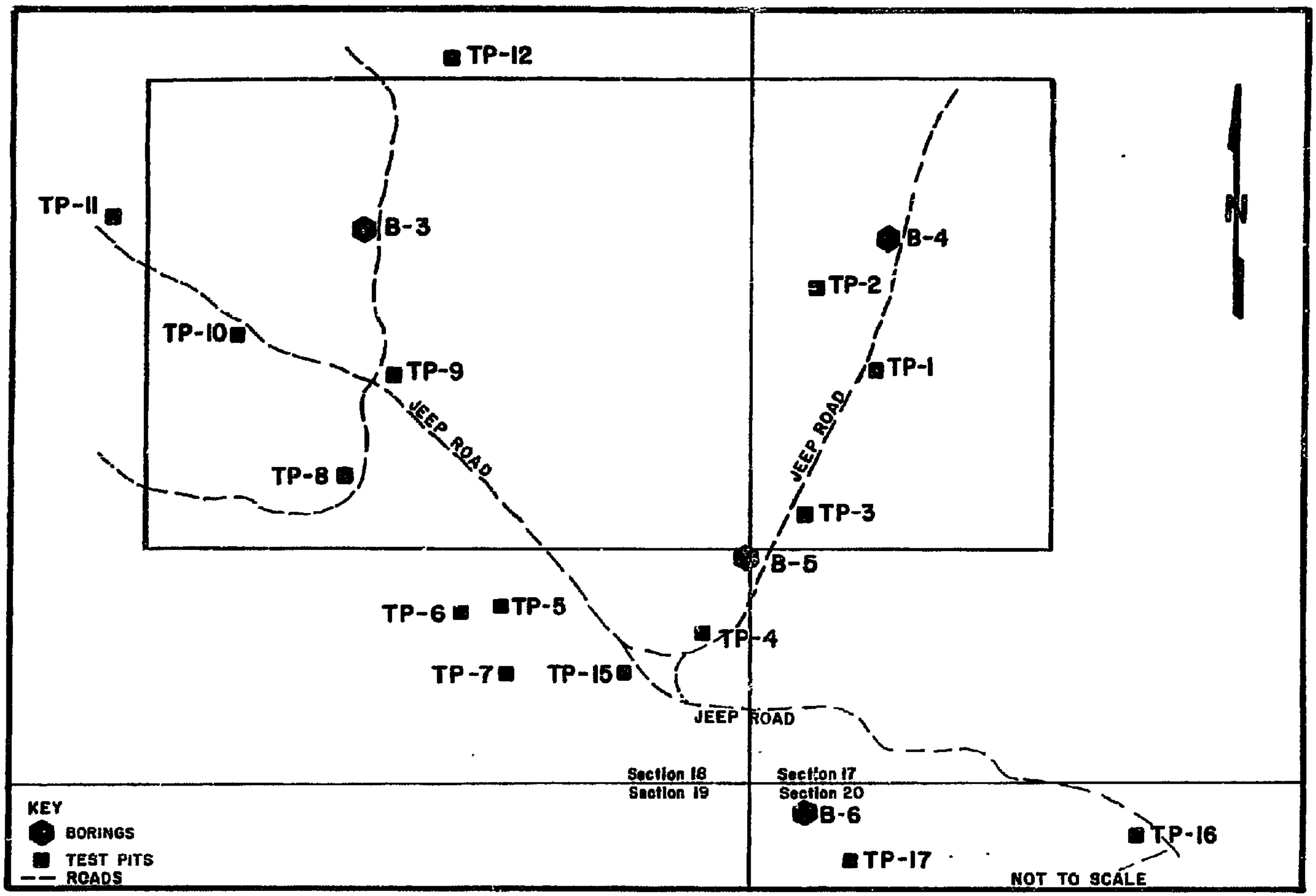


FIGURE 3.7 LOCATIONS OF SOIL TEST (CIRI/PLACER-AMEX PLANT SITE)

