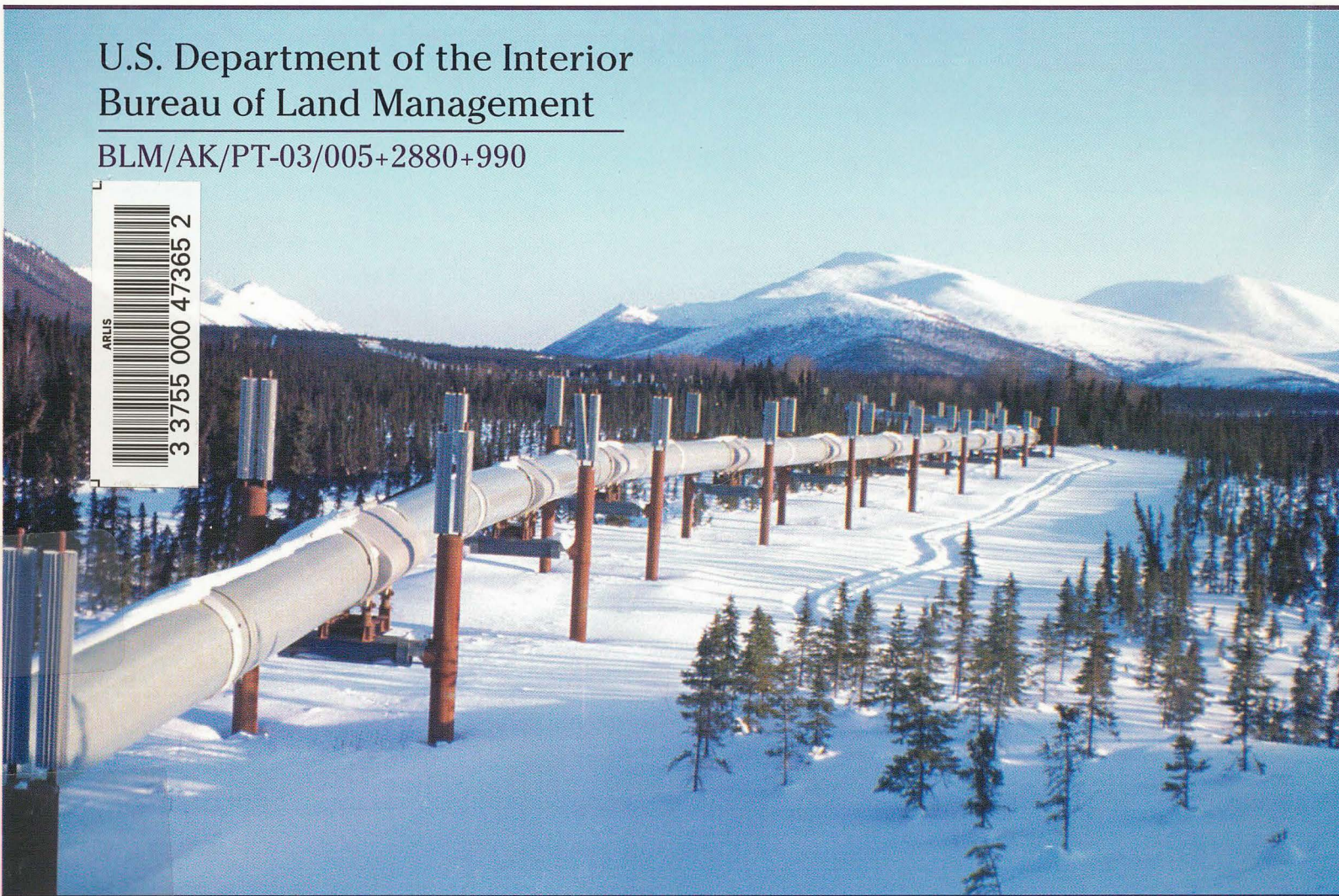


Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way

November 2002

U.S. Department of the Interior
Bureau of Land Management

BLM/AK/PT-03/005+2880+990



Volume 2: Chapters 1 through 3

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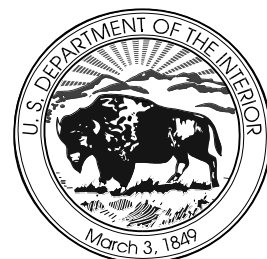
Final Environmental Impact Statement

Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way

Volume 2: Chapters 1 through 3

U.S. Department of the Interior
Bureau of Land Management

November 2002





United States Department of the Interior

BUREAU OF LAND MANAGEMENT
ALASKA STATE OFFICE
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2801 (990) PT 9.0
01-062-CHC

November 26, 2002

Dear Reader,

I am pleased to present the *Final Environmental Impact Statement: Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way*. This Final Environmental Impact Statement (EIS) provides analysis critical to the Bureau of Land Management's decision on renewal of the Right-of-Way (ROW) for the Trans-Alaska Pipeline System (TAPS).

This document reflects the work of many people in the Bureau of Land Management (BLM) and its contractor, the Department of Energy's Argonne National Laboratory, as well as experts from other federal and state agencies both inside and outside the Joint Pipeline Office. It also reflects the comments we received from the public on the Draft EIS. I especially want to thank those who spoke at public hearings and those who submitted comments for helping us make the Final EIS as factual and inclusive as possible. By presenting your views, knowledge, and insights, you have added much to the final product.

The BLM conducted its renewal analysis in close partnership with the Alaska Department of Natural Resources (DNR). The DNR is conducting its own independent analysis as part of its responsibility for renewing the part of TAPS that crosses state land. Information on the DNR process and its analysis is available at <http://www.tapsrenewal.jpo.doi.gov>.

If you have any questions about the renewal process or this document, please contact Rob McWhorter (907-257-1355).

Sincerely,

Henri R. Bisson
State Director

DOCUMENT CONTENTS

VOLUME 1

Executive Summary

VOLUME 2

Chapter 1: Introduction
Chapter 2: Alternatives
Chapter 3: Affected Environment

VOLUME 3

Section 4.1: Existing Mitigation Measures
Section 4.2: Impacting Factors
Section 4.3: Proposed Action Alternative Analysis – Routine Operations
Section 4.4: Spills Analysis for Proposed Action
Section 4.5: Less-Than-30-Year Renewal Alternative Analysis
Section 4.6: No-Action Alternative Analysis

VOLUME 4

Section 4.7: Cumulative Effects
Section 4.8: Other NEPA Considerations
Section 4.9: References for Chapter 4
Chapter 5: Consultation and Coordination
Chapter 6: Review and Analysis of Comments Received on the Draft
Environmental Impact Statement
Chapter 7: List of Preparers
Chapter 8: Glossary
Chapter 9: Glossary of Laws, Executive Orders, and Regulations Cited in This EIS

VOLUME 5

Appendix A: Methodology Descriptions
Appendix B: Agreement and Grant of Right-of-Way for the Trans-Alaska Pipeline
Appendix C: Hazardous Materials and Waste Management
Appendix D: Subsistence in the Vicinity of the TAPS
Appendix E: ANILCA Section 810 Analysis of Subsistence Impacts
Appendix F: Alaska Native Utilization Agreement and Implementation Plan

Appendix G: Special Requirements
Appendix H: Example of Guaranty

VOLUME 6

Comment Response Document

Part 1: Comment Documents 1-98

Part 2: Comment Documents 99-172

Part 3: Comment Documents 173-271

Part 4: Comment Documents 272-387

VOLUME 7

FEIS Maps and the TAPS ROW Map Atlas

CONTENTS

VOLUME 2

1	Introduction	1-1
1.1	Purpose and Need	1-1
1.2	Scope of the Decision and Analysis	1-2
1.3	Description of the TAPS and Its Surrounding Area	1-3
1.4	Relationships of the TAPS to BLM Policies, Plans, and Programs	1-5
1.5	References for Chapter 1	1-5
2	Alternatives	2-1
2.1	Introduction	2-1
2.2	Proposed Action — Renew Federal Grant for 30 Years	2-1
2.2.1	Projected TAPS Operation	2-1
2.2.2	Requirements and Responsibilities under the Federal Grant	2-2
2.2.3	Projected BLM Oversight	2-3
2.3	Time-Dependent Alternative: Renew Federal Grant for less than 30 Years	2-5
2.4	No-Action Alternative: Do Not Renew Federal Grant	2-5
2.5	Alternatives and Issues Considered but Eliminated from Detailed Analysis	2-5
2.6	Comparison of Alternatives	2-16
2.7	References for Chapter 2	2-16
3	Affected Environment	3.1-1
3.1	TAPS Background	3.1-1
3.1.1	History	3.1-1
3.1.2	Existing Infrastructure	3.1-3
3.1.2.1	Infrastructures Directly along the TAPS ROW	3.1-5
3.1.2.2	Infrastructures for Other Components of the Alaska North Shore Oil Production and Transportation System	3.1-19
3.2	Physiography and Geology	3.2-1
3.2.1	Arctic Coastal Plain	3.2-1
3.2.2	Arctic Foothills	3.2-1
3.2.3	Brooks Range	3.2-4
3.2.4	Chandalar Ridge and Lowland Section	3.2-4
3.2.5	Kokrine-Hodzana Highlands and Yukon-Tanana Uplands	3.2-5
3.2.6	Tanana Lowland	3.2-5
3.2.7	Northern Foothills and Alaska Range	3.2-5
3.2.8	Gulkana Upland	3.2-6
3.2.9	Copper River Lowland	3.2-6
3.2.10	Chugach Mountains	3.2-7
3.3	Soils and Permafrost	3.3-1
3.3.1	Descriptions of Soils and Permafrost Conditions by Physiographic Province	3.3-2
3.3.1.1	Arctic Coastal Plain	3.3-2
3.3.1.2	Arctic Foothills	3.3-2
3.3.1.3	Brooks Range	3.3-2
3.3.1.4	Chandalar Ridge and Lowland Section	3.3-2
3.3.1.5	Kokrine-Hodzana Highlands and Yukon-Tanana Uplands	3.3-3
3.3.1.6	Tanana Lowland	3.3-3
3.3.1.7	Northern Foothills and Alaska Range	3.3-4

CONTENTS (Cont.)

3.3.1.8	Gulkana Upland.....	3.3-4
3.3.1.9	Copper River Lowland	3.3-4
3.3.1.10	Chugach Mountains.....	3.3-4
3.3.2	Geomorphic Processes Related to Soils and Permafrost	3.3-5
3.3.2.1	Mass Wasting Processes	3.3-5
3.3.2.2	Permafrost Degradation and Aggradation	3.3-5
3.3.3	Existing Contaminated Sites	3.3-7
3.4	Seismicity.....	3.4-1
3.4.1	Seismicity and Faults	3.4-1
3.4.2	Seismic Hazards, Designed Seismic Zones, and Ground Motions	3.4-2
3.5	Sand, Gravel, and Quarry Resources.....	3.5-1
3.6	Paleontology	3.6-1
3.7	Surface Water Resources.....	3.7-1
3.7.1	Hydrological Regions	3.7-1
3.7.1.1	North of the Brooks Range	3.7-1
3.7.1.2	South Side of the Brooks Range	3.7-2
3.7.1.3	Interior.....	3.7-2
3.7.1.4	Alaska Range	3.7-3
3.7.1.5	Glennallen to Valdez	3.7-3
3.7.2	Existing Conditions and Historical Impacts	3.7-3
3.7.2.1	Erosion and Sedimentation	3.7-4
3.7.2.2	Flooding.....	3.7-6
3.7.2.3	Surface Water Use along the ROW.....	3.7-7
3.7.2.4	Contingency Plans.....	3.7-8
3.7.2.5	Surface Water Quality along the ROW.....	3.7-9
3.7.2.6	Historical Spills of Crude Oil.....	3.7-11
3.8	Groundwater Resources.....	3.8-1
3.9	Physical Marine Environment	3.9-1
3.9.1	Location and Description.....	3.9-1
3.9.2	Bathymetry	3.9-2
3.9.3	Hydrography and Circulation.....	3.9-2
3.10	Marine Water Chemistry	3.10-1
3.10.1	General Marine Water Chemistry.....	3.10-1
3.10.2	Nutrients	3.10-1
3.11	Anthropogenic Influences on Physical Marine Environment	3.11-1
3.11.1	Discharges from the Valdez Marine Terminal	3.11-1
3.11.1.1	Conditions.....	3.11-1
3.11.1.2	Mitigation	3.11-3
3.11.2	Trace Elements	3.11-3
3.11.2.1	Conditions.....	3.11-3
3.11.2.2	Mitigation	3.11-4
3.11.3	Hydrocarbons	3.11-4
3.11.3.1	Conditions.....	3.11-4
3.11.3.2	Mitigation	3.11-5

CONTENTS (Cont.)

3.11.4	TAPS-Related Marine Transportation	3.11-6
3.11.4.1	Tanker Traffic.....	3.11-6
3.11.4.2	Ship Escort/Response Vessel System	3.11-6
3.11.4.3	Valdez Marine Terminal Operations	3.11-6
3.11.4.4	Procedures for Tanker Operations	3.11-7
3.11.5	Exxon Valdez Spill.....	3.11-8
3.11.5.1	Background.....	3.11-8
3.11.5.2	Current Conditions.....	3.11-9
3.11.6	Tsunamis	3.11-9
3.12	Climate and Meteorology	3.12-1
3.12.1	Wind	3.12-1
3.12.2	Temperature and Humidity	3.12-1
3.12.3	Precipitation and Evaporation	3.12-2
3.12.4	Fog.....	3.12-2
3.12.5	Severe Weather.....	3.12-2
3.12.6	Atmospheric Dispersion Characteristics	3.12-2
3.12.7	Climate Change in Alaska	3.12-6
3.12.7.1	Introduction	3.12-6
3.12.7.2	Historical Climate Trends in Alaska.....	3.12-6
3.13	Air Quality	3.13-1
3.13.1	Existing Emissions	3.13-1
3.13.1.1	Criteria Pollutants	3.13-5
3.13.1.2	Hazardous Air Pollutants	3.13-9
3.13.1.3	Other Emissions	3.13-9
3.13.2	Existing Air Quality	3.13-9
3.13.2.1	Criteria Pollutants	3.13-9
3.13.2.2	Hazardous Air Pollutants	3.13-18
3.13.2.3	Visibility.....	3.13-18
3.13.2.4	Acid Deposition.....	3.13-21
3.14	Noise.....	3.14-1
3.15	Transportation.....	3.15-1
3.15.1	Aviation Transportation Systems.....	3.15-1
3.15.2	Marine Transportation Systems	3.15-2
3.15.3	Rail Transportation Systems	3.15-2
3.15.4	Road Transportation Systems	3.15-3
3.16	Hazardous Materials and Waste Management.....	3.16-1
3.16.1	Hazardous Material Usage	3.16-1
3.16.2	Hazardous Waste	3.16-1
3.16.3	Solid Waste	3.16-2
3.16.4	Wastewater.....	3.16-2
3.16.5	Special Wastes.....	3.16-3
3.17	Human Health and Safety	3.17-1
3.17.1	Occupational.....	3.17-1
3.17.2	Public.....	3.17-2
3.17.2.1	Body Burdens of Key Contaminants.....	3.17-2
3.17.2.2	Cancer Rates among Alaska Natives.....	3.17-6
3.17.2.3	Background on Human Health Risk Assessment.....	3.17-8

CONTENTS (Cont.)

3.17.2.4	Hazardous Air Pollutants in Ambient Air and Potential Health Hazards	3.17-8
3.17.2.5	Existing Site Contamination	3.17-10
3.18	Terrestrial Vegetation and Wetlands	3.18-1
3.18.1	TAPS ROW	3.18-1
3.18.1.1	Lowland Tundra	3.18-1
3.18.1.2	Upland Tundra	3.18-9
3.18.1.3	Boreal Forest	3.18-13
3.18.1.4	Coastal Forest	3.18-16
3.18.2	Beaufort Sea	3.18-17
3.18.3	Prince William Sound	3.18-18
3.19	Fish, Reptiles, and Amphibians	3.19-1
3.19.1	Fish	3.19-1
3.19.1.1	TAPS ROW	3.19-1
3.19.1.2	Beaufort Sea	3.19-31
3.19.1.3	Prince William Sound	3.19-33
3.19.2	Reptiles and Amphibians	3.19-37
3.20	Birds	3.20-1
3.20.1	TAPS ROW	3.20-1
3.20.1.1	Waterfowl, Seabirds, and Shorebirds	3.20-1
3.20.1.2	Raptors	3.20-4
3.20.1.3	Grouse and Ptarmigan	3.20-5
3.20.1.4	Passerines	3.20-5
3.20.2	Beaufort Sea	3.20-5
3.20.3	Prince William Sound	3.20-7
3.21	Terrestrial Mammals	3.21-1
3.21.1	TAPS Row	3.21-1
3.21.1.1	Moose	3.21-1
3.21.1.2	Caribou	3.21-2
3.21.1.3	Musk Ox	3.21-6
3.21.1.4	American Bison	3.21-6
3.21.1.5	Dall Sheep	3.21-8
3.21.1.6	Sitka Black-Tailed Deer	3.21-8
3.21.1.7	Mountain Goat	3.21-9
3.21.1.8	Brown Bear	3.21-9
3.21.1.9	Black Bear	3.21-10
3.21.1.10	Gray Wolf	3.21-10
3.21.1.11	Other Species	3.21-11
3.21.2	Beaufort Sea	3.21-11
3.22	Threatened, Endangered, and Protected Species	3.22-1
3.22.1	TAPS Row	3.22-1
3.22.1.1	Spectacled Eider	3.22-7
3.22.1.2	Steller's Eider	3.22-8
3.22.1.3	Eskimo Curlew	3.22-8
3.22.1.4	Arctic Peregrine Falcon	3.22-9
3.22.1.5	American Peregrine Falcon	3.22-9
3.22.2	Beaufort Sea	3.22-10
3.22.2.1	Bowhead Whale	3.22-10
3.22.2.2	Gray Whale	3.22-11

CONTENTS (Cont.)

3.22.2.3	Beluga Whale	3.22-12
3.22.2.4	Pacific Walrus	3.22-12
3.22.2.5	Spotted Seal	3.22-13
3.22.2.6	Ringed Seal	3.22-13
3.22.2.7	Bearded Seal	3.22-14
3.22.2.8	Polar Bear	3.22-14
3.22.3	Prince William Sound	3.22-15
3.22.3.1	Humpback Whale	3.22-16
3.22.3.2	Fin Whale	3.22-16
3.22.3.3	Steller Sea Lion	3.22-17
3.22.3.4	Harbor Seal	3.22-18
3.22.3.5	Sea Otter	3.22-19
3.23	Economics	3.23-1
3.23.1	North Slope Oil Production and World Oil Prices	3.23-1
3.23.2	National Economic Issues	3.23-1
3.23.2.1	Domestic Oil Production and National Energy Security	3.23-2
3.23.2.2	Balance of Trade	3.23-2
3.23.2.3	Federal Tax Revenues	3.23-2
3.23.2.4	Marine Transportation	3.23-2
3.23.3	State Economic Issues	3.23-3
3.23.3.1	Population	3.23-3
3.23.3.2	Gross State Product	3.23-3
3.23.3.3	Employment and Unemployment	3.23-5
3.23.3.4	Personal Income	3.23-5
3.23.3.5	State and Local Government Revenues and Expenditures	3.23-7
3.23.3.6	Public Services	3.23-10
3.23.4	Alaska Regional Economic Issues	3.23-12
3.23.4.1	Population	3.23-12
3.23.4.2	Employment and Unemployment	3.23-12
3.23.4.3	Personal Income	3.23-13
3.23.4.4	Local Government Revenues and Expenditures	3.23-14
3.23.4.5	Education	3.23-15
3.23.5	Village Economies	3.23-15
3.23.6	Subsistence	3.23-18
3.23.7	Alaska Native Corporations	3.23-19
3.24	Subsistence	3.24-1
3.24.1	Introduction	3.24-1
3.24.2	Community Harvest Patterns	3.24-3
3.24.2.1	North Slope	3.24-5
3.24.2.2	Yukon River Drainage	3.24-13
3.24.2.3	Copper River Basin	3.24-23
3.24.2.4	Prince William Sound and Lower Cook Inlet	3.24-33
3.24.3	Access to Subsistence Resources	3.24-41
3.24.4	Sport Harvests Versus Subsistence	3.24-43
3.25	Sociocultural Systems	3.25-1
3.25.1	Alaska Native Sociocultural Systems	3.25-1
3.25.1.1	Major Alaska Native Sociocultural Systems along the TAPS	3.25-3
3.25.1.2	Alaska Native Claims Settlement Act	3.25-16
3.25.1.3	Overview of Modern Alaska Native Sociocultural Concerns and Benefits	3.25-18
3.25.2	Non-Native Rural Alaskan Sociocultural Systems	3.25-20

CONTENTS (Cont.)

3.26	Cultural Resources	3.26-1
3.26.1	Archaeological Context	3.26-1
3.26.2	Known Cultural Resources	3.26-1
3.26.3	Traditional Cultural Properties	3.26-5
3.26.4	Historic Structures	3.26-5
3.27	Land Uses and Coastal Zone Management	3.27-1
3.27.1	Land Ownership and Uses	3.27-1
3.27.1.1	Land Ownership	3.27-1
3.27.1.2	Land Uses	3.27-2
3.27.1.3	Special Land Uses	3.27-3
3.27.2	Coastal Zone Management	3.27-3
3.28	Recreation, Wilderness, and Aesthetics	3.28-1
3.28.1	Recreation	3.28-1
3.28.2	Wilderness	3.28-5
3.28.3	Aesthetics	3.28-6
3.29	Environmental Justice	3.29-1
3.29.1	Minority Populations	3.29-2
3.29.2	Low-Income Populations	3.29-3
3.30	References for Chapter 3	3.30-1

TABLES

VOLUME 2

2-1	TAPS ROW Renewal FEIS Summary of Direct and Indirect Effects	2-17
3.1-1	Summary of Major Features of the Trans Alaska Pipeline System	3.1-4
3.1-2	Location and Characteristics of Water Wells along the TAPS ROW	3.1-8
3.1-3	Typical Sanitary Discharges from Pump Stations and Mobile Contingency Camp Facilities	3.1-9
3.1-4	Features and Capabilities of the TAPS Control System	3.1-13
3.1-5	Salient Aspects of the TAPS Fire Protection Response Teams	3.1-13
3.1-6	TAPS Oil Spill Major Contingency Equipment	3.1-15
3.1-7	Summary of Facilities at Valdez Marine Terminal	3.1-18
3.2-1	Physiographic Provinces Crossed by the TAPS ROW	3.2-2
3.2-2	Geologic Time Line	3.2-2
3.2-3	Special Terms Used in Section 3.2	3.2-3
3.3-1	27 Active Contaminated Sites along the TAPS	3.3-8
3.3-2	Active Contaminated Sites at the Valdez Marine Terminal	3.3-11
3.4-1	Seismic Design Zones for Design Contingency Earthquake	3.4-3
3.4-2	Design Ground Motions for Design Contingency Earthquake	3.4-4
3.4-3	Peak Ground Acceleration and the Design Ground Acceleration for a Design Contingency Earthquake	3.4-4
3.4-4	Engineering Design Criteria of Pipeline for Ground Movement for Active Fault Zone Crossings	3.4-5
3.5-1	Active TAPS Operations Material Sites on Public Lands	3.5-2
3.6-1	Marine Invertebrate Fossils	3.6-3
3.6-2	Paleontological Sites near the TAPS ROW	3.6-3
3.7-1	Historical Activities Performed for River Control along the ROW	3.7-5
3.8-1	Six Contaminated Sites along the TAPS ROW	3.8-4
3.11-1	Monitoring Schedules at Valdez Marine Terminal Required by NPDES Permit	3.11-3
3.12-1	Summary of Climatic and Meteorological Data at Six NWS Stations along the TAPS	3.12-3

TABLES (Cont.)

3.13-1	Stationary Emission Sources Installed at TAPS Pump Stations	3.13-2
3.13-2	Stationary Emission Sources Installed at Valdez Marine Terminal	3.13-4
3.13-3	Estimated Potential Emissions of Criteria Pollutants from Existing TAPS Facility Sources.....	3.13-6
3.13-4	Comparison of Estimated Potential Emissions from TAPS Facilities with Those from Major Facilities Located in Adjacent Areas	3.13-7
3.13-5	Estimated 2001 Emissions of Criteria Pollutants and VOCs from Vehicles Used for TAPS Operation	3.13-8
3.13-6	Estimated Potential Emissions of Hazardous Air Pollutants from TAPS Facility Sources	3.13-10
3.13-7	Inventory and Emissions of Ozone Depleting Substances from TAPS Facilities	3.13-11
3.13-8	National Ambient Air Quality Standards, Alaska Ambient Air Quality Standards, and Maximum Allowable Increments for Prevention of Significant Deterioration	3.13-12
3.13-9	Monitored and Modeled Ambient Data for Criteria Pollutants in and around TAPS Facilities.....	3.13-15
3.13-10	Ambient Air Quality Trends in the Prudhoe Bay Area.....	3.13-19
3.13-11	Ambient Concentrations of Hazardous Air Pollutants in the Valdez Area Prior to Installation of Tanker Vapor Recovery System at the Valdez Marine Terminal	3.13-20
3.14-1	Direction and Distance of Nearest Human Residence and Town from Each TAPS Facility	3.14-3
3.15-1	Average Daily Traffic Counts on the Richardson Highway for the Year 2000	3.15-4
3.17-1	Annual Incidence Rates of Occupational Injuries and Illnesses to TAPS Employees and Contractors, 1995-2001	3.17-3
3.17-2	Measures of PCBs in Tissues of Alaska Natives and Western Canadian Inuit	3.17-5
3.17-3	Measures of Mercury in Tissues of Alaska and Canadian Natives	3.17-7
3.17-4	Valdez Area Ambient VOC Concentrations and Risk-Based Guideline Levels.....	3.17-11
3.18-1	Wetland Systems and Classes along the TAPS ROW, Beaufort Sea, and Prince William Sound.....	3.18-2
3.18-2	Vegetation Types and Associated Landforms Found in Each Major Vegetation Zone Crossed by the TAPS ROW.....	3.18-3
3.19-1	Fish Species Occurring within Major Regions along the TAPS ROW	3.19-2
3.19-2	Fish Streams along the TAPS Corridor	3.19-8
3.20-1	Important Waterfowl Concentration Use Areas near the TAPS ROW	3.20-3

TABLES (Cont.)

3.21-1	Important Moose Habitat Areas near the TAPS ROW.....	3.21-2
3.21-2	Harvest Summaries for Alaska Wildlife within the Game Management Units That Are Crossed by or Occur near the TAPS ROW.....	3.21-3
3.21-3	Caribou Herd Size, Harvest Summaries, and Limiting Factors for Herds Occurring near the TAPS ROW	3.21-4
3.22-1	Threatened, Endangered, and Protected Species That Could Occur in the Vicinity of the TAPS or in the Beaufort Sea or Prince William Sound.....	3.22-2
3.23-1	Trends in North Slope Oil Production and World Crude Prices.....	3.23-2
3.23-2	Alaska Population Statistics, 1970–2000.....	3.23-3
3.23-3	Alaska Gross State Product by Industry	3.23-4
3.23-4	Total Employment in Alaska by Industry.....	3.23-6
3.23-5	Unemployment Rates	3.23-7
3.23-6	State Personal Income and Alaska Permanent Fund Dividend.....	3.23-8
3.23-7	State Government Revenues	3.23-9
3.23-8	Local Government Revenues	3.23-10
3.23-9	State Government Expenditures.....	3.23-11
3.23-10	Local Government Expenditures	3.23-11
3.23-11	State Public Service Employment Data, 2000.....	3.23-12
3.23-12	Pipeline Corridor Region Population	3.23-13
3.23-13	Pipeline Corridor Region Employment by Industry, 1999.....	3.23-14
3.23-14	Pipeline Corridor Region Unemployment Rates.....	3.23-15
3.23-15	Pipeline Corridor Region Personal Income.....	3.23-16
3.23-16	Pipeline Corridor Region Local Government Tax Revenues, 2000.....	3.23-17
3.23-17	Pipeline Corridor Region Local Government Expenditures, 2000.....	3.23-18
3.23-18	Pipeline Corridor Region Local Education Data, 1999	3.23-18
3.24-1	Subsistence Resource Pounds Harvested per Capita in Directly Affected and Other Selected Rural Communities, Selected Recorded Year.....	3.24-7
3.24-2	Percent Households in Directly Affected and Other Selected Rural Communities Participating in Subsistence Harvest, Selected Recorded Year.....	3.24-11
3.25-1	Directly Affected Villages in the Vicinity of the TAPS	3.25-5

TABLES (Cont.)

3.25-2	Selected Characteristics of Regional Sociocultural Systems, Shortly after Contact, in the Vicinity of the TAPS	3.25-7
3.25-3	Non-Native Rural Communities in the Vicinity of the TAPS	3.25-21
3.26-1	Prehistoric Context for Areas along the TAPS ROW	3.26-2
3.26-2	Alaska Historic Time Line	3.26-3
3.26-3	Cultural Resources Located along the TAPS	3.26-4
3.27-1	Conservation System Units in the Vicinity of TAPS.....	3.27-5
3.28-1	Visual Resources, Viewpoints, and Overlooks along the TAPS ROW Corridor	3.28-7
3.29-1	Minority and Low-Income Percentages for the State of Alaska, 29 Block Groups Intersecting the TAPS, and 45 Communities Likely To Be Affected Directly by Continued TAPS Operation, 2000	3.29-4

FIGURES

VOLUME 2

3.1-1	Water Use at TAPS Facilities, 1994–1999	3.1-7
3.1-2	Operations Control Center at Valdez Marine Terminal.....	3.1-12
3.1-3	Valdez Marine Terminal	3.1-17
3.9-1	Changes in Temperature and Salinity Distributions in Port Valdez	3.9-3
3.11-1	Annual Flow and Levels of Benzene, Toluene, Ethylbenzene, and Xylene and Total Suspended Solids for Valdez Marine Terminal Treated Ballast Water Discharges	3.11-2
3.12-1	Trends in Annual Average Temperatures at Six National Weather Service Stations along the TAPS	3.12-5
3.24-1	Example Combination of Subsistence Resources on the North Slope.....	3.24-6
3.24-2	Example of the Seasonality of the Subsistence Harvest on the North Slope	3.24-6
3.24-3	Variability in Anaktuvuk Pass Caribou Harvest Over Time.....	3.24-11
3.24-4	Variability in Nuiqsut Subsistence Harvest Over Time	3.24-12
3.24-5	Example Combination of Subsistence Resources in the Yukon River Drainage	3.24-14
3.24-6	Example of the Seasonality of the Subsistence Harvest in the Yukon River Drainage.....	3.24-15
3.24-7	Variability in Alatna/Allakaket Subsistence Harvest Over Time	3.24-16
3.24-8	Variability in Alatna Subsistence Harvest of Large Mammals Over Time	3.24-16
3.24-9	Variability in Allakaket Subsistence Harvest of Large Mammals Over Time	3.24-17
3.24-10	Variability in Evansville/Bettles Subsistence Harvest Over Time	3.24-18
3.24-11	Variability in Evansville Subsistence Harvest of Large Mammals Over Time	3.24-19
3.24-12	Variability in Tanana Subsistence Harvest of Large Mammals Over Time	3.24-22
3.24-13	Example Combination of Subsistence Resources in the Copper River Basin	3.24-24
3.24-14	Example of the Seasonality of the Subsistence Harvest in the Copper River Basin	3.24-25
3.24-15	Variability in Chitina Subsistence Harvest Over Time	3.24-26
3.24-16	Variability in Copper Center Subsistence Harvest Over Time.....	3.24-27
3.24-17	Variability in Gakona Subsistence Harvest Over Time.....	3.24-28
3.24-18	Variability in Glennallen Subsistence Harvest Over Time	3.24-29

FIGURES (Cont.)

3.24-19	Variability in Gulkana Subsistence Harvest Over Time	3.24-30
3.24-20	Variability in Kenny Lake Subsistence Harvest Over Time	3.24-31
3.24-21	Variability in Tonsina Subsistence Harvest Over Time.....	3.24-33
3.24-22	Example Combination of Subsistence Resources in Prince William Sound	3.24-34
3.24-23	Example of the Seasonality of the Subsistence Harvest in Prince William Sound	3.24-35
3.24-24	Variability in Chenega Bay Subsistence Harvest Over Time.....	3.24-36
3.24-25	Variability in Cordova Subsistence Harvest Over Time.....	3.24-38
3.24-26	Variability in Nanwalek Subsistence Harvest Over Time.....	3.24-38
3.24-27	Variability in Port Graham Subsistence Harvest Over Time.....	3.24-40
3.24-28	Variability in Tatitlek Subsistence Harvest Over Time.....	3.24-41
3.24-29	Approximated Sport and Subsistence Harvests of Caribou in Uniform Coding Units that Intersect Subsistence Use Areas of Rural Communities Examined in this EIS	3.24-45
3.24-30	Approximated Sport and Subsistence Harvests of Mountain Goats in Uniform Coding Units that Intersect Subsistence Use Areas of Rural Communities Examined in this EIS	3.24-45
3.24-31	Approximated Sport and Subsistence Harvests of Moose in Uniform Coding Units that Intersect Subsistence Use Areas of Rural Communities Examined in this EIS	3.24-46
3.24-32	Approximated Sport and Subsistence Harvests of Dall Sheep in Uniform Coding Units that Intersect Subsistence Use Areas of Rural Communities Examined in this EIS	3.24-46
3.24-33	Sport Fishing Indicators North of Atigun Pass, 1983-1999.....	3.24-48
3.24-34	Sport Fishing Indicators between Atigun Pass and the Yukon River, 1995–1999	3.24-49
3.24-35	Variability in Subsistence Harvests of Salmon in Communities Examined in the EIS, Grouped by Region	3.24-49

Notation

The following is a list of acronyms and abbreviations (including units of measure) used in this document. Certain abbreviations used only in tables, equations, and as reference callouts are not included here but are defined in the respective tables, equations, and reference lists.

Acronyms and Abbreviations

AAQS	Alaska Ambient Air Quality Standards
AAC	Alaska Administrative Code
AADT	annual average daily traffic
ACEC	area of critical environmental concern
ACM	asbestos-containing material
ACMA	Alaska Coastal Management Act
ACMP	Alaska Coastal Management Program
ACS	Alaska Clean Seas
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADGC	Alaska Department of Government Coordination
ADNR	Alaska Department of Natural Resources
ADPS	Alaska Department of Public Safety
ADT	average daily traffic
AFB	Air Force Base
AFFF	aqueous film-forming foam
AFN	Alaska Federation of Natives
AK	Alaska
AKOSH	Alaska Occupational Safety and Health
ALOHA	Areal Locations of Hazardous Atmospheres
AMHS	Alaska Marine Highway System
AMM	asset maintenance management
ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act
ANSI	American National Standards Institute
ANUA	Alaska Native Utilization Agreement
ANWR	Arctic National Wildlife Refuge
AO	Authorized Officer (Joint Pipeline Office)
AOGCC	Alaska Oil and Gas Conservation Commission
APHIS	Animal and Plant Health Inspection Service
API	American Petroleum Institute
APSC	Alyeska Pipeline Service Company
AQCR	Air Quality Control Region
AQRV	air-quality-related value
ARCO	Atlantic Richfield Company
ARRC	Alaska Railroad Corporation
ARRT	Alaska Regional Response Team
AS	Alaska Statute
ASME	American Society of Mechanical Engineers
ATV	all-terrain vehicle
BE	biological evaluation
BLM	Bureau of Land Management (U.S. Department of the Interior)

BLS	Bureau of Labor Statistics
BMP	best management practice
BOD	biochemical oxygen demand
BOD ₅	biochemical oxygen demand measured over a five-day period
BP	British Petroleum
BPXA	British Petroleum Exploration (Alaska), Inc.
BS&W	basic sediments and water
BTEX	benzene, toluene, ethylbenzene, xylene
BTT	biological treatment tank
BWT	ballast water treatment
BWTF	Ballast Water Treatment Facility
BWTS	ballast water treatment system
CBR	Constitutional Budget Reserve
CBRF	Constitutional Budget Reserve Fund
CCP	Central Processing Plant
CDMS	Corrosion Data Management System
CEO	chief executive officer
CEQ	Council on Environmental Quality
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
Cir.	Circuit Court
CMP	Coastal Management Program
	or
	Comprehensive Monitoring Program
CNG	compressed natural gas
CO	carbon monoxide
CO ₂	carbon dioxide
CP	Contingency Plan
CPF	Central Production Facility
CPlan	Contingency Plan
CS	containment site
CSU	conservation system unit
CY	calendar year
CZ	coastal zone
CZM	coastal zone management
CZMA	Coastal Zone Management Act
DAF	dissolved air flotation
DBGC	designated big-game crossing
DCE	design contingency earthquake
DDT	dichloro-diphenyl-trichloro-ethane
DEIS	draft environmental impact statement
DHCMA	Dalton Highway Corridor Management Area
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DOT/OPS	U.S. Department of Transportation, Office of Pipeline Safety
DRA	drag reducing agent
DRO	diesel-range organics
DS	drill site
DSMA	digital strong-motion accelerograph

EIA	Energy Information Administration
EFH	essential fish habitat
e.g.	exempli gratia (for example)
EGHP	exhaust-gas horsepower
EIA	Energy Information Administration
EIS	environmental impact statement
EMS	environmental monitoring system
	or
	earthquake monitoring system
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	environmental report
ERPG	emergency response planning guideline
ESA	Endangered Species Act
et al.	and others
ETT	enhanced tractor tug
FAA	Federal Aviation Administration
FACA	Federal Advisory Committee Act
FDA	U.S. Food and Drug Administration
FDS	Fire Dynamics Simulation (computer model)
Fe	iron
Fe ₂ O ₃	ferric oxide
FEIS	final environmental impact statement
FEOC	Fairbanks Emergency Operations Center
FLIR	forward looking infrared
FOSC	Federal On-Scene Coordinator
FR	Federal Register
FSIH	Fire Safety and Industrial Hygiene
FTE	full-time equivalent
GAO	General Accounting Office
GC	Gathering Center
GHG	greenhouse gas
GIS	geographic information system
GMU	Game Management Unit
GNOME	General NOAA Oil Modeling Environment
GRO	gasoline-range organics
GSP	gross state product
H ₂ O ₂	hydrogen peroxide
H ₂ S	hydrogen sulfide
HAP	hazardous air pollutant
HAZCORE	Hazardous Materials Consolidation and Redistribution
HAZMAT	hazardous material
HAZWOPER	hazardous waste operations
HC	hydrocarbon
HCFC	hydrochlorofluorocarbon
HCl	hydrogen chloride
Hg	mercury
HRR	heat release rate
HVAC	heating, ventilation, and air conditioning

ICS	Incident Command System
i.e.	that is (id est)
IMPROVE	Interagency Monitoring of Protected Visual Environments
IRIS	Integrated Risk Information System
IRT	Initial Response Team
ISC3	Industrial Source Complex Model (Version 3)
ISCST	Industrial Source Complex Short Term
IWSS	industrial wastewater sewer system
JPO	Joint Pipeline Office
L _{dn}	day-night average sound level
L _{eq}	equivalent steady sound level
LEFM	leading-edge flow meter
LNG	liquefied natural gas
LVB	line volume balance
MAP	Man in the Arctic Program
MCCF	mobile contingency camp facility
MCL	maximum contaminant level
MEI	maximally exposed individual
MEK	methyl ethyl ketone
MGV	manual gate valve
MLA	Mineral Leasing Act
MLR	Mainline Refrigeration
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MP	milepost
MSDS	Material Safety Data Sheets
MSFCMA	Magnuson-Stevens Fisheries Conservation and Management Act
MSGP	Multi-Sector General (NPDES) Permit
MSWLF	municipal solid waste landfill
N	nitrogen
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NAICS	North American Industry Classification System
NANA	Northwest Alaska Native Association
NEPA	National Environmental Policy Act
NF	National Forest
NFRAP	no further remedial action planned
NGL	natural gas liquid
NH ₃	ammonia
NHPA	National Historic Preservation Act
NMDS	National Missile Defense System
NMFS	National Marine Fisheries Service
no.	number
NO _x	nitrogen oxides
NO ₂	nitrogen dioxide
NO ₃ ⁻	nitrate
NOA	Notice of Availability

NOAA	National Oceanic and Atmospheric Administration
NOD	Notice of Disposal
NOI	Notice of Intent
NORM	naturally occurring radioactive material
NP	national park
NPDES	National Pollutant Discharge Elimination System
NPP	national park and preserve
NPR	National Petroleum Reserve
NPR-A	National Petroleum Reserve-Alaska
NPS	National Park Service
NRA	national recreation area
NRHP	National Register of Historic Places
NS	North Slope
NSB	North Slope Borough
NSC	National Safety Council
NSPTS	North Slope Production and Transportation System
NTP	Notice to Proceed
NWR	national wildlife refuge
NWS	National Weather Service
O ₃	ozone
O&M	operation and maintenance
OCC	Operations Control Center
OCS	Outer Continental Shelf
ODC	ozone-depleting chemical
ODP	ozone-depleting potential
ODS	ozone-depleting substance
OMB	Office of Management and Budget
OMS	operational material site
OPA	Oil Pollution Act
OPS	Office of Pipeline Safety (U.S. Department of Transportation)
ORC	oxygen-releasing compound
ORV	off-road vehicle
OSHA	Occupational Safety and Health Administration
OSHTF	(Alaska) Oil Spill Health Task Force
OSPPR	Oil Spill Prevention, Preparedness, and Response
OSV	oil spill volume
P	phosphorus
PA	Programmatic Agreement
PAH	polycyclic aromatic hydrocarbon
PAI	Phillips Alaska, Inc.
Pb	lead
PBT	persistent, bioaccumulative, and toxic
PCB	polychlorinated biphenyl
PDF	pipeline design flood
PELs	permissible exposure limits
PF	Permanent Fund
PG	Pasquill-Gifford
pH	hydrogen ion concentration
P.L.	Public Law
PM	particulate matter
PM _{2.5}	particulate matter with a diameter less than or equal to 2.5 micrometers
PM ₁₀	particulate matter with a diameter less than or equal to 10 micrometers

PMP	probable maximum precipitation
PO ₄ ³⁻	phosphate
POP	persistent organic pollutant
POTW	publicly owned treatment works
PPE	personal protective equipment
PPV	peak particle velocity
PRT	prevention and response tug
PS	pump station
PSD	Prevention of Significant Deterioration
PWS	Prince William Sound
QA	quality assurance
RAC	Resource Advisory Council
RCAC	Regional Citizens' Advisory Council
RCM	reliability-centered maintenance
RCRA	Resource Conservation and Recovery Act
REAA	Regional Educational Attendance Area
RGV	remote gate valve
RMP	Resource Management Plan
ROD	Record of Decision
ROS	recreation opportunity spectrum
ROW	right-of-way
RRO	residual-range organics
RSC	reduced sulfur compounds
SARA	Superfund Amendments and Reauthorization Act
SCADA	supervisory control and data acquisition
SD	standard deviation
SDWA	Safe Drinking Water Act
SERVS	Ship Escort/Response Vessel System
SHPO	State Historic Preservation Officer
Si	silicon
SIC	Standard Industrial Classification
SIP	state implementation plan
SO ₂	sulfur dioxide
SOSC	State On-Scene Coordinator
SO _x	sulfur oxides
SPC	State Pipeline Coordinator
spp.	species
SRS	state recreation site
Stat.	statute
SWDS	solid waste disposal site
SWPPP	Storm Water Pollution Prevention Plan
SWTP	sanitary waste treatment plant
TAPAA	Trans-Alaska Pipeline Authorization Act
TAPS	Trans-Alaska Pipeline System
TAGS	Trans-Alaska Gas System
TCA	1,1,1-trichloroethane
TCC	Tanana Chiefs Conference
TCP	traditional cultural property
TEEL	temporary emergency exposure limit
TEF	toxic equivalency factor

TFE	tetrafluoroethylene
TLV	threshold limit value
TPQs	Threshold Planning Quantities
TRI	Toxics Release Inventory
TSDF	treatment storage and disposal facility
TSP	total suspended particulates
TSS	total suspended solids
TVB	transient volume balance
TVR	tanker vapor recovery
UAA	University of Alaska-Anchorage
UC	Unified Command
UIC	underground injection control
USACE	U.S. Army Corps of Engineers
USC	United States Code
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	ultraviolet
VAHS	Valdez Air Health Study
VHF	very high frequency
VHS	viral hemorrhagic septicemia
VMT	Valdez Marine Terminal
VOC	volatile organic compound
VRM	visual resource management
VSM	vertical support member
VTs	Vessel Traffic Service
WSR	Wild and Scenic River
ZRAs	Zone of Restricted Activities

Units of Measure

acre-ft	acre-foot (feet)	GW	gigawatt(s)
bbl	barrel(s)	h	hour(s)
Btu	British thermal unit(s)	ha	hectare(s)
°C	degree(s) centigrade	hp	horsepower
cm	centimeter(s)	in.	inch(es)
cm ³	cubic centimeter(s)	in. ²	square inch(es)
cSt	centistoke(s)	j	joule(s)
d	day(s)	K	kelvin degree(s)
dB	decibel(s)	kg	kilogram(s)
dBA	A-weighted decibel(s)	km	kilometer(s)
°F	degree(s) Fahrenheit	km ²	square kilometer(s)
ft	foot (feet)	knot(s)	nautical mile(s) per hour
ft ²	square foot (feet)	kW	kilowatt(s)
ft ³	cubic foot (feet)	L	liter(s)
g	gravitational acceleration	lb	pound(s)
gal	gallon(s)	m	meter(s)

m ²	square meter(s)	psig	pound(s) per square inch gauge
m ³	cubic meter(s)	rpm	revolution(s) per minute
mg	milligram(s)	s	second(s)
mi	mile(s)	scf	standard cubic foot (feet)
mi ²	square mile(s)	scfm	standard cubic foot (feet) per minute
min	minute(s)	wk	week(s)
mL	milliliter(s)	YA	year(s) ago
mm	millimeter(s)	yd	yard(s)
mmole	millimole(s)	yd ³	cubic yard(s)
mph	mile(s) per hour	yr	year(s)
MW	megawatt(s)	μg	microgram(s)
MYA	million year(s) ago	μg-atoms	microgram-atom(s)
ng	nanogram(s)	μm	micrometer(s)
pCi	picocurie(s)	μmoles	micromole(s)
ppb	part(s) per billion	μR	microroentgen(s)
ppm	part(s) per million	\$/bbl	dollar(s) per barrel
psi	pound(s) per square inch		

1. Introduction

1.1 Purpose and Need

The Trans-Alaska Pipeline System (TAPS) was constructed in 1974–1977 through the central portion of Alaska from the North Slope oil fields at Prudhoe Bay to a marine terminal at the Port of Valdez (Map 1-1).¹ The pipeline was constructed on a right-of-way (ROW) granted by federal, state, and private landowners.² The federal and state ROWs were granted for periods of 30 years, which expire in January and May 2004, respectively.³

On May 2, 2001, the Bureau of Land Management (BLM) of the U.S. Department of the Interior (DOI) received an application for renewing the federal “Agreement and Grant of Right-of-Way for Trans-Alaska Pipeline” (Federal Grant) for 30 years beyond the current expiration date of January 22, 2004. The application for renewal was received from the current owners of the Trans-Alaska Pipeline System (TAPS Owners): BP Pipeline (Alaska), Inc. (46.9263% share); Phillips Trans Alaska, Inc. (26.7953%); ExxonMobil Pipeline Company (20.3378%); Williams Alaska Pipeline Co. (3.0845%); Amerada Hess Pipeline Corp. (1.5000%); and Unocal Pipeline Company (1.3561%). The renewal of the Federal Grant covers the TAPS ROW as well as ROWs and permits for related facilities on lands subject to federal administration. The BLM determined that a decision to renew the Federal Grant would represent a major federal action under the National Environmental Policy Act (NEPA). Thus, the BLM is undertaking this environmental impact statement (EIS) process to assess the positive and negative environmental, social, and economic impacts associated with the application.

The DOI issued the Federal Grant for the primary ROW for the TAPS on January 23, 1974. Because the Mineral Leasing Act (MLA) limits ROWs to no more than 30 years, the Federal Grant will expire in January 2004. Moreover, although they were issued on different dates by the federal government, some grants for the ROWs for related facilities and access roads also expire on January 22, 2004, as does a Memorandum of Understanding (MOU) for the use of 95 oil spill contingency sites. The ROWs and sites involved include 175 access roads, a fuel gas line and related facilities, a power and communication line, and a communication site and access road.

The MLA states, “The Secretary [of the Interior] or agency head shall renew any right-of-way, in accordance with the provisions of this section, so long as the project is in commercial operation and is operated and maintained in accordance with all of the provisions of this section” (*United States Code*, Volume 30, Section 185(n) [30 USC §185(n)]). It also states that the Secretary or agency head can renew such ROWs only “when he is satisfied that the applicant has the technical and financial capability to construct, operate, maintain, and terminate the project for which the right-of-way . . . is requested in accordance with the requirements of this section” (30 USC §185(j)). In addition, the law empowers the Secretary or agency head to impose terms and conditions “regarding extent, duration, survey, location, construction, operation, maintenance, use, and termination” of the ROW (30 USC §185(f)). Terms and conditions may be imposed or modified at any time. The MLA directs the

¹ All maps referred to by map number in this EIS are contained in Volume 7.

² The TAPS and its related facilities are authorized under a bundle of separate rights-of-way. Common usage is to refer to the TAPS rights-of-way as a single right-of-way (i.e., ROW). This EIS generally follows that practice.

³ Under the Administrative Procedures Act, once an application to renew is filed, the system will continue to operate under the existing grant until processing is completed, even if the grant expires while the application is pending. The BLM has determined the TAPS Owners’ application to be complete (Brossia 2001).

Secretary or agency head to impose “requirements for the operation of the pipeline and related facilities in a manner that will protect the safety of workers and protect the public from sudden ruptures and slow degradation of the pipeline” (30 USC §185(g)).

In the early 1970s, many Americans saw the construction of the TAPS as a key means of lessening dependence on foreign oil supplies, a concern highlighted by the 1973 oil embargo. In that year, the United States imported 26% of its crude oil and 34% of all its petroleum (EIA 2001). The TAPS was seen as a necessary development that would bring North Slope oil, discovered in 1968 at Prudhoe Bay, to market. Prudhoe, the largest oil discovery in United States history, and its neighboring fields were viewed as critical to markedly increasing American domestic oil production and reducing reliance on foreign oil imports.

Congress enacted the Trans-Alaska Pipeline Authorization Act (TAPAA) on November 16, 1973. TAPAA mandates federal oversight of all TAPS activities and allows modification of operating conditions at any time. It directs that “the Secretary of the Interior and other appropriate Federal officers and agencies . . . take all necessary action to administer and enforce rights-of-way, permits, leases, and other authorizations that are necessary for or related to the construction, operation, and maintenance of the trans-Alaska oil pipeline system” (43 USC §1652(b)). At the same time, Congress also gave the government broad authority to protect the public interest. TAPAA states, “The Secretary of the Interior and the other Federal officers and agencies are authorized at any time when necessary to protect the public interest, pursuant to the authority of this section and in accordance with its provisions, to amend or modify any right-of-way, permit, lease, or other authorization issued under this chapter” (43 USC §1652(e)). The TAPAA remains in full force and effect.

The TAPS continues to be recognized as an important component of the nation’s energy infrastructure. President George W. Bush’s National Energy Policy states that the TAPS is “the single most important crude oil pipeline in the United States.” Alaska’s North Slope oil

fields currently account for 17% of domestic oil production and about 6% of the nation’s oil consumption. In 2000, the United States imported 60% of its crude oil and 52% of all its petroleum (EIA 2001). Recognizing this, the President’s energy policy calls for the “most expeditious process for renewal of the Trans-Alaskan Pipeline System right-of-way to ensure that Alaskan oil continues to flow uninterrupted to the West Coast of the United States” (National Energy Policy Development Group 2001). The national policy to expedite energy-related projects such as renewal of the TAPS ROW is further supported by Executive Order 13212 issued on May 18, 2001, which directs federal agencies “to expedite projects that will increase the production, transmission, or conservation of energy.”

1.2 Scope of the Decision and Analysis

The TAPAA provides the Secretary of the Interior with the authority and obligation to oversee the construction, maintenance, operation, and termination of the entire pipeline system. The TAPAA provides more specific flexibility and authority for regulating the TAPS, inclusive of and beyond the usual requirements of Section 28 of the MLA. The BLM can impose new or supplementary requirements on the TAPS permittees at any time, not just at the time of ROW renewal. Even though some portions of the pipeline system — including Pump Station (PS) 1, 8, and 9 and the Valdez Marine Terminal — are on land owned by the TAPS Owners, the TAPAA and Federal Grant provide that all TAPS operations (i.e., even those on state and private lands as well as federal lands) are subject to BLM systemwide oversight and decisions. The Federal Grant specifies many of the federal responsibilities. Thus, this EIS evaluates alternative decisions, analyzes impacts, and considers mitigation measures applicable to all parts, and any part, of the TAPS, regardless of the underlying land ownership (Map 1-2). The State of Alaska also has specific authorities over state lands that relate to its oversight of the TAPS. As a practical matter, the State of Alaska and the BLM coordinate on major oversight actions.

The TAPS Owners have applied for renewal of an array of uses, ranging from the main-line ROW to oil spill contingency plan sites. The scope of the BLM decision and analysis encompasses the array of renewal considerations found in the TAPS Owner's application as amended (see www.tapsrow.com for the full application, including line lists at Volume 2, tabs D through H). Further summary descriptions of the array of renewal considerations found in the application can be found in Section 2.2 of this EIS.

NEPA regulations require federal agencies to analyze the totality of the affected environment associated with a federal action, including cumulative impacts (*Code of Federal Regulations*, Title 40, Part 1508, Section 25 [40 CFR 1508.25]). In the case of the TAPS, indirect and cumulative impacts may include past, present, and reasonably foreseeable future actions that would affect the (1) same resources and lands as those that are affected by the pipeline system itself, (2) North Slope oil fields that depend on the pipeline to deliver oil to market, and (3) tanker traffic associated with transporting oil from the Valdez Marine Terminal to market. The TAPS is distinct from the North Slope oil fields and tanker traffic, relating to them as follows:

- TAPS/North Slope oil fields: The upstream end of the TAPS begins at the foot of the workpad at PS 1.
- TAPS/tanker traffic: The downstream end of the TAPS extends to the end of the loading arms for crude oil located at the tanker loading berths in the Valdez Marine Terminal; vapor control and ballast water treatment systems are considered part of the TAPS.

1.3 Description of the TAPS and Its Surrounding Area

The TAPS crosses seven major physiographic provinces and widely varying landscape features, including three major mountain ranges (Map 1-3). More than half of the topography along the route has been heavily

influenced by past and present glaciation, which has produced steep side slopes in the mountains and linear U-shaped valleys that are often bisected by streams and braided rivers carrying large loads of sediment. The highest elevation along the route occurs at Atigun Pass in the Brooks Range (4,739 ft). Oil must also be pumped over Isabel Pass (3,420 ft) in the Alaska Range and over Thompson Pass (2,812 ft) in the Chugach Mountains. Because of the widely varying topography, soil, and climate of the land that the pipeline traverses, vegetative communities range from the tundra-covered coastal plain of the North Slope, to the extensive spruce-birch forests of the Interior, to the western hemlock and Sitka spruce forests of the Prince William Sound coastal areas.

The TAPS is a complex industrial system. Its major components are described here.

Pipeline: Oil flows from PS 1 near the Prudhoe Bay oil field to the Valdez Marine Terminal on Port Valdez through an 800-mi, 48-in.-diameter hot oil pipeline (Map 1-1). Approximately half the pipeline is buried. To prevent thawing of permafrost, half of the pipeline is aboveground, mounted on approximately 78,000 vertical support members (VSMs), and some buried sections are insulated or refrigerated and insulated. The pipeline makes hundreds of crossings over and under rivers, streams, and other water bodies. It is buried at most crossings; most aboveground stream crossings are on VSMs over small streams, but there are 13 bridge crossings. The pipeline system also includes armored banks and specially constructed embankments (river entrainment structures) that protect the pipeline from the potentially erosive migration of the rivers it crosses or parallels. One hundred and fifty-three valves help control oil flow along the pipeline. Sixty-three are remote gate valves (RGVs) that allow Alyeska Pipeline Service Company (APSC) (which operates the TAPS for the TAPS Owners) to rapidly (in 4 to 12 minutes) shut down the flow of oil through electronic instructions from the pipeline control center in Valdez. Eighty-one check valves located on or near slopes operate automatically if oil flow in the pipeline reverses. Nine manually controlled gate valves provide backup support to the check valves and facilitate maintenance operations. The pipeline also incorporates technology that

detects pressure and flow fluctuations that can indicate leaks or the buildup of excessive pressure in the pipeline.

Pump Stations: Six operating pump stations (PS 1, 3, 4, 7, 9, and 12) propel oil through the pipeline. One additional pump station (PS 5 on the southern slope of the Brooks Range) operates only to relieve pressure in the line. As a result of the decline in throughput in the 1990s, four other pump stations (2, 6, 8, and 10) were placed on standby in 1996 and 1997. PS 11 was never constructed. Natural gas powers the turbines at PS 1, 3, and 4; farther south, liquid fuel turns the turbines.

The pump stations include valves, pipe, tanks, and control equipment designed to relieve excessive pressures on the pipeline when the pipeline or a pump station shuts down. Map 1-4 provides a view of PS 1, which, while more complex than the other pump stations, highlights the important components found at each pump station. Pressure relief valves open automatically when the pipeline pressure exceeds set limits, and they can also be opened by controllers by resetting the pressure limits.

Relief tanks are located at all pump stations south of PS 1 to temporarily contain oil discharged from the pipeline by pressure relief valves at the pump stations. At PS 1, there are tanks to balance and meter oil before it is injected into the pipeline. Other tanks along the TAPS store fuels used to run the pump stations. To prevent the escape of crude oil or fuel oils, the tanks are surrounded by secondary containment structures. Those for the relief tanks and other large tanks are generally composed of earthen dikes and a geosynthetic liner.

PS 1, 7, and 9 include drag reducing agent injection facilities, including a storage tank and piping to an injection pump and injection ports in the pipeline. Drag reducing agent is a viscous hydrocarbon added in small quantities to the crude oil to improve flow in the pipeline. Five of the active pump stations have living quarters. Pump stations are also equipped with fire detection and suppression systems, completely fenced, and provided with security services.

Access Roads and Bridges: There are 284 access roads (175 access roads cross federal land and are included in the applicant's renewal request) that traverse state, federal, municipal, and private lands as they extend from state roads to the pipeline, material sites, disposal sites, and pump stations. These access roads typically consist of two-lane gravel embankments constructed of locally available granular material. The roads cross approximately 44 bridges over water drainages.

Valdez Marine Terminal: The Valdez Marine Terminal is a 1,000-acre facility on land owned by APSC on the southern shore of Port Valdez, across from the town of Valdez (Map 1-5). The Valdez Marine Terminal performs two major functions: it stores and loads oil onto tankers for shipment to market and it houses the Operations Control Center (OCC).

The pipeline delivers crude oil to the Valdez Marine Terminal, where it is first measured at the East Metering Building. From there, either it can be directly loaded onto tankers through one of four loading berths or it can be placed in one of the eighteen 510,000-bbl storage tanks to be loaded onto tankers later. Lined earthen dikes provide secondary containment for the crude oil storage tanks. Vapor control systems are in place for the tanks and for the two primary tanker loading berths. Ballast water removed from incoming tankers and all other oily water collected at the Valdez Marine Terminal is processed (secondary treatment). Treated water is discharged into Port Valdez, and recovered oil is returned to the crude oil system. Water treatment is required to meet all U.S. Environmental Protection Agency (EPA) permit requirements.

The OCC controls the flow of oil through the Valdez Marine Terminal and along the entire TAPS. By using remote sensors and electronic communications systems, operators at the OCC are able to monitor the oil flow rate, temperature, pipeline pressure, and valve positions along the TAPS. Operators can react to detected abnormalities by slowing or stopping pumps and by closing main-line valves or opening relief valves.

Telecommunications: Satellite, cable, and terrestrial microwave radio systems provide key communications along the TAPS. Satellite and land-based microwave radio systems transmit critical signals to control the flow of oil through the pipeline. Fiber-optic cable along the pipeline route, backed up by the satellite system, is the primary transmission medium for all other communications among the OCC, pump stations, oil-producing companies at Prudhoe Bay, transient construction sites, and APSC administrative offices in Fairbanks.

Workpads: Workpads are mineral-material-filled embankments on which the travel lane next to much of the pipeline is located, or they are fill areas used during construction to provide access to diverse items of heavy equipment and to act as a sound working surface for this equipment. Some workpads are insulated to assure that ice in underlying soils does not melt.

Gas Line: Natural gas is produced along with oil at Prudhoe Bay. Some of this gas is piped to a metering, filtering, compressing, and cooling facility at PS 1. A buried 149-mi gas pipeline transports this fuel to power PS 3 and 4.

1.4 Relationships of the TAPS to BLM Policies, Plans, and Programs

The BLM develops land use plans to guide use activities, stewardship goals, and management approaches. Within Alaska, the BLM plans recognize the importance of energy resources.

The BLM has three multiple-use land use plans that encompass portions of the TAPS. The Southcentral Management Framework Plan was issued in 1980 (BLM 1980). It covers portions of the TAPS on BLM lands south of the Alaska Range but discusses no management decisions affecting the TAPS. The Fort Greely Resource Management Plan (RMP) was issued in 1994 (BLM and U.S. Department of Defense 1994). It acknowledges the prior existence of the TAPS and states that the BLM will protect “valid existing rights.” In the Utility Corridor Proposed RMP (BLM 1989), the BLM makes the

preeminence of energy delivery very clear for its lands north of the Yukon River near the TAPS. The Utility Corridor Proposed RMP states, “No proposed management action [in the plan] should be interpreted as limiting current or future energy transportation needs in the Utility Corridor. The need for the transportation of energy minerals supersedes all other uses of the Utility Corridor” (BLM 1989). The Utility Corridor RMP’s 1991 Record of Decision (ROD) (BLM 1991) states that “the primary management direction and use of BLM-administered lands in the Utility Corridor is for energy transportation.” All three plans are consistent with the proposed action.

In the past five years (1997–2002), the BLM has undertaken planning efforts for the National Petroleum Reserve-Alaska (NPR-A). In 1998, it completed the northeastern NPR-A integrated activity plan/EIS and made approximately 4 million acres available for leasing oil and gas. In 1999, the BLM conducted a lease sale for this area, and oil companies purchased 133 tracts. The BLM conducted a second lease sale in this area in June 2002. Oil companies have conducted exploratory activities for their lease holdings. In November 2001, the BLM initiated a similar planning process for the northwestern NPR-A, which may result in additional acreage being offered for leasing oil and gas. The BLM in its studies anticipated that any crude oil obtained from NPR-A would depend on the TAPS to reach markets.

1.5 References for Chapter 1

BLM (Bureau of Land Management), 1980, *Management Framework Plan for the Southcentral Planning Area*, Anchorage District Office, Anchorage, Alaska.

BLM, 1989, *Utility Corridor Proposed Resource Management Plan and Final Environmental Impact Statement*, Arctic District Office, Fairbanks, Alaska.

BLM, 1991, *Utility Corridor Resource Management Plan/Environmental Impact Statement Record of Decision*, Arctic District Office, Fairbanks, Alaska, Jan. 11.

BLM and U.S. Department of Defense, 1994, *Fort Greely Proposed Resource Management Plan Final Environmental Impact Statement*, Steese/White Mountains District, Report No. BLM/AK/PT/94/010+1600+080, Anchorage, Alaska.

Brossia, J., 2001, letter from Brossia (Authorized Author, Bureau of Land Management/Office of Pipeline Management) to S. Jones (Renewal Project Manager, Alyeska Pipeline Service Company), Anchorage, Alaska, May 31.

EIA (Energy Information Administration), 2001, *Annual Energy Review 2000*, U.S. Department of Energy, Washington, D.C., p. 123.

National Energy Policy Development Group, 2001, *Reliable, Affordable, and Environmentally Sound Energy for America's Future: Report of the National Energy Policy Development Group*, Washington, D.C., p. 7-10.

2. Alternatives

2.1 Introduction

This chapter discusses various alternatives related to renewal of the Federal Grant for the TAPS ROW. Three alternatives are discussed in detail: to renew the Federal Grant for 30 years (proposed action), to renew the Federal Grant for less than 30 years (less-than-30-year-renewal or time-dependent alternative), and to not renew the Federal Grant (no-action alternative). The impacts of these alternatives are analyzed in detail in Chapter 4. This chapter describes other alternatives that were considered, and explains why they were not analyzed further.

At this stage, the BLM has identified the proposed action as its preferred alternative. The agency's ultimate decision will be defined in the ROD that will follow this EIS and may include a mix of studied elements as the final decision.

2.2 Proposed Action — Renew Federal Grant for 30 Years

The proposed action would be to grant the TAPS Owners' application to renew the existing Federal Grant for the TAPS ROW for 30 years. The renewed Federal Grant would cover not only the original TAPS ROW issued under two serial numbers (F-12505 and AA-5847), but also the rights associated with the Federal Grant and pipeline system, which include (1) the fuel gas pipeline that provides gas from Prudhoe Bay south to PS 4, (2) access roads authorized under numerous serial numbers, (3) oil spill contingency plan sites authorized through a Memorandum of Understanding (MOU) issued in June 1991, (4) a prospective power and communication line running to the Prospect Airport, and (5) a communication site and access road near the Gulkana River crossing of the TAPS (see the "line list" furnished as part of the TAPS Owners' application for renewal, as amended [www.tapsrow.com] or contact the Joint Pipeline Office's (JPO's) Renewal Team for a description of all ROWs in

the application). The proposed action reflects the TAPS Owners' application.

Land titles for the TAPS and all related facilities originally and subsequently granted to the TAPS Owners by the United States and the State of Alaska were examined and coordinated between Alaska and the United States to ensure that the entire TAPS was reauthorized by either Alaska or the United States. Amendments will be made as necessary to correct any errors or omissions.

The terms and conditions of the Federal Grant, as modified or supplemented by special requirements (See Appendix G) through the date of any ROD on the proposed action, would continue under the proposed action. (See Appendix B for the version of the Grant proposed for renewal.) Both the Federal Grant and Section 203(e) of TAPAA (43 USC §1652(e)), 43 CFR 2881.1-1(f) give the BLM broad authority to impose additional requirements at any time as necessary for safety and to protect the environment. The BLM has exercised this authority from time to time since issuance of the original Federal Grant. (See Section 4.1.1.2 of this EIS.) Therefore, the obligations of the Federal Grant as it is proposed to be renewed, include requirements placed upon the TAPS Owners in writing by the BLM's Authorization Officer (AO) for TAPS in accordance with the Federal Grant and TAPAA.

2.2.1 Projected TAPS Operation

The TAPS Owners' application sets forth details of how the TAPS would operate if renewed. The TAPS Owners are not proposing any specific changes to the system in their renewal application. However, they recognize that the system's configuration and operation would continue to evolve to meet changing oil throughput, respond to changes in environmental conditions, and take advantage of new technology. The applicants anticipate that six pump stations would move oil through the pipeline at the beginning of the

renewal period. The TAPS Owners state in their application that throughput variation and the cost of drag reducing agent, which increases the efficiency of oil movement, might prompt intermittent shutdown of one of the six pump stations — PS 12 north of Thompson Pass — in the early renewal years, and, in later years, these factors might eventually lead to discontinuing the use of both PS 12 and PS 7 north of Fairbanks. In addition to the pump stations that push oil through the line, one pump station would operate only for pressure relief. The applicants anticipate that they would continue to use drag reducing agent to facilitate oil movement.

The application posits that Berths 4 and 5 would be used for the majority of oil loading at the Valdez Marine Terminal during the renewal period. Berths 1 and 3 would furnish additional capacity, although one or both of these berths might be demobilized if loading demand declines.

Throughout the renewal period, the TAPS Owners would be required to monitor, maintain, and repair the system. In their application, the TAPS Owners noted several of the more significant potential inspection and repair operations, including these:

- Gathering corrosion data through instrumented-pig runs, digging up belowground pipe where necessary, examining it, and, if necessary, replacing corroded pipe;
- Upgrading the cathodic corrosion protection system and/or excavating and recoating the pipeline;
- Inspecting and repairing belowground valves;
- “Sleeving” damaged pipeline or replacing sections of pipeline that cannot be more economically repaired by sleeving;
- Monitoring and maintaining the aboveground pipe supporting systems, including VSMs, and, if necessary, replacing nonperforming VSMs;
- Repairing and upgrading armored banks and designed embankments; and
- Mining gravel and rock from existing or new quarries (TAPS Owners 2001, pages 1.1-2 and 4.1-1 through 4.1-4).

2.2.2 Requirements and Responsibilities under the Federal Grant

The application for the ROW renewal does not ask for any changes to the Federal Grant’s terms. Under the proposed action, the Federal Grant would encompass the modifications and supplementations made to it by special requirements through the date of any ROD on the proposed action. Additional mitigation measures, such as those discussed in Section 4.8.4, might be adopted at the time of the ROD.

The Federal Grant defines the relationship between the TAPS Owners and the federal government and contains provisions addressing technical, environmental, employment, and subsistence issues related to the TAPS. The Federal Grant places obligations on the TAPS Owners. Provisions related to the operation, maintenance, and termination of the TAPS also are requirements binding on the TAPS Owners’ common agent (as defined in Stipulation 1.4.2), APSC. The following paragraphs describe some of the salient obligations and responsibilities imposed by the Federal Grant. The entire Federal Grant as it is proposed to be renewed is reproduced in Appendix B; more information on the relationship among the TAPS Owners, APSC, and the federal government can be found in Section 4.1 of this EIS.

Administrative: The Federal Grant describes the lands conveyed by the ROW and the ROW’s location, width, and duration. The Federal Grant obligates the TAPS Owners to comply with applicable federal laws and regulations and lawful orders of the Secretary of the Interior and AO. It provides that the AO has the authority to require modifications to the TAPS and to the Federal Grant. The Federal Grant states that the Secretary can suspend or terminate the ROW if the TAPS Owners fail to comply substantially with requirements of the MLA, TAPAA, or Federal Grant. It requires that before the permittees begin significant ground-disturbing construction or modification of the TAPS, that they submit an application for a Notice to Proceed (NTP) and the documentation needed to enable the AO to assess whether the work conforms to appropriate engineering criteria. The TAPS Owners are further obligated to reimburse the federal government for

the expenses incurred by the DOI in processing applications related to the TAPS and in monitoring the system. The DOI is to avoid “unnecessary employment of personnel and needless expenditure of funds” (Section 12.E, Federal Grant). The TAPS Owners have the right to audit the DOI’s records of expenditures, subject to all existing privacy and disclosure laws, and the DOI has the right to examine all TAPS records.

Technical: The Federal Grant requires design standards that guard against hazards associated with earthquakes, tsunamis, erosion, flooding, permafrost, glacial surges, and corrosion. It requires shutoff valves along the pipeline, and it requires dikes or other oil spill containment structures at pump stations and the Valdez Marine Terminal. It specifically names certain industry and government technical standards that the pipeline operator must meet or exceed, and it authorizes the AO to impose additional standards to address Alaska’s subarctic and arctic environments.

Human and Natural Environment: The Federal Grant requires the TAPS Owners to have a surveillance and maintenance plan and a quality assurance (QA) program that can detect and prevent damage to the natural environment, maintain the pipeline’s physical integrity, and provide for public health and safety. The TAPS Owners are to promptly abate hazards to public health or worker safety and threats that could cause serious and irreparable harm or damage to the environment. The TAPS Owners are also responsible for rehabilitating natural resources damaged or destroyed by their operation of the TAPS, to the satisfaction of the AO, and/or for paying money damages for such loss. There are specific requirements addressing pollution control; oil spill detection, control, and cleanup; use of pesticides, herbicides, and other chemicals; waste management; erosion control; fish, wildlife, and habitat protection; paleontological, archaeological, and historic sites; aesthetics; and public and worker health and safety. The AO may temporarily suspend any and all TAPS operations if, in the AO’s judgment, suspension is necessary to protect public health and safety or the environment. The Federal Grant also states that when the TAPS Owners terminate their use of the pipeline, they must remove all improvements and equipment and rehabilitate the environment, except as otherwise approved by the AO.

Employment: The Federal Grant mandates that the TAPS Owners assure that no person is denied workplace opportunities on the grounds of race, creed, color, national origin, or sex. In addition, they are to conduct pre-employment and on-the-job training for Alaska Natives and “do everything practicable” to secure employment for Alaska Natives who successfully complete the training program. They are further required to enter into an agreement with the DOI regarding Alaska Native recruitment, training, and employment. The current agreement is provided in Appendix F.

Subsistence: The TAPS Owners are to avoid damage to subsistence resources and, upon the order of the Secretary of the Interior, shall provide emergency subsistence and other aid to those whose subsistence resources are impacted.

Discretionary Authority: The Federal Grant provides significant discretion to the AO in exercising authority to correct problems. It enables the AO to change requirements to respond to changing situations. For example, in 2001, the AO and the Alaska Department of Natural Resources (ADNR) State Pipeline Coordinator (SPC), who has analogous authority for the State TAPS ROW, under the authority of the Federal Grant and State Lease, jointly imposed new or modified design requirements. These requirements were related to (1) the stability of slopes along the pipeline; (2) monitoring for fault movements and glacial surges; (3) fill for certain portions of the buried pipeline; (4) brushing restrictions; (5) a limit on the amount of time allowed between the time when a deviation from the design criteria for a critical aboveground facility (e.g., a VSM that supports aboveground pipe) is discovered and the time when an appropriate engineering correction is made; (6) proper restoration of lands disturbed by TAPS activity; and (7) intervention criteria to be used to determine when the pipeline, because of curvature or deformation, requires corrective maintenance.

2.2.3 Projected BLM Oversight

Under the proposed action, the BLM would continue to assure compliance with TAPAA, the MLA, and the Federal Grant as part of its responsibilities. Through its authority to issue NTPs and temporary use permits for TAPS-associated actions, the BLM would continue to

exercise control over significant ground-disturbing actions and alterations of the TAPS. It is anticipated that during the renewal period, the BLM would continue to exercise its TAPS monitoring responsibilities through coordinated efforts with other federal and state pipeline regulatory agencies collocated in the JPO.

The BLM and a dozen other federal and state agencies located in the JPO cooperate in the oversight and monitoring of the TAPS to identify deficiencies and compel corrective actions. The JPO facilitates a coordinated oversight of the TAPS. The JPO member agencies receive their individual authority through federal and state laws and regulations. In addition, the BLM and ADNR have broad oversight authority under the Federal Grant and the State Lease.

Although specific approaches to allow the BLM to carry out responsibilities under the MLA and TAPAA might change in order to better respond to changing conditions, it is anticipated that the following processes would prevail. The BLM would continue to learn about concerns about the pipeline in the following ways:

JPO Field Investigations and Record Reviews: JPO employees detect problems or concerns during the course of conducting “surveillances” in the form of field investigations of TAPS facilities or reviews of APSC records. These surveillances would be conducted to verify conformance with Federal Grant and regulatory requirements as part of the JPO’s Comprehensive Monitoring Program.

TAPS Owners’ Quality Assurance and Monitoring Programs: APSC is the common agent that the TAPS Owners incorporated in August 1970 to construct and operate the pipeline. As agent for the TAPS Owners and in accordance with the requirements of the Federal Grant, APSC would continue to conduct QA and monitoring programs to detect problems, which it would then report to the BLM.

TAPS Employees: TAPS employees and contractors would be able to find problems and report concerns to the BLM, independently from APSC’s QA and monitoring programs.

Incident: Sometimes an accident or other incident may occur on the TAPS that would draw

the JPO’s attention to a previously undetected problem.

The JPO agencies would continue to use a risk-based approach to overseeing operations. They would calibrate their response to a problem to match the risk inherent in the problem. Some discrepancies spotted during surveillances or as part of APSC’s internal quality and monitoring programs would be fixed on the spot. JPO inspectors would then note the deficiency and the subsequent correction for the record, and subsequent surveillances would assure that the problem would not recur. Some solutions might be relatively obvious and straightforward, and the JPO and APSC would readily orally agree to an appropriate, prompt response. If a problem that was immediately identifiable as being serious arose, and if the solution was apparent, the JPO may formally give written notice of a deficiency finding to APSC and direct the pipeline operator to take remedial action by a specified time. If a problem that required in-depth scientific or engineering study was identified, or if an analysis to determine whether a noted deficiency is symptomatic of a wider problem was appropriate, the JPO would produce a technical, engineering, or assessment report. These reports may result in findings of failure to conform to the Federal Grant. A failure to conform could precipitate the development of a memorandum of agreement (MOA) with APSC to correct the problem, an order to be issued by the JPO to APSC, or, if correction does not occur, the hiring of a contractor by the AO and paid for by the TAPS Owners to perform the corrective task. The JPO would subsequently monitor APSC’s implementation of corrective actions through surveillances and other follow-up actions.