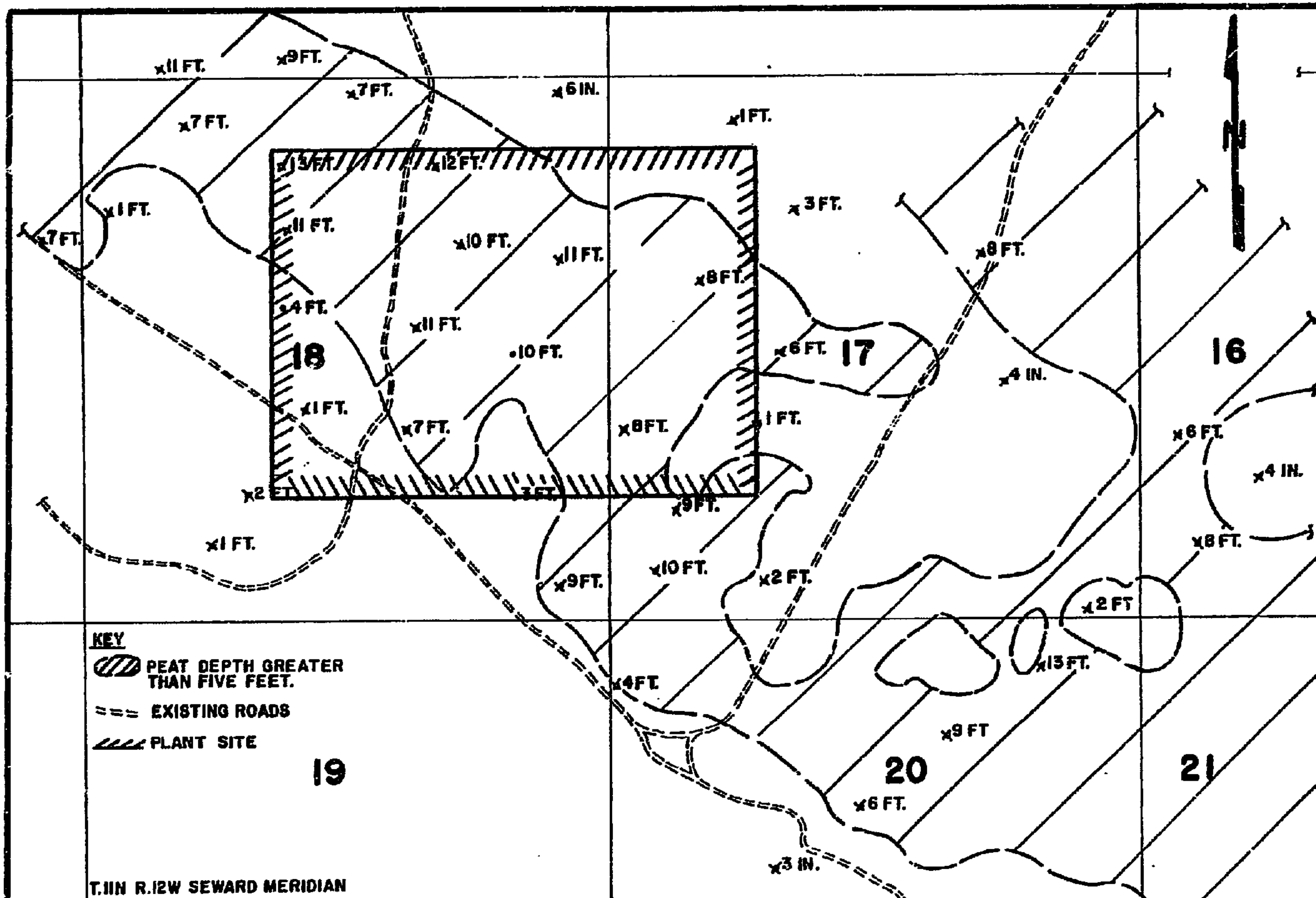


FIGURE 3.8 IDEALIZED PEAT DISTRIBUTION METHANOL PLANT AREA

W.O. NO. D13131
LOGGED BY O. H.

BORING 3 - PLANT

ELEVATION = 334'

DEPTH (FEET)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	OTHER TESTS	N (BLOWS/FT)	DESCRIPTION	DEPTH
0					BROWN PEAT, SATURATED, SOFT (PT)	
5				2		
10				1		
13.0					F-4, BROWN TO GREY SILT AND ORGANIC SILT WITH RANDOM GRAVEL, SOFT (OL ML)	13.0'
15				9		
17.0					F-2, BROWN SILTY GRAVELLY SAND, MOIST, DENSE (SM)	17.0'
20			MA	174		
23.5					NFS/F-2, GREY GRAVELLY SAND AND SANDY GRAVEL, SATURATED, VERY DENSE (SP)	23.5'
25				100		
30				100	BOTTOM OF TEST HOLE = 30.0'. COMPLETED 5/15/81.	30.0'

KEY
PP = UNCONFINED COMPRESSIVE STRENGTH (PENETROMETER) (TSF)
TV = SHEAR STRENGTH (TORVANE) (TSF)
MA = MECHANICAL ANALYSIS
LL = LIQUID LIMIT (%)
PI = PLASTIC INDEX
- GRAB SAMPLE
- SPT SAMPLE
- 2.5" I.D. SPOON SAMPLE 340# WEIGHT, 30" FALL
- SHELBY TUBE - PUSHED
- GROUND WATER TABLE WHILE DRILLING

DOWL

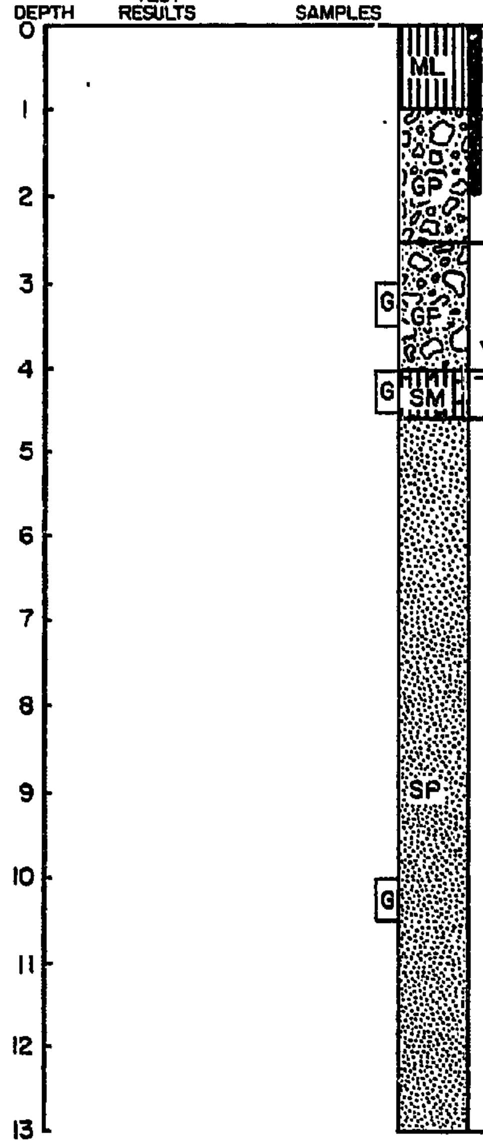
LOG OF BORING

FIGURE 3.9

TEST PIT 9

WORK ORDER D13132
LOGGED BY T. Barber

DOWL



DEPTH	ELEVATION= N E	DEPTH
0–1.0	F-4, BROWN SANDY SILT, (TOPSOIL)	1.0'
1.0–2.5	F-1, BROWN SILTY SANDY GRAVEL, SUBROUNDED 3" GRAVEL	2.5'
2.5–4.0	NFS, BROWN TO GREY SANDY GRAVEL, 4" SHARP AND SUBROUNDED GRAVEL	4.0'
4.0–4.5	F-2/F-3, GREY VERY SILTY SAND AND VOLCANIC ASH MIXED, WET TO SATURATED, MEDIUM DENSE	4.5'
4.5–13.0	F-2, GREY SILTY GRAVELLY SAND, SUBROUNDED GRAVEL, 10" COBBLE, WET TO SATURATED, VERY DENSE	13.0'