The JPO and APSC would continue a program to anticipate ways that the TAPS could cause safety or environmental problems and to assure that the TAPS Owners would take steps to avoid these problems. The current strategy to achieve this goal is through a reliability-centered maintenance (RCM) program in which both APSC and the JPO participate. In this process, the JPO and APSC employees jointly examine, through a structured analysis, ways in which the TAPS’ critical systems could fail to properly perform their functions. The joint team, which is focused on employees working directly with the systems,

identifies the potential consequences of such failures. It then identifies appropriate monitoring and maintenance steps to preclude each system's failure. If such a failure cannot be prevented solely by monitoring and maintenance, the JPO and APSC experts determine what modifications to hardware, procedures, or training are needed to eliminate the potential for the identified failure. (For more on RCM, see Section 4.1.1.7) Although the precise structure of this proactive program may change over the term of a new Federal Grant, such a preventive monitoring, maintenance, repair, and replacement system would remain in force through the life of the 30-year renewal period. The BLM retains the authority to require any necessary action without the agreement of APSC.

2.3 Time-Dependent Alternative: Renew Federal Grant for Less Than 30 Years

This alternative proposes renewal of the Federal Grant for a period of less than 30 years. The less-than-30-year renewal alternative would not functionally change or modify the federal government's implementation of its responsibilities (e.g., mitigating factors, laws, regulations, oversight) from its implementation under the proposed alternative.

The time-dependent alternative is presented as a basis for documenting environmental, social, cultural, economic, or operational issues that can be shown to have a potential time-dependent effect over the proposed action period associated with a 30-year renewal period. The analysis addresses both linear and nonlinear time-dependent factors. If time dependency is not an important characteristic of the impacting factor or receptor, the analysis presented in this FEIS under the proposed action would apply.

2.4 No-Action Alternative: Do Not Renew Federal Grant

Under the no-action alternative, the BLM would deny the application to renew the TAPS

ROW. It would require that the TAPS ROW be restored to a condition similar to the condition that existed prior to construction unless the AO provides otherwise. The TAPS Owners would be obliged to pay for removal of, or themselves remove, all improvements and equipment, except as otherwise approved by the BLM AO. The BLM would undertake appropriate NEPA review of any demobilization decision. It is anticipated that the AO's decision would be made in consultation with the SPC. A range of restoration steps are possible and are described generally in Chapter 4. Steps could include cleaning all aboveground and belowground piping and pump stations, removing all aboveground piping, removing all equipment, and completely removing roads and workpads or recontouring them. Other options could also be considered; the most notable options would be removing the buried piping, leaving some or all of the roads and workpads in place, and leaving some aboveground pipe and other structures for alternative uses. Final decisions on the removal and restoration of TAPS and its associated components would involve an extensive analysis to ensure that all closure decisions would meet rigorous engineering and environmental considerations. Thus, the analysis presented in this EIS discusses one general scenario, which is not necessarily the final AO's decision on demobilization of the TAPS.

This no-action alternative would impact North Slope oil exploration, development, and production. In this EIS, the direct and indirect economic impacts on the Alaska economy (public and private) from stopping North Slope oil production are considered. Other issues related to North Slope oil production are addressed in the cumulative analysis.

2.5 Alternatives and Issues Considered but Eliminated from Detailed Analysis

The public brought forward a number of suggestions related to the future of the TAPS. Although the suggestions summarized below do not generally meet the criteria for TAPS renewal alternatives, the BLM has considered all of them. This EIS addresses some of the suggestions heard

during scoping to help the public understand why these alternatives have not been analyzed in detail. One reason common to several of the suggested alternatives is that the BLM does not require additional authority to achieve the purpose of the suggested alternatives. Because of the broad authority granted in TAPAA, the BLM could undertake some of the following suggested alternatives under its current authority at any time. The BLM, for example, could establish advisory committees or conduct audits at any time based upon authority provided by statute, regulation, and the Federal Grant.

The law's requirements on what sort of alternatives are appropriate for the BLM to consider provide additional explanation for why the following alternatives were not analyzed in detail. The BLM is required by law to select alternatives in its NEPA analysis that foster "informed decision-making and informed public participation."¹ NEPA does not require the analysis of alternatives "whose effect cannot be reasonably ascertained, and whose implementation is deemed remote and speculative".¹ Nor must an agency analyze alternatives that are infeasible, ineffective, or inconsistent with the basic policy objectives for the management of the area.¹ In other words, alternatives not responsive to policy objectives of management plans need not be analyzed. Finally, NEPA does not require a separate analysis of alternatives that are not significantly distinguishable from alternatives actually analyzed, or that have substantially similar consequences.²

Thus, the BLM considered the following 12 alternatives but eliminated them from detailed analysis for the reasons described below.

1. Transfer Ownership of the TAPS to Another Entity. The BLM determined not to analyze in detail in this EIS an alternative that would transfer ownership of the TAPS ROW. Such an alternative would have had ownership of the TAPS ROW denied to some or all of the current owners. This alternative would have the BLM granting the ROW to a new mix of owners or to a single company.

Historical Background: On October 28, 1968, eight months after oil was discovered at Prudhoe Bay, three oil firms active in Alaska North Slope oil exploration—ARCO, British Petroleum (BP), and Humble (renamed Exxon in 1972) – formed an organization called the Trans-Alaska Pipeline System to pipe North Slope crude to market. On June 6, 1969, this organization applied for ROWs to build and operate a pipeline from Prudhoe to Valdez Harbor (Mead 1978; Coates 1993). In January 1970 BP swapped its North Slope oil leases for eventual control of Sohio. Thus, in August 1970, when a consortium of oil companies formed APSC to represent their joint interest in building a pipeline across Alaska, the consortium consisted of ARCO, Sohio, and Humble, as well as more minor North Slope leaseholders – Mobil, Phillips, Union, and Amerada Hess (Mead 1978). These seven companies agreed to coordinate their applications for a ROW for the TAPS, to incur the costs for building the TAPS, and to apportion rights to pass oil through the pipeline in proportion to their contribution to construction costs.

In January 1974, after intense study in a pioneering EIS, federal enabling legislation, and complex and lengthy legal battle, the DOI granted the seven oil companies a ROW on which to build the TAPS. In May 1974, the State of Alaska provided a similar ROW over state land. Once it had acquired the rights to build the TAPS on federal, state, and private land, the TAPS Owners initiated construction of their facilities on the ROW. By the time the oil companies completed construction, they had spent approximately \$8 billion to build TAPS (Mead 1978). The oil companies also have maintained and upgraded their TAPS facilities over the last 25 years. For example, the TAPS Owners spent more than \$100 million between 1994 and 1997 on a tanker vapor-control system at the Valdez Marine Terminal (VMT) and nearly \$38 million between 1997 and 2000 to upgrade controls and repair of four pipeline valves.

¹ Headwaters v. BLM, 914 F.2d 1174, 1180 (9th Cir. 1990).

² Northern Plains Resource Council v. Lujan, 874 F.2d 661, 666 (9th Cir. 1989)

The ownership of the TAPS infrastructure and the legal rights afforded the owners through the federal and state ROWs have changed hands since issuance of the grant 28 years ago. Oil company mergers and the desire of some companies to sell their interest in the TAPS have changed the list of TAPS owners and have altered the proportion of ownership among the companies. Section 22 of the grant requires that the Secretary approve any transfer of ownership. Current ownership in the TAPS is as follows: BP Pipeline (Alaska), Inc. (46.9263% share); Phillips Trans Alaska, Inc. (26.7953%); ExxonMobil Pipeline Company (20.3378%); Williams Alaska Pipeline Co. (3.0845%); Amerada Hess Pipeline Corp. (1.5000%); and Unocal Pipeline Company (1.3561%). Additional changes in ownership could occur in the future, consistent with existing statutory authority and the Federal Grant.

Discussion: The scope of this EIS is limited to determining whether to renew the current ROW for the TAPS with its current owners and what different conditions, if any, should be applied to the ROW. This FEIS responds to an application for renewal from the current holders of the ROW. No other entity has applied for the ROW; thus, the BLM has no application from others to which to respond.

Federal laws and regulations provide certain rights to renewal to holders of pipeline ROWs. The MLA (30 USC §185(n)) states that the Secretary of the Interior “shall renew any right-of-way, . . . so long as the project is in commercial operation and is operated and maintained in accordance with all of the provisions of this section.” Regulations (43 CFR 2881.1-1(f)) state that ROWs such as the TAPS “shall be renewed if the pipeline is being operated and maintained in accordance with all provisions of the right-of-way grant, these regulations and the Act.” The determination of whether the TAPS and the current ROW holders are in compliance shall be made at the time the ROD is issued.

If they are in compliance as required by law and regulation, the BLM will adopt one of the two renewal alternatives described above. If they are not in compliance, the BLM will adopt the no-action alternative and reject the applicants’ renewal application. If the BLM rejects the renewal application, a new applicant could submit a request for a ROW to continue operations of the

TAPS. The BLM would process that application in accordance with applicable laws, regulations, and policies.

2. Transfer Operation to Another Common Agent.

The BLM determined not to analyze in detail in this EIS an alternative that would require a new common agent for the TAPS Owners. This alternative would require that the TAPS Owners no longer use APSC as their common agent. Rather, the BLM would require the TAPS Owners to authorize one of the TAPS Owner companies or another company other than APSC to act as the common agent for all of the TAPS Owners.

Historical Background: Prior to creation of APSC in 1970, the oil companies with North Slope oil leases attempted to advance the construction of the TAPS through a committee of the parties. This proved unwieldy. Secretary of the Interior Walter Hickel complained of its inefficiency, stating that, “by the time all the principals could be telephoned in Texas, New York, California, and London, it could take weeks just to get an agreement on what color to paint the toilets in the construction camps.” Hickel also said that the consortium had “more consultants than a psychiatric ward, more colonels than Kentucky, and not a general in the place” (Coates 1993). APSC was created to avoid these inefficiencies.

In 1974, the TAPS Owners in the Federal Grant affirmed an earlier commitment that APSC would design and construct the TAPS. The TAPS Owners also indicated that they intended to appoint APSC to operate, maintain, and terminate the TAPS. APSC oversaw TAPS construction of the TAPS and has served as the common agent for the TAPS Owners since its creation. It has maintained operations and maintenance staff along the pipeline and at the Valdez Marine Terminal. In 1989, it created the Ship Escort/Response Vessel System (SERVS) to provide escorts through Prince William Sound to help avoid oil spills and to provide response in case a spill should occur. APSC currently employs more than 900 workers as well as hundreds of contractors at pump stations along the full length of the TAPS, at the Valdez Marine Terminal, with SERVS, and at its offices in Anchorage, Fairbanks, and Valdez.

Discussion: The TAPS ROW grant as it is proposed for renewal requires the TAPS Owners to appoint a common agent. Stipulation 1.4.2 states: "Permittees shall maintain a common agent for the construction, operation, maintenance and termination of the Pipeline System at all times during this Agreement." Defects in actions by the agent are the responsibility of the TAPS Owners and can be remedied through government oversight under the provisions of the proposed renewal of the grant, regardless of who is acting as common agent. Changing the agent in and of itself, in contrast, would not ensure improved operation. Indeed, changing agents could, to the extent that the new agent relied on different personnel, cause significant disruptions. To the extent that the new agent would rely on current personnel, this alternative would have the same environmental effects and is therefore the same as the proposed action.

3. Require Payment of the Exxon Valdez Oil Spill Settlement. The BLM determined not to analyze in detail in this FEIS an alternative that would require ExxonMobil Corporation to pay a \$5 billion jury award for punitive damages stemming from the *Exxon Valdez* oil spill before renewing that corporation's TAPS ROW.

On March 24, 1989, the *Exxon Valdez* ran aground in Prince William Sound, spilling approximately 11 million gallons of North Slope crude oil and causing extensive environmental, economic, and social harm. Exxon (since merged to become ExxonMobil) reached a settlement with the federal government and Alaska in 1991 for criminal charges as well as civil claims brought by the federal and state governments for recovery of natural resources. This settlement included a criminal fine of \$150 million (\$125 million of it remitted to the company in recognition of Exxon's cooperation in cleaning up the spill and paying certain private claims), \$100 million in criminal restitution payment, and \$900 million (in annual payments of \$90 million) as part of a civil settlement. The settlement has a "reopener window" from September 1, 2002, to September 1, 2006, in which the federal and state governments may make claims for up to an additional \$100 million.

Private parties, including many fishermen and other coastal entities, pursued their own civil

lawsuit. In 1994, a jury at the U.S. District Court in Anchorage awarded the plaintiffs \$5 billion. Exxon appealed to the 9th Circuit Court of Appeals. In November 2001, the appeals court ruled that the \$5 billion award was excessive and recommended that the District Court set a lower penalty. The case remains before the District Court for a decision based upon the appeals court direction.

Discussion: The BLM determined not to analyze this alternative in detail. This alternative would not help the BLM meet the purpose and need of this FEIS described in Chapter 1.

4. Give the BLM the Authority to Fine the TAPS Owners. The BLM determined not to analyze in detail in this FEIS an alternative that would have provided the BLM with the authority to fine the TAPS Owners. Under such an alternative, the BLM would have authority to fine the TAPS Owners for a variety of reasons, including failure to implement orders from the BLM in a timely fashion; failure to abide by the agreement for Alaska Native employment outlined in the Federal Grant; violations of Federal Grant provisions that protect pipeline integrity, worker safety, human health, or the environment; substantiated harassment or intimidation to prevent whistle-blowing by employees; and retaliation against whistle-blowers.

The BLM has assessed damages against APSC for extracting mineral materials without proper authorization. Other agencies within JPO, including the U.S. Department of Transportation (DOT) and the State Departments of Fish and Game, Labor, and Environmental Conservation have fined the TAPS Owners for violation of their respective regulations.

Section 18 of the Federal Grant also provides that if the TAPS Owners fail to comply with an order from the AO to perform certain actions, the federal government has the right to perform the actions at the sole expense of the TAPS Owners. Under the provisions of Stipulation 1.7.1.3, the AO may also require the TAPS Owners to stop a project to protect or maintain the stability of geologic material, protect or maintain the integrity of the TAPS, prevent serious and irreparable harm to the environment, or remove hazards to public health and safety. The AO has not taken any of these measures to date.

Discussion: New rule making and perhaps new legislation would be required to give the BLM the authority to levy fines for this wide range of actions of the TAPS Owners. In addition, a separate process, including NEPA review, would be required to adopt such regulations. Adopting such a rule making could be undertaken at any time; it does not have to occur at the time of renewal. Consideration of such regulations is outside the scope of this FEIS.

The Oil Pollution Act of 1990 gives the Secretary of the Interior the authority to impose civil penalties on the TAPS Owners or APSC for any discharge of oil from the pipeline or at its terminal (43 USC § 1656 [2002]). While this penalty authority is limited, it is still one method the Secretary has at her disposal to discourage these types of problems.

5. Establish an Advisory Committee Funded by the TAPS Owners. The BLM determined not to analyze in detail in this FEIS an alternative that would have established an advisory or oversight committee. Such a committee could take in all aspects of the TAPS or focus on specific aspects, such as Native-related issues or subsistence. Such a committee could be entirely voluntary or could have funding of various levels from the BLM or from the TAPS Owners. It might be authorized and sponsored by the BLM alone, or be authorized and sponsored by the various agencies within the JPO. It might be composed of local officials and tribal leaders representing the communities along or near the TAPS. Alternatively, it could be structured more broadly such as with the Regional Citizens' Advisory Councils (RCACs) for Prince William Sound and Cook Inlet established pursuant to the Oil Pollution Act of 1990.

The federal and state governments have long overseen the TAPS. To oversee construction, the Department of the Interior designated an AO and the state appointed a SPC in January 1974 (Mead 1978). The federal government and its contractors alone employed 150 people to monitor construction. Following construction, oversight staffing was reduced until 1990 when the BLM and the ADNRC formed the JPO. Additional federal agencies — Department of Transportation's Office of Pipeline Safety, U.S. Environmental Protection Agency, U.S. Coast Guard, U.S. Corps of Engineers, and the Minerals Management Service

— and state agencies — Department of Environmental Conservation, Department of Fish and Game, Department of Labor, Department of Transportation and Public Facilities, Division of Governmental Coordination, and Fire Marshal's Office — joined the JPO in subsequent years. Combined under the JPO umbrella, these agencies provide coordinated oversight with a wide variety of expertise and extensive authority. In addition, the JPO can, and has in the past, contracted with independent firms to conduct audits of TAPS operations. The TAPS Owners pay for these audits, as they have for federal and state monitoring activities through the JPO. (See Section 4.1.1 of this EIS for a description of JPO's oversight.) The following discussion of past audits describes why the BLM has not analyzed an alternative in detail that would require periodic audits.

The public has numerous means of directly advising the JPO and its member agencies. The JPO has an Executive Council composed of the agency heads of its constituent offices. That group meets periodically to review important JPO issues and provides policy-level guidance. Those meetings are open to the public, and opportunity for public comment is provided in the agenda.

BLM-Alaska has a legally authorized (under the Federal Advisory Committee Act — FACA) Resource Advisory Council (RAC) that meets regularly to discuss land management issues in Alaska. The RAC is composed of a diverse cross-section of citizens representing industry, conservation, dispersed recreation, elected officials, Alaska Natives, and the public at large. They provide advice to the BLM through a collaborative setting. The meetings (generally held quarterly) are public and are noticed in the *Federal Register* and in BLM news releases and public service announcements to local media. The BLM keeps the RAC informed of the renewal process throughout the processing of the TAPS Owners' application. The RAC chooses the issues on which it wishes to focus. It may form subgroups, comprised of a membership that extends beyond that of the RAC itself, to advise the RAC on specific issues. For example, in the 1990s the RAC formed a subgroup that focused on and provided advice to the BLM on small-scale placer mining on the Wild and Scenic Fortymile River.

The public also has input into oil spill contingency planning. APSC oil spill contingency plans for the TAPS undergo review by the Alaska Department of Environmental Conservation (ADEC) every three years. The ADEC conducts a public review and takes written comments to stay abreast of the public's views on current issues and other matters of concern related to the TAPS. The BLM participates in this process and so is apprised of the public's concerns when conducting its own annual reviews of the spill contingency plans. The ADEC completed its most recent pipeline contingency plan public review in 2001 and is currently reviewing the Valdez Marine Terminal plan.

Discussion: Establishment of a citizens' oversight committee for TAPS operations and maintenance is generally outside the scope of the EIS process for the renewal of the Federal Grant of Right-of-Way. The BLM and other federal and state agencies have statutory authority to provide regulatory oversight for TAPS operations and maintenance activities. (See Section 4.1 for descriptions of federal and state oversight.) This authority and responsibility cannot be displaced, shared, or abdicated. Agencies that operate within the framework of the JPO also derive their oversight responsibilities from specific statutes and regulations. As with the BLM, these authorities form a legally binding regulatory responsibility on the agency. An additional layer of oversight would not increase authority over the TAPS, nor relieve the agencies of their statutory obligations.

Citizen participation and citizen input have and will continue to be fundamental components of the government's responsibility to ensure safe and environmentally protective TAPS operations. Nothing prohibits the BLM from establishing an advisory group at any time. At this time, however, the agency believes that a citizens' advisory committee is unnecessary because, as noted above, there are several processes and advisory committees currently seeking public input, and a new advisory committee would be redundant and would potentially cause public confusion as to which committee is most suitable for any given topic.

6. Conduct Periodic Audits. The BLM determined not to analyze in detail this alternative that would require periodic audits of the operation of the TAPS. Under such an alternative, the TAPS

Owners would be required to fund an independent audit of TAPS at specified intervals, for example, every five years. Under this alternative, continued authorization of the TAPS ROW would be contingent upon the results of these periodic audits.

Historical Background: The TAPS Owners currently fund federal and state oversight of the TAPS. This includes JPO's Comprehensive Monitoring Program (CMP) and RCM program. These two programs are described briefly below. For a more comprehensive description of them and all aspects of JPO's oversight programs, see Section 4.1.1 of this EIS.

Surveillance is the most frequent and routine CMP function and normally involves physical inspections as well as reviews of critical operating and monitoring data. JPO has data from more than 1,300 surveillances of the TAPS. The CMP process also includes assessment reports and technical and engineering reports. An assessment report usually combines the results of several related surveillance actions and of related and independently conducted engineering surveys to identify discrete compliance deficiencies as well as trends. Technical and engineering reports address issues of a highly technical nature for which scientific or engineering judgment and documentation of calculations or rationale for professional opinion are required. CMP Reports, now numbering 12 since 1996, provide an overview of the findings and conclusions of monitoring occurring under the CMP.

RCM is an ongoing system-by-system analytical audit that determines function, failure modes, consequences, and preventive maintenance of critical systems. RCM identifies maintenance strategies necessary to preserve operational safety and reliability. The RCM process describes actions, including monitoring, necessary to prevent a particular failure or reduce the likelihood and consequences of its occurrence. For example, the JPO has issued a special requirement for slope stability monitoring that formally incorporates static and dynamic factor performance standards. RCM is widely used in the airline and other industries as the standard tool for reducing risk of failure to critical system components. The BLM is committed to RCM and believes that this process represents a proactive approach to oversight and regulation of the TAPS. APSC has similarly committed in a June

2002 MOA with the JPO to a maintenance program consistent with RCM and has modified its maintenance manuals to adopt the RCM strategy.

In addition to JPO's own direct oversight, the BLM and APSC have contracted with private experts to conduct a series of TAPS audits. In 1993, the BLM contracted with Quality Technology Company to investigate the physical condition of the TAPS and the management of operations provided by APSC and its contractors. In the early 1990s, the TAPS Owners conducted or contracted for more than 40 studies that addressed specific aspects of TAPS operation, such as corrosion, leak detection, and solid waste management. In 1993, the TAPS Owners contracted with Arthur D. Little to provide a comprehensive independent assessment of TAPS' operations (GAO 1995). Other audits and inspections include BLM's 1996–1997 audit of the TAPS Employee Concerns Program, JPO's 1997 audit of Section 29 compliance, and Alaska Occupational Safety and Health Division's inspection of electrical systems. These audits resulted in thousands of "audit action items" that APSC and the JPO have tracked to assure that deficiencies identified by the audits are appropriately addressed. All audit action items have been resolved.

Discussion: The BLM does not see a need to conduct an immediate independent audit of TAPS facilities and the associated management and operation processes, or to conduct a continuing series of third-party audits at predetermined intervals. As noted above, audits are one of the tools that the BLM and the agencies of the JPO commonly use to evaluate and regulate TAPS operations and maintenance. The BLM has existing discretion and authority under the Federal Grant to conduct or contract for independent reviews and audits as appropriate and needed. Consequently, this alternative was eliminated from detailed analysis because it is already available to the BLM under current operating practices so it is effectively analyzed by the analysis presented in the proposed action.

7. Establish an Escrow Account for TAPS Removal and ROW Rehabilitation.

The BLM determined not to analyze in detail in this EIS an alternative that would require the TAPS Owners to establish an escrow account that could be drawn upon to remove the TAPS and rehabilitate the ROW after the TAPS has been

terminated. Such an escrow account would be readily available to the government, independent of any action by the TAPS Owners, to assure that TAPS removal and rehabilitation are conducted promptly and satisfactorily following completion of the use of the TAPS.

Historical Background: The TAPS ROW grant imposed an obligation on the TAPS Owners to properly remove the TAPS and rehabilitate the ROW following termination of operations. Federal Grant Stipulation 1.10 (Completion of Use) (See Appendix B) states that owner companies "shall promptly remove all improvements and equipment, except as otherwise approved in writing by the Authorized Officer, and shall restore the land to a condition that is satisfactory to the Authorized Officer or at the option of Permittees pay the cost of such removal and restoration."

The grant also included two sections designed to assure that the ROW holders are financially capable of meeting their obligations, including that for removal of the TAPS and restoration of the ROW. (Both these sections remain unchanged in the proposed renewed grant. See Appendix B.) Section 15 required each TAPS Owner to provide an "unconditional guaranty of the full and timely payment of all liabilities and obligations" to the United States. Such guaranty must be satisfactory to the Secretary of the Interior. (See Appendix H for an example of the current guarantees.) Section 22 provided additional assurance that the TAPS Owners are capable of meeting their financial obligations. It required that before ownership in the TAPS can transfer to a new owner, the proposed new owner (Transferree) must "demonstrate, to the satisfaction of the Secretary, that the Transferree is capable of performing all of the liabilities and obligations of the Transferor relating to the interest to be transferred." The section authorizes the Secretary to have access to all relevant documents, including financial records, to assure that the proposed new owner is technically and financially capable of meeting its liabilities and obligations.

In 1982, the federal government promulgated regulations (43 CFR 2883.8) that require a holder of a pipeline ROW to "remove such structures and improvements and restore the site to a condition satisfactory to the Authorized Officer." If the grant holder fails to meet those requirements, the structures and improvements become the property

of the United States, but the grant holder remains “liable for the cost of removal of the structures and improvements and for restoration of the site.”

Funds for dismantling, removal, and restoration (termination) are factored into the pipeline’s tariff. The oil company’s taxes and royalty payments to Alaska are calculated at the refinery price of the oil produced in the state, minus transportation costs. When oil began flowing through the TAPS, the methodologies for calculating transportation costs for royalties and taxes had not been established. After protracted litigation before the Federal Energy Regulatory Commission, however, the state and the oil companies reached a settlement in 1985. As part of the settlement, the TAPS Owners were allowed to collect a charge that by 2011 would be sufficient to cover the then projected costs of termination, that is, to fulfill the requirements of the federal grant’s Stipulation 1.10 and the analogous state lease provision. Adding termination to the tariff calculation provided substantial savings on royalties and taxes to the oil companies. Considering the TAPS Owners to be financially able to meet the legal obligations of the grant and lease to remove TAPS and restore the land, the state’s attorneys did not seek to force the oil companies to place the termination funds in an escrow account. Critics of the decision not to require escrowing termination funds have argued that termination has amounted to a financial windfall for the TAPS Owners, and that without an escrowed account, there is less assurance that removal and restoration will be carried out properly (Fineberg 1992–2002).

Discussion: Proper removal of the TAPS and rehabilitation of the TAPS ROW are valid concerns. The BLM believes that the legal commitments in regulations and the guarantees provided by the TAPS Owners constitute adequate assurances to ensure full-cost recovery from the TAPS Owners for the DR&R of the ROW upon the termination of TAPS. In addition, prior to renewing the ROW the Secretary, pursuant to the Mineral Leasing Act (Section 28(j), 30 U.S.C. § 185(j)) will determine whether the TAPS Owners have “the technical and financial capability to . . . terminate the project.” Renewal cannot proceed without such a determination. Therefore, evaluating this alternative is redundant as the environmental effects would be the same as the proposed action.

8. Establish an Escrow Account to Fund Emergency Aid for Loss of Subsistence or Economic Benefit Because of TAPS Activities and Permit Individuals to Sue for Such Aid. The BLM determined not to analyze in detail in this EIS an alternative that would require the TAPS Owners to establish an escrow account from which subsistence users and others could be compensated for loss because of the TAPS. The BLM also determined not to analyze in detail an alternative that would allow individuals to sue the TAPS Owners to obtain emergency subsistence and other aid.

Historical Background: The TAPAA (Section 204(a)(1)) imposed a liability on the holder of the TAPS ROW, with certain limited exceptions, for damage along or in the vicinity of the ROW to “fish, wildlife, or biotic or other natural resources relied upon by Alaska Natives, Native organizations, or others for subsistence or economic purposes.” The law also stated that the ROW holder shall, upon the order of the Secretary, “provide emergency subsistence and other aid” to those who claim such damage.

The TAPAA also created a Trans-Alaska Pipeline Liability Fund funded by collections of 5 cents per barrel loaded on tankers at the Valdez Marine Terminal. This fund was to be available to pay for cleanup and compensation for damages caused by discharge of oil from a tanker. This fund is now administered by the U.S. Coast Guard, but it is still available as a fund to provide relief to those who have been harmed by the TAPS.

Section 30 of the Federal Grant requires permittees to give special attention to the protection of subsistence resources in the vicinity of the TAPS, as well as to comply with any additional requirements the Secretary may impose to protect the interests of people in the area who rely on subsistence resources. The section also incorporated the liability, damage claim, and emergency aid provisions of TAPAA. It stated that the Secretary may order permittees to provide emergency subsistence or other aid, pursuant to claims submitted under Section 204(a) of the TAPAA.

Native groups have initiated three filings for damages under Section 30, though none have been resolved. In 1997 and 1998, Stevens Village and Ahna, Inc., respectively, filed claims with the

Secretary. The BLM's State Director responded on behalf of the Secretary. The State Director asked for "evidence of causation between the operation of the Federal pipeline right-of-way and damage to your subsistence resources." Such information has not been received. In July 2002, the Native Village of Eyak wrote to the Secretary requesting damages. The letter cited "loss of access to subsistence and economic resources in Prince William Sound in the areas of the tanker lanes." The Department is studying this request and will make a determination once all the information has been adequately reviewed.

Discussion: The BLM determined not to analyze this alternative in detail because the obligations placed on the TAPS Owners by law and the Federal Grant assures compensation for loss of subsistence resources as well as expedited aid. Nothing in law or policy would prevent affected individuals from suing TAPS Owners or the federal government for harms caused by operation of the TAPS. Consequently, this alternative does not substantially differ from the proposed action.

9. Establish an Escrow Account to Fund Studies of Impacts of the TAPS on Rural Alaska and to Address Those Impacts.

The BLM determined not to analyze in detail in this FEIS an alternative that would require the TAPS Owners to establish an escrow account to fund studies of impacts of the TAPS on rural Alaska and to address those impacts. Some rural Alaskans contend that TAPS has had enormous impacts on rural Alaska, though the scope of these impacts is not well understood. Studies might determine what impacts on rural Alaska stem from the pipeline. On the basis of the better understanding the studies would provide on this issue, the escrow account would also fund remedies to rural problems.

Historical Background: This EIS provides an overview of the past and potential future impacts of the TAPS on rural Alaska based on existing studies and public input received while conducting this FEIS. For this overview, see the Subsistence and Sociocultural sections of Chapters 3 and 4, particularly Sections 4.3.20 and 4.3.21, and Appendix D.

Discussion: The BLM has the ability to fund any studies it finds necessary in the course of its monitoring of the TAPS and can oblige the TAPS Owners to fund such studies. If additional specific

studies of such impacts are considered necessary, the BLM, under all the alternatives, may conduct them or hire an appropriate contractor to do them. Consequently, this alternative does not substantially differ from the proposed action.

10. Require Maintenance of 20% Native-Hire Employment and Allow Natives to Bring Suit for Failure to Achieve That Goal.

The BLM determined not to analyze in detail in this EIS an alternative that would specifically require that 20% of employees working on the TAPS be Natives. The agency also determined not to analyze in detail an alternative that would grant Natives the ability to sue the TAPS Owners for failure to achieve that percentage.

Historical Background: Alaska Natives raised the issue of jobs on the TAPS soon after oil companies began to plan a pipeline to bring North Slope oil to market. During the summer and fall of 1969, the oil companies reached agreements with Native groups in which the Natives relinquished title claims to lands needed for the pipeline project in return for promises of contracts, training, and jobs during construction and operation. The DOI's stipulations for the pipeline being drafted that fall reflected this arrangement. The DOI included language mandating training and employment of Natives during construction. A promise by the TAPS Owners through their agent, APSC, to provide jobs for Natives was part of an agreement in 1972 which induced five Native villages to voluntarily dismiss with prejudice a lawsuit impeding pipeline construction (APSC 1972).

The TAPS grant incorporated a provision—Section 29—that required the TAPS Owners to enter into an agreement with the Secretary of the Interior "regarding recruitment, testing, training, placement, employment, and job counseling of Alaska Natives." A plan of action approved by the DOI required APSC to provide 3,500 training or employment opportunities to Alaska Natives during the construction of the TAPS. APSC exceeded this goal, hiring 5,770 Alaska Natives during construction, though most of the Natives hired worked eight or fewer weeks.

The TAPS Owners also committed in 1974 to train and employ Alaska Natives so that within two years after TAPS began operating, Alaska Native's percentage in the work force would be equivalent

to or greater than their proportion of Alaska's population. Their proportion was then estimated at 20%. In 1976, APSC altered its Alaska Native employment goal to 16%, though the DOI did not approve this revision. The TAPS Owners failed to meet the 20% goal, and by 1994 Alaska Native employment on TAPS had slipped to less than 5%.

Audits and a generally elevated interest by the government in regulatory oversight of the TAPS prompted a letter from the JPO to APSC stating that the government considered the lack of Alaska Native employment on TAPS "a serious breach of a long-standing agreement to provide recruiting and permanent placement for Alaska Natives." The letter requested that APSC provide the JPO with a plan to achieve full compliance with its commitments.

The JPO, APSC, and the Alaska Federation of Natives discussed how to reach an agreement acceptable to the Native community. These discussions culminated in an Alaska Native Utilization Agreement (ANUA) signed in October 1995. The ANUA described hiring goals that would gradually increase Alaska Native employment to a goal of 20% by 2004. The ANUA allowed credits toward employment goals for Alaska Natives receiving an APSC-funded scholarship or enrolled in an APSC intern program. APSC drafted an Initial Plan of Implementation, which the BLM approved in April 1996. The Initial Plan of Implementation broadly described the activities and strategies APSC and its contractors would undertake to implement the ANUA.

In September 1997, the JPO issued an audit on the progress made by the APSC and its contractor to implement the ANUA. It concluded that APSC was making progress on increasing Native employment and that it was in compliance with the ANUA's major terms. The audit recommended adopting such "gateway" employment opportunities as apprenticeships and co-op student programs, investigating vocational-education opportunities, establishing consistent procedures for routinely verifying Alaska Native tribal enrollment status, establishing a clear link between scholarship funding and the expectation of future employment on the TAPS or in Alaska's oil and gas industry, and expanding the list of contractors required by the TAPS Owners to participate in the Section 29 program.

In conformance with a provision in the ANUA, it has been reviewed at three-year intervals. (The 2001 ANUA is reproduced in Appendix F.) The 1998 ANUA adopted the recommendations of the 1997 audit. The 2001 ANUA more fully realized some of the recommendations put forward in the audit, including expanding the number of contractors covered by the agreement.

Employment of Alaska Natives has increased substantially since the signing of the 1995 ANUA. Alaska Natives comprised 8.8% of the TAPS work force in 1996, 12.8% in 1998, and 16.9% in 2000. By the fourth quarter of 2001, Alaska Natives composed 18.2% of the work force; credits for education and training raised the percentage to 19.8%. As of June 30, 2002 these percentages had risen to 20% and 21.4%, respectively.

Discussion: The authority in the renewal grant is sufficient to assure Alaska Native hire goals, as is demonstrated by the recent success of TAPS Owners to meet Alaska Native employment goals. Consequently, the BLM determined not to analyze this alternative in detail. The BLM already has the authority to require that the TAPS Owners reach their Native Alaskan employment objectives; thus, this alternative is substantially similar to the proposed action analyzed in detail in this EIS.

11. Close the Dalton Highway or Restrict Access along the Highway. The BLM determined not to analyze in detail in this EIS an alternative that would close or restrict access along the Dalton Highway, which parallels the TAPS from near Livengood north to the Prudhoe Bay oil fields. This alternative would have allowed only oil-related traffic or access by oil-related traffic and local residents. Traffic on the highway may impact migrating animals, including caribou that are important for local subsistence. In addition, anglers and hunters from other areas can use the highway to access this remote part of Alaska, thus competing with local residents for fish and game and potentially subtly changing the local culture.

Historical Background: The Dalton Highway was built to support construction of TAPS. In 1969, when oil companies attempting to build the TAPS applied for the pipeline ROW, they also applied for a ROW for a parallel road from Livengood to Prudhoe Bay. Following Congressional approval of a modification to Secretary Stewart Udall's land

freeze, the oil companies that summer built a 53-mile road from Livengood to the Yukon River. The companies were required to build the road to meet state secondary highway standards and to turn the road over to the state. The state received control of the road in 1972 and began maintenance of it at that time.

Construction of the rest of the road was a top priority once the TAPS grant and lease were signed by the DOI and the state in early 1974. That summer, the APSC built the road from the Yukon River to Prudhoe Bay at a cost of \$180 million. The federal government provided \$25 million for construction of the bridge over Yukon River. The state gained control of, and assumed responsibility for maintaining, the highway on October 15, 1978. In 1980, the state legislature authorized opening the road north to Dietrich Camp in the southern Brooks Range. Beginning the following summer, the state opened the road to nonpipeline and oil field traffic in the summer to Dietrich Camp (Coates 1993; Mead 1978; Ott 2002). In 1994, the state opened the entire highway to all traffic. By opening the road, the state became eligible to obtain federal highway funding for reconstruction and repair work. The state remains responsible for all road maintenance.

Discussion: The Dalton Highway is a federal aid highway under the jurisdiction of the State of Alaska Department of Transportation. The BLM does not have the authority to regulate access to the Dalton Highway. Moreover, the highway is an integral part of the infrastructure needed not only to maintain and operate the TAPS, but also to provide numerous other public benefits, including tourism, sight-seeing, security or law enforcement access, and hunting and fishing. This alternative does not allow the BLM to accomplish its purpose and need for this EIS.

12. Increase Oil Spill Response Capabilities by Training, Hiring, and Equipping Additional Local Oil Spill Response Crews. The BLM determined not to analyze in detail in this EIS an alternative that would involve training, hiring, and equipping additional local oil spill response crews. The intent of such crews would be increased oil spill response capabilities and additional employment opportunities for communities along the TAPS.

Historical Background: The TAPS Owners have produced spill plans for the pipeline approved by the AO in accordance with Stipulation 2.14 since prior to TAPS startup. These plans placed spill response crews and response equipment at all pump stations. In 1990 and 1991, the TAPS Owners substantially upgraded their pipeline response capability. They added additional equipment, placing some at remote storage sites along the TAPS. They added front-line spill response supervisors and staff and formed an incident command system to mobilize and coordinate pipeline spill response. And they improved access along the pipeline to facilitate quick spill response. In the course of subsequent spill contingency plan reviews, changes have been made to readjust and relocate personnel and equipment to react to pump station closings, to meet the requirements of ADEC regulations promulgated in the 1990s, and to adapt to reorganizations within APSC. The TAPS Owners have also provided training for spill response crews in Rampart and Stevens Village. These arrangements are separate from the spill response plan.

Discussion: Oil spill prevention and response planning are central to the BLM's and other agencies' missions within the JPO. The oil spill planning and prevention effort in the JPO is a large-scale, multiagency endeavor. Each of five participating agencies [BLM, ADEC, EPA, ADNR, and the DOT's Office of Pipeline Safety] has a particular focus, but these are all considered collectively in the JPO TAPS oil spill response and planning group.

Oil spill response planning involves a separate process and is not part of the decision on the application to renew the Federal Grant. APSC submits oil spill contingency plans for the TAPS to the BLM and other federal and state agencies within the JPO that have regulatory authority over the pipeline. These oil spill plans address the training, hiring, and equipping of oil spill response crews. The BLM reviews these plans annually and participates in the triannual reviews of such plans by the ADEC. The ADEC's reviews incorporate public reviews of the plans. The BLM completed its most recent review in April 2002, and the ADEC completed its most recent review in November 2001. In addition, the EPA completed its review of spill response plans for oil storage facilities in

1998 and participated in ADEC's review in the fall of 2001. Also, the DOT completed a review of the TAPS spill response plan in September 2000. None of these reviews indicated a need to train, hire, or equip additional local oil spill response crews. Future reviews, however, may reexamine that question.

Readers should note that this EIS discusses ongoing mitigation measures for the proposed action that address impacts described in the DEIS and by the public in commenting on the DEIS. These mitigation measures may be adopted in the ROD. Mitigation measures are discussed in Section 4, and particularly in Section 4.8.4.

2.6 Comparison of Alternatives

Table 2-1 summarizes the impacts of the three alternatives.

2.7 References for Chapter 2

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TABLE 2-1 TAPS ROW Renewal FEIS Summary of Direct and Indirect Effects

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
<i>Physiography and Geology</i>		
Soils and Permafrost		
<i>Action Impacts:</i> Geologic processes associated with the TAPS are expected to be confined to localized areas near the TAPS. Destruction of vegetation cover, erosion, and siltation would be localized and would not increase over levels seen historically during TAPS operations. An increase in oil throughput could expand thaw bulbs and result in ground settlement near the TAPS. A reduction in throughput could result in frost heaves.	<i>Action Impacts:</i> The types of impacts on geology during the renewal period would be similar to those of the proposed action. Excavation associated with pipeline maintenance (e.g., rerouting of pipeline, valve replacements, corrosion digs) and spill cleanup and heat transfer associated with oil throughput would impact soil and permafrost similarly to such activities under the proposed action. However, such activities may be fewer and cease sooner under a shorter-term renewal.	<i>Action Impacts:</i> The impacts on geology during the first two years of termination activities would be comparable to those of the proposed action, though the risk of impacts from spill cleanup would be reduced. Dismantlement and removal of the TAPS would cause minor change in geological processes and the removal of some geologic material.
<i>Cumulative Impacts:</i> Oil and gas activities, as well as other construction activities and human habitation would impact soils and permafrost in local areas. Travel on gravel roads would generate road dusts, which would facilitate thawing of permafrost along roadways. If the current warming trend in Alaska would continue to occur, permafrost changes would occur with time. The TAPS would be a minor contributor to cumulative effects.	<i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	During the first 2 years of preparatory work for termination activities, the impacts on soils and permafrost would be about the same as those from the proposed action. Increased traffic, movements of heavy equipment, and ground disturbance during the dismantlement and removal phase would degrade previously stabilized permafrost. These impacts would be limited to areas adjacent to the aboveground portions of the pipeline and access roads. An estimated 4,525 acres would be disturbed. Activities associated with the restoration of disturbed land would temporarily increase soil erosion and siltation in nearby water bodies. In addition, the dismantlement and removal of TAPS components would redistribute the thermal regime of the surface soil, possibly resulting in thermokarst topography. The impact on soils from the decrease in heat flow in the belowground pipeline, once the crude oil stopped flowing, would be local and minor. With time, the belowground pipeline segments left in place would become corroded and collapse. Ground depressions might be created above such collapses.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Soils and Permafrost (Cont.)		<i>Cumulative Impacts:</i> If the operation of the TAPS was terminated, there would be no impacts from new oil development on the North Slope; however, geologic impacts would continue with gas development and production and construction of a new buried natural gas pipeline. There could still be impacts from gas development, including both additional drilling pads and associated roads and construction of a gas pipeline. Termination activities would temporarily increase soil disturbance and increase generation of dusts from roads, which would affect permafrost in the vicinity of the pipeline and in the vicinity of oil production facilities being dismantled. Longer-term impacts to soils would be reduced due to reduced petroleum activities and less oil-related traffic on unpaved roads. Other construction activities and human habitation would continue to impact soils and permafrost. The current warming trend in Alaska would continue to occur, compounding permafrost effects with time.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Sands, Gravels, and Quarry Resources		
<i>Action Impacts:</i> Less than 100,000 yd ³ /yr of sand, gravel, and quarry stone would be extracted for maintenance.	<i>Action Impacts:</i> Less than 100,000 yd ³ /yr of sand, gravel, and quarry stone would be extracted for maintenance during the renewal period.	<i>Action Impacts:</i> Field activities in the first 2 years of termination activities might use more of these resources than the proposed action (i.e., less than 100,000 yd ³ /yr). These materials would not be needed after the preparatory phase of the termination activities; therefore, subsequent impacts on these resources would be much smaller than for the proposed action.
<i>Cumulative Impacts:</i> Oil and gas development, mining, urban development, and logging would require sand, gravel, and quarry resources, primarily from local sources. Quarry stones would be transported to the North Slope from the Brooks Range. TAPS operation would be a minor contributor to requirements for these resources.	<i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Cumulative Impacts:</i> Following an initial demand during facility removal, use of these resources would decline with the decline in oil exploration, development, and production. Other uses, such as requirements for a buried natural gas transportation pipeline, road building, mining, and urban development would continue.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Paleontology <i>Action Impacts:</i> Renewal of the Federal Grant would be unlikely to adversely affect paleontological resources. There is a very low potential for contamination of nonpetrified paleontological materials by an oil spill. <i>Cumulative Impacts:</i> Depending on the local presence or absence of fossil-bearing deposits, ground-disturbing activities, such as construction, have the potential to impact paleontological resources, and these resources would require mitigation or protection on a case-by-case basis. TAPS operation would be a small contributor to the risk of impacts to paleontological resources.	<i>Action Impacts:</i> Renewal of the Federal Grant would be unlikely to adversely affect paleontological resources. There is a very low potential for contamination of nonpetrified paleontological materials by an oil spill. <i>Cumulative Impacts:</i> Depending on the local presence or absence of fossil-bearing deposits, ground-disturbing activities, such as construction, have the potential to impact paleontological resources, and these resources would require mitigation or protection on a case-by-case basis. TAPS operation would be a small contributor to the risk of impacts to paleontological resources. Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Action Impacts.</i> Although no adverse effects on paleontological resources are anticipated under the no-action alternative, there is a very small potential that ground disturbance during dismantlement could damage or obscure paleontological resources. Following termination activities, the potential for impacts from TAPS would cease. <i>Cumulative Impacts:</i> Depending on the local presence or absence of fossil-bearing deposits, ground-disturbing activities have the potential to impact paleontological resources, and these resources would require mitigation or protection on a case-by-case basis. There is a very small potential that ground disturbance during TAPS facility dismantlement could damage or obscure paleontological resources. However, reduced oil exploration, development, and production would reduce the overall risks to paleontological resources from disturbance.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Surface Water Resources		
<i>Action Impacts:</i> Impacts to surface water from routine operations would be small and local, and not produce a large impact on any single water body. However, spills could produce substantial contamination if they occur over or near surface water.	<i>Action Impacts:</i> On an annual basis, the number of small and local impacts and the risk of substantial impacts would be the same as in the proposed action. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative.	<i>Action Impacts:</i> Until the oil is removed from the pipeline in 2004, impacts and the risk of impacts would be the same as those under the proposed action. Subsequent impacts during termination would be small and local and cease at the conclusion of termination activities. Once termination activities are completed, there would be no further impacts from the TAPS until and unless corrosion caused the collapse of underground pipe, which could drain adjacent wetlands. This impact, however, would be negligible.
<i>Cumulative Impacts:</i> The large amount of water required for ice roads for oil and gas development and production on the North Slope would be met from surface sources. Impacts on water quantity and quality in taliks would be small when winter withdrawals are limited by permit restrictions. There would be small, localized discharges to surface water from other actions. Impacts to surface waters would be localized unless an oil spill occurs, in which case impacts could be substantial. TAPS operation would have a very small effect on surface water quantity.	<i>Cumulative Impacts:</i> As for the proposed action, during the renewal period, impacts to surface waters would be small and localized unless an oil spill occurs, in which case impacts could be substantial. Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Cumulative Impacts:</i> During the initial dismantlement period, local impacts on the quantity and quality of surface waters would continue, as ice roads would continue to be needed for facilities being dismantled and for gas exploration, development, and production. After the initial dismantlement period, surface water requirements and the risks of small oil spills would decline due to declining oil and gas development. The reduced need for ice roads would reduce potential local surface water impacts. Water requirements and discharges to surface water from other activities would continue.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Groundwater Resources		
<i>Action Impacts:</i> Impacts to groundwater quality from routine operations would be small and local but an oil spill, depending on its size, location, and the effectiveness of response activities, could create local small to very large impacts.	<i>Action Impacts:</i> The impacts from routine operations and the number and risk of spills would be the same on an annual basis as those described for the proposed action. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative.	<i>Action Impacts:</i> There would be negligible to minor local impacts to groundwater through completion of termination activities. Other water users might be impacted by dismantlement only along the southern portion of the TAPS, where there is a greater dependence on groundwater than on the North Slope. After completion of these activities, there would be no additional impacts to groundwater.
<i>Cumulative Impacts:</i> Withdrawals from all activities would have small and local effects. Fairbanks and Valdez are the largest groundwater users. Municipal use would have minor impacts. However, an oil spill from the TAPS or oil development activities, could impact groundwater quality to a small to large extent, depending on the spill's size, location, and the effectiveness of response activities.	<i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Cumulative Impacts:</i> Impacts from dismantling the TAPS would be of a short duration and would occur along a substantial portion of the length of the pipeline. Impacts from dismantlement would be greater along the southern portion of the TAPS, where there is a greater dependence on groundwater than on the North Slope. Once oil development, production, and transportation ends with the shutdown of the TAPS, impacts from those activities on the southern portions of the pipeline would cease. On the northern portion, produced water injections to groundwater would be reduced with declining oil industry. Other groundwater uses would continue.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Physical Marine Environment		
<i>Action Impacts:</i> Impacts from routine operations are expected to be no more than those in the past, that is, small and local. They may be less than those in the past because discharges are expected to be reduced from current volumes because of reduced throughput and the segregation of ballast water in new tankers. Discharges from routine operations would continue to comply with applicable regulations. Most spills from the Valdez Marine Terminal would be local and impacts short-lived. However, a very unlikely large spill from the Valdez Marine Terminal could have large impacts over up to 2 miles of shoreline.	<i>Action Impacts:</i> Impacts would be similar to those for the proposed action for the length of the renewal after the introduction of double-hulled tankers. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative.	<i>Action Impacts:</i> Impacts from Valdez Marine Terminal releases resulting from termination activities would generally be smaller than current TAPS impacts. However, while historical releases have been continuous, releases under the no-action alternative would be temporary and cease with the completion of termination activities. The impacts to physical marine resources from scrap metal transport would be short-lived and would cease with the completion of termination activities.
<i>Cumulative Impacts:</i> Other activities could affect the marine environment from spills in oil and gas production areas reaching the Beaufort Sea and spills from tanker and other forms of marine transportation in Prince William Sound or along Pacific transportation routes. Reasonably foreseeable spills would be small and rapidly cleaned up and of local consequence. Larger, less probable spills might take longer to clean up and result in widespread contamination of the marine environment.	<i>Cumulative Impacts:</i> The type, magnitude, and risk of impacts on a per-year basis would be similar to those for the proposed action. These risks are not time-dependent; thus, a shorter renewal period would not reduce the per-year risk. However, a shorter renewal period would eliminate the risk at the end of the shorter renewal period compared to a 30-year renewal.	<i>Cumulative Impacts:</i> Impacts from oil-related spills in both the Beaufort Sea and Prince William Sound would decline as North Slope oil production and transportation of North Slope oil ends. However, impacts from spills due to other marine transport could increase without the presence of the oil industry's spill containment response apparatus and personnel.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Air Quality <i>Action Impacts:</i> Air quality impacts from routine operations are generally expected to be local, temporary, and small, and within regulatory limits for the TAPS and federal and state air quality standards. Impacts on air quality from spills, including those associated with a spill involving a fire, would pose health risks for people within the immediate area of the spill. These impacts would rapidly diminish with distance from the spill and with time after the spill. <i>Cumulative Impacts:</i> Little or no long-term or short-term impacts on air quality from the routine activities of all actions are anticipated. As stated above, impacts of a large spill involving a fire may have human health consequences.	<i>Action Impacts:</i> Impacts and risks of impacts on air quality would be expected to continue as described for the proposed action. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative. <i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Action Impacts:</i> Impacts would be the same as those under the proposed action while oil flows in the pipeline. Impacts would be less than those for the proposed action on an annual basis during the three years of peak dismantlement, removal, and restoration activities and substantially less during the last year of termination activities. Thereafter, the TAPS would not impact air quality. <i>Cumulative Impacts:</i> Impacts from all activities on the North Slope and from marine transportation in Prince William Sound would decline with the termination of the TAPS and its associated oil production. Other impacts would be largely the same as for the proposed action.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Noise		
<i>Action Impacts:</i> Construction and maintenance activities are anticipated to generate short-lived and small noise impacts, which would be barely distinguishable above background noise beyond TAPS facility boundaries. No adverse impacts are anticipated from such activities. Air traffic, particularly helicopter pipeline surveillance, may disturb wildlife temporarily. <i>Cumulative Impacts:</i> All activities would have the potential to produce local impacts on noise.	<i>Action Impacts:</i> Impacts would be similar to those for the proposed action on an annual basis during the renewal period. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative. <i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Action Impacts:</i> Impacts would be less than those under the proposed action in all years except for the third year of termination activities. In the third year, impacts would be comparable to current levels. At the end of the termination period, all noise and vibration due to TAPS-related activities would cease. <i>Cumulative Impacts:</i> All activities would have the potential to produce local impacts on noise. Local noise generated by the TAPS and associated oil production facilities would be comparable to current levels, until after the termination period. Thereafter, these noise sources would be reduced or absent.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Transportation		
<i>Action Impacts:</i> No adverse impacts are anticipated because the current transportation infrastructure is adequate to support continued TAPS operations at any anticipated throughput level.	<i>Action Impacts:</i> No adverse impacts are anticipated.	<i>Action Impacts:</i> Considerable road traffic would be generated by termination activities, particularly in the immediate vicinity of dismantlement. However, this level of traffic would be well within the current traffic borne by the road network. Air traffic to areas north of Fairbanks might increase slightly for up to several years during dismantlement to handle the transport needs of the increased workforce. After termination activities have been completed, air and highway traffic, particularly north of Fairbanks would greatly decrease.
<i>Cumulative Impacts:</i> Anticipated increases in traffic volume from new or growing activities would not be large and could be accommodated by existing infrastructure. No increases in traffic would result from continued TAPS operations.	<i>Cumulative Impacts:</i> Anticipated increases in traffic volume from new or growing activities would not be large and could be accommodated by existing infrastructure. No increases in traffic would result from continued TAPS operations during a shorter renewal period.	<i>Cumulative Impacts:</i> Anticipated increases in traffic volume from new and existing actions and from termination activities and decline of oil production could be accommodated by existing infrastructure. After the termination period, traffic would decline. SERVS would not be available to provide services to the marine industry in Prince William Sound.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Waste Management		
<i>Action Impacts:</i> Impacts on waste management from TAPS operation, including spill cleanup would be within acceptable limits as set by regulatory standards.	<i>Action Impacts:</i> Impacts on waste management from TAPS operation, including spill cleanup, would be within acceptable limits as set by regulatory standards during a shorter renewal period.	<i>Action Impacts:</i> Impacts on waste management from TAPS termination, including spill cleanup, would be within acceptable limits as set by regulatory standards.
<i>Cumulative Impacts:</i> Impacts on waste management from all actions are expected to be within acceptable limits, as set by regulatory standards.	<i>Cumulative Impacts:</i> Impacts on waste management from all actions are expected to be within acceptable limits, as set by regulatory standards for the renewal period.	<i>Cumulative Impacts:</i> Impacts on waste management from termination of the TAPS and from declining oil production, as well as all other actions, are expected to be within acceptable limits as set by regulatory standards.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Human Health and Safety		
<i>Action Impacts:</i> Over a 30-year renewal period, the total anticipated number of worker fatalities would be approximately six. The estimated annual numbers of recordable injuries would be 125–153, and lost time injuries would be 76–92. Health risk to the public would be small, though individuals who remain in the vicinity of a spill or fire or eat noticeably spill-impacted fish could be adversely affected. <i>Cumulative Impacts:</i> Best management practices could reduce fatality and injury rates for all industries. Operating procedures could limit exposure to naturally occurring radioactive material (NORM). TAPS operation does not produce NORM. No adverse health impacts would be expected from inhalation of industrial air emissions in the Valdez area. Valdez Marine Terminal operations contribute to, but are not the sole source of, organic air pollutant emissions in the Valdez area. Levels of polychlorinated biphenyls (PCBs) and mercury in tissues of Alaska Natives and others consuming contaminated natural food supplies would be elevated from past actions and global sources. There would be no impact from other actions or from TAPS operation. The general public would be exposed to more vehicle emissions over the next 30 years unless additional controls are placed on such emissions. Accidental releases of hazardous materials and spills into the marine environment also could have small impacts on public health.	<i>Action Impacts:</i> There would be fewer anticipated fatalities and recordable injuries under a shorter renewal period. <i>Cumulative Impacts:</i> There would be fewer anticipated fatalities and recordable injuries under a shorter renewal period. After the renewal period, either a further renewal would be approved, with similar consequences as the proposed action, or the operations of the pipeline would be terminated, with impacts similar to no action.	<i>Action Impacts:</i> The total number of fatalities over the 6-year termination period would be approximately one. The estimated annual number of recordable injuries (43–109) and lost time injuries (20–204) represent upper bound ranges on the physical hazard risks of injuries to TAPS workers during termination. Public health risks would essentially cease once oil no longer flows through the TAPS. <i>Cumulative Impacts:</i> The types of impacts would be similar to those for the other alternatives; however, the contribution of the TAPS to those hazards would cease with the completion of termination actions.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Terrestrial Vegetation and Wetlands		
<i>Action Impacts:</i> Impacts, including variations in vegetation types compared with types outside the ROW and disturbance to vegetation (with subsequent restoration) from excavation, dust shadow, or spills, would be small and local.	<i>Action Impacts:</i> Impacts would be similar to those under the proposed action on an annual basis during the renewal period. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative.	<i>Action Impacts:</i> Disturbances to terrestrial vegetation and wetland communities would continue during the 6-year termination period, as described for the proposed action. The ROW, pump station sites, and other TAPS areas would eventually become vegetated with stable terrestrial and wetland vegetative communities. These communities would have many similarities to adjacent undisturbed communities; however, differences in their structure and species composition would likely remain over the long term.
<i>Cumulative Impacts:</i> The cumulative impacts of all the anticipated actions would be minor to negligible and local in extent.	<i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Cumulative Impacts:</i> A temporary increase in disturbance would result from removal of TAPS facilities. Declining oil exploration and development would reduce impacts. Following termination activities, there would be a small long-term recovery of vegetation communities.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Fish		
<i>Action Impacts:</i> With the exception of the occurrence of a large oil spill under unfavorable circumstances, impacts to fish would be small and temporary, with no population-level effects. A major spill into a waterway could be severe and possibly long term, depending on the size of the receiving waterbody, the affected fish community, and the season of the year. <i>Cumulative Impacts:</i> Habitat alternation would be minor and not substantially affect fish populations. Impacts of obstructions to fish passage would be low to moderate. Increased human access would have minor impacts. Impacts of small spills would be local and minor. Risks of large spills with large consequences would be low, as stated above. .	<i>Action Impacts:</i> Impacts would be similar to those under the proposed action on an annual basis during the renewal period. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative. <i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Action Impacts:</i> There would be an increased potential for short-term impacts to fish habitat during the pipeline removal phase because of localized increases in workers, traffic, and construction activity. Over the long-term, however, impacts would be less than those from the proposed action, though reductions in statewide employment and income could increase pressure on fish through sport, commercial, and subsistence fishing. <i>Cumulative Impacts:</i> Impacts to fish would be reduced after TAPS termination and as North Slope oil development and production declined. The potential for accidental spills would decline on the North Slope, along the TAPS, and from tankers in Prince William Sound and Pacific transportation routes, as would the potential for introduction of nonnative organisms from tankers in Prince William Sound.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
<i>Birds and Terrestrial Mammals</i> <i>Action Impacts:</i> Impacts generally are anticipated to be local, affect only individual animals, and have no adverse impacts to populations. Population level impacts are considered very unlikely. They only would be anticipated from a very large spill or a spill that contaminated a crucial habitat in which a large number of animals were concentrated. <i>Cumulative Impacts:</i> Impacts from many activities could be large in local areas but would be minor on the population level.		
	<i>Action Impacts:</i> Impacts would be similar to those under the proposed action on an annual basis during the renewal period. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative. <i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Action Impacts:</i> Small, localized impacts would be associated with termination activities. Following termination, habitat conditions along the TAPS would, over a matter of several years or several decades, return to those of adjacent lands. <i>Cumulative Impacts:</i> Indirect adverse impacts could potentially result if wild food was used to compensate for the loss of income (e.g., by increasing loss of wildlife through subsistence hunting). However, overall impacts, particularly on the North Slope, would be reduced because of the decline of oil development, production, and transportation activities.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
<i>Threatened, Endangered, and Protected Species</i>		
<i>Action Impacts:</i> Impacts are not expected to produce population-level effects that are distinguishable from natural variation in numbers, unless a low-probability, high-volume spill reached marine waters such as Prince William Sound. In the latter case, impacts may be moderate on the population level. <i>Cumulative Impacts:</i> Impacts are anticipated to be negligible to minor and are not anticipated to threaten population viability, unless a low-probability, high-volume spill from oil transportation occurred in Prince William Sound or along Pacific transportation routes. Such a spill might cause impacts that would be high on a local level and moderate on a local level.	<i>Action Impacts:</i> Impacts would be similar to those for the proposed action on an annual basis during the renewal period. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative. <i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Action Impacts:</i> During termination, impacts on an annualized basis would be greater than those for the proposed action. Thereafter, impacts would be less than for the proposed action. Population-level impacts are not anticipated to be distinguishable from natural variation. <i>Cumulative Impacts:</i> Impacts on the North Slope and Prince William Sound would decline with declining oil exploration, development, and production. Removal of TAPS facilities might create temporary, minor impacts.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Economics		
<i>Action Impacts:</i> North Slope oil production would make a substantial, though declining (14% by 2020), contribution to domestic oil production and would continue to reduce the need for foreign oil imports, thus improving national energy security and the overall balance of trade. Significant federal tax revenues would be generated with continued TAPS operations, together with marine and shipbuilding employment and employment in the economy as a whole. Gross state product, population, employment, personal income, and tax revenues would experience slow to moderate growth, though North Slope oil production and resultant employment and revenues would decline. <i>Cumulative Impacts:</i> Overall cumulative impacts are reflected in the above discussion. Temporary, local negative cumulative economic impacts might occur during the construction of a gas pipeline and the National Missile Defense System (NMDS), because they would primarily test the capabilities of local services. No long-term or statewide negative cumulative impacts are anticipated. Anticipated positive economic impacts of these two projects likely would help to offset declines in economic activity expected to accompany reduced oil volumes transported through the TAPS over the coming decade.	<i>Action Impacts:</i> With a shorter renewal period, investment in new North Slope production could be reduced, and that reduction could have economic repercussions at the local, state, and national levels. On the national level, TAPS contribution to oil production, energy security, the balance of trade, federal revenues, and marine and shipbuilding employment could be reduced, depending on prevailing economic conditions and the length of the renewal period. A shorter TAPS renewal period might reduce the prospect of further diversification of the Alaska economy by creating a riskier business climate. This condition would result in less predictable employment prospects, slower income growth, and slower growth in population. A shorter TAPS ROW renewal period would reduce the flow of funds into state and local governments, thereby reducing their ability to implement a wide range of programs requiring long operating lives. <i>Cumulative Impacts:</i> Overall cumulative economic impacts are reflected in the above discussion. Construction and operation of a natural gas pipeline and the NMDS could help to offset the projected decline in oil throughput and revenues.	<i>Action Impacts:</i> Reduction in economic activity would occur. A major source (17% currently) of U.S. oil production would stop production, with related impacts to national energy security, the balance of trade, and federal taxes. The gross state product and state revenues would drop substantially following the end of oil production in 2003; gross state product would not recover to 2003 levels in the following three decades. Impacts on employment and personal income in the state would be substantial, but less severe. Growth would be expected in both of these measures over the period 2004–2034, especially during the second half of that period, but it would be substantially less than under the proposed action. <i>Cumulative Impacts:</i> Overall cumulative impacts are reflected in the above discussion. Construction and operation of a natural gas pipeline and the NMDS could help to offset the projected decline in oil throughput and revenues.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Subsistence <i>Action Impacts:</i> TAPS renewal for 30 years would have small impacts on subsistence. <i>Cumulative Impacts:</i> There would be low impacts on subsistence, except on the North Slope where impacts would be moderate. Subsistence hunting and fishing, particularly on the North Slope (and, to a lesser extent, in Interior Alaska) could be negatively impacted, primarily as a result of restrictions in areas where subsistence can be pursued and as a result of possible disruptions to the movement of subsistence resources from human presence and activities. However, both of these main impacts are not anticipated to be severe, with restricted access affecting relatively small portions of large subsistence harvest areas and with changes in animal movement patterns often temporary and usually affecting only a relatively few individual animals. Contributions from the TAPS to these cumulative impacts are expected to be relatively small.		
	<i>Action Impacts:</i> There would be smaller impacts to subsistence under the less-than-30-years alternative than in the proposed action. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative. <i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Action Impacts:</i> Adoption of the no-action alternative would result in a slight improvement in subsistence. <i>Cumulative Impacts:</i> Certain impacting factors in different local areas would be different from those described under the proposed action (e.g., reduced employment, reduced competition from sport hunting and recreation, increased need for resources, removal of barriers), but the overall cumulative effect might be the same.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Sociocultural Systems		
<i>Action Impacts:</i> The proposed action would contribute to continued change in Alaska Native and rural non-Native sociocultural systems that likely would be small.	<i>Action Impacts:</i> Impacts would be similar to those for the proposed action on an annual basis during the renewal period. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative.	<i>Action Impacts:</i> The overall impacts of the no-action alternative on sociocultural systems would likely be negative and sufficiently large to be detectable. Short term impacts would occur during termination.
<i>Cumulative Impacts:</i> In sociocultural systems founded on cooperation and subsistence, cumulative impacts might accompany their continued interaction with modern American society and the continued growth in the importance of a cash economy. However, these changes are largely a part of changes occurring throughout Alaska and are not attributable solely to cumulative actions considered in this EIS. The contribution of the TAPS to these cumulative impacts would be relatively small.	<i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Cumulative Impacts:</i> Impacts of the same type and substantially similar in degree as those under the proposed action.
Cultural Resources		
<i>Action Impacts:</i> Mitigation measures should adequately address possible impacts from routine operations. The risk of impact to cultural resources, therefore, is low because the chance of a large oil spill that could impact these resources is low.	<i>Action Impacts:</i> Impacts would be similar to those for the proposed action on an annual basis during the renewal period. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative.	<i>Action Impacts:</i> Mitigation measures should adequately address impacts from termination activities and from the dismantlement and removal of the TAPS, which may be determined eligible for listing on the National Register of Historic Places (NRHP). Impacts from oil spills would be much lower than those under the other alternatives.
<i>Cumulative Impacts:</i> Negative cumulative impacts to cultural resources are expected to be absent or negligible, in part as a result of adhering to existing state and federal regulations on such resources during project development and operation.	<i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Cumulative Impacts:</i> Cumulative impacts to cultural resources are expected to be absent or negligible, in part, as a result of adhering to existing state and federal regulations on such resources during project development and operation.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Land Uses and Coastal Zone Management		
<i>Action Impacts:</i> Under the proposed action, there could be some access and use conflicts with private land holders, temporary noise impacts on recreationists from TAPS construction work, and impacts from spills (of varying degrees, depending on volume, timing, duration, and location) on other users of the area along the TAPS. There would be no conflict with coastal management programs (CMPs). <i>Cumulative Impacts:</i> Negative cumulative impacts on land use are anticipated to be minor. Negative cumulative impacts similarly are anticipated to be minor both on the North Slope and in Prince William Sound. The contribution of TAPS operation to these cumulative impacts is expected to be relatively small. However, an oil spill to marine waters from marine transportation or from oil production could impact implementation of CMPs.	<i>Action Impacts:</i> Impacts would be similar to those for the proposed action on an annual basis during the renewal period. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative. <i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Action Impacts:</i> Termination activities may temporarily impact recreation uses near the TAPS. After termination, there would be no impacts. There would be no conflict with CMPs. <i>Cumulative Impacts:</i> The reduced economic activity as a result of the shutdown of the TAPS would result in less commercial, municipal, and residential development. There would be no conflict with CMPs.

TABLE 2-1 (Cont.)

Proposed Action (Renew for 30 Years)	Less-Than-30-Year Renewal Alternative (Renew for Less Than 30 Years)	No-Action Alternative (Do Not Renew)
Recreation, Wilderness, and Aesthetics		
<i>Action Impacts:</i> Under the proposed action, restrictions on recreational use of the ROW; noise from associated TAPS road and air traffic; the visual impact of the pipeline, pump stations, and the Valdez Marine Terminal; and the risk of an oil spill creating local temporary, and possibly long-term, impact on recreation, aesthetics, and (less likely) wilderness values would continue for 30 years.	<i>Action Impacts:</i> Impacts would be similar to those for the proposed action on an annual basis during the renewal period. Total impacts over the period of renewal would be comparable to a similar duration under the 30-year renewal alternative.	<i>Action Impacts:</i> Termination activities would impact recreational opportunities, aesthetics, and, to a lesser extent, wilderness. Following termination, aesthetics would return to a state similar to that prior to construction of the pipeline. The recreational experience would change to the extent that opportunities to learn about the TAPS would have been removed and a less developed landscape along the current TAPS ROW would be presented.
<i>Cumulative Impacts:</i> Construction of a gas pipeline parallel to the TAPS, of other anticipated facilities near the TAPS, and of additional oil and gas facilities on the North Slope, as well as potential oil and gas spills could impact recreation, aesthetic, and wilderness values. Construction impacts would be short term, but the presence of these structures and spills could result in long-term impacts. Long-term aesthetic impacts along the TAPS may be major.	<i>Cumulative Impacts:</i> Impacts for this renewal period would be similar to those under the proposed action, depending upon the level of North Slope petroleum activities. Thereafter, if an additional renewal period were approved, impacts would be similar to those described for the proposed action. If an additional renewal period were not requested or were not approved, then subsequent impacts would be similar to those described for no action.	<i>Cumulative Impacts:</i> Impacts would be similar to those under the other alternatives except that the recreation, visual, and wilderness impacts associated with the TAPS may not last as long.

3. Affected Environment

3.1 TAPS Background

3.1.1 History

On October 28, 1968, eight months after oil was discovered at Prudhoe Bay, three oil firms active in North Slope oil exploration – ARCO, British Petroleum, and Humble (renamed Exxon in 1972) – formed an organization called the Trans-Alaska Pipeline System to pipe North Slope crude to market. On June 6, 1969, this organization applied for a ROW to build and operate a pipeline from Prudhoe Bay to Valdez Harbor (Mead 1978; Coates 1993). Secretary of the Interior Hickel formed the Alaska Field Group to develop protective stipulations to be attached to any Federal Grant of ROW. This interdepartmental team, along with representatives from the state of Alaska and from other federal agencies, developed a set of stipulations that was approved by the Secretary on September 29, 1969.¹

On December 11, 1969, the Senate Interior Committee cleared the way for the Secretary to issue a road permit (Naske and Slotnick 1979; Coates 1993). The DOI issued an eight-page environmental statement to address the impacts of a road from the Yukon River to the North Slope on March 20, 1970, less than three months after NEPA had become effective.

However, previously, on March 9, the Alaska Native villages of Allakaket, Bettles, Minto, Rampart, and Stevens Village had filed suit to stop construction, arguing that the likely pipeline route would pass over lands claimed by them. A little more than two weeks later, environmental groups brought a separate suit, arguing that the TAPS proposal violated the width-of-ROW provisions of the MLA and that the DOI's environmental statement inadequately addressed the requirements

of NEPA. In April, U.S. District Court Judge George Hart first halted any TAPS activities on lands claimed by Stevens Village, and then, agreeing with the environmental groups' arguments, he imposed a preliminary injunction against the entire project (Coates 1993).

The TAPS Owners and APSC realized that the pipeline could be built only if Alaska Native land claims were resolved. During much of 1970 and 1971, the oil industry worked with Alaska Natives toward the passage of the Alaska Native Claims Settlement Act (ANCSA) (Coates 1993; Naske and Slotnick 1979). ANCSA, which passed in 1971, provided lands to Alaska Natives and gave the Secretary of the Interior the authority to withdraw land for the pipeline from state and Native land claims, which he did in Public Land Order 5150. APSC was also able to gain dismissal of the Native villagers' suit, which thwarted construction, by agreeing to hire and train Alaska Native village residents (APSC 1972).

The DOI released a Draft EIS (DEIS) for the TAPS in January 1971. The Final EIS (FEIS), issued in March 1972, contained nine volumes, including three on economic and security aspects of the project. The FEIS responded to the large number of comments received on the DEIS. It extensively analyzed a no-action alternative as well as alternative methods of delivering North Slope oil to market. It included a substantial rewrite of the stipulations and more extensive discussions of potential impacts.

In August 1972, Judge Hart removed his injunction against TAPS construction, ruling that

¹ See two BLM documents "Chronology of Events," Record Group 49, Box 225 22/01/01(5), and "Stipulations for the Trans Alaska Pipeline System," Record Group 49, Box 19 17/08/08(3), in the National Archives-Pacific Region, Anchorage, Alaska.

the FEIS met the requirements of NEPA and that the ROW proposed by the applicant would not violate the width provisions of the MLA. The environmentalist plaintiffs took the case to the U.S. District Court of Appeals in Washington, D.C., where they won a partial victory in February 1973. The appeals court was silent on NEPA, but it ruled unanimously that Section 28 of the MLA did not allow the pipeline builders to have a construction ROW of more than 50 ft plus the width of the pipe. In April, the Supreme Court announced that it would not hear an appeal of the case (Coates 1993; Berry 1975).

In November 1973, Congress enacted TAPAA and amendments to the MLA to address the legal challenges impeding TAPS (Coates 1993). On January 16, 1974, Judge Hart dissolved the injunction against TAPS construction. A week later, on January 23, Secretary of Interior Morton signed the Federal Grant, which gave the TAPS Owners the ROW for constructing TAPS. Included in this Federal Grant were a set of stipulations and 41 sections setting out additional terms and agreements.

At the time the DOI issued the Federal Grant for the TAPS ROW, approximately 200 mi of the TAPS route was expected to be on state-owned land. Thus, a State Lease from the ADNOR was required. The pipeline was also expected to cross scores of small private parcels. The TAPS Owners were able to accommodate private parties through perpetual ROW agreements. To receive permission to cross state-owned land, the TAPS Owners applied to the ADNOR for a ROW on March 7, 1974. ADNOR issued the State Lease pursuant to Alaska Statute (AS) 38.35.100 on May 3, 1974. Because state representatives had been working with the federal team to develop stipulations for the TAPS since 1969, the State Lease adopted much of the Federal Grant language. The State Lease was intended to apply to the ROW on then-current state lands as well as on future land acquired from the state. Today, the State Lease applies to approximately 344 mi of the pipeline and includes four pump stations (Map 1-2).²

To oversee construction of the TAPS, in January 1974, the DOI designated an Authorized Officer (AO), and the ADNOR appointed a State

Pipeline Coordinator (SPC) (Mead 1978). Federal and state engineers on the AO's and SPC's staffs and a joint state/federal fish and wildlife advisory team (established to provide guidance to minimize impacts to fish, wildlife, and their habitats) reviewed the design plans. On the basis of this review and required revisions, the BLM and ADNOR issued hundreds of Notices to Proceed to APSC (Mead 1978).

The DOT certified the pipeline on June 16, 1977. On June 19, the AO gave APSC permission to operate the pipeline. Oil reached the Valdez Marine Terminal on July 28, 1977 (Mead 1978).

In the years immediately after construction, both the federal and state governments reduced their oversight of the TAPS. The state disbanded the SPC's office entirely in 1977, returning permitting activities to individual line agencies (Simenson 1999). In 1979, the DOI delegated its pipeline oversight role to the BLM's Alaska State Office, which placed responsibility for TAPS oversight in its Office of Special Projects. By 1984, the BLM had assigned six individuals to the office (renamed the Branch of Pipeline Monitoring), and during the second half of the 1980s, the BLM had two TAPS field inspectors (General Accounting Office [GAO] 1991).

APSC's announcement in February 1989 that an improved corrosion detection program had revealed serious problems along sections of the pipeline, followed in March by the Exxon Valdez oil spill, heightened the public's concern about the pipeline. The result was a government reevaluation and reformation of TAPS oversight. By March 1990, the BLM and ADNOR had formed the core of the JPO to more efficiently and effectively oversee pipeline operations (BLM 1990). By the spring of 1991, the JPO had expanded to include four agencies and 38 employees.

In its first years of existence, the JPO primarily addressed ongoing problems and issues. Major projects included monitoring the rerouting of 8.5 mi of pipeline at Atigun Pass to resolve corrosion problems and reviewing two revisions to the APSC's oil spill response plan. However, a GAO report (GAO 1991) charged the JPO with faulty oversight. In subsequent months, workers and

² All maps referred to in this document are presented in Volume 7.

citizens complained to Congress about the TAPS, alleging serious safety problems, employee harassment, and concerns about pipeline integrity. Congressional hearings in 1993 motivated APSC and the JPO to reexamine operations and oversight.