BOTTOM OF EXPLORATION = 13.0'

TEST KEY:

W = MOISTURE CONTENT
LL = LIQUID LIMIT
PL = PLASTIC LIMIT
MA = MECHANICAL ANALYSIS

LOG OF TEST PIT

bluffs. It is very dense as shown by the standard penetration blow counts in excess of 100, and consists of poorly graded, brown silty sand with gravel. A gradation curve for a sample from Test Hole 3 is shown in Figure 3.11. The sandy silt is hard, nonplastic to slightly plastic, and contains some gravel. No clay was found on the site.

A layer of volcanic ash was observed close to the bottom of the peat layer and resembles reddish brown silt. This layer is less than one foot thick.

- Groundwater

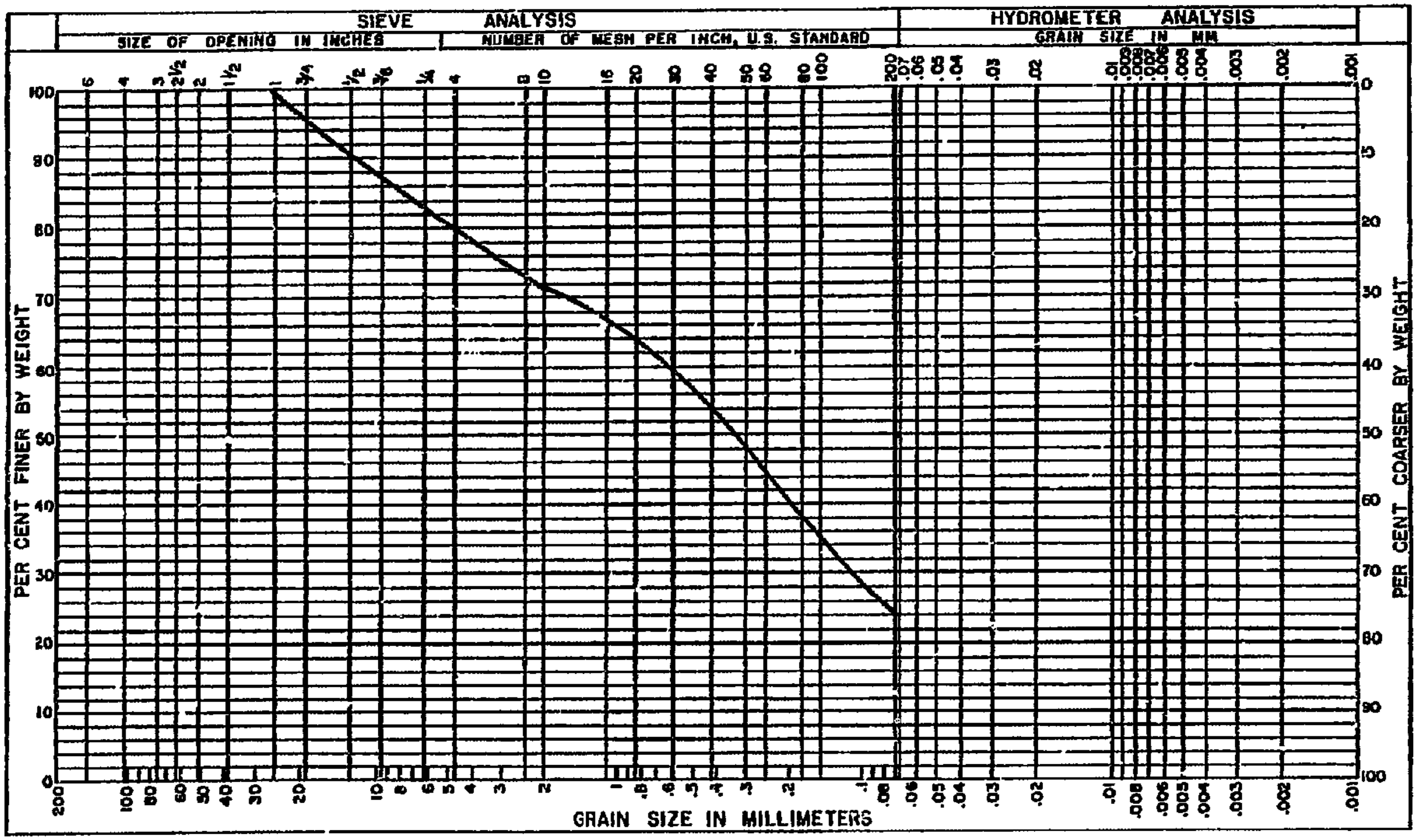
Groundwater is near the surface due to the high water level in the peat. Water level depth increased north of the site in areas with little peat and along the southern bluff. Well drillers indicated artesian conditions may exist in deep, water bearing strata. Groundwater is discussed in more detail in Section 4.0 HYDROLOGY.

Permeability of the dense silty sand is low (estimated to be .0001 inches/second or less), but the occasional layers of poorly graded, clean sand have moderate to high permeabilities. Estimates of the coefficient of permeability for this material range from 1 to .001 inches/second. However, these highly permeable layers are not expected to be large in area, and well pump tests also indicate limited aquifer extent.

Steeply eroded stream channels provide surface water drainage. These channels also are found in the peat bogs, where they may be 5 to 10 feet deep.

- Plant Site Conditions

The inorganic soils in the plant site are medium dense to very dense and offer generally excellent foundation conditions, but



KEY	LOCATION	SAMPLE NO.	DEPTH	UNIFIED CLASS.	FROST CLASS.	SOIL DESCRIPTION
————	TH 3.	4	--	SM	F-2 esti.	Silty Gravelly Sand

W.O. D12780

FIGURE 3.11 GRAIN SIZE DISTRIBUTION — GRADATION CURVE these soils are often covered with peat and/or organic silt to depths up to 13 feet (Figure 3.8). The peat is generally unacceptable foundation material although limited service roads may be constructed on it using deep gravel overlays. Peat depths are deep near the middle of the site, and become shallower along the northern and southern boundaries. Existing roads were generally placed in areas with little peat.

The dense inorganic soil has good stability and a very low potential for settlement or liquefaction. Soil bearing capacity is good, generally in the range of 4,000 to 8,000 lbs. per square foot. However, the very dense, coarse material is moderately difficult to excavate, especially in areas with numerous boulders. Boulders with diameters of 5 feet and more were observed, and they appear to be well distributed throughout the site. Soil strength was not measured directly, but standard penetration values indicate the very dense till has an angle of internal friction of approximately 40°, and no cohesion.

The till, or silty sand, which forms much of the moraine should be easily compacted with vibratory equipment, provided the moisture can be closely controlled. The material contains a moderate amount of silt (10 to 20%) and will not compact if it contains too much water. The silty material may require dust control during dry periods. The clean sands and coarse upper soils found in isolated areas throughout the moraine should compact easily with vibratory equipment within a wide range of moisture content.

The lack of large quantities of clean on-site fill indicates that silty sand may be needed for a large amount of fill, both for plant and road foundations. Frost protection of roads would require use of up to 18 or more inches of non-frost-susceptible (NFS) sub-base. NFS materials are granular inorganic soils which contain less than 3% by weight finer than 0.02 millimeters. Existing logging roads are in excellent condition and are constructed with material from on-site borrow pits and with gravel obtained from the Chakachatna River. Much of the road material is silty sand, but NFS material was scalped from many small knolls. Roads occasionally are of gravel-covered log corduroy construction in deep peat areas.

No impermeable fine-grain soils were found on site, but some clayey silt was found in the Granite Point beach area. These slightly plastic silts generally make poor impoundment material, but a specific analysis should be performed for each application. Beach borings in the prospective dock area indicate large quantities of the silt material, but the quality may vary from slightly plastic silt to nonplastic sandy silt.