In 1994, the JPO developed additional technical engineering, design, and quality process expertise; began evaluating specific National Electric Code questions; assessed pipeline integrity and safety; and conducted an organizational study of JPO staffing needs. In addition, unresolved findings from seven audits that had been conducted since 1990 resulted in the identification of 4,920 unresolved findings regarding the TAPS. APSC developed a database on these findings or deficiencies, and the JPO began monitoring the pipeline operator's response to each of these "audit action items." The JPO approved the operator's fixes to all but about 100 audit action items by the end of 1996 (Brna et al. 1997). All of these items have subsequently been closed (Reimer 2002).

One deficiency that was apparent in the mid-1990s was APSC's failure to live up to commitments to hire Alaska Natives to fulfill Section 29 of the Federal Grant. In an agreement pursuant to the Federal Grant, the pipeline operator had committed to train and employ Alaska Natives in a proportion equivalent to their proportion in Alaska's population in the mid-1970s. That percentage was estimated to be 20%. By 1994, employment of Alaska Natives for the TAPS had slipped to less than 5%. In October 1995, APSC and the DOI signed an agreement requiring the operator and its contractors to take specific actions to increase employment of Alaska Natives (Brna et al. 1997). DOI and APSC renewed and revised the agreement in 1998 and 2001. APSC committed itself and its contractors to recruit, train, and employ Alaska Natives at all levels; the target was for Alaska Natives to make up 20% of TAPS employees by 2004. APSC receives credit toward that employment goal for Alaska Natives enrolled in its Alaska Native training and scholarship programs. At the end of 2001, employment of Alaska Natives for the TAPS, adjusted for training and scholarship credits, was 19.8%.

In the mid-1990s, in response to Congressional direction to provide comprehensive

oversight of the TAPS, the JPO began its comprehensive monitoring program. This program fundamentally shifted the emphasis of JPO oversight from response to prevention. The JPO identified major functional elements of the TAPS for which it had oversight responsibility (e.g., project design, QA, maintenance, safety, the employee concerns program). It also developed systematic plans to assess APSC's performance in each element. Depending on the topic, the assessment process (which continues today) involves the examination of APSC records, engineering designs, and other documents and site visits by JPO staff to examine TAPS facilities. The GAO favorably cited JPO's initiation of the comprehensive monitoring program process (GAO 1995). More recently, the JPO has enhanced its efforts to ensure pipeline integrity and safety through an RCM program.

3.1.2 Existing Infrastructure

This section describes the various auxiliary infrastructures supporting the operation of the TAPS, including those on the North Slope, at the Valdez Marine Terminal, and in Prince William Sound. The description of the pipeline itself and its main components is given in Section 1.3; a summary of the main components of the TAPS is provided in Table 3.1-1. More detailed information on design features that directly support existing mitigation measures is presented in Section 4.1. The supporting infrastructures discussed in this section are grouped into two main categories: infrastructures directly along the TAPS ROW and infrastructures supporting other components of the North Slope Production and Transportation System (NSPTS).

As mentioned in Section 1.3, the TAPS is a 48-in. single pipeline system that stretches from Prudhoe Bay in the north to the Valdez Marine Terminal in the south. The pipeline traverses a total distance of 800 mi, about half of which is aboveground; the remaining half is belowground. Of the 11 pump stations originally constructed for the TAPS, only 7 are currently operating. PS 1, 3, 4, 7, 9, and 12 provide pumping action, while PS 5 serves as a relief station (pressure control). The TAPS crosses more than 30 major rivers, about 800 smaller streams, and three mountain ranges. A total of 13 bridges support the pipeline system.

TABLE 3.1-1 Summary of Major Features of the Trans Alaska Pipeline System

Component	Type	Data
Area covered by the TAPS	NA ^a	16.3 square mi (includes Valdez Marine Terminal)
Length of pipeline	NA	800 mi
Design mode	Aboveground Conventional belowground Refrigerated belowground	420 mi 376 mi 4 mi
Typical ROW width	Federal lands, buried pipe Federal lands, elevated pipe State lands Private lands	54 ft 64 ft 100 ft 54 to 300 ft
Vertical support members	Number Types Diameter Number with heat pipes Depth embedded	78,000 16 for different soil and permafrost conditions 18 in. 61,000 15 to 70 ft
Animal crossings	Elevated Buried Buried (refrigerated)	554 23 2 (MP 645 and 649)
Bridges	Orthotropic box girder Plate girder Suspension Tied arch	1 (Yukon River, shared with Alaska Department of Transportation) 9 (Atigun, Dietrich, Koyukuk [south and middle forks], Hammond, and Tatalina Rivers; Unnamed, Hess, and Shaw Creeks) 2 (Tanana and Tazlina Rivers) 1 (Gulkana River)
Pump stations	Operating (1999) Stand-by Relief	PS 1, PS 3, PS 4, PS 7, PS 9, PS 12 PS 2, PS 6, PS 8, PS 10 PS 5
Pipeline valves	Check valves Gate valves Ball valves	81 95 (including pump station isolation valves) 1
Fuel gas line	Buried natural gas pipeline	From PS 1 to PS 3 and PS 4; 8 to 10 in. diameter; approximately 144 mi long
Access roads		Approximately 284 secondary roads (from 120 ft to 7.5 mi long) linking state roads with pipeline, pump stations, material sites, disposal sites, and airfields
Valdez Marine Terminal	Total area Crude oil storage Tanker berths	1,000 acres 9.18 million bbl total in 18 tanks (510,000 bbl each) 4 (1 floating, 3 fixed platform)
Ship Escort/Response Vessel System (SERVS)	Tugs Other vessels Skimmers Containment boom Response centers	2 enhanced tractor tugs, 3 prevention/ response tugs, 4 other 10 workboats, 7 response barges, 48 mini-barges More than 70 More than 42 mi 5 (Valdez, Cordova, Whittier, Chenega Bay, Tatitlek)
Communications sites	Microwave stations Satellite earth stations VHF repeaters	42 (operated by AT&T) 7 (operated by AT&T) 22

^a NA = not applicable.

Source: Modified from TAPS Owners (2001a, Table 2.1-1).

Typical ROW width specifications for the TAPS are as follows: buried segments on federal lands, 54 ft; elevated segments on federal lands, 64 ft; segments on state lands, 104 ft; and segments on private lands, 54 to 300 ft (TAPS Owners 2001a).

3.1.2.1 Infrastructures Directly along the TAPS ROW

The TAPS infrastructure support systems under this category include (1) electrical; (2) fuel; (3) water; (4) road; (5) communication and control; (6) site safety and emergency response; (7) other support systems, which include airstrips, operations material sites, and disposal sites; and (8) the Valdez Marine Terminal.

3.1.2.1.1 Electrical System. Power sources that make up the TAPS electrical system include on-site generator units for the pump stations, propane-fueled generators, batteries for remotely controlled gate valves (RGVs), and commercially available power from nearby grids or utilities to supplement on-site generator output (TAPS Owners 2001a; Technica, Inc. 1991; APSC 2001a).

All pump stations along the TAPS ROW (i.e., PS 1 through 12) have at least one on-site electric generating unit powered by either natural gas or diesel fuel. Generator units at PS 1 through 4 are gas-fueled (a natural gas line serves PS 1 to 4), while generator units at PS 5 through 12 are diesel-fueled (diesel or liquid turbine fuel is trucked from commercial vendors) (Technica, Inc. 1991). PS 8, 9, and 10 have commercially available power in addition to their diesel-fueled generating units. The size of the power units ranges from 400 to 800 kW, and the number of generator sets varies at the stations depending on the required power. The installed size ranges from 1.3 MW at PS 12 to 4.7 MW at PS 6. The size of the power units depends on the availability of commercial power and vapor recovery systems. (Crude oil topping units are located at PS 6, 8, and 10. The topping units have been placed on standby since 1997 because economics pointed to the use of commercially available fuel.)

In general, electric power is used for lighting, heating, ventilation, and air-conditioning of offices and living quarters at the pump stations (PS 1, 8, and 9 do not have permanent living quarters). Electric power also supports the TAPS instrumentation, communication and control systems, and other vital station functions.

Smaller-sized propane-fired generators are used to provide charging power to batteries supporting RGVs and remote cathodic protection installations. RGVs are placed at major river crossings and other locations where quick closure would be necessary in an emergency. Each RGV is powered by batteries that are kept charged by two propane-fired generators or by commercial electrical utilities where available. Remote cathodic protection installations are also electrically powered by gas-fired generators. Where the generator sets are in close proximity to the fuel gas line, they are fueled by natural gas (methane). In other areas, buried propane tanks supply the liquefied gas for fuel. Where commercial electricity is available, the local commercial power system is used (TAPS Owners 2001a).

3.1.2.1.2 Fuel Systems. Moving crude oil from PS 1 to Valdez requires a well-designed fuel delivery system to energize the pump stations along the pipeline, to support operations of the Valdez Marine Terminal, and to fuel other miscellaneous functions (e.g., lighting, heat, air-conditioning, and other machinery). Two major energy sources are used for the TAPS: natural gas and liquid turbine fuel (TAPS Owners 2001a; Technica, Inc. 1991).

Fuel Gas and Gas Pipeline. The fuel gas line supporting the TAPS generally parallels the main line crude oil pipeline, from Prudhoe Bay to PS 4, traversing a total distance of 149 mi. (Natural gas is produced with the crude oil on the North Slope. Processing facilities separate the gas, and APSC purchases a portion of the gas to use as fuel.) The fuel gas line is under ground throughout most of its length. Its main function is to carry natural gas from North Slope fields to fuel turbines at pump stations north of the Brooks Range (i.e., PS 1 through 4). Turbines at stations south of the Brooks Range are fueled by liquid turbine fuel (Technica, Inc. 1991; TAPS Owners 2001b).

The gas pipeline segment from PS 1 to TAPS Milepost³ (MP) 34 is 10 in. in diameter; the segment from MP 34 to PS 4 is 115 mi long with a diameter of 8 in. The gas pipeline has a design pressure of 1,335 pounds per square inch gauge (psig) and a nominal operating pressure of 1,090 psig. Two 1,200-hp gas turbine compressors at PS 1 boost gas pressure from

Pigs

Pigs are cylindrical objects inserted into the pipeline periodically that are propelled by the moving oil or gas and used for cleaning. Sometimes the pigs are instrumented (hence their name smart pigs) to detect corrosion, deformation, wall-thinning, or curvature changes in the pipe.

approximately 600 to 1,100 psig. (Gas is delivered to PS 1 by Prudhoe Bay Natural Gas at about 600 psig.) Maximum gas temperature at the PS 1 suction end is 30°F (APSC 2001a). If there is an interruption of natural gas supply, the turbines at PS 1, 3, and 4 can be converted to operate on turbine fuel (TAPS Owners 2001a). Pig launching and receiving facilities for the gas line are located at PS 1, MP 34, and PS 4 (APSC 2001a). The fuel gas pipeline is maintained and operated in compliance with federal regulations for cross-country gas pipelines. It is pigged periodically and is the focus of a corrosion-monitoring program, much like the crude oil pipeline (TAPS Owners 2001b).

Liquid Turbine Fuel and Topping

Units. Liquid turbine fuel is used to fuel pump stations (including electric generators) south of the Brooks Range (i.e., PS 5 to 12) and at various places in the system (e.g., Valdez Marine Terminal). The liquid turbine fuel is purchased from commercial fuel vendors and delivered in tank trucks (TAPS Owners 2001a). Prior to 1997, crude oil topping units located at PS 6, 8, and 10 produced turbine fuel and naphtha to support pump station operations (Technica, Inc. 1991). (A small amount of commercial electric power is purchased at PS 8, 9, and 12.)

In 1999, APSC used 7.776 billion standard cubic feet (SCF) of fuel gas and purchased 46 million gal of turbine fuel (TAPS Owners 2001a). Annual consumption of diesel fuel is approximately 1,116,000 gal (about 95,000 gal per month).

3.1.2.1.3 Water Systems. Operation of the TAPS requires the availability of freshwater for domestic (i.e., manned facilities) and industrial uses (e.g., equipment washing, dust abatement on roadways and pads, and hydrostatic testing). The use of Alaska's water resources and the issuance of permits for temporary or long-term water appropriations are regulated by the ADNR (TAPS Owners 2001a). APSC has certificates of appropriation for water use at permanent facilities, including each pump station except PS 1 and 6. Water used at PS 1 is purchased from the North Slope Borough's Service Area 10 water utility. A well at 5-Mile Camp is used as a water source for PS 6, for which water is trucked across the Yukon River Bridge. Each active pump station typically consumes between 4,500 and 7,500 gal/d, mostly for domestic uses. Volumes of water use (domestic and industrial) at various facilities are illustrated in Figure 3.1-1. Table 3.1-2 gives the characteristics of the water wells located along the TAPS ROW.

Additional temporary water-use permits are maintained by APSC for facilities such as mobile contingency camp facilities (MCCFs) and for special projects. Volumes of water for temporary use vary significantly. The largest single project for which temporary-water-use permitting was necessary occurred in 1997, when 7.4 million gal was withdrawn from East Lake, near MP 0, for tank cleaning and testing at PS 1 (TAPS Owners 2001a).

Potable Water Use. Typical potable water consumption (i.e., drinking water, food preparation, and personal hygiene) at the TAPS living quarters is about 100 gal per person per day. At the pump stations and camps, potable water is generally supplied by local wells maintained by APSC for that purpose. Living quarters for workers are not maintained at PS 1,

³ To provide locational references, the length of the TAPS is marked by mileposts (MPs), beginning at its origin in the North Slope (MP 0) and ending at its terminus in the Port of Valdez (MP 800).

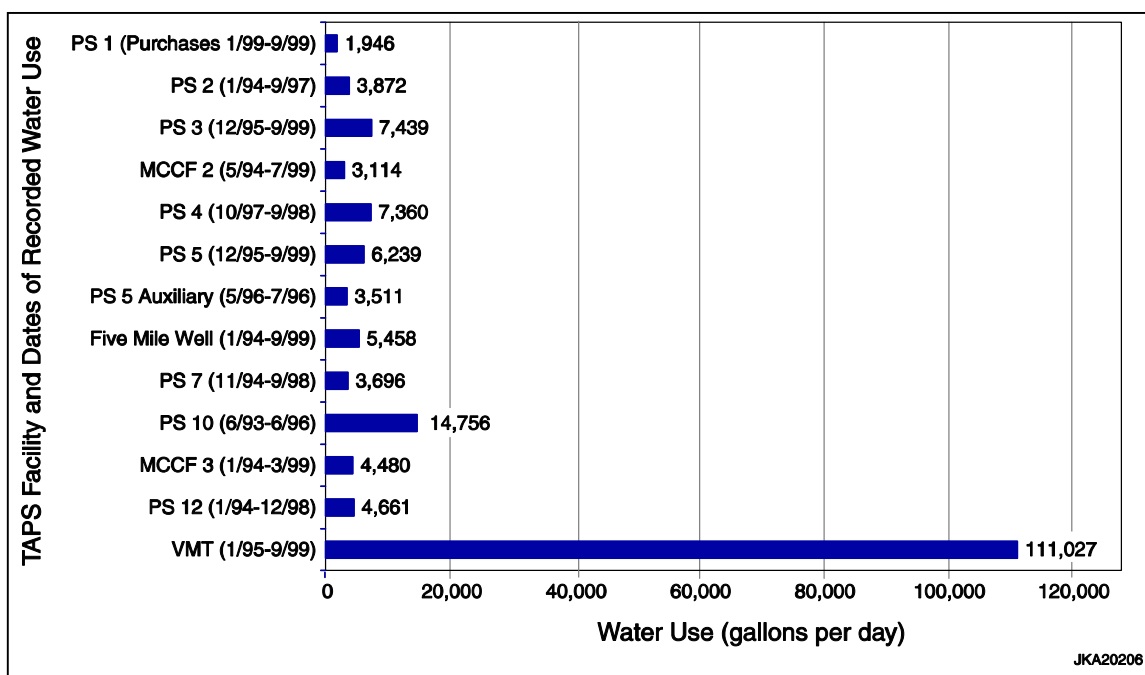


FIGURE 3.1-1 Water Use at TAPS Facilities, 1994–1999 (Source: TAPS Owners 2001a, Figure 4.11-3)

8, and 9 because of their proximity to local communities or other facilities; thus, the amount of potable water used is much lower at these stations. Currently, only PS 1, 3, 4, 5, 7, 9, and 12 are in use, further diminishing total water use. As additional pump stations are ramped down (operated at reduced levels), water use will be diminished or discontinued at those stations as well.

Industrial Water Use. The amount of water used for industrial cooling or process needs at the active pump stations is far less than that used for domestic purposes. Hydrostatic testing occurs only infrequently as part of pipeline replacement or tank repair activities. The use of water for washing down equipment, such as vehicles, turbine fans, and other equipment, is occasional, and dust suppression water uses are nominal (Jokela 2001).

Sanitary Discharges from Pump Stations and MCCFs. Discharges of sanitary wastewater take place in accordance with state and federal permits, including the EPA NPDES permits. Table 3.1-3 summarizes typical sanitary discharges from pump stations and MCCFs.

These discharges are treated by various means. In permafrost areas, discharge to groundwater is impracticable, and long-term discharge of wastewaters across tundra is viewed as increasing the potential for thermal erosion. Only PS 5 has ongoing discharge of sanitary wastewater to tundra wetlands. For years, this facility was served by a lagoon system. Wastewater was contained and treated via facultative biological decomposition, with discharge to tundra wetlands. In 1999, the lagoon system was upgraded to conventional aerobic secondary treatment using a small mechanically activated sludge plant. Discharge from this process is distributed through a diffuse outfall across tundra wetlands.

At PS 1, 3, and 4, sanitary wastewater is screened by using a fine-mesh rotary strainer. The screened wastewater is stored in a holding tank and then pumped to the exhaust stacks of the engines powering the crude oil pumps. High-pressure nozzles inject the wastewater into the hot exhaust flow, where it is atomized and evaporated. Any remaining organic material dissolved in the liquid stream is volatilized and disinfected in the hot exhaust. The exhaust-gas

TABLE 3.1-2 Location and Characteristics of Water Wells along the TAPS ROW

Well Identifier	Depth (ft)	Capacity (gal/min)	Source	Active?
5796 MP 200 Campsite	9	30	Dietrich River	No
11506 Old Man 2	420	Not reported	Talik and Kanuti River	No
25086 Sag River Pump Station 2	32	75	Sagavanirktok River	No
25087 Pump Station 3 PW-1	30	40	Sagavanirktok River	Yes
25088 Pump Station 3 PW-2	39	Not reported	Sagavanirktok River	No
25089 Pump Station 3	37	Not reported	Sagavanirktok River	No
25090 Pump Station 4	171	75	Atigun River	Yes
25091 Pump Station 5	48	Not reported	Jim River	Yes
25092 Pump Station 6	800	30	Subpermafrost	No
25093 Pump Station 6	275	20	Subpermafrost	No
25094 Pump Station 7	345	17.5	Subpermafrost	Yes
25095 Pump Station 8	28	Not reported	No ice mentioned	No
25096 Pump Station 8	302	Not reported	No ice mentioned	No
25097 Pump Station 9	520	25	Subpermafrost	Yes
25098 Pump Station 9	300	No groundwater found	Dry well	No
25099 Pump Station 10	75	40	Delta River	No
25100 Pump Station 10	90	72	No ice mentioned	No
25101 Pump Station 10	240	Not reported	Subpermafrost	No
25102 Pump Station 12	77	35	No ice mentioned	Yes
25103 Pump Station 12	80	Not reported	Talik and Little Tonsina River	No

Source: Keyes (2002).

flow disperses the relatively small volume of sterilized water particles into the atmosphere. To ensure that full dispersal takes place, APSC has established operating procedures in conjunction with the ADEC. Sewage injection can commence only when reaction turbines are running at least 2,350 rpm, and exhaust gas temperatures exceed 750°F. Air is injected in conjunction with the wastewater flow at a minimum pressure of 70 psig, and liquid pressure is continuously monitored to ensure appropriate atomization. Nozzles are inspected regularly and replaced as needed. Screenings are incinerated at each pump station. Periodically, holding tank sludge is

trucked away for disposal to a private wastewater treatment facility located off the pipeline corridor, thereby eliminating local sanitary discharges to surface or groundwater at these facilities. If injection is impractical because of maintenance or inadequate exhaust gas temperatures, wastewater is trucked to a remote permitted disposal facility.

Sanitary wastewater at PS 7 through 12 and at the Fly Camp at PS 6 is treated through conventional septic treatment systems. These systems are serviced regularly to maintain appropriate septage levels for waste treatment.

TABLE 3.1-3 Typical Sanitary Discharges from Pump Stations and Mobile Contingency Camp Facilities

PS or Camp	Status	Permanent Living Quarters	Current Population	Typical Flow (gal/d)	Design Capacity (gal/d)	Current Wastewater Disposal
1	Open	No	50 day-use	2,000	10,000	Stack injection
2	Ramped down 1996	Yes	0	4,000	10,000	Not in use
3	Open	Yes	45	7,500	10,000	Stack injection
MCCF #2	Inactive	NA ^a	0	2,900	14,000	Secondary biological
4	Open	Yes	40	4,700	10,000	Stack injection
5	Relief only; no pumps	Yes	60	6,300	8,000	Secondary biological
6	Ramped down 1997	Yes	0	6,500	6,000	Not in use
Fly Camp at PS 6	Open	Yes	16	950	850	Septic
7	Open	Yes	30	3,800	3,400	Septic
8	Ramped down 1997	No	0	600	1,000	Septic
9	Open	No	25 day-use	780	1,000	Septic
10	Ramped down 1997	Yes	0	4,200	12,000	Septic
MCCF#3	Inactive	NA	0	3,500	14,000	Secondary biological
11	Never constructed	NA	NA	NA	NA	NA
12	Open	Yes	35	4,200	9,100	Septic

^a NA = not applicable.

Source: Based on TAPS Owners (2001a).

Each MCCF has a self-contained sanitary wastewater secondary treatment system that uses rotating biological contractor technology and a holding tank. Treated wastewater from each site is discharged locally in accordance with the linewide NPDES permit.

Disposal of Other Wastewater Discharges. Wherever possible, wastewaters, such as washwaters, hydrotest waters, storm water, and snowmelt, are discharged to dry channels, tundra, or upland areas. Direct discharges to surface water are uncommon. The

linewide NPDES discharge permit specifies rules for the discharge of sanitary wastewater, hydrotest waters, and excavation dewatering. In applying for a renewal of that permit in 1998, APSC inventoried all types of wastewater discharges from normal operation.

Hydrotesting. Hydrostatic testing is conducted to ensure that repair work on pipeline segments or tank components are leak proof. Hydrostatic testing occurs infrequently. The maximum annual volume of water for hydrostatic testing was 3.8 million gal in 1991, when more

than 8 mi of pipeline was reconstructed because of corrosion of the pipeline in the Atigun River valley. Water from hydrostatic testing is discharged in accordance with the linewide NPDES permit, which mandates laboratory characterization, documentation, and erosion protection requirements for the discharge.

Excavation Dewatering. Excavation of buried pipeline segments is performed to confirm pipeline pig findings or other test data and to repair the pipe and coating system. Whenever groundwater is encountered during these excavations, the water must be removed and discharged away from the trench. Dewatering is performed in a manner that permits safe working conditions within the trench, allows for unhindered examination of the portion of the pipeline in question, and poses no significant environmental concerns. Dewatering discharge has been regulated through various permits, beginning with a State of Alaska wastewater discharge permit since 1983. The current NPDES permit requires notification, volume estimates, and descriptions of procedures employed to minimize erosion and discharge of pollutants from excavation dewatering.

Draining of Secondary Containment Dikes. Secondary containment structures along the TAPS serve as catchments for oil and incidental snowmelt and rainwater that accumulate in the impervious enclosure. These structures are drained periodically to maintain their full retention capacity. Snowmelt and rainwater removed from the containment systems are typically unaffected by contact with the tanks and other structures. Dewatering of secondary containment of waters is allowed by a State of Alaska Wastewater General Permit, which established monitoring requirements and effluent limitations. To guard against discharge of pollutants, the discharge is visually inspected for sheen. No discharge of waters bearing hydrocarbon sheen is allowed by the general permit.

In 1997, more than 60 different secondary containment structures along the pipeline were drained. There were 297 occasions for dewatering, including more than a dozen repeat visits to a few stations. Total water drained was 15,678,000 gal. More than two-thirds of the volume came from early summer dewatering of

the tank farm at PS 1, where the secondary containment volume was highest. At the Valdez Marine Terminal, discharge from secondary containment structures is directed to the BWTF to remove oil.

Storm-Water Runoff. Currently, only a limited number of facilities along the TAPS meet the applicability criteria of the EPA Storm Water Multi-Sector General NPDES Permit (MSGP) for Industrial Activities and have the potential to affect waters. APSC operates the sites in conformance with the MSGP standards. The affected sites are all material sites that may, under certain circumstances as specified by MSGP, discharge rainwater or snowmelt from mined areas to surface waters. Construction activities that disturb more than 5 acres, do not involve excavation dewatering, and have the potential to impact waters of the United States are covered under the NPDES Permit for Storm Water Discharge from Construction Activities Associated with Industrial Activity. For TAPS projects that meet criteria for coverage under this permit, specific notices of intent are submitted to the EPA (TAPS Owners 2001a).

3.1.2.1.4 Road System. Overall, the road infrastructure in Alaska is not well-developed, which explains, in part, the popularity of air travel in the state. Roads and highways that provide access to and support the TAPS include Dalton, Elliott, Steese, Alaska, Richardson, and Glenn Highways and Chena Hot Springs and Dayville Roads (Map 3.1-1). In addition, there are approximately 284 secondary roads that provide access to the pipeline, pump stations, and airstrips. Roads are now used to carry supplies to the North Slope and to various pipeline-related facilities, and roads would be used to haul dismantled sections of the pipeline if the ROW were not renewed. Access roads range in length from 120 ft to 7.5 mi and are generally 28 ft wide with a mineral material base (APSC 2001a).

The Dalton Highway is a 28-ft-wide crushed-rock road that extends 416 mi from the town of Livengood to the industrial complex of Deadhorse. Dalton Highway was built to provide an overland route between Fairbanks and Prudhoe Bay for construction of the TAPS and

now provides overland access to the northern half of Alaska (TAPS Owners 2001a).

Roads along the TAPS segment from the Yukon River to Delta Junction include Elliott, Steese, and Richardson Highways and Chena Hot Springs Road, along with connections to the Alaska Highway.

3.1.2.1.5 Communication System.

The TAPS communication system has a total of 71 stations, including 42 microwave stations, 7 satellite earth stations, and 22 very high frequency (VHF) repeater stations (APSC 2001a). The primary system for communication is the microwave, with satellite-based communications as backup (TAPS Owners 2001b). Networks are provided for supervisory control and telemetry, seismic monitoring, RGV status monitoring and control, administrative and logistical data, en route mobile radio, in-plant radio, marine and aircraft radio, voice telephone service, and oil spill prevention and response communications.

APSC uses microwave, satellite, and radio technology for remote monitoring and control of pipeline operations. The TAPS voice communication system consists of a private telephone network and a mobile radio system. Two party-line channels on the microwave system are allocated for voice communications between all stations and Valdez. The mobile radio system consists of a VHF radio base and microwave repeater stations located at strategic sites, microwave control channels, and interconnecting links to the telephone network throughout the system. Other systems are being considered to serve as the primary communication system for TAPS: fiber optics and digital microwave systems. A fiber-optic communication system has already been installed along the TAPS and is currently used for noncritical voice and data communication.

The TAPS OCC is situated at the Valdez Marine Terminal. The basic functions of the control system are to provide real-time monitoring, control all significant aspects of operation, and detect pipeline leaks. Operators in the OCC monitor the system 24 hours per day and control oil movement through the pipeline

and loading of tankers (APSC 2001a). A picture of the inside portion of OCC is shown in Figure 3.1-2. The OCC continually monitors the status of all pump stations and critical valves by using supervisory control and data acquisition (SCADA) systems with remote sensors. Data on parameters such as pressure, flow rate, temperature, tank level, and valve position are recorded and analyzed for abnormal operations or any indication of a pipeline leak.

The Pipeline Controller at the OCC can rectify any abnormal operation by changing settings for pump speed or relief valves or by issuing idle or stop commands to the main-line pumps. The OCC Controller can also activate remote control valves. The monitoring and analysis systems include backup communications equipment and computers. Leak detection for the pipeline consists of three independent systems: line volume balance (LVB) compares the volume of oil entering the line with the volume leaving the line; transient volume balance (TVB) compares reported flow with calculated flow and can identify the probable location of a leak by pipeline section; and alarms will signal deviations in pressure, flow, or flow rate balance. If emergency conditions occur, the Pipeline Controller can shut down an entire pump station and isolate it from the line or shut down the entire pipeline. Pressure relief systems are in place to prevent overpressurization during each type of shutdown (TAPS Owners 2001a). Table 3.1-4 summarizes some of the salient aspects of the TAPS control system.

3.1.2.1.6 Site Safety Services.

Safety services supporting the TAPS operation include fire protection and management, oil spill emergency response, security, and seismic monitoring.

Fire Protection. Warnings of potential and actual fires are conveyed to operations personnel by various fire detection systems installed along the pipeline. Various devices detect anomalies and alert people through numerous alarms (TAPS Owners 2001b).



FIGURE 3.1-2 Operations Control Center at Valdez Marine Terminal
(Source: TAPS Owners 2001a, Photo 2.1-3)

Automatic fire detection systems are installed throughout the pump station facilities. The main fire-alarm system at each station provides coverage in all buildings that are linked by the station hallway system. Fire suppression systems are automatically activated when a fire has been detected. Pump station fire panels normally operate in automatic mode, which allows all actions to occur expeditiously. Actions can also be initiated manually at the fire control panel or at the local fire alarm stations. Automatic actions will also occur when the amount of hydrocarbon gases in an area reaches threshold levels (TAPS Owners 2001b).

Halon is the primary fire retardant agent used in buildings where flammable hydrocarbons may be found. It can be discharged automatically by ultraviolet (UV) detectors, thermal detectors, or by a hazardous atmosphere detection system. Manual discharge could be accomplished either by pull stations in the hallways or by firing switches on the fire control panel. The aqueous film forming foam

(AFFF) system serves as a backup to the Halon system (Technica, Inc. 1991).

All pump stations have at least one fire truck, with the following extinguishing agents on board: water, foam, and purple K dry chemical powder. Hose stations and portable fire extinguishers are located throughout the pump stations (Technical, Inc. 1991). Some of the personnel at each pump station also serve on the Emergency Response Team for their station. They undergo periodic training to fulfill this duty. Table 3.1-5 summarizes the various aspects of the TAPS Fire Protection Response Teams.

Fire Management Relating to Wilderness Fires. Fires along the TAPS ROW are subject to the jurisdiction of various state or federal agencies. The Alaska Division of Forestry provides fire protection and management for the southern half of the ROW, while the northern part is covered primarily by the BLM's Alaska Fire Service with support from the U.S. Forest Service (TAPS Owners 2001a). The Alaska Interagency Fire Management Plan

TABLE 3.1-4 Features and Capabilities of the TAPS Control System

Aspects	Description
Computer type	Data General MV/20000, IBM RS/6000, various personal computers
Software programming functions	Data acquisition and control, alarm and data processing and display, hydraulic modeling, leak detection, historical archiving and reporting, and seismic evaluation
Points monitored along the pipeline	3,047 input points, 352 control points
Points monitored at the marine terminal	1,074 input points, 461 control points
Remote data acquisition units for pipeline	14 (one for each pump station plus the North Pole Metering Facility and Petro Star Refinery) ^a
Remote data acquisition units for Valdez Marine Terminal	24

^a Data-gathering units are installed in all 11 pump stations. The communication facilities at North Pole metering facility and the Petro Star Refinery are now shut down.

Source: Based on APSC (2001a).

TABLE 3.1-5 Salient Aspects of the TAPS Fire Protection Response Teams

Aspect	Description
Fire response team	Pump station personnel or crew
Crew size	Varies per station, 10-15 APSC employees
Crew shifts	One week on/one week off or two weeks on/two weeks off, depending on the station; 12-hour workday
Fire system types	Halon, water, foam, dry chemical, wet chemical, and carbon dioxide
Fire trucks	One per station; pump stations associated with airports have additional designated airfield fire-fighting trucks
Fire training	Annual live fire training and monthly fire response training; airfield rescue fire training provided at stations associated with airports
Fire training facilities	Each station has fire extinguisher training props

Source: Based on APSC (2001a).

provides for a full range of suppression responses, from aggressive control that extinguishes the fire to surveillance. Suppression action is based on the fire's threat to human life, inhabited property, designated physical developments, structural resources such as those designated as National Historic Landmarks, natural resource high-value areas, and other high-value areas such as identified cultural and historical sites. Decisions on fire suppression are at the discretion of the state or federal agency involved. Fires that threaten

pump stations receive more control action than most of the pipeline route (TAPS Owners 2001a).

Fire is a natural force in Interior Alaska, and most forest communities have been extensively influenced by recurring fire. Much debate has been engendered on the effect that fire suppression has on the natural fire cycle, which has been estimated to range from 50 to 200 years. Gabriel and Tande (1983) suggest that Alaska may still be in a "wilderness fire"

stage and that fire suppression has had no pronounced effect on the natural fire cycle (TAPS Owners 2001a).

Oil Spill Emergency Response.

APSC uses an Incident Command System that, in a response to an oil spill, transforms into a unified command with state officials from ADEC and federal officials from the EPA or U.S. Coast Guard. At each online pump station, APSC maintains a seven-member team of oil spill response personnel designated as the Initial Response Team (IRT). An IRT should be able to control a small-volume spill. Details on pertinent spill response actions are given in Section 4.1.4.

The TAPS is required to comply with the *TAPS Oil Discharge Prevention and Contingency Plan* (CP-35-1) approved every three years by multiple federal and state agencies. The plan covers the following: (1) equipment and resources and field training for spill responders; (2) electronic leak detection capabilities; (3) improved leak detection and leak prevention alarm systems for pump station tanks; (4) more than 220 sites along the pipeline ROW designated as oil spill equipment staging and deployment areas, and dedicated oil spill contingency plan buildings and equipment at each pump station; (5) mutual aid agreements with villages near the pipeline to use residents and equipment in the event of a spill; (6) 12 spill scenarios covering a variety of terrain, oil products, spill volumes, and seasonal conditions; and (7) aerial photographs of the pipeline to aid in spill response planning. Table 3.1-6 summarizes the spill response equipment available along the TAPS.

Security. Security for the TAPS is an issue of national importance. Elaborate security measures and plans involving numerous federal and state agencies are in place, are regularly updated, and are tested in joint exercises. The BLM has reviewed in detail these confidential plans and the various components of them, including overflights, remote camera surveillance, alarms (including leak detection systems), and other surveillance measures. The BLM is cognizant of them and is prepared to fully participate in planning and response activities, as appropriate. Opportunities to strengthen these measures will always be pursued diligently by the agencies involved.

Earthquake Monitoring System. The earthquake monitoring system processes seismic data to evaluate the severity of earthquake ground shaking along the pipeline route and to assess the potential for damage to the pipeline and supporting facilities. The system's most important objectives are to determine whether the pipeline should be shut down in response to an earthquake and to delineate inspection requirements for the affected portion of the route (TAPS Owners 2001b).

On the basis of preestablished criteria, the earthquake monitoring system will sound alarms, generate event reports, and describe recommended structural inspections and their locations. The system also maintains a historical database of event parameters for detailed analysis. An earthquake monitoring system has been part of the pipeline control system since start-up in 1977. The earthquake monitoring system consists of 11 remote digital strong-motion accelerograph (DSMA) stations located at PS 1, PS 4 through 12, and the Valdez Marine Terminal.

The DSMA stations use a network to share data among the various processes at each station and between stations. All stations sense and process ground-motion data and perform systemwide processing of data that are broadcast and shared with all other DSMAs. The central computer for the pipeline control system is also connected to the earthquake monitoring system network to retrieve information to create displays and alarms at the Pipeline Controller's console in the Valdez Marine Terminal OCC.

If an earthquake is detected, the DSMA switches into event mode and records the time histories for each of the three axes' measurements. Visual and audible alarms are activated, and event alarms are passed to the pipeline control system for display at the OCC. When the earthquake has ended, the DSMA switches to post-event mode and computes and stores event parameters that characterize earthquake severity.

Immediately after an earthquake, the earthquake monitoring system network distributes data from each affected DSMA so that all sites have data on the earthquake. Each

TABLE 3.1-6 TAPS Oil Spill Major Contingency Equipment

Category	Type/Description	Quantity
Vessels	Work barge with trailer	2
	River boat with trailer	13
	Airboat with trailer	11
	Boat without trailer	1
	Inflatable rafts	13
	Anchors	30
	Personal flotation devices	>250
	1/2-in. line	42,000 ft
Boom	Fire resistant boom	2,156 ft
	Protected-water boom	33,400 ft
	Palletized boom	32
Skimmers	Weir skimmers	22
	Manta bay skimmers	12
	Skimpack skimmers	11
	Oleophilic skimmers	27
Storage	Tanks/bladders	961,300 gal
	Drums (55-gal)	220
Miscellaneous	Mobile camp	1
	Communication modules	2
	Portable shelters	24
	Portable generators	24
	Helicopters	4
	Helitorch	1
	Push trucks	3
	Light vehicles	59
	Tractors, semis	11
	Fork lifts	12
	Backhoes	5
	Vacuum trucks	11
	Space heaters	22
	Light tower/plant	22
	Pressure washers	11

Source: Based on TAPS Owners (2001a); APSC (2001b).

DSMA processes the data to determine the severity of ground shaking along the pipeline route. The computer generates graphs and printed reports that assist the Pipeline Controller in decision making and guide post-earthquake inspection efforts. A key report section compares computed earthquake parameters to design limits. If the shaken area requires an inspection, a checklist is generated to guide the field response teams.

The Pipeline Controllers determine the need for pipeline shutdown and field inspection by reviewing earthquake monitoring system-generated alarm displays and other control system information. Shutdowns are initiated manually by the Pipeline Controller; however, a shutdown sequence will occur automatically if system alarms are not acknowledged at the OCC within a preset period.

3.1.2.1.7 Other Support Services and Facilities. Other facilities that are scattered along the pipeline and used to support the operation of the pipeline include airstrips, material storage, and disposal sites.

Airstrips. Currently, two permanent airfields directly support the operation of the TAPS. Galbraith Lake (near PS 4) and Prospect (near PS 5) Airfields. Galbraith Lake is a 5,200-ft long runway situated on federal land but operated under state lease. Prospect is a 5,000-ft airfield also on federal land and subject to state lease. These two airfields are part of about 14 temporary airstrips used during the construction of the TAPS (TAPS Owners 2001a). Several other active airstrips are also utilized by the TAPS. Map 3.1-1 shows the locations of various airstrips along the TAPS ROW. Additional details on the State's and the TAPS-related aviation transportation network are provided in Section 3.15.1.

Operations Material Sites and Disposal Sites. Mineral mining sites and disposal sites are located at numerous points along the TAPS ROW in support of general pipeline maintenance and handling of materials. Operations material sites usually contain gravel and other natural materials (sand, bedrock, etc.) intended primarily for use as refill materials for various excavation works associated with

pipeline maintenance as well as for repair of workpads and access roads. Currently, 69 active operations material sites are located along the TAPS ROW on either federal or state lands (TAPS Owners 2001a). Disposal sites are essential for handling routine and nonroutine wastes generated as part of the TAPS operation. Disposal sites include landfills, incinerators, and other solid and liquid waste disposal sites (APSC 2000a). A detailed discussion of the operation of disposal sites, including their specific locations along the TAPS ROW, is presented in Section 3.16 (Waste Management).

3.1.2.1.8 Valdez Marine Terminal.

The Valdez Marine Terminal is the southern terminus of the TAPS and is located on ice-free Port Valdez at the northeastern end of Prince William Sound. The Valdez Marine Terminal site occupies approximately 1,000 acres on the southern shore of Port Valdez, extending from sea level to 538 ft in elevation at the West Tank Farm (Figure 3.1-3).

Table 3.1-7 summarizes the facilities located at the Valdez Marine Terminal, where oil is loaded onto tankers for shipment to markets. The terminal has storage facilities for 9.18 million bbl of crude and four loading berths (Berths 1, 3, 4, and 5; Berth 2 was never built). Berths 4 and 5 have vapor-control systems and will be the primary loading berths in the future. Berths 1 and 3 are not vapor controlled but remain available for use in special situations. Future use of Berths 1 and 3 is under study.

Crude oil arriving at the Valdez Marine Terminal is measured at the East Metering Building and then transferred to storage tanks or can be directly loaded onto tankers. Ballast water from incoming tankers is piped to the BWTF for treatment before discharge to Port Valdez, in accordance with state and federal permits. Vapor from tankers and crude storage tanks is piped to the vapor recovery system. Approximately 350 people work at the Valdez Marine Terminal (TAPS Owners 2001b), which also houses the OCC for the TAPS.

As mentioned in Section 3.1.2.1.5 (Communication System), the OCC is key to pipeline operations and control. Pipeline controllers at the OCC monitor and control the

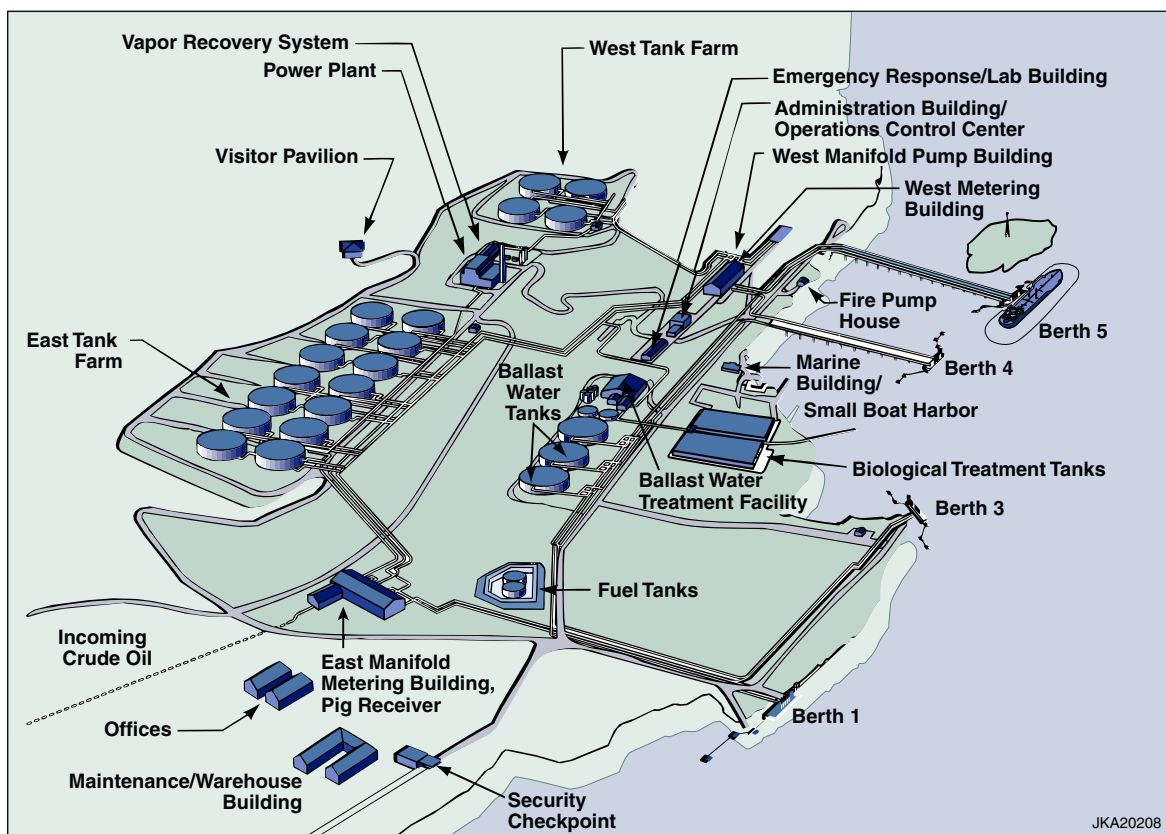


FIGURE 3.1-3 Valdez Marine Terminal (Source: TAPS Owners 2001a, Figure 2.1-5)

pipeline to ensure safe and reliable operation. Central to OCC is the SCADA host computer and associated equipment. The host computer interfaces between the OCC controllers (people) and computers at remote locations such as pump stations and RGVs.

Water Treatment and Vapor Control. The BWTF processes ballast water off-loaded from incoming tanker ships and wastewater from a variety of waste streams collected in the Valdez Marine Terminal industrial wastewater sewer system.

The vapor control system for the Valdez Marine Terminal controls atmospheric emissions of crude oil vapors from storage tanks and from the tankers during loading. The vapor control system also provides inert (oxygen-deficient) vapor to the crude oil storage tanks, thus maintaining a safe operating condition by preventing the hydrocarbon vapor in the storage tanks from becoming combustible. Because a

fire cannot sustain itself without oxygen, limiting the amount of oxygen in the tanks is a very effective fire prevention measure.

Electrical System. The Valdez Marine Terminal's primary power plant facilities include three steam boilers coupled to three condensing steam turbine generators, each with a rated output of 12.5 MW (total of 37.5 MW). Two generators with a total capacity of 2.8 MW serve as backup (secondary) power sources. For essential control equipment, four uninterruptible power supply systems supported by a 125-volt battery bank are deployed (APSC 2001a).

Potable Water Use. The Valdez Marine Terminal operates continually; however, no living quarters are provided for the staff at the terminal. Most of the staff reside in Valdez and use municipal water supplies as a principal source of potable water. As a result, potable water use at the terminal is generally less than

TABLE 3.1-7 Summary of Facilities at Valdez Marine Terminal

Facility	Function
Operations Control Center	This center controls the entire pipeline, directs the flow of oil to the tank farms and to vessels at the berths, and monitors the operation of the ballast water treatment system and the tanker loading berths.
18 crude oil holding tanks	Four tanks are at West Tank Farm, and 14 are at East Tank Farm. Each tank has a 510,000-bbl capacity; total capacity is 9.18 million bbl. All tanks are within secondary containment and are connected to a vapor control system.
Two manifold/metering buildings	These measure incoming oil from the pipeline (East Manifold/Metering Building). Pressure relief valves prevent incoming oil pressure from exceeding design limits and divert oil to relief tanks, if necessary. Oil is routed to berth meters for loading onto tankers or into storage tanks (East Metering). Oil loaded onto tankers is measured.
Four tanker loading berths (1, 3, 4, and 5; 2 was never built)	Berth 1 is a floating berth with up to 80,000 bbl/h capacity. The other three berths are fixed berths with up to 110,000 bbl/h capacity each. Two loading arms at Berth 1 can also off-load fuel oil from tankers. Berths 4 and 5 have tanker vapor collection systems.
Ballast water treatment system	All oily water collected in the Valdez Marine Terminal, including ballast water, is processed through this system; it handles an average of 400,000 bbl/d. It recovers an average of 2,000 bbl/d of oil; recovered oil is returned to the crude oil system. After treatment, ballast water is discharged into Port Valdez.
Major support systems	These are power generation and other utility systems; systems for maintenance, security, materials receiving and control, emergency response, and tanker escort; harbor facilities for support vessels; and systems for tanker and tank farm vapor recovery.

Source: Based on TAPS Owners (2001a).

25 gal per person per day (TAPS Owners 2001a).

Fire Protection. The Valdez Marine Terminal is equipped with fire detection and suppression systems. Suppression systems include portable fire extinguishers, water and foam systems, Halon, and carbon dioxide (CO₂). The Valdez Marine Terminal has at least four fire trucks and six tugboats equipped with fire fighting equipment. Regular training of personnel is also part of the fire protection program at the terminal (APSC 2001a).

Spill Response. The Valdez Marine Terminal is also equipped with spill response

equipment to handle potential spills. In addition, the terminal deploys a 10-person spill response team on continuous duty. Major spill equipment includes five self-propelled skimmers, several workboats, and about 6 mi of oil boom. The Valdez Marine Terminal is required to adhere closely with the rules set forth in APSC's ADEC-approved *Valdez Marine Oil Discharge and Prevention Plan (CP-35-2)* (APSC 2001c).

Other Support Systems. The Valdez Marine Terminal's other support systems include maintenance, security, materials receiving and control, and other utility systems (e.g., telecommunication and industrial water).

3.1.2.2 Infrastructures for Other Components of the Alaska North Shore Oil Production and Transportation System

Support infrastructures under this category pertain to related aspects outside the TAPS ROW but are an integral part of the overall operation of the TAPS. These include the North Slope and Prince William Sound.

3.1.2.2.1 Marine Transportation System. Currently, a fleet of 26 tankers — 3 with double hulls and 13 with double sides — serves the Valdez Marine Terminal. However, the composition of the fleet must change in the future to stay in compliance with the Oil Pollution Act of 1990. Beginning in 2014, the fleet will consist entirely of double-hulled tankers. Double-hulled tankers offer environmental advantages in terms of a reduced likelihood and reduced volumes of oil spills. The number of tankers will decrease substantially from the present 26 to 8 to 10 tankers by 2020. Reduced tanker transit, use of double-hulled tankers, and other improvements will substantially reduce the annual probabilities of accident and oil spills (TAPS Owners 2001a).

Since the Exxon Valdez spill in 1989, significant improvements have been made in spill prevention and response capability for Prince William Sound, including the creation of APSC's Ship Escort/Response Vessel System (SERVS). SERVS is responsible for the safe transit of oil tankers from the Valdez Marine Terminal to approximately 17 mi outside of Hinchinbrook Entrance. Its duties are primarily related to spill prevention and spill response. A study by Det Norske Veritas et al. (1996), which did not consider future benefits of double-hulled tankers, estimated that the risk of a large oil spill was reduced by 75% as a result of the creation of SERVS and related measures.

SERVS has nine vessels assigned to escorting, docking, and response duties, and at least two escort vessels are required for each laden tanker transiting the sound. Tethered escort is required through the Valdez Narrows. In the northern sound, the escort vessel is within

one quarter nautical mile of the tanker when not tethered. In the central sound, a conventional tug or a prevention and response tug maintains close escort, while the second escort vessel goes on sentinel duty to provide response coverage to a larger area. A vessel is on sentinel duty in the Hinchinbrook Entrance area (Map 3.1-2). A third escort vessel may be added, depending on weather conditions. Additional vessels are available if needed for a response or to fill in during scheduled and unscheduled maintenance.

In addition, APSC spill response equipment includes more than 70 oil skimming systems, seven storage barges, and 35 mi of containment boom. Equipment is stationed in Port Valdez and at five response centers across Prince William Sound. In addition, APSC has contracts with 300 fishing vessel owners to respond to a potential spill. Fishermen also provide local knowledge to help identify at-risk areas and provide protection methods.

Other improvements made in the wake of the Exxon Valdez oil spill include (1) regular oil spill drills and training exercises at a variety of locations along the pipeline and in Prince William Sound and (2) formation of the Prince William Sound Regional Citizens Advisory Council in accordance with the Oil Pollution Act of 1990. This citizens group participated in the design of APSC's new system based on prevention and readiness for response.

3.1.2.2.2 North Slope. The TAPS was built for the specific purpose of transporting crude oil produced from the North Slope region to the Valdez Marine Terminal. The North Slope is a gently sloping to flat, treeless plain, covering about 88,000 mi², extending from the foothills of the Brooks Range to the Beaufort Sea (Arctic Ocean). It encompasses the coastal plain portion of the Arctic National Wildlife Refuge, the westernmost boundary of which is located about 90 mi east of the Prudhoe Bay oil field. Prudhoe Bay is also used generally to describe the oil exploration and development province on Alaska's North Slope, which includes more than a dozen separate oil fields spread across several hundred square miles of land in the vicinity of Prudhoe Bay.

Modern petroleum exploration and development on the North Slope began in the late 1950s and continued for more than 20 years. (Some of the earliest drillings and explorations in the early 1900s were conducted by the Navy and U.S. Geological Survey.) Many unsuccessful exploratory wells were drilled, and many companies gave up the search before the Prudhoe Bay discovery well was drilled by Atlantic Richfield Company and Humble Oil and Refining Company in 1967. A confirmation well the following year proved the discovery of the large reservoir of oil (23 billion bbl) and gas (26 trillion ft³) (TAPS Owners 2001a; APSC 2001a). Field development began in 1969 (TAPS Owners 2001a).

Map 3.1-3 shows the distribution of producing units presently operating on the North Slope. Oil fields are legally organized into producing units, which customarily group all of the owners of the leased area over a petroleum accumulation to avoid conflicts over extraction and ownership of the resource. The Prudhoe Bay Unit, discovered in 1967, was the first oil-producing area on the North Slope. This unit began production as soon as the TAPS was opened in 1977. Recent developments in this unit include the Lisburne (2 billion bbl), Point McIntyre (800 million bbl), and Niakuk (reserves figure not available) oil fields, which began production in 1986, 1993, and 1994, respectively (TAPS Owners 2001a).

The Kuparuk River Unit (5.3 billion bbl), the second-oldest oil-producing area in the region, began production in 1981. In 2000, production from Kuparuk averaged 236,000 bbl/d. A seawater treatment plant and waterflooding facility, along with a 700-ft dock, were established at Oliktok Point in 1985 to support this and potentially other units (e.g., Alpine). Production from the Milne Point Unit (100 million bbl) began in 1985, establishing it as the third major oil field in the region. Production from this unit was suspended in early 1987 because of unfavorable oil prices; the unit resumed production in 1989 (TAPS Owners 2001a).

Endicott (350 million bbl) was the fourth producing oil field on the North Slope, beginning production in 1987. It was the first off-shore production facility in the North American Arctic. Built in the winter of 1984 to 1985, Endicott's two artificial islands were connected by a curved, 3.7-mi-long, gravel-fill causeway; this segment is connected to shore by a 1.6-mi-long causeway, which contains three breaches for fish passage (TAPS Owners 2001a).

The Badami, Alpine, and Northstar oil fields are the most recent developments reflecting the most modern technology. The Badami and Alpine fields began production in 1998 and 1999, respectively. The Northstar fields began production in 2001. Collectively, the oil fields of the Prudhoe Bay region were, and still are, the largest oil and natural gas discoveries in the history of North American petroleum exploration.

3.2 Physiography and Geology

The TAPS crosses a wide variety of terrains, including three mountain ranges, several intermontane basins, and an arctic coastal plain. The land features along the ROW comprise 10 physiographic provinces (Wahrhaftig 1965) (Map 3.2-1 and Table 3.2-1). The characteristics of each province are briefly summarized in the following sections. Because the ROW is narrow and the TAPS facilities are on or very near the ground surface, the descriptions emphasize the surface landforms and the near-surface geology. For areas where bedrock is exposed, the description summarizes general rock types and geologic ages. However, most of the pipeline is on unconsolidated sediments of Quaternary age (see Table 3.2-2 for geologic time line). The surficial geology rather than bedrock geology is described for such areas.

The threat posed to the pipeline by volcanic activity is not considered significant. The volcanic field closest to the pipeline is in the Wrangell Mountains to the east. The volcanic field is characterized by nonexplosive summit calderas (craters) and is separated from the pipeline by the Copper River Valley. The closest crater (Drum Volcano) is about 20 mi east of the pipeline.

The following subsections provide background physiographic and geologic information for the TAPS. The impacts of TAPS construction on physiography and geology were negligible and local.

3.2.1 Arctic Coastal Plain (MP 0–60)

The Arctic Coastal Plain extends from the Beaufort Sea south to the Arctic Foothills. It is a smooth plain, rising gradually for 60 mi to the south to an elevation of about 600 ft (Wahrhaftig 1965). This physiographic province is characterized by a network of polygonal ground and oriented thaw lakes in low-lying areas (see Table 3.2-3 for definitions of special terms). Locally, pingos form in nearly level, low-lying ground on drained or sediment-filled ponds or

Physiography and Geology

Physiography is the physical geography of an area, or the description of its physical features.

A *physiographic province* is a region in which the landforms are similar in geological structure and differ significantly from the landform patterns in adjacent regions.

Geology deals with the materials that make up the planet earth and the processes that act on them.

lakes (BLM and Alaska Natural History Association 1993). Bedrock hills composed of poorly consolidated shale and sandstone of Tertiary age are scattered on the smooth plain. The Sagavanirktok River that drains this area is braided.

Through most of this province, the pipeline is buried in the floodplain of the Sagavanirktok River (MP 12–60). The river has many shallow water channels. Sheet ice from successive overflows develops on various sections of the floodplain in winter (TAPS Owners 2001a). The first 12 mi of the pipeline (MP 0–12) crosses an area rich in polygonal ground and thaw lakes developed on marine, fluvial, eolian, and lacustrine sediments of Quaternary age (Kreig and Reger 1982).

3.2.2 Arctic Foothills (MP 60–140)

The Arctic Foothills Province is a generally hilly area formed of glacial moraines and bedrock hills of sandstone, siltstone, and shale of Cretaceous age (BLM and Alaska Natural History Association 1993). The area is drained primarily by the north-flowing Sagavanirktok River. This river is characterized by a meandering channel in its upper reach (MP 85–110) and a braided river system in the lower reach (MP 60–85).

TABLE 3.2-1 Physiographic Provinces Crossed by the TAPS ROW

Province	Extent of Pipeline Crossing ^a
Arctic Coastal Plain	60 miles (MP 0–60)
Arctic Foothills	80 miles (MP 60–140)
Brooks Range	97 miles (MP 140–237)
Chandalar Ridge and Lowland Section	20 miles (MP 237–257)
Kokrine-Hodzana Highlands and Yukon-Tanana Uplands	258 miles (MP 257–515)
Tanana Lowland	45 miles (MP 515–560)
Alaska Range and Northern Foothills	50 miles (MP 560–610)
Gulkana Upland	35 miles (MP 610–645)
Copper River Lowland	75 miles (MP 645–720)
Chugach Mountains	80 miles (MP 720–800)

^a MP = Milepost. Milepost 0 is at the start of the pipeline on the North Slope; MP 800 is at the end of the pipeline at the Valdez Marine Terminal (Port of Valdez).

TABLE 3.2-2 Geologic Time Line

Era/Period	Time Period
Cenozoic Era	Present to 65 million years ago (MYA)
Quaternary Period	Present to 1.8 MYA
Holocene Epoch	Present to 8,000 years ago
Pleistocene Epoch	8,000 years ago – 1.8 MYA
Tertiary Period	1.8 – 65 MYA
Mesozoic Era	65 – 248 MYA
Cretaceous Period	65 – 145 MYA
Jurassic Period	145 – 210 MYA
Triassic Period	210 – 248 MYA
Paleozoic Era	248 – 570 MYA
Permian Period	248 – 290 MYA
Pennsylvanian Period	290 – 330 MYA
Mississippian Period	330 – 365 MYA
Devonian Period	365 – 408 MYA
Silurian Period	408 – 430 MYA
Ordovician Period	430 – 500 MYA
Cambrian Period	500 – 570 MYA
Proterozoic Era	570 – 2,500 MYA

Source: USGS (2001a).

TABLE 3.2-3 Special Terms Used in Section 3.2

Term	Definition
Alluvial fan	A gently sloping mass of alluvium deposited where a stream issues from a narrow canyon onto a plain or valley floor. Viewed from above, it has the shape of an open fan, the apex being at the valley mouth.
Alluvium	Unconsolidated material deposited by a stream or river in relative recent geologic time.
Braided river	A river with an interlacing network of channels.
Cirque	A semicircular recess with steep walls located at the head of a mountain valley.
Colluvial	Pertaining to or composed of colluvium (i.e., loose deposits of rock, usually at the foot of a slope or cliff and brought there under the influence of gravity [a process known as mass wasting]).
Eolian	Pertaining to the wind or deposits that have been laid down by the wind.
Fluvial	Of or pertaining to rivers or to deposits laid down by rivers.
Glaciofluvial	Pertaining to meltwater streams flowing from glaciers or to the deposits made by such streams.
Hanging valley	A glacial valley whose mouth is at a relatively high level on the steep side of a larger glacial valley.
Lacustrine	Pertaining to or produced by a lake or lakes, e.g., lacustrine sands.
Moraine	A mound, ridge, or plain material deposited by the direct action of glacial ice.
Oriented thaw lake	A lake or pond in a permafrost area formed by the thawing of ground ice and enlarged by wind currents.
Outwash fan	A fan-shaped body of sediments deposited by streams of a melting glacier.
Permafrost	Ground that has been frozen for two or (often) more consecutive years (see Section 3.3).
Pingo	A rounded or conical mound containing ice at its core; raised in part by hydrostatic pressure of water within or below the permafrost.
Polygonal ground	A form of patterned ground outlined by cracks that are filled with ice wedges and produced by frost action.
Talus	Accumulation of rock debris at the base of cliffs.
Thermokarst lake	A lake formed in a depression by the thawing of ground ice in soil above permafrost.
Till	Unstratified mixture of clay, silt, sand, gravel, and boulders deposited directly by a glacier without reworking by meltwater.

The pipeline follows the valley of the Sagavanirktok River from MP 60 to 90 and is mostly buried in the coarse-grained floodplain of the river (TAPS Owners 2001a). Sedimentary rocks of Cretaceous age are exposed and form hilly areas near the flanks of the river. To the south (MP 90-140), the pipeline traverses a series of glacial moraines until it reaches Galbraith Lake. Tilted, bedded sandstone, siltstone, and clay shale of Cretaceous age are exposed in scattered bedrock hills near the ROW (e.g., Slope Mountain near MP 115) (BLM and Alaska Natural History Association 1993).

3.2.3 Brooks Range (MP 140–237)

The Brooks Range Province contains rugged glaciated east-west trending mountains. It rises from the Arctic Foothills to elevations of about 8,000 ft in the northern part. The elevations in the southern part range from 4,000 to 6,000 ft (Wahrhaftig 1965). Erosional landforms associated with alpine glaciers, such as cirques and U-shaped valleys, are common in the mountains. Talus slopes, alluvial fans, moraines, and outwash fans are well developed at the base of steep slopes of valleys and cirques.

The drainages in the northern part of the mountains discharge to the Arctic Ocean, and the drainages in the southern part discharge to the Bering Sea. Most of the major drainages flow in U-shaped valleys that were scoured by Pleistocene glaciers.

The bedrock in the Brooks Range includes three belts. Folded and thrust Paleozoic and Mesozoic sedimentary rocks are exposed in the northern flank of the range, deformed Paleozoic metamorphic rocks occur in the central Brooks Range, and Late Proterozoic to Paleozoic metamorphic rocks occur in the southern Brooks Range (Moore et al. 1994).

The pipeline follows the U-shaped valley of the Atigun River from Galbraith Lake to the Continental Divide (MP 166) and then follows the valleys of the Dietrich and Middle Fork Koyukuk Rivers to Coldfoot (MP 237) before entering the Chandalar Ridge and Lowland Province. Except near the Continental Divide, where bedrock units are exposed, the surficial deposits are of fluvial,

colluvial, glacial, and glaciofluvial origin in the valleys.

3.2.4 Chandalar Ridge and Lowland Section (MP 237–257)

Near the southern end of the Alaska Range, the pipeline enters the Chandalar Ridge and Lowland Section (MP 237-257) near Coldfoot (MP 237). This section consists of low ridges and lowlands. The pipeline follows the floodplain of the Middle Fork Koyukuk River, which cuts across a low mountain ridge, and crosses the lowlands drained by the South Fork Koyukuk River (Wahrhaftig 1965). The lowlands are underlain by Quaternary unconsolidated deposits. Late Paleozoic and Mesozoic igneous rocks (both volcanic and intrusive) are exposed on the ridges (BLM and Alaska Natural History Association 1993). The South Fork Koyukuk River marks the location of the South Fork Fault

Rock Types

The rocks that form the earth's solid crust are of three basic types: sedimentary, igneous, and metamorphic.

Sedimentary rocks: Rocks formed by consolidation of loose sediment that has accumulated in layers through deposition by wind, water, or ice. Sandstone is an example.

Igneous rocks: Rocks formed by the solidification of molten magma. Examples are *volcanics* (rocks formed near the earth's surface by the rapid cooling of molten magma from a volcano) and *intrusives* (formed when molten material solidified deep in the earth). Examples are basalt (a volcanic) and granite (an intrusive).

Metamorphic rocks: Rocks formed from preexisting rocks by mineralogical, structural, and chemical changes in response to extreme changes in temperature, pressure, and shearing stress. Metamorphism occurs deep in the earth's crust, below the zone of weathering and sedimentation. Metamorphic rocks are sometimes referred to simply as *metamorphics*. An example is slate.

that separates this section from the Kokrine-Hodzana Highlands Physiographic Province to the south. The pipeline in this section is located in the floodplain of the Middle Fork Koyukuk River, except for the last 5 mi (MP 252–257), where it is in the valley bottom of the South Fork Koyukuk River.

3.2.5 Kokrine-Hodzana Highlands and Yukon-Tanana Uplands (MP 257–515)

The Kokrine-Hodzana Highlands (MP 257–377) consist of rounded hills rising to 2,000 to 4,000 ft and extending from MP 257 to the Hess River, which marks the Rampart Trough (Wahrhaftig 1965). The highlands have not been glaciated and are commonly covered with colluvial and eolian deposits. The low-lying areas are covered with retransported eolian deposits. The northern part of the province is composed primarily of Proterozoic through Paleozoic metamorphic rock, with some igneous intrusions of Cretaceous age (BLM and Alaska Natural History Association 1993). The southern part consists predominantly of fine-grained, massive volcanics and relatively thin beds of fossilized chert of Late Paleozoic to Middle Mesozoic ages (BLM and Alaska Natural History Association 1993). The Yukon and Koyukuk Rivers and their tributaries are major systems draining the highlands.

The Rampart Trough near the Hess River (MP 257) is a narrow depression. It was created by erosion along a tightly folded belt of soft coal-bearing rocks of Tertiary age. Topographically, it is 500 to 2,500 ft below the Kokrine-Hodzana Highlands and the Yukon-Tanana Uplands on either side (Wahrhaftig 1965).

South of the Rampart Trough to Tanana River (MP 515), the Yukon-Tanana Uplands are characterized by rounded hills with gentle side slopes. The hills, at elevations of 1,500 to 3,000 ft, rise 500 to 1,500 ft above adjacent valleys. The valleys are generally a quarter to a half mile wide within a few miles of headwaters and are filled with alluvium. Most streams are tributaries of the Yukon and the Tanana Rivers

(Wahrhaftig 1965). They flow either northeast to the Yukon River or southeast to the Tanana River. The two rivers supply the silt that is deposited on the top of the hills by wind. The bedrock in the uplands contains metamorphic rocks of Paleozoic age (Foster et al. 1994).

From the South Fork Koyukuk River to the Jim River (MP 277), the pipeline follows the valleys of local streams and the Jim River. It then crosses a series of hills and lowlands. Several major lowlands are drained by the Yukon River, Hess Creek, Tolovana River, Tatalina River, Chatnika River, Chena River, and Salcha River. These river valleys contain extensive Quaternary fluvial and eolian sediments.

3.2.6 Tanana Lowland (MP 515–560)

The Tanana Lowland is a broad depression between the Yukon-Tanana Upland on the north and the Alaska Range on the south. Coalescing outwash fans from the Alaska Range are present in the lowland. Near the heads of the fans, rivers, including the Delta River, flow in broad terraced valleys that can be up to several hundred feet deep. Glacial moraines lie on the upper end of some fans (Wahrhaftig 1965). Thermokarst lakes are well developed on the terraces and the low-lying areas away from the heads of the fans. The Delta and Tanana Rivers are two major rivers draining in this province.

The pipeline is in the floodplains of the Tanana and Delta rivers until MP 550 to 560, where it is on the outwash fan of the Delta River.

3.2.7 Northern Foothills and Alaska Range (MP 560–610)

The Northern Foothills consist of a belt of flat-topped east-trending hills (Wahrhaftig 1965) that are separated by lowlands composed of moraines or outwash plains deposited by the glaciers from the Alaska Range. The hills are largely unglaciated. Thermokarst lakes develop in the lowlands.

The Alaska Range is characterized by rugged glaciated terrain, 6,000 to 9,000 ft in elevation (Wahrhaftig 1965). Landforms associated with Alpine glaciers are common, including cirques, U-shaped valleys, moraines, outwash fans, and alluvial fans. The pipeline crosses several faults, including the Denali Fault and the Hines Creek Fault (or McGinnis Glacier Fault), near MP 589 (Nokleberg et al. 1994). North of the Denali Fault, metamorphic rock is exposed near the pipeline. Late Paleozoic marine sedimentary and volcanoclastic rocks are exposed south of the Denali Fault (TAPS Owners 2001a). Most of the glacier-fed streams drain to the Tanana River to the north.

The pipeline passes the Northern Foothills near the Donnelly Dome and enters the valleys of the Delta River and Phelan Creek. Several alpine glaciers, such as Black Rapids, Castner, and Cantwell, come within 1 to 2 mi of the pipeline. These glaciers have been retreating during the last few decades. The pipeline is situated on the Pleistocene moraines on the side of the U-shaped valley and the floodplain of the Delta River and Phelan Creek. The valley and the floodplain are underlain by glacial, colluvial, lacustrine, fluvial, and glaciofluvial deposits.

The Black Rapids Glacier (MP 579) and Castner Glacier (MP 587) are more than 1 mi from the pipeline. The Black Rapids Glacier made a rapid advance of 4 mi in 1937. However, both glaciers have been retreating since the pipeline was built (TAPS Owners 2001a). No proglacial lake is present in front of the Black Rapids and Castner Glaciers. Currently, none of the glaciers pose a threat to the pipeline.

3.2.8 Gulkana Upland (MP 610–645)

The Gulkana Upland is in the southern flank of the Alaska Range, elevated above the Copper River Lowland to the south. The upland is characterized by round east-west trending ridges and broad lowlands (Wahrhaftig 1965). From Isabel Pass (MP 610) to Hogan Hill (MP 645), the upland crossed by the pipeline contains moraines, outwash plains, and river terraces. Summit Lake and Paxson Lake adjacent to the pipeline are located in basins that were scoured

by Pleistocene glaciers from the Alaska Range. Both lakes are fed by melted water from Gulkana Glacier. Small thermokarst lakes are common in this area.

Igneous and metamorphic bedrock of late Paleozoic and Mesozoic ages is exposed on the upland ridges (Nokleberg et al. 1994; Kreig and Reger 1982).

3.2.9 Copper River Lowland (MP 645–720)

The Copper River Lowland is bounded on the north by the Alaska Range, on the west by the Talkeetna Mountains, on the south by the Chugach Range, and on the east by the Wrangell Mountains. It is a relatively flat plain, 1,000 to 2,000 ft in elevation, trenched by the valleys of the Copper River and its tributaries (Wahrhaftig 1965). The relief of the valley can be as much as 500 ft. The central part of the lowland was occupied by Lake Atna, an ancient glacier-dam lake, during the Pleistocene (Hamilton 1994). Adjacent to the lowland, the terrain consists of hilly areas at the foothills of the Alaska Range on the north (the Gulkana Uplands) and the Chugach Range on the south.

From Hogan Hill (MP 645) to Willow Mountain (MP 710), the pipeline crosses the floor of the Copper River Lowland where ancient Lake Atna was located and then crosses the meandering Gulkana River. This area is underlain by complexly interlayered glacial, glaciofluvial, glaciolacustrine, colluvial, eolian, and fluvial deposits (Kreig and Reger 1982). The lake received sediments from glacier-fed streams from the mountains surrounding the Copper River Lowland during the Pleistocene. Pleistocene deposits can be more than 500 ft thick locally (TAPS Owners 2001a). Thermokarst ponds are common in the area.

From Willow Mountain (MP 710) to the Tonsina River crossing (MP 720), the pipeline crosses the margin of ancient Lake Atna that is dissected by the valley of the Tonsina River. Bedrock hills are common on the western side of the pipeline. The upper reach of the Tonsina River is in a U-shaped valley of glacial origin. This area contains complex alluvial fan,

glaciofluvial, and glacial deposits. The bedrock on the hills consists of Paleozoic metamorphic rocks (Nokleberg et al. 1994) and Late Triassic to Early Cretaceous *mélange* (rock that includes fragments and blocks of all sizes, both native and exotic, embedded in a fragmented and fine-grained matrix) (McHugh Complex) (Plafker et al. 1994a).

3.2.10 Chugach Mountains (MP 720–800)

The Chugach Mountains Physiographic unit is characterized by rugged mountains 7,000 to 13,000 ft high along the coast of the Gulf of Alaska (Wahrhaftig 1965). The range has been heavily glaciated and is dominated by ridges, cirques, hanging glaciers, U-shaped valleys, and moraines. Major drainages, including the Tiekel, Tsaina, and Lowe Rivers, are situated in U-shaped valleys and are fed by the meltwater of glaciers.

The pipeline traverses the mountains between MP 720 and the Valdez Marine Terminal at MP 800 (TAPS Owners 2001a). It follows the valleys of the Tonsina, Little Tonsina, Tickel, Tsaina, and Lowe Rivers. Most of the pipeline is buried in the glacial, colluvial, and glaciofluvial deposits within the valleys. The valleys are flanked by outcrops of folded and faulted metamorphic and volcanic rocks of Late Cretaceous age (Plafker et al. 1994a). The Border Ranges Fault System crosses the northern part of this province, where sedimentary, metamorphic, and volcanic rocks are exposed.

The Worthington Glacier (MP 772) in the Chugach Mountains is about 0.4 mi from the pipeline. The glacier has been retreating over the last 25 years (TAPS Owners 2001a). A small pond is present in front of the glacier. Currently, the glacier does not pose a threat to the pipeline.

3.3 Soils and Permafrost

Soil and permafrost characteristics vary greatly along the 800 mi of the TAPS ROW. The origins of the soil range from weathered bedrock; glacial till and outwash; fluvial gravel, sand, silt and clay; lacustrine silt and clay; colluvium; to windblown silt and fine sand. During construction of the pipeline, borings were taken to evaluate the soil conditions along the ROW. Areas with soils prone to liquefaction (temporary transformation into a fluid mass) or landslides were avoided to the maximum extent possible.

Soil and Permafrost

Soil, as the term is used in this section, consists of the unconsolidated sediment on the surface of the ground. The type and origins of soil can vary greatly from place to place. Soil can have formed from the weathering of underlying rock or can have been deposited by various geologic processes.

Permafrost is ground that has been frozen for two or (often) more consecutive years. The depth, distribution, and characteristics of permafrost can vary greatly with distance and climatic influences.

Permafrost table is the top of the permafrost layer within soil or rock.

Active layer is the layer of soil above the permafrost table that is subject to seasonal freezing and thawing.

Permafrost is encountered extensively along the TAPS ROW (Map 3.2-1). Above the permafrost table, the soil will undergo seasonal freezing and thawing, producing an active layer. The depth of the active layer ranges from 1 ft to about 15 ft, depending on climate, vegetation cover, soil moisture content, slope aspect, depth of snow cover, and other factors (TAPS Owners 2001a). On the basis of its extent, permafrost is classified as continuous (covering from 90% to 100% of an area), discontinuous (50 to 90% coverage), sporadic (10 to 50% coverage), or isolated patches (up to 10% coverage) (Brown et al. 1997). Within each type of permafrost, the presence of frozen ground also depends on the

presence of surface water bodies, disturbance of the ground, and the types of soils beneath the areas. Permafrost can occur in soils as well as bedrock. Generally, the ice content in the soil or bedrock is related to porosity and the moisture content of the material before the geologic material is frozen. Higher ice content occurs in finer grained soil than in coarser grained soil. The latter, in turn, has more ice content than fractured bedrock. Stability of the permafrost can be disrupted naturally (e.g., disturbance of vegetative ground cover by forest fires, drainage of lakes) or artificially. Climate warming can cause the degradation of permafrost (Thomas and Ferrell 1983; Klinger et al. 1983; Lawson 1986).

Evidence shows that regional warming has occurred over the last 25 years in Alaska (Osterkamp et al. 1998) and along the pipeline (see Section 3.12.7). The evidence includes the general retreat of glaciers in Alaska. Near the southern margin of the permafrost (MP 735–736), the permafrost table has lowered because of thawing (Michael Baker, Jr., Inc., 2001). In the southern end of the discontinuous permafrost zone, warming of the permafrost may have contributed to soil creep on slopes on the banks of Squirrel Creek (MP 715–720), Klutina Hill (MP 698), and Tazlina Hill (MP 687) (APSC 2000b). Degradation of permafrost has also been evidenced by continuous soil creep movement at various rates on slopes near Treasure Creek (MP 442) (APSC 2000b).

The degradation of permafrost could impact the integrity of the pipeline. Previously stable slopes on permafrost may become unstable, requiring that corrective maintenance be taken to stabilize the pipeline. Thawing in near-surface permafrost may also create a perched saturated zone over the deepening permafrost table. A thawed, loose granular soil deposit located below a groundwater table may become liquefied when it is subjected to sudden movements such as a strong earthquake. A detailed analysis of liquefaction potential along the TAPS is beyond the scope of this study. In the following paragraphs, the general soils and permafrost conditions along the pipeline are described for the individual physiographic

provinces crossed by the ROW. The soil and the permafrost conditions in the 10 physiographic provinces along the ROW (Map 3.2-1) are described in Section 3.3.1, and the geomorphic processes related to soil and permafrost that may affect the stability of the pipeline are introduced in Section 3.3.2.

3.3.1 Descriptions of Soils and Permafrost Conditions by Physiographic Province

3.3.1.1 Arctic Coastal Plain (MP 0–60)

Typical soil in the Arctic Coastal Plain consists of several feet of ice-rich organic silt over coarse sands and gravels (TAPS Owners 2001a). Massive ground ice is widespread as vertical wedges, films, lenses, pore-fillings and segregated masses. Networks of ice wedges create a polygonal pattern on the ground surface. Along the braided Sagavanirktok River, unvegetated coarse-grained alluvium predominates on the active floodplain (BLM and Alaska Natural History Association 1993). Locally, the channel may be floored with sandy silt that represents former floodplain deposits overlying sand and gravel (Kreig and Reger 1982).

The coastal plain is underlain by thick, continuous permafrost with a temperature less than -7°C (Brown et al. 1997; Ferrians 1965). The permafrost is 670 to 2,150 ft thick (Péwé 1975). Frozen soil rich in ice occurs at a shallow depth. Polygonal ground and oriented lakes formed by the thawing of ice-rich soils characterize the low-lying areas. Beneath active river channels and lakes deeper than 6 ft, shallow thaw bulbs may be present (Kreig and Reger 1982).

3.3.1.2 Arctic Foothills (MP 60–140)

The moraines in the Arctic Foothills are composed of coarse-grained till deposits covered with organic windblown silt. Flat-floored upland depressions are partially filled with ice-rich peat and organic-rich slope wash deposits.

Colluvium may partially fill thaw ponds and basins.

This province is underlain by continuous permafrost with a temperature of less than -7°C (Brown et al. 1997). Massive ground ice, up to 50% by volume (Kreig and Reger 1982), is common in the till. Old till generally contains more massive ground ice than young till. In the floodplain of the Sagavanirktok River, frozen ground occurs in the area away from the active channel, and discontinuously frozen ground is present adjacent to the active channel.

3.3.1.3 Brooks Range (MP 140–237)

Coarse-grained sand and gravel are believed to underlie the Atigun River and Dietrich River valleys that the pipeline traverses in the Brooks Range province. Windblown silt and sand may deposit in part of the Atigun River floodplain (Kreig and Reger 1982). Near the toe of steep slopes where alluvial fans, moraines, and talus are located, unsorted coarse to very coarse sediments are common. In previously glacier-scoured basins (e.g., Galbraith Lake), lacustrine silt and clay may overlie the more coarse-grained glaciofluvial and glacial deposits.

The Brooks Range province is underlain by continuous permafrost that has temperatures of -3° to -7°C . Ground ice content varies from up to 15% in fluvial silt and sand to 25 to 95% in lacustrine silt and clay near Galbraith Lake. In the river valleys, the vegetated areas of moraine, fan, and alluvial deposits are continuously frozen from the ground surface to more than 50 ft deep in the northern Brooks Range (Kreig and Reger 1982). The depth to the permafrost increases with the grain size of the sediment and from north to the south. Permafrost is discontinuous in the alluvium beneath major active streams (Ferrians 1965; Kreig and Reger 1982).

3.3.1.4 Chandalar Ridge and Lowland Section (MP 237–257)

The soils of this section are strongly influenced by the several glacial advances in the area during the Pleistocene (see Table 3.2-2 for

geologic time line). Generally, coarse-grained glacial and glaciofluvial sediments are distributed near the main channels of the Middle Fork Koyukuk and the South Fork Koyukuk Rivers. Away from the channels, the soils consist of fine-grained silt and clay of eolian and lacustrine origin over coarse-grained glacial till (Hamilton 1986).

This section is underlain by discontinuous permafrost with a temperature of -1° to -3°C (Brown et al. 1997). Permafrost is generally absent beneath the floodplains that are not vegetated. However, on old floodplains, permafrost can be 5 to 50 ft thick (Kreig and Reger 1982). Thaw lakes are well developed in the silt of the lowland between the Middle and the South Fork Koyukuk Rivers.

3.3.1.5 Kokrine-Hodzana Highlands and Yukon-Tanana Uplands (MP 257–515)

The soil types on the uplands depend on the distance from the Tanana and Yukon Rivers. In areas far from the rivers, residual soils from weathering bedrock are dominant on hilltops and are generally a few feet thick. Windblown sand and silt there are not significant. In the bottom of the valleys, soils can be more than 40 ft thick. The soils here are a combination of colluvium, fluvial sand and gravel, and weathered bedrock (Kreig and Reger 1982).

Windblown silt is very common on the uplands near the Tanana and the Yukon Rivers. The silt is transported from the floodplains of the rivers and deposited as a mantle over coarser textured subsoil. The thickness of the mantle declines with distance from the rivers and can be several tens of feet thick (Péwé 1975). Colluvium deposits, mostly composed of coarse-grained rock debris, and retransported silt from the hills are transported by mass wasting and become dominant on the lower hillsides away from the river valleys. The colluvium is estimated to be 1 to 18 ft thick. In the lowlands between the hills, silty colluvium from the hills is incorporated with

organic matter (Péwé 1975; Péwé and Reger 1983).

The entire area is underlain by discontinuous permafrost with a temperature of -1° to -3°C (Brown et al. 1997). The depth to the frozen ground in general increases from north to south.

Near the main channels of major streams, frozen ground may be absent (Ferrians 1965). However, older floodplains and river terraces may have permafrost underneath as the permafrost aggrades into new floodplains because of the migration of the rivers. Near the Yukon and the Tanana Rivers, the thick windblown silt on the uplands can contain massive ice as thick as 55 ft (Kreig and Reger 1982). The lowlands between the uplands where retransported silts accumulate may have even thicker ice-rich soils.

In uplands where the windblown silt is thin or absent, the ice content in colluvium or weathered bedrock is substantially less. The soils in valley bottoms among the rounded hills are ice-rich and at a depth from the ground surface to more than 50 ft deep (Kreig and Reger 1982). Thermokarst lakes are common in the valley bottoms.

3.3.1.6 Tanana Lowland (MP 515–560)

Windblown silt and sand dominate the surface material in the area. The silt and sand were derived from the braided floodplains and outwash plains of the major rivers. Coarse-grained sand and gravel are common near the active channel of the main rivers. Coarse-grained glacial till is present below the elevated moraine on the Donnelly Dome (MP 560) (Péwé 1975; Kreig and Reger 1982).

The lowland and the terraces along the Delta River have shallow and discontinuous permafrost with a temperature of -1° to -3°C (Brown et al. 1997). The permafrost can be more than 50 ft thick, but frozen ground is absent under the river. Isolated masses of permafrost are present in areas with coarse-grained deposits (Ferrians 1965; Kreig and Reger 1982).

3.3.1.7 Northern Foothills and Alaska Range (MP 560–610)

Coarse-grained sediment is expected along most of the pipeline. Locally, fine-grained loess (a wind blown silty deposit) may cover some of the outwash deposits in the lowland of the Northern Foothills.

Permafrost is extensive in both the Northern Foothills and the Alaska Range, with a temperature of 0° to -1°C (Brown et al. 1997). Ice-rich permafrost and thermokarst lakes develop in the lowland of the Northern Foothills where loess was deposited. Near the floodplains of the Delta and the Phelan Rivers, however, permafrost is present at much greater depth. Permafrost may be absent on south-facing slopes with coarse-texture soils.

3.3.1.8 Gulkana Upland (MP 610–645)

Coarse-grained gravels are common in the moraines, outwash terraces, and fluvial terraces on the Gulkana Upland. They were deposited by glaciers and glacier-fed streams from the Alaska Range on the north (Ferrians 1965). The coarse sediment may complexly interbed with finer lacustrine and fluvial sediments deposited from previous proglacial lakes and braided outwash streams. Windblown silt and sand may be present on the top of the coarse sediment.

The upland is underlain by discontinuous permafrost with a temperature of 0° to -1°C (Ferrians 1994). The coarse-grained gravel deposits along streams, as well as in areas near large water bodies (e.g., Summit and Paxson Lakes), are free of permafrost (Kreig and Reger 1982). The lowland between the ridges may contain fine-grained sediment and commonly has underlying permafrost, as demonstrated by small thermokarst ponds or lakes. On the uplands where the ice-rich sand and silt are present, thaw lakes may occur.

3.3.1.9 Copper River Lowland (MP 645–720)

Along the pipeline, the greater part of the lowland is primarily underlain by sand, silt, and clay of lacustrine (lake) origin. Near the lowland margin on the south near the Chugach Mountains, coarse-grained gravels become dominant. After ancient Lake Atna drained, permafrost developed into the Copper River Lowland. The fine-grained unconsolidated deposits in the lowland are perennially frozen from a few feet below the ground surface to depths of up to 200 ft (Ferrians 1965). The shallow permafrost creates an impermeable subsoil layer and promotes the formation of saturated soils and ponds in the floor of the lowland. Areas near highways and developed areas have a permafrost table from 10 to 20 ft below the surface (Ferrians 1965).

Along the pipeline, discontinuous permafrost with a temperature of 0° to -1°C (Brown et al. 1997) extends north of the Tazlina River (MP 687). Sporadic permafrost (up to 50% perennially frozen ground) covers an area south of the Tazlina River crossing (MP 687) south to Willow Mountain (MP 710) (Kreig and Reger 1982).

3.3.1.10 Chugach Mountains (MP 720–800)

The majority of the U-shaped valleys traversed by the pipeline are underlain by gravelly sediments. They were deposited by glaciers, glacial-fed streams, and rock slides.

In the north slope of the Chugach Mountains near the Tonsina River valley, patchy permafrost is encountered, with a temperature between 0° and -1°C. Near PS 12 (MP 735–736), where the patchy permafrost zone is about to end, previous permafrost has thawed since the pipeline was constructed. Permafrost is absent south of MP 736 (the Upper Tiekkel River) (TAPS Owners 2001a).

3.3.2 Geomorphic Processes Related to Soils and Permafrost

Because of the wide variety of landforms, geologic material, and climates that occur along the 800-mi pipeline, numerous geomorphic processes can occur. These processes may present challenges and engineering problems in the operation of the TAPS and must be considered from two perspectives: (1) the potential impacts of the geomorphic processes on the integrity of the TAPS; and (2) the environmental impacts of the TAPS on the processes and the environment. Processes working on the TAPS can increase the risk of spill and thus the potential for contamination of the environment. The effects of TAPS on the processes can involve disruption of the stability of the thermal regime of the permafrost, resulting in degradation (melting) or aggradation (propagation) of permafrost that can change the local conditions of hydrology. Increased warming due to climate change (see Section 3.12.7) further complicates the situation. Various geomorphic processes that are related to the operation of the TAPS are described in the following sections.

Geomorphic Processes

Geomorphic processes are processes at the earth's surface that shape the landscape and result in specific deposits. The processes can be physical, chemical, or biological. For example, eolian processes (involving wind action) can produce dunes and loess deposits; glacial processes can result in moraine land forms and till deposits. Mass wasting and glacial action can give rise to particular land forms, like talus slopes.

3.3.2.1 Mass Wasting Processes

Mass wasting is a general term used to describe the geologic processes that are primarily driven by the action of gravity. These processes include avalanches, rock falls, and slides, and slumps on steep slopes, as well as

widespread solifluction in cold regions. Where freezing and thawing of soil moisture are very active processes, frost action can fracture rocks to produce debris. Gravity creates an erosional landform by moving the debris down slope. Depending on the water, ice, and snow content in the loose material and the slope angles, the transport processes may include frost creep, rockfall and slide, solifluction, and slopewash (Davis 2000). These processes produce depositional landforms such as talus at the footslopes or valley bottoms.

The effects of mass wasting can be seen at several locations along the pipeline. Near Atigun Pass (MP 167), several avalanches, rock falls, and ice expansions caused extensive damage to heat pipes (Shannon & Wilson, Inc. 1997). Slow creeps on slopes caused by the degradation of permafrost due to warming climate change and ground surface disturbance pose pipeline stability concerns at the Treasure Creek Hill site (MP 442), PS 11 site (MP 686), Tazlina Hill site (MP 687), and the Squirrel Creek site (MP 717) (APSC 2000b). These areas are under close surveillance and monitoring (see Section 4.1, Existing Mitigation Measures). The remainder of the TAPS route is also being monitored for changes in geotechnical conditions.

3.3.2.2 Permafrost Degradation and Aggradation

Permafrost degradation occurs by progressive warming of soil temperature, melting of near-surface permafrost, and lowering of the permafrost table. Permafrost aggradation is the result of cooling soil temperature and expansion of permafrost. Both degradation and aggradation can be triggered naturally or artificially. Examples of natural causes are disturbance of vegetative cover by forest fires, climate change, migration of drainage channels, and drainage of surface water bodies. Artificial causes include the alteration of surface material by mining and construction, clearing or compaction of vegetative cover, diversion of drainage channels, presence of road dust, and activities that cause heating or cooling of the ground (Thomas and Ferrell 1983; Klinger et al. 1983; Lawson 1986).

Special Terms

Frost creep: Soil movement caused by frost heaving and subsequent settling after thawing.

Frost heave or jacking: Expansion in soil volume due to the formation of ice; generally expressed as an upward movement of the ground surface.

Ice surge: Fast advance of a glacier in response to melting.

Periglacial: Area where geomorphic processes are dominated by frost action.

Proglacial lake: A lake formed by the damming action of moraines in front of a glacier as the glacier melts.

Slopewash: The action of water from rain or melted snow carrying (washing) soil down a slope.

Solifluction: Slow movement of soil caused by a combination of *frost creep* and down-slope movement of wet, unfrozen soil.

Thaw bulb: In permafrost, an area of thawed ground below a building, pipeline, river, or other heat source.

Thermokarst: Pits and depressions in the ground resulting from the thawing of ground ice.

The effects of the degradation and aggradation of permafrost on the TAPS is primarily through heaving, subsidence, or thermokarst, and solifluction of the soil near the pipeline, access roads, workpads, and operational material sites (borrow pits). The magnitude of the effects is closely related to the ground ice content and the nature of the soil. Frost heaving commonly occurs in silty soil and is caused by expansion in soil volume because of the formation of ice in soils and also by drawing water to the freezing front where ice lenses form. Subsidence or thermokarst is caused by the melting of ice within the soil material, causing the ground surface to lower or settle. Subsidence is most pronounced in ice-rich soils, especially those with large bodies of ground ice. This ground ice is formed by the migration of moisture to a freezing surface, creating a mass of ice that forms along the freezing front. With time, ground ice builds up. In general, potential problems of frost heave,

subsidence, thermokarst, and solifluction are greater when the ice content of the soil is greater and when the soil contains more silt and clay particles. Areas of coarse-grained sediment and bedrock are less susceptible.

Frost heave and subsidence, particularly in silty soils, have historically occurred along the ROW. Subsidence is observed at aboveground VSMs (APSC 2001b). If not corrected, it can cause integrity problems when it occurs unevenly (differential settlement). Occasionally, differential settlement is large enough to buckle the pipeline and cause leakage. For example, in 1979, melting of thick ice lenses in weathered bedrock beneath a section of buried pipeline at Atigun Pass (MP 166) caused the loss of pipe support, resulting in a leak of 63,000 gal of crude oil. The oil reached the adjacent Atigun River (TAPS Owners 2001a).

In the same year, the settlement of the pipeline near PS 12 (MP 734) caused by melting of ground ice and subsidence of silty sediment resulted in a leak of 168,000 gal of crude oil. Further investigation in the late 1970s identified eight additional locations where the pipe was approaching buckling curvature (Thomas and Ferrell 1983). In 1985, several feet of vertical settlement of a segment of buried pipeline occurred at MP 200 in the Dietrich River floodplain (TAPS Owners 2001a). Near MP 680 in the Copper River Lowland, horizontal frost heaving creates alignment problems of the pipeline support system (APSC 2000b). The thawed ground at MP 735–736 may create potential for soil liquefaction if a major earthquake occurs near that general area.

Minor ground surface cracking, sinkhole formation, and ponding due to ground subsidence were observed in the late 1970s along several segments of buried pipeline (Thomas and Ferrell 1983). These features are local and have many causes, including lateral growth of thaw bulbs aggravated by groundwater convection below the warm pipeline, poor compaction and thawing of backfill material, and melting of massive ice, such as ice wedges.

Although many of these effects are short term, long-term effects, such as flooding and ponding along workpads and gravel roads, have also occurred in cold regions. For example,

Klinger et al. (1983) reported that elevated gravel roadbeds on the Arctic Coastal Plain promoted the formation of snowbanks. Also, the road dust along heavily used roads hastens snowmelt in the spring. Drainage of meltwater through culverts can be blocked by snowbanks. Shallow permafrost table prevents the meltwater from infiltrating into the subsurface, producing extensive early summer flooding near the roads.

Workpad areas, access-road embankments, and a pipeline that is warmer than the adjacent ground can also promote local degradation of permafrost, increased meltwater, and subsequent ponding. The historical excavation and placement of the buried pipeline and the building of access roads and workpads disturbed the vegetative covers that previously insulated the permafrost. These activities caused the ground to absorb more solar energy, resulting in thawing of near-surface permafrost, increased meltwater, and perching of the meltwater on the lowered permafrost table. In addition, a thaw bulb developed in the permafrost around the warm pipeline. Thawing of the permafrost can induce both subsidence of the ground surface and formation of small ponds in areas that are ice rich. Cases of ponding along workpads can be observed on aerial photographs taken near MP 12 to 18 and MP 500 (APSC 1995b) and as reported in the Environmental Report (TAPS Owners 2001a, Figure 4.3-2).

3.3.3 Existing Contaminated Sites

Soil contamination has occurred during the construction and operation of the TAPS. The contamination has resulted primarily from the release of fuels and crude oil at pump stations and previous constructional camps both along the TAPS right-of-way and at the Valdez Marine Terminal. Additional sites of contamination include locations of road accidents. The causes of the releases on land include traffic accidents, operational errors, corrosion, mechanical failures, and vandalism. The range of releases has been from less than 1 gal to 672,000 gal (TAPS Owners 2001c). It should be noted that cleanup responses immediately after the releases reduce the number of contaminated

sites that require long-term cleanup. Currently, 87 sites have been categorized as contaminated, about 2% of the total number of spills reported since 1977 (OASIS Environmental 2001). Seventy of the 87 sites are along the pipeline; the rest are at the Valdez Marine Terminal (OASIS Environmental 2001). Detailed information on historical volumes of contaminated soils and wastes and their treatment is provided in Appendix C.

Of the 70 contaminated sites along the pipeline, 23 are officially "closed" (no further action required) by the ADEC because they are deemed to pose little to no risk to human health or the environment. Twenty contaminated sites have been proposed for no further remediation, and official closure has been requested. The remaining 27 sites are active sites that are being monitored or remediated (OASIS Environmental 2001) (Table 3.3-1). Of the 17 contaminated sites at the Valdez Marine Terminal, 8 have been closed, 1 is planned for no further remedial action, and 8 are active (Table 3.3-2). The contaminants at the active sites include gasoline, diesel fuel, turbine fuel, therminol (a synthetic heat transfer fluid), and crude oil.

The spill volume for the active sites has ranged from less than 25 to 34,076 gal. The spills span the time from the mid-1970s, when the pipeline was constructed, to August 2001, and most occurred at former construction camps and pump stations. (The most recent spill, the Livengood spill, released approximately 285,600 gal of crude oil near MP 400 on October 4, 2001). One active contaminated site involves mechanical failure of a check valve (Check Valve 92, MP 594).

Generally, the extent of soil contamination in each site is local, at a maximum a few acres. The Livengood Spill at MP 400 resulted (including suprapermfrost groundwater and regular groundwater) in a contaminated area of about 3 acres. However, contaminants have spread to subsurface water in many other sites because of the presence of permafrost and a shallow groundwater table (OASIS Environmental 2001). These sites may need additional cleanup and monitoring. The impact of the groundwater contamination is described in Section 3.8.

TABLE 3.3-1 27 Active Contaminated Sites along the TAPS^a

ID #	Location - Site Name	Year of Spill or Discovery	Type of Spill	Spill Volume (gal)	APSC Relative Priority	Year 2001 Status Comments
6 & 61	PS 6 - Leach Field/Fuel Island and Fueling Area	1992, 1997, 1998	DRO (and gasoline?)	87	High	Possible sources: fuel island, tank farm, generator building, and fueling area spill. Soil-vapor extraction pilot testing performed in 2000; system installation planned for 2001.
15	PS 1 - Former Gas Tank Area	1992	Gasoline	112	High	Gasoline-contaminated soil removed or being remediated in situ. Groundwater monitoring results indicate benzene levels decreasing near gasoline spill.
41	Happy Valley (former construction camp)	1970-1975	Diesel	16,800	High	Cleanup efforts significant in 1970s following spill, and closure status assigned in early 1980s. Site assessment was initiated in 1996 based on possible change in land use. Additional site assessment and remediation may be required.
42	Toolik (former construction camp)	1974, 1975	Diesel	13,500	High	Cleanup efforts significant in 1970s following spill, and closure status assigned in early 1980s. Site assessment was initiated in 1996 based on possible change in land use. The site may be closed after 2001 groundwater and surface water monitoring if contaminant levels continue to exhibit stable or decreasing trend documented since 1997.
4	PS 3 - Fuel Island	1992, 1993	Petroleum hydro-carbons	<25	Medium	Groundwater monitoring conducted from 1994 through 1996. Additional work to be conducted in 2002 if required.
18	PS 10 - Tank 200	1980, 1992	Crude oil	11,555	Medium	Risk reduced because facility on standby, groundwater not used for drinking water. ADEC not requiring new groundwater sampling. Respiration test planned for 2001.
36	PS 1 - Equipment Shop	1994	Petroleum hydro-carbons	<25	Medium	Ongoing ground/surface-water monitoring since 1995. Low risk.
50	Franklin Bluffs (former construction camp)	1975	Diesel	30,000	Medium	Cleanup efforts significant in 1970s following spill, and closure status assigned in early 1980s. Site assessment initiated in 1996 based on possible changes in land use. Additional monitoring planned for 2001. Environmental consultant recommends limited removal of additional contaminated soils in 2001. Closure expected in 2001.

TABLE 3.3-1 (Cont.)

ID #	Location - Site Name	Year of Spill or Discovery	Type of Spill	Spill Volume (gal)	APSC Relative Priority	Year 2001 Status Comments
51	Check Valve 92	1996	Crude oil	34,076 ^b	Medium	Continue groundwater monitoring and product recovery in 2001. APSC will examine alternatives for site closure in 2001.
53	PS 5 - Tank Farm	1998	Therminol	33	Medium	Annual groundwater monitoring conducted 1998-2000. APSC will propose to discontinue monitoring after 2001 if monitoring results show stable or decreasing trend. NFRAP status has been requested from ADEC.
54	PS 9 - Former Mainline Turbine Sump	1996	Diesel	55	Medium	Continue groundwater monitoring and product recovery in 2001.
1	PS 2 - Underground Storage Tank	1990	Petroleum hydro-carbons	<25	Low	Contaminated soil excavated. No groundwater observed during tank excavation. No further work planned. Closure expected in 2001.
7	PS 1 - Therminol	1990	Therminol 44	Not available	Low	Releveling project near Tank 111 resulted in segregation of 10,000 cubic yards of Therminol 44-contaminated soil. Stockpiled soil has been treated; NFRAP will be requested in 2001.
11	PS 12 - Fuel Island Area	1992	Turbine fuel	90	Low	DRO in soil up to 5,000 milligrams/kilogram under liner for turbine fuel offloading area. Requested institutional control (NFRAP).
16	PS 4 - Deadleg Ex.	1984	Crude oil	Not available ^c	Low	Low priority based on limited extent of impact; last ADEC correspondence in 1994.
35	PS 1 - Turbine Fuel Offloading Area	1994	Diesel	<1 ^b	Low	Annual groundwater monitoring performed since 1995. Monitoring planned for 2001 to further document stable plume.
55	Van Horn Facility	1984	Diesel	4,000	Low	Continue groundwater monitoring/product recovery in 2001.
57	PS 2 - Therminol Spill	1998	Therminol	5	Low	Site assessment planned for demobilization in 2002.
58	Galbraith Airport Spill	1999	Diesel	Not available ^c	Low	Site assessment in 2000 to support planned excavation of contaminated soils in 2001.
60	PS 12 - Mainline Turbine Sump	1996	Turbine fuel	30 ^b	Low	Contaminated soils remain under adjacent building. NFRAP will be requested in 2001.

TABLE 3.3-1 (Cont.)

ID #	Location - Site Name	Year of Spill or Discovery	Type of Spill	Spill Volume (gal)	APSC Relative Priority	Year 2001 Status Comments
63	PS 8 - Manifold Bldg.	1996	Diesel	5 ^b	Low	Alternative cleanup levels being developed for closure.
66	PS 3 - Man Camp Generator Release	1998	Diesel	40	Low	NFRAP to be requested due to low risk from remaining contamination. Additional remediation may be required, however.
68	MP 108 Spill	1997	Diesel	56	Low	Closure requested in 1997; requesting closure again because correspondence was misfiled at ADEC.
71	PS 1 - Mainline Turbine Sump	1996	Turbine fuel	<25	Low	Closure requested in 1996; requesting closure again because correspondence was misfiled at ADEC.
77	PS 5 - Vehicle Fuel Dispenser Island	1991	DRO, gasoline	<25	Low	Reviewing 1991 report for status of recommendations.
130	PS 1 - Generator Building	2000	Diesel	25	Low	Assessment planned for 2001 season.
131	Remote Gate Valve 123	2000	Diesel	50	Low	Groundwater monitoring to start in 2001. If monitoring results below maximum contaminant levels for two spring seasons, site will be closed.

^a Notes:

- PS = pump station; DRO = diesel-range organics (mid-range petroleum products such as diesel fuel); ADEC = Alaska Department of Environmental Conservation; NFRAP = no further remedial action planned.
- APSC has managed Dan Creek as a contaminated site, but was not the responsible party. That site is not included in this table.
- For all sites, immediate responses were conducted to stop or contain releases and to remove/recovery product as much as practical (to the agency's satisfaction).
- Institutional controls may include fences, deed restrictions, or other mechanisms typically designed to limit access.

^b From TAPS spills database (TAPS Owners 2001c).

^c Spill or cleanup status descriptors not discernable in the TAPS spills database.

Source: Modified from OASIS Environmental (2001, Table 3-2a).

TABLE 3.3-2 Active Contaminated Sites at the Valdez Marine Terminal

ID#	Location Site Name	Year of Spill or Discovery	Type of Spill	Spill Vol. (gal)	Soil Vol. Treated (yd ³)	APSC Relative Priority	Status Comments
118	Power Vapor	1995	Petroleum condensate	341	<100	High	Initial response included soil excavation, groundwater monitoring, and product removal. Soil vapor extraction initiated in 1999 (ongoing). Site located more than 1/4 mi from marine waters.
95/88/94/101/103	East Tank Farm	1991, 1992	Oily water	~5	5,500 (in situ)	Medium	Remediation included in situ bioventing and groundwater extraction. In 2000, ADEC approved discontinuing operation of three bioventing systems. Groundwater extraction discontinued, groundwater monitoring continues.
107	East Metering Building - Valve L11	1993	Crude oil	3	100	Medium	Weathered crude discovered, excavated to 16 ft. ADEC approved excavation backfilling 9/1/93. Site is monitored, but no further work planned.
114	West Fire Foam Building	1994	Crude oil	84	550	Medium	No groundwater impact documented, some contaminated soil could not be removed. Bioventing to continue in 2001 (spill volume 84 gal).
124	West Tank Farm Catch Basin #2	1997	Crude oil	42 ^a	Not available	Medium	Approximately 42 gal crude recovered initially. Surface water monitoring is ongoing. One in situ bioventing well installed, will be connected to ID#114 bioventing system in 2001.
92	"U" Site ("Q" included)	1987	Oil water	2,940 ^a	Not available	Low	Crude-contaminated soils excavated in 1993. Site is monitored, but no further work since 1993 due to low risk, extensive piping in area (none planned in 2001).
104	Tank 51/52 - Arctic Diesel	1992	Diesel	32.5 ^a	~200	Low	No-further-action status proposed to ADEC on the basis of institutional controls – waiting for ADEC approval.
105	80s Tanks	1994	Crude oil	Not available	Not available	Low	Liner and tank repairs completed. Groundwater diverted to Ballast Water Treatment Plant. Risk reduced, so no further work planned.

^a From TAPS spills database (TAPS Owners 2001c).

Source: Modified from OASIS Environmental (2001, Table 3-4a).

3.4 Seismicity

Earthquakes can pose a major hazard to human beings and man-made structures. Information on faults and historical earthquakes can be used to assess seismic potential. Such assessments then can be used along with information on the types of geologic material on the surface to determine the seismic hazard in a particular area and to design and build structures accordingly.

Another earthquake-related hazard in addition to ground movement that must be considered in coastal areas is seismic sea waves (tsunami). Tsunamis are generated when earthquakes occur under the sea, deforming the nearby sea floor. They propagate across an ocean and can cause substantial damage in coastal areas hundreds, or even thousands, of miles away. When the TAPS was built, the potential threat of tsunami was recognized. The only nearshore facility, the Valdez Marine Terminal, was purposely built on high ground beyond the reach of potential seismic sea waves. Therefore, the threat of tsunami damage to the TAPS is considered insignificant.

The following sections describe the fault systems and seismicity (distribution of earthquake magnitudes and their occurrence in time and space) in areas along the pipeline, the seismic hazards, and the basic assumptions used in the seismic design of the TAPS.

3.4.1 Seismicity and Faults

The northern part of the pipeline from the Arctic Coast to the Brooks Range (MP 0–237) is a region of low seismicity, although numerous faults have been identified in the Brooks Range (Plafker et al. 1994b). From 1880 to 2000, 76 small earthquakes with magnitudes of 4.0 to 5.5 on the Richter scale were recorded (TAPS Owners 2001a; Wesson et al. 1999). Only one with a magnitude as high as 5.5 was recorded. It occurred in the Brooks Range, more than 100 mi from the pipeline (TAPS Owners 2001a). Seismic activity is low between the Brooks Range and Yukon River (MP 237–355).

South of the Yukon River, the pipeline crosses three seismic zones (the Minto Flats,

Seismic Activity

Generally, seismic activities, or earthquakes, are closely related to movements of land along faults or ruptures in the geological material. The faults may be exposed on the ground surface or buried in the subsurface. Long faults are likely to be sites for large earthquakes. Faults that have had more recent movements tend to be more active.

Fairbanks, and Salcha seismic zones) that trend northeast in the Yukon-Tanana Upland (AEIC 2001). Fourteen earthquakes with Richter magnitudes of 5 or greater have been recorded in these zones since 1904. Three had Richter magnitudes of 7.2 to 7.3 and occurred between 1904 and 1937 within 100 mi of what is now the pipeline ROW (AEIC 2001; TAPS Owners 2001a). Prior to November 2002, no rupture was documented on the ground surface from these earthquakes. The November 3, 2002 earthquake is discussed in the text box on the following page.

The most significant fault crossed by the pipeline is the Denali Fault in the Alaska Range at MP 589 (Map 3.4-1). This fault is several hundred miles long, and movement has been recorded in a few segments of the fault (TAPS Owners 2001a; Plafker et al. 1994b). Two other smaller faults, the McGinnis Glacier Fault and Donnelly Dome Fault, are present near the Denali Fault. The Denali, McGinnis, and Donnelly Dome faults are considered active. An earthquake of magnitude of 7.2 was recorded in the Alaska Range in 1912 with an epicenter west of Paxson and about 18.5 mi from the current location of the pipeline (TAPS Owners 2001a; AEIC 2002).

Southern Alaska, especially south of the Chugach Mountains, is a very seismically active area. Most of the earthquakes in this area occur along faults where the Pacific Plate slides and thrusts under the North America Plate (the Alaska-Aleutian megathrust). The famous Great Alaska Earthquake of 1964, which had an epicenter about 40 mi west of what is now the Valdez Marine Terminal, occurred along the Alaska-Aleutian megathrust. The earthquake

November 2002 Earthquake

An earthquake registering 7.9 on the Richter scale occurred at 1:12 p.m. (AST) on November 3, 2002, on the Denali Fault 55 mi west of the pipeline. The TAPS Earthquake Monitoring System (EMS) performed as designed by initiating automatic shutdown of the pipeline, calculating the severity of the event, and identifying locations and features to be evaluated for damage. Pipeline controllers brought the pipeline to a safe shutdown condition an hour later. The pipeline was not breached and no oil was released.

The earthquake damaged eight aboveground vertical support members near MP 589; eight pipeline support shoes separated from the pipe at those locations and five cross beams were damaged (see Figure 4.1-3 for an illustration of a vertical support member). A number of shoes displaced longitudinally, including those at the Denali Fault crossing. Longitudinal movement of the pipe tripped a number of anchor assemblies, which were installed on the pipeline to absorb energy from external initiating events such as this earthquake. Soil cracks were noted along the TAPS ROW and near remote gate valve 91.

On the basis of output from the EMS, a list of approximately 160 items was prepared for inspection and evaluation of the pipeline. These items include detailed inspections of the aboveground and belowground portions of the pipeline, valves, communications equipment, vertical support members, and bridges in this area. The belowground ROW will be inspected for depressions, mounds, or cracks that might indicate pipeline movement, and an internal inspection of the belowground pipe will be performed using a pig (see Section 4.1.3.2.1 for a description of pigs). Following an inspection of critical items and completion of a number of repairs, such as temporary supports for the damaged vertical support members, the flow of oil through TAPS was restarted on November 6. Work on repairing the damaged sections of the pipeline continues and should be completed by early December.

had a moment magnitude (a calculated magnitude based on the actual physical area of a moving fault, the average amount of slip, and the rigidity properties of the rocks that slip) of 9.2 and a magnitude of 8.2 to 8.7 on the Richter scale. The old town of Valdez, which was located on a delta with unconsolidated sediment underneath, was destroyed in the earthquake (Cohen 2000). The Valdez Marine Terminal was built on bedrock on high ground on the south shore of Valdez Arm. Since the TAPS was built, three large earthquakes with moment magnitudes of 7.5 (1979), 7.8 (1988), and 7.9 (1987) have been recorded in southern Alaska (AEIC 2001). All were more than 190 mi east or southeast of Valdez, and no damage occurred to the TAPS.

3.4.2 Seismic Hazards, Designed Seismic Zones, and Ground Motions

A seismic hazard can be evaluated to estimate the probabilities that various levels of earthquake ground motion will be exceeded at a site in a period of time. Basically, the evaluation

Richter Scale and Moment Magnitude Scale

The magnitude of an earthquake is a measure of the energy released during the event. It is measured on the Richter scale, which runs from 0.0 upwards, with the largest earthquakes recorded having a magnitude of 8.6. The Richter scale is logarithmic, so a quake of magnitude 5.0 is 10 times more destructive than a quake of magnitude 4.0. Earthquakes greater than magnitude 6.0 can be regarded as significant, with the likelihood of damage to nearby structures not designed to withstand such forces and loss of life (Press and Siever 1982).

Scientists and seismologists prefer to use the "moment magnitude scale," which is a measure of total energy released by an earthquake. The moment scale is more precise.

uses three inputs: the seismic source, seismicity, and a ground motion attenuation function (a function of earthquake magnitude and distance). The results of the evaluation can be

TABLE 3.4-1 Seismic Design Zones for Design Contingency Earthquake

Zone	Pipeline Milepost	Richter Magnitude
A	0 – 258	5.5
B	258 – 560	7.5
C	560 – 620	8.0
D	620 – 710	7.0
E	710 – Valdez	8.5

Source: APSC (2001e)

used to compare ground motions (primarily the acceleration) used in the TAPS design.

Two levels of earthquake hazards were considered in designing the TAPS — the design contingency earthquake and design operating earthquake (APSC 2001e). The design contingency earthquake is a rare, intense earthquake with an estimated occurrence frequency (return period) of 500 years or more (Nyman 1995). In design concept, a design contingency earthquake could possibly lead to some damage of the TAPS and require repair. However, the design of TAPS was intended to ensure that no structural collapse or release of oil or hazardous substances would be likely. The functionality of essential control, communications, and emergency systems should be maintained without interruption. The design operating earthquake is a lower intensity earthquake with ground motion amplitudes about one-half of those associated with the design contingency earthquake. A design operating earthquake or smaller earthquake would not cause significant deformation of the TAPS or interrupt its operation (TAPS Owners 2001a).

In the design of the TAPS, the 800-mi route was divided into five seismic zones on the basis of the expected Richter magnitude of a design contingency earthquake in that zone (Table 3.4-1). The division was based on the findings of a USGS study (APSC 2001e). The design seismic motions were developed for a design contingency earthquake on the basis of both damage assessments and observed ground

Plate Tectonics

The crust of the earth is composed of a small number of plates that independently float on the more fluid underlying mantle of the earth. The edges of these plates can rub together as they slide in opposite directions, or they can even overlap, with the edge of one plate thrusting over or under the edge of another, in areas where two or more plates converge. Such movement is generally extremely slow, averaging a few centimeters a year. These areas of contact are often locations of considerable seismic activity.

motions of major earthquakes around the world (including the 1964 Great Alaska Earthquake) (Table 3.4-2). The values in the table represent effective peak values (or design ground acceleration values that represent the means of peak values). It should be noted that absolute peak acceleration that is from a field measurement could be two or more times the design ground acceleration. The design ground values are used for evaluating landslides, rock falls, mudflows, and other types of mass movements that might cause damage to the pipeline (APSC 2001e). Because of the interaction of the soils and structures and the amount of ductility and energy dissipation in the structures, the design ground values are further reduced by a factor of approximately two when they are used to develop design response spectra for structural design (APSC 2001e).

In the late 1990s, the USGS (Wesson et al. 1999) conducted a seismic hazard analysis for Alaska. The seismic sources used in the analysis included (1) those explicitly identified, such as the Alaska-Aleutian megathrust and active faults (e.g., the Denali Fault) with known slip rates, (2) shallow earthquakes from sources not included above, and (3) deeper earthquakes.

The results of the analysis of the peak ground acceleration (in %g) with a 2% probability of exceedance in 50 years (which corresponds to a recurrence interval of 2,500 years, resulting in a much more conservative estimate than the recurrence interval of 500-1,000 years used for the TAPS) are presented in Table 3.4-3 and Map 3.4-2. The values of the peak ground

TABLE 3.4-2 Design Ground Motions for Design Contingency Earthquake

Richter Magnitude	Zone	Acceleration (g)	Velocity (in./s)	Displacement (in.)
8.5	E	0.6	29	22
8.0	C	0.6	29	22
7.5	B	0.45	22	16
7.0	D	0.3	14	11
5.5	A	0.12	6	4.5

Source: APSC (2001e)

TABLE 3.4-3 Peak Ground Acceleration and the Design Ground Acceleration for a Design Contingency Earthquake

Milepost	Seismic Zone	Peak Ground Acceleration (g)	Design Ground Acceleration for DCE (g)	Maximum Ratio between Peak and Design Ground Acceleration
0 - 258	A	0.08 – 0.23	0.12	1.9
258 - 560	B	0.23 – 0.4	0.45	0.67
560 - 620	C	0.3 – 1.2	0.6	2.0
620 - 710	D	0.18 – 0.3	0.3	1.0
710 - Valdez	E	0.3 – 0.6	0.6	1.0

Sources: APSC (2001e); Wesson et al. (1999).

acceleration along the TAPS ranges from 0.08 g (8% g) to 0.9 g (90% g). The highest peak ground accelerations are in the Alaska Range (Seismic Zone C, 0.3 to 0.9 g) and the Chugach Mountains (Seismic Zone E, 0.4 to 0.6 g) (Wesson et al. 1999). The ratio between the upper bound of the peak ground acceleration and the design ground acceleration ranges from 0.67 to 1.9 (Table 3.4-3), which is equal to or less than 2, and is consistent with the claim used in the design (APSC 2001e). The originally specified TAPS seismic design criteria met the seismic zoning criteria proposed by the USGS (Wesson et al. 1999).

In addition to consideration of the dynamic loading produced by the design contingency earthquake as indicated in Table 3.4-2, the TAPS was designed to accommodate permanent ground deformation related to liquefaction, slope

movements, or surface-fault offsets that might be triggered by earthquakes.

For belowground segments of pipeline, areas that have potential slope instabilities or liquefaction-susceptible soils were identified, and the pipeline was routed to avoid those potential hazards to the extent possible. The pipe was designed so that if liquefaction did occur and the extent of the area was small or extremely large, the pipeline would bridge the small liquefaction area to conform to large deflections without unreasonable, large strains (APSC 2001e). However, locally overstressed conditions might develop along the pipeline if the extent of the liquefaction area was intermediate. The pipeline would also become vulnerable if a landslide occurred on a cross slope, resulting in the pipe's being carried down the slope with the slide (APSC 2001e). On the basis of available

geotechnical data and ongoing surveillance and monitoring programs, APSC is unaware of any field geotechnical conditions that could potentially lead to earthquake-induced ground failure of sufficient severity to cause pipeline failure.

A strong earthquake can rupture the ground surface in addition to causing movements along a surface fault, producing a large displacement near the surface. At any arbitrary location, the belowground pipeline is designed to survive an offset of a 2-ft horizontal displacement with a two 2-ft vertical displacement (APSC 2001e). In crossing the three active faults, the pipeline was designed to be aboveground so it can glide on long supported beams to accommodate large offsets across the active faults. The design movements for the active faults for the aboveground pipeline are shown in Table 3.4-4.

In the 1964 Great Alaska Earthquake (which occurred before the TAPS was built), ground cracks and landslides were observed in the Copper River Lowlands and the Chugach

Mountains (Ferrians 1966). The majority of ground cracks occurred in coarse-grained unconsolidated deposits in proximity of steep slopes, along shores of lakes, or in areas cleared of vegetation for several years within a radius of 100 mi from the earthquake epicenter. These areas are characterized as follows: (1) permafrost was absent or deep lying, (2) the groundwater table was near the surface, (3) slopes were steep, and/or (4) bedrock was relatively deep lying. Besides the ground cracks, a few earthquake-triggered landslides, rockslides, and avalanches were also recorded, especially in the Chugach Mountains (Ferrians 1966).

An example of a landslide site is near mile 65 of the Richardson Highway (near the current TAPS PS 12) by the Little Tonsina River. At this location, a slide occurred by a small hill underlain by unconsolidated silt, sand, and gravel deposits. Ground cracks with a maximum width of 3 ft and a depth of about 5 ft and pressure ridges appeared near the toe of the landslide (Ferrians 1966).

TABLE 3.4-4 Engineering Design Criteria of Pipeline for Ground Movement for Active Fault Zone Crossings

Active Fault	Horizontal Movement (ft)	Vertical Movement (ft)
Denali	20	7
McGinnis Glacier	8	6
Donnelly Dome	3	10

Source: APSC (2001e).

3.5 Sand, Gravel, and Quarry Resources

Deposits of sands, gravels, and quarry stones are abundant along the TAPS ROW. Because of previous glacier advances and the mechanical breakdown of bedrock under periglacial conditions, sands and gravels are plentiful in glacial till deposits and in floodplains along river valleys, especially near the three mountain ranges crossed by the pipeline. In areas on the Kokrine-Hodzana Highlands and the Yukon-Tanana Uplands where the windblown silt is thin, bedrock is easily available in hills for mining of quarry stones. Sands and gravels are abundant in the glaciated Brooks Range, Alaska Range, and Chugach Mountains and are good sources of construction material for the TAPS.

Sands, gravels, and quarry stones have been mined for TAPS construction, regular operation, and maintenance of workpads, road beds and surface materials, flood damage control, and river embankments. Currently, APSC has contracts to purchase granular materials from 69 borrow sites (or operational material sites, OMSs) (TAPS Owners 2001a). All of these sites are on public lands. The sites include bedrock quarries and sand and gravel pits on floodplains, alluvial fans, outwash fans, and glacial moraines. Most of the sites are jointly used with the State of Alaska (Table 3.5-1).

The OMSs range in size from 4 to 80 acres and are scattered along the TAPS ROW; they are located from a quarter mile to a few miles from the ROW. Half of the OMSs are stone

quarries and half are sand and gravel pits. Most of the bedrock quarries are located on the Kokrine-Hodzana Highlands and the Yukon-Tanana Uplands. The majority of the sand and gravel pits are on the floodplains of major rivers. From 1995 to 1999, the annual use of borrow material from the 69 sites ranged from about 30,000 to 97,000 yd³ (TAPS Owners 2001a).

Because the borrow sites are a quarter mile or more from the TAPS, the impacts of their use do not extend to the TAPS itself. In the bedrock quarries, geologic materials are removed to produce riprap, leaving locally visible scars on newly exposed bedrock outcrops.

Historically, the impacts of the sand and gravel mining on the environment varied. For sites located on braided river floodplains or alluvial fans, permafrost was absent and the drainage channels shifted regularly. The sediment load in the rivers may have temporarily increased because of the mining operations. However, the time needed to reestablish equilibrium conditions in the environment was short.

For sites located on stabilized floodplains or river terraces, sand and gravel mining operations disturbed vegetative cover and, in some instances, the underlying permafrost. The resulting impacts included removal of the sand and gravel resources, and increased soil erosion and siltation temporarily.

TABLE 3.5-1 Active TAPS Operations Material Sites (OMSs) on Public Lands

OMS No.	Pipeline MP	Land Owner ^a	Joint Use ^b	Material Type	Volume Extracted (yd ³)	Remaining Estimated Yield (yd ³)	Work Area (acres)
3-1.1	787	S		Sand/Gravel	200,000	70,000	8
3-2	785	S	Yes	Sand/Gravel	143,000	190,000	55
5-2	779	S		Gravel	212,000	90,000	25
7-1M	769	S	Yes	Sand/Gravel	112,000	70,000	31
7-2M	768	S		Bedrock	85,000	40,000	11
9-4R	753	F		Sand/Gravel	230,000	100,000	9
13-3.1	732	F		Sand/Gravel	270,000	1,230,000	80
14-0	724	F	Yes	Bedrock	13,000	100,000	13
27-3N	647	F	Yes	Gravel/Bedrock	392,000	172,000	21
28-1R	642	F		Sand/Gravel	105,000	250,000	13
30-0	633	F		Gravel/Sand	25,000	344,000	13
30-2R	630	F		Gravel/Sand	54,000	150,000	14
32-0.0	623	F		Bedrock	300,000	100,000	37
35-1.2	604	S	Yes	Sand/Gravel	100,000	50,000	12
37-0R	595	F		Bedrock	455,000	800,000	41
38-1R	586	F		Sand/Gravel	33,000	54,000	9
39-1.1	580	F	Yes	Bedrock	106,000	180,000	13
39-4	575	F		Gravel	160,000	165,000	10
41-1R	569	S		Sand/Gravel	150,000	200,000	28
44-1R	553	F		Gravel/Sand	185,000	200,000	4
49-3	520	S		Sand/Gravel	220,000	230,000	14
53-2	498	S		Gravel	35,000	200,000	13
55-1	489	FNSB		Gravel/Sand	NA	NA	NA
56-3	480	F		Gravel	NA	NA	NA
63-1	440	S		Bedrock	95,000	140,000	13
63-4	463	S		Bedrock	138,000	100,000	9.5
64-2	433	F	Yes	Bedrock	110,000	50,000	10
65-1M	426	S		Bedrock	125,000	200,000	23
66-1R	419	S		Gravel/Bedrock	130,000	230,000	17
67-1	413	S		Bedrock	50,000	200,000	8.5
68-1	409	S		Bedrock	200,000	100,000	15
68-4	406	S		Bedrock	100,000	174,000	10
69-1R	403	S		Bedrock	95,000	155,000	5
70-0.0	397	S	Yes	Bedrock	42,661	157,339	30
71-0	393	S		Bedrock	133,000	75,000	11
71-1HR	390	S	Yes	Bedrock	231,000	150,000	34
72-1	384	S		Bedrock	69,483	143,517	5
73-1R	381	S		Bedrock	80,000	80,000	11
74-2HR	375	S	Yes	Bedrock	120,000	100,000	46

TABLE 3.5-1 (Cont.)

OMS No.	Pipeline MP	Land Owner ^a	Joint Use ^b	Material Type	Volume Extracted (yd ³)	Remaining Estimated Yield (yd ³)	Work Area (acres)
75-1R	369	S	Yes	Bedrock	80,000	1,300,000	37
76-2.1	361	S		Bedrock	246,000	373,000	13
78-1	349	F	Yes	Bedrock	720,000	600,000	17
79-2	344	F	Yes	Bedrock	232,000	100,000	34
82-0	330	F		Gravel/Sand	310,000	350,000	20
83-1	322	F	Yes	Bedrock	476,000	70,000	23
83-2	320	F	Yes	Bedrock	476,000	100,000	45
86-2	304	F	Yes	Bedrock	600,000	330,000	60
88-3	293	F	Yes	Bedrock	352,000	110,000	33
89-3	285	F	Yes	Silt/Gravel	344,000	150,000	22
91-3.1A	274	F	Yes	Bedrock	300,000	30,000	15
92-3.1	267	F	Yes	Sand/Gravel	400,000	300,000	40
94-0	259	F	Yes	Gravel/Sand	100,000	50,000	7.5
95-1	255	F	Yes	Bedrock	466,000	144,000	13
95-2	253	F	Yes	Sand/Gravel	140,000	75,000	13
96-1	252	F	Yes	Sand/Gravel	138,000	150,000	33
97-2	244	F	Yes	Sand/Gravel	98,890	60,000	11
98-3.1	235	S	Yes	Gravel/Sand	700,000	500,000	40
100-1.2	226	F	Yes	Gravel/Sand	360,000	370,000	14
100-2.1	227	F	Yes	Bedrock	80,000	200,000	24
102-1	215	F	Yes	Gravel	500,000	300,000	49
105-1	199	F		Sand/Gravel	416,000	64,000	26
106-1	192	F		Gravel	290,000	400,000	29
106-1.1	190	F	Yes	Bedrock	192,000	200,000	7
111-2	160	F	Yes	Gravel	600,000	100,000	62
112-3.1	152	F	Yes	Bedrock	108,000	300,000	14
114A-2	138	F	Yes	Gravel/Sand	200,000	60,000	25
117-2BD	125	F	Yes	Bedrock	600,000	450,000	42
119-4	111	S	Yes	Gravel	400,000	500,000	30
133-2A	26	S		Peat/Silt	125,000	400,000	18

^a Landowner abbreviations: F = federal, S = state, FNSB = Fairbanks North Star Borough.

^b Jointly used by APSC and Alaska Department of Transportation and Public Facilities.

Source: TAPS Owners (2001a, Table C-1).

3.6 Paleontology

Paleontological resources are any physical evidence of past life, including fossilized remains, imprints, and traces of plants and animals. Fossilized plants of marine and terrestrial origin, as well as invertebrate and vertebrate animal remains, have been found along the length of the TAPS ROW. These fossils document nonhuman life in Alaska during the last 570 million years.

As nonrenewable resources, no matter how common or rare they may be, fossils of scientific value are protected by the Antiquities Act of 1906. Fossils on federal lands are protected by the Federal Land Policy and Management Act of 1976. Two other federal laws, the Archaeological Resources Protection Act of 1979 and the Federal Cave Resources Protection Act of 1988, protect fossils in archaeological context and fossils from significant caves, respectively. Paleontological resources are protected in Alaska under the state's Alaska Historic Preservation Act.

The underlying bedrock along the TAPS ROW consists of igneous, metamorphic, and sedimentary rocks of varying age and depth. The sedimentary rocks often contain fossil-bearing strata. Along the ROW, these sedimentary rocks usually are overlain by fossil-bearing, unconsolidated glacial, fluvial, and eolian deposits (see Section 3.2).

Fossils can occur throughout the state and range from single-celled organisms to large vertebrates — the latter including Mesozoic dinosaurs and Pleistocene mammoths. (See text box; a broader coverage of geologic time periods is provided in Table 3.2-2.) The amount of paleontological evidence in Alaska varies, and with respect to the TAPS can be characterized broadly by location (see Map 3.6-1, Alaska chronology by area). The North Slope is particularly rich in paleontological remains. The oldest fossil from that area is a tooth plate from a vertebrate fish found in a Middle Devonian rock formation from 380 million years ago (Lindsey 1986). Post-Devonian sedimentation on the North Slope has, in some cases, developed up to 20,000 ft of fossil-bearing strata. Fossils of marine invertebrates include bryozoans,

Epochs of the Quaternary Period

The Quaternary Period (1.8 million years ago [MYA] to present) can be subdivided into two epochs: the Pleistocene and the Holocene.

The Pleistocene (1.8 MYA to 11,000 YA) is characterized by alternating advances and recessions of moraine ice sheets (glaciers) in North America, southern Europe, and northern Asia. Large mammals roamed unglaciated forests and plains. Modern humans developed during this epoch.

During the Holocene (11,000 YA to present), the large ice sheets have retreated. Landforms, vegetation, and fauna have developed into what is seen today.

brachiopods, pelecypods, gastropods, ostracods, cephalopods (e.g. belemnites, ammonites), crinoids, trilobites, belemnites, ammonites, and coral (see Table 3.6.1). Marine plants also occur in these sedimentary rocks. By the Middle Jurassic and continuing into the Cretaceous (c. 160 million years ago), wood and nonmarine plants appear in the North Slope fossil assemblages, indicating episodic retreats and advances of the sea. Twelve types of dinosaurs, from Late Cretaceous beds (c. 72–68 million years ago), have been found on the North Slope (BLM 2001b). Although the TAPS parallels Late Cretaceous sandstones for approximately 11 mi (MP 57–68), no dinosaur fossils have been found near the ROW. Fewer invertebrate fossils occur in Tertiary beds along the Arctic Coastal Plain. The post-Eocene fossil record on the North Slope does not resume until the Pliocene and Pleistocene (see text box, next page). Marine and terrestrial mammals (such as otter, seal, whale, mammoth, moose, caribou, musk ox, bison, antelope, camel, horse, lion) and birds have been found in Quaternary glacial deposits along the Colville River, approximately 90 mi west of the TAPS ROW. Possibly because of the effects of later glacial activity, no Pleistocene faunal remains have been discovered in the part of the North Slope

Epochs of the Tertiary Period

The Tertiary Period (65–1.8 MYA) can be subdivided into five epochs: the Paleocene (65–54 MYA), the Eocene (54–38 MYA), the Oligocene (38–23 MYA), the Miocene (23–5 MYA), and the Pliocene (5–1.8 MYA).

Mammals became the dominant land vertebrates during the Eocene. By the Pliocene, distinctly modern flora and fauna appeared.

occupied by the TAPS (Lindsey 1986; Péwé 1975; Guthrie and Stoker 1990).

The TAPS ROW crosses three mountain ranges: the Brooks Range, Alaska Range, and Chugach Mountains. These mountains are composed of sedimentary rocks, interspersed with metamorphic and igneous strata. Upthrusts and faulting have exposed fossil-bearing strata at ground surface. In areas where it is buried, the pipeline lies in weathered bedrock and in glacial, colluvial, alluvial, lacustrine, and aeolian deposits across these ranges. Concentrations of invertebrate fossils from sedimentary and metamorphic rocks are found along mountainous stretches and paralleling the TAPS ROW.

Three of the physiographic units that the TAPS ROW crosses are associated with major river drainages: the South Fork Koyukuk, Yukon, and Tanana in the Yukon-Tanana Uplands; the Tanana River Valley; and the Gulkana and Copper Rivers in the Copper River Basin. The pipeline also crosses numerous smaller rivers and creeks in these units. The underlying bedrock associated with these river units is usually metamorphic, with sedimentary and igneous episodes. The bedrock often is deeply buried by Quaternary glacial, glaciofluvial, outwash, lacustrine, alluvial, and eolian deposits derived from flanking mountainous zones (Péwé 1975; Hamilton and Ashley 1993). Fossils of many mammals (such as mammoth, mastodon, antelope, musk ox, elk, moose, saber-toothed cats, voles) have been found in frozen silts and organic deposits, primarily Wisconsinan in age (75,000–10,000 years ago). Approximately one-third of these mammals are now extinct (Foster et al. 1994). Invertebrate fossils (pelecypods, gastropods, and insects) also occur in Quaternary deposits in these valleys (Péwé 1975).

Data on paleontological sites in Alaska are maintained by the State Historic Preservation Office and by the Department of Paleontology at the University of Alaska-Fairbanks. Table 3.6-2 lists how many known paleontological resources have been recorded in the vicinity of the ROW.

TABLE 3.6-1 Marine Invertebrate Fossils

Fossil	Description
Brachiopods	Asymmetrical bivalves (Cambrian to Recent)
Bryozoans	Aquatic, colonial animal with moss-like or branching growths (Ordovician to Recent)
Cephalopods	Class of mollusk with internal or external shell and tentacles, such as ammonites, belemnites (Mid-Cambrian to Recent)
Coral	Aquatic solitary or colonial coelenterates. Bodies have a two-layered wall and a single opening for ingestion and excretion (Pre-Cambrian to recent)
Crinoid	Echinoderm with long, segmented anchoring stalk surmounted by a cup with attached, radiating, feathery arms (Ordovician to Recent)
Gastropods	Mollusk with a single, usually coiled, shell (Cambrian to Recent)
Ostracod	Small crustacean with bivalved carapace (Cambrian to Recent)
Pelecypod	Bivalved mollusk, such as oysters, clams, mussels (Ordovician to Recent)
Trilobite	Marine arthropod with three major divisions of the body and a three-lobed, segmented thorax (Cambrian to Permian)

TABLE 3.6-2 Paleontological Sites near the TAPS ROW

Proximity to TAPS ^a	North Slope	Brooks Range	Yukon-Tanana Uplands	Tanana River Valley	Alaska Range	Copper River Basin	Chugach Mountains
Within 1/4 mi of the TAPS							
Vertebrates	0	0	3	0	0	0	0
Invertebrates	1	6	0	0	1	0	0
Plants	0	0	0	0	0	0	0
Within 1/2 mi of TAPS							
Vertebrates	0	0	3	0	0	0	0
Invertebrates	4	11	5	0	8	0	0
Plants	1	0	1	0	0	0	0

^a See Map 3.6-1.

3.7 Surface Water Resources

The 800-mi long pipeline crosses 80 major rivers and approximately 800 smaller streams (TAPS Owners 2001a). These surface water bodies range in size from the Yukon River (typically 1,900 ft wide at the pipeline crossing [APSC 2001a] with an average maximum flow of 476,000 cubic feet per second [ft^3/s] at Stevens Village) to creeks only a few feet wide. The primary river and creek types crossed by the pipeline include braided channels, split channels, single channels, and alluvial fans.

In addition to the river crossings, the pipeline is often located within or parallel to the active channels or floodplains of the Sagavanirktok, Atigun, Chandalar, Dietrich, Middle Fork Koyukuk, and Delta Rivers and Phelan Creek (TAPS Owners 2001a). Hydrological characteristics of the streams crossed by the ROW are varied, and stream flows vary considerably with the time of year (TAPS Owners 2001a). Water velocities in the rivers and streams vary considerably from each other and vary within themselves according to season. Velocities, in general, range from 0.0 to 10 ft/s, with zero to low velocities occurring during the winter when significant portions of the rivers are frozen (APSC 2001g).

Surface water along the TAPS ROW can be affected by the following:

- Sanitary wastewater discharges,
- Water from hydrostatic testing of the pipeline,
- Water from dewatering construction and maintenance sites,
- Water from draining secondary containment structures, and
- Rainwater or snowmelt runoff.

Surface water is used along the ROW and at the Valdez Marine Terminal for many purposes, including fresh water for potable purposes at manned facilities, equipment washing, tank cleaning, dust abatement on roads and workpads, and hydrostatic testing.

River and Stream Types

Braided channels: Wide, steep, high-bedload, multichannel systems such as the Sagavanirktok, Delta, and Dietrich Rivers, and Phelan Creek.

Split channels: Rivers with more than one main channel, such as the lower parts of the Middle Fork Koyukuk.

Single channels with floodplains: Rivers or streams that exhibit one primary channel, such as the South Fork Koyukuk, Chena, and Salcha Rivers and Moose Creek, or deeply incised channels with no floodplains, such as Sulphide Gulch.

Alluvial fans: The majority of creeks that flow into the Delta River in the vicinity of PS 10, and Sheep, Brown, and unnamed creeks flowing into the Lowe River.

3.7.1 Hydrological Regions

Five hydrological regions have been used by APSC to characterize naturally occurring surface flows along the ROW: North of the Brooks Range, South of the Brooks Range, Interior, Alaska Range, and Glennallen to Valdez (TAPS Owners 2001a) (Map 3.7-1).

3.7.1.1 North of the Brooks Range

The North of the Brooks Range Hydrological Region extends from MP 0 to about MP 166 (Continental Divide). This region is located within the Arctic Slope Drainage that extends from MP 0 to 170 (TAPS Owners 2001a). Important rivers in this region are the Sagavanirktok, Kuparuk, and Atigun. The dominant drainage in this region is the Sagavanirktok River, which flows north to the Beaufort Sea. The Sagavanirktok River and smaller channels are classified as anadromous fish habitat and are an important component of the coastal zone management plan. Peak flows in these rivers are highly variable and are driven

by a combination of weather conditions (including the history of precipitation and time of year).

Peak flows in the Brooks Range are the result of heavy rains in July and August. Flows increase and decrease rapidly in response to the rainfall events because the characteristics of the Brooks Range and the permafrost conditions of the slope result in little capacity for storing precipitation. Winter flows in these rivers are small to nonexistent. Low flows during the winter in the Sagavanirktok River lead to extensive accumulations of groundfast ice (aufeis). Aufeis is a seasonal accumulation of ice that is superimposed on the frozen surface of a stream or landscape (Slaughter 1990). Aufeis accumulations constitute a major management problem for roadways, culverts, and structures that are located in areas subject to ice accumulation. Breakup flows (river flows during ice breakup in the spring) over the aufeis generally produce maximum water levels in the rivers.

Between MP 20 and 54, the buried pipeline crosses more than 36,900 ft of Sagavanirktok floodplain and crosses the Sagavanirktok River four times. In this region, the Sagavanirktok River floodplain is more than 4 mi wide and is a highly braided system with multiple channels. Such braided systems tend to develop where flood discharges are high and fluctuate rapidly, where sediment transport rates along the stream bed are high, where the channel gradient is steep, and where the stream banks are formed in weak noncohesive sand and gravel (Dunne and Leopold 1978). In general, channel patterns of such systems are controlled predominantly by sediment supply conditions (Thorne et al. 1987) and are active, high-energy sediment transport systems that frequently re-form and destroy sedimentary structures (Richards 1982). Changes in these types of systems are difficult to predict and exhibit random variability.

3.7.1.2 South Side of the Brooks Range

The South Side of the Brooks Range Hydrological Region extends from the Continental Divide (MP 166) to about MP 265. This region is part of the Yukon Drainage that

extends from MP 170 to 605 (TAPS Owners 2001a). Principal rivers within this region are the Dietrich, Bettles, Middle Fork Koyukuk, Hammond, and the South Fork Koyukuk. The principal rivers flow into the Koyukuk River, a major tributary of the Yukon River. The Yukon River discharges to the Bering Sea. Flows within the Dietrich River are classified as critically sensitive for fish populations year-round; its tributaries are sensitive habitats during May to October (TAPS Owners 2001a). The Dietrich River and its tributaries do not support anadromous fish, but the Dietrich River is a tributary of the Middle Fork of the Koyukuk River, which does support anadromous fish. The Hammond River is also classified as anadromous. It flows through the eastern wilderness section of Gates of the Arctic National Park and Preserve and joins with the Middle Fork Koyukuk River at about MP 222.

Maximum flows are usually triggered by intense rainfall, similar to maximum river flows on the north side of the Brooks Range. Between MP 208 and 213, the aboveground pipeline crosses more than 18,000 ft of the Middle Fork Koyukuk floodplain; between MP 200 and 201, the aboveground pipeline crosses about 5,800 ft of Dietrich River floodplain.

3.7.1.3 Interior

The Interior Hydrologic Region extends from MP 265 to Donnelly Dome (MP 560). This region is also part of the Yukon Drainage (TAPS Owners 2001a). Important surface water features within this region include the Jim River, Bonanza Creek, Kanuti River, Ray River, Yukon River, Hess Creek, Tolovana River, Chatanika River, Chena River, Little Salcha River, Salcha River, Redmond Creek, Shaw Creek, Tanana River, and Delta River. Principal rivers in the Interior Region flow into the Yukon River, which discharges into the Bering Sea. The Jim and Yukon Rivers are classified as critically sensitive all year for fish species. The Tolovana River (MP 399) supports anadromous fish about 25 mi downstream of the TAPS. The following streams and creeks are major anadromous water bodies in this region: Yukon River (MP 352), Chatanika River (MP 438), Chena River (MP 460), Little Salcha River (MP 491), Salcha River (MP 496), Redmond Creek (MP 500), Shaw Creek

(MP 520), and Tanana River (MP 531). The Delta River supports anadromous fish near its confluence with the Tanana River (MP 531). Other nonanadromous streams and segments are sensitive from April through October.

The Yukon River is the largest river in Alaska and carries a substantial load of suspended glacial sediment during the spring. The Tanana River is an extensively braided river that flows to the west and north to the Yukon River after joining the Delta River near the former Delta Campsite at MP 531. Flows within the Interior Hydrological Region are highly variable and depend largely on the watershed and its runoff characteristics. Along the Jim River from MP 271 to 272, the pipeline parallels the riverbed and crosses more than 7,000 ft of Jim River floodplain. Both elevated and buried crossings occur here.

3.7.1.4 Alaska Range

The Alaska Range Hydrologic Region extends from Donnelly Pass (MP 560) to Isabel Pass (MP 610). This region is located within the Yukon Drainage (TAPS Owners 2001a). The Delta River (Wild and Scenic River designation) and Phelan Creek are the principal surface water bodies of this region. The pipeline is also in a National Conservation Area (OASIS Environmental 2001). Streams in the Alaska Range Region flow into the Tanana River, a major tributary of the Yukon River, which discharges into the Bering Sea. No anadromous fish streams are found between the Tanana River (MP 531) and Sable Pass (MP 605) (TAPS Owners 2001a). The Delta River and Phelan Creek are considered to be critically sensitive for fish species during spring and fall.

Rivers in the Alaska Range Region are characterized by low winter flows and significant aufeis development in their wide, braided systems. Near the confluence of Phelan Creek and the Delta River (MP 594), the braided systems have a width of almost 1 mi. Between MP 584 and 585, the underground pipeline crosses 3,735 ft of Delta River floodplain.

3.7.1.5 Glennallen to Valdez

The Glennallen to Valdez Hydrologic Region extends from Isabell Pass (MP 610) to the end of the pipeline at Valdez (MP 800). This region is within the Copper River Drainage (MP 606–800) (TAPS Owners 2001a). Important surface waters within this region include Summit, Mud, Willow, Pippin, Paxson, and Meier's Lakes; the Gulkana (Wild and Scenic River designation), Copper, Tazlina, Klutina, Tonsina, Little Tonsina, Tsina, and Lowe Rivers; and Sheep, Brown, and Allison Creeks. These water bodies eventually discharge into Prince William Sound. The Copper, Gulkana, Tazlina, Tonsina, Little Tonsina, Lowe, and Klutina Rivers and Allison Creek are classified as anadromous (TAPS Owners 2001a). From the Lowe River crossing (MP 780) to the Valdez Marine Terminal, nearly all tributaries, streams, and creeks are considered to be anadromous fish habitat. They are sensitive year round and critically sensitive from late summer through much of the winter in conjunction with fish spawning and overwintering.

Maximum flows in these water bodies are generally triggered by releases from glacier-dammed lakes (TAPS Owners 2001a). In the Valdez area, heavy rains can produce high flows on the Lowe River and its major tributary, Brown Creek. Near MP 778, the underground pipeline crosses about 2,500 ft of Sheep Creek floodplain.

3.7.2 Existing Conditions and Historical Impacts

Existing conditions and historical impacts and their mitigation are used as a baseline to evaluate the proposed action and no-action alternatives. The topics discussed below include erosion and sedimentation, flooding, water use, contingency planning, water quality, and historical spills.

3.7.2.1 Erosion and Sedimentation

Erosion and sedimentation in streams and rivers are common natural processes along the TAPS ROW. Braided systems, such as the Sagavanirktok and Delta Rivers, are particularly subject to bed and bank erosion and subsequent downstream sediment deposition because of their physical characteristics. Two types of impacts are possible for erosion and sedimentation. First, the erosion of the beds and banks of surface water bodies can affect the pipeline by destabilizing its supports. Second, the pipeline and its structures can modify the rate of erosion in areas where they are in contact with flowing water. Pipeline structures and supports can be eroded by general scour (i.e., geomorphic processes, such as long-term adjustments of a channel from changes in basin hydrology, hydraulics, or sediment movement), contraction scour (i.e., the general lowering of the channel bed under the structure), and local scour (i.e., the removal of material around piers, abutments, spur dikes, and embankments caused by acceleration of the flow and turbulence near bridge substructural elements and embankments) (Heinreichs et al. 2001). Scour processes are accelerated during high-flow conditions. Under high-flow conditions (e.g., 100-year floods), contraction scour and pier scour can extend deeper than 10 ft. Similarly, sedimentation can impact structures in streams and river channels, and the structures within the channels can affect the deposition of sediment downstream.

The ROW crosses 80 major rivers, either buried or aboveground, and is in or adjacent to a number of river valleys (TAPS Owners 2001a). About 96 mi of the pipeline consists of buried or elevated river crossings, instream alignments, or alignments near major river channels, such as the Sagavanirktok, Atigun, Dietrich, Middle Fork Koyukuk, and Delta Rivers and Phelan Creek. These crossings were designed to accommodate foreseeable erosion, scour, ice conditions, and river meanders under Stipulation 3.6.1.1 (TAPS Owners 2001a).

Depending on the magnitude, duration, and time of the flow and characteristics of the materials involved, beds and banks can undergo

significant scour, erosion, and sedimentation. Floodplain overflow during spring ice breakup, when the ground is still frozen, produces few channel modifications or new channels. For example, frequent and almost annual overflows occur along and across the Dalton Highway along certain sections of the Sagavanirktok River (TAPS Owners 2001a). These overflows produce minor changes in the floodplain. However, dramatic scour, bank erosion, enlargement of channels, and development of new channels can occur if the ground is thawed during a flood event. For example, major late-summer floods (e.g., the August 1992 flood on the Sagavanirktok River and the very high flows on the Dietrich/Middle Fork Koyukuk River systems in 1994) produced substantial changes to the river systems and their floodplains.

Glacial melt during long warm periods can produce relatively high, sustained flows that scour and erode stream beds and banks. The sudden release of multiple glacier-dammed lakes, in combination with high prior rainfall, can produce extremely high flows in rivers and induce major changes in the channel morphology (e.g., high release flows on the Tazlina River in 1997 significantly modified its channel morphology) and require a timely response to protect the pipeline. Similarly, debris accumulations in small streams can produce significant local bank or bed scour and significant changes in flow patterns, particularly in the area of alluvial fans, which have a high potential for bedload sedimentation, bank erosion, and the development of new channels (TAPS Owners 2001a).

The effect of erosion on the pipeline system is well studied, monitored, and surveyed along the ROW, and many mitigation activities have been implemented to reduce adverse impacts. These mitigation measures have been performed as routine maintenance along the ROW and as immediate responses to prevent adverse impacts to the pipeline. Some specific remediation methods include the following:

- Adding spur dikes (elongated structures having one end on the bank of a stream and the other end projecting perpendicularly into the current, used to protect eroding stream banks and shallow buried pipeline in the floodplain),

- Constructing revetments (armored structures parallel to the flow in a river or stream) to prevent further movement of the river toward the pipeline,
- Adding riprap (large rocks placed in the water and up the slope of an eroding shoreline) to control erosion along streambanks and lakeshores where vegetation is not sufficient to prevent erosion caused by high water or wave action,
- Armoring (placing riprap) to control erosion, and
- Adding gabion guidebanks (wire mesh baskets filled with cobblestones that range in size from 4 to 8 in.) to control erosion.

Some of the major repairs and new structures for river control are listed in Table 3.7-1. These repairs and new structures have been very effective in preventing adverse impacts to the pipeline.

In addition to erosion having a potential impact on the pipeline, the presence of the pipeline can also affect local rates of erosion. The degree of impact depends on whether river training structures such as spur dikes, revetments, and guidebanks, are used; what type of structure is used; and whether the

pipeline is located in the active or main channel area or in floodplain fringe areas (TAPS Owners 2001a). In areas where the pipeline is buried, its presence no longer has any effect on river flows or erosion potential. Any adverse impacts were eliminated after ditches and low spots were filled with flood sediment during the first year of pipeline operation.

At aboveground river crossings, the amount of impact created by the pipeline depends on whether there are river training structures present to guide flow. These structures are necessary to reduce scour and bank erosion, thereby protecting the integrity of the bridge piers and abutments. No training structures are located at the Yukon River Bridge and the Atigun River Bridge. These bridges have had little or no impact on erosion, except for a local deepening of the river immediately in front of and alongside the piers, at a distance of about one to two times the size of the pier (Norton 2001a). Increased erosion on the opposite bank has not been documented.

Bridged crossings at the Tanana, Middle Fork Koyukuk, and Hammond Rivers employ river training structures. Riprap was placed along the banks of the Middle Fork Koyukuk River in 1996 near the location of the bridge crossing. The riprap did not extend very far into the water and had little or no effect on the river.

TABLE 3.7-1 Historical Activities Performed for River Control along the ROW

River	Activity	Location	Year
Sagavanirktok River	Spur dike added	MP 22	1993
	3 spur dikes added	MP 47	1993
Dietrich River	New spur constructed	MP 196	1995
	New revetment constructed	MP 198	1997
	Emergency armoring at valve site	MP 186	1998
	Revetment constructed	MP 188	1999
Middle Fork Koyukuk River	Spur repaired	MP 218	1995
	Revetment constructed	MP 231	1995
	Revetment constructed	MP 218	1999

Source: TAPS Owners (2001a).

The large guidebanks at the Middle Fork Koyukuk and Hammond River bridges are parallel to the flow and have had little impact on the rivers, except for limiting local movement of the water.

Along the ROW, many stream crossings are on VSMs. Bank erosion or channel scour can erode the bases of the VSMs, causing them to “stick up” excessively. Riprap islands have occasionally been placed around the piles or training structures to modify the flow regime and reduce erosion at the base of the VSMs. For example, high flows in Vanish Creek (MP 145) in 1999 resulted in significant VSM stick-ups. This situation was corrected by deflecting the flow in the channel, without measurably impacting the behavior of the creek or its flow pattern (TAPS Owners 2001a). Riprap is also used on alluvial fans to reduce erosion. The effect of riprap on wide alluvial fans (such as those at Snowden Creek) is insignificant. A similar method of protection is used to armor pipeline valve installations, including the accessories. For example, valve RGV 34 (MP 186) in the Dietrich River was armored for protection. This armoring prevented further movement of the river but did not impact downstream reaches of water.

In addition to river training structures and riprap, revetments and spurs are used to reduce erosion and protect the pipeline. On the Middle Fork Koyukuk and Delta Rivers, the impacts of revetments on flow patterns and overall river behavior are minimal. At the alluvial fan at Trims Creek, a revetment prevents spillage of the creek into PS 10. When spur dikes are added to a river system, such as the Sagavanirktok River, the flow deflection created by the structure forms new channels or vegetates bars, or deepens existing channels. In 1994, natural erosion near MP 231 was almost 100 ft. Construction of the revetment in 1995 (Table 3.7-1) halted erosion of the bank. A similar reduction in bank erosion occurred along the Sagavanirktok River at MP 47 as a result of spur construction (Table 3.7-1). Because an integral component of river training structure design is selecting a design that minimizes the impact on erosion of the opposite bank, as well as impacts on upstream and downstream erosion, impacts on the system have been local and negligible. Erosion typically occurs in the immediate vicinity

of the structure and extends outward for only 10 to 20 ft (Norton 2001a). Deposition of the eroded material has also been local and not measurable in a braided system such as the Sagavanirktok.