An investigation of the extent of organic soils was performed at the proposed plant and town sites. This entailed an interpretation of available air photos and literature, field reconnaissance traverses of the site, and hand-probing the depth of organic soils. The peat probes were spaced approximately 600 feet apart, with traverses following existing seismic line cuts, and on random traverses. An idealized map of the plant area has been prepared (Figure 3.8) showing the depth of organic soils to range from 0 to 13-plus feet. The organic soil ranged in depth from 0.2 to 3 feet in the town site. A map showing the location of organic soil in the proposed town site was not prepared because there are no significant deep organic soil areas.

Slope stability is generally good due to the dense soil and moderate slopes in the vicinity of the plant site. Small areas adjacent to streams have been over steepened by erosion and are unstable, but these areas can be avoided or cut to a stable slope. The maximum observed slopes of 10° to 20° would be marginally stable under 0.4g loading and high groundwater conditions, but the majority of the slopes would be stable for all expected earthquake accelerations. Cut stability would be good and temporary cuts should stand at slopes of 1:1 for short periods. Long-term slope stability probably would be controlled by erosion criteria, and slopes approaching 2:1 may be required. The very dense coarse material generally has a low potential for erosion, but layers of silty material can erode rapidly under either wind or water action.

Town Site

- Topography

The proposed town site is located on the Nikolai moraine, two miles northwest of the plant site. The site is approximately one mile from the Nikolai escarpment and has an elevation of about 450 feet.

Topography generally slopes to the southwest at about 200 feet per mile, but becomes increasingly steep near the escarpment. An intermittent stream with a steeply eroded channel cuts across the north end of the site.

The land surface is typical of the Nikolai moraine, which is a complex of ground and lateral moraines with numerous kames. The area has generally low relief but is moderately well drained. Peat bogs which contain 2 to 3 feet of peat are found in poorly drained areas near the southern portion of the site, but most of the proposed town site appears to have, at most, only a few feet of peat.

- Subsurface Conditions

Two borings and five test pits to depths up to 30 feet reveal the town site has a surface layer of peat which is underlain by medium dense silty sand or sandy silt extending to a depth of about 2 to 5 feet (Figure 3.12). The next deeper layer is NFS gravelly sand which may contain numerous boulders between depths of 5 and 15 feet. Very dense silty sand and sand are