Pipeline maintenance or extension of structures or construction of new structures is done in accordance with construction plans approved by regulatory agencies in order to reduce potential erosion and sedimentation. In the design and layout of all structures and maintenance work, the impacts on adjacent structures, natural vegetation, and flow patterns are considered to ensure that impacts are minimal and well within the kinds of changes produced by natural river processes, which can be very large and unpredictable in braided systems. Winter scheduling is also used to minimize instream work on waterways that have little or no flow during the winter, such as the Dietrich and Sagavanirktok Rivers.

Erosion and sedimentation were widespread problems during the initial construction and operation of the pipeline; most have been eliminated by corrective maintenance (TAPS Owners 2001a). APSC's environmental monitors issued 190 noncompliance reports related to erosion control and surface drainage problems in 1977. This number was reduced to 24 in 1979, and to 3 in 1980 (GAO 1981). Since 1980, events of noncompliance have been sporadic. None of these noncompliance events has caused any oil spills. The most serious problems were associated with cross-drainage, caused by combined thermal and hydraulic erosion downslope from the Haul Road. Impacts of these processes were sufficiently small to be considered a negligible component of habitat impacts (Pamplin 1979). Successful mitigative strategies included use of mulches, benches, diversion barriers, rock armoring, and gabions. Many culverts were also replaced with low-water crossings.

3.7.2.2 Flooding

Because the pipeline crosses 80 major rivers and more than 800 streams along the ROW and because 96 mi of the pipeline consists of buried or elevated river crossings, instream alignments, or alignments near major river channels and their floodplains, the effects of

floods on the pipeline were a major consideration during the pipeline's original design and continue to be so during ongoing maintenance. Because of prompt mitigation and continuous surveillance, impacts on the pipeline have been negligible. As discussed in the Environmental Report (TAPS Owners 2001a), the pipeline was designed for the pipeline design flood (PDF). The PDF is a theoretical flood size computed for every significant river and river crossing under Stipulation 3.6.1.1.1.2 of the Federal Grant. South of the Brooks Range, the PDF was computed by using 50% of the probable maximum precipitation (PMP); to the north of the Brooks Range, the PDF was computed by using 100% of the PMP in 1973 and 1974 (Norton 2001a) because of a lack of site-specific information. The PMP is the critical depth-duration-area rainfall relationship that would be produced by a storm containing the most severe meteorological conditions probable for a given location during the seasons of the year (Viessman et al. 1972).

The PDF does not have a specified return period. A 1:200 year flood calculated by the USGS (Jones and Fahl 1994 as cited in TAPS Owners 2001a) is used by regulators as a check on flood flows to compare the relative magnitude of flood events that have occurred during the period of pipeline operation. The major flood that occurred on the Sagavanirktok River in 1992 produced an estimated peak flow of about 42,900 ft³/s at the monitoring station near Sagiwan. Because of high flows from the Ivishak River, downstream flows were much higher and estimated to be about two times the pipeline design flood, which exceeded the estimated PDF. The flood required the immediate placement of riprap and large, gravel-filled bags and the installation of a short rock spur at MP 47 to protect the overland buried pipeline from bank erosion. In the winter of 1993, three gravel spurs were built to deflect the main channel permanently away from the eroding west bank. These structures were designed for the higher 1992 peak flow (Norton 2001a).

At small stream crossings, the pipeline has produced local ponding of water. This ponding is often in ruts (created by vehicular traffic) that are deep enough to impede the free flow of water along the natural drainage. Such local damming

of streams can adversely affect the migration of fish (TAPS Owners 2001a). Activities that can obstruct fish movements are reviewed under ADF&G Alaska Statute Title 16 and the Fish Habitat Permit processes. Historically, APSC has removed these flow impediments as part of its routine pipeline maintenance and surveillance programs.

3.7.2.3 Surface Water Use along the ROW

Pipeline operations require fresh water for drinking, cooking, and personal hygiene at manned facilities; equipment washing; dust abatement on roads and workpads; and hydrostatic testing (TAPS Owners 2001a). The ADNR regulates use of Alaska's water resources. That agency issues permits for temporary or long-term appropriation of water. APSC has certificates of appropriation for water use at permanent facilities, including each pump station, except PS 1 and PS 6. For example, temporary water use permit PCOTWP 97-3 permitted APSC to appropriate 20,000 gallons of water per day (gal/d), not to exceed a total withdrawal of 80,000 gal for tank cleaning purposes, and 3,000,000 gal/d, not to exceed a total withdrawal of 9,000,000 gal for hydrostatic testing during the life of the permit. This water was to be withdrawn from surface impoundments near PS 1 between July 1 and September 30, 1997 (ADNR 1997). APSC maintains other temporary water-use permits for facilities such as MCCFs and for special projects.

The largest single project for which temporary-water-use permitting was required occurred in 1997. At that time, 7.4 million gal of water (170 acre-ft — an acre-ft of water is the amount of water contained in a volume that has a surface area of one acre [43,560 ft²] and a depth of 1 ft) were withdrawn from East Lake near MP 0 for tank cleaning and testing at PS 1. Because this lake occupies more than about 300 acres and has an assumed depth of about 8 ft, typical of lakes and the North Coastal Plain of Alaska (Ryan 1990), removing 170 acre-ft of water (about 10% of the available water) had a small, temporary effect. The water was discharged under the linewide NPDES permit, which mandates laboratory characterization,

documentation, and erosion protection requirements for the discharge.

In addition to complying with ADNR regulations and permits, temporary and permanent withdrawals of water must be consistent with the Alaska Coastal Management Program. Withdrawals are acceptable if all water withdrawals cumulatively do not reduce the instream flows below the level necessary to support anadromous and resident fish.

Water used at PS 1 is purchased from the North Slope Borough's Service Area 10 water utility. At PS 6, a well at 5-Mile Camp is used as a source of water and then trucked across the Yukon River Bridge. Each active pump station uses between 4,500 and 7,500 gal/d for primarily domestic purposes. Water in the North Slope Borough is obtained from the Isatkoak Reservoir. Supplies average about 200,000 gal/d (AWWA 2002). Maximum pump station use from the borough is therefore negligible (less than 4% of typical water use by the borough).

The largest user of water along the ROW is the Valdez Marine Terminal (TAPS Owners 2001a). Industrial water is used there for power plant boiler water, stack-scrubber systems, steam-cleaning of equipment, and other washdown processes. The Valdez Marine Terminal has an appropriation permit for withdrawing water from Allison Creek. Since October 1995, the average water withdrawn from the creek has been about 110,000 gal/d.

Because all of the surface water uses along the TAPS ROW are strictly regulated by the ADNR through various appropriation permits and must be consistent with the Alaska Coastal Management Program, and because the historical appropriations have been small, impacts on surface water resources have been negligible to small.

3.7.2.4 Contingency Plans

Operation of TAPS is governed by the TAPS Oil Discharge Prevention and Contingency Plan (CP-35-1) (APSC 2001g). This plan is approved by the ADEC and the BLM every 3 years. The contingency plan divides the 800 mi of the pipeline into five regions (APSC 2001g).

Region 1 extends from MP 0 to 206, Region 2 from MP 206 to 353, Region 3 from MP 353 to 496, Region 4 from MP 496 to 648, and Region 5 from MP 648 to 800.

The plan provides detailed information for reconnaissance, response, and containment actions in the event of an oil spill within each region. To facilitate response, the pipeline is further divided into a three-tiered hierarchy of regions, contingency areas, and segments. The five regional boundaries, in general, represent major river drainages crossed by the pipeline. These boundaries have been modified to take into account geographic features in APSC business unit boundaries. Each region is divided into contingency areas that cover a distinct drainage pattern. The contingency areas are then divided into segments for containment actions, access, and detailed environmental information. For example, Region 1 is divided into 10 contingency areas between MP 0 and 206. One of these areas is the Atigun River Contingency Area, which extends from MP 141 to 167. The Atigun River Contingency Area is further subdivided into four segments.

The plan provides for the following:

- Equipment and resources and field training for spill responders,
- Electronic leak detection capabilities,
- Improved leak detection and leak prevention alarm systems for pump station tanks,
- More than 220 sites along the ROW that are designated as oil-spill equipment staging and deployment areas, and dedicated oil-spill contingency plan buildings and equipment at each of the pump stations;
- Mutual aid agreements with villages near the pipeline to use residents and equipment in the event of a spill;
- Thirteen spill scenarios that cover a variety of terrains, oil products, spill volumes, and seasonal conditions; and
- Aerial photographs of the pipeline to aid in spill-response planning.

Table 3.1-5 summarizes oil-spill contingency equipment along the TAPS ROW. If water velocities in the rivers or streams exceed safe operating limits, APSC is to continue to monitor and track oil until an appropriate containment and recovery area becomes available.

In addition to stipulating on the equipment and person power needed to respond to a spill, the plan also provides specific instructions on how to respond to a spill in each specific contingency area. For example, the following contingency plan applies to a spill occurring during the summer in Segment 2 (MP 144) of the Atigun River Contingency Area (APSC 2001g). This spill occurs over land, with subsequent overland flow to the nearby river. Specifics of the plan include:

- Confining the spill to the workpad by using materials from the pump station pad to construct berms and barriers.
- Constructing berms or barriers in front of the leading edge of the spill to prevent oil from reaching flowing water.
- Deploying booms to contain the oil in the ponds, if oil reaches a pond or ponds west of the pump station. Constructing an underflow dam at CS3-31 (a small drainage at the confluence with the Atigun River west of PS 4) to prevent oil from reaching the Atigun River.
- Deploying a series of diversion booms downstream from the Dalton Highway Bridge to divert oil to the south bank, if oil reaches the Atigun River.

Any oil that escapes containment by the booms is assumed to form patches of sheen. These sheens would follow river currents downstream. The sheens would evaporate, dissolve in the water column, bind with inorganic silt particles, and be removed from the water surface quickly because of vertical mixing.

In addition to outlining detailed response activities, the plan also provides detailed response strategies for 13 hypothetical spills (APSC 2001g). These spills are assumed to occur along various sections of the ROW. The hypothetical spills illustrate the implementation

of a range of response strategies within the framework of the response organization and use real data and locations to demonstrate how resources will be allocated in the event of a spill.

3.7.2.5 Surface Water Quality along the ROW

In cold regions, such as those traversed by the ROW, the following water quality characteristics are applicable (Jokela 1990):

- Glacial streams have high turbidity in summer, which limits light penetration and plant productivity.
- Ice cover on streams and lakes can prevent or retard reaeration, leading to hypoxic or anoxic (little oxygen) conditions in water beneath the ice.
- Stream flows during ice breakup tend to contain a relatively small amount of dissolved solids because of their high proportion of snowmelt when compared with the groundwater contribution of the stream flows.
- Groundwater-fed streams tend to have higher concentrations of dissolved solids and nutrients than do glacial streams.

Little information is available on the quality of surface water along the ROW. Some water quality measurements were made by the U.S. Geological Survey (USGS) before installation of the pipeline (Childers 1975; Nauman and Kernodle 1973), but there have been no comprehensive follow-up studies on water quality. Although no complete field studies have been performed to evaluate surface water quality along the ROW after installation of the pipeline, operations have not significantly affected stream or river flows, and the existing surface water quality conditions along the ROW are expected to be similar to pre-pipeline conditions. These conclusions follow from three arguments.

First, of more than 800 rivers and streams crossed by the pipeline, only two (Goldstream Creek [MP 448] and the Chena River [MP 460]) have impaired water quality according to ADEC. Water-quality-limited water bodies are surface

waters for which actual or imminent persistent exceedances of water quality criteria, and/or adverse impacts to designated uses, as defined in the state's water quality standards (ADEC 2002), have been documented. ADEC maintains a list of impaired waters in accordance with Section 303(d) of the Clean Water Act (33 USC §1313(d)). The pipeline near Fairbanks crosses both of these streams. Neither of these streams has been impaired by TAPS operation. Placer mining is reported to be the cause of turbidity increases in Goldstream Creek, whereas runoff from urban and military lands may be introducing sediment and petroleum compounds into the Chena River.

Second, observations by nonprofit organizations have not identified any specific degradation of water quality or habitat that is attributable to TAPS operations (TAPS Owners 2001a). These nonprofit organizations include the Yukon River Intertribal Watershed Council, the Copper River Watershed Council, and the Tanacross Village Watershed Council. All of these councils are interested in maintaining pristine conditions in specific waterways along the ROW and are funded by the EPA for certain activities, such as visual observations of water bodies, envisioned as promoting the health of a watershed.

Third, all surface water discharges along the ROW are regulated under various release permits, including a linewide NPDES Permit, a State of Alaska Wastewater General Permit, and an NPDES Permit for Storm Water Discharge from Construction Activities Associated with Industrial Activity. These permits delineate the type and concentrations of compounds that can be discharged to Alaska waters. Compliance with these permits ensures that any water released will not have a substantial adverse effect on the waters of the United States. Some minor noncompliances with the linewide permit have been self-reported by APSC. These noncompliances have not measurably affected surface water quality (TAPS Owners 2001a).

The linewide NPDES permit regulates the release of treated wastewater from each MCCF, in addition to discharges released onto the workpads. In permafrost areas, discharge to groundwater is not practical, and long-term discharge of wastewater across the tundra can

Placer Mining

A placer is a deposit of gravel that may contain gold particles. The word placer was derived from the Spanish word meaning "sand bank." Early forms of placer mining included gold panning, sluicing, and the use of a rocker (a "cradle" or a "dolly" used when water is in short supply or when the depth of the stream or creek is too shallow to use a sluice-box) (Davies 1998).

promote erosion. Only PS 5 has a permanent discharge of sanitary wastewater to tundra wetlands (TAPS Owners 2001a). (MCCFs can discharge wastewater, but their locations are temporary.) In 1999, the lagoon treatment system at PS 5 was upgraded to a conventional aerobic secondary treatment process by adding a small mechanically activated sludge plant. Discharge from this process is distributed through a diffuse outfall across the tundra under the linewide NPDES permit.

In addition to treated wastewater, the line-wide NPDES permit specifies rules for discharging hydrostatic-test waters and excavation dewatering (TAPS Owners 2001a). Hydrostatic testing is performed on segments of the pipeline or on tankage brought into service following installation or repair to ensure that the repair or construction is soundproof and leakproof. Hydrostatic testing occurs infrequently. In 1991, 3.8 million gal of water was released when more than 8 mi of pipeline was reconstructed to improve pipeline stability in the Atigun River valley.

In 1996 and 1997, a total of about 7,800,000 gal of hydrostatic test water was released. The composition of the discharge generated by hydrostatic testing includes small quantities of inorganic residual materials left in the pipe prior to testing, such as dust and welding slag. The linewide permit mandates laboratory characterization of the water, documentation, and erosion protection at the point of release. Most water is discharged to dry channels or snow (TAPS Owners 2001a). The appropriate technologies for these discharges are physical treatment methods, such as filtration, overland treatment, and/or settling ponds that can control settleable solids and

turbidity (EPA 1997a). This technology is established as best conventional pollutant control technology and best available technology technically achievable.

Excavation of buried pipeline is occasionally required to confirm findings of pipeline pigs (instrumented probes used in the pipeline to determine its condition and operation) or other test data and to make necessary repairs. If groundwater is encountered during the maintenance digs, the water must be removed and discharged away from the trench. Dewatering discharge has been regulated through various permits, beginning with a State of Alaska wastewater discharge permit in 1983. The current line-wide permit requires notification, volume estimates, and descriptions of procedures employed to minimize erosion and the discharge of pollutants (e.g., filtration, overland treatment, and/or settling basins). Between 1993 and 1999, there were about 90 reported discharges. Of these, 12 were to surface water. The total volume of water released was on the order of 1 billion gal. Most of this water was released during 1996 (approximately 800 million gal in 25 releases).

Secondary containment structures at pump stations and the Valdez Marine Terminal may trap snowmelt and rainwater. These structures must be periodically drained to ensure that the full capacity of the secondary containment systems is maintained (TAPS Owners 2001a). Dewatering of secondary containment structures is allowed by a State of Alaska Wastewater General Permit. This permit establishes monitoring requirements and effluent limitations. To guard against discharge of pollutants, the discharge is visually inspected for sheen. No discharge of water that bears hydrocarbon sheen is allowed; water with a sheen must be treated prior to release. In 1997, more than 600 secondary containment structures along the ROW were drained. The total volume of water drained was 15,678,000 gal. More than two-thirds of this water came from early summer dewatering of the tank farm at PS 1, where the secondary containment volume is the greatest. At the Valdez Marine Terminal, discharge from the secondary containment structures is to the Ballast Water Treatment Facility.

Eleven of the ROW facilities currently meet the applicability criteria of the EPA Storm Water Multi-Sector General NPDES Permit (MSGP) for Industrial Activities that can potentially affect surface water. APSC operates the sites in conformance with the MSGP standards. The affected sites are all material sites that might discharge rainwater or snowmelt from areas used to mine sand and gravel to surface water. To mitigate the discharge of potentially contaminated storm water and to comply with the general storm-water permit, APSC performs the following storm-water monitoring and inspections (TAPS Owners 2001a):

- Evaluation of non-storm-water discharges at the site,
- Quarterly inspections,
- Quarterly visual examinations of storm-water runoff (performed during a storm event), and
- Quarterly analytical monitoring for total suspended solids, pH, and nitrate/nitrogen (performed during a storm event).

Compliance with the permit ensures that impacts from releases are minimized and that water quality is maintained.

Construction activities that disturb more than 5 acres, do not involve excavation dewatering, and have a potential to impact waters of the United States are covered under an NPDES Permit for Storm Water Discharge from Construction Activities Associated with Industrial Activity. Specific notices of intent are submitted to the EPA, and for projects that meet the criteria for coverage under the permit, regulations are adhered to.

3.7.2.6 Historical Spills of Crude Oil

Between 1977 and 1999, more than 4,400 spills were recorded for the pipeline and Valdez Marine Terminal (TAPS Owners 2001a). The spills included about 38,000 bbl of crude oil, 60% of which came from the Steel Creek and Livengood pipeline sabotage events. Almost all of the other spills were either contained in a lined area or cleaned up within about 1 year.

Spills of crude oil to inland surface waters have been very infrequent. One of the largest spills that affected surface water occurred on June 10, 1979. It resulted from a hairline crack in the pipeline caused by settlement at Atigun Pass (MP 166.43). In this spill, approximately 1,500 bbl (63,000 gal) of oil was released, and the pipeline was shut down for about 54 hours (APSC 2002). The crude oil migrated from the point of release through a culvert downslope to the Atigun River, where it produced some impacts (TAPS Owners 2001a), including an oil slick that traveled 25 mi downstream (Behr-Andes et al. 2001). Impacts of this spill have produced no long-term effects on surface water quality in the area of the spill. Spill sites can be grouped according to the location of the event: pump station facilities, the Valdez Marine Terminal, construction-era camps, disposal sites, and miscellaneous sites (e.g., sites along the TAPS ROW but outside the boundaries of any pump station or the Valdez Marine Terminal).

Currently, there are 87 spill sites in the APSC database that require management under the APSC Contaminated Site Management Program (OASIS Environmental 2001). These spills represent less than 1% of the number of spills reported since 1977 for TAPS and the Valdez Marine Terminal. Seventy of these sites occur along the pipeline, and 17 are located at the Valdez Marine Terminal. Twenty-seven of the sites along the pipeline are classified as active; that is, the sites are currently being assessed, monitored, or remediated. Twenty sites are classified as requiring no further action. (These are sites for which an application for closure has been submitted to the ADEC, but for which closure has not been formally approved.) Twenty-three sites are classified as closed. (These are sites that have been formally closed by the ADEC, with regulator concurrence that the sites present little to no risk to human health or the environment.) Of the 17 sites at the Valdez Marine Terminal, 8 are active, 1 requires no further action, and 8 are inactive.) Detailed information on historical volumes of contaminated soils and wastes and their treatment is given in Appendix C.

In the event of a spill along the ROW, a predefined management process is implemented

in accordance with the contingency plan (APSC 2001g). This process includes discovery, characterization, remediation, monitoring (if needed), and, finally, closure (OASIS Environmental 2001). Following discovery and characterization of the spill, a variety of contaminant management strategies have been used at contaminated sites. The response always includes removal of as much free product as possible, and, in most cases, excavation of the most contaminated soil to minimize the potential of direct exposure and to inhibit contaminant migration to both surface and groundwater resources. ADEC cleanup standards adopted in January 1999 are the current basis for investigation, cleanup, and monitoring activities at the contaminated sites.

Four high-priority contaminated sites along the ROW are Happy Valley Camp, the PS 6 leach field/fueling island, the PS 1 former gas tank area, and Toolik Camp. The Power Vapor Area at the Valdez Marine Terminal (OASIS Environmental 2001) also has a high priority (see Table 3.8-1). All of these sites are actively being managed. Spills at these sites ranged from 87 gal at PS 6 to 33,619 gal at Check Valve 92 (medium priority). One of these sites has produced measurable contamination of some surface water seeps from the gravel pad that enter Happy Valley Creek. This site is a construction-era facility, Happy Valley Camp (MP 80). Four spills, each of more than 1,000 gal of diesel fuel, occurred at Happy Valley West, a gravel pad located at a former construction campsite west of the Dalton Highway. These spills included 6,000 gal in 1970, 1,000 gal in 1972, 8,000 gal in 1973, and 1,800 gal in 1975.

Response actions to the above spills included excavating interceptor trenches and recovering free product. The site was subsequently restored in accordance with the APSC Erosion Control Plan and reclamation was approved through the formal "Greensheet" process in the early 1980s (OASIS Environmental 2001). APSC voluntarily undertook a program to reevaluate residual impacts at the site in 1996. Since 1996, surface water monitoring in Happy Valley Creek has indicated hydrocarbon contamination originating from residual soil contamination in the adjacent gravel pad. Stained soil near the surface was excavated and

treated off site in 1998. APSC is currently evaluating remedial options and was to perform additional water quality sampling in 2001.

A large spill recently occurred near MP 400 (TAPS MP 400 event; see Section 4.1.1.8) when the pipeline was shot with a high-power rifle. This event released 285,600 gal of oil to the environment. About 175,793 gal of free product has been recovered at the site with interceptor trenches (TAPS

Owners 2002a). Removal of the contaminated soils and vegetation is underway.

Because surface water quality has not been significantly affected by pipeline operations, as discussed in the previous section, the remediation activities detailed in the TAPS contingency plan apparently have been successful.

3.8 Groundwater Resources

Groundwater is subsurface water that occupies the spaces between particles within a geologic formation (Todd 1980). In Alaska, where permafrost occurs beneath about 85% of the land surface, groundwater is further designated as *subpermafrost* or *suprapermafrost*, depending on whether it occurs below or above permafrost, respectively (Nelson and Munter 1990). In the zone of continuous permafrost, suprapermafrost groundwater is available seasonably as part of the active zone (the zone in which the permafrost thaws) and is subject to contamination. The underlying permafrost forms a confining unit for the subpermafrost aquifers (Miller and Whitehead 1999). In northern regions, the active zone and any associated suprapermafrost aquifers can be very thin, approaching a thickness of only a few inches (Davis 2001).

Suprapermafrost groundwater occurs beneath rivers and lakes as a thin layer above the top of the permafrost, and in aquifers above permafrost at depths of tens of feet (Nelson and Munter 1990). If the thickness of the permafrost is great, suprapermafrost groundwater may be the only groundwater resource available. Suprapermafrost groundwater plays an important role in creating distinctive geomorphic features, such as wetlands, patterned ground (a mosaic of polygons ranging up to 20 ft in diameter on the tundra that are formed by freeze/thaw cycles), pingos (Inuit word for ice-cored hills in permafrost formed when the hydrostatic pressure of freezing groundwater causes the upheaval of a layer of frozen ground), and shallow lakes.

Subpermafrost aquifers occur in permeable material below the base of permafrost. In areas of continuous permafrost, these aquifers consist mostly of bedrock. In the zone of discontinuous permafrost, they commonly consist of unconsolidated deposits (Miller and Whitehead 1999). When present, subpermafrost groundwater can be expensive to extract and commonly brackish to saline, particularly near coastal areas. Subpermafrost groundwater from alluvium is generally unavailable in the zone of continuous permafrost; however, some wells

have obtained water from sedimentary, metamorphic, or igneous rocks (Nelson and Munter 1990). Within areas of discontinuous permafrost, groundwater supplies can generally be developed, but the occurrence and distribution of permafrost may affect the placement and operation of the wells.

Groundwater also occurs in taliks and thaw bulbs. As indicated in Table 3.1-1, taliks have been, and are still being, used to supply water along the TAPS ROW. At PS 3, water is being obtained from a large talik along the pipeline (Keyes 2002). This talik was formed by warm oil in the pipeline flowing through thaw-stable permafrost. The talik conveys water from the Sagavanirktok River year round.

Taliks and Thaw Bulbs

In areas of permafrost, taliks and thaw bulbs can be sources of groundwater.

Taliks are unfrozen zones that occur beneath lakes and rivers that are either underlain by permafrost at depth or that are completely open to subpermafrost groundwater.

Thaw bulbs are localized regions of melted permafrost produced by some local source of heat, for example, by the warm oil flowing through buried pipeline along the TAPS ROW.

Pipeline operations require fresh water for drinking, cooking, and personal hygiene for manned facilities; equipment washing; dust abatement on roads and workpads; and hydrostatic testing. Potable use at pump stations averages about 100 gal of water per day per person (TAPS Owners 2001a). At the pump stations and camps, potable water is generally obtained from local wells that are maintained by APSC. At PS 1, potable water is purchased from the North Slope Borough's Service Area 10 water utility. A well at 5-Mile Camp is used as a water source for PS 6.

As shown in Table 3.1-1, 20 wells along the ROW have been used for the production of

potable water, except for well 25098 which is dry (no groundwater was found in this well to a depth of 300 ft). Currently, six wells are active. Each active pump station uses between 4,500 and 7,500 gal of water per day (gal/d), mostly for domestic use (TAPS Owners 2001a). The wells range in depth from 28 ft at PS 8 to 800 ft at PS 6 (MWH 2001). Most of the wells extract water from taliks. The capacities of the wells along the ROW are all low, ranging from 20 to 75 gallons per minute (gal/min) (well 25093 at PS 6 and well 25086 at PS 2, respectively). The well capacities thus greatly exceed the daily use even for maximum use (7,500 gal/d, or 5.2 gal/min). The combined current capacity for active wells used for groundwater TAPS operations along the ROW is at least 190 gal/min (270,000 gal/d). The well at PS 5 is active, but has no reported capacity (estimated to be about 25 gal/min). Use of water along the TAPS ROW is regulated by the ADNRR. Historical compliance with water-use permits has limited the impacts of water withdrawal to minor, local, and temporary.

The major user of groundwater in the vicinity of the TAPS ROW is the City of Fairbanks. It derives all of its water from wells in an adjacent, hydraulically independent aquifer. In 1996, the monthly mean water withdrawal was about 6 million gal/d (USGS 2002). The total groundwater use by the TAPS is, by comparison, less than 1% of the use at Fairbanks. For a typical single well along the TAPS ROW that extracts 5 gal/min (7,200 gal/d), the percentage of Fairbanks water use is even less.

The quality of groundwater in Alaska can range from very good to saline, depending on the location and depth of the well. In regions near Fairbanks, groundwater tends to have high arsenic levels derived from formations of schist rocks (Farmer et al. 1998). Regular water-quality monitoring is required for public water supply systems, such as those at each pump station along the ROW. Under State of Alaska regulations (18 AAC 80), nitrate monitoring is required annually. Generally, the concentration of nitrates found in wells at the TAPS pump stations is about 0.3 mg/L (TAPS Owners 2001a). This value is within the U.S. Environmental Protection Agency (EPA) drinking water standard (maximum contaminant level, MCL) for

nitrate as nitrogen (10 mg/L) (EPA 1996). Similarly, the arsenic concentration in pump station wells (about 0.01 mg/L) (TAPS Owners 2001a) is less than the current EPA MCL (0.05 mg/L). By January 2006, the EPA MCL for arsenic will be reduced to 0.01 mg/L (EPA 2001c). At that time, compliance of water from the pump station wells may become an issue.

No direct releases of untreated wastewater to groundwater occur along the ROW. Indirect releases of treated sanitary wastewater can occur from conventional septic systems at PS 6 (Fly Camp), 7, 9, 10, and 12, and discharges of sanitary wastewater to the ground at PS 5 can indirectly affect groundwater through infiltration. The septic systems leachfields at PS 7, 9, 10, and 12 (capacities of 3,400, 1,000, 12,000, and 9,100 gal, respectively [Mikkelsen 1997]) will be nearing their typical useful life in the next decade and will be replaced if necessary (TAPS Owners 2001a). Historical impacts from sanitary wastewater management are expected to have been small and localized because of the presence of permafrost that limits deep percolation of the water, the assimilation properties of the local groundwater, and compliance with other regulatory requirements.

Groundwater can also be affected by spills along the ROW. Between 1977 and 1999, 4,283 spills were recorded and reported (OASIS Environmental 2001). Approximately 98% of those spills were either contained in a lined area or were cleaned up within about 1 year. Spill sites can be grouped according to the location of the event: pump station facilities, the Valdez Marine Terminal, construction-era camps, disposal sites, and miscellaneous sites (e.g., sites along the ROW, but outside of the boundaries of any pump station or the Valdez Marine Terminal).

As discussed in the Section 3.3.3, there are 87 spill sites in the APSC database that require management under the APSC's Contaminated Site Management Program (OASIS Environmental 2001). These spills represent about 2% of the number of spills reported since 1977 for the TAPS and the Valdez Marine Terminal. Of the 70 spill sites along the pipeline (17 spill sites are located at the Valdez Marine Terminal), the ADEC has approved closure for 23, 20 have no further remediation planned

(closure pending), and 27 are active (remediation or monitoring being planned or underway). A predefined management process is implemented in the event of a spill along the ROW. This process includes discovery, characterization, remediation, monitoring (if needed), and finally closure (OASIS Environmental 2001). Following discovery and characterization of the spill, a variety of contaminant management strategies have been used at contaminated sites. ADEC cleanup standards adopted in January 1999 are the current basis for investigation, cleanup, and monitoring activities at the sites. The response always includes removal of as much free product as possible and, in most cases, excavation of the most contaminated soil to minimize the potential of direct exposure and to inhibit contaminant migration to both surface and groundwater resources. Detailed information on historical values of contaminated soils and wastes and their treatment is given in Appendix C.

Four active contaminated sites occur along the ROW: Happy Valley Camp, the PS 6 leach field/fueling island, the PS 1 former gas tank area, and Toolik Camp. The Power Vapor Area is a high-priority site at the Valdez Marine Terminal (OASIS Environmental 2001). Check Valve 92 is a medium-priority site along the pipeline. Table 3.8-1 summarizes information for these sites. Sites that have high priorities require the greatest attention to ensure protection of people and the environment. The other 21 active sites have relative priorities of either medium or low. All of these sites are being actively managed and have contaminated groundwater (suprapermafrost meltwater in the active zone). The spills that occurred at these sites ranged from 87 gal at PS 6 to 33,619 gal at Check Valve 92. The extent of groundwater contamination at these sites is also variable; the largest occupies an area of about 2 acres (Toolik Camp).

An even larger spill has recently occurred near MP 400 (Livengood spill) due to shooting of the pipeline with a high-power rifle. This event released 285,600 gal of oil to the environment. About 160,000 gal of free product have been recovered at the site with interceptor trenches; however, shallow groundwater has become

contaminated. Additional characterization is currently underway and remediation activities appropriate for the site have commenced. As of April 2002, the following activities have been completed at the Livengood site: an estimated 300 yd³ of oiled trees and 1,480 yd³ of heavily oiled vegetative mat removed from the site; an estimated 3,280 yd³ of lightly oiled soil removed from a Department of Transportation pit; a total of 22,610 yd³ of lightly oiled soil and 720 yd³ of heavily oiled soil removed from the spill site; and 175,793 gal of recovered oil reinjected into the pipeline at PS 7 (Willson 2002).

The Valdez Marine Terminal has 17 contaminated sites, with 8 sites being active. All of these sites are located within the confines of an industrial facility and currently pose no threat to drinking water supplies or the marine water (OASIS Environmental 2001). The contaminated sites are generally located in oil storage or process areas, including the East Tank Farm, the Power Vapor Area, and the BWTF. The primary contaminants released include crude oil, diesel fuel, and oily ballast water. As part of the remediation activities for the contaminated sites, a soil-vapor extraction system was operated from June to October 1999. This system removed more than 3,000 lb of volatile organic compounds from contaminated soil. System operation was resumed during the summers of 2000 and 2001. In addition, the remediation consisted of free-product removal from the groundwater and groundwater extraction at the source area to control off-site migration of contaminated groundwater during periods of high seasonal watertables. This remediation has decreased benzene concentrations and free-product thickness at the Power Vapor Site, and monitoring results indicate that contamination will not reach marine waters of Port Valdez.

Procedures for remediation of contaminated groundwater at spill sites along the ROW include removing the sources of contamination (free-product recovery by use of interceptor trenches and skimmers and removal of contaminated soil and vegetation) and various in-situ techniques, such as:

- Soil vapor extraction — An in-situ remedial technology that reduces the concentration of volatile constituents in petroleum products that are adsorbed to the soil by applying a

TABLE 3.8-1 Six Contaminated Sites along the TAPS ROW

Site	Date of Occurrence or Discovery	Contaminant	Estimated Volume (gal)	Comments
Happy Valley	1970 - 1975	Diesel	16,800	Spill at former construction camp. Cleanup in 1970s after spills. Closure status issued in early 1980s. Change in land use in 1996 required site assessment. Additional assessment and remediation may be required.
Pump Station 6 leach field	1992, 1997, 1998	Diesel-range organics (DRO)	87	Fuel island, tank farm, generator building, and fueling area may be sources. Pilot soil-vapor extraction system tested in 2000. System installation planned for 2001.
Check Valve 92	1996	Crude oil	33,619	Groundwater monitoring and product recovery continued in 2001. Site closure alternatives will be examined in 2002.
Pump Station 1	1992	Gasoline	112	Former gas tank area. Contaminated soil removed or being remediated in-situ. Benzene levels decreasing near gasoline spill location.
Toolik Camp	1974, 1975	Diesel	13,500	Former construction camp. Cleanup in the 1970s after spill. Closure status assigned in early 1980s. Change in land use status in 1996. Site may be closed in 2002 after groundwater and surface water monitoring if contaminant concentrations continue to exhibit stable or decreasing trends documented since 1977.
Power vapor condensate release at Valdez Marine Terminal	1995	Petroleum condensate	341	Soil excavation, groundwater monitoring, and product removal. Soil-vapor extraction initiated in 1999 continues.

Source: OASIS Environmental (2001).

vacuum to create a negative pressure gradient that causes movement of vapors toward extraction wells in regions in which the void spaces are not filled with water (unsaturated zone) (EPA 1995a);

- Air sparging — An in-situ remedial technology that reduces the concentrations of volatile constituents in petroleum products that are adsorbed to soil and dissolved in groundwater by injecting contaminant-free air into the region of saturated groundwater (all void spaces are filled with water) (EPA 1995a); and
- Biodegradation — A process of adding oxygen-releasing compounds (ORC) that enhance biodegradation of the contaminants.

Lined dikes are also used to limit the migration of mobilized contaminants. Characterization of the extent of contaminated groundwater and evaluation of the effectiveness of the remediation methods rely on groundwater monitoring.

By quickly implementing the provisions of the ROW site contingency plans (e.g., APSC 2001g) and following the existing contaminated sites' management processes, historical groundwater contamination has been limited to a few small sites. Remediation of these contaminated areas is ongoing, and the extent and magnitude of groundwater contamination is being reduced with time, as evidenced by the 23 sites that have attained closure.

3.9 Physical Marine Environment

3.9.1 Location and Description

Port Valdez is a fjord approximately 5 km wide by 18 km long that extends in an easterly direction and is separated from the Valdez Arm of Prince William Sound by the Valdez Narrows (Map 3.9-1). The Valdez Narrows is a narrow channel that trends north-northeast. It is considered the dividing line between Port Valdez and the Valdez Arm of Prince William Sound (Colonell 1980). Port Valdez and the Valdez Arm together are about 45 km long and form a northeasterly extension of Prince William Sound (Colonell 1980). The Hinchinbrook Entrance, located approximately 100 km from the Valdez Narrows, connects Prince William Sound with the Gulf of Alaska and the Pacific Ocean (Map 3.1-2). The Town of Valdez is near the northeastern corner of Port Valdez, and the Valdez Marine Terminal is on the southern shore.

Port Valdez is a narrow, deep, glaciated fjord with steep rocky shores in the Chugach Mountains. The Lowe and Robe Rivers and the Valdez Glacier stream empty into the head of Port Valdez and have formed an extensive outwash plain where the old Town of Valdez was located. The old Town of Valdez was destroyed by the Great Alaska Earthquake of 1964. The new Town of Valdez is located on an outwash plain from Mineral Creek on the northern shore (near the eastern end) of the fjord. Both outwash plains are poorly consolidated alluvial and glacial deposits of silt, sand, and gravel (Hood et al. 1973). Large tidal flats have formed on the edges of these outwash plains because of the relatively high tidal range of 5.5 m (Hood et al. 1973) and the large amount of fine sediments deposited in the fjord from the local streams and rivers.

Prince William Sound covers approximately 6,500 km² (Det Norske Veritas et al. 1996) and extends about 90 km from Cape Hinchinbrook (east) to Cape Puget (west) (Map 3.1-2). Prince William Sound has numerous islands, the largest being Montague Island, which extends into the Gulf of Alaska near the Hinchinbrook

Location of Valdez and Prince William Sound

Port Valdez is a narrow, deep, glaciated water-filled valley (fjord) with steep rocky shores in the Chugach Mountains. About 5 km wide and 18 km long, it extends east and is separated from the Valdez Arm of Prince William Sound by the Valdez Narrows. Prince William Sound covers about 6,500 km² and extends about 90 km from Cape Hinchinbrook to Cape Puget.

Entrance. The Hinchinbrook Entrance is the main entrance to Prince William Sound for marine traffic. It is about 10 km wide and provides a clear passage, with the exception of Seal Rocks (Det Norske Veritas et al. 1996). The shoreline of Prince William Sound is generally steep and rocky, with numerous bays and fjords.

The waters of Prince William Sound are chilled by surrounding glaciers and cold, freshwater inflows (Det Norske Veritas et al. 1996), although the waters are protected by the surrounding land mass. The meeting of cold water and cold air from the Chugach Mountains and the warmer water and moist air from the Gulf of Alaska causes sudden squalls, and thick fog is common (Det Norske Veritas et al. 1996). Weather in Prince William Sound and Port Valdez can be significantly different.

The shoreline of Port Valdez is composed of interbedded, dark gray to black, hard, slaty shales and dark gray, hard, fine-grained shaly siltstones with quartz veins. The bedding planes strike in an east-west direction and have an average dip of approximately 55° to the north (Hood et al. 1973). The exposures in Port Valdez have a complex system of fractures, the larger of which are perpendicular to the strike and influence the north-south orientation of the streams that enter Port Valdez.

Glaciers moved from the Chugach Mountains into Port Valdez, then west and south into Prince William Sound, as recently as the late Pleistocene era. Glaciation is ongoing in Prince William Sound and the mountains above Port Valdez. Evidence of glaciation has been found as high as 975 m above sea level in Port Valdez. When the glaciers receded, the fjord was filled with morainal material. Seismic surveys have identified three separate units in the fjord. The bottom unit is bedrock, the middle unit is unconsolidated outwash material, and the third unit consists of post-glacial deposits and is finer grained (Hood et al. 1973). The unconsolidated material of the second and third units ranges in depth from 400 m thick near the center of Port Valdez to the shallow sills¹ at the mouth of Port Valdez. At the Valdez Narrows, little Pleistocene or Holocene deposition occurred, and the bedrock unit is near the surface.

3.9.2 Bathymetry

The east-west trending Port Valdez has a morphology that is typical of a glaciated fjord and consists of a U-shaped valley with a complex sill near the entrance (Hood et al. 1973). The bottom of the fjord has a very flat bottom at a depth varying between 230 and 250 m. The bottom of the fjord rises steeply on the north and south, but more gently at the eastern end, beginning 2 or 3 km east of the Valdez Marine Terminal, to the Valdez outwash delta created by fluvial deposits (Hood et al. 1973). The Valdez Narrows, which form the mouth of the fjord, are approximately 1.5 km wide and have two sills, with the shallower one at a depth of between 110 and 128 m (Map 3.9-1). The Port Valdez depth-volume curve (which plots the volume of water in the basin versus the water depth for the basin) is almost linear (i.e., the change in depth plotted against the change in volume is a straight line), reflecting the regular nature of the bathymetry of the fjord (Colonell 1980).

Water in Prince William Sound is deep, averaging about 300 m (Det Norske Veritas et al. 1996). The shorelines are generally steep, both above and below the water; however, there are outwash plains in the bays and fjords.

3.9.3 Hydrography and Circulation

Hydrography and circulation in Port Valdez depend on variables, such as tides, precipitation, freshwater inflows, winds, air temperatures, and mixing with the waters of Prince William Sound (Hood et al. 1973). Port Valdez waters are generally stratified (layered) with respect to both salinity and temperature from May to October, when freshwater inflows are high. During one field season, Hood et al. (1973) observed the maximum stratification to occur in July. During the period from December to April, when freshwater inflows are at a minimum and surface cooling and wind mixing are at a maximum, the waters of Port Valdez were found to be well mixed vertically (Hood et al. 1973). A longer study was conducted by Colonell (1980) over a 36-month period beginning in 1976. That study supported the earlier findings that Port Valdez waters have a pronounced annual cycle; they are strongly stratified in the summer, and, from the late fall to early spring, they completely mix, resulting in a nearly homogenous state. Both

Port Valdez Hydrography and Circulation

Hydrography and circulation in Port Valdez depend on tides, precipitation, freshwater inflows, winds, air temperatures, and mixing with the waters of Prince William Sound. Port Valdez waters are generally layered with respect to both salinity and temperature from May to October, when freshwater inflows are high.

A conservative estimate is that waters reside in Port Valdez for only a few weeks.

¹ The "shallow sills" constitute a bedrock ridge at a shallow depth near the mouth of a fjord. It separates the deep water of the fjord from the deep ocean water.

studies (Hood et al. 1973; Colonell 1980) show that mixing occurs to the bottom of the water column in the fjord, producing oxygen-rich water at depth. Seasonal changes in density structure are illustrated in Figure 3.9-1. Hood et al. (1973) noted that the Prince William Sound waters appeared to have a similar regime of summer stratification and winter mixing of both salinity and temperature.

Port Valdez tides are mixed, semidiurnal type with a maximum range of approximately 5.3 m and a mean amplitude of about 3 m (Colonell 1980). Mixed, semidiurnal tides occur twice a day, with a period of about 12 hours, with two high tides and two low tides per day. High-tide and low-tide amplitudes are unequal. The tidal prism (the volume delineated by the shoreline and the high and low tide levels)

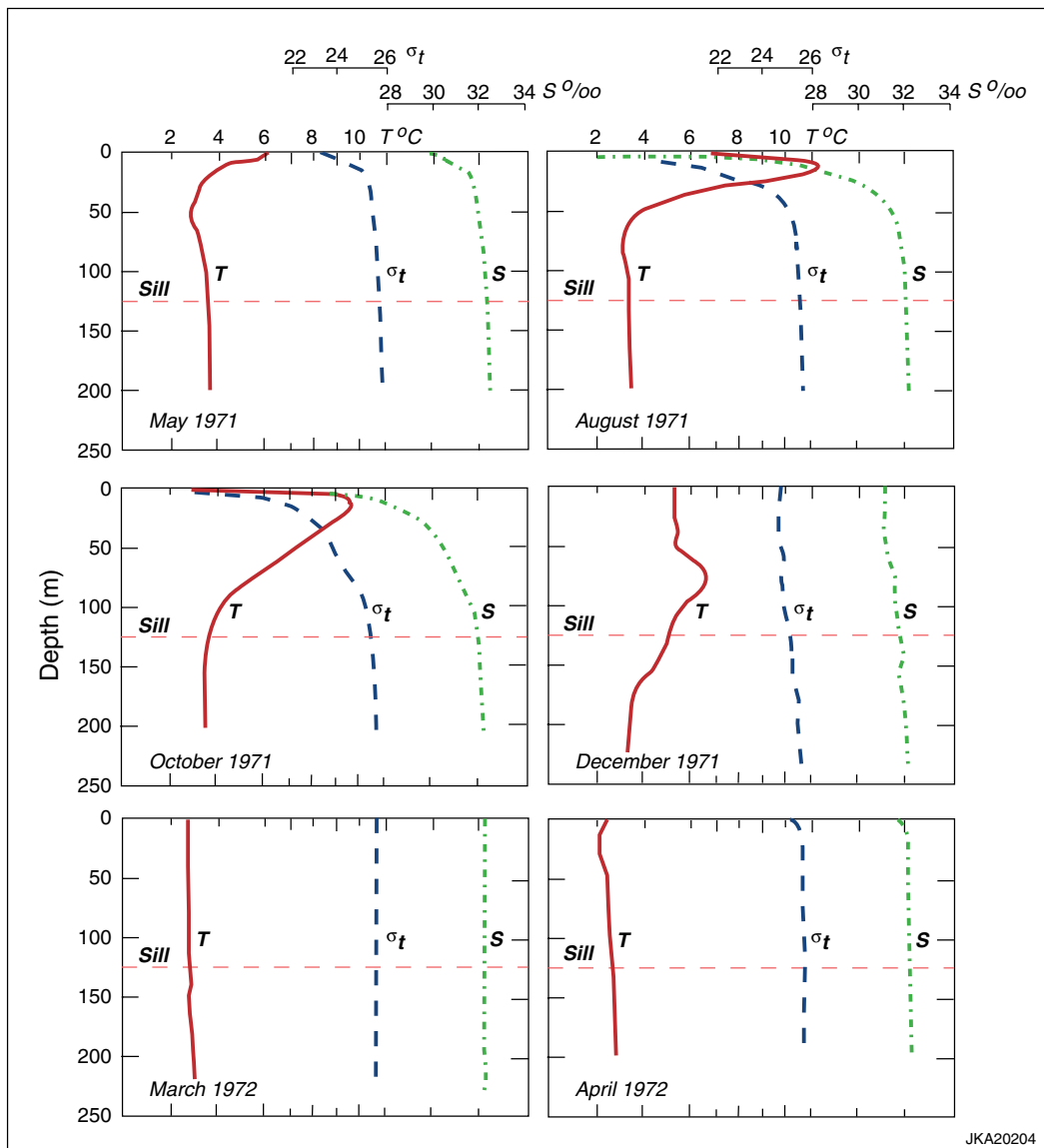


FIGURE 3.9-1 Changes in Temperature and Salinity Distributions in Port Valdez (T = temperature, S = salinity, σ = density) (Source: TAPS Owners 2001a, Figure 3.1-14)

corresponds to about 1.6% of the total volume of water contained in Port Valdez, and during well-mixed winter conditions, provides for refreshment of half the volume of Port Valdez about every 22 days (TAPS Owners 2001a).

In the summer and early autumn, cold, dense marine water from the Continental Shelf pours into Prince William Sound and Port Valdez. This water is subsequently mixed with surface water and ongoing inflow to provide for a hydraulic residence time for these deep waters of approximately 40 days (TAPS Owners 2001a).

Summer flows in Port Valdez are characterized as typical of estuarine flow. These flows are driven by the thin layer of fresh water on the surface of the fjord that moves seaward, while the return flow occurs in the deeper layers. Field studies have estimated the maximum tidal current velocity to be approximately 20 cm/s, while nontidal water velocities are approximately 2 to 3 cm/s (Hood et al. 1973). Below about 15 m, water movements are slow, less than 5 cm/s (Colonell 1980), and they have a random direction, with bursts of motion that do not seem related to either winds or tides (Colonell 1980).

In addition to the noted estuarine-type flows (i.e., surface flows seaward and deep flows inward), Colonell (1980) noted that when field-measured flow data were processed to remove tidal influences, reverse estuarine flow events were occasionally noticeable. These events appeared to be weather related. Colonell (1980) noted that, because of the volume of these

events, it would take only a few such events to flush Port Valdez thoroughly.

In addition to these flows, during certain weather conditions, large volumes of surface water are introduced into Port Valdez from Prince William Sound, displacing much of the deeper waters of the fjord relatively quickly. Measurements of currents in the Valdez Narrows by Colonell (1980) suggest that residence times for deep waters in Port Valdez during passage of weather systems could be reduced to a few days. Thus, climatological influences may be more important in promoting deep-water exchange than are either tides or mixing with surface waters (TAPS Owners 2001a).

Colonell (1980) suggests that specifying a "typical" residence time for waters in Port Valdez is inappropriate. Colonell (1980) notes three main drivers for flushing: tidal flushing, seasonal deep water exchange (estuarine flow), and surges related to weather systems with accompanying large flows. The first two factors are largely seasonal and predictable; the third is more random. On the basis of these observations, Colonell (1980) suggests that a conservative estimate of residence time of waters in Port Valdez does not exceed a few weeks.

The surface temperature of waters in Port Valdez ranges from -1.2°C in winter to a typical maximum of 16°C in the summer (TAPS Owners 2001a). Previous studies have noted a smaller variation; Hood et al. (1973) noted a low water temperature of only 2°C , while Colonell (1980) noted a high of 15°C .

3.10 Marine Water Chemistry

3.10.1 General Marine Water Chemistry

The general chemical parameters reported for marine waters are pH, alkalinity (buffering capacity), total carbon dioxide, and dissolved oxygen. (Salinity is also important and is discussed in Section 3.9.3 and Figure 3.9-1.) These parameters are used here to present the baseline chemistry of Port Valdez. According to Hood et al. (1973), these parameters have significant interrelationships. This source reported that during a study period in 1971, pH reached a maximum of 8.86 in July and a minimum of 8.10 in December. These pH values corresponded closely with the primary production observed in the system. (Primary production is the growth of photosensitive organisms.) Alkalinity was reported as varying widely during the summer months, with Port Valdez waters being generally less alkaline than Prince William Sound. During the winter, alkalinity was more uniform in Port Valdez and slightly higher than it was in Prince William Sound.

Total carbon dioxide was reported to vary from 0.72 to 2.28 millimoles per liter (mmole/L) in 1971. The lower values were observed during the summer, when there were high inflows of freshwater and higher rates of photosynthesis. The higher values were observed in the winter, which coincided with more vertical mixing, low freshwater inflows, and low photosynthesis rates (Hood et al. 1973). Dissolved oxygen was reported to be uniformly high throughout the year in the surface water, with high values near 8 mL/L and lows near 6.5 mL/L. In deep waters, the minimum reported value was 5.5 mL/L. The authors noted that these high values for dissolved oxygen in deep waters indicated complete replenishment of the deep Port Valdez waters, especially in the winter. They also noted that the deep waters showed no signs of oxygen deficiency at any time during the year.

3.10.2 Nutrients

Seawater has relatively high concentrations of certain inorganic nutrients that are needed by

Current Status of Marine Water Chemistry

pH levels vary with growth of photosensitive organisms. Alkalinity varies more in summer than winter; Port Valdez waters tend to be less alkaline in summer and more alkaline in winter than Prince William Sound waters. Total carbon dioxide is lower in summer than winter. Dissolved oxygen is high all year, indicating complete replenishment.

marine microorganisms, including sulfur, magnesium, potassium, and sodium (Hood et al. 1973). Other necessary inorganic nutrients, such as nitrogen, phosphorus, silicon, cobalt, and iron, are present in lower concentrations. Hood et al. (1973) studied inorganic nitrogen (nitrate, nitrite, and ammonia), dissolved inorganic phosphate, and soluble silica for one year beginning in May 1971. Their data indicated that these nutrients had regular seasonal cycles. In general, surface concentrations were highest in the winter, and a large reduction was noted in the spring when phytoplankton growth started. During the summer, the upper water layers were nearly depleted of these nutrients, but, in general, sufficient amounts were present to allow limited growth. In small areas, where significant amounts of glacier runoff were the exception, higher concentrations of these nutrients were present in the summer.

Hood et al. (1973) reported that ammonia (NH_3) concentrations in Port Valdez and the Valdez Arm were similar to those in other coastal marine systems, ranging from less than 0.1 to about $2.5 \mu\text{g-atoms NO}_3^- \text{-N/L}$. (The unit of measure "gram-atoms" refers to the quantity of an element whose mass in grams equals the atomic number of the element. This quantity is also referred to as a mole; e.g., $\mu\text{g-atoms/L}$ is the same as $\mu\text{moles/L}$. Concentrations are reported as nitrogen [N] rather than nitrate [NO_3^-].) Concentrations below the euphotic zone (the upper layer of water that receives sufficient

light for photosynthesis and the growth of green plants) varied with depth and appeared to be related to decomposition. Elevated concentrations of NH_3 were not found near freshwater discharges. Hood et al. (1973) also reported that NO_3^- concentrations in Port Valdez and the Valdez Arm were also similar to those reported for other coastal systems, with concentrations of nitrate ranging from less than 0.2 to 20 $\mu\text{g-atoms NO}_3^- \text{-N/L}$ in the euphotic zone, varying with the season. Concentrations below the euphotic zone increased with depth to a maximum of about 23 $\mu\text{g-atoms NO}_3^- \text{-N/L}$ near the bottom. Seasonal differences in concentrations occurred between Port Valdez and the Valdez Arm. The differences were related to phytoplankton growth. In the winter, deep mixing restored concentrations in the surface waters to levels common before depletion by phytoplankton growth.

Hood et al. (1973) reported that Si(OH)_4 concentrations in Port Valdez and the Valdez Arm were typical of those in other Pacific ecosystems, ranging from less than 1 to 50 $\mu\text{g-atoms Si(OH)}_4\text{-Si/L}$ with seasonal variation. Si(OH)_4 is an important element for diatom growth. The highest concentrations were noted in areas receiving freshwater discharges. In general, concentrations of Si(OH)_4 were observed to increase with depth, with a maximum of about 36 $\mu\text{g-atoms Si(OH)}_4\text{-Si/L}$ near the bottom (Hood et al. 1973). The seasonal variations in concentrations of Si(OH)_4 were similar to those observed for nitrate, except for changes attributed to diatom growth. Near the head of Port Valdez, which receives a significant amount of river discharge, Si(OH)_4 remained

Current Status of Marine Water Nutrient Levels

Concentrations of certain inorganic nutrients are high. Others are low but usually sufficient to allow limited growth of marine microorganisms. NH_3 and NO_3^- concentrations are typical of those of coastal marine systems. Si(OH)_4 and phosphate levels are similar to those of other Pacific ecosystems.

high throughout the summer, with concentrations of about 50 $\mu\text{g-atoms Si(OH)}_4\text{-Si/L}$ occurring in the top meter of water (Hood et al. 1973). Winter mixing restored concentrations in the surface layers in the other areas.

Hood et al. (1973) reported that phosphate (PO_4^{3-}) concentrations in Port Valdez and the Valdez Arm were similar to those in other Pacific ecosystems, with concentrations ranging from less than 0.03 to 2.0 $\mu\text{g-atoms PO}_4^{3-}\text{-P/L}$. In general, phosphate concentrations increased with depth. The authors noted that river water entering Port Valdez was depleted with respect to phosphate. Phosphate concentrations varied on a seasonal basis in the surface layers, similar to both nitrogen and silica concentrations, which suggests that phytoplankton growth was the main driving factor. During the summer, phosphate concentrations declined to levels near those that are limiting for phytoplankton growth. Winter mixing restored concentrations throughout the study area (Hood et al. 1973).

3.11 Anthropogenic Influences on Physical Marine Environment

3.11.1 Discharges from the Valdez Marine Terminal

3.11.1.1 Conditions

Two outfalls from the Valdez Marine Terminal discharge into Port Valdez and are covered an NPDES permit (see Section 3.16.4). These outfalls are from the Ballast Water Treatment Facility (BWTF) and sanitary water treatment plant. The total BWTF effluent flow for the year 2000 was 3,785,050,000 gal; the estimated effluent outflows by month are listed in Appendix C, Table C.6.

Discharges

The Valdez Marine Terminal is in compliance with all applicable NPDES permits that regulate discharges from the terminal to marine waters.

The Valdez Marine Terminal sanitary water treatment plant is authorized to treat 10,000 gal/d of sanitary wastewater from the Western Operations Area. Treated wastewater is discharged into Port Valdez through a diffuser located offshore of the Valdez Marine Terminal. The diffuser is a device that mixes the discharge with the surrounding waters. The total effluent flow from the sanitary water treatment plant for the year 2000 was 705,399 gal. The average monthly flows of effluent from the sanitary water treatment plant in the year 2000 are shown in Appendix C, Table C.8.

Effluent limitations for the Valdez Marine Terminal outfalls are established for flow rate, biochemical oxygen demand (BOD₅, which is biochemical oxygen demand measured over a 5-day period), total suspended solids (TSS), BTEX, and pH (see Section 3.16.4). The NPDES permit also establishes a mixing zone and effluent monitoring requirements. Figure 3.11-1 shows measured effluent values from 1977 through 1999 (TAPS Owners 2001a) for flow; benzene, toluene, ethylbenzene, and xylene (BTEX); and TSS. BTEX values were above

about 2 mg/L before 1989 but were much lower after then because of the installation of a biological treatment stage and other operation improvements. Discharged BTEX is now typically less than 0.02 mg/L. TSS levels ranged from 10 to 20 parts per million (ppm) (1 ppm is equal to 1 mg/L) over the 10-year period of 1991 to 2001, with average annual discharges of approximately 15 million gal/d. Table 3.11-1 lists the monitoring frequencies for various constituents. Under current regulations, the mixing zone at the Valdez Marine Terminal discharge consists of two designated areas: a small acute zone near the diffuser (50 ft in any direction from the diffuser) and a larger chronic zone (approximately 4,000 by 1,000 ft). The acute zone is an area where concentrations are permitted to reach levels that can potentially cause acute effects in exposed biota. Acute effects are those that are noticed in a short period of time. The chronic zone is an area where concentrations are permitted to reach levels that can potentially cause chronic, or long-term effects, in exposed biota. Chronic criteria concentrations of target pollutants (derived from testing the responses of marine biota to various concentrations of pollutants) are permitted to be exceeded inside the chronic mixing zone. Criteria maximum concentrations (acute exposure criteria) are permitted to be exceeded within the acute mixing zone provided that passing organisms will not encounter lethal exposure levels.

In addition to the two permitted outfalls, storm-water discharge to Port Valdez is also governed under a linewide permit detailed in Section 3.16.4 and Appendix C. The majority of storm water that is potentially contaminated is captured and routed through the BWTF. The rest of the storm-water runoff is routed through holding ponds or reservoirs before being discharged into Port Valdez. These ponds or reservoirs are visually inspected for oily sheens.

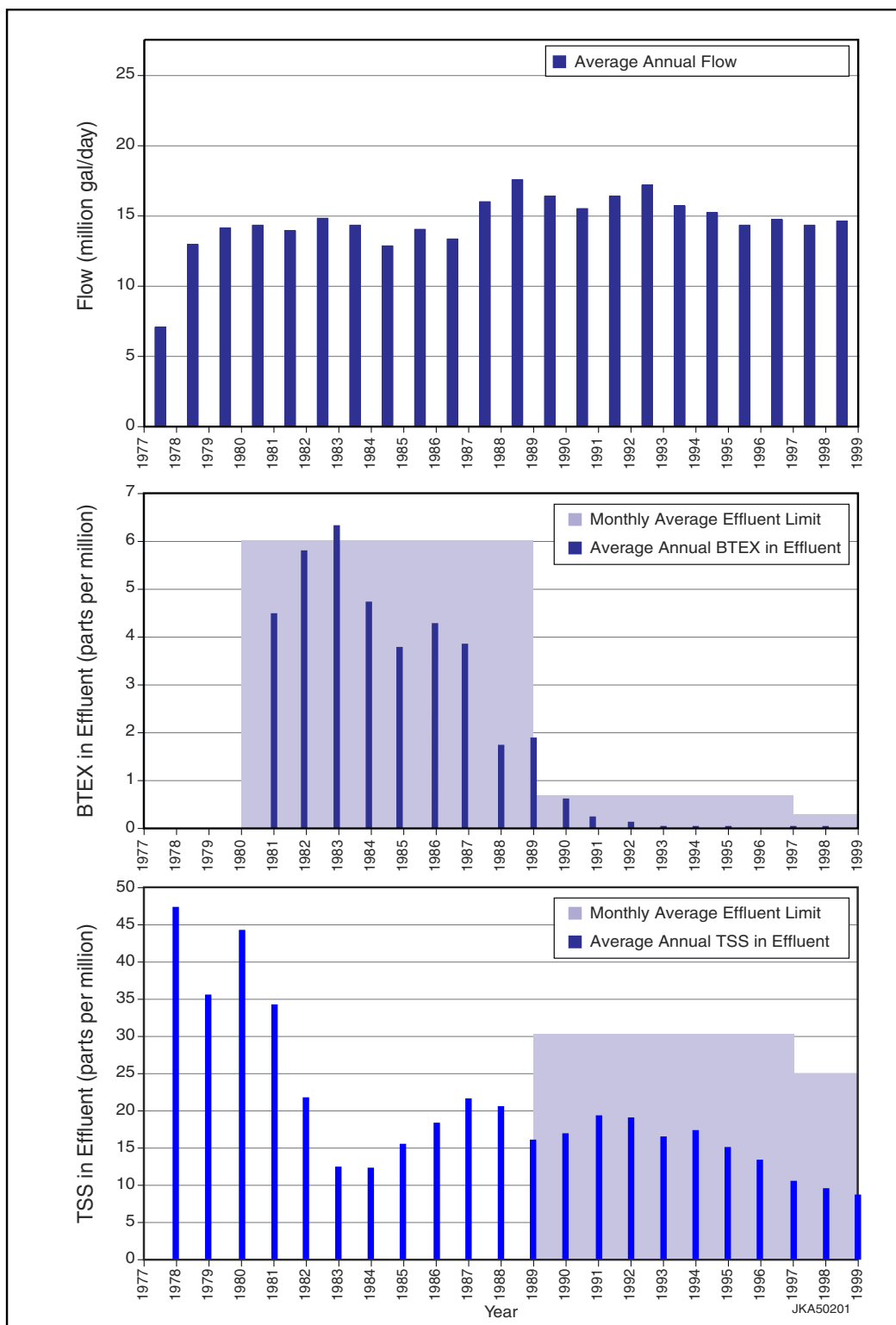


FIGURE 3.11-1 Annual Flow and Levels of Benzene, Toluene, Ethylbenzene, and Xylene and Total Suspended Solids for Valdez Marine Terminal Treated Ballast Water Discharges (Source: TAPS Owners 2001a, Figure 4.3-14)

TABLE 3.11-1 Monitoring Schedules at Valdez Marine Terminal Required by NPDES Permit

Location of Discharge	Parameter	Frequency
Ballast Water Treatment Facility	Total aqueous hydrocarbons	Monthly
	BTEX	3 times per week
	Total suspended solids	3 times per week
	pH	Continuous
	Whole effluent toxicity	Quarterly
	Dissolved inorganic phosphorus	Monthly
	Ammonia	Monthly
	Flow	Continuous
	Density	Weekly
	Total recoverable zinc	Quarterly
Sanitary Waste	Biochemical oxygen demand	Monthly
	Total suspended solids	Monthly
	pH	Daily
	Fecal coliform bacteria	Quarterly
	Flow	Continuous

3.11.1.2 Mitigation

The Valdez Marine Terminal is in compliance with all applicable NPDES permits that regulate discharges from the terminal to marine waters. Figure 3.11-1 graphically illustrates measured levels of BTEX and TSS along with the allowable discharge levels under the NPDES permit. Measured discharge levels are well below permit requirements. A detailed monitoring schedule has been developed and is followed to meet the NPDES permit requirements. Table 3.11-1 lists the monitoring frequencies used for various constituents.

APSC uses best management practices to minimize the volumes of wastewater generated, as well as to ensure that the wastewater is handled and disposed of properly on a linewide basis. Best management practices also cover wastewater-generating activities at the Valdez Marine Terminal (TAPS Owners 2001a). In response to stipulations of the 1989 reissuance of the NPDES permit for the Valdez Marine Terminal and BWTF, a Technical Advisory Group was formed to (1) give technical experts and the public an opportunity to review and comment on draft monitoring reports prepared by

APSC consultants and (2) help agencies evaluate the operation of the BWTF and the reporting requirements of the NPDES permit. The original group included six members who represented a broad range of expertise in environmental monitoring of marine systems. In 1993, ADEC, with the EPA, Technical Advisory Group, APSC, and Prince William Sound Regional Citizens Advisory Council, established a broader working group to build an understanding of BWTF issues and make recommendations to oversight agencies. From 1990 to 1999, the work group met 32 times and initiated changes to plant operations and monitoring procedures, including instituting a pollution prevention framework and annual review process as part of the current NPDES permit (Kitagawa 2000).

3.11.2 Trace Elements

3.11.2.1 Conditions

Eight elements (aluminum, arsenic, chromium, cadmium, copper, mercury, nickel, and selenium) were surveyed in Port Valdez

waters between 1976 and 1978 by Gosnik (1979). This survey effort included establishing a sampling station over the diffuser outfall and one near the mouth of the Lowe River; other stations within the fjord were used as controls. Both water and sediment samples were taken at each sampling station.

Discharges of Trace Elements

The Valdez Marine Terminal is in compliance with all applicable permits governing the discharge of trace elements to marine waters.

Gosnik (1979) found concentrations of the elements to be typically in the normal to low range for clean systems. Exceptions were found in 1978 for aluminum and copper concentrations in ballast water treatment effluent from an unknown source. Plant operations were modified to address discharges of aluminum (which was used in the treatment process). The occurrence of elevated copper levels was considered an isolated event (Gosnik 1979). None of the trace elements mentioned is considered a pollutant of concern today. Regulatory requirements for wastewater discharges from the Valdez Marine Terminal do not include effluent limitations or water quality monitoring for these trace elements (EPA 1997b).

3.11.2.2 Mitigation

No further water-quality data for trace elements and metals have been collected for comparison to prepipeline conditions, although various monitoring efforts have been designed and implemented to ensure that the most likely occurrences of water quality degradation are identified and resolved (TAPS Owners 2001a). The Valdez Marine Terminal is in compliance with all applicable permits governing discharge to marine waters.

3.11.3 Hydrocarbons

3.11.3.1 Conditions

Hydrocarbons present in the waters of Port Valdez and Prince William Sound come from a number of sources, including natural background from oil seeps, oily shales, and coal; historic TAPS operations and related activities; past anthropogenic sources, such as spills and industrial operations; the Exxon Valdez oil spill in 1989; ongoing TAPS operations and related activities; and ongoing anthropogenic activities not related to TAPS, such as boating, fishing, and atmospheric fallout.

Hydrocarbon Discharges

APSC has implemented a number of procedures designed to limit hydrocarbon releases from normal operation to the marine waters of Port Valdez and Prince William Sound.

At the time of the Exxon Valdez spill, the environment at Prince William Sound was generally characterized as “pristine.” However, considerable oil spillage had occurred in this region historically, notably during World War II and as a result of the great Alaska earthquake of 1964. The 1964 earthquake dramatically altered vast areas within the intertidal zone by vertically displacing areas by up to 10 m (TAPS Owners 2001a). Oil and asphalt storage tanks at Valdez and Whittier ruptured, and their contents spilled into Prince William Sound. Thus, Prince William Sound was contaminated with anthropogenic oil residues 25 years before the Exxon Valdez oil spill, and these residues were still present at the time of the spill (Hostettler et al. 1999). In addition to these major sources, atmospheric fallout, runoff from onshore, and operation of boats for military, fishing, and tourism contributed to pre-1989 anthropogenic hydrocarbon levels.

Hydrocarbons and trace metals were measured in the water column in Port Valdez between 1976 and 1978. Before Valdez Marine Terminal operations began, hydrocarbons included pristane, heptadecane, alkane chains, and squalene. In 1978, following initiation of ballast water treatment and disposal, samples from the area near the diffuser showed additional hydrocarbons, including xylenes, alkyl benzenes, naphthalenes, and phytane. The total hydrocarbon concentration ranged from 44 to 104 ng/g. At sampling locations as close as 700 from the discharge point, these additional hydrocarbons were undetectable, indicating a dilution of at least 100-fold (Colonell 1980).

A number of studies have focused on hydrocarbon concentrations in Prince William Sound since the Exxon Valdez oil spill. The fjord bottom at Port Valdez is composed principally of silts and clay-sized minerals derived from glacial river sediment loads (TAPS Owners 2001a). The typical total organic carbon content of the bottom averages 4.7 mg/g. Levels appear to be decreasing.

Feder and Shaw (2000) reported that on the basis of field sampling, hydrocarbon concentrations in the sediments of Port Valdez were less than they were in the same locations in 1989, 1995, 1996, 1997, and 1998. The authors reported that current sediment hydrocarbon concentrations were significantly below various sediment quality guidelines. They reported that in 1999, measured total aromatic hydrocarbon concentrations in the shallow sediments near the diffuser ranged from about 20 to 50 ng/g. Values in the deep sediment ranged from about 15 ng/g near the diffuser to 30 g/g in the far field. This increase in value away from the diffuser could be attributed to hydrocarbon sources in Port Valdez other than the Valdez Marine Terminal. These sediment hydrocarbon values were below various sediment guidelines by a factor of 10 or more. Feder and Shaw (2000) presented three guidelines for evaluating concentrations of hydrocarbons in sediment. The Hepatic Lesion Prevalence model has an allowable value of 620 ng/g; the National Oceanic and Atmospheric Administration (NOAA) low-range-effect level is 4,022 ng/g; and the NOAA medium-range-effect level is 44,792 ng/g. Values for other

hydrocarbons measured were also significantly below the various sediment concentration guidelines (Feder and Shaw 2000).

The Prince William Sound region has relatively high hydrocarbon background concentrations. The area east of Prince William Sound, near Katalla, has numerous oil seeps and oil-bearing shales that contribute to background hydrocarbon levels (Boehm et al. 2001). In addition, coal deposits also contribute to measured hydrocarbon levels through erosion and deposition in Prince William Sound sediments (Short et al. 1999). Total polynuclear aromatic hydrocarbon (PAH) concentrations in sediments were reported to be up to nearly 2,000 ng/g within Prince William Sound and up to more than 4,000 ng/g near West Kayak Island, which is located east of the Hinchinbrook Entrance off the coast of Katalla. Sediment concentrations within Prince William Sound ranged from 326 to 1,990 ng/g of total PAHs (Short et al. 1999).

Although there is general agreement on the typical concentrations of hydrocarbons in the sediments of Prince William Sound, there is an ongoing debate in the scientific literature on which source — oil seeps and shales or coal — is the main contributor to these hydrocarbon levels (for example, see Short et al. 1999; Boehm et al. 1998, 2001; Short and Heintz 1998; Bence et al. 2000; Hostettler et al. 2000). The latest paper by Boehm et al. (2001) presents compelling evidence that although significant amounts of hydrocarbons found in the sediment are derived from coal deposits, the majority of the hydrocarbons found in the Prince William Sound area come from eroding organic shales and, to a lesser extent, oil seeps.

3.11.3.2 Mitigation

In addition to effluent monitoring, which is described in Section 3.11.1, APSC has implemented a number of procedures designed to limit hydrocarbon releases from normal operation to the marine waters of Port Valdez and Prince William Sound. These procedures require various activities, such as completely surrounding arriving oil tankers with containment booms before any off-loading or on-loading activities begin, conducting surveillance to

identify oil sheens, and other measures to quickly identify and respond to any releases of hydrocarbons to marine waters (TAPS Owners 2001a).

3.11.4 TAPS-Related Marine Transportation

3.11.4.1 Tanker Traffic

Oil tankers are loaded with North Slope crude oil at the Valdez Marine Terminal in Port Valdez and deliver this crude oil to various markets. All tankers pass through Prince William Sound en route to the Gulf of Alaska, then alter their course in accordance with their destination (see Map 3.9-1).

The primary market for North Slope crude is the U.S. West Coast. Small shipments also have been sent to Kenai, Alaska; the Hawaiian Islands; and Asia Pacific markets. Laden tankers are required to remain more than 200 mi offshore, outside the U.S. Exclusive Economic Zone. Several classes of tanker, ranging in size from 50,000 to 262,000 deadweight tons, have participated in the Valdez trade. Cargo capacities have ranged from 300,000 to 2,000,000 bbl.

Spill Prevention Measures Associated with TAPS-Related Marine Transportation

SERVS assists in the transit of oil tankers from the Valdez Marine Terminal to international waters. Its duties are primarily related to spill prevention and spill response.

Oil storage and transportation facilities at the Valdez Marine Terminal are designed to prevent spills.

The USCG has established tanker lanes and rules, and it tracks all tankers.

Tanker traffic is restricted when weather conditions (notably wind) are bad.

The current fleet serving the Valdez Marine Terminal consists of 26 tankers (National Research Council 1991) – 3 with double hulls and 13 with double sides. The number of tankers involved is projected to decrease to 8 to 10 tankers by 2020 (TAPS Owners 2001a). Tanker transits are also expected to decrease (TAPS Owners 2001a).

A smaller tanker fleet will require fewer berths at the Valdez Marine Terminal. The terminal currently has four berths; one is a floating berth (currently not operational), and three are fixed-platform berths. One or two of these berths may be shut down in the future. The two berths with tanker vapor control facilities will remain in operation (TAPS Owners 2001a).

3.11.4.2 Ship Escort/ Response Vessel System (SERVS)

SERVS assists in the transit of oil tankers from the Valdez Marine Terminal to international waters. Its duties are primarily related to spill prevention and spill response. More details on SERVS resources and accident response issues can be found in Chapter 4. SERVS has nine vessels assigned to escorting, docking, and response duties, and at least two escort vessels are required for each laden tanker transiting the sound. Tethered escort is required through Valdez Narrows. In the northern sound, the escort vessels must be within one-quarter nautical mile of the tanker when not tethered. In the central sound, a conventional tug or a prevention and response tug must maintain close escort, while the second escort vessel goes on sentinel duty to provide response coverage to a larger area. A vessel is on sentinel duty in the Hinchinbrook Entrance area when tankers are in transit. A third escort vessel may be added, depending on weather conditions. Additional vessels are available if needed for a response or to fill in during scheduled and unscheduled maintenance.

3.11.4.3 Valdez Marine Terminal Operations

Oil storage and transportation facilities at the Valdez Marine Terminal are designed to prevent

spills. The most likely sources of contamination during normal operations at the terminal derive from maintenance and system integrity problems, including pinhole corrosion leaks in pipes, improperly installed fittings, leaking gaskets, and leaking valve packings (TAPS Owners 2001a). A number of procedures, requirements, and items of equipment are in place to mitigate potential marine contamination from Valdez Marine Terminal tanker operations. Some of these measures include the following:

- Secondary containment and drainage into tertiary systems;
- Visual inspections (hourly during loading) and camera surveillance of both grounds and equipment;
- Overfill alarms;
- Locking valves;
- Backpressure automatic shutdown devices;
- Tanker booming during loading;
- Maintenance and inspection procedures;
- Transfer procedures, including hourly volume/quantity comparisons to verify amount loaded;
- Inspection and maintenance of storage tanks and secondary containment;
- Rockwall monitoring;
- Leak detection program;
- Preventive maintenance;
- Surveillance and monitoring;
- Earthquake monitoring;
- Fire wires for rapid pickup by a tug to tow a tanker from the dock;
- Tanker size limitations for berths; and
- Minimum mooring line requirements for tankers.

Additional procedures, requirements, and equipment not listed here are in place to mitigate

potential spills and leaks and other potential releases of contamination to marine waters. The Valdez Marine Terminal is equipped with spill response equipment to handle potential spills, and a 10-person spill response team is always on duty at the terminal. More details on the resources available for accident response are provided in Section 4.1, along with descriptions of some of the additional procedures, requirements, and equipment used that are not listed in this section.

3.11.4.4 Procedures for Tanker Operations

The USCG has established tanker lanes and rules, and it tracks all tankers on its Vessel Traffic Service (VTS). State-licensed marine pilots are required to operate tankers going to and from Bligh Reef. In addition, precautions are taken during periods of high winds and low visibility and when ice presents a potential hazard. Once tankers reach the Valdez Marine Terminal, the entire transfer operation is monitored, and response equipment and personnel are on standby. Before departure, the tanker and escort vessel masters, SERVS response coordinator, and harbor pilot confer to discuss the upcoming laden tanker transit. The VTS radar tracks each laden tanker through the sound until the tanker is 17 mi into the Gulf of Alaska.

3.11.4.4.1 Docking and Loading Procedures. As soon as a tanker is moored at the Valdez Marine Terminal, an oil spill containment boom is placed around it before it begins unloading its ballast water for treatment in the BWTF and taking on crude oil. USCG regulations govern all transfers of liquids between the Valdez Marine Terminal facilities and a tanker. Before any transfer, a conference is held to discuss unique transfer procedures and safety measures. A berthed tanker is inspected hourly for any sign of a spill or leak.

3.11.4.4.2 Escorts for Laden Tankers. Nine vessels are assigned to escorting, docking, and response duties, and at least two escort vessels are required for each

laden tanker transiting the sound. Details of the procedures are given in Section 3.11.4.2.

3.11.4.4.3 Glaciers. The Columbia Glacier is about 10 mi from the tanker lanes in Prince William Sound, and ice is sighted in the tanker lanes on an average of 10 to 15 times a month. When the USCG Captain of the Port determines hazardous ice conditions exist in Valdez Arm, the Valdez Narrows ice-routing measures are placed into effect. These measures include the following:

- Outbound tankers are required to use an ice-scout vessel if ice is within 1 mi of the traffic lanes.
- The USCG routes traffic around ice, as appropriate. These routing measures may include use of one-way zones. An ice-scout vessel may also be used, and tanker speeds may be reduced.
- During low visibility, when ice is spotted or if no ice report has been received in 6 hours, SERVS dispatches an escort vessel to act as an ice scout for empty inbound tankers.
- The scout vessel, using searchlights, lookouts, and radar, keeps about 1/2 mi ahead of the tanker to assess ice hazards.
- The scout vessel maintains a position between the tanker and Columbia Glacier on the trip to the Valdez Marine Terminal. When a laden tanker leaves, an escort vessel acts as a scout through the sound.
- The maximum speed for tankers under ice escort is 6 knots.
- If no safe routing exists, Port Valdez is closed to tanker vessel traffic.

3.11.4.4.4 Weather Restrictions.

The primary weather concern in Prince William Sound is wind. Weather condition restrictions in the Sound include the following:

- If winds are below 30 knots, tankers may loiter in Port Valdez for up to 3 hours. If winds are above 30 knots, the USCG determines whether a tanker may loiter.

- Port Valdez and Valdez Narrows are closed when the steady wind is above 40 knots.
- Outbound tanker transits through Hinchinbrook Entrance are restricted when the steady wind exceeds 45 knots or when the sea states exceed 15 ft.
- For tankers smaller than 150,000 deadweight tons, a third escort vessel participates in outbound transits when the steady wind exceeds 30 knots (the speed at which transits for larger tankers are prohibited).

3.11.5 Exxon Valdez Spill

3.11.5.1 Background

On March 24, 1989, the Exxon Valdez oil tanker went off course and ran aground on Bligh Reef in northeastern Prince William Sound (State of Alaska 1990). The tanker was carrying a full cargo of more than 1.25 million bbl of crude oil. Approximately 257,000 bbl of oil, or more than 10 million gal, was spilled (Boehm et al. 1998).

The Exxon Valdez oil spill occurred under calm winds, and the oil spread slowly southwest. Within three days, however, a northerly gale blew the oil slick beyond any hope of containment. The storm thoroughly mixed the initial slick with subsurface seawater by wave action, promoting the solution of sparingly soluble petroleum hydrocarbons. Trace amounts of the polycyclic aromatic hydrocarbon (PAH) component of the oil were measured at water depths to 15 ft. Subsequent measurements showed concentrations of PAHs were highest near heavily oiled beaches (TAPS Owners 2001a).

By May 1989, most of the floating oil either had been removed by skimmers, had left the coastal area, had evaporated, had degraded, or was stranded on the shoreline or in sediments. Estimates of the amount of oiled shoreline vary. Exxon Corporation reported oil on at least 2,090 of the 5,470 km of shoreline surveyed in 1989, or about 15% of the area's 14,480-km shoreline. Other investigators reported some 5,221 km of

shoreline was oiled to some degree, of which 912 km of shoreline was moderately to heavily oiled (TAPS Owners 2001a).

3.11.5.2 Current Conditions

Boehm et al. (1998) performed field studies to examine sediments from two bays on Knight Island located in Prince William Sound. The sample locations were the Bay of Isles, which was heavily oiled by the Exxon Valdez spill, and Drier Bay, which received little impact from the spill. Bottom sediment samples showed hydrocarbons from four sources: (1) North Slope crude oil that Boehm et al. attributed to the spill; (2) oil from natural oil seeps; (3) pyrogenic sources (i.e., residue from the atmospheric fallout of hydrocarbon combustion products [either fossil fuels such as coal and oil, or other sources such as wood]); and (4) biogenic sources (i.e., hydrocarbons from biological processes in the sediments).

The field measurements by Boehm et al. (1998) noted that the Bay of Isles had proportionally significantly more hydrocarbons from North Slope origins (46.3%) than did Drier Bay (1.7%). However, the highest concentrations of total PAHs in sediment were measured in Drier Bay (1,500 ng/g); they were almost twice the highest concentration measured in the Bay of Isles (800 ng/g). The higher concentrations measured at Drier Bay were attributed to historic cannery operations and other anthropogenic sources and natural background levels. The study concluded that all measured sediment concentrations were well below the low effects range value of 4,022 ng/g for total PAHs. They

also noted that there was no evidence of large-scale offshore transport of Exxon Valdez crude to subtidal sediments.

Sediment Contamination from the Exxon Valdez Oil Spill

Study results for two bays indicated that the Bay of Isles has a higher proportion of hydrocarbons that came from North Slope origins (including the Exxon Valdez oil spill). However, Drier Bay has higher PAH concentrations, which came from natural sources and anthropogenic sources other than the oil spill. All concentrations were well below the low effects range.

There was no evidence of large-scale offshore transport of Exxon Valdez crude to subtidal sediments.

3.11.6 Tsunamis

The tanker loading berths at the Valdez Marine Terminal have been designed for estimated maximum tsunami wave and wave run-up conditions that can be expected at Jackson Point (Stipulation 3.7). The oil storage tanks were built above the estimated tsunami run-up to reduce the probability of the tanks' being compromised by a tsunami.

Tsunami Wave Action

The berths at Valdez Marine Terminal are designed to be protected from tsunami damage.

3.12 Climate and Meteorology

Alaska has a variable climate because of its large size, position between two oceans, high latitude, and wide range in altitude of land surface (USGS 2001b). The five major climate zones of Alaska, as described relative to the state's geographical subdivisions (Map 3.12-1), are (1) a maritime zone that includes southeastern Alaska, the south coast, and southwestern islands; (2) a maritime-continental zone that includes the western portions of Bristol Bay and the west-central zones; (3) a transition zone between continental and maritime zones in the southern portion of the Copper River zone, the Cook Inlet zone, and the northern extremes of the south coast zone; (4) a continental zone made up of the remainders of the Copper River and west-central divisions, and the interior basin; and (5) an arctic zone shown in Map 3.12-1 as the arctic drainage division (Ruffner 1985). Summary descriptions of climate and meteorological conditions along the TAPS ROW are presented in Map 3.12-2. Further details are provided in reports by Searby (1968); Ruffner (1985); WRRC (1999); and USGS (2001b).

The TAPS spans all climatic zones of Alaska except the maritime-continental zone. The weather data recorded at six National Weather Service (NWS) stations along the TAPS ROW (Barrow, Bettles, Fairbanks, Delta Junction, Gulkana, and Valdez) are used to characterize the climate and meteorological conditions at various TAPS facilities. All of these weather stations except the Barrow station are located within about 30 mi of TAPS facilities. The Barrow station is located about 200 mi west of Prudhoe Bay, near where PS 1 is located. Information from the Barrow station, however, is considered representative of Prudhoe Bay because both the station and the bay are located in the same climate zone, and there are no physical terrain obstructions between the two.

The TAPS facilities and cities where the six NWS stations are located are also shown in Map 3.12-1. A summary of climatic and meteorological data at these weather stations is provided in Table 3.12-1 and briefly discussed below.

3.12.1 Wind

Wind roses for the six NWS stations and Prudhoe Bay for the period of record 1990 to 1995 and 1991 to 1995, respectively, are shown in Map 3.12-3. (The wind rose for the Barrow NWS station shows strong similarity in prevailing wind directions to the wind rose for the Prudhoe Bay Pad A station.) Prevailing wind directions are east-northeast, north-northwest quadrant, north, east-southeast, south, and east-northeast for Barrow, Bettles, Fairbanks, Big Delta, Gulkana, and Valdez, respectively.

Wind Rose

A wind rose is a graphical representation summarized on a polar diagram of the wind speed and wind direction over a given period at a particular location. The positions of the spokes show the direction from which the wind was blowing, and the length of the segments indicate the percentage of the wind speed categories represented by the width of spokes.

Among the six NWS stations, winds are weakest at Fairbanks, with an annual mean wind speed of 5.3 mph (NCDC 2000). The monthly mean wind speed at Fairbanks varies from a minimum of 3.0 mph in December to a maximum of 7.5 mph in May. Barrow shows strongest winds with an annual mean wind speed of 12.5 mph. The monthly mean wind speed at Barrow ranges from a minimum of 11.8 mph in March to a maximum of 13.6 mph in October.

3.12.2 Temperature and Humidity

The lowest annual mean temperature recorded among the six NWS stations is 9.4°F at Barrow and the highest is 37.7°F at Valdez. The lowest monthly mean temperature varies from -17.8°F at Barrow in February to 20.5°F at Valdez in January, while the highest monthly mean temperature ranges from 39.3°F at Barrow to 62.5°F at Fairbanks, both occurring in July.

Figure 3.12-1 shows plots of annual average temperatures at the six NWS stations since 1974, when construction of the TAPS facilities began. The annual average temperatures at these stations appear to have changed little during the 27-year period (1974-2000), except at Barrow. An increase of about 4.5°F over the period (about 0.2°F per year on average) is suggested at this station. However, a longer-term record since 1921 indicates that there is no clear increasing or decreasing trend in annual average temperature at Barrow (ACRC 2002).

The range of annual mean relative humidity is from 65% at Fairbanks to 81% at Barrow. The lowest monthly mean relative humidity varies from 50% at Fairbanks in May to 72% at Valdez in February; the highest monthly mean relative humidity ranges from 74% at Fairbanks in October to 91% at Barrow in August.

3.12.3 Precipitation and Evaporation

Among the six NWS stations, Valdez receives the greatest amount of precipitation, with a mean annual precipitation total of 64.04 in. The remaining five stations each average less than 14 in. of precipitation annually, with Barrow receiving the smallest amount (4.49 in.). The mean annual snowfall total also shows a similar pattern, with the greatest amount at Valdez (315.7 in.) and the smallest amount at Barrow (28.7 in.).

Although most of the areas surrounding TAPS facilities receive relatively small amounts of precipitation, the low temperatures, high humidity, and cloudy skies that prevail over most of the state minimize the rate of evaporation. Short summers minimize the time during which vegetation actively grows and, thus, negligible amounts of water are returned to the atmosphere by evapotranspiration (USGS 2001b).

3.12.4 Fog

The average number of days with heavy fogs with visibility equal to or less than 0.25 mi

ranges from 6.7 days per year in Bettles to 59.2 days in Barrow. During the winter at temperatures of -20°F or colder, dense ice fog is frequently formed from water vapor generated by domestic combustion sources in urban areas. In Fairbanks, the largest urban area along the TAPS ROW, cold snaps accompanied by ice fog generally last from about one to three weeks. The fog is usually about 300 ft deep, so that surrounding uplands are usually in the clear, with warmer temperatures. Visibility in the ice fog is sometimes quite low, which can hinder aircraft operations for as much as several days in severe cases (TAPS Owners 2001a).

3.12.5 Severe Weather

On the average, thunderstorms occur on less than 8 days per year; the highest frequency is 7.5 days per year at Bettles, and the lowest frequency is 0.1 day per year at Barrow. Only one tornado was reported in Alaska during the period of record 1950 to 1996. The tornado that was reported was a small one on November 4, 1959, that caused minor damage near Cape St. Elias Light Station on Kayak Island, about 105 mi southeast of Valdez (Storm Prediction Center 1999).

3.12.6 Atmospheric Dispersion Characteristics

Atmospheric dispersion improves if the wind speed increases (resulting in improved ventilation), stability conditions of the atmosphere become more unstable (resulting in enhanced vertical mixing), and the depth of mixing layer (or mixing height) increases (resulting in increased space for pollutants to

Atmospheric Stability

Stability conditions of the atmosphere reflect the degree of vertical mixing. Under stable conditions, pollutants disperse more slowly than under unstable conditions when more vigorous vertical mixing occurs.

¹ Ice fog is composed of suspended particles of ice, partly ice crystals 20 to 100 µm in diameter.

TABLE 3.12-1 Summary of Climatic and Meteorological Data at Six NWS Stations along the TAPS

Parameter	Meteorological Parameter	NWS Station					
		Barrow	Bettles	Fairbanks	Delta Junction	Gulkana	Valdez
Wind speed (mph)	Annual mean	12.5	6.4	5.3	8.4	6.6	6.2
	Monthly mean, range	11.8 Mar.	5.6 Jan.	3.0 Dec.	6.1 July	3.5 Dec.	4.2 Aug.
		13.6 Oct.	7.6 Apr.	7.5 May	10.9 Jan.	8.9 May	8.2 Feb.
Wind direction (degree) ^a	Prevailing	70	330	360	100	170	60
Temperature (°F)	Annual mean	9.4	22.0	26.9	27.8	27.0	37.7
	Monthly mean, range	-17.8 Feb.	-12.7 Jan.	10.1 Jan.	-4.0 Jan.	-5.7 Jan.	20.5 Jan.
		39.3 July	59.1 July	62.5 July	60.2 July	57.4 July	54.9 July
Relative humidity (%)	Annual mean	81	69	65	68	71	77
	Monthly mean, range	70 Feb.	60 June	50 May	56 May	58 May	72 Feb.
		91 Aug.	78 Oct.	74 Oct.	79 Oct.	80 Nov.	85 Aug.
Precipitation (in.)	Annual total	4.49	13.74	10.87	11.96	10.87	64.04
	Monthly total, range	0.15 Feb.	5.6 Jan.	0.32 Apr.	0.25 Mar.	0.24 Apr.	3.08 June
		0.96 Aug.	7.6 Apr.	1.96 Aug.	2.72 July	1.78 July	8.37 Sep.
	Annual snowfall	28.7	82.9	70.8	45.9	48.0	315.7
Heavy fog ^b (no. of days)	Annual mean	59.2	6.7	17.7	9.0	12.8	15.8
Thunderstorm (no. of days)	Annual mean	0.1	7.5	6.8	5.1	4.4	1.1

TABLE 3.12-1 (Cont.)

Parameter	Meteorological Parameter	NWS Station					
		Barrow	Bettles	Fairbanks	Delta Junction	Gulkana	Valdez
Mixing height (m)	Morning, annual mean	403	- ^c	293	-	-	-
	Seasonal range	263 winter	-	150 winter	-	-	-
		661 fall		419 summer	-	-	-
	Afternoon, annual mean	312	-	1,115	-	-	-
	Seasonal range	166 winter	-	149 winter	-	-	-
		388 summer	-	1,895 summer	-	-	-

^a For wind direction, the word “degree” refers to compass direction, which is divided into 360 degrees. Clockwise on a compass, east is 90 degrees, south is 180 degrees, west is 270 degrees, and north is 360 degrees.

^b With visibility $\leq$ 0.25 mi.

^c A dash indicates data are not available.

Source: NCDC (2000; 2001a).

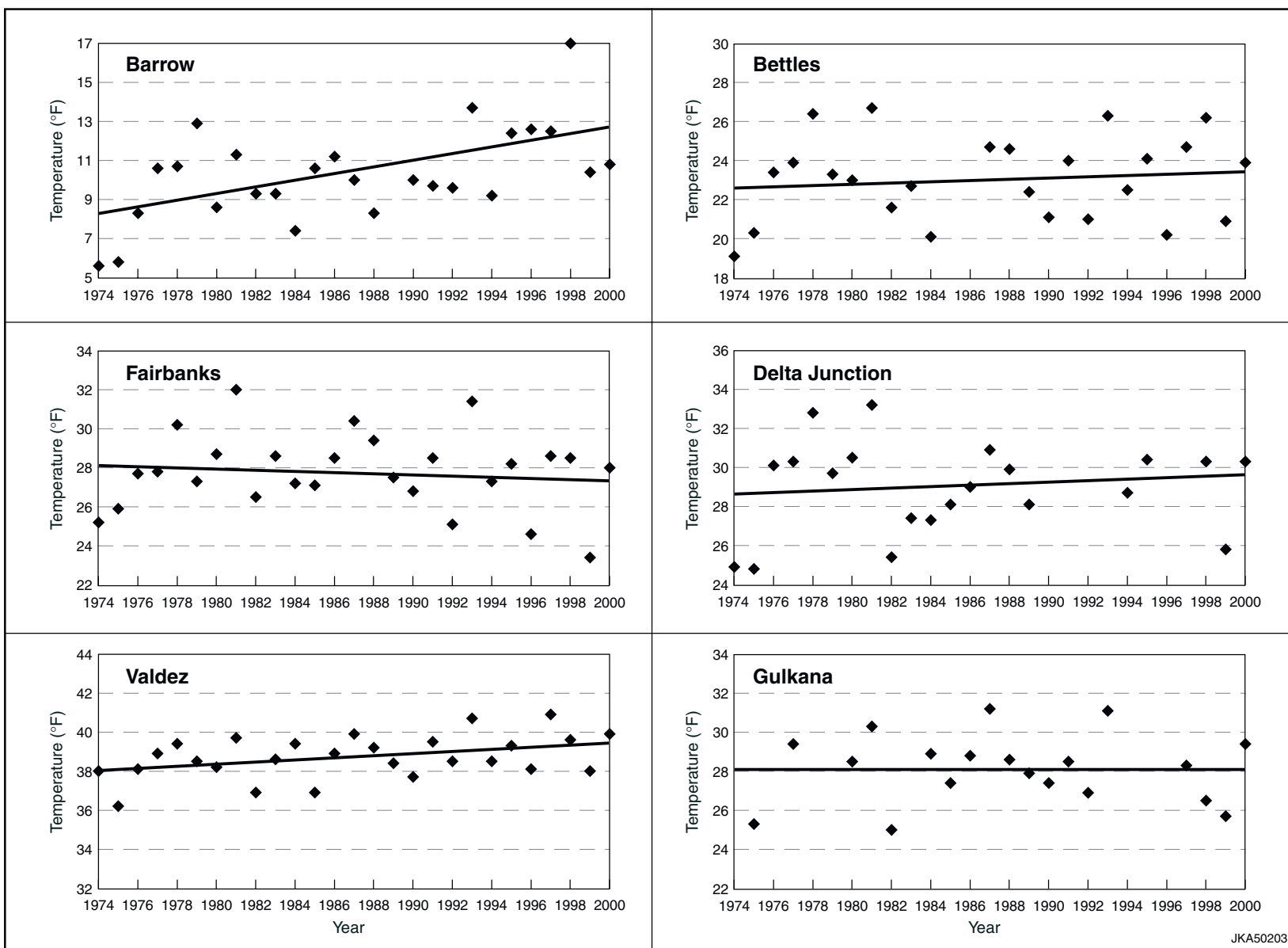


FIGURE 3.12-1 Trends in Annual Average Temperatures at Six National Weather Service Stations along the TAPS

disperse). The prevalent stability conditions are neutral (about 70% of the time) in Prudhoe Bay and the Kuparuk River areas (Mitchell and Timbre 1979). Neutral stability conditions are also most prevalent at all of the six NWS stations (Barrow, Bettles, Fairbanks, Big Delta, Gulkana, and Valdez), with frequencies of occurrence of about 81, 50, 41, 58, 52, and 66% of the time, respectively. Frequencies of occurrence of stable conditions that represent poor dispersion conditions are 15, 32, 38, 10, 12, and 21% of the time at Barrow, Bettles, Fairbanks, Big Delta, Gulkana, and Valdez, respectively.

The mixing height (or depth) defines the height above the surface through which relatively vigorous vertical mixing occurs. For the two NWS stations at which mixing height data are collected (Barrow and Fairbanks), the annual mean morning mixing height ranges from 293 m at Fairbanks to 403 m in Barrow, while the annual mean afternoon mixing height ranges from 312 m at Barrows to 1,115 m at Fairbanks.

3.12.7 Climate Change in Alaska

3.12.7.1 Introduction

Since the late 19th century, the average global surface temperature has increased 0.6°C (Folland and Karl 2001). Most of the increase has occurred in two periods — from about 1910 to 1945, and since 1976. The warming periods were separated by a slight cooling period. The warming after 1976 was detected globally and is manifested in the Northern Hemisphere continents during winter and spring. A similar warming pattern has been observed in Alaska during the 20th century (Center for Global Change and Arctic System Research 1999).

The change of climate in Alaska can potentially affect the reliability of the TAPS. The following section describes the historical climate trends over the last several decades in Alaska, especially in areas traversed by the TAPS. The areas described extend from the Arctic Ocean to the southern margin of the permafrost (near MP 735–736).

3.12.7.2 Historical Climate Trends in Alaska

3.12.7.2.1 Surface Air

Temperature. Between 1961 and 1990, the surface air temperature in Alaska increased. Using data on monthly air temperatures from land surface stations and monthly sea surface temperatures, Chapman and Walsh (1993) demonstrated that the mean annual air temperature increased at an average rate of 0.5 to 0.75°C per decade in Interior Alaska and the Arctic regions. Seasonally, the rate of increase was significantly higher in winter and spring than in summer and fall. The increase was especially prominent in 1977, when sudden increases of 1.5° and 1.4°C were recorded at Fairbanks and Gulkana, respectively (Osterkamp and Romanovsky 1999). These areas correspond with the central and southern section of the TAPS.

3.12.7.2.2 Arctic Ocean Ice.

Warming has been observed in the Arctic Ocean during the last several decades. This warming is reflected in the decreasing extent of sea-ice cover (Gloersen and Campbell 1991; Cavalieri et al. 1997), sea-ice thickness (Rothrock et al. 1999), and water temperature and salinity (McPhee et al. 1998). By comparing the sea-ice thickness data between 1958 and 1976 and 1993 and 1997, Rothrock et al. (1999) demonstrated that the sea ice in the Beaufort Sea and Chukchi Cap (north of Alaska) has decreased about 0.9 m (2.7 ft) in thickness. Cavalieri et al. (1997) reported that the areal extent of sea ice has decreased 2.9% per decade in the Arctic from November 1978 through December 1996. A similar decrease of sea-ice extent was observed by MCPhee et al. (1998) in Beaufort Gyre (near latitude $75^{\circ}30'\text{N}$ and longitude 145°W). Also, the sea water in the upper 100 m (330 ft) was warmer in 1990s than in mid-1970s.

3.12.7.2.3 Permafrost.

Measuring temperatures in permafrost has been proposed as a useful method for detecting climate change in the past (Smith and Riseborough 1996; Lachenbruch and Marshall 1986). To this end, temperature data have been collected from bore

holes for the permafrost in Alaska over the last two decades. Using oil exploration wells distributed in the Arctic Coastal Plain and the foothills, Lachenbruch and Marshall (1986) measured the temperatures of permafrost to depths of more than 600 ft and showed that the mean surface temperature is likely to have warmed 2° to 4°C during the last few decades to a century. Since the early 1980s, Osterkamp and Romanovsky (1999) have collected temperature data for the discontinuous permafrost in Alaska. Most of the sites they selected are along a north-south transect parallel with the TAPS from Old Man through Yukon River Bridge, Fairbanks, Birch lake, Bonanza Creek, to Gulkana. The observation sites were on undisturbed permafrost and far from surface water bodies. From the late 1980s to 1996, the temperatures at the permafrost table of these sites were 0.5° to 1.5°C warmer. The permafrost table near the University of Alaska at Fairbanks was lowered at a rate of 0.1 m/yr (0.33 ft/yr) (Osterkamp and Romanovsky 1999).

3.12.7.2.4 Field Evidence for Warming in Alaska. In addition to the inference from temperature measurements for surface air, sea ice, and permafrost, field evidence supports the hypothesis that Alaska has experienced a warming climate over the last several decades. The glaciers in Alaska have retreated. Thermokarst lakes have developed near Mentasta, Cantwell, and Healy, in the Tanana River floodplain (Osterkamp and Romanovsky 1999). It should be noted that the thermokarst lakes developed near Healy were extensive and occurred on undisturbed ground (Osterkamp and Romanovsky 1999). Near the southern margin of the permafrost (MP 735-736), the permafrost table has lowered because of thawing (Michael Baker, Jr., Inc., 2001). Warming of permafrost in the discontinuous permafrost zone resulted in persistent creep movements on slopes on the banks of Squirrel Creek (MP 715-720), Klutina Hill (MP 698), and Tazlina Hill (MP 687) (APSC 2000b).

3.13 Air Quality

Air quality in a given area is a function of the air pollutant emissions in that area (type of pollutant, rate, frequency, duration, exit conditions, and location of release), atmospheric conditions (climate and meteorology), characteristics of the area itself (size of air shed and topography of the area), and the presence of pollutants transported from outside the area. Air quality along most of the TAPS ROW is generally considered very good because of minimal human habitation and industrial development. Localized sources of emissions include man-made (anthropogenic) sources of industrial, residential, and transportation-related emissions, and natural sources of windblown dust and forest fires, which contribute to temporary increases in air pollution.

3.13.1 Existing Emissions

Air pollutants generated at TAPS facilities consist of emissions from stationary, mobile, and fugitive sources. Stationary sources include fuel-burning equipment such as pipeline turbine/pump units, booster pumps, power generation turbines, process and space heaters, water pumps, incinerators, and petroleum storage tanks. In addition, air pollutants are emitted from open burning at TAPS facilities and along the pipeline. Mobile sources include vehicles, such as passenger vehicles and light-duty trucks operated by APSC and its employees, and heavy construction equipment.

Fugitive emissions of air pollutants occur from vehicular traffic as road dust, dust generated by earthmoving activities of heavy equipment, and leaks or programmed releases from petroleum-handling equipment (e.g., from valves and fittings).

Tables 3.13-1 and 3.13-2 list the size (rating, capacity, or throughput) and number of stationary sources permitted to operate at each of the TAPS pump stations and the Valdez Marine Terminal, respectively. All TAPS facilities use liquid fuel¹ for fuel-burning equipment, except for PS 1 through 4. At those pump stations, natural gas from the North Slope production facility is used as the primary fuel, with liquid fuel as a backup (TAPS Owners 2001a). The sulfur content of the liquid fuel used at each TAPS facility is limited by permit conditions: 0.24% (by weight) for PS 3, 4, 6 through 10, and 12; 0.3% for PS 1 and 2; and 0.5% for Valdez Marine Terminal. Pump Station 5 does not have a fuel sulfur content limit; however, a liquid fuel with a sulfur content equal to or less than 0.5% is used at this facility.

Each of the TAPS pump stations, except PS 5, and the Valdez Marine Terminal are regulated individually with an (air quality) operating permit issued by the State of Alaska. An air quality permit has not been required for PS 5 because the emissions from existing sources are below the threshold for a permit under state regulations. Under the new state Title V permitting program, which was established by the Clean Air Act Amendment of 1990 and delegated to the state, all TAPS facilities, including PS 5, have applied for new operating permits. Some equipment at PS 2 and 7 and the Valdez Marine Terminal are also subject to various limits of the Prevention of Significant Deterioration (PSD) regulations, also established under the Clean Air Act.

Pump stations 2, 6, 8, and 10 are currently in rampdown mode, and, therefore, current actual emissions from these pump stations are substantially less than the potential emissions described below.

¹ Characteristics of liquid turbine fuel used at TAPS facilities are similar to those of fuel oil. The fuel supplier blends No. 1 and No. 2 turbine fuels to obtain the desired level of sulfur content.

TABLE 3.13-1 Stationary Emission Sources Installed at TAPS Pump Stations^a

Equipment Unit	Rating/Capacity/ Throughput	Number of Units										
		PS 1	PS 2 ^b	PS 3	PS 4	PS 5 ^c	PS 6 ^b	PS 7	PS 8 ^b	PS 9	PS 10 ^b	PS 12
Avon gas generator (mainline turbine/ pump unit)	24,600 EGHP ^d	3	2	3	3	— ^e	3	2	3	3	3	3
Solar turbine booster pump	1,135 hp	3	—	—	—	—	—	—	—	—	—	—
Solar turbine injector pump	12.6 × 10 ⁶ Btu/h	—	—	—	—	2	—	—	—	—	—	—
Cummins/Detroit fire water pump	1.17~1.84 × 10 ⁶ Btu/h	1	1	—	1	—	1	1	—	1	1	—
Solar turbine electric generator	12.6 × 10 ⁶ Btu/h	—	—	—	—	—	2	—	1	—	1	—
Solar turbine electric generator	800 kW	2	3	2	1	1	—	2	—	1	—	1
Garret turbine electric generator	510 kW	5	—	3	3	3	6	—	2	1	5	1
Detroit diesel electric generator	354~731 kW	—	1	3	—	—	2	1	—	—	5	—
Solar turbine gas compressor	1,135 hp	2	—	—	—	—	—	—	—	—	—	—
Eclipse therminol heater	20.6 × 10 ⁶ Btu/h	3	—	2	2	2	2	—	2	2	2	2
Broach compressor module heater	3.0 × 10 ⁶ Btu/h	1	—	—	—	—	—	—	—	—	—	—
Carotek heater	7.8 × 10 ⁶ Btu/h	—	2	—	—	—	—	2	—	—	—	—
Personnel-living quarter space heater ^f	0.763 × 10 ⁶ Btu/h	2	—	—	1	2	—	—	—	—	—	—
Applied air systems heater	2.8 × 10 ⁶ Btu/h	—	—	1	—	—	—	—	—	—	—	—
Topping unit crude (Born) heater	35.0 × 10 ⁶ Btu/h	—	—	—	—	—	1	—	1	—	1	—
Weils McClain boiler	1.7 × 10 ⁶ Btu/h	—	—	2	—	—	—	—	—	—	—	—
Topping unit flare	44.8 × 10 ⁶ Btu/h	—	—	—	—	—	1	—	1	—	1	—
Vapor recovery flare	32.2 × 10 ⁶ Btu/h	1	—	—	—	—	—	—	—	—	—	—
Solid waste incinerator	1.0~2.4 × 10 ⁶ Btu/h	1	1	2	1	1	1	1	—	—	1	1
Crude breakout tank	55,000 bbl	2 ^g	1	1	1	1	1	1	1	1	1	1
Turbine fuel tank	3,500~20,000 bbl	1	6	1	1	—	2	2	2	2	2	2
Topping unit residuum tank	1,000 bbl	—	—	—	—	—	1	—	1	—	1	—
Miscellaneous fuel tank	1,000~10,000 bbl	—	1	—	—	—	—	—	—	—	1	—

See next page for footnotes.

TABLE 3.13-1 (Cont.)

- a With operating permits from ADEC.
 - b Pump stations are currently in rampdown mode.
 - c PS 5 does not require an air quality permit because the emissions from existing sources are below the threshold level for a permit under Alaska state regulations. (Source: TAPS Owners 2001a).
 - d Exhaust-gas horsepower.
 - e A dash indicates no units installed.
 - f Source: TAPS Owners (2001a).
 - g Crude breakout tank capacity at PS 1 is 420,000 bbl.
- Source: ADEC (1996a-j), except as noted.

TABLE 3.13-2 Stationary Emission Sources^a Installed at Valdez Marine Terminal

Equipment Category	Equipment Unit	Rating/Capacity/ Throughput for Each Unit	Number of Units
Power boilers	Combustion engineering power boiler	242×10^6 Btu/h ^b	3
Incinerators	John Zink waste gas incinerator	400×10^6 Btu/h	3
	Therm-Tec solid waste incinerator	800 lb/h	1
Diesel-fired generators	General Motors emergency generator	1,670 kW	1
	Stewart-Stevenson lifeline generator	1,050 kW	1
Diesel-fired pumps	Cummins main firewater diesel pump driver	1,325 hp	3
	Cummins east firewater diesel pump driver	763 hp	2
	Cummins west firewater diesel pump driver	864 hp	2
Petroleum storage tanks	East Tank Farm crude oil tank	510,000 bbl	14
	West Tank Farm crude oil tank	510,000 bbl	4
	Fuel oil/diesel/gasoline tank	87,171 bbl ^c	16
	Used oil storage tank	1,000 gal	1
Fire training site equipment	Fire training fuel tank	1,300 gal ^c	3
	Fire training pit	NA ^d	1
Ballast water treatment system equipment	Recovered crude tank	36,000 bbl	2
	Ballast water storage tank	430,000 bbl	3
	Dissolved air flotation tanks	5,800 gal/min	6
	Dissolved air flotation effluent channel	30×10^6 gal/d	1
	Biological treatment tanks	5.5×10^6 gal	2
	Air stripper	20,000 scfm	4
Marine vapor collection system equipment	Tanker loading berth with vapor collection	100,000 bbl/h ^e	2
	Tanker loading berth without vapor collection	100,000 bbl/h ^e	2

^a Sources with operating permits from ADEC.

^b Hart (2001).

^c Total capacity.

^d NA = not applicable.

^e Loading capacity.

Source: ADEC (1996k).

3.13.1.1 Criteria Pollutants

Estimated potential emissions² of criteria pollutants³ and volatile organic compounds (VOCs)⁴ from each pump station and the Valdez Marine Terminal are listed in Table 3.13-3. As shown in the table, the Valdez Marine Terminal is the largest emission source of ozone precursors (nitrogen oxides [NO_x] and VOCs) and particulate matter with a diameter of 10 μm or less (PM₁₀). PS 10 is the largest emission source for sulfur dioxide (SO₂), and PS 2 is the largest emission source for carbon monoxide (CO). The sources with the least emissions are PS 2 for SO₂, PS 5 for NO_x, PS 5 for CO, PS 2 and 5 for PM₁₀, and PS 4 and 5 for VOCs. Current emission levels at PS 2, 6, 8, and 10 are lower than the values listed in Table 3.13-3 because these pump stations are currently in rampdown mode. Table 3.13-4 lists the estimated potential emissions of criteria pollutants from other major emission sources located in the vicinity of TAPS facilities. It also gives the emissions from the nearby TAPS facility and the significance of TAPS facility emissions as a percentage of the total emissions.

PS 1 is one of many industrial facilities in the North Slope area. Criteria pollutant and VOC emissions from PS 1 contribute only a small fraction of the North Slope area emissions (less than 5% of each criteria pollutant and VOC). PS 7, located about 30 mi north-northwest of Fairbanks, or PS 8, located about 25 mi southeast of Fairbanks, are minor contributors in the area; each contributes less than 10% of each criteria pollutant and VOC emissions.

Fort Greely is the only facility in the vicinity of PS 9 or 10 (located about 5 mi east and 30 mi

south of Fort Greely, respectively), with emission levels comparable to those from PS 9 or 10. The Valdez Marine Terminal is the dominant emission source in the Valdez area; it contributes 90% or more of each criteria pollutant and VOC to the total emissions. No major emission sources are located near the pump stations that are not listed in Table 3.13-4 (PS 2 through PS 6 and PS 12); emissions from these pump stations represent the largest contributions to the emissions in their vicinities.

Table 3.13-5 presents actual 2001 emissions of criteria pollutants and VOCs from the vehicles used for TAPS operation at various TAPS facilities and along various sections of the pipeline. The TAPS facility or the section along the pipeline with the largest vehicle-related emissions is Valdez Marine Terminal, with annual emission rates of 0.4, 4.8, 25.9, 0.7, and 2.4 tons per year of sulfur oxides (SO_x), NO_x, CO, PM₁₀, and VOCs, respectively. These emission rates represent about 0.02, 0.3, 19, 0.2, 0.04%, respectively, of the emissions of SO_x, NO_x, CO, PM₁₀, and VOCs from the stationary sources at Valdez Marine Terminal (Table 3.13-3). These emissions, except for CO, are very small compared with the emissions from stationary sources at the Valdez Marine Terminal. The total vehicle-related emissions for the entire TAPS listed in Table 3.13-5 similarly show that they are small compared with the total emissions from all TAPS stationary sources (Table 3.13-3). They are equivalent to about 0.04, 0.3, 1.7, 0.5, and 0.2% of SO_x, NO_x, CO, PM₁₀, and VOC emissions from stationary sources, respectively.

² Potential emissions refer to the maximum possible emissions calculated on the basis of maximum allowable fuel use and/or other equipment operating parameters that determine emissions.

³ Criteria pollutants are a group of very common air pollutants regulated by EPA on the basis of criteria (information on health and/or environmental effects of pollution) and for which National Ambient Air Quality Standards (NAAQS) were established. Criteria pollutants include: sulfur dioxide (SO₂), nitrogen dioxide (NO₂), ozone (O₃), particulate matter (PM₁₀ and PM_{2.5}), carbon monoxide (CO), and lead (Pb).

⁴ A volatile organic compound (VOC) is defined by EPA as any organic compound that participates in atmospheric photochemical reactions. All organic or carbon-containing chemicals are considered VOCs unless they have been specifically excluded (FR Vol. 62, No. 164, pp 44900–44903).

TABLE 3.13-3 Estimated Potential Emissions of Criteria Pollutants from Existing TAPS Facility Sources^a

TAPS Facility	Annual Emission Rate (tons/yr)					
	SO ₂	NO _x	CO	PM ₁₀	Pb	VOCs
PS 1	39	771	543	120	_b	28
PS 2 ^c	12	608	748	33	–	64
PS 3	44	678	427	106	–	12
PS 4	45	626	400	97	–	8
PS 5 ^d	65	175	50	33	–	8
PS 6 ^c	655	1,333	176	100	–	46
PS 7	373	913	389	72	–	28
PS 8 ^c	618	1,115	126	90	–	41
PS 9	581	1,207	451	91	–	37
PS 10 ^c	1,765	1,393	298	107	–	46
PS 12	578	1,196	458	95	–	39
VMTE ^e	1,757	1,578	137	278	–	3,464 ^f
Total	6,532	11,593	4,203	1,222	–	3,821

^a ADEC (1996a-k) unless otherwise noted. Potential annual emission rates for combustion sources were calculated values based on maximum allowable annual fuel use rates and tested source, or EPA's AP-42 emission factors (EPA 2001a). Actual emissions are generally smaller.

^b A dash indicates that the amount emitted is estimated to be negligible.

^c Pump stations are currently in rampdown mode.

^d PM₁₀ and VOC emission rates at PS 5 are not available, but conservatively estimated to be similar to those at PS 2 and PS 4, respectively.

^e VMT = Valdez Marine Terminal; source: Norton (2001b).

^f Thomas (2002a).

TABLE 3.13-4 Comparison of Estimated Potential Emissions from TAPS Facilities with Those from Major Facilities Located in Adjacent Areas

Facilities	Annual Emission Rate (tons/yr)				
	SO ₂	NO _x	CO	PM ₁₀	VOCs
TAPS PS 1	39	771	543	120	28
Adjacent Facilities Prudhoe Bay Unit (Eastern and Western Operating Areas) and Kuparuk River Unit	1,828	66,440	14,212	2,131	1,055
Total emissions ^a	1,867	67,211	14,755	2,251	1,083
% of PS 1 emissions to total emissions	2	1	4	5	3
TAPS PS 7 or 8 ^b	618	1,115	389	89	41
Adjacent Facilities Williams N. Pole Refinery, Golden Valley Electric Assoc., Petro Star North Pole Refinery, Fort Wainwright, Eielson Air Force Base, Aurora Energy, and University of Alaska Power Station	9,625	10,711	5,221	2,550	407
Total emissions	10,243	11,826	5,610	2,639	448
% of PS 7 or 8 emissions to total emissions	6	9	7	3	9
TAPS PS 9 or 10 ^b	1,765	1,393	451	106	46
Adjacent Facilities Fort Greely ^c	370	1,169	589	94	157
Total emissions	2,135	2,562	1,040	200	203
% of PS 9 or 10 emissions to total emissions	83	54	43	53	23
Valdez Marine Terminal	1,757	1,578	137	278	3,464
Adjacent Facilities Petro Star Refinery, City of Valdez, Valdez Airport	128	111	— ^d	30	—
Total emissions	1,885	1,689	—	308	—
% of VMT emissions to total emissions	93	93	—	90	—

^a Total emissions are the sum of emissions from TAPS facilities and nearby major stationary sources.

^b Emission rates listed are the higher values between the two pump stations.

^c Fort Greely is currently closed for military use. PSD application for future use of the base for the national missile defense project is in preparation.

^d A dash indicates that no data are available.

Source: HMM (2001a).

TABLE 3.13-5 Estimated 2001 Emissions of Criteria Pollutants and VOCs from Vehicles Used for TAPS Operation

Location Where Vehicles Are Assigned ^a	Annual Emission Rate (tons/year) ^b				
	SO _x	NO _x	CO	PM ₁₀	VOCs
PS1 - PS3	0.11	1.48	2.11	0.29	0.56
PS2 - PS3	0.04	0.71	0.87	0.10	0.21
PS3 - 00 ^c	0.00	0.00	0.00	0.00	0.00
PS3 - PS3	0.18	3.04	4.22	0.43	0.93
PS3 - PS4	0.10	1.36	1.72	0.26	0.50
PS5 - Fairbanks	0.11	1.62	2.08	0.27	0.55
PS6 - Fairbanks	0.06	0.93	1.16	0.16	0.32
Livengood - Fairbanks	0.07	1.40	1.93	0.17	0.38
PS7 - Fairbanks	0.09	1.22	2.29	0.22	0.46
Fairbanks	0.05	0.66	1.28	0.11	0.24
Fairbanks - Fairbanks Fabrication Facility	0.02	0.27	0.64	0.05	0.11
Fairbanks - Van Horn Facility	0.67	9.70	14.78	1.63	3.36
Fairbanks - Nordale Yard at North Pole	0.07	0.73	1.06	0.18	0.33
Fairbanks - S8	0.02	0.34	0.63	0.04	0.10
Fairbanks - PS9	0.08	1.07	2.27	0.19	0.42
Fairbanks - PS10	0.04	0.52	0.64	0.09	0.17
Fairbanks - Anchorage	0.01	0.06	0.59	0.01	0.04
PS11 - Valdez Marine Terminal	0.07	1.09	1.36	0.19	0.37
PS12 - Valdez Marine Terminal	0.15	2.55	3.21	0.36	0.76
SERVS Facility at Valdez	0.01	0.11	0.49	0.02	0.05
Valdez Marine Terminal - 00 ^c	0.00	0.00	0.02	0.00	0.00
Valdez Marine Terminal	0.43	4.82	25.90	0.67	2.35
Fairbanks - Linewide Application ^d	0.15	2.08	3.46	0.36	0.75
Total	2.54	35.77	72.70	5.81	12.97

^a The location where vehicles are assigned to a TAPS facility exclusively or to operate between two locations.

^b Based on the vehicle-miles-driven for vehicles operated for TAPS business by vehicle type from January 1, 2001, to November 12, 2001 (Hardesty 2001) and the EPA emission factors for SO_x and PM₁₀ (EPA 1995b), and for NO_x, CO, and VOCs (EPA 2002a). Data to November 11 were scaled up by multiplying by the ratio (365/316) to obtain annual emissions; represents exhaust emissions only. VOC emissions are conservatively represented by hydrocarbon (HC) emissions.

^c Designates seasonal equipment such as snowmobile.

^d Assigned to the Fairbanks Business Unit but could be located anywhere along the pipeline and is not assigned to be in any specific location.

3.13.1.2 Hazardous Air Pollutants

In addition to emitting criteria pollutants, TAPS facilities also emit hazardous air pollutants (HAPs),⁵ ozone depleting substances (ODSs), and greenhouse gases (GHGs). Sources of HAPs at TAPS facilities include flaring of vapor released from crude oil tanks, the combustion of the displacement vapors from the vapor recovery system in the power boilers, as well as the incineration of any excess vapors in the vapor incinerators at the Valdez Marine Terminal, releases from breakout tanks, exhausts from combustion equipment, and leaks from various pieces of equipment. Table 3.13-6 lists the potential annual emission rates of various HAPs from TAPS facilities. As the table indicates, the largest HAPs emitter among all TAPS facilities is the Valdez Marine Terminal (123 tons/yr), followed by PS 8 (13 tons/yr). The single HAP with the largest potential emission rate is benzene (50 tons/yr), followed by hexane (44 tons/yr) and toluene (42 tons/yr). All TAPS facilities except the Valdez Marine Terminal are classified as "minor sources" of HAPs; the annual potential emission rate of any individual HAP is less than 10 tons/yr and for all HAPs combined is less than 25 tons/yr.

3.13.1.3 Other Emissions

Currently, an in-service and storage/reserve inventory of ODSs (Halon 1211, Halon 1301, R-11, R-12, R-502, and R-22) is maintained at various TAPS facilities for fire protection and refrigeration purposes. A small fraction of in-service inventory is released into the atmosphere primarily through leaks and accidental releases. Table 3.13-7 gives the inventory of these ODSs at various TAPS facilities in 2000 and gives the number and amounts of releases during 1999 and 2000. Those releases were small, and use of these materials at TAPS facilities will be gradually phased out. Production of ODSs was phased out

in 2000, and they are being replaced as industry develops suitable substitutes.

Combustion of fossil fuels for TAPS facility and equipment operation results in emissions of CO₂, a greenhouse gas. The total annual CO₂ emissions resulting from fossil fuel combustion at all TAPS facilities in 2001 are estimated at about 300,000 tons/yr as carbon (Haas 2002), which corresponds to about 0.004% of the estimated annual global CO₂ emission of 7.3 billion tons of CO₂ as carbon in 1998 attributable to fossil fuel combustion (Marland et al. 2001).

3.13.2 Existing Air Quality

3.13.2.1 Criteria Pollutants

To protect human health and welfare, NAAQS (40 CFR 50) and Alaska Ambient Air Quality Standards (AAAQS) (18 AAC 50.010) establish maximum air pollutant levels that are not to be exceeded. Air Quality Control Regions (AQCRs) have been established to implement the air quality standards. In addition, PSD regulations (18 AAC 50.020) limit the maximum allowable incremental increases in ambient concentrations above an established baseline (Table 3.13-8). By limiting the allowable increases in pollutant concentrations, the PSD regulations were intended to protect air quality in areas attaining the ambient standards from deteriorating up to these standards. As shown in Table 3.13-8, smaller increments are established for Class I areas, such as national parks or wilderness areas, than for other areas (Class II areas). PSD regulations apply to major new sources and modifications to existing sources.

The TAPS ROW passes through two of Alaska's four AQCRs. PS 1 through 10 are located in the Northern Alaska Intrastate AQCR, and PS 12 and the Valdez Marine Terminal are in the South Central Intrastate AQCR. The only

⁵ A hazardous air pollutant (HAP) is defined as any air pollutant listed in Section 112(b) of the Clean Air Act. Although the number of HAPs in the initial list was 189, the current list has only 188 after caprolactam was delisted in 1996. Examples of HAPs include such air pollutant as benzene, toluene, ethyl benzene, and xylene.

TABLE 3.13-6 Estimated Potential Emissions of Hazardous Air Pollutants from TAPS Facility Sources

TAPS Facility	Annual Emission Rate (tons/yr) ^a											Total
	Benzene	Toluene	Ethyl Benzene	Xylene	Hexane	Trimethyl-pentane	Acrolein	Acet-aldehyde	Form-aldehyde	Naphthalene	1,3 Butadiene	
PS 1	0.57	0.47	0.06	0.18	2.93	0.55	0.00	0.13	0.24	0.05	0.00	5.18
PS 2 ^b	0.31	0.28	0.05	0.09	1.54	0.29	0.00	0.07	0.05	0.01	0.00	2.69
PS 3	0.77	0.49	0.05	0.24	2.92	0.54	0.00	0.24	0.27	0.06	0.00	5.58
PS 4	0.35	0.38	0.05	0.21	1.82	0.33	0.00	0.22	0.24	0.05	0.00	3.65
PS 5	0.96	0.58	0.04	0.08	5.63	1.05	0.00	0.00	0.62	0.61	0.00	9.57
PS 6 ^b	0.63	0.41	0.03	0.08	3.45	0.63	0.00	0.03	1.96	1.29	0.00	8.51
PS 7	0.77	0.46	0.04	0.07	4.40	0.81	0.00	0.01	0.59	0.33	0.00	7.48
PS 8 ^b	1.26	0.76	0.06	0.10	7.32	1.37	0.00	0.00	1.46	1.13	0.00	13.46
PS 9	0.23	0.16	0.02	0.03	1.31	0.25	0.00	0.00	1.03	0.71	0.00	3.74
PS 10 ^b	1.07	0.64	0.05	0.09	6.12	1.13	0.00	0.00	1.54	1.16	0.00	11.80
PS 12	0.18	0.14	0.01	0.03	0.99	0.18	0.00	0.00	1.00	0.69	0.00	3.22
VMTC ^c	42.82	37.67	3.30	21.92	5.87	11.00	0.02	0.06	0.15	0.01	0.04	122.9
All	49.92	42.44	3.76	23.12	44.30	18.13	0.04	0.76	9.15	6.10	0.04	197.8

^a Source: Norton (2002). Emissions for PS1 through PS10 and PS12 are from crude oil storage tanks (flared), breakout tanks, combustion equipment, and equipment leaks. Emissions from breakout tanks based on 1995 throughput data and those from crude oil storage tanks (flared) at PS 1 based on 1997 throughput data were adjusted to correspond to the conditions of 2.1 million bbl/d crude oil throughput. Emissions from combustion equipment are based on maximum allowable fuel consumption rates. Current levels of emissions from PS 2, 6, 8, and 10 are lower because of their rampdown-mode operation.

^b Pump stations are currently in rampdown mode.

^c VMT = Valdez Marine Terminal. Sources: Thomas (2001); Goldstein et al. (1992). Emissions from crude oil and other fuel storage tanks, combustion equipment, equipment leaks, uncontrolled vessel loading, and the BWTF. Estimated potential emissions of benzene, toluene, ethyl benzene, and xylene from the BWTF are 41.52, 36.17, 3.27, and 21.77 tons/yr, respectively.

TABLE 3.13-7 Inventory and Emissions of Ozone Depleting Substances (ODSs) from TAPS Facilities

Ozone-Depleting Substance	Usage	Inventory ^a (lb)			Emissions			
					1999		2000	
		In-Service	Storage/ Reserve	Total	No. of Releases	lb/yr	No. of Releases	lb/yr
Halon 1211 (CF ₂ ClBr)	Portable fire	3,228	99	3,327	_b	—	—	—
Halon 1301 (CF ₃ Br)	Total flood fire/inertion	212,013	172,244	384,297	15	11,065	3	2,525
R-11 (CFC-11)	Process refrigeration	911	60	971	—	—	—	—
R-12 (CFC-12)	Process refrigeration	0	209	209	—	—	—	—
R-502 (CFC blend)	Process refrigeration	0	90	90	—	—	—	—
R-22 (HCFC-22)	Process refrigeration	14,063	4,109	18,173	5	444	0	0
	Commercial/chiller refrigeration	60	0	60	—	—	—	—
	Stationary HVAC refrigeration	119	0	119	—	—	—	—

^a Inventory for year 2000.

^b A dash indicates that no data are available.

Source: Thomas (2002b).

TABLE 3.13-8 National Ambient Air Quality Standards (NAAQS), Alaska Ambient Air Quality Standards (AAAQS), and Maximum Allowable Increments for Prevention of Significant Deterioration (PSD)

Pollutant ^a	Averaging Period	NAAQS ^b		AAAQS ^b	PSD Increments (µg/m ³)	
		Primary	Secondary		Class I	Class II
SO ₂	3 hours	— ^c	0.50 ppm (1,300 µg/m ³)	1,300 µg/m ³	25	512
	24 hours	0.14 ppm (365 µg/m ³)	—	365 µg/m ³	5	91
	Annual	0.03 ppm (80 µg/m ³)	—	80 µg/m ³	2	20
NO ₂	Annual	0.053 ppm (100 µg/m ³)	0.053 ppm (100 µg/m ³)	100 µg/m ³	2.5	25
CO	1 hour	35 ppm (40 mg/m ³)	—	40 mg/m ³	—	—
	8 hours	9 ppm (10 mg/m ³)	—	10 mg/m ³	—	—
O ₃	1 hour	0.12 ppm (235 µg/m ³)	0.12 ppm (235 µg/m ³)	235 µg/m ³	—	—
	8 hours ^d	0.08 ppm (157 µg/m ³)	0.08 ppm (157 µg/m ³)	—	—	—
PM ₁₀	24 hours	150 µg/m ³	150 µg/m ³	150 µg/m ³	8	30
	Annual	50 µg/m ³	50 µg/m ³	50 µg/m ³	4	17
PM _{2.5} ^d	24 hours	65 µg/m ³	65 µg/m ³	—	—	—
	Annual	15 µg/m ³	15 µg/m ³	—	—	—
Pb	Calendar quarter	1.5 µg/m ³	1.5 µg/m ³	1.5 µg/m ³	—	—
NH ₃	8 hours	—	—	2.1 mg/m ³	—	—
RSC	30 minutes	—	—	50 µg/m ³	—	—

^a Notation: CO = carbon monoxide; NH₃ = ammonia; NO₂ = nitrogen dioxide; O₃ = ozone; Pb = lead; PM_{2.5} = particulate matter ≤2.5 µm; PM₁₀ = particulate ≤10 µm; RSC = reduced sulfur compounds; SO₂ = sulfur dioxide.

^b NAAQS and AAAQS, other than those for O₃ and PM₁₀ and those based on quarterly and annual averages, are not to be exceeded more than once per year. The O₃ 1-hour standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the standard is less than or equal to 1. The O₃ 1-hour standard applies only to areas that were designated nonattainment when the O₃ 8-hour standard was adopted in July 1997. The O₃ 8-hour standard is attained when the average of the annual fourth-highest daily maximum 8-hour average concentration is less than or equal to the standard. The PM₁₀ 24-hour standard is attained when the expected number of days with a 24-hour average concentration above the standard is less than or equal to 1. The PM₁₀ annual standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard. The PM_{2.5} 24-hour standard is attained when the 98th percentile 24-hour concentration is less than or equal to the standard.

Footnotes continued on next page.

TABLE 3.13-8 (Cont.)

^c A dash indicates that no standards or monitoring data exist.

^d New O₃ 8-hour and PM_{2.5} standards were promulgated by the EPA on July 18, 1997.

Sources: *Code of Federal Regulations*, 40 CFR 50 and 40 CFR 52.21; *Alaska Administrative Code*, 18 AAC 50.010; EPA (2002b).

Air Quality Standards

National Ambient Air Quality Standards (NAAQS) are established by EPA for criteria pollutants for the purpose of protecting public health and welfare as required by the Clean Air Act. (See Table 3.13-8 for numerical values of the NAAQS.)

Prevention of Significant Deterioration (PSD) is a construction air pollution permitting program designed to ensure that ambient air quality does not degrade beyond the NAAQS levels or beyond specified incremental amounts above prescribed base levels. (See Table 3.13-8 for numerical values of the PSD increments.)

Conformity of General Federal Actions requires that no department, agency, or instrumentality of the federal government shall engage in, support in any way, provide financial assistance for license or permit, or approve any activity that does not conform to an applicable state implementation plan (18 AAC 50.725-50.735; 40 CFR 51, Subpart W).

designated nonattainment areas for NAAQS in the vicinity of the TAPS ROW are the Fairbanks and North Pole urban areas, which are designated by EPA as in nonattainment with respect to the NAAQS for CO. None of the TAPS ROW is located within either of these two nonattainment areas. However, ancillary TAPS maintenance and administrative facilities (North Star Terminal and Van Horn Facility) are located off the ROW but within the Fairbanks nonattainment area. Within Alaska, one National Park and three National Wilderness Areas are designated as Class I areas (40 CFR 81.402). The PSD Class I area nearest to the TAPS ROW is the Denali National Park (including the Denali Wilderness, but excluding the Denali National Preserve), located about 80 mi southwest of PS 8 (Map 3.12-1).

Monitored ambient air quality data are available for the areas in the vicinity of three TAPS facilities (PS 1, PS 8, and the Valdez Marine Terminal). For the remaining TAPS facilities (PS 2 through 7, PS 9, PS 10, and

PS 12), ambient air quality is described by using modeled data. Current and past ambient air quality monitoring programs for the areas in the vicinity of TAPS facilities include (1) Prudhoe Bay oil field program (1986–present) and Kuparuk River oil field program (June 1986–June 1987 and November 1990–October 1992) near PS 1, (2) EPA state and local air monitoring program in Fairbanks, Alaska (1996–present), and Williams North Pole Refinery ambient air monitoring program (February 2000–January 2001) near PS 8, and (3) APSC monitoring program (October 1990–March 1993) at the Valdez Marine Terminal.

Table 3.13-9 lists the highest or highest second high concentration among the values observed at these monitoring stations during the monitoring periods, as well as the highest ambient concentrations estimated by modeling conducted to assess potential impacts of proposed operations and modifications of TAPS facilities. Table 3.13-9 also lists the background

Determining Compliance

When ambient air quality data are available from a monitoring station, the observed annual average concentration value is used to determine compliance with the applicable annual ambient air quality standard, and the observed second-highest short-term (equal to or less than 24 hours) average concentration value is used in most cases to determine compliance with the applicable short-term ambient air quality standard.

When the results of a dispersion modeling study are used, the highest value among all the annual average concentration values predicted at individual receptors is used to determine compliance with the applicable annual ambient air quality standard, and the highest value among all the second-highest short-term (equal to or less than 24 hours) average concentration values predicted at an individual receptor location is used in most cases to determine compliance with the applicable short-term ambient air quality standard. (See footnote b in Table 3.13-8 for further details.)

TABLE 3.13-9 Monitored and Modeled Ambient Data for Criteria Pollutants in and around TAPS Facilities

		Ambient Concentration (µg/m ³)										PSD Class II Increments (µg/m ³)					
		Pollutant:	SO ₂			NO ₂	CO		O ₃	PM ₁₀		Pb	SO ₂			NO ₂	
			Averaging Period:	3	24	Annual	Annual	1	8	1	24	Annual	Quarter	3	24	Annual	Annual
				Hours	Hours			Hour	Hours	Hour	Hours			Hours	Hours			Hours
Monitoring/ Modeling Program	Standard:	1,300	365	80	100	40,000	10,000	235	150	50	1.5	512	91	20	25		
	Location																
Prudhoe Bay Oil Field Monitoring ^a	CCP	34	24	3	26	_b	–	116	70	12	–	–	–	–	–		
	GC 1	131	39	3	21	–	–	112	155	12	–	–	–	–	–		
	A Pad	–	–	–	13	–	–	180	–	–	–	–	–	–	–		
Kuparuk River Oil Field Monitoring ^a	CPF 1	44	26	5	16	<1,300	<950	116	108	11	–	–	–	–	–		
	DS-1F	55	10	3	5	<1,300	<950	100	57	7	–	–	–	–	–		
PS Modeling	PS 2 ^c	–	–	–	55	–	–	–	–	–	–	–	–	–	2		
	PS 7 ^c	171	76	19	64	–	–	–	–	–	–	6	2	1	5		
	PS 7 ^d	211	84	21	–	–	–	–	–	–	–	–	–	–	–		
	PS 8 ^d	427	264	66	–	–	–	–	–	–	–	–	–	–	–		
	PS 9 ^d	181	80	20	–	–	–	–	–	–	–	–	–	–	–		
	PS 10 ^d	244	109	27	–	–	–	–	–	–	–	–	–	–	–		
	PS 12 ^d	422	188	48	–	–	–	–	–	–	–	–	–	–	–		
	Generic PS ^e	225	187	15	87	3,600	1,700	–	110	15	–	24	26	1	–		
EPA Monitoring ^f	Fairbanks	–	–	–	–	21,600	13,800	–	98	29	–	–	–	–	–		
Williams Refinery Monitoring ^g	North Pole	107	55	8	12	–	–	–	–	–	–	–	–	–	–		
VMT Monitoring ^h	VMT-TVR	222	65	10	17	2,100	1,100	122	87	15	0.1	–	–	–	–		
VMT Modeling ⁱ	VMT-TVR	1,187	280	23	33	–	–	–	65	11	–	117	34	7	4		

TABLE 3.13-9 (Cont.)

		Ambient Concentration (µg/m³)										PSD Class II Increments (µg/m³)				
		SO2			NO2	CO		O3	PM10		Pb	SO2			NO2	
		Averaging Period:			Annual	1 Hour	8 Hours	1 Hour	24 Hours	Annual	Quarter	3 Hours	24 Hours	Annual	Annual	
		Standard:	1,300	365	80	100	40,000	10,000	235	150	50	1.5	512	91	20	25
Monitoring/ Modeling Program	Location															
	Background	North Slope ^j	10	7	3	3	–	–	–	8	2	–	–	–	–	–
		Beluga Site ^k	13	5	3	2	3,100	1,500	104	32	7	–	–	–	–	–
		Valdez ^l	35	16	3	6	–	–	–	23	7	–	–	–	–	–

- ^a Highest recorded value between 1986 and September 30, 1999 (TAPS Owners 2001a; SECOR 1995). CCP = Central Processing Plant; GC = Gathering Center; CPF = Central Production Facility; DS = Drill Site.
- ^b A dash indicates data not available, not modeled, or not relevant.
- ^c Maximum values estimated by modeling conducted for 1990 PSD application for addition of rim cooling to mainline turbine units (APSC 1990a,b).
- ^d Maximum values estimated by modeling conducted for 1991 application for increase in turbine fuel sulfur content (APSC 1991).
- ^e Maximum values estimated by modeling conducted for 1997 modeling report for generic pump station (PS) under actual maximum operating conditions using fuel with 0.24% sulfur content, including background concentration (APSC 1997).
- ^f Highest (or highest second high) value recorded at ambient monitoring stations in Fairbanks (three stations for CO and two stations for PM₁₀) between 1996 and 2000 (EPA 2001b).
- ^g Highest (or highest second high) value recorded at ambient monitoring stations at the Williams Alaska North Pole Refinery monitoring site between February 1, 2000 and January 31, 2001 (HMH 2001b).
- ^h TVR = Tanker Vapor Recovery; VMT = Valdez Marine Terminal; highest (or highest second high) values recorded at two VMT ambient monitoring sites between 1st quarter 1990 and 1st quarter 1993 (Fluor and TC 1995).
- ⁱ Maximum values estimated by modeling for total post-construction facility impacts conducted for 1995 Valdez Marine Terminal PSD application for tanker vapor recovery system (Fluor and TRC 1995).

Footnotes continued on next page.

TABLE 3.13-9 (Cont.)

- j 1999 measurements at the Alaska North Slope Eastern Region Monitoring Station (DeWandel 2001).
- k Highest background values from the site located in Cook Inlet, used for generic modeling purpose (APSC 1997).
- l Background values estimated from the monitoring data in the Valdez area, used in air quality impact modeling study for the VMT-TVRR project (Fluor and TRC 1995).

concentrations⁶ for the North Slope area and the ambient concentrations monitored at Beluga site in Cook Inlet used as background concentrations for generic modeling purposes. All monitored ambient concentration data are in compliance with applicable ambient air quality standards, with an exception for short-term (24-hour) PM₁₀ concentration data at the GC-1 site in the Prudhoe Bay oil field. This excursion slightly above the ambient standard that occurred during the 1990 to 1992 period was attributed to high winds causing re-entrained fugitive dust from roads and wind erosion from disturbed land (TAPS Owners 2001a). All ambient concentration and increment data estimated by modeling are in compliance with applicable ambient and increment standards.

Ambient air quality has been monitored at three monitoring stations in the Prudhoe Bay area (Central Processing Plant, Gathering Center 1, and Pad A) since 1986. Table 3.13-10 lists ambient concentration levels of SO₂, NO₂, O₃, and PM₁₀ in the Prudhoe Bay area for the period 1987 through 2000. The ambient data over the 14-year period are well below applicable ambient air quality standards and do not show any clear trends of increasing or decreasing.

3.13.2.2 Hazardous Air Pollutants

Table 3.13-11 listed data on the ambient concentrations of six HAPs as collected at four monitoring stations in the Valdez area during the period November 1990 through October 1991, when the average TAPS crude oil throughput was about 1.8 million bbl/d (Goldstein et al. 1992). The data for benzene, toluene, ethyl benzene, m,p-xylene, o-xylene, and n-hexane indicate that ambient concentrations of these HAPs were highest at the East Gate station located near the eastern boundary of the Valdez Marine Terminal for all averaging periods. This finding reflects the fact that the Valdez Marine Terminal is a major emission source of these HAPs in the Valdez area (Table 3.13-6). Ambient

concentrations of HAPs at the Old Valdez station were substantially lower than those at the East Gate station; in general, they were higher than those at the High School and Spit stations.

The HAPs concentration data in Table 3.13-11 were collected during the 1990–1991 period before the installation of the tanker vapor recovery system at the Valdez Marine Terminal in March 1998. It was estimated that recovery of VOCs by the tanker vapor recovery system and subsequent destruction of collected VOCs in incinerators or power boiler furnaces would result in elimination of about 27,600 tons per year of VOCs containing the above-mentioned HAPs (Fluor and TRC 1995), about eight times the current estimate of potential VOC emissions from the Valdez Marine Terminal. Therefore, it is estimated that current ambient HAPs concentrations in the Valdez area would be substantially lower than the values listed in Table 3.13-11.

Neither the EPA nor the State of Alaska has established ambient HAP standards. The EPA guideline levels for these HAPs that were used to rank HAPs toxicity under the Clean Air Act and potential health effects due to exposures to these HAPs are discussed in Section 3.17.2.4.

3.13.2.3 Visibility

Information on heavy fogs and ice fogs that limit visibility in the vicinity of the TAPS ROW is described in Section 3.12.4. As a part of meeting the requirements of the Clean Air Act Amendments of 1997 for preventing future and remedying existing visibility impairment due to man-made pollution, the EPA identified visibility as an important value at 156 mandatory Class I federal areas. These areas include large national parks and wilderness areas. Such mandatory Class I federal areas in Alaska include Denali National Park (NP), Bering Sea National Wildlife Refuge (NWR), Simeonof NWR, and Tuxedni NWR.

⁶ Background concentrations are the ambient concentrations in the vicinity of an emission source that are due to emissions from all other sources.

TABLE 3.13-10 Ambient Air Quality Trends in the Prudhoe Bay Area^a

Pollu- tant	Averaging Period	Monitor Station ^b	Concentration ($\mu\text{g}/\text{m}^3$)														NAAQS
			1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
SO ₂	3 hours	CCP	_c	—	16	13	13	13	11	13	13	13	18	24	29	37	1,300
		GC1	—	—	—	—	131	34	101	21	45	100	73	16	21	37	
	24 hours	CCP	—	—	13	11	8	11	8	11	11	11	13	18	18	18	365
		GC1	—	—	—	—	52	13	39	8	16	31	24	8	13	31	
	Annual	CCP	8	8	8	3	3	3	3	3	3	3	3	5	5	5	80
		GC1	—	—	—	—	4	4	3	3	3	3	5	3	3	5	
NO ₂	Annual	CCP	16	18	13	17	19	19	16	18	26	15	17	26	21	28	100
		GC1	—	—	—	—	21	16	20	16	19	11	11	11	9	9	
		Pad A	8	8	9	9	10	9	12	8	9	8	8	8	8	7	
O ₃	1 hour	CCP	92	94	106	98	92	94	112	82	116	112	102	96	94	104	235
		GC1	—	—	—	—	76	98	106	80	94	112	100	90	96	98	
		Pad A	96	247	120	106	147	153	180	104	106	98	110	110	96	108	
PM ₁₀	24 hours	CCP	—	—	24	16	21	17	29	28	54	13	47	70	28	21	150
		GC1	—	—	—	—	19	155	55	64	—	—	—	—	—	—	
	Annual	CCP	—	—	6	5	5	6	6	7	12	3	5	8	4	3	50
		GC1	—	—	—	—	8	16	11	10	—	—	—	—	—	—	

^a Monitored value during 1987-2000 period.

^b CCP = Central Processing Plant; GC = Gathering Center. The CCP is located approximately 5 mi northeast of PS 1, GC1 approximately 7 mi northwest of PS 1, and Pad A approximately 3 mi west-northwest of PS 1.

^c A dash indicates that no monitoring data exist.

Source: ENSR (1988–2001).

TABLE 3.13-11 Ambient Concentrations of Hazardous Air Pollutants in the Valdez Area Prior to Installation of Tanker Vapor Recovery System at the Valdez Marine Terminal^a

HAP Species	Monitor Location ^c	Concentration ($\mu\text{g}/\text{m}^3$) ^b			
		1 Hour	8 Hours	24 Hours	Annual
Benzene	East Gate	1,248	848	848	22
	Old Valdez	361	261	261	4
	High School	136	43	43	4
	Spit	319	98	58	5
Toluene	East Gate	1,131	682	682	19
	Old Valdez	272	205	205	4
	High School	314	70	42	7
	Spit	215	69	42	4
Ethyl benzene	East Gate	144	77	77	3
	Old Valdez	30	20	20	1
	High School	50	12	8	1
	Spit	20	6	5	1
m,p-Xylene	East Gate	316	95	70	7
	Old Valdez	75	55	55	2
	High School	211	50	28	5
	Spit	65	15	12	2
o-Xylene	East Gate	73	36	36	2
	Old Valdez	18	8	8	1
	High School	61	16	10	2
	Spit	14	4	4	1
n-Hexane	East Gate	3,838	1,188	711	69
	Old Valdez	685	170	125	6
	High School	165	69	36	4
	Spit	358	125	49	5

^a The average loading rate for the terminal during 1990-1991 was about 1.8 million bbl of oil per day.

^b Data collected from November 1, 1990, through October 30, 1991, except that the data for n-hexane were available only for June through October 1991. One-half of the detection limit was substituted for undetected concentrations in the average. One-hour concentrations are the highest values, and 8-hour and 24-hour concentrations are the highest running average concentrations.

^c East Gate - located near the eastern boundary of Valdez Marine Terminal; Old Valdez - located on the eastern edge of Port Valdez; High School - located on the northern edge of Valdez; Spit - located along the shore at New Valdez.

Source: Goldstein et al. (1992).

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program was initiated in 1985 to aid in the implementation of legislation. Under the IMPROVE program, visibility has been measured since July 1987 at the Denali NP (Park Headquarters), a mandatory Class I federal area located about 80 mi southwest of PS 8 (Map 3.12-1). The median visual range at the park during the period 1988 to 1998 averaged about 127 mi, without significant change over the 11-year period (Malm 2000).

3.13.2.4 Acid Deposition

Deposition of acidic air pollutants, primarily secondary sulfates and nitrates, on sensitive ecosystems in the remote regions of Alaska would result from long-range transport, chemical conversion, and deposition of precursors from sources located within as well as outside of the

state. The only place within 100 km (about 62 mi) from any of the TAPS pump stations and Valdez Marine Terminal where acidic deposition is monitored as part of the National Atmospheric Deposition Program (NADP) is Poker Creek, located about 25 mi south-southeast of PS 7. The PSD Class I area nearest to any of the TAPS facilities is Denali National Park and Preserve, located about 81 mi southwest of PS 8. Acid deposition is also monitored at this location under the NADP. Unlike the northeastern United States, where annual acid deposition rates are high (both sulfate and nitrate up to 27 kg/ha as SO_4^- and NO_3^- , respectively), annual acid deposition rates monitored at the two locations in Alaska are very low (sulfate about 1 kg/ha as SO_4^- and nitrate less than 1 kg/ha as NO_3^-) and show a decreasing trend for sulfate and no significant change for nitrate for the period 1980–2000 (NADP 2002).

3.14 Noise

Man-made (anthropogenic) noise sources within the site boundaries of TAPS facilities include pumps, compressors, electric generators, boilers, heaters, incinerators, flares, and various construction equipment and vehicles. At site boundaries of TAPS facilities, away from these industrial facilities and equipment, noise from these sources is barely distinguishable from background noise levels. Beyond site boundaries of TAPS facilities, noise is generated primarily by the Prudhoe Bay industrial complex near PS 1; vehicles traveling along access roads and nearby highways; equipment operating at material sites; aircraft overflights, including those of fixed-wing aircraft and helicopters for pipeline surveillance purposes by the APSC; and tanker and other boat traffic near the Valdez Marine Terminal.

Examples of noise levels at 50 ft from anthropogenic noise sources are 84 to 89 dBA¹ for a heavy-duty truck; 69 to 76 dBA for a passenger automobile; 87 to 102 dBA for a bulldozer; and up to 85 dBA for machines, outboard motors, and float planes (Golden 1979; EPA and DOI 1984). Noise from fixed-wing aircraft and helicopters during takeoff and landing ranges from 72 to 115 dBA (Golden 1979).

No data on noise measurements within and in the immediate vicinity of TAPS facilities are available (Haas 2001). The original TAPS EIS (BLM 1972) estimated that the noise levels from a TAPS pump station would be 74 dBA at a distance of 600 ft. This estimate was overly conservative when compared with actual sound measurements at similar facilities at the North Slope. Measurements in the Prudhoe Bay area in 1979 identified sound levels from the Central Compressor Plant of 74 dBA at 50 ft from the

turbine air intake and 60 dBA at 395 ft from a vapor-relief flare operation (HLA 1988).

Although the TAPS ROW itself is developed, most of the area adjacent to the pipeline is undeveloped and sparsely populated, and, therefore, ambient noise levels are generally low. Most ambient noise is generated by the wind and moving water. Data for similar locations indicate that typical noise levels usually range from 15 to 45 dBA, which is considered quiet (HLA 1988).

Background noise in the Valdez area is quite low, with road traffic and aircraft the most significant sources. Valdez is typical of many small Alaskan cities, with moderate traffic and limited sources of noise. Some ambient noise originates from the Valdez Marine Terminal, mainly from sources associated with power/vapor operations; however, beyond site boundaries it is generally not audible. Natural background noise levels are low except when boats or aircraft pass by (Fluor and TRC 1995).

The Noise Control Act of 1972, together with its subsequent amendments (Quiet Community Acts of 1978, 42 USC 4901-4918), leaves it to the states to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. The State of Alaska and the boroughs in which the TAPS ROW is located have not yet established any noise regulations that specify acceptable community noise levels. The EPA guideline recommends an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974).² For protection against hearing loss in the general population from nonimpulsive noise, the

¹ dBA (A-weighted decibel) is a unit of weighted sound-pressure level, measured by the use of the metering characteristics and the A-weighting specified in the *American National Standard Specification for Sound Level Meters* (ANSI S1.4-1983) and its Amendment (S1.4A-1985) (Acoustical Society of America 1983, 1985).

² L_{dn} is the day-night weighted equivalent sound level.

EPA guideline recommends an L_{eq} of 70 dBA or less over a 40-year period.³

Table 3.14-1 lists the residence and town nearest to the site boundary of each TAPS facility. At these residences and towns, noise from normal operation of TAPS facilities would not be distinguishable from background noise levels. However, noise from fixed-wing aircraft and helicopters operated by the APSC on a regular basis for pipeline surveillance and monitoring would be audible at locations close to the pipeline. No public complaints or adverse impacts on wildlife due to noise from TAPS facilities have been identified (Haas 2001). Some disturbances of wildlife have been observed as a result of air traffic, particularly helicopters, during pipeline overflights (TAPS Owners 2001a). Detailed discussions on such disturbances are provided in Section 4.3.17.2.

During the summer of 1996, the TAPS experienced vibrations in a section of the pipeline near Thompson Pass, 25 mi north of Valdez. On occasion, the vibration could be detected by residents living near the pipeline at the bottom of the pass. Close to the source of the phenomena, small bushes could be seen moving in response to the vibrations, and a noise similar to “mortars firing in the distance” could be heard. An extensive investigation of the phenomena by the APSC determined that the vibrations were a result of pressure pulses originating near the slackline-packline⁴ interface. This vibration occurred only when the slackline-packline interface was positioned near a terraced portion of the pipeline topography on the downstream side of the pass. This knowledge allowed the APSC to control the pressure pulsations by using back-pressure control at Valdez to move the slackline-packline interface well above the terrace location where the vibration was being initiated (Norton et al. 1998; Baskurt et al. 1998; Hart et al. 1998).

³ L_{eq} is the equivalent steady sound level that, if continuous during a specific time period, would represent the same total acoustic energy as the actual time-varying sound. For example, $L_{eq}(1-h)$ is the 1-hour equivalent sound level.

⁴ Slackline is a pipeline flow condition in which the oil stream does not completely fill the pipe cross-section. When the oil stream completely fills the pipe cross section, it is referred to as packline condition.