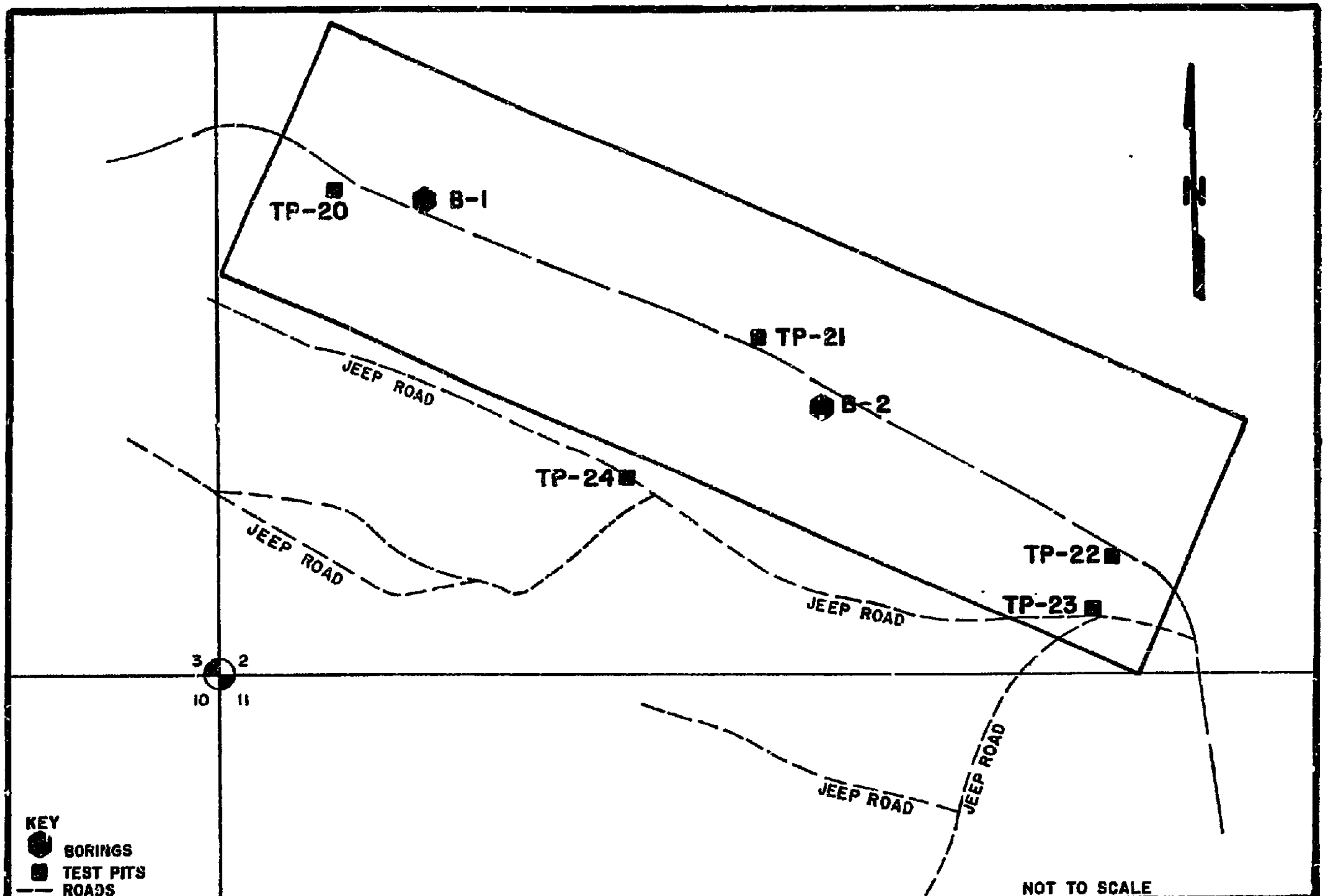


FIGURE 3.12 LOCATIONS OF SOIL TEST (CIRI/PLACER-AMEX TOWNSITE)

found below the boulders. Volcanic ash layers up to 4 inches thick may also be found beneath the boulder layer.

A boulder layer has been identified in many parts of the moraine, but its source has not been firmly established. It may represent volcaniclastic debris or glacially transported volcanic material. Volcanic debris at this distance from known volcanos would represent volcanic activity more intense than currently anticipated. Logs of a typical test hole and test pit are shown in Figures 3.13 and 3.14.

° Groundwater

The town site is generally well drained due to the proximity of the escarpment, but the southern section of the town site contains small areas of peat. The upper coarse soils have a moderate to high permeability, but the underlying silty sand is very dense and possesses a moderate to low permeability.

Groundwater was observed in the peat at depths of 2 to 4 feet, but this appears to be surface water which is inhibited from draining by the low permeability silt underlying the peat. Sufficient slope exists to permit surface drainage through channels, and the shallow water level should not provide extensive problems for construction. Coarse soils with moderate to high permeabilities are found directly below the surface silt and peat. This soil could be used to provide on-site wastewater disposal if systems could be placed in areas with a low water table.

° Construction Feasibility

The proposed town site is characterized by very dense soil underlying a few feet of surface peat and silt. The upper soft soils are sufficiently thin to allow excavation to expose very dense granular soil. The dense soil provides excellent bearing capacity,

W.O. NO. D13131
LOGGED BY O. H.