TABLE 3.14-1 Direction and Distance of Nearest Human Residence (within 2 mi) and Town from Each TAPS Facility

TAPS Facility	Human Residence ^a		Town			
	Direction	Distance	Name	Direction	Distance (mi)	Population ^b
PS 1	— ^c	—	Prudhoe Bay	SE	6	5
PS 2	—	—	Prudhoe Bay	N	54	5
PS 3	—	—	Anaktuvuk Pass	SW	87	282
PS 4	—	—	Anaktuvuk Pass	WSW	87	282
PS 5	—	—	Evansville	WNW	22	28
PS 6	—	—	Stevens Village	NE	21	87
PS 7	—	—	Livengood	NNW	13	29
PS 8	NE	200 ft	Salcha	SW	2	854
PS 9	S	0.5 mi	Fort Greely	N	2	461
PS 10	—	—	Paxson	NNW	18	43
PS 12	NE	200 ft	Tonsina	NNE	9	92
Valdez Marine Terminal	—	—	Valdez	N	4	4,336 ^d

^a Source: Norton (2001b).

^b Based on 2000 decennial census data.

^c A dash indicates that there is no human residence within 2 mi of the specified TAPS facility.

^d 2001 population (Von Barga 2002).

3.15 Transportation

Because of the distances involved and the magnitude of TAPS activities, all segments of the Alaskan transportation network play important roles in the pipeline operations. Material and personnel associated with operation and maintenance of the pipeline are transported by air, water, rail, and highway. Map 3.1-1 is a map of the state's transportation network relevant to the TAPS.

3.15.1 Aviation Transportation Systems

Aviation is critical to the movement of goods and people in Alaska because of the distances between cities and much of the state's lack of a significant highway and railroad infrastructure. Alaska has approximately 9 times the number of airports, 10 times the number of registered general aviation aircraft, and 5.9 times the number of Federal Aviation Administration (FAA)-licensed pilots per 100,000 residents as the rest of the United States (TAPS Owners 2001a). Many charter and air taxi operations and several Alaska-based airlines operate within the state. Anchorage is the state's largest hub for passenger and cargo traffic, followed in importance by Fairbanks. Daily service is provided by major U.S. domestic airlines both to the contiguous 48 states and international destinations. In addition, Anchorage and Fairbanks have become important air-cargo transfer centers for goods to and from Asia.

At the beginning of construction of the TAPS, six public airports were located near what had become the pipeline ROW. These facilities were in Deadhorse, Sagwon, Fairbanks, Delta Junction, Gulkana, and Valdez. Deadhorse and Sagwon had been established to support oil exploration activities north of Atigun Pass. Fairbanks and Delta Junction were well-established aviation centers that supported military and mining operations and served as staging points for transportation to villages, outposts, and camps. Gulkana and Valdez were small airstrips that serviced their communities.

Travel outside of these established airports along the pipeline route was restricted to helicopters or small fixed-wing aircraft able to land on gravel bars or lakes. Twelve improved gravel airstrips were built between 1971 and 1972 to support the construction of the TAPS (TAPS Owners 2001a). Each airstrip supported C-130 Hercules aircraft and DC-3 tankers. Eight of these airstrips remain under state or private control; some are used by general aviation but are not listed on current FAA sectional charts. The remaining four airstrips were later shut down and the land reclaimed after construction of the TAPS and are no longer available for aircraft use.

Current air transport operations in support of the TAPS include the movement of personnel and supplies to some TAPS-related facilities. Workers at PS 1 fly to Deadhorse; workers at PS 3 and 4 fly to the Galbraith Lake Airport on ERA Aviation; workers at PS 5 fly to the Prospect Airport on ERA or Frontier Airlines; and workers at PS 12 fly to Gulkana Airport on ERA Airlines (TAPS Owners 2001a). Workers at PS 7 and 9 live in the Fairbanks and Delta areas, respectively. The other pump stations are currently on standby status. Routine supplies are shipped by truck, and only time-critical parts and supplies are sent via air cargo. In addition to the movement of materials and personnel, aviation support to the operation of the TAPS includes routine surveillance of the pipeline itself. Surveillance of the pipeline includes security patrols and mapping activities associated with maintenance operations.

The Deadhorse Airport, which is owned and operated by the State of Alaska, primarily provides support to TAPS operations and oil exploration and production activities along the North Slope. Alaska Airlines and oil company charters provide daily service to Deadhorse from Anchorage and Fairbanks, with an estimated 200,000 passengers transported to and from Deadhorse annually (USACE 1999). About 648 tons of cargo is transported by air to the North Slope annually (USACE 1999).

3.15.2 Marine Transportation Systems

Equipment and supplies for TAPS operations often pass through the ports of Anchorage, Seward, and Whittier. The Port of Anchorage is the most northern deep-draft port in the United States and is open year-round. Five terminals provide service for standard cargo ships and specialized vessels (USACE 1999). For the years 1995 through 1998, about 3 million tons of cargo passed through the port annually. Roughly half was container cargo, and the other half was primarily petroleum products, including jet fuel for airport operations (Municipality of Anchorage 2001).

The Port of Seward is 125 mi south of Anchorage at the southern end of the Seward Highway. The port is served also by the Alaska Railroad. The Port of Seward primarily services cruise ships; however, it also handles some container shipments, general cargo, and bulk cargo. About 31,000 tons of freight, including logs, pipe, and coal, passed through the port in 1996 (USACE 1999).

The Port of Whittier is an ice-free, deepwater port strategically located between Prince William Sound and Interior Alaska. The port is at the head of the Passage Canal, which made it part of a historical portage route used originally by Natives of Prince William Sound and Cook Inlet, Russian and American explorers, and eventually prospecting miners. Today, Whittier is connected by highway to Anchorage and is served by the Alaska Marine Highway System (AMHS) and the Alaska Railroad. Freight off-loaded at the port in 1996 totaled approximately 300,000 tons (USACE 1999).

The AMHS is sponsored by the State of Alaska and was established in 1964 to provide marine transport of passengers, freight, and vehicles between coastal Alaskan communities where the highway facilities on land would not meet the needs of residents (Parsons Brinckerhoff 2001). The AMHS now has nine vessels serving 32 Alaskan communities, as well as providing service to Bellingham, Washington, and Prince Rupert, British Columbia.

Marine transportation plays an important role in the Prince William Sound area, including its role in shipping petroleum products from the Valdez Marine Terminal. The ports of Valdez and Seward are equipped with the highest level of marine infrastructure that accommodates interstate and international cargo receipt and shipment, while providing a minimum draft of 20 ft (Parsons Brinckerhoff 2001). The Port of Valdez is an ice-free port with access to Interior Alaska, the United States Pacific Northwest, Northern Canada, and Pacific Rim trade routes. This deepwater port has containerized storage and containerized roll-on/roll-off and lift-on/lift-off capabilities (City of Valdez 2001). The port has access to the Richardson Highway, the Valdez Airport, and the AMHS.

A number of communities in Prince William Sound provide a lower level of marine service; community service facilities are geared toward accommodating community supply and movement of people while providing maximum drafts less than 20 ft. Such communities include Cordova, Chenega Bay, Tatitlek, Valdez, and Whittier. The Port of Cordova is one of the primary centers for commercial fishing in Prince William Sound. Chenega Bay and Tatitlek are small Alaska Native communities supported by commercial fishing and subsistence activities.

All ports in the Prince William Sound area discussed here provide facilities for the AMHS. The AMHS provides scheduled service to Cordova, Seward, Valdez, and Whittier and, as of 1996, provides "whistlestop" service to Chenega Bay and Tatitlek.

3.15.3 Rail Transportation Systems

Equipment and supplies for operation of the TAPS are often transported on the Alaska Railroad. The railroad is owned and operated by the Alaska Railroad Corporation (ARRC) for the State of Alaska. The ARRC operates 535 route miles over which it provides freight and passenger service from Seward in the south through Anchorage to Fairbanks in the north; a spur connects Whittier to the main line near Anchorage. Dock and handling yards are maintained by the ARRC at the ports of

Anchorage, Seward, and Whittier for handling freight reaching Alaska by barge. The Alaska Rail Marine, managed by the railroad, operates rail-equipped barges year-round that transport freight between Seattle and Whittier.

Freight hauled by the ARRC includes petroleum products, coal, gravel, oil field and mining supplies, chemicals, and consumer goods (ARRC 2001). More than 7 million tons of freight was hauled in 1999, with a decrease of almost 15% in 2000 (ARRC 2000; 2001). Passengers transported dropped from more than 670,000 in 1999 to approximately 501,000 in 2000 (ARRC 2000; 2001). The decrease was attributed to the opening of the highway to Whittier and also to lower airfares to Europe that decreased the number of tourists visiting the area (ARRC 2001).

3.15.4 Road Transportation Systems

The highway system in Alaska provided access for construction of the TAPS and now provides access for maintenance and repairs. The pipeline parallels the Richardson Highway for 363 mi from Valdez to Fairbanks. In Fairbanks, the Richardson Highway connects to the Steese Highway that follows the pipeline for 11 mi until the intersection with the Elliot Highway. The pipeline then parallels the Elliot Highway 72 mi north to Livengood. The northern half of the pipeline follows the Dalton Highway that stretches 415 mi from Livengood to Deadhorse. In addition, approximately 284 secondary roads provide private access to the pipeline, pump stations, and airstrips (TAPS Owners 2001a).

These highways, with the exception of the Dalton Highway, are typically asphalt-paved two-lane roads. In a populated center such as

Fairbanks, more than two lanes may exist. Except near Valdez and Fairbanks, traffic congestion is not a problem, although road maintenance activities may cause traffic delays.

Annual average daily traffic (AADT) counts along the Richardson Highway vary significantly between Valdez and Fairbanks from approximately 300 to 22,400 vehicles per day, depending on location (see Table 3.15-1). Traffic during the summer can be double the annual averages and is typically higher near the communities of Valdez, Glennallen, Delta Junction, and Fairbanks.

The Dalton Highway, originally known as "the Haul Road," was built using federal funds to support the construction of the TAPS and initially was open only to authorized commercial traffic. The highway is now under the jurisdiction of the State of Alaska DOT. It is a 28-ft-wide crushed gravel road used to support TAPS operations and North Slope oil field exploration and production. As a federal aid highway, it was opened to the public to the Dietrich River in 1981 and for its entire length in 1994. It now supports additional traffic from privately owned vehicles and commercial tour operators. However, access to areas beyond the northern end of the Dalton Highway at Deadhorse, including the Prudhoe Bay industrial oil complex and the Arctic Ocean, is restricted by the oil field operators. In 2000, the AADT over the Dalton Highway's 415-mi length was 233 vehicles per day (ADTPF 2001a), approximately 40% of which was commercial truck traffic (Richards 2002). The Dalton Highway is undergoing a major improvement program that includes widening to a uniform 32 ft and resurfacing with a high-float emulsion that will improve road quality and significantly reduce vehicle fugitive dust emissions. Under the current plan, approximately 90 to 95% of the Dalton Highway will be resurfaced by the end of 2006 (ADTPF 2001b).

TABLE 3.15-1 Average Daily Traffic Counts on the Richardson Highway for the Year 2000

Richardson Highway Milepost	AADT ^a	Mid-Summer ADT ^b
MP 3 (Valdez)	5,540	7,500
MP 62 (Ernestine Creek, near PS 12)	450	1,125
MP 118 (Gulkana Airport)	1,000	2,000
MP 218 (Trims Creek, near PS 10)	300	600
MP 345 (Moose Creek/Fairbanks)	9,100	11,000
MP 359 (Fairbanks)	22,400	26,400

^a AADT = annual average daily traffic (vehicles per day).

^b ADT = average daily traffic.

Source: Richards (2002).

3.16 Hazardous Materials and Waste Management

This section provides an overview of hazardous materials used in TAPS operations, the wastes that routinely result from TAPS operations, and the current management strategies for those wastes. A substantial detailed operating record has resulted from the past 25 years of TAPS operations with respect to waste generation and management. A more detailed discussion of that record is provided in Appendix C.¹

3.16.1 Hazardous Material Usage

A wide variety of hazardous materials are needed to support TAPS operations, including various equipment and vehicle fuels, organic solvents, heat transfer fluids, coolants, refrigerants, protective coatings, and cleaning agents. The purchase and use of hazardous materials by APSC personnel and TAPS operating contractors are centrally controlled, and both environmental and health and safety factors are considered before approval for use is issued. Storage of hazardous materials occurs at various pump stations, off-ROW repair facilities, and the Valdez Marine Terminal. APSC provides annual reports to state and federal authorities as required by the Emergency Planning and Community Right-To-Know Act (EPCRA) regarding the amounts and types of hazardous materials present at its facilities. APSC also engages local emergency planning authorities in the development of contingency plans for dealing with emergencies involving the hazardous materials present at APSC facilities. Diesel fuel is the most prevalent hazardous material, with over 8 million gal nominally present at all APSC facilities, collectively at any given time. Gasoline, propane, and glycol-based

coolants are also present in substantial quantities.

3.16.2 Hazardous Waste

Hazardous wastes result from the operation of pump stations and the Valdez Marine Terminal and from various routine and preventative maintenance and repair activities along the ROW and at off-ROW repair and maintenance facilities. Hazardous wastes are initially containerized and accumulated² at pump stations or the Valdez Marine Terminal. Hazardous wastes are also stored at the three Mainline Refrigeration Units, Ship Escort Response Annex, Ship Escort Response Base, North Pole Metering Station, Nordale Yard, Northstar Terminal, Van Horn Facility, North Pole Laboratory, and Bragaw facility. Hazardous wastes generated along the ROW are delivered to the nearest pump station for storage and are collected from all storage locations by a licensed transportation contractor and delivered to permitted treatment, storage, and disposal facilities (TSDFs) in the Lower 48 States. Transportation involves both truck and barge transport.

Only relatively small amounts of hazardous waste result from routine operation and maintenance. In general, the TAPS maintains the status of “conditionally exempt small quantity generator” or “small quantity generator” for each of its hazardous waste accumulation locations, except for the Valdez Marine Terminal, which is a “large quantity generator.” Routinely generated hazardous wastes include spent thinners and cleaning solvents, flammable paints and coatings, corrosive acids, flammable adhesives, used oils containing chlorinated compounds,

¹ Various terms used in the discussions on wastes in Sections 3.16, 4.3.12, 4.5.2.12, 4.6.2.12, and 4.7.5.1 are defined in the Glossary (Chapter 8).

² Under federal regulations, no permit is required for hazardous waste accumulated at or near its point of generation in quantities of 55 gal or less (per waste stream) for a period of up to 90 days. (See Title 40, Parts 262.34(a) and (b) of the *Code of Federal Regulations* [40 CFR 262.34(a)(b)].) No TAPS facilities currently hold a RCRA permit for storage of hazardous waste.

spent coolants, spent aerosol cans, and crushed fluorescent lights. Sludge and residues regularly cleaned out from pump stations and Valdez Marine Terminal equipment and sumps also normally exhibit characteristics of hazardous waste. Tank bottoms and “materials in process” that are periodically removed from equipment and bulk crude oil and refined product storage tanks also exhibit hazardous waste characteristics and represent the largest volume of hazardous waste that is generated. Spill debris and contaminated media also occasionally exhibit hazardous waste characteristics. APSC generated approximately 142,118 lb of hazardous wastes systemwide over the period 1998 to 1999.

3.16.3 Solid Waste

Nonhazardous solid wastes from pipeline and Valdez Marine Terminal operations fall into one of three categories: industrial solid waste, office waste, or domestic solid waste. Both domestic and industrial solid wastes are generated throughout the TAPS. Domestic solid wastes result primarily from the operation of living quarters and support facilities, such as kitchens and cafeterias. Office wastes are generated at virtually every APSC facility. The primary sources of office wastes, however, are the administrative facilities in Fairbanks and Anchorage. Industrial solid wastes are generated primarily at the pump stations and at the Valdez Marine Terminal.

Numerous management options are in use for solid wastes. Incinerators at PS 1, 2, 3, 4, 5, 6, 7, and 10 and at the Valdez Marine Terminal are used to reduce the volumes of solid wastes generated at those locations. APSC maintains three Class III landfills in off-ROW locations. These landfills are authorized to receive ash from the incinerators as well as limited amounts of inert solid wastes from nearby APSC facilities. APSC also uses seven municipal landfills located in the North Slope Borough and the communities of Fairbanks, Delta Junction, Glennallen, Valdez, Palmer, and Anchorage. All municipal landfills as well as APSC landfills operate under the authority of permits issued by the ADEC. APSC generated more than

6,000 yd³ of solid waste systemwide in calendar year (CY) 2000.

APSC also maintains a number of recycling programs for solid waste. In recent years, scrap metals, copy machine toner cartridges, thermometers, office furniture, waste office paper, and newspaper have all been successfully diverted from landfill disposal as a result of these recycling programs. Recycling markets in Alaska are not reliable, however, and sometimes it is necessary to divert these waste streams to conventional disposal paths. The amounts of solid wastes recycled annually vary widely. In CY 1999, recycled wastes included 51,408 lb of lead acid batteries, 910.44 tons of scrap metal, 18,000 gal of heat transfer fluids (burned for energy recovery), and 500 yd³ of office paper (burned for energy recovery).

3.16.4 Wastewater

Both domestic sanitary wastewaters and industrial wastewaters are generated at a variety of APSC facilities. Sanitary domestic wastewaters are generated at every occupied facility; however, the largest volumes result from the operation of personnel living quarters at some pump stations. A variety of mechanisms are used to manage domestic wastewater, including disinfection and flash evaporation in the turbine pump exhausts at PS 1, 3, and 4; treatment in package plants with eventual discharge to surface waters; treatment in septic tanks; and discharge to community sewer systems for treatment in municipally run publicly owned treatment works (POTWs). Volumes of sanitary wastewaters delivered to the turbine exhausts or treated at the pump stations are nominally low and normally do not exceed 10,000 gal per day (the maximum rated capacity of the stack injector system that delivers wastewater to the turbine exhaust stacks). APSC also operates a sanitary waste treatment plant at the Valdez Marine Terminal under an NPDES permit issued by the EPA with ADEC concurrence. Treated wastewater from this facility discharges to Prince William Sound. In CY 2000, 705,399 gal of treated sanitary wastewater was discharged to Prince William Sound.

APSC also holds a linewide NPDES permit for discharges of treated domestic sewage and some industrial wastewaters at various facilities (primarily pump stations) along the pipeline route. This permit, issued by the EPA in 1993, governs discharges of precipitation waters, uncovered secondary containment structures, excavation dewatering at work sites along the ROW, hydrostatic testing water, and domestic sanitary wastewaters from mobile construction camps. Hydrostatic testing waters routinely represent the largest volume of wastewater covered under this permit and account for over 7 million gal in the 1996 to 1997 time frame.

The permit establishes minimum discharge volumes for each type of discharge above which a notice of disposal, effluent limitations, and monitoring requirements apply (e.g., 500,000 gal for excavation dewatering). The permit also requires that the APSC develop and maintain a Storm Water Pollution Prevention Plan (SWPPP) for industrial activities, including excavation dewatering projects where the disturbed land surface is in excess of 5 acres.³ APSC has also applied to the ADEC for a permit to cover industrial wastewater discharges at various locations. Wastewaters addressed in this application include discharges of secondary containment water, waters potentially containing oils and/or sediments, petroleum product spill wastes, waters containing chlorine, waters containing aqueous film forming foam, and waters collected from active cells in the three APSC-operated landfills. Although a permit has not yet been issued, the ADEC has given verbal approval for all of the proposed actions and expects APSC to comply with proposed effluent limitations contained in APSC's application.

Industrial wastewaters are generated at various locations and at the Valdez Marine Terminal. By far, the largest volume wastewater stream is tanker ballast water treated in the BWTF at the Valdez Marine Terminal. The BWTF operates under the auspices of an NPDES permit issued by the EPA. Various other industrial wastewaters generated at the Valdez

Marine Terminal, as well as storm-water runoff captured from the industrial areas of the Valdez Marine Terminal are also treated in the BWTF. Tanker ballast accounts for as much as 93% of the wastewaters treated in the BWTF. The permit establishes effluent limitations for the discharge of treated water to Prince William Sound. In CY 2000, average daily effluent flows from the BWTF were 10.37 million gal per day, and the total amount of treated water discharged was 3,785,050,000 gal.

In 1999, APSC filed Notices of Intent to be governed by the EPA Multi-Sector General Permit for Industrial Activities for each of 12 industrial areas.⁴ The Multi-Sector General Permit authorizes storm-water discharges from certain types of industrial facilities and requires APSC to develop SWPPPs that identify and incorporate best management practices appropriate at each location. As needed, APSC also files Notices of Intent under the NPDES General Permit for Discharge of Stormwater Associated with Construction Activities for construction activities that disturb more than 5 acres.

3.16.5 Special Wastes

TAPS operations also have the potential to generate special wastes. These include waste PCBs contained in the dielectric fluids of some electrical equipment that is being removed or replaced; asbestos waste from the remodeling or removal of building materials containing asbestos; pesticide wastes; drag reducing agent wastes; spent glycols; tanker garbage; medical waste; spent sandblast media; asphalt removed during road reconstruction; radioactive wastes from the disposal of items such as smoke detectors that contain small amounts of radioactive elements; naturally occurring radioactive material (NORM); spill debris; and remediation wastes. All of the above waste streams require special handling either because of their chemical makeup or the circumstances of their generation. These particular procedures

³ Storm-water discharges are governed under the EPA NPDES Multi-Sector General Permit discussed below. (See Appendix C for more detailed discussion.)

⁴ However, APSC reports that only nine industrial areas are now covered by the EPA Multi-Sector General Permit (Jokela 2002).

incorporate federal and state regulatory requirements that control the management and disposal of these special wastes. With the possible exception of spill debris and remediation wastes, all of these special wastes are generated in very limited quantities and all are managed by special procedures. NORM wastes, resulting from the precipitation of naturally occurring radioactive species present in the formation waters from which crude oils are recovered, have a very low probability of occurrence within the TAPS. Surveys to date have confirmed that NORM wastes have not resulted from TAPS operations.

Management of spill debris and remediation waste is governed by an ADEC-approved remediation plan (APSC 1999) under which APSC develops specific plans for each spill event. Management might include temporary storage of contaminated media at any of

12 ADEC preapproved contaminated media storage areas. Ultimately, and always after no more than 2 years of storage (4 years of storage at Valdez Marine Terminal), nonhazardous contaminated media are trucked to a commercial facility where they undergo thermal treatment. Contaminated media and spill debris that exhibit characteristics of hazardous waste are containerized and managed in accordance with existing hazardous waste management procedures (see Section 3.16.2). The amounts of spill debris generated are directly a function of the number and magnitude of spill events as well as the circumstantial factors at the spill site that govern remediation. In 1999, approximately 2,302 tons of contaminated soils was delivered for thermal treatment. Amounts of contaminated soils stockpiled at the Valdez Marine Terminal (the largest stockpile area) ranged from 237.4 tons in 1996 to 1,561.9 tons in 2001 (see Section C.6.12).

3.17 Human Health and Safety

Two types of risks are addressed and discussed below: the industrial (physical hazard) risk to workers and the potential risk from chemical exposures to the general public under current baseline conditions.

3.17.1 Occupational

Currently, the TAPS employs approximately 2,500 individuals, including APSC and contractor personnel (APSC 2001a). APSC employees are distributed (as of April 2001) as follows: 130 employees in Anchorage, 429 in Fairbanks, and 382 in Valdez (APSC 2001a). The types of workers employed to operate and maintain the TAPS include engineers, pipeline maintenance and operations workers (e.g., laborers, heavy equipment operators, truck drivers, electricians), administrative and office workers, health and safety specialists, and security officers and fire fighters. In addition, boat operators and crew are required for operating and maintaining the SERVUS oil response equipment. The hazards associated with these jobs vary considerably, and workers receive training to address their specific job hazards.

Stipulation 1.20, Health and Safety, of the Federal Grant requires a health and safety program that protects employees involved in the construction, operation, maintenance, or termination of the pipeline; abates any health and safety hazards; and reports serious accidents to the Authorized Officer and State Pipeline Coordinator. Consequently, APSC developed a *Corporate Safety Manual* (APSC 2001f) to provide specific guidance for compliance with the requirements of the grant and lease stipulations. The manual addresses implementation of the standards within each major area of business operations. The manual contains two sections that apply the Alaska Occupational Safety and Health Standards to the general operations and to construction activity. It also contains a third section of additional APSC safety requirements that are not explicitly driven by State of Alaska standards.

For its general operations, APSC has developed safety procedures addressing the following types of issues: working over water;

hearing and eye protection; oil spill response; flame resistant clothing; hand, foot, and head protection; respiratory protection; operation of large equipment; and exposure to toxic substances. The standards related to construction activity address safety issues such as the use of hand tools, scaffolding, and vacuum trucks, and excavations. Finally, the third section of the manual addresses safe operation of various types of vehicles and vessels. It also sets out procedures for maintenance of safety devices, for materials storage and handling, and for protection of personnel from extreme cold. In addition, it defines several management and incentive systems for promoting health and safety.

A number of fire protection safety services also support TAPS operations. These include various warning devices installed along the pipeline; automatic fire detection systems installed throughout pump station facilities; Halon use as the primary fire retardant agent in pump station buildings where flammable hydrocarbons may be found; and emergency response teams with duties that include initial fire response. (For additional details, see Section 3.1.2.)

Although worker physical hazard risks (i.e., risks of fatality or injury from on-the-job accidents) can be minimized when workers adhere to safety standards and use protective equipment as necessary, certain rates of accidents have been associated with all types of work. Risks can be calculated on the basis of historical safety performance data reported for normal TAPS operations and compared with historical industrywide statistics, as described below.

The historical safety performance data reported for normal operations of the TAPS between January 1995 and July 2001 are summarized in Table 3.17-1. (Note that it is alleged that Houston/Northwest Alaska Native Association (NANA) JV has not properly recorded its injuries in the Occupational Safety and Health Administration (OSHA) 200 log; thus, its accident rates may be higher than reported (Elleven 2002a,b). This problem may exist with other contractors and APSC; the allegation is

being investigated by Alaska Occupational Safety and Health (AKOSH). Consequently, the historical safety performance data used in the present analysis may underpredict APSC's past occupational injuries.) Specifically, the incidence rates of occupational injuries and illnesses to TAPS employees and contractors have been calculated (expressed as cases or lost workdays per 100 full-time employees, using 200,000 employee hours as the equivalent), on the basis of the reported number of OSHA-recordable injuries and total number of hours worked by all employees during the period covered. APSC's incidence rates can then be compared with the incidence rates for "pipelines, except natural gas," which are based on reports of National Safety Council members (NSC 2000).

While APSC's incidence rates are generally comparable to industrywide statistics, the NSC states that these rates may not be representative of the industries listed or of NSC member companies. Nevertheless, APSC's actual annual incidence rate of 1.93 per 100 full-time workers (total of 64 recordable and 20 lost workday injuries) for all employees and contractors in 2000 (the most recent year for which complete reporting data are available) represents baseline risks for existing TAPS operations, unless APSC's accident rates increase as a result of the AKOSH investigation.

Fatalities from operations-related incidents, as well as incidents related to pipeline operations, are also noted in Table 3.17-1. For comparison, the expected annual number of worker fatalities for specific industry types is calculated on the basis of rate data from the Bureau of Labor Statistics as reported by the NSC (2001) and on the number of annual fulltime equivalent (FTE) workers required for TAPS operations. Employment for TAPS is approximately 2,500 total employees and contractors, as of April 1, 2001 (APSC 2001a). It is assumed that, in general, the types of activities required for these employees would be similar to those for the transportation and public utilities sector (pipelines are not broken out separately); thus, those fatality rates are used to estimate an annual risk. Using a rate of 11.5 fatalities per 100,000 FTEs, the estimated annual number of fatalities for TAPS workers is less than 1 (specifically, 0.29 per year); in

actuality, there was one fatality in 2000 from a vehicle accident at the Valdez Marine Terminal. These recent physical hazard risks represent baseline risks for existing TAPS operations.

3.17.2 Public

Human health can be adversely affected by hazardous chemical contaminants in the environment. This section discusses how humans can become exposed to these materials and the existing health conditions along the TAPS ROW and the surrounding area. The discussion addresses currently existing body burdens of key contaminants in Alaskans, existing cancer rates, existing air toxics levels, existing contamination along the TAPS ROW, and other potential exposure pathways.

3.17.2.1 Body Burdens of Key Contaminants

Over the past 25 years, the contamination of the Arctic by industrial and agricultural chemicals has been increasingly recognized and documented. A group of contaminants termed "persistent, bioaccumulative, and toxic" (PBT) has been identified as of special concern (EPA 2001d). The PBT contaminants include persistent organic pollutants (POPs) such as certain pesticides, PCBs, and some PAHs, and the heavy metal mercury. These contaminants generally originate outside of Alaska; they are deposited there as the result of long-range transport. They may persist longer in the Arctic environment than in other locations because of the lower temperatures.

Traditional diets based on Arctic ecosystems include large proportions of muscle, fats, and organ meats from animals that accumulate contaminants over relatively long lives. POPs have been found in blubber and other tissues of some Alaska species, such as polar bears, seals, and beluga whales, at levels associated with adverse effects in laboratory and field studies. Levels in caribou and moose do not appear to be as high as those found in marine

TABLE 3.17-1 Annual Incidence Rates of Occupational Injuries and Illnesses to TAPS Employees and Contractors, 1995–2001^a

Year	Employees/ Contractors	Recordable Injuries	Lost Time Accidents	Man-Hours Worked	Incidence Rate ^b	
					APSC	National ^c
2001 (Jan.-July)						
2000	APSC	10	2	995,915	2.01	— ^d
	Contractors	12	3	2,443,666	0.98	—
	Combined	22	5	3,439,581	1.28	—
	APSC	17	8	1,799,622	1.89	—
	Contractors	47	12	4,818,078	1.95	—
	Combined	64	20	6,617,700	1.93	—
1999	APSC	18	6	1,671,890	2.15	1.15
	Contractors	39	13	4,397,361	1.77	1.15
	Combined	57	19	6,069,250	1.88	1.15
1998	APSC	18	5	1,710,569	2.10	1.55
	Contractors	48	13	4,579,801	2.10	1.55
	Combined	66	18	6,290,369	2.10	1.55
1997	APSC	14	6	1,789,546	1.56	1.59
	Contractors	54	5	5,273,038	2.05	1.59
	Combined	68	11	7,062,584	1.93	1.59
1996	APSC	15	5	2,017,395	1.49	2.32
	Contractors	63	10	5,352,174	2.35	2.32
	Combined	78	15	7,369,569	2.12	2.32
1995	APSC	9	2	2,308,884	0.78	2.29
	Contractors	68	18	5,688,310	2.39	2.29
	Combined	77	20	7,997,194	1.93	2.29

^a In addition to 31 fatalities that resulted from incidents directly related to pipeline construction, 9 fatalities resulted from operations-related incidents (including APSC, contractors, and subcontractors): PS 8 explosion, 1977; PS 8 snow-clearing accident, 1978; Valdez Marine Terminal heavy equipment accident, 1984; charter aircraft accident, Glennallen, 1985 (three fatalities); security helicopter accident, Keystone Canyon, 1987; traffic accident near MP 57 on the Elliot Highway, 1997; vehicle accident, Valdez Marine Terminal, 2000 (APSC 2001a; Elleven 2002a).

^b Incidence rate is calculated as:

$$\frac{\text{number of recordable injury cases or days} \times 200,000 \text{ hours}}{\text{number of employee hours worked during year.}}$$

^c For “pipelines except natural gas,” as reported in NSC (2000); based on reports of NSC members, which may not be representative of particular industries.

^d A dash indicates data not available at this time.

Source: Elleven (2001).

mammals and polar bears that are at the top of the food chain (Chary 2000). The resulting human body burdens of contaminants are poorly documented for Alaska Natives. However, ongoing EPA studies of the PBT content of traditional Alaska Native foods and Alaska Native fetal cord blood may soon shed light on whether dietary PBTs are adversely affecting Alaska Natives' health (EPA 2001d). There are already indications of concentrations above levels of concern in some other populations, for example, in eastern Arctic Canada and Greenland (Van Oostdam et al. 1999).

As a result of growing concern about Arctic pollution, the Canadian government has sponsored the Northern Contaminants Program, an extensive, multifaceted attempt to understand physical and biological systems in the Arctic and the implications of the contamination for human health. The program's research into the presence and effects of POPs, heavy metals, and radionuclides has identified several contaminants that may reach levels of concern for human health. The United Nations-sponsored Arctic Monitoring and Assessment Program has identified a similar group of POPs of concern, including PCBs (AMAP 1997). Both the EPA's PBT program and the Northern Contaminants Program have particularly targeted PCBs and mercury for study and reduction efforts (Furgal and Keith 1998; EPA 2001d). Body burden data for POPs, especially PCBs, and for mercury are summarized below. Although no known releases of PCBs or mercury have been associated with TAPS construction and operation, these data are important for consideration of the probable baseline exposure and health conditions of the Alaska Native population.

Additional discussion of background concentrations of radionuclides is also provided. Radionuclides are of concern for the TAPS because naturally occurring radioactive materials may be deposited in oil production pipes, and exposures may occur when the equipment is taken out of production.

No data were available for Alaska or Canada body burdens of PAHs, although the most well-studied PAH (benzo[a]pyrene) has been identified as a PBT (EPA 2001d). PAHs are components of crude oil; their main adverse health effect is cancer.

3.17.2.1.1 PCBs and Other POPs.

PCBs are synthetic organic chemicals that may exist in either solid, liquid, or vapor form. Though banned virtually worldwide, they persist in the environment because of past manufacture and use. They generally enter the environment as mixtures of individual PCBs, known as congeners. The toxicity of PCBs depends on the presence and proportions of various congeners in the mixture. With high exposures, PCBs are known to cause acne and rashes. Health effects associated with low exposures are less certain but may include respiratory and gastrointestinal system effects. Long-term exposure may cause reproductive effects or liver cancer. Prenatal exposure may cause decreased birth weight, neurological effects, or immune system impairment.

Table 3.17-2 presents the available measures of human body burden of PCBs in various populations in Alaska and western Canada. The studies in the Northwest Territories and in the Aleutian and Pribilof Islands include populations that typically have marine mammals and fish as a major component of their diet. Thus, they can be considered likely to have elevated PCB exposure. Health Canada has derived a PCB level of concern for maternal blood of 5 µg/L. The equivalent level for the cord blood of newborns is 2.5 µg/L (Van Oostdam et al. 1999). Both of the studies of adult Alaska Natives listed in Table 3.17-2 found mean or median values for PCBs in blood serum that approach the Canadian level of concern. Serum from women of childbearing age from the Aleutian and Pribilof Islands showed a lower concentration, 2.9 µg/L. Lower concentrations are typically found in women of this age group because of the transfer of PCB burdens to children during gestation and lactation (Chary 2000; Middaugh et al. 2000a,b). The Canadian study of Inuit newborns found mean levels that are about half of the level of concern. In all of the available studies, some individuals had PCB levels that are substantially higher than the relevant level of concern.

To date, there have only been a few analyses of concentrations of POPs in body tissues of Alaska Natives. These analyses have found that levels tend to be higher in older individuals than in younger persons and higher in men than in women. Levels of POPs appear to

TABLE 3.17-2 Measures of PCBs in Tissues of Alaska Natives and Western Canadian Inuit

Date	Location	Subjects ^a	Tissue	Concentration ^b (range) (µg/L)
1985	Alaska	Native women (126)	Serum	Mean, 4.6 Maximum, 17.7 ^c
1993-1995	Northwest Territories	Western Inuit newborns (62)	Cord blood	Mean, 1.32 (0.2-5.1) ^d
1999	Aleutian and Pribilof Islands	Native women (15-44 years; 40)	Serum	Mean, 2.9 (0.0-14.9) ^e
1999	Aleutian and Pribilof Islands	Alaska Natives (166)	Serum	Median, 4.8 (0.0-53.7) ^e

^a Number of subjects is in parentheses.

^b Range is in parentheses.

^c Source: Egeland et al. (1998, p. 85-86).

^d Source: Van Oostdam et al. (1999, Table 19, p. 33) (measured as Aroclor[®] 1260).

^e Source: Middaugh et al. (2000a,b) (not lipid adjusted, sum of 36 congeners).

be higher in persons for whom marine mammals compose a major portion of the diet than in persons subsisting on foods from terrestrial ecosystems, including freshwater species. Available data for Alaska are sparse but generally consistent with the greater body of data for Arctic Canada. Canadian data for human tissues show a spatial trend, with higher levels in the east, generally reflecting higher environmental levels of contaminants. PCB concentrations at levels suspected to cause health effects have been found in Inuit children in eastern Canada. Data for POPs concentrations in blood or breast milk show considerable variation among locations and pollutants but are generally within the range found in populations at lower latitudes.

Analyses of the risk of POPs to human health (Kinloch et al. 1992; Wolfe 1996; Egeland et al. 1998; Van Oostdam et al. 1999) have concluded that the benefits of traditional foods outweigh the hazards associated with current contamination levels. The need for ongoing monitoring of the situation is widely recognized, however.

3.17.2.1.2 Mercury. Mercury is the only “heavy metal” that occurs as a vapor in the atmosphere. Mercury is primarily found in the environment in inorganic and organic compounds rather than as elemental metal. Methylmercury is a toxic form of organic mercury created by biological processes in fresh- and saltwater. Fish take up methylmercury and concentrations biomagnify in the food chain. Consumption of methylmercury-contaminated fish and wildlife can lead to progressive nervous system effects. Long-term high doses can also damage the kidneys, and the gastrointestinal and reproductive systems. All forms of mercury can cause kidney damage if present in sufficient quantities. Prenatal or postnatal (through breast feeding) exposure to organic mercury adversely affects the development and maturation of the nervous system.

Mercury has some of the same characteristics that make POPs problematic in the Arctic: cold condensation, bioaccumulation in animals, biomagnification in the food chain, and persistence. Trends indicate increasing atmospheric concentrations and increasing deposition in the Arctic (Macdonald et al. 2000).

Though data are limited, there are indications that concentrations are increasing in tissues of both Arctic animals used as food and in the humans eating them (Egeland et al. 1998). Most of the total body mercury in fish is found in muscle as methylmercury, while mammals can demethylate mercury to some extent, converting it to the less toxic, inorganic form which is mainly found in the liver, kidneys, and brain. There are some indications that the toxicity of methylmercury may be limited by relatively high levels of vitamin E (present in fish such as salmon) and selenium (more concentrated in marine than terrestrial animals) in the diet (Egeland et al. 1998).

In populations that lack significant mercury exposures, blood mercury values are generally less than 2 µg/L, and values for hair less than 2 µg/g (Van Oostdam et al. 1999). A review of studies in various countries without identified exposure sources found an average of 8 µg/L in blood (ATSDR 1999). For hair, the range of mean values from a number of U.S. studies is 0.47 to 3.8 µg/g for adults (ATSDR 1999).

Body burdens of mercury have been the subject of more studies in the Arctic than is the case for the other PBTs. Relevant findings are summarized in Table 3.17-3. Mean mercury concentrations in hair were elevated in Arctic populations relative to those in other parts of the United States in most of the older studies conducted in Alaskan coastal areas, but not in the more recent studies in Nome. Studies have also shown higher levels among Alaska Natives than in the general population (Egeland et al. 1998) and, in Canada, among those who consume the largest amounts of traditional foods (Berti et al. 1998a). Canadian studies have identified several Arctic populations with mercury intakes or body burdens that reach a level of concern (Van Oostdam et al. 1999). None of the studies found any indications in Alaska Natives of adverse health effects induced by mercury.

3.17.2.1.3 Radionuclides. Both natural and man-made sources contribute radionuclides in the arctic environment. Of the two, natural sources are by far the larger contributor to the total (Macdonald et al. 2000). Together, they do not generally reach a level of

concern in either arctic marine or terrestrial ecosystems, but are about the same or lower than those in air, water, and soil at lower latitudes (Van Oostdam et al. 1999). Localized sources from military or industrial activity are likely to only affect immediately proximate areas.

Cesium deposited in the Arctic from the atmosphere is the radionuclide of greatest concern. It originates primarily from aboveground nuclear tests and from the Chernobyl accident. Levels in the environment have been declining and generally do not reach a level of concern.

While environmental exposures are relatively low, there are dietary pathways that can lead to elevated exposures for those consuming a traditional diet. For example, ingestion of caribou meat is the most important route of exposure for cesium and naturally occurring nuclides, followed by ingestion of freshwater fish. The caribou acquire the radionuclides by eating lichen on which both natural and man-made radionuclides are deposited from the atmosphere. The resulting dietary exposure to radioactivity can exceed limits recommended by the International Commission on Radiological Protection (Berti et al. 1998b).

3.17.2.2 Cancer Rates among Alaska Natives

Cancer incidence and prevalence rates in a population may provide clues as to the types of significant exposures that could be occurring, although in general, causes of individual cancer cases cannot be tied to specific contaminant exposures. For Alaska Natives, the most recent tumor registry data indicate that the overall age-adjusted cancer incidence rate for 1993 to 1997 was slightly higher among Alaska Natives than in the U.S. White population (Lanier et al. 2000). Lung cancer rates in Alaska Natives were twice those of Whites. This increase is attributed to increased rates of cigarette smoking. The rate of stomach cancer in Alaska Natives was three times higher than the rate in Whites. Rates of digestive system cancers overall were about twice those in Whites, while rates of skin, brain, and bladder cancers, and lymphoma were lower. Digestive system cancers may be of particular

TABLE 3.17-3 Measures of Mercury in Tissues of Alaska and Canadian Natives

Date	Location	Subjects ^a	Tissue	Concentration ^b
<i>Mercury</i>				
1972	Pribilof Islands	Seal liver eaters (15)	Hair	5.6 µg/g (1.7) ^c
1972	Pribilof Islands	No seal liver (13)	Hair	4.9 µg/g (2.2) ^c
1972	Pribilof Islands	Total Alaska Natives (28)	Hair	4.6 µg/g (1.0) ^c
1972	Pribilof Islands	Residents (13)	Hair	5.8 µg/g (0.3 – 13.2) ^c
1972	Bethel	Mothers (14)	Hair	5.1 µg/g (1.5 – 9.1) ^c
1972	Yukon-Kuskokwim River Villages	Residents (56)	Hair	1.2 µg/g (0.0 – 3.0) ^c
1976	Yukon-Kuskokwim Coastal	Alaska Native mothers (12)	Hair	4.3 µg/g (0.6) ^c
1976	Yukon-Kuskokwim Interior	Alaska Native mothers (6)	Hair	3.6 µg/g (0.7) ^c
1977	Yukon	Inuit (185)	Hair	7.63 µg/g (7.19) ^d
1977	Yukon	Inuit newborns (31)	Cord blood	4.12 µg/L (1.87) ^d
1977–1978	Yukon	Inuit (83)	Blood	7.04 µg/L (4.01) ^d
1990	Nome	Women (200)	Hair	1.0 µg/g (1.0) ^c
1991	Nome	Women (80)	Hair	1.4 µg/g (1.0) ^c
1994–1995	Northwest Territories	Western Inuit (67)	Maternal blood	3.46 µg/L (0.6 – 12.84) ^d
1994–1995	Northwest Territories	Western Inuit (62)	Cord blood	5.72 µg/L (0.6 – 27.88) ^d

a Number of subjects is in parentheses.

b Numbers in parentheses are standard deviation (single value) or range.

c Source: Egeland et al. (1998, Table 6, p. 53).

d Source: Van Oostdam et al. (1999, Table 23, p. 42).

concern because they are associated with PAH exposures. PAHs are present in crude and refined oil products, but exposures through cigarette smoke and smoked food products are also common.

3.17.2.3 Background on Human Health Risk Assessment

Human exposure to chemicals in air, water, or soil may occur through ingestion, inhalation, or skin contact. Methods used to assess hazards associated with chemical exposures may simply involve a comparison of concentrations in air, water, or soil with health-risk based standards or guidelines available from state and federal agencies. More detailed assessments estimate the extent of human exposure resulting from a particular source, and compare that exposure with benchmark levels for noncarcinogenic risks ("hazard index" approach) or guidelines for acceptable carcinogenic risks.

In estimating either noncancer risks (i.e., chemical exposure-associated noncancer adverse health outcomes such as liver damage or developmental impairment) or increased lifetime cancer risk, the first step is to estimate the chemical concentration in air, water, and/or soil, either present due to natural sources or attributable to man-made sources. The concentration estimate is combined with an estimate of the human intake level to produce a chemical-specific daily intake estimate. (The estimated intake level is usually from the upper end of the expected range of possible intakes to ensure that risk estimates are protective for individuals who have unusually high intakes). Estimated intakes are compared with chemical-specific reference doses or cancer slope factors. The reference doses and cancer slope factors are developed by the EPA for many commonly used chemicals and are based on a broad range of toxicological data. These methods are used in this EIS for the assessment of risks from human exposure to TAPS-associated contaminants or to other contaminants present in the environment. (See text box on next page for more details.)

3.17.2.4 Hazardous Air Pollutants in Ambient Air and Potential Health Hazards

Table 3.13-4 lists major facilities located near the TAPS and gives estimates of annual emissions of VOCs from those facilities. Total VOC emissions may be considered an indicator for emissions of hazardous air pollutants, which are components of VOCs. As shown in the table, annual operational emissions of VOCs from the Valdez Marine Terminal are more than 4 times higher than emissions in other areas (i.e., North Slope, Fairbanks area, or Fort Greely). To address the potential for health hazards from exposure to TAPS-associated VOCs, a comparison of ambient VOC levels in the Valdez area with risk-based guidelines has been conducted and is discussed below. Health risks along other TAPS ROW areas would be less than those near the Valdez Marine Terminal, both because VOC emissions are lower and because the pump stations are located farther from residential areas than is the Valdez Marine Terminal.

The Valdez Air Health Study was conducted to estimate the health risks associated with the inhalation of VOCs by Valdez residents, and the portion of that risk attributable to Valdez Marine Terminal emissions (Goldstein et al. 1992). The study measured ambient air concentrations of five VOCs at four Valdez locations in 1990 and 1991, when the throughput rate for the pipeline was higher than the present rate, about 1.8 million bbl/d. Subsequent to the study, in 1998, a vapor-recovery system was installed on two of the four tanker berths at the Valdez Marine Terminal, substantially decreasing VOC emissions. Therefore, current Valdez Marine Terminal-attributable ambient air VOC concentrations would be expected to be much lower than those measured in the Valdez Air Health Study because of the reduced emission levels. However, the Valdez Air Health Study risk estimates are of interest for the purpose of bounding the potential risks from TAPS emissions (that is, current risks would be lower than those measured in the study).

Concepts in Estimating Risks from Exposures to Chemicals in Air, Water, and Soil

Reference Dose: Oral intake level of a chemical that is very unlikely to have adverse effects; measured in units of mg per kg of body weight per day (mg/kg-d).

Reference Concentration: Concentration of a chemical in air that is very unlikely to have adverse effects if inhaled continuously during a lifetime.

Hazard Quotient: A comparison of the estimated intake level or dose of a chemical in air, water, or soil with its reference dose or concentration; expressed as a ratio.

Example: If 5 parts per million (5 mg/L) toluene is in groundwater used for drinking and 2 L/d are ingested by a 150-lb (70-kg) person over a period of 10 years, then:

Intake = $(5 \text{ mg/L} \times 2 \text{ L/d}) / 70 \text{ kg} = 0.14 \text{ mg/kg-d}$.

The reference dose for chronic ingestion of toluene is 0.2 mg/kg-d.

The toluene hazard quotient is $0.14 / 0.2 = 0.7$. This hazard quotient is less than 1, indicating that the exposure is unlikely to cause adverse noncancer health effects.

Hazard Index: The sum of hazard quotients for all chemicals to which an individual is exposed. Used as a screening tool; a hazard index of less than 1 indicates that adverse health effects are unlikely. However, a hazard index of greater than 1 does not necessarily mean adverse health effects will occur, because different chemicals may react differently in the human body (i.e., have different, nonadditive kinds of toxicity).

Slope Factor: An upper-bound estimate of a chemical's probability of causing cancer over a 70-year lifetime, on the basis of the extent of intake during the exposure period and given in units of inverse intake $(\text{mg/kg-d})^{-1}$ or $1/(\text{mg/kg-d})$. For a carcinogen, different slope factors often apply for oral and inhalation exposures.

Increased Lifetime Cancer Risk: An upper-bound estimate of the likelihood that an individual will develop cancer as a result of exposure to a cancer-causing chemical. It is the product of the intake level and the slope factor.

Example: Benzene is a cancer-causing chemical, with an oral slope factor of up to $0.055 (\text{mg/kg-d})^{-1}$ ($0.055/\text{mg/kg-d}$).

Assuming 5 parts per billion (0.005 mg/L) in water and calculating intake as above, but averaging over a lifetime of 70 years, the increased lifetime cancer risk for benzene would be:

$0.00014 \text{ mg/kg-d} \times 0.055 (\text{mg/kg-d})^{-1} \times 10\text{-yr exposure} / 70\text{-yr lifetime} = 0.000001$ (also can be stated as 1×10^{-6} , or 1 in 1 million).

This increased risk level would be considered to be negligible. It is at the lower end of the increased risk level range of 0.000001 (10^{-6} , or 1 in a million) to 0.0001 (10^{-4} , or 1 in 10,000), which generally does not require mitigating actions.

The VOCs included in the Valdez Air Health Study were benzene (the only known carcinogen), toluene, xylenes, ethylbenzene, and n-hexane. (Cyclohexane, n-heptane, naphthalene, n-octane, and styrene were also measured on personal exposure monitors for Valdez residents, but not in ambient air samples.) The specific VOCs measured were selected on the basis of their presence in Prudhoe Bay crude oil, emission rates from the Valdez Marine Terminal, and their known toxicity at high doses. Of the four locations selected for ambient air monitoring, one (East Gate) was near the boundary of the Valdez Marine Terminal and was chosen to represent the highest ambient concentrations from the terminal. The other three sites were located in Valdez residential areas. The location nearest to the Valdez Marine Terminal consistently had the highest measured VOC concentrations.

In addition to measurement of ambient air concentrations of VOCs, the Valdez Air Health Study estimated the portion of VOCs in ambient air attributable to the Valdez Marine Terminal by releasing a tracer gas from the Valdez Marine Terminal. The gas released was not otherwise present in Valdez and allowed the determination of when terminal emissions were present in the residential areas and how concentrated those emissions were. The study found that only about 1 to 10% of the VOC exposures of Valdez residents (as measured using personal monitoring devices) were attributable to Valdez Marine Terminal emissions. This would be true for two main reasons. First, VOC concentrations are actually higher in indoor air than outdoor air (also a finding of the Valdez Air Health Study), indicating that several indoor sources such as heating fuel, solvents, or cigarette smoke are significant sources of VOC exposures. Second, approximately 50 to 60% of the time, the wind flow patterns in the Valdez basin transport terminal emissions away from the residential areas.

The ambient concentrations of VOCs measured at the Valdez Marine Terminal fence line location and the maximum concentrations of three Valdez residential area locations are presented in Table 3.17-4, along with a risk-based guideline level the EPA uses to rank hazardous air pollutants (Smith et al. 1999). Table 3.17-4 also includes levels of five other

VOCs measured on personal monitoring devices of Valdez residents and the risk-based guideline levels for these VOCs. The fence line ambient level of benzene somewhat exceeded the comparison level (ambient level of $22 \mu\text{g}/\text{m}^3$, upper end comparison level of $13 \mu\text{g}/\text{m}^3$); the ambient benzene level at residential locations, however, was lower, within the 10^{-6} to 10^{-4} (1 in 1 million to 1 in 10,000) increased cancer risk range level used by the EPA as an indicator of risks generally not requiring mitigating actions (EPA 1990). In addition, the ambient naphthalene level measured on personal monitors just exceeded the comparison level (3.0 versus $3.3 \mu\text{g}/\text{m}^3$) and could be associated with adverse effects. The Valdez Marine Terminal may not be the major source of naphthalene in the residential areas; another possible source could be combustion of home heating fuel.

Since the Valdez Marine Terminal only contributes about 10% to the outdoor residential area VOC concentrations, and since VOC emissions from the Valdez Marine Terminal have decreased substantially since the time of the study, it is concluded that current TAPS-associated emissions are not likely to lead to adverse human health impacts.

3.17.2.5 Existing Site Contamination

The Federal Grant stipulations require that essentially any spill along the TAPS be reported, regardless of impacts. As of August 2001, APSC has a total of 87 contaminated sites resulting from spills along the pipeline (70 sites) and at the Valdez Marine Terminal (17 sites) (OASIS Environmental 2001). Twenty-seven of the sites along the pipeline and 8 at the Valdez Marine Terminal are presently classified as active sites; that is, they are being actively assessed, monitored, or remediated, with spill volumes ranging from 5 gal Therminol to 33,619 gal crude oil. These include six higher-priority, actively managed contaminated sites that are used by OASIS Environmental (2001) to illustrate APSC's program for managing contaminated sites. ADEC regulatory oversight is designed to provide a clearly defined framework for moving

TABLE 3.17-4 Valdez Area Ambient VOC Concentrations and Risk-Based Guideline Levels^a

Volatile Organic Compound	Annual Average Fence Line Concentration (µg/m ³)	Maximum Annual Average Residential Area Concentration (µg/m ³)	EPA Guideline Level (µg/m ³)
Ambient air monitoring			
Benzene	22	5	0.13-13 ^b
Ethyl benzene	3	1	1,000
n-hexane	69	6	200
Toluene	19	7	400
Xylene	9	7	390,000
Personal air monitoring			
Cyclohexane	NA ^c	12	21,000 ^d
n-Heptane	NA	27	NA
Naphthalene	NA	3.3	3.0
n-Octane	NA	4.9	NA
Styrene	NA	3.6	1,000

- ^a Ambient levels in 1990 and 1991 at approximately 1.8 million bb/d throughput, as reported in Goldstein et al. (1992). EPA guideline levels as given in Smith et al. (1999, Table 2); used to rank the toxicity of hazardous air pollutants under the Clean Air Act.
- ^b Where a range is given, the range corresponds to a 10⁻⁶ to 10⁻⁴ risk level (i.e., the concentration that if inhaled for a lifetime would result in an increased individual risk of developing cancer of between 1 in 1 million and 1 in 10,000).
- ^c NA = data not available.
- ^d Risk-based guideline not available in Smith et al. (1999); cited level from EPA Region IX Preliminary Remediation Goals (EPA 2001e).

sites through the process of discovery, characterization, remediation, monitoring (if necessary), and closure. A variety of management techniques for contaminated sites are used at the actively managed sites to complete cleanup and ensure that no unacceptable health risk remains (OASIS Environmental 2001). These techniques always include removal of free product and usually excavation of contaminated soil to eliminate the potential for direct exposure; other approaches include in situ remediation, intrinsic remediation, site monitoring, and risk assessment (OASIS Environmental 2001).

Currently, Alaska's groundwater is protected primarily through the regulation of contaminated sites, storage tanks, spill response, and specific waste disposal activities under state and federal programs. The ADEC manages several programs that contribute to the protection of groundwater, including its Contaminated Sites; Storage Tank; Prevention and Emergency Response; Industry Preparedness and Pipeline; Solid Waste; Pesticides; Water and Wastewater; Watershed Development; Water Quality Protection; and Community Assistance and Information Programs (ADEC 2001).

The eight actively managed contaminated sites at the Valdez Marine Terminal currently do not appear to pose a threat to drinking water supplies (OASIS Environmental 2001). Water used for drinking water and food preparation at the pump stations and camps is generally supplied by local wells built and maintained by APSC for that purpose. Although few of Alaska's aquifers have been characterized and few water quality data are available (ADEC 2001), well

monitoring results at pump stations indicate that nitrates and arsenic are less than the current EPA MCLs for drinking water (see Section 3.8). However, arsenic concentrations may be an issue in the future as the MCL is reduced from 0.05 to 0.01 mg/L.

Procedures are in place to minimize risks to the public associated with accidental releases, as described in Section 4.1.4.

3.18 Terrestrial Vegetation and Wetlands

This section describes the terrestrial vegetation and wetland communities within the TAPS ROW and adjacent areas, along the Beaufort Sea coastline, and in the area of Prince William Sound, including Port Valdez and the Valdez Marine Terminal. Descriptions of wetland and upland vegetation communities are from Viereck et al. (1992); wetland system terminology is from Cowardin et al. (1979) and is presented in Table 3.18-1.

3.18.1 TAPS ROW

The TAPS ROW passes through four major vegetation zones from MP 0 on the North Slope near Prudhoe Bay to MP 800 at Port Valdez (Map 3.18-1). These major vegetation zones are lowland tundra, upland tundra, boreal forest/taiga, and coastal forest (Viereck et al. 1992). Each zone includes a complex of terrestrial and wetland vegetation types (Table 3.18-2), the distribution and extent of which are strongly influenced by elevation, soil characteristics, temperature, and moisture. These vegetation complexes are described below for each zone. A large portion of the ROW passes through wetland areas. On the basis of estimates made for the adjacent Trans-Alaska Gas System proposed route (BLM and USACE 1988), approximately 51% of the TAPS ROW route may consist of wetlands.

Wetlands

The wetland areas included in this discussion are those identified by the National Wetland Inventory. They are defined as areas that are transitional between terrestrial and aquatic systems and have a water table usually at or near the substrate surface or a substrate that is covered by shallow water (Cowardin et al. 1979).

3.18.1.1 Lowland Tundra

The northernmost portion of the TAPS ROW is within the Arctic Coastal Plain, from MP 0 to approximately MP 60. Coastal plain soils are mostly fine-grained and have an extremely high ice content (Brown 1968; Brown and Sellman 1973; Rawlinson 1993; Shur and Jorgenson 1998). Thick permafrost underlies the coastal plain, impeding drainage and creating saturated soils in most areas. Numerous small lakes are scattered throughout this zone. The coastal plain supports lowland tundra vegetation types. Wetland plant communities, characterized by sedges, grasses, and mosses, are the predominant vegetation feature of the lowland tundra zone, and many of the plant communities along the TAPS ROW in this zone are wetlands. Small areas of wet tundra occur frequently in shallow water areas and primarily support wet sedge meadow tundra and wet sedge-grass meadow community types (Walker et al. 1980; Walker and Acevedo 1987). Sites with deeper water (up to 3 ft) typically support fresh grass marsh communities.

Wet sedge meadow tundra, the predominant vegetation type in this zone consists primarily of tall cottongrass (*Eriophorum angustifolium*) and water sedge (*Carex aquatilis*) (Viereck et al. 1992). Areas of wet sedge meadow are typically inundated to a few inches in depth early in the growing season (Viereck et al. 1992). This vegetation type is classified as palustrine emergent persistent wetland.

Small-scale variations in the land surface elevation also influence the distribution of plant communities. These variations include strangmoor ridges (alternating ridges and hollows oriented perpendicular to water flow), frost scars, polygons bordered by ice wedges, and naturally induced thermokarst (Peterson and Billings 1978; Webber 1978; Walker et al. 1980). These small disturbances alter patterns of species occurrence and result in complex structures of plant communities (Walker 1983).

TABLE 3.18-1 Wetland Systems and Classes along the TAPS ROW, Beaufort Sea, and Prince William Sound

Wetland System/Class	Description
System	
Estuarine	Tidal areas near land with access to open ocean, somewhat diluted by fresh water
Lacustrine	Large (generally over 20 acres) or deep water bodies lacking persistent vegetation
Limnetic	Deepwater areas in the lacustrine system
Littoral	Nearshore, shallow areas in the lacustrine system
Marine	Areas exposed to open ocean waves and currents with little freshwater dilution
Palustrine	Wetlands dominated by trees, shrubs, or persistent emergents or small, shallow wetlands
Riverine	Areas contained within a channel, at least periodically with moving water, lacking persistent vegetation
Class	
Aquatic bed	Vegetation growing on or under the water surface; inundation at least seasonal
Emergent	Dominated by erect, rooted, herbaceous vegetation
Forested	Dominated by woody vegetation at least 20 ft tall
Rocky shore	Primarily bedrock, stones, or boulders with less than 30% vegetation cover
Scrub-shrub	Dominated by woody vegetation less than 20 ft tall
Unconsolidated bottom	A substrate of small particles with less than 30% vegetation cover; surface water nearly always present
Unconsolidated shore	A substrate of less than 75% stones, boulders, or bedrock and less than 30% vegetation cover other than pioneer species

Source: Cowardin et al. (1979).

Lowland Tundra

From MP 0 to 60, the TAPS ROW crosses the Arctic Coastal Plain. This area supports primarily lowland tundra vegetation types. The term "tundra" refers to a cold-climate arctic or alpine landscape characterized by a dominant vegetation of mosses, lichens, herbs, and low shrubs. Trees are generally absent. The exact vegetation mix depends on local soil, moisture, geological, and climatic conditions.

Wetland plant communities are the predominant vegetation type in the lowland tundra zone and along the portion of the TAPS ROW crossing this zone.

Ice wedges form directly below the active soil layer, which adjusts weakly to changes in energy balance at the surface, and so are particularly sensitive to disturbances. Ice wedges can easily melt as a result of disturbance, resulting in deep troughs, often bordering high-centered polygons (Lawson 1986; Walker et al. 1987).

Small areas of moist tundra drain soon after spring runoff. These moist tundra types are relatively common and include such areas as the rims of low-centered polygons, the centers of weakly developed high-centered polygons, low hummocks, strangmoor ridges, and well-drained areas along streams. These moist locations support sedge-willow tundra (primarily sedges of the genus *Carex* with up to 25% willows — *Salix* spp.) and sedge-dryas tundra (primarily sedges of the genus *Carex* with up to 25% dwarf shrubs of the genus *Dryas*) community types. Many occurrences of these community types, with suitable soil and hydrologic characteristics, are wetland communities.

TABLE 3.18-2 Vegetation Types and Associated Landforms Found in Each Major Vegetation Zone Crossed by the TAPS ROW

Zone/Landform, Landscape Position ^{a,b}	Vegetation Type ^b	Dominant Species
<i>Lowland Tundra Zone</i>		
Active and inactive floodplains	Open and Closed Low Willow Shrub ^c	Richardson, diamondleaf, and grayleaf willows; alpine milk vetch, dwarf fireweed
Low-centered polygons, non-patterned ground	Open Low Willow-Sedge Shrub Tundra ^d	Diamondleaf willow, water sedge, arctic sweet coltsfoot, polar grass
Active floodplain	Seral Herbs	Dwarf fireweed, wormwood, dwarf hawk's beard, northern sweetvetch
Low-centered polygon rims, high-centered polygons, pingos	Sedge-Dryas Tundra ^d	Water sedge, Bigelow sedge, entire-leaf mountain-avens, white mountain-avens
Active sand dunes	Dunegrass	Dunegrass, Dupontia, <i>Senecio pseudo-amica</i>
Thaw lakes and ponds	Fresh Grass Marsh ^c	Arctic pendant grass, water sedge
Drained thaw lakes, nonpatterned ground	Wet Sedge Meadow Tundra ^c	Tall cottongrass, water sedge, mosses
Margins of drained lakes and rivers	Dryas Dwarf Shrub Tundra	White mountain-avens
Coastal salt Marsh	Halophytic Sedge Wet Meadow ^c	Hoppner sedge, Ramenski sedge, loose-flowered alpine sedge
Coastal salt Marsh	Halophytic Grass Wet Meadow ^c	Alkali grass
<i>Upland Tundra Zone-Arctic Foothills</i>		
Silty colluvium	Open Low Mesic Shrub Birch-Ericaceous Shrub ^c	Resin birch, bog blueberry, mountain-cranberry, Labrador tea, feathermoss
Silty colluvium	Open Low Willow Shrub ^c	Richardson, diamondleaf, and grayleaf willows; alpine milk vetch; dwarf fireweed
Alpine sandstone and till slopes and ridges	Dryas and Dryas-Lichen Dwarf Shrub Tundra	White mountain-avens, arctic willow, bog blueberry, <i>Stereocaulon tomentosum</i> , <i>Cladonia</i> spp.
Silt-capped valleys and gentle slopes	Tussock Tundra ^c	Tussock cottongrass, diamondleaf willow, Bigelow sedge
Polygons, gentle slopes	Open Low Mixed Shrub-Sedge Tussock Tundra ^c	Tussock cottongrass, resin birch, dwarf arctic birch, narrow-leaf Labrador tea, mountain cranberry, bog blueberry
Drained lake basins, valley depressions; lacustrine or fine-grained silts	Wet Sedge Meadow Tundra ^c	Tall cottongrass, water sedge, mosses

TABLE 3.18-2 (Cont.)

Zone/Landform, Landscape Position ^{a,b}	Vegetation Type ^b	Dominant Species
<i>Upland Tundra Zone-Brooks Range</i>		
Pond margins, stream banks; silt loam over gravel	Open Low Willow-Sedge Shrub Tundra ^C	Diamondleaf willow, water sedge, Bigelow sedge, arctic sweet coltsfoot
Alpine drainages and solifluction lobes	Willow Dwarf Shrub Tundra	Least and netleaf willows, crowberry sedges, lichens
Floodplain terraces; silt loam over gravel	Open Low Alder-Willow Shrub ^C	American green alder, diamondleaf willow, sedges, mosses
Till slopes and ridges	Dryas Dwarf Shrub Tundra	White mountain-avens, arctic willow, bog blueberry, bearberry
Mid-slope; thin, stony soil	Dryas-Sedge Dwarf Shrub Tundra	White mountain-avens, northern single-spike sedge and other sedges, mosses, and lichens
Rocky ridges and upper slopes	Ericaceous Dwarf Shrub Tundra	Alpine bearberry, mountain-cranberry, bog blueberry, Bigelow sedge, alpine azalea, lichens
Drained lake basins, valley depressions	Wet Sedge Meadow Tundra ^C	Tall cottongrass, water sedge, mosses
<i>Upland Tundra Zone-Alaska Range</i>		
North-facing slopes at treeline	Open Black Spruce-Willow Shrub	Black spruce, white spruce, Labrador tea, willows, feathermosses
Steep to moderate slopes at treeline; silt loams	Open Tall Shrub Birch Willow Shrub	Resin birch; diamondleaf, Barratt, and Richardson willows; fescue grass
Moderately well drained slopes; stony silt loams	Open Low Mesic Shrub Birch-Ericaceous Shrub	Resin birch, Labrador tea, mountain-cranberry, bog blueberry, crowberry, fescue grass
Steep to moderate slopes at treeline, drainageways	Closed Tall Alder-Willow Shrub ^C	American green alder, diamondleaf willow, sedges, moss
Alpine drainages and solifluction lobes	Willow Dwarf Shrub Tundra	Least and netleaf willows, crowberry, sedges, lichens
Wetland borders	Open and Closed Low Willow Shrub ^C	Richardson, diamondleaf, and grayleaf willows; alpine milkvetch, arctic sweet coltsfoot
Drainageways near treeline	Open Low Alder-Willow Shrub ^C	American green alder, diamond leaf willow, sedges, mosses
Gentle slopes	Open Low Mixed Shrub- Sedge Tussock Tundra ^C	Tussock cottongrass, resin birch, dwarf arctic birch, narrow-leaf Labrador tea, mountain cranberry, bog blueberry, mosses
Streambanks, protected swales	Mesic Sedge-Grass Meadow Tundra	Water sedge, short-stalk sedge, Carex microchaeta, arctic bluegrass, polar grass
<i>Upland Tundra Zone-Pacific Coastal Mountains</i>		
Subalpine slopes, drainages, floodplains; moderately well- drained loams (often stony)	Closed Tall Alder Shrub ^d	American green alder, diamondleaf and grayleaf willows, fescue grass, polargrass

TABLE 3.18-2 (Cont.)

Zone/Landform, Landscape Position ^{a,b}	Vegetation Type ^b	Dominant Species
Slope depressions, snowbed communities; thin, stony soils	Closed Low Ericaceous Shrub	Copperbrush
Alpine slopes, snowbeds; thin, stony soils	Mountain-heath Dwarf Shrub Tundra	Aleutian mountain heath, starry cassiope, bog and dwarf blueberry
Alpine slopes; commonly north-facing; thin, stony soils	Cassiope Dwarf Shrub Tundra	Mertens cassiope, Aleutian mountain heath, bog and dwarf blueberry, crowberry
Depressions	Subarctic Lowland Sedge-Shrub Wet Meadow ^c	Meadow horsetail, variegated scouring-rush, yellow marsh-marigold
Seepage areas, pond and marsh margins; saturated or semi-permanently flooded silts or sands; shallow organic horizon	Subarctic Lowland Herb Wet Meadow ^c	Lyngbye sedge, sweetgale, willow
<i>Boreal Forest Zone-Interior</i>		
Well-drained hillsides, treeline, young river terraces, inactive floodplains	Open and Closed White Spruce Forest	White spruce, alder, highbush cranberry, twinflower, prickly rose, buffaloberry, bluejoint, horsetail
Well-drained slopes of shallow bedrock, or poorly drained silts on floodplain terraces or north-facing slopes	Open and Closed Black Spruce Forest ^d	Black spruce, resin birch, Labrador tea, bush cinquefoil, mountain-cranberry, horsetail
Near treeline or poorly drained silts on floodplain terraces	Open and Closed Black Spruce-White Spruce Forest ^d	Black spruce, white spruce, Labrador tea, willows, feathermosses
Wet lowlands, shallow permafrost	Open Black Spruce-Tamarack Forest ^c	Black spruce, tamarack, resin birch, Labrador tea, mosses
Well-drained slopes of shallow bedrock or very poorly drained silts	Black Spruce Woodland ^c	Black spruce, cottongrass, willows, sphagnum moss
Floodplain terraces	Closed Balsam Poplar Forest	Balsam poplar, thinleaf alder, willows, prickly rose
Upland loess soils	Closed Paper Birch Forest	Paper birch, willows, alder, Labrador tea
Well-drained slopes, upland slopes, commonly south-facing	Closed Quaking Aspen Forest	Quaking aspen, highbush cranberry, twinflower
Very poorly drained lowlands, shallow permafrost	Open Black Spruce Dwarf Tree Scrub ^c	Black spruce, Labrador tea, tussock cottongrass, sphagnum moss
Active and young floodplains	Open and Closed Tall Willow Shrub ^d	Feltleaf, grayleaf, diamondleaf, and littletree willows; bluejoint; dwarf fireweed; meadow horsetail

TABLE 3.18-2 (Cont.)

Zone/Landform, Landscape Position ^{a,b}	Vegetation Type ^b	Dominant Species
Upland drainageways, seepages	Open Tall Shrub Swamp ^C	Thinleaf, American green alders, bluejoint
Nonpatterned wetlands with thick organic mat	Open Low Shrub Birch- Ericaceous Shrub Bog ^C	Resin birch, mountain-cranberry, bog blueberry, Labrador tea, sedges, sphagnum moss
Poorly drained silty lowlands to well-drained upland slopes	Bluejoint ^d	Bluejoint
Lake and pond margins, sloughs; silty or organic soils	Subarctic Lowland Sedge Wet Meadow ^C	Water sedge, <i>Carex saxatilis</i> , meadow horsetail
Wetland margins	Subarctic Lowland Sedge- Shrub Wet Meadow ^C	Lyngbye sedge, sweetgale, willow
Sloughs, oxbow lakes, lake margins; silty or organic soils	Fresh Herb Marsh ^C	Swamp horsetail, buckbean, water smartweed
<i>Boreal Forest Zone-Copper Plateau</i>		
Inactive floodplains; silts over coarse gravels	Open White Spruce Forest	White spruce, alder, highbush cranberry, twinline, prickly rose, buffaloberry, bluejoint, horsetail
Poorly drained lowlands, shallow permafrost	Open Black Spruce Forest ^d	Black spruce, resin birch, Labrador tea, bush cinquefoil, mountain-cranberry, horsetail
Floodplain terraces	Closed Balsam Poplar Forest	Balsam poplar, thinleaf alder, willows, prickly rose
Moderately to well-drained upland soils	Closed Paper Birch Forest	Paper birch, willows, alder, Labrador tea
Poorly drained lowlands, shallow permafrost	Open Black Spruce Dwarf Tree Scrub ^C	Black spruce, Labrador tea, tussock cottongrass, sphagnum moss
Seeps, stream banks; silts with interbedded organics	Closed Tall Shrub Swamp ^C	Thinleaf alder, diamondleaf willow, water sedge, bluejoint
Nonpatterned wetlands with thick organic mat	Open Low Shrub Birch- Ericaceous Shrub Bog ^C	Resin birch, mountain-cranberry, bog blueberry, Labrador tea, sedges, sphagnum moss
Organic soils overlaying silts	Open Low Mesic Shrub Birch-Ericaceous Shrub	Resin birch, dwarf arctic birch, bog blueberry, mountain cranberry, narrow-leaf Labrador tea, bearberry, crowberry
Floodplain sloughs, poorly drained terraces	Open Low Mixed Shrub- Sedge Tussock Bog ^C	Tussock sedge, resin birch, dwarf arctic birch, narrow-leaf Labrador tea, bog blueberry, mountain cranberry
Lake and pond margins, sloughs; silty or organic soils	Subarctic Lowland Sedge Wet Meadow ^C	Water sedge, <i>Carex saxatilis</i> , meadow horsetail
Sloughs, oxbow lakes, lake margins; silty or organic soils	Fresh Herb Marsh ^C	Swamp horsetail, buckbean, water smartweed

TABLE 3.18-2 (Cont.)

Zone/Landform, Landscape Position ^{a,b}	Vegetation Type ^b	Dominant Species
<i>Coastal Forest Zone</i>		
Active alluvial fans and floodplains	Open Sitka Spruce Forest	Sitka spruce, Sitka alder, bluejoint
Slopes, benches, poorly drained soils with relatively thick organic surface layer	Open Western Hemlock - Sitka Spruce Forest	Western hemlock, Sitka spruce, devilsclub, rusty menziesia, salmonberry
Upper mountain slopes; shallow, poor to well-drained soils	Closed Mountain Hemlock Forest ^d	Mountain hemlock, bog and dwarf blueberry, lace flower, ferns
Poorly drained lowlands on shallow soils, permafrost absent	Open Black Spruce Forest ^c	Black spruce, resin birch, Labrador tea, bush cinquefoil, mountain-cranberry, horsetail
Floodplains, thin silt loam overlying glacial outwash	Open Black Cottonwood ^d	Black cottonwood, thinleaf alder, salmonberry, tall fireweed, devilsclub
Floodplains, glacial outwash	Closed Black Cottonwood ^d	Black cottonwood, prickly rose, high bush cranberry, devils club, bluejoint, horsetail
Slopes, floodplains	Open Tall Alder-Willow Shrub	American green alder; Sitka alder; Richardson, grayleaf, diamondleaf, and Barclay willows
Lowland depressions	Open Low Shrub Ericaceous Shrub Bog ^c	Crowberry, bog blueberry, mountain-cranberry
Depressions	Subarctic Lowland Sedge-Bog Meadow ^c Subarctic Sedge-Herb Wet Meadow ^c	Russet cottongrass, shore sedge, many-flowered sedge
Active floodplains	Open and Closed Tall Willow Shrub ^d	Feltleaf, grayleaf, diamondleaf, and littletree willows; bluejoint

^a Source: Walker (1985).

^b Source: Viereck et al. (1992).

^c Vegetation types classified as wetlands.

^d Can be classified as upland or wetland, depending on soil and hydrologic conditions.

Both large-scale and small-scale landscape features related to permafrost conditions are important in creating the topographic variations that determine the occurrence of wet, moist, and dry tundra. Locations of increased surface elevation support communities containing dwarf shrubs, cushion plants, lichens, and graminoid plants (grasses and grass-like plants) that are adapted to the better-drained soils (Walker 1985). Tussock tundra, characterized by tussock cottongrass (*Eriophorum vaginatum*), occurs within this zone at mesic locations (sites that are

characterized by moist, rather than wet soils). These sedges are generally 4 to 24 in. tall and often are interspersed with low shrubs much shorter than the sedges (Viereck et al. 1992). Several species of willow (*Salix* spp.) comprise the shrub component of these communities, especially near the coastline (McKendrick 2002). Farther inland, additional low shrub species, such as entire-leaf mountain-avens (*Dryas integrifolia*), alpine bearberry (*Arctostaphylos alpina*), and bog blueberry (*Vaccinium*

uliginosum), are present. Mosses and lichens are also common in this vegetation type.