BORING 2-TOWN

ELEVATION = 430'

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	OTHER TESTS	N (BLOWS/FT)	FROST DEPTH	SOIL	DESCRIPTION	DEPTH
					PT	BROWN PEAT, SOFT	1.0'
					ML	F-4, BROWN SILT, SLIGHTLY PLASTIC, SATURATED, SOFT TO STIFF	4.5'
			152		GP	NFS, BROWN SANDY GRAVEL WITH OCCASIONAL COBBLES TO 12"+ MAXIMUM PARTICLE SIZE, MOIST, DENSE	12.0'
	11.2		166		SM	F-2, BROWN GRAVELLY SILTY SAND WITH OCCASIONAL COBBLES TO 12"+ MAXIMUM PARTICLE SIZE, MOIST, VERY DENSE	18.0'
			68, 100+, 100+		SM	F-2, BROWN GRAVELLY SILTY SAND WITH OCCASIONAL COBBLES, MOIST, MEDIUM DENSE TO VERY DENSE	29.0'

BOTTOM OF TEST HOLE = 29.0'. COMPLETED 5/14/81.

DEPTH (FEET): 0, 5, 10, 15, 20, 25, 30

KEY

PP = UNCONFINED COMPRESSIVE STRENGTH (PENETROMETER) (TSF)
TV = SHEAR STRENGTH (TORVANE) (TSF)
MA = MECHANICAL ANALYSIS
LL = LIQUID LIMIT (%)
PI = PLASTIC INDEX
- GRAB SAMPLE
- SPT SAMPLE
- 2.5" I.D. SPOON SAMPLE 340# WEIGHT, 30" FALL
- SHELBY TUBE - PUSHED
- GROUND WATER TABLE WHILE DRILLING

LOG OF BORING

FIGURE 3.13

TEST PIT 20

WORK ORDER D13132
LOGGED BY T.B.

DEPTH | TEST RESULTS | SAMPLES | ELEVATION= N E | DEPTH

Samples: G at approx. 5'; G at approx. 10'; G at approx. 11'

Depth	
0 – 1.5'	F-4, BROWN PEAT AND ORGANIC SANDY SILT.
1.5' – 2.5'	F-2, GREY SILTY GRAVELLY SAND WITH WOOD AND ORGANICS MIXED, ANGULAR AND SUBROUNDED 8"+ GRAVEL AND COBBLES, MEDIUM DENSE.
2.5' – 11.5'	F-2, BROWN SILT SAND AND 1' COBBLES, MEDIUM DENSE. BECOMING CLEANER WITH DEPTH.
11.5' – 12.0'	GREY AND PINK VOLCANIC ASH AND SILT.
12.0' – 14.5'	F-2, GREY SILTY GRAVELLY SAND WITH COBBLES, MOIST TO WET, VERY DENSE.

BOTTOM OF EXPLORATION = 14.5'

TEST KEY:

- W = MOISTURE CONTENT
- LL = LIQUID LIMIT
- PL = PLASTIC LIMIT
- MA = MECHANICAL ANALYSIS

LOG OF TEST PIT

generally in the range of 4,000 to 8,000 lbs. per square foot for spread footings. Stability of the dense soil is good, and the liquefaction and settlement potentials are low.

Extensive cobbles and boulders found there would create moderately difficult excavation conditions, but cuts and exposed slopes would be stable at relatively steep angles. Precautions to prevent boulder slides should be provided during excavation. Slope stability is good, and only the small slopes along streams which have been over steepened by erosion present stability problems. These areas may be cut to a stable configuration or avoided entirely with only a small loss of area. Removal of the surface peat and silt near bluffs would contribute to increased water infiltration and may possibly increase bluff erosion.

Dock Site

° Topography

Topography at the proposed dock area consists of a narrow (200 feet or less), level beach which is submerged or only a few feet above water during extreme high tides. The shore slopes southward at a rate of about 20 to 40 vertical feet per mile. Bluffs up to 120 feet high with slopes of 30° to 40° border the beach strand on the north. The bluffs are cut by numerous small streams which have formed narrow channels. Ground surface above the bluffs also slopes to the south at about 50 feet per mile.

The bluffs are continuously eroding and the toe of the slope often has deposits formed by erosion debris or slumped material. This material forms a bench about 10 to 30 feet above extreme high water.