Thaw lakes (typically 3 to 23 ft in depth), are shaped and oriented by wind direction and cover 20 to 50% of the coastal plain surface area (Gallant et al. 1995). Most of the lakes in this zone are classified as lacustrine limnetic unconsolidated bottom wetlands, while the ponds, which are smaller and shallower, are generally palustrine unconsolidated bottom wetlands. Lake margins and smaller ponds in this zone frequently support the fresh grass marsh vegetation type, generally in surface water depths of 6 in. to 7 ft (Viereck et al. 1992). The dominant species of these marsh communities is arctic pendant grass (*Arctophila fulva*), with water sedge also frequently present. Common maretail (*Hippuris vulgaris*) communities also occur in shallow water, generally 2 to 12 in. in depth (Viereck et al. 1992). Fresh grass marsh and common maretail communities are classified as lacustrine littoral emergent nonpersistent along lake margins and palustrine emergent nonpersistent in smaller ponds.

The large-scale opening of areas for colonization and succession on the coastal plain is primarily the result of processes shaping the land surface and river channels (Billings 1987). Thaw lakes typically follow a cyclic pattern of draining and reforming in response to the degradation and subsequent reforming of ice-rich permafrost (Britton 1957; Carson and Hussey 1961; Billings and Peterson 1980).

Following the drainage of a thaw lake, the wet lake basin is typically colonized within a few years by pioneer species of graminoid plants (grasses and grass-like plants) and mosses (Ovendon 1986). Sedge-willow tundra, wet sedge-herb meadow tundra, wet sedge meadow tundra, and wet sedge-grass meadow tundra vegetation types commonly become established in drained basins. Wet sedge-grass meadow communities are often the dominant vegetation type in thaw-lake basins that are recently vegetated (Billings and Peterson 1980; Bliss and Peterson 1992). These communities, dominated by sedges and grasses, are commonly composed of tundra grass (*Dupontia fischeri*) and water sedge or tall cottongrass (Viereck et al. 1992). Surface water in wet sedge-grass

meadow communities may be present much of the growing season and may be up to 6 in. deep (Viereck et al. 1992). The predominant vegetation types of the basins typically succeed to wet sedge meadow tundra communities, which are common in older basins (Billings and Peterson 1980; Funk et al. 1991; Bliss and Peterson 1992). The ice content of the underlying permafrost, the age of the lake prior to draining (Billings and Peterson 1980), and the substrate characteristics within the basin (Funk et al. 1991) are factors in determining the plant species composition and stages of community succession. Plant communities near the Sagavanirktok River tend to be maintained in early and mid-successional stages by the deposition of alkaline windblown silt from the river channel (Walker 1985; Walker and Everett 1991).

Small areas of dry tundra occasionally occur in the lowland tundra zone. Dry tundra community types occur on well-drained soils such as the margins of old lake basins and rivers and on soils formed from gravelly stream deposits. The soils on these locations usually have very little organic material in the surface layer. These communities are predominantly sedge-dryas tundra and dryas dwarf shrub tundra (Walker 1985). The latter community type is characterized by dwarf shrubs less than 8 in. tall, primarily species of *Dryas* (Viereck et al. 1992).

Large gravel bars and sandbars (Bliss and Cantlon 1957; Bliss and Peterson 1992) and sand dunes (Peterson and Billings 1978, 1980) occur along rivers on the Arctic Coastal Plain in the vicinity of the TAPS ROW. Active dunes primarily occur along river margins (Tedrow and Brown 1967) and coastal areas, but also occasionally occur on the shores of thaw-lakes (Walker 1973). Active dunes support dunegrass (*Elymus arenarius*) communities. Active and inactive floodplains support open and closed low willow shrub communities. Seral herb communities occur on active floodplains, riverbanks, and eroding bluffs. Large, braided rivers on the Arctic Coastal Plain, such as the Sagavanirktok River, include extensive areas of riverine unconsolidated shore and unconsolidated bottom wetlands that are predominantly unvegetated or sparsely

vegetated. Halophytic sedge wet meadow communities, characterized by salt-tolerant sedges (*Carex* spp.), and halophytic grass wet meadow communities, characterized by salt-tolerant alkali grass (*Puccinellia* spp.), are the predominant community types of coastal salt marshes (Meyers 1985; Noel and Funk 1999).

Initial preparation of the ROW and construction of the pipeline and related facilities, the Dalton Highway, and oil field facilities resulted in the loss of areas of lowland tundra communities. A total of approximately 1,522 acres of wet-meadow tundra was impacted north of PS 4 (MP 144) during construction (including both lowland tundra and upland tundra zones), with much of the impact coming from the development of material sites (Pamplin 1979). Over 700 acres of tundra communities previously occurred within the ROW itself, within the lowland tundra zone (MP 0 to 60). These areas were lost by the placement of fill material, primarily gravels from the Sagavanirktok River channel, or replaced by other communities, such as those colonizing ROW surfaces. The basins of lakes drained for TAPS construction have been colonized by tundra vegetation communities. Within the TAPS ROW, gravel, moisture, nutrients, organic material, and thickness of the surface organic mat differ from the surrounding undisturbed areas (McKendrick 2002). The TAPS ROW generally has a high gravel content and significantly lower moisture level, lower organic matter, and greatly reduced organic mat thickness than the surrounding area.

These differences in conditions have resulted in differences between ROW vegetation communities and adjacent natural communities. While vegetation communities of the surrounding area are predominantly wetland communities of sedges, low shrubs, or shallow water marshes, the communities within the ROW are primarily composed of species originally planted for revegetation purposes, such as red fescue (*Festuca rubra*) or species that frequently colonize gravels of the nearby river channel, such as dwarf fireweed (*Epilobium latifolium*). Stands of tall willows occur along the ROW margins in a number of areas. The ROW contains more forb species and more grass species, but fewer sedge species, than the

adjacent undisturbed areas. The ROW typically contains many species that are not found in the nearby undisturbed communities, while many species of the natural communities have not successfully invaded the ROW. The latter condition in some locations may be due to competition from grasses planted in the ROW during revegetation efforts, along with low moisture levels (McKendrick 2002). Some species from the adjacent habitats, however, have become established within the ROW over the years (McKendrick 2002; Moore 1992). Species planted under the current revegetation program for ROW maintenance include native varieties of red fescue and Bering hairgrass.

Past operation of TAPS has resulted in spills of crude oil and other materials (Section 3.3.3), which have affected vegetation communities in the vicinity of the ROW. The BLM monitored the area affected by a spill at check valve 7 (MP 26), which occurred in June 1977 (BLM 1984). The spill resulted in light to heavy oiling of 3.8 acres and a trace of oil on an additional 9.7 acres. While much of the vegetation in the affected area was injured or killed by the oil, cleanup efforts and reseedling of the area resulted in a substantial recovery of the lowland tundra vegetation (BLM 1984; TAPS Owners 2001a).

3.18.1.2 Upland Tundra

The upland tundra vegetation zone occurs on the Brooks Range (including the northern foothills), the Alaska Range, and the Pacific Coastal Mountains. The upland tundra zone

Upland Tundra

The TAPS ROW crosses the upland tundra vegetation zone in the Brooks Range (MP 60 to about MP 190) the Alaska Range (MP 550 to 610), and the Pacific Coastal Mountains (MP 720 to 780). The exact vegetation types crossed by the ROW in these zones varies with elevation, aspect, slope, and soil and moisture conditions. The zone typically includes moist tundra, alpine (dry) tundra, and shrub or high brush tundra. Tussock tundra is a predominant vegetation type within this zone north of the Arctic Circle.

includes moist tundra, alpine (dry) tundra, and shrub or high brush tundra (Viereck et al. 1992). A predominant vegetation type within this zone, north of the Arctic Circle, is tussock tundra, with dryas dwarf shrub tundra occurring on dry rocky locations and exposed ridges (Viereck et al. 1992). Dryas tundra and ericaceous shrub tundra are the most frequently occurring communities above the treeline in mountain areas. Near the treeline, in the Alaska Range and Brooks Range, shrubland communities are extensive, mainly low shrub dwarf birch. This major vegetation zone extends from approximately TAPS MP 60 to approximately MP 190 across the Brooks Range (including the northern foothills), MP 550 to 610 in the Alaska Range, and MP 720 to 780 in the Pacific Coastal Mountains.

Thick permafrost extends over the hills and plateaus of the northern foothills of the Brooks Range. The foothills have more distinct drainage patterns and fewer lakes than the Arctic Coastal Plain. Drainage patterns and the processes of weathering and deposition primarily determine the distribution of vegetation communities. These processes include frost creep, solifluction (downslope movement of soil), erosion, wind deposition, ice aggradation, and thermokarst (see Sections 3.2 and 3.3), which alter surface characteristics in the landscape (Jorgenson 1984).

The most common vegetation type of the foothills is tussock tundra (Table 3.18-2), which is the predominant type on old glacial moraines. Dwarf shrub communities occur on rocky moraine ridges. Active floodplains and small drainages support willow and alder shrub communities. Inactive floodplains support extensive wet sedge meadows.

The system of drainages on the upland slopes of the northern foothills results in water tracks caused by the movement of surface water and groundwater above the level of permafrost (Jorgenson 1984; Walker, D.A., et al. 1989; Giblin et al. 1991). This drainage system reduces surface water collection and decreases the occurrence of thermokarst development and the potential for ice-wedge melting.

Most soils of the northern foothills are poorly drained (Brown 1980). Tussock tundra

communities occur on the gentle slopes of glacial moraines, which have poorly drained soils (Walker et al. 1994). Gravelly soils on ridges and terraces adjacent to the major rivers are moderately well drained to well drained (Brown 1980). The drier, more exposed locations on the upper slopes and ridges support dryas-lichen tundra and dryas tundra communities (Walker et al. 1994). Open low willow shrub communities occur along drainages and on active floodplains. Wet sedge meadow tundra is the predominant community type in drained lake basins, valley depressions, and abandoned floodplains.

Uplands occur on south-facing sandstone outcrops and on exposed till. However, much of the landscape adjacent to the TAPS ROW in the northern foothills consists of wetlands. The valley bottoms and hill slopes have poorly drained soils with thick organic layers (Walker, M.D., et al. 1989). The silty soils, particularly on upper slopes, are thick enough to impede surface water drainage and remain saturated. Wetland plant communities of the northern foothills include tussock tundra, open low mixed shrub-sedge tussock tundra, open low mesic shrub birch ericaceous shrub, open low willow shrub, and wet sedge meadow tundra.

On the rugged mountains of the Brooks Range, vegetation is sparse because of the steep, highly erodable slopes, shallow soils, high winds, and arctic climate. Vegetation is primarily found in the valleys and on the lower hillsides. Soil development on slopes is poor, and valley soils are derived primarily from glacial till. A shallow thaw depth and poor soil drainage result from thick permafrost, but the soils are generally thaw-stable (Kreig and Reger 1982). Large patches of bare rock and soil are exposed by slope failures that result from steep slopes and a high moisture content in the active soil layer (Brown and Kreig 1983). Patterns of vegetation distribution are affected by frost mounds and heaving, as well as by the migration of river channels (Brown et al. 1983). Wildfires also alter vegetation patterns and are common on the south side of the Brooks Range. Fires may range in size from less than 2 acres to nearly 270,000 acres (Gabriel and Tande 1983).

The most common plant communities on the upper slopes and ridges of the Brooks Range

are ericaceous dwarf shrub tundra (including vaccinium dwarf shrub tundra and bearberry dwarf shrub tundra), dryas-sedge dwarf shrub tundra, and dryas dwarf shrub tundra (Table 3.18-2), the latter on the more exposed sites. These communities occur on well-drained soils and are dominated by shrubs less than 8 in. tall. Taller shrubs, if present, are relatively sparse, and the herbaceous species typically exceed the shrubs in height (Viereck et al. 1992). Trees are generally absent from these communities. Pond margins and stream banks in this zone support open low willow-sedge shrub tundra, with shrubs commonly 8 to 20 in. tall and very few, if any, trees. Vegetation communities within the basins of drained lakes and in valley depressions are generally wet sedge meadow tundra communities (Cooper 1986). Much of the TAPS ROW in this region of the Brooks Range is located in or along floodplains. Floodplain vegetation communities on river terraces where gravel is overlain by silt loam soils are typically open low alder-willow shrub communities. The shrubs generally are more than 8 in. but less than 5 ft tall (Viereck et al. 1992). Trees are generally absent or very scarce.

Wetland communities occur on the Brooks Range where sufficient fine-grained sediments have accumulated along rivers and drainageways on lower slopes. Soils in lowland areas have a relatively thick organic surface layer of peat, with a mucky silt loam layer below. These soils are poorly drained because of the presence of shallow permafrost. These lowland areas support wet sedge meadow tundra and open low willow-sedge shrub tundra communities (Cooper 1986). Riparian wetland soils generally are poorly drained (Rieger et al. 1979). These riparian wetlands predominantly support open low alder-willow shrub communities (Cooper 1986).

The Alaska Range is characterized by high mountains, steep slopes, and broad valleys. The land surface predominantly consists of rocky slopes, ice fields, and glaciers. The distribution of plant communities in the Alaska Range is primarily determined by slope and aspect. The soils of upper hillsides and ridge tops are shallow and gravelly. Vegetation on these well-drained, windswept, alpine sites consists of dwarf shrub communities (Table 3.18-2). Slopes

and drainageways that are more protected support communities of dwarf and tall shrubs.

Most open habitat in the Alaska Range is the result of slope failures, avalanches, and river channel migration, while fires are relatively small and infrequent (Gabriel and Tande 1983). Permafrost is generally restricted to relatively thaw-stable, coarse-grained deposits of alluvial fans, glacial till, glaciofluvial outwash, and deposits of thick loess (Kreig and Reger 1982). Patterns of vegetation distribution in the Alaska Range are, therefore, little influenced by the occurrence of thermokarst landscape features.

Moderately drained slopes with stony silt loam soils support open low mesic shrub birch-ericaceous shrub communities. The dominant shrubs of these communities are birch, generally 20 in. to 5 ft in height (some taller), forming an overstory, with shorter blueberry, bearberry, crowberry, or Labrador tea, 8 in. to 5 ft in height (Viereck et al. 1992). Shrubs provide up to 75% cover of the land area. Trees are generally absent or very scarce, and grasses and sedges may be common. Vegetation communities of moist to mesic sites (sites that are characterized by moist, rather than wet soils) in drainages and on solifluction lobes are typically willow dwarf shrub tundra communities. Shrubs in these communities are mostly 8 in. tall or less, herbaceous plants may be common, and trees are generally absent or very sparse (Viereck et al. 1992).

Silt loam soils of steep to moderate slopes near the treeline support open tall shrub birch-willow shrub communities. These communities are characterized by shrubs over 5 ft in height and comprising up to 75% cover of the land area (Viereck et al. 1992). Trees, if present, may exceed the shrubs in height but are generally absent or scarce. Steep to moderate slopes near the treeline also support closed tall alder-willow shrub communities. These communities also occur along stream banks and in drainages. Shrubs of these communities are generally 5 ft or more tall and cover over 75% of the ground. Herbaceous plants are generally sparse.

Patches of wet meadow occur above the treeline in the Alaska Range; however, wetlands of the Alaska Range near the TAPS ROW occur primarily in valley bottoms and on the lower

slopes on poorly drained soils. Wetland community types of the Alaska Range are primarily low shrub, shrub-sedge tundra, and mesic meadow tundra. These community types include open low willow shrub communities, having less than 75% cover of low shrubs (at least 8 in. tall), few tall shrubs, and generally no trees (Viereck et al. 1992). Dwarf shrubs and herbaceous plants usually form a low vegetation layer. Closed low willow shrub communities have more than 75% cover of low shrubs (Viereck et al. 1992). Tall shrubs are sparse or absent, trees, if any, are very scarce, and herbaceous plants are common. Open low alder-willow shrub communities, with up to 75% cover of low shrubs, usually lack trees, have few tall shrubs, and have a number of herbaceous species, often including a continuous moss mat (Viereck et al. 1992). Open low mixed shrub-sedge tussock tundra communities are dominated by sedges (generally tussock cottongrass) that form tussocks (clumps), typically 6 to 14 in. wide, and have very few or no trees (Viereck et al. 1992). The tussocks are interspersed with mosses and dwarf shrubs. The shrubs include birch, Labrador tea, cranberry, and blueberry. Mesic sedge-grass meadow tundra communities have few or no woody plants or broad-leaved herbaceous plants (Viereck et al. 1992).

The Pacific Coastal Mountains are characterized by alpine barrens, glaciers, and ice fields. The distribution of plant communities in these mountains (as in the Alaska Range) is strongly affected by aspect and slope. Permafrost is largely absent, other than isolated patches in lowland areas, and, therefore, thermokarst is rare in the Pacific Coastal Mountains (Kreig and Reger 1982). Above the treeline, the most common vegetation types are dwarf shrub and low shrub communities (Table 3.18-2).

South-facing alpine slopes and areas of snow accumulation in the Coastal Mountains support mountain-heath dwarf shrub tundra on thin stony soils. Aleutian mountain-heath, up to 8 in. tall, is the dominant species, while other dwarf shrubs may be present; taller shrubs and trees are lacking or scarce (Viereck et al. 1992). North-facing alpine slopes often support cassiope dwarf shrub tundra on thin stony soils.

These communities are characterized by *Mertens cassiope* up to 8 in. tall (Viereck et al. 1992). Trees are absent and taller shrubs are absent or scarce, although other species of dwarf shrubs are frequently present. At lower elevations, in areas where deep snow accumulates and persists until late spring, closed low ericaceous shrub communities occasionally form dense thickets. These communities are dominated by copperbush (*Cladanthamnus pyrolaeiflorus*) at least 8 in. tall; generally, trees, tall shrubs, or other associated species are scarce or absent (Viereck et al. 1992). Slopes, drainages, and floodplains in subalpine areas of the Pacific Coastal Mountains support closed tall alder shrub communities. These communities consist of shrubs over 5 ft in height forming a canopy over at least 75% of the ground, with a variable amount of herbaceous plants (Viereck et al. 1992). Tall willows and trees may be present, while shorter shrubs are typically absent. These communities occur on stony loam soils that are moderately well drained. Upper elevation mesic sites (sites that are characterized by moist, rather than wet, soils) in protected drainageways occasionally support extensions of the closed mountain hemlock forests from lower elevations.

Wetland communities of the Pacific Coastal Mountains occur only in low mountain passes and valleys, on slopes affected by seepage and drainages, where soils are poorly drained and develop characteristics of saturated, anaerobic conditions. Wetland communities that occur in the seeps and drainageways include open tall alder shrub and open tall alder-willow shrub communities. Morainal depressions support wetland communities of subarctic lowland sedge-shrub wet meadow types and subarctic lowland herb wet meadow types. Lyngbye sedge is the dominant plant species in the sedge-shrub communities (Viereck et al. 1992). These wetlands include up to 25% ground cover of shrubs such as sweetgale or willow, with trees generally absent. The herb communities consist primarily of species such as horsetail, scouring rush, marsh-marigold, or rush, although grasses and sedges may be present (Viereck et al. 1992). Trees and shrubs are absent or scarce.

Approximately 3,000 acres of upland tundra previously occurred within the TAPS ROW.

Initial construction of the pipeline and Dalton Highway resulted in the loss of portions of upland tundra communities because of the placement of fill material or replacement by other communities as conditions changed. A total of approximately 1,522 acres of wet-meadow tundra was impacted north of PS 4 (MP 144) during construction (including both lowland tundra and upland tundra zones), with much of the impact coming from the development of material sites (Pamplin 1979).

The TAPS ROW generally has a lower moisture level and reduced organic mat thickness (McKendrick 2002) compared with adjacent undisturbed areas. These conditions, combined with post-construction planting, have resulted in differences between ROW vegetation communities and adjacent natural communities. The communities within the ROW contain a number of species originally planted for revegetation purposes, such as red fescue (*Festuca rubra*). Some species from the adjacent habitats, however, have become established within the ROW (McKendrick 2002; Moore 1992). Generally only 15 to 25% of plant species are common to both the ROW and adjacent undisturbed areas.

Vegetative cover within the ROW is generally much lower than in the surrounding areas, likely because of the lower occurrence of fine soil particles within the ROW, particularly in alpine areas (McKendrick 2002). In low elevation areas of this zone, maintenance of the ROW includes brush cutting, which may also contribute to lower vegetative cover in some areas. In certain areas, TAPS maintenance activities appear to temporarily eliminate or reduce plant cover. Methods for revegetation of disturbed areas are assessed individually for each project and require approval of the Authorized Officer. Species planted under the current revegetation program for ROW maintenance include native varieties of red fescue and Bering hairgrass.

Past operation of TAPS has resulted in spills of crude oil and other materials (Section 3.3.3), which have affected vegetation communities in the vicinity of the ROW. The BLM monitored the areas affected by three spills in the upland tundra vegetation zone: at check valve 23 (MP 114.7, January 1981), at Atigun Pass

(MP 166, June 1979), and at MP 734, (June 1979) (BLM 1984). The spills resulted in light to heavy oiling of 7.8 acres at check valve 23, approximately 30 mi of stream channel below Atigun Pass, and 0.5 acre at MP 734. While much of the vegetation in the affected areas was injured or killed by the oil, cleanup efforts and reseeding of the areas resulted in a substantial recovery of much of the upland tundra vegetation (BLM 1984). Vegetation recovery within the ROW at Atigun Pass has been sparse, primarily because of the extreme climate and lack of fine soil particles (McKendrick 2002). A portion of the affected area at MP 734 was buried and seeded in 1984, with subsequent establishment of vegetation.

3.18.1.3 Boreal Forest

The Boreal Forest vegetation zone occurs in the interior region to the northern forest limits on the Copper Plateau and between the Alaska Range and the Pacific Coastal Mountains. The predominant vegetation types of the boreal forest zone are evergreen forests of black and white spruce. Extensive areas of deciduous forest also occur in this zone, as well as large areas of shrub and herbaceous vegetation types, such as subarctic lowland sedge, sedge-moss bog meadows, and shrub bogs (Viereck et al. 1992). Alder and willow shrub communities become established following disturbances such as fire or alluvial deposition. This zone extends from about MP 190 to about 550 across the interior region, and MP 610 to 720 on the Copper Plateau.

Boreal Forest

The boreal forest vegetation zone consists of a complex association of forest, grassland, shrub, bog, and tundra community types in the vicinity of the ROW (Van Cleve et al. 1991). The forest communities include both evergreen forests of black and white spruce and extensive deciduous forests. The TAPS ROW crosses the boreal forest vegetation zone from about MP 190 to 550 across the interior region and from MP 610 to 720 on the Copper Plateau.

The distribution of vegetation community types within this zone is influenced primarily by slope, aspect, elevation, parent material, and succession following wildfire (Viereck et al. 1986). Large differences in the vegetation of north- and south-facing slopes result from the dry continental climate and low sun angle. Vegetation distribution is also affected by the presence or absence of permafrost, which is often related to slope and aspect (Viereck et al. 1986). Thermokarst features, such as high-centered polygons, thaw lakes, and collapse-scar bogs and fens, are common in lowland areas of the boreal forest zone (Drury 1956; Racine et al. 1998; Jorgenson et al. 1999). These areas are particularly sensitive to disturbance because of the high ice content of lowland permafrost. Large changes in hydrology, soils, and vegetation can be caused by fire (Viereck 1973; Dyrness et al. 1986), climatic warming (Osterkamp et al. 1998; Osterkamp and Romanovsky 1999), and human-caused disturbances.

South-facing, well-drained slopes in the interior portion of the state are vegetated with closed¹ quaking aspen forest, closed paper birch forest, and closed white spruce forest communities (Table 3.18-2) (Viereck 1975, 1979). Near the treeline on surrounding hills, at about 2,460 ft elevation, forests of open and closed black spruce-white spruce communities occur. Mid-successional communities on river floodplains where permafrost is absent are composed primarily of broadleaf closed balsam poplar forests and quaking aspen forest, which lead to open or closed white spruce forests (Viereck et al. 1986; Adams and Viereck 1992; Adams 1999). North-facing slopes and wet lowlands, where permafrost is near the surface, are the principal locations for black spruce forests (Viereck 1975). The soils of black spruce forest communities are typically saturated and consist of a moderately thick organic surface layer over silt loam (Rieger et al. 1979). Lowland areas with a shallow active layer over permafrost also support open black spruce-tamarack forest. Forested areas may be generally separated into two types: (1) cold, wet sites usually underlain by permafrost and supporting black spruce

communities and (2) warm, well-drained, mesic sites (sites that are characterized by moist, rather than wet soils) that are permafrost-free, supporting white spruce communities and successional stages leading to white spruce (Viereck et al. 1986). In the Ft. Wainwright area, south of Fairbanks, black spruce is common on lower slopes and valleys, while birch and aspen forests occur on upper slopes (Racine et al. 1997).

Lower slopes and valleys of the Alaska Range support open coniferous forests and woodlands. These forests and woodlands consist primarily of open white spruce forest or open black spruce-white spruce forest communities. Open white spruce forest occurs near the treeline and on inactive floodplains. Open black spruce-white spruce forest is generally restricted to areas near the treeline on north-facing slopes (Viereck et al. 1992).

Most forest stands in the interior boreal forest zone are maintained in immature stages by frequent fires, limiting the occurrence of mature and climax forest types (Dyrness et al. 1986). Wildfires vary greatly in size, from 2 acres to more than 700,000 acres (Gabriel and Tande 1983). Most fires generally occur from June through early August. Estimates of the natural fire cycle, or time of recurrence at any location, within the boreal forest zone vary from 50 to 200 years (Heinselman 1978; Yarie 1981; Dyrness et al. 1986). Vegetation on recently burned areas typically consists of early successional communities of broadleaf herbaceous species, dominated by fireweed. These communities are replaced over time by grass-like herbaceous communities dominated by bluejoint, and (later) willow scrub communities. On uplands, south-facing slopes, or well-drained river terraces, these willow communities are eventually replaced by broadleaf forests. However, on east-, west- and some north-facing slopes, and in flat areas, paper birch stands succeed willow. Mixed forests occur in locations where spruce has become established in broadleaf forest communities. These mixed forests are eventually replaced by spruce-dominated forests

¹ A "closed" forest is one that has a tree canopy coverage of 60 to 100%; an "open" forest is one that has a tree canopy coverage of 25 to 60%.

in many areas (Viereck 1975; Viereck et al. 1986; Adams and Viereck 1997).

The most prevalent wetland types in the interior portion of the boreal forest zone, along the TAPS ROW, are open and closed canopy black spruce forest communities. The floodplains of the Tanana River and smaller streams also support a variety of riparian shrub wetland communities and wetlands composed of grassy herbaceous species. The riparian shrub communities include open tall willow shrub, closed tall willow shrub communities, and open tall shrub swamp. Poorly drained areas on old floodplain terraces support black spruce woodland, several types of open low mesic shrub communities, and bog communities of resin birch and ericaceous shrubs (Luken and Billings 1983; Luken 1984). Herbaceous wetland communities include bluejoint and bluejoint-herb meadows, subarctic lowland sedge wet meadow, subarctic lowland sedge-shrub wet meadows, and fresh herb marsh. These communities occur on poorly drained and very poorly drained soils.

The Copper Plateau is a level to rolling plain between the Alaska Range and Pacific Coastal Mountains. The most common plant communities on the Copper Plateau are black spruce forests, which are interspersed with wetland shrub communities. Collapse-scar bogs and thaw lakes are common and form in abandoned meltwater channels and depressions. Poorly drained soils occur in areas of shallow permafrost, while well-drained soils occur on gravelly deposits with deep permafrost or where permafrost is lacking. Wildfires in uplands also result in well-drained soils.

The poorly drained lowlands with shallow permafrost on the Copper Plateau typically support open black spruce forest (Table 3.18-2). In wetter areas, open black spruce dwarf tree scrub communities occur. These communities include *Sphagnum* moss and tussock cottongrass. Open low shrub birch-ericaceous shrub bogs form nonpatterned wetlands and develop a thick organic surface mat. Mosses (particularly *Sphagnum* moss species) are abundant in these bogs. Sloughs, oxbow lakes, and lake and pond margins support herbaceous wetland communities, including subarctic lowland sedge wet meadow and fresh herb marsh. Drier locations on inactive floodplains

support open white spruce forests. Floodplain terraces support closed balsam poplar forest communities, and moderately drained to well-drained upland locations support closed paper birch forest communities. Valleys and drainageways at low elevations of the Pacific Coastal Mountains, on the southern margin of the Copper Plateau, support tall shrub and forest communities. Some forested areas in the southeastern portion of the Copper Plateau have experienced past infestations of spruce bark beetle and resulting tree mortality (USDA 2002). Areas with a high percentage of tree mortality are at an increased risk for wildfire. Spruce bark beetle infestations on the Copper Plateau had generally subsided by 2001 (USDA 2002).

The types of wetlands on the Copper Plateau and their distribution on the landscape are comparable to those in the northern boreal forest zone. The most prevalent wetland types along the TAPS ROW on the Copper Plateau are open black spruce forest and black spruce dwarf tree woodland communities. Open low mixed shrub-sedge tussock bog and open low mesic shrub birch-ericaceous shrub communities also are common. The poorly drained soils of these wetlands are frequently underlain by permafrost.

Initial construction of the TAPS, ROW, and Dalton Highway resulted in the loss of portions of boreal forest communities. Approximately 5,700 acres of boreal forest previously occurred within the ROW. These areas were lost to the placement of fill material or were replaced by other, early- to mid-successional communities. The TAPS ROW in the boreal forest zone generally has a lower moisture level and reduced organic mat thickness compared with nearby undisturbed areas (McKendrick 2002). This condition, combined with post-construction planting, has resulted in differences between ROW vegetation communities and adjacent natural communities. Some species, such as balsam poplar (*Populus balsamifera*), occur frequently within the ROW but seldom in the adjacent community. The communities within the ROW contain a number of species originally planted for revegetation purposes, such as red fescue (*Festuca rubra*). Some species from the adjacent habitats, however, have become established within the ROW (McKendrick 2002; Moore 1992). Species planted under the current

revegetation program for ROW maintenance include native varieties of red fescue and Bering hairgrass. Generally only 15 to 25% of plant species are common to both the ROW and adjacent undisturbed areas. Over most of the boreal forest zone, maintenance of the ROW includes tree and brush cutting.

Past operation of TAPS has resulted in spills of crude oil and other materials (Section 3.3.3), which have affected vegetation communities in the vicinity of the ROW. The BLM monitored the areas affected by spills at check valve 68A (Washington Creek, MP 432.2, October 1977) and Steele Creek (MP 474, February 1978) in the boreal forest vegetation zone (BLM 1984). The spills resulted in light to heavy oiling of up to 1 acre at check valve 68A, and 4 acres at Steele Creek. While much of the vegetation in the affected areas was injured or killed by the oil, cleanup efforts and reseedling of the areas resulted in a substantial recovery of the vegetation (BLM 1984). A portion of the affected area at Steele Creek was buried and seeded in 1981, with subsequent establishment of vegetation on most of the area.

3.18.1.4 Coastal Forest

The coastal forest vegetation zone occurs along Alaska's southern coast and on the coastal islands. The predominant vegetation type of this zone is evergreen forest, primarily Sitka spruce-western hemlock. Deciduous forest occurs primarily along floodplains, streamsides, and in disturbed areas. Extensive freshwater and salt marshes of sedge and grass wet meadow community types occur on coastal river deltas.

Coastal Forest

The last 20 mi of the TAPS ROW (from MP 780 to 800) crosses the coastal forest vegetation zone. The predominant vegetation type in this zone, which occurs along Alaska's southern coast and on the coastal islands, is evergreen forest, primarily Sitka spruce-western hemlock. Scattered deciduous forests do occur along floodplains, streamsides, and in disturbed areas, and marshes, both freshwater and saltwater, occur on coastal river deltas.

This zone extends from about TAPS MP 780 to 800.

The coastal forest zone of south-central Alaska is characterized by a landscape of steep footslopes, alluvial fans, floodplains, outwash plains, scattered moraines, river terraces, and river deltas of the Pacific Coastal Mountains (Gallant et al. 1995). This region supports a variety of coastal forest communities, scrub communities, and wetland plant communities because of the relatively long growing season, high annual precipitation, and mild temperatures. River deltas, terraces, alluvial fans, and floodplains are subject to flooding and tidal inundation (Crow 1977; Thilenius 1995; Boggs 2000).

Needleleaf forests, broadleaf forests, and mixed forests are the characteristic plant communities in this region. These coastal forests are predominantly western hemlock-Sitka spruce forest communities. The most common forest type growing on footslopes, benches, and poorly drained soils with thick organic surface layers is open western hemlock-Sitka spruce forest (Table 3.18-2). Mountain hemlock forest communities are also common in the northern portion of the coastal forest zone near Valdez (Cooper 1942). This may be the predominant forest type near the treeline (Viereck et al. 1992). Active alluvial fans and floodplains in the region frequently support open Sitka spruce forest. Vegetation communities on poorly drained lowlands with shallow soils are predominantly open black spruce forest. Some floodplain locations support broadleaf forests of open black cottonwood.

Wetland plant communities of the coastal forest zone, along the TAPS ROW, are rarely influenced by permafrost. Organic surface soils composed of a thick *Sphagnum* peat, over a silty or sandy loam, may be present in morainal or outwash plain depressions. Glacial outwash areas subject to seasonal flooding support wetland communities of open black cottonwood forest, open tall willow shrub, and open tall alder-willow shrub. Areas of persistent flooding support closed black cottonwood forest and closed tall willow shrub communities. Gently sloped areas with saturated soils support open western hemlock-Sitka spruce forest and Sitka spruce woodland. Lowland areas with saturated

soils support open black spruce and open low shrub ericaceous shrub bog. Bogs have the highest diversity of plant species of all wetland types in the coastal forest zone. These bog communities also include subarctic lowland sedge-bog meadow and subarctic sedge-herb wet meadow community types.

Wetlands in the vicinity of the Valdez Marine Terminal include several small palustrine unconsolidated bottom wetlands that are permanently flooded, some of which are excavated. A small palustrine emergent wetland that is seasonally flooded is just to the west of the facility. An area of estuarine intertidal flats is located along the shoreline to the northeast with a small area of emergent persistent wetland, that is irregularly flooded, on the shoreward margin.

Initial construction of the TAPS and ROW resulted in the loss of portions of coastal forest communities. About 250 acres of coastal forest previously occurred within the ROW. However, a total of approximately 586 acres of coastal forest was impacted during construction of the pipeline and Valdez Marine Terminal (Pamplin 1979). These areas were lost by the placement of fill material or were replaced by other, early to mid-successional communities.

The TAPS ROW in the coastal forest zone generally has a lower moisture level and reduced organic mat thickness than adjoining undisturbed areas (McKendrick 2002). This condition and post-construction vegetation planting have resulted in differences between ROW vegetation communities and adjacent natural communities. Some species, such as bluegrass or red fescue, occur frequently within the ROW but seldom in the adjacent community. A number of species from the adjacent habitats, however, have become established within the ROW (McKendrick 2002; Moore 1992). Species planted under the current revegetation program include native varieties of red fescue and Bering hairgrass. Generally only 15 to 20% of plant species are common to both the ROW and adjacent undisturbed areas. Within this zone, maintenance of the ROW includes tree and brush cutting.

3.18.2 Beaufort Sea

Most of the Beaufort Sea is classified by the National Wetland Inventory as marine subtidal deepwater habitat with an unconsolidated bottom. This marine habitat is permanently flooded and unvegetated. Nearshore areas, for example shoreward of Jones Islands near Beechey Point, are classified as estuarine subtidal deepwater habitat with an unconsolidated bottom. These areas are continuously submerged and unvegetated.

The Arctic coastline is subject to severe erosive action and experiences tides of small fluctuation. Subsequently, coastal salt marshes are smaller and less common than on southern coasts (Viereck et al. 1992). These scattered areas along the coastline are classified as estuarine intertidal wetlands with persistent emergent vegetation, and are exposed at low tides. Coastal salt marshes consist of halophytic (salt-tolerant) sedge wet meadow communities where inundation from tides ranges from several times per month to once a summer and halophytic grass wet meadow communities where tidal inundation is regular or daily (Viereck et al. 1992). Halophytic sedge wet meadow communities often form the main body of the coastal marsh and are characterized by a dense growth of salt-tolerant sedges (primarily *Carex ramenskii* and *C. subspathacea*), sometimes only a few centimeters high.

The dominant species of the shoreward marsh community is generally loose-flowered alpine sedge (*Carex rariflora*), 8 to 16 in. high. The seaward margin often adjoins a halophytic grass wet meadow community. Halophytic grass wet meadow communities are characterized by a sparse growth of salt-tolerant alkali grass (*Puccinellia* spp.), often associated with salt-tolerant forbs (Viereck et al. 1992). The inland portion of these marshes is often taller and denser halophytic sedge wet meadow. Halophytic herb wet meadow communities occur in early successional stages on seaward portions of beaches and coastal marshes where inundation occurs at least a few times per month (Viereck et al. 1992). These communities are

characterized by salt-tolerant forbs, such as maritime arrow grass (*Triglochin maritimum*). Brackish ponds within coastal marshes of deltas, tidal flats, and bays may support fourleaf marestail (*Hippuris tetraphylla*) communities (Viereck et al. 1992).

The Arctic Coastal Plain is relatively flat and supports lowland tundra vegetation communities. The presence of thick, continuous permafrost, that is generally near the soil surface, restricts soil drainage and results in saturated soils over most of the area. Wet sedge meadow tundra is the predominant vegetation type, and numerous thaw lakes are scattered across the landscape.

3.18.3 Prince William Sound

The islands and mainland of Prince William Sound support terrestrial vegetation communities typical of the coastal forest vegetation zone. The open water areas of Prince William Sound are estuarine subtidal deepwater habitat with an unconsolidated bottom. These areas are continuously submerged and never exposed by tides. The coastline within the sound consists of numerous peninsulas and islands with irregular shorelines forming bays, lagoons, and steep prominences. Much of the shoreline consists of steep upland slopes lacking intertidal wetland development.

Wetland areas along the coastline are sporadic and scattered in many locations but extensive and complex in other areas. These coastal wetlands include estuarine intertidal rocky shore and unconsolidated shore wetlands that are unvegetated. However, also occurring are coastal salt marshes with persistent emergent vegetation and intertidal aquatic bed wetlands with submerged or floating vegetation. These wetlands are all periodically inundated or exposed by tides. Also occurring along or near the shoreline are palustrine forested wetlands, palustrine wetlands with persistent emergent vegetation, aquatic bed, and scrub-shrub

wetlands that are not tidally influenced but that have saturated soils or are seasonally or continuously flooded.

Marine aquatic community types in Prince William Sound occur in estuarine aquatic bed wetlands and include eelgrass communities and marine algae communities. Eelgrass (*Zostera marina*) communities occur in subtidal and low intertidal areas in protected bays, inlets, and lagoons (Viereck et al. 1992). Eelgrass typically does not share dominance with other plant species. Marine algae communities occur in subtidal and intertidal zones, often along exposed rocky shores (Viereck et al. 1992). These communities consist solely of marine algal species and may include *Fucus* spp., *Gigartina* spp., *Porphyra* spp., and others.

Coastal salt marshes in Prince William Sound may contain a complex arrangement of vegetation community types under tidal influence ranging from irregularly exposed to irregularly inundated. The upper parts of coastal marshes may support subarctic lowland sedge-scrub wet meadow communities, typically characterized by lingbye sedge (*Carex lyngbyae*) and up to 25% cover of shrubs such as sweetgale (*Myrica gale*) or willows (Viereck et al. 1992). These communities are not normally subject to tidal inundation but may be flooded during storm surges. The outer margins of coastal salt marshes typically consist of halophytic sedge wet meadow communities and halophytic grass wet meadow communities (Viereck et al. 1992).

Halophytic sedge wet meadow communities are characterized by a dense growth of salt-tolerant sedges, primarily lingbye sedge, generally over 3 ft high. The dominant species of the shoreward marsh community is generally many-flowered sedge (*Carex pluriflora*), 8 to 16 in. high. The seaward margin often adjoins a halophytic grass wet meadow community. Such communities are characterized by a sparse growth of salt-tolerant alkali grass, often associated with salt-tolerant forbs (Viereck et al. 1992).

The inland portion of these marshes often includes taller and denser halophytic sedge wet meadow. Halophytic herb wet meadow communities occur in early successional stages on seaward portions of beaches and coastal marshes where inundation occurs at least a few times per month (Viereck et al. 1992). These communities are characterized by salt-tolerant forbs such as maritime arrow grass (*Triglochin maritimum*), goose-tongue (*Plantago maritima*), and oysterleaf (*Mertensia maritima*).

Brackish ponds within coastal marshes of deltas, tidal flats, and bays may support fourleaf marestail (*Hippuris tetraphylla*) communities (Viereck et al. 1992). These communities occur

in 2 to 20 in. of water that are periodically subject to tidal inundation. Brackish pondweed communities may also occur in permanent brackish ponds that are irregularly flooded by tides (Viereck et al. 1992). The dominant species are usually fennel-leaf pondweed (*Potamogeton pectinatus*) or filiform pondweed (*P. filiformis*).

Wetlands occur sporadically along the shoreline of Port Valdez and include estuarine intertidal flats, intertidal emergent persistent and beach/bar wetlands, palustrine scrub/shrub wetland, and emergent persistent wetlands. The estuarine intertidal flats and beach/bar wetlands are the most common wetland type.

3.19 Fish, Reptiles, and Amphibians

3.19.1 Fish

This section presents information about fish species and habitats in the vicinity of the TAPS ROW, in the Beaufort Sea near oil production areas, and in Prince William Sound near the Valdez Marine Terminal. Information is provided for freshwater, marine, and anadromous fish species (which spawn in fresh water but spend part of their life at sea). Anadromous species include Arctic cisco, Bering cisco, least cisco, broad whitefish, rainbow smelt, eulachon, inconnu (sheefish), Dolly Varden, rainbow (steelhead) trout, chum salmon, sockeye (red) salmon, chinook (king) salmon, pink salmon, and coho (silver) salmon. Information about essential fish habitat (EFH), as defined in the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), is also provided. Periods or seasons during which specific fish habitat locations are considered sensitive or critical for various streams and rivers along the TAPS ROW also are identified.

3.19.1.1 TAPS ROW

Twenty-nine species of fish are known to occur or could occur in the streams, rivers, and other water bodies near the TAPS ROW (Table 3.19-1). Because the fish communities associated with streams and rivers crossed by the pipeline differ in the major hydrological regions, the discussion of fish resources along the TAPS ROW is broadly divided into those species and habitats that occur (1) within the North Slope region north of the Brooks Range (MP 0–170), (2) in Interior Alaska between the Brooks Range and the Alaska Range (MP 170–605), and (3) south of the Alaska Range (MP 605–800) (Map 3.19-1).

Primary information sources used to compile descriptions of fish habitat and usage along the TAPS include documents from the Alaska Department of Fish and Game (ADF&G 1986a-c, 1999a-c); the Bureau of Land Management (BLM 1987a,b); Alyeska Pipeline Service Company (APSC 1993); and the APSC Fish Stream Database (APSC undated). The

Magnuson-Stevens Fishery Conservation and Management Act of 1996

The Magnuson-Stevens Fishery Conservation and Management Act of 1996 (Public Law 104-267) established a requirement to describe and identify “essential fish habitat” (EFH) in each fishery management plan.

EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.”

The Magnuson-Stevens Act requires federal agencies to consult with the National Marine Fisheries Service on all actions or proposed actions permitted, funded, or undertaken by the agency that may adversely affect EFH.

database includes information on fish species in many of the streams along the ROW.

The Alaska Administrative Code defines “Waters Important to Anadromous Fish” [5 AAC 95.010] as those important for spawning, rearing, or migration of anadromous fishes. The *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes* and its companion Atlas are adopted by reference to identify such waters. The Catalog and Atlas are divided into six volumes corresponding to Alaska’s six fish and game resource management regions. The volumes that encompass the areas associated with the TAPS ROW are for the arctic (ADF&G 1999a), interior (ADF&G 1999b), and southcentral (ADF&G 1999c) regions. The Catalog lists the water bodies documented as used by anadromous fish. It also lists the USGS quadrangle map, latitude, longitude, and legal description of the mouth and upper known extent of anadromous fish use for each specified water body. The Atlas is a compilation of topographic maps that show the locations of the specified anadromous fish-bearing waters, the species using these waters,

TABLE 3.19-1 Fish Species Occurring within Major Regions along the TAPS ROW

Family/ Common Name	Scientific Name	Region			Life History and Distribution
		North Slope	Interior Alaska	Southern Alaska	
Petromyzontidae					
Arctic lamprey	<i>Lampetra japonica</i>	No	Yes	No	Two forms — parasitic anadromous and non-parasitic freshwater forms. Spawn in fast-flowing stretches of clear large streams. Parasitic adults prey upon some commercially important species such as salmon, lake trout, and lake whitefish. Occurs along Pacific Coast of Alaska, in the Mackenzie River system of the Northwest and Yukon Territories, and on the North Slope.
Cyprinidae					
Lake chub	<i>Couesius plumbeus</i>	No	Yes	No	Prefers cooler waters of lakes, streams, and rivers. Spawns during summer when water temperatures are greater than 50°F, sometimes migrating from lakes into tributary streams.
Catostomidae					
Longnose sucker	<i>Catostomus catostomus</i>	Yes	Yes	Yes	Widely distributed in clear, cold streams and rivers of Alaska, occasionally entering brackish waters in the Arctic region. Spawns during late spring and early summer.
Esocidae					
Northern pike	<i>Esox lucius</i>	Yes	Yes	No	Occurs in a wide variety of habitats, including rivers and lakes. Spawns after ice melts in late spring or early summer. Mostly occurs in freshwater, but occasionally enters brackish water. Widely distributed in the Yukon River drainage in Alaska and the Colville River system on the North Slope.
Umbridae					
Alaska blackfish	<i>Dallia pectoralis</i>	Yes	Yes	No	Distributed throughout central Alaska lowlands, including Yukon and Tanana River systems and the Colville River system on the North Slope. Occurs in swamps and ponds with abundant vegetation, vegetated streams, rivers, and lakes. Typically migrates to deeper areas of rivers and larger lakes before freezing in winter.
Osmeridae					
Pond smelt	<i>Hypomesus olidus</i>	No	No	Yes	Nonanadromous, freshwater species that occupies lakes and streams. Spawns between April and June. Occurs in the Copper River drainage.
Rainbow smelt	<i>Osmerus mordax</i>	Yes	Yes	No	Anadromous and landlocked populations exist. Spawn in early spring, often during ice breakup. Occur in many North Slope river systems and in some interior lakes.

TABLE 3.19-1 (Cont.)

Family/ Common Name	Scientific Name	Region			Life History and Distribution
		North Slope	Interior Alaska	Southern Alaska	
<i>Eulachon</i>	<i>Thaleichthys pacificus</i>	No	Yes	Yes	Anadromous. Generally spawn during spring over any gravel bottoms in the lower reaches of streams and rivers. Known to migrate and spawn in the Lowe River drainage in Port Valdez and in the Copper River, where a large population exists.
<i>Salmonidae</i>					
Arctic cisco	<i>Coregonus autumnalis</i>	Yes	No	No	Anadromous. One of the most abundant and valued subsistence species along Alaska's North Slope. Produced in the Mackenzie River system of Canada and transported, as juveniles, to Alaskan waters by strong westerly currents. Occurs mainly in the Colville River area, with limited distributions in the Sagavanirktok and Putuligayuk Rivers.
Arctic grayling	<i>Thymallus arcticus</i>	Yes	Yes	Yes	Widespread in lakes, rivers and streams throughout most of Alaska. Migrates between spawning and feeding areas in the spring and overwintering areas in deeper portions of lakes and rivers during the winter.
Bering cisco	<i>Coregonus laurettae</i>	Yes	Yes	No	Anadromous. Occurs in Yukon River drainage. The Bering cisco migrates long distances and spawning occurs as far as 1,200 mi up the Yukon River. Spawns during the fall in natal rivers. Important commercial fish in the Colville River.
Broad whitefish	<i>Coregonus nasus</i>	Yes	Yes	No	Anadromous. Occurs mostly in rivers, but sometimes in lakes. In Yukon River, broad whitefish are important for local consumption and for commercial purposes. There are spawning and overwintering populations in Sagavanirktok River and Yukon River drainages.
Chinook (king) salmon	<i>Oncorhynchus tshawytscha</i>	Incidental	Yes	Yes	Anadromous. Adults return to spawn in natal streams, especially in areas that have subsurface water flow through the spawning gravel. Abundant from the southeastern panhandle to Yukon River. Major populations return to the Yukon and Copper Rivers and important runs also occur in many smaller streams. Approximately 90% of the subsistence harvest of Chinook salmon occurs in the Yukon and Kuskokwim Rivers.

TABLE 3.19-1 (Cont.)

Family/ Common Name	Scientific Name	Region			Life History and Distribution
		North Slope	Interior Alaska	Southern Alaska	
Chum (dog) salmon	<i>Oncorhynchus keta</i>	Yes	Yes	Yes	Anadromous. The most abundant commercially harvested salmon species in arctic, northwestern, and Interior Alaska, but relatively less important in other areas of the state. Spawns in small side channels and other areas of large rivers with upwelling springs, small streams, and intertidal zones. By fall, juvenile fish move out into the Bering Sea and Gulf of Alaska. In arctic, northwestern, and Interior Alaska, chum salmon are an important year-round subsistence resource.
Coho (silver) salmon	<i>Oncorhynchus kisutch</i>	No	Yes	Yes	Anadromous. Found in coastal waters of Alaska from southeast to Point Hope on the Chukchi Sea and in Yukon River to Alaska-Yukon border. Occurs in nearly all accessible bodies of fresh water. Congregate in central Gulf of Alaska in June, later migrating along the coast until they reach their stream of origin. Spawning occurs primarily in October and November.
Dolly Varden ^a	<i>Salvelinus malma</i>	Yes	Yes	Yes	Anadromous (some resident). Locally abundant in all coastal waters of Alaska. Dolly Varden spawn in streams, usually from mid-August to November. One of Alaska's most important and sought-after sport fish.
Inconnu (sheefish)	<i>Stenodus leucichthys</i>	No	Yes	No	Most abundant in Kuskokwim and Yukon river drainages. Upper Yukon River populations are anadromous, while lower Yukon populations overwinter in the delta. Migrates upstream from overwintering areas during the period of ice breakup to feeding or spawning areas. Important as a subsistence resource; popularity as a sport fish is increasing.
Humpback whitefish	<i>Coregonus pidschian</i>	Yes	Yes	Yes	Distributed throughout drainages north of the Alaska Range, as well as in the Copper and Susitna Rivers, Bristol Bay drainages, and isolated river systems farther south. Upstream migration starts during the summer and fall and spawning occurs in the upper reaches of rivers in October, usually over a gravel bottom. Important as subsistence and commercial resource.
Lake trout	<i>Salvelinus namaycush</i>	Yes	Yes	Yes	Alaska's largest freshwater fish. Inhabits deeper lakes along the central Arctic Coastal Plain, as well as waters in the Brooks Range and Alaska Range. Also occurs in interior lakes, including Summit Lake and Paxson Lake. Spawning occurs over clean, rocky lake bottoms from September through November.

TABLE 3.19-1 (Cont.)

Family/ Common Name	Scientific Name	Region			Life History and Distribution
		North Slope	Interior Alaska	Southern Alaska	
Lake whitefish	<i>Coregonus clupeaformis</i>	No	No	Yes	Occupies deeper, colder parts of the lakes in summer; moves into shallow water to spawn in late October.
Least cisco	<i>Coregonus sardinella</i>	Yes	Yes	No	Anadromous. Annual migrations from winter habitats in freshwater to summer feeding habitats in saltwater. Mature least cisco migrate upstream in early October to spawn in clear streams with gravel bottoms north of the Alaska Range. A sport fishery exists for least cisco in the upper Chatanika River.
Pygmy whitefish	<i>Prosopium coulteri</i>	No	No	Yes	Occurs in some lakes of southwestern Alaska. Spawning occurs in autumn or early winter in lakes or streams.
Pink (humpback) salmon	<i>Oncorhynchus gorbuscha</i>	Yes	No	Yes	Anadromous and occurs in most coastal streams of Alaska. Important to commercial fisheries, sport fisheries, and subsistence users. Adults enter spawning streams between late June and mid-October. Most spawn within a few miles of the coast, and spawning within the intertidal zone or the mouth of streams is common. After entering salt water, juveniles feed along the beaches in dense schools near the surface and then move into the ocean feeding grounds in the Gulf of Alaska and Aleutian Islands.
Rainbow trout (steelhead)	<i>Oncorhynchus mykiss</i>	No	Yes	Yes	Anadromous. Found in coastal streams of the Gulf of Alaska. The Gulkana River drainage supports spring-run steelhead that spawn from mid-April through early June.
Round whitefish	<i>Prosopium cylindraceum</i>	Yes	Yes	Yes	Widely distributed in shallow water along the TAPS ROW. Spawning occurs along lake and stream shorelines in autumn over gravel shoals of lakes or at river mouths.
Sockeye (red) salmon	<i>Oncorhynchus nerka</i>	No	Yes	Yes	Anadromous; occurs along coast and in coastal streams from southeastern Alaska to western Alaska and in Bering Sea. Limited numbers occur in the Beaufort Sea. Important subsistence resource. Some runs have been developed or enhanced by using artificial propagation at a private nonprofit hatchery located on the Gulkana River.

TABLE 3.19-1 (Cont.)

Family/ Common Name	Scientific Name	Region			Life History and Distribution
		North Slope	Interior Alaska	Southern Alaska	
Gadidae					
Burbot	<i>Lota lota</i>	Yes	Yes	Yes	Considered a valuable food and recreational fish that occupies most large clear and glacial rivers and many lakes throughout Alaska. Burbot spawn under the ice in late winter.
Cottidae					
Slimy sculpin	<i>Cottus cognatus</i>	Yes	Yes	Yes	Most widespread sculpin in Alaska and the only sculpin in Interior Alaska. Occupies streams and lakes.
Gasterosteidae					
Ninespine stickleback	<i>Pungitius pungitius</i>	Yes	Yes	Yes	Mostly occurs in lakes, ponds, slow-moving streams, and estuaries containing emergent vegetation. Spawns in freshwater during summer months.

^a Fish of the genus *Salvelinus* caught in North Slope drainages and along the Beaufort Sea coast before the mid-1980s were identified as the western Arctic Bering Sea form of the Arctic Char (*S. alpinus*). Morrow (1980) contended that these fish are northern forms of Dolly Varden (*S. malma*), and current consensus conforms to this taxonomic designation.

Sources: ADF&G (1986a-c, 1999–2001), BLM (1987a,b); APSC (1993); Hebert and Wearing-Wilde (2002); Armstrong (1996).

and, to the extent known, the fish life history phases for which the waters are used. Note that streams that are not designated as anadromous fish streams in the catalog may still contain or be used by anadromous fish.

Identification of sensitive habitat was based, in part, on listings in BLM documents (1987a,b), which present the official federal Authorized Officer's list of key fish and wildlife areas on federally administered lands along the TAPS. BLM (1987a) classifies water bodies along the pipeline route as either not sensitive, sensitive, or critically sensitive for the fish species inhabiting those water bodies and identifies sensitive periods of the year. These definitions were originally established by BLM on the basis of an overview of the spawning, migration, and rearing activities of important fish species and assemblages along the pipeline route. Streams crossed by TAPS, fish species present in those streams, and streams and periods that are considered sensitive are identified in Table 3.19-2. Designated EFH for salmon fisheries in Alaska includes all freshwater systems that are accessible to salmon in the state, either currently or historically (North Pacific Fishery Management Council 1998). Designated anadromous fish streams along the TAPS corridor, as identified in the Anadromous Waters Catalog (ADF&G 1999a-c), are also identified in Table 3.19-2.

Although aquatic invertebrates are important food items for the young of most and adults of some of the fish species present in streams crossed by TAPS, there is little specific information about the invertebrate communities that are present in these streams. However, common invertebrates are likely to include aquatic worms (Oligochaeta) and larvae of insects such as midges (Chironomidae) and mayflies (Ephemeroptera).

3.19.1.1.1 North Slope Region. The portion of the pipeline within the North Slope region (MP 0-170) primarily runs along or crosses the Sagavanirktok River and its side channels and tributaries (Figure 3.19-1). The pipeline also crosses the headwaters of the Kuparuk River at MP 124 and MP 126. Fifteen species of fish have been reported along the TAPS ROW in the North Slope region

Water-Body Sensitivity Classification

Classification of water bodies as sensitive or critically sensitive during particular times of the year is intended to guide the need for restricting pipeline operations and maintenance activities to protect spawning, migration, and rearing activities of important fish species and fish assemblages.

(Table 3.19-1), with the most common being Dolly Varden, broad whitefish, Arctic cisco, and Arctic grayling. The presence of chum salmon, least cisco, and humpback whitefish is less common or incidental, and those species do not represent large spawning stocks (Craig 1984).

Compared with other in-state sport fisheries, effort and harvest is low in the portions of rivers and streams near the TAPS ROW. Dolly Varden (both anadromous and resident populations; see footnote on Table 3.19-1), and Arctic grayling are the species most often targeted by anglers. No subsistence or commercial fishery has been identified along the Sagavanirktok River itself, although juvenile Arctic cisco that overwinter in the lower reaches and delta of the river may eventually be recruited to stocks harvested by both commercial and subsistence fisheries in the Colville River. In addition, some anadromous Dolly Varden from the Sagavanirktok River may be taken in subsistence fisheries along the coast during summer (Craig 1989a).

PS 1 (MP 0) is located next to the Putuligayuk River, which is classified as an anadromous fish stream in its lower reaches because of the presence of Arctic cisco, broad whitefish, and least cisco during the summer. After leaving PS 1, the ROW parallels the Sagavanirktok River, crossing 48 of its side channels from MP 18 (Low Life Creek) to MP 93. The river and smaller channels are classified as anadromous fish habitat along this entire length, primarily because of the presence of anadromous Dolly Varden. Side channels also contain Arctic grayling, ninespine stickleback, round whitefish, and slimy sculpin and are considered sensitive during the May-to-October open-water season. The main channel of the Sagavanirktok River is considered sensitive

TABLE 3.19-2 Fish Streams along the TAPS Corridor

Stream Name ^a	Milepost	Crossing Mode/Structure ^b	Fish Species ^c	Sensitivity, ^d by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Putuligayuk R.	0.00	Near PS-1	BW; CA; CS; LT; SB					- -	- -	** **	** **				
Low-life Cr.	17.98	B/G, LWC	S9					** **	** **	** **	** **	**			
Sag. R. side chan.*	20.55–22.41	B/G, Blockpoint	AC?; CN; GR; RW					- -	- -	** **					
Sag. R. side chan.*	24.03	B/G, LWC	AC?; GR					- -	- -	** **					
Sag. R. side chan.*	24.91	B/G, LWC	AC?; GR; S9					- -	- -	** **					
Sag. R. side chan.*	25.05	133-APL-4, LWC	AC?; GR					- -	- -	** **					
Sag. R. side chan.*	25.10	B/G, LWC	AC?; GR					- -	- -	** **					
Sag. R. side chan.*	25.15	B/G, LWC	AC?; GR					- -	- -	** **					
Sag. R. side chan.*	25.56	B/G, LWC	AC? GR					- -	- -	** **					
Sag. R. side chan.*	25.63	B/G, LWC	AC?; GR					- -	- -	** **					
Sag. R. side chan.*	27.67–28.88	B/G, LWC	AC?; BB; BW?; CN?; GR; RW?; S9					- -	- -	** **					
Sag. R. side chan.*	29.62–30.45	B/G, LWC	AC?; BB; BW?; CN?; GR; RW?; S9					- -	- -	** **					
Thelma Cr.	30.45	B/G, LWC	AC; CN?; GR; S9					- -	- -	** **					
Sag. R. side chan.*	32.88	B/G, LWC	AC?; GR?; BB; WF					- -	- -	** **					
Sag. R. side chan.*	33.37	B/G, LWC	AC; GR; S9?					- -	- -	** **					
Sag. R. side chan.*	37.46	B/G, LWC	AC?; GR?; CD					- -	- -	** **					
Sag. R. side chan.*	37.93	B/G, LWC	AC?; CN; GR; CD					- -	- -	** **					
Sag. R. side chan.*	38.51	B/G, LWC	AC?; CN; GR					- -	- -	** **					
Sag. R. side chan.*	40.19	B/G, LWC	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			
Sag. R. side chan.*	40.63	B/G, LWC	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			
Sag. R. side chan.*	40.78	B/G, LWC	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			
Sag. R. side chan.*	40.93	B/G, LWC	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			
Sag. R. side chan.*	41.15	B/G, LWC	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			
Sag. R. side chan.*	41.39	B/G, LWC	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			
Sag. R. side chan.*	41.77	B/G, LWC	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			
Sag. R. side chan.*	42.12	B/G, LWC	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			
Sag. R. side chan.*	42.25	130-APL-5, CMP	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			
Sag. R. side chan.*	42.25	B/G, LWC	AC?; CN?; GR; S9					- -	- -	- -	- -	- -			

3.19-9

AFFECTED ENVIRONMENT

AFFECTED ENVIRONMENT

3.19-10

3.19-11

AFFECTED ENVIRONMENT

TABLE 3.19-2 (Cont.)

Stream Name ^a	Milepost	Crossing Mode/Structure ^b	Fish Species ^c	Sensitivity, ^d by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Tyler Cr.	153.25	A/G, LWC	CN; GR; RW					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Tyler Cr.	153.33	A/G, LWC	CN; GR; RW					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
One-one-two Cr.	153.47	A/G, LWC	GR					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Tyler Cr.	153.59	A/G, LWC	CN; GR; RW					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Trevor Cr.	154.12	A/G, LWC	AC; CN; GR; RW					- -	- -	.. ..	.. -	- -	- -		
157 Mile Creek	157.10														
Atigun R. floodplain	157.11–165.45	B/G, LWCs&111- APL-3, LWCs	AC; BB?; CN; GR; LT?; RW					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
N.F. Chandalar R.	170.60–170.79	B/G, LWC	CN; CI?; DV?; GR; HW?; NP?; RW					- -	- -	.. ..	.. ..	- -	- -		
N.F. Chandalar R.	171.50	109-APL-3A, Bridge	CN; CI?; DV?; GR; HW?; NP?; RW					- -	- -	.. ..	.. ..	- -	- -		
N.F. Chandalar R.	173.28–173.44	B/G, Blockpoint	CN; CI?; DV?; GR; HW?; NP?; RW					- -	- -	.. ..	.. ..	- -	- -		
Andy's Cr.	175.38	B/G, LWC	CN; DV; GR					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Dietrich R.	177.28–177.78	B/G, Blockpoint	BB?; CN; DV; GR; LS?; RW					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Oskar's Eddy	178.79	A/G, LWC	DV; GR					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Dietrich R.	179.33–180.41	B/G, Blockpoint	BB; CN; DV; GR; LS; RW	- -	- -	- -	- -	- -	.. ..	.. ..	.. ..	- -	- -	- -	- -
Dietrich R.	180.74–181.39	B/G, Blockpoint	BB; CN; DV; GR; LS; RW	- -	- -	- -	- -	- -	.. ..	.. ..	.. ..	- -	- -	- -	- -
Dietrich R.	181.63–181.93	B/G, Blockpoint	BB; CN; DV; GR; LS; RW	- -	- -	- -	- -	- -	.. ..	.. ..	.. ..	- -	- -	- -	- -
Dietrich R.	182.58–184.21	B/G, Blockpoint	BB; CN; DV; GR; LS; RW	- -	- -	- -	- -	- -	.. ..	.. ..	.. ..	- -	- -	- -	- -
Nutirwik Cr.	184.28	B/G, Blockpoint	CN; DV; GR; RW?					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Beaver Dam Brook	185.98	B/G, LWC	GR; CN					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Dietrich R.	185.98–186.70	B/G, Blockpoint	BB; CN; DV; GR; LS	- -	- -	- -	- -	- -	.. ..	.. ..	.. ..	- -	- -	- -	- -
Burger's Bayou	189.92	B/G, LWC	BB; CN; DV; GR					.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Dietrich R.	192.33–192.99	B/G, Blockpoint	BB?; CN; DV?; GR; LS?; RW	- -	- -	- -	- -	- -	.. ..	.. ..	.. ..	- -	- -	- -	- -

3.19-13

AFFECTED ENVIRONMENT

AFFECTED ENVIRONMENT

3.19-14

TABLE 3.19-2 (Cont.)

Stream Name ^a	Milepost	Crossing Mode/Structure ^b	Fish Species ^c	Sensitivity, ^d by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Marion Cr.	233.26	B/G, Blockpoint	CN; DV; GR; KS; RW				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Sharon Cr.	233.38	B/G, CMP	BB?; CN?; GR?; LS?; RW?				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Sharon Cr.	233.54	B/G, CMP	BB?; CN?; GR?; LS?; RW?				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Mary Angel Cr.	234.24	B/G, CMP	BB; CN; GR; LS; WF				- -	- -	- -	.. ..	.. ..	- -	- -		
S.F. Mary Angel Cr.	234.31	B/G, CMP	CN; GR				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Texas Slough**	235.49	B/G, Parallel	CN; GR; KS				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
1079 Slough	235.62	B/G, CMP	CN; GR				- -	- -	- -	.. ..	.. ..	- -	- -		
Organo Cr.	236.07	B/G, LWC	CN?; DV; GR				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Equisetum Cr.	236.17	B/G, CMP	GR				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Clara Cr.	236.49	A/G, CMP	CN?; GR; RW?				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Clara Cr. overflow	236.76	A/G, CMP	CN?; GR; RW?				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
S.F. Clara Cr.	236.83	A/G, CMP	CN; DV?; GR; RW				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Calf Cr.	237.04	A/G, CMP	CD?; DV?; GR; RW?				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Slate Creek*	237.57	B/G, Blockpoint	CN; DS; DV; GR; KS; RW				- -	- -	- -	.. ..	- -	- -	- -		
Horseshoe Slough	239.10	A/G, CMP	GR?				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Horseshoe Slough	239.26	A/G, CMP	GR?				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Spring Slough*	239.76	A/G, LWC	CD?; GR; KS				- -	- -	- -	.. ..	.. ..	- -	- -		
E.F. Spring Slough*	240.13	A/G, CMP	GR; KS				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
E.F. Spring Slough*	240.26	A/G, LWC	GR; KS				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Spring Slough*	240.37	A/G, CMP	CD?; GR; KS				- -	- -	- -	.. ..	.. ..	- -	- -		
Spring Slough*	240.40	Dike, CMP	CD?; GR; KS				- -	- -	- -	.. ..	.. ..	- -	- -		
Spring Slough*	240.60	Dike, CMP	CD?; GR; KS				- -	- -	- -	.. ..	.. ..	- -	- -		
S.F. Spring Slough*	240.66	A/G, CMP	CN?; GR; NP; KS				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Spring Slough*	240.79	A/G, CMP	CN?; GR; KS				- -	- -	- -	.. ..	.. ..	- -	- -		
Rosie Cr. *	242.89	B/G, LWC	CN?; DV?; GR; RW?; KS				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Rosie Cr. *	243.10-243.40	Dikes (3), CMPs	CN?; DV?; GR; RW?; KS	.. ..	.. ..	.. ..	- -	- -	- -	.. ..	.. ..	- -	- -	.. ..	.. ..

TABLE 3.19-2 (Cont.)

Stream Name ^a	Milepost	Crossing Mode/Structure ^b	Fish Species ^c	Sensitivity, ^d by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Rosie Cr.*	243.41	B/G, CMP	CN?; DV?; GR; RW?; KS	.. ..	.. ..	.. ..	- -	- -	- -	.. ..	.. ..	- -	- -	.. ..	.. ..
Mud Cr.	243.94	B/G, CMP	BB; GR				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Jackson Slough**	244.84	A/G, CMP	CN; GR; KS; RW				- -	- -	- -	.. ..	.. ..	- -	- -		
Jackson Slough**	244.85-245.00	Dikes (2), CMPs	CN; GR; KS; RW				- -	- -	- -	.. ..	.. ..	- -	- -		
Jackson Slough**	245.26	A/G, CMP	CN; GR; KS; RW				- -	- -	- -	.. ..	.. ..	- -	- -		
Jackson Slough**	245.53	A/G, Blockpoint	CN; GR; KS; RW				- -	- -	- -	.. ..	.. ..	- -	- -		
Trent's Trickle	246.26	A/G, CMP	CN; GR; NP?	.. ..	.. ..	.. ..	- -	- -	- -	.. ..	.. ..	- -	- -	.. ..	.. ..
N.F. Windy Arm Cr.	248.19	A/G, Blockpoint	CN; GR; NP?				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Chapman Cr.	250.50	A/G, LWC	CD?; GR; NP?				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
S.F. Koyukuk R.*	256.26-256.36	A/G, Blockpoint	BB?; BW?; CN; DS; GR; HW?; KS; LS; NP?; RW; SK?	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Aba-dabba Cr.	258.39	A/G, CMP	CN; GR	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
Jim R.*	268.12	B/G, Blockpoint	BB; CN; DS; GR; HW; KS; LS; NP; RW	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Beaver Spring	268.44	A/G, CMP	CN?; GR?; KS?; RW?	- -	- -	- -	- -	- -	- -	.. ..	.. ..	- -	- -	- -	- -
Dee Cr.	269.00	A/G, CMP	CN; DV?; GR; RW	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
Douglas Cr.*	270.45	A/G, LWC	CN; GR; RW?; KS				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Jim R. side chan.*	271.62	B/G, Blockpoint	BB; CN; DS; GR; HW; KS; LS; NP; RW	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Jim R. side chan.*	271.92	B/G, Blockpoint	BB; CN; DS; GR; HW; KS; LS; NP; RW	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Little Piddler	272.21	A/G, CMP	GR				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
Prospect Cr.*	277.14	A/G, Blockpoint	CN; GR; KS; LS; NP; RW	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Little Nasty Cr.	281.88	A/G, Blockpoint	CN; GR; RW				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
S.F. Little Nasty	282.14	A/G, CMP	CD?; GR				.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..		
N.F. Bonanza Cr.	284.40	B/G, Blockpoint	BB; CN; GR; HW?; LS; LW; NP; RW				- -	- -	- -	.. ..	.. ..	- -	- -		
Oxbow Lake System	285.53	B/G, CMP	GR?				- -	- -	- -	.. ..					

3.19-17

AFFECTED ENVIRONMENT

AFFECTED ENVIRONMENT

3.19-18

3.19-19

AFFECTED ENVIRONMENT

AFFECTED ENVIRONMENT

3.19-20

3.19-21

AFFECTED ENVIRONMENT

AFFECTED ENVIRONMENT

3.19-22

TABLE 3.19-2 (Cont.)

Stream Name ^a	Milepost	Crossing Mode/Structure ^b	Fish Species ^c	Sensitivity, ^d by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Gulkana R.*	654.90	26-APL-2, Bridge	BB; CD; GR; KS; LS; LT; LW; RB; RS; RW; SH	.. ..	.. ..	.. ..	.. ..	- -	- -	- -	- -	- -	- -	.. ..	.. ..
Three-Sisters Cr.	659.69	A/G, CMP	CD; GR					- -	- -	.. ..	.. ..				
Bear Cr.	672.40	23-APL-1A, CMP	GR; DV?; KS					- -	- -	.. ..	.. ..	.. ..	.. ..		
Dry Cr.	680.20	22-APL-1, CMP	GR; DV?; KS?; RS?					- -	- -	.. ..	.. ..	.. ..	.. ..		
Moose Cr.	686.55	B/G, Parallel	GR; SK					- -	- -	.. ..	.. ..				
Tazlina R.*	686.78	A/G, Blockpoint	BB; DV; GR; KS; LS; LT; PW; RS; RW; SH				.. ..	- -	- -	- -	- -	- -	- -	.. ..	.. ..
Tazlina R. Trib.	690.09–690.28														
N.F. Yetna Cr.	691.71	A/G, LWC	GR					- -	- -	.. ..	.. ..				
Yetna Cr.	691.87	A/G, LWC	GR					- -	- -	.. ..	.. ..				
SW.F. Yetna Cr.	694.47	A/G, LWC	GR					- -	- -	.. ..	.. ..				
S.F. Yetna Cr.	696.06	A/G, LWC	GR					- -	- -	.. ..	.. ..				
Klutina R.*	697.33	B/G, Blockpoint	BB; DV; GR; KS; LT; LW; PW; RS; SH; SS				.. ..	- -	- -	- -	- -	- -	.. ..	.. ..	
Willow Cr.	706.68	A/G, Blockpoint	GR					- -	- -	.. ..	.. ..				
Rock Cr.	712.25	A/G, LWC	GR					- -	- -	.. ..	.. ..				
Squirrel Cr.	717.28	A/G, LWC	CD; DV; GR; KS	.. ..	.. ..	.. ..		.. ..	- -	- -	- -	- -	- -	.. ..	.. ..
Tonsina R. Trib.	720.95														
Tonsina R.*	723.89	B/G, LWC	BB; CD; DV; GR; KS; LT; PW; RS; RW; SH; SS				.. ..	.. ..	- -	- -	- -	- -	- -	.. ..	
Tonsina R.*	724.01	B/G, Bridge	BB; CD; DV; GR; KS; LT; PW; RS; RW; SH; SS				.. ..	.. ..	- -	- -	- -	- -	- -	.. ..	
Silver Spawning Cr.**	730.17	B/G, LWC	DV; SS									.. ..	.. ..		
Silver Spawning Cr.**	730.25	B/G, LWC	DV; SS; CD							.. ..	.. ..	.. ..	.. ..		
N.F. Crack Cr.**	730.36	B/G, LWC	CD; SS												
S.F. Crack Cr.**	730.47	B/G, LWC	CD; DV; SS												
L. Tonsina Flats**	730.66	B/G, CMP	CN; DV; GR; SS								.. ..	.. ..			

TABLE 3.19-2 (Cont.)

Stream Name ^a	Milepost	Crossing Mode/Structure ^b	Fish Species ^c	Sensitivity, ^d by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
L. Tonsina Flats**	730.72	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	730.78	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	730.85	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.00	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.16	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.26	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.34	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.44	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.50	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.69	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.78	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.86	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
L. Tonsina Flats**	731.95	B/G, LWC	CN; DV; GR; SS								.. ..	.. ..			
Slate Cr.*	732.02	B/G, Bridge	DV; GR; KS; SS	- -	- -	.. ..	.. ..	.. ..	.. ..			- -	- -	- -	- -
L. Tonsina Marsh**	732.29	B/G, LWC	SS								.. ..	.. ..			
L. Tonsina Marsh	732.41	B/G, LWC	CD; DV												
Little Tonsina R.*	732.80	B/G, Bridge	BB; CD; DV; GR; KS; LT; RS; SS; WF	- -	- -	.. ..	.. ..	.. ..	- -	- -	- -	- -	- -	- -	- -
Little Tonsina R.*	734.66	B/G, Bridge	BB; CD; DV; GR; KS; LT; RS; SS; WF	- -	- -	.. ..	.. ..	.. ..	- -	- -	- -	- -	- -	- -	- -
Quarry Cr.	739.26	B/G, LWC	DV												
Fifty-nine Mi. Cr.	741.04	B/G, LWC	DV	.. ..	.. ..	.. ..					- -	- -	- -	- -	- -
Squaw Cr.	745.26	B/G, LWC	DV	.. ..	.. ..	.. ..					- -	- -	- -	- -	- -
S.F. Squaw Cr.	745.68	B/G, LWC	DV	.. ..	.. ..	.. ..					- -	- -	- -	- -	- -
S. Squaw Cr.	745.98	B/G, LWC	DV	.. ..	.. ..	.. ..					- -	- -	- -	- -	- -
Boulder Cr.	748.07	B/G, LWC	DV	.. ..	.. ..	.. ..					- -	- -	- -	- -	- -
Tiekel R.	749.07	B/G, Blockpoint	CD; DV	.. ..	.. ..	.. ..	.. ..				- -	- -	- -	- -	- -
Tiekel R. trib.	749.37	B/G, LWC	DV	.. ..	.. ..	.. ..					- -	- -	- -	- -	- -
Tiekel R. trib.	749.43	B/G, CMP	DV	.. ..	.. ..	.. ..					- -	- -	- -	- -	- -
Small Cr.	751.95	B/G, LWC	DV	.. ..	.. ..	.. ..					- -	- -	- -	- -	- -

3.19-25

AFFECTED ENVIRONMENT

TABLE 3.19-2 (Cont.)

Stream Name ^a	Milepost	Crossing Mode/Structure ^b	Fish Species ^c	Sensitivity, ^d by Month											
				Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Abercrombie Slough**	795.27	B/G, CMP	DS; PS; SS	- -	- -	- -	- -	- -	- -	-	-	- -	- -	- -	- -
Abercrombie Gulch*	795.87	B/G, Blockpoint	DS; DV; PS; SS	- -	- -	** **	** **	** **	** **		- -	- -	- -	- -	- -
Dayville Flats Cr.*	796.63	B/G, CMP	CD; DV; PS; SS	- -	- -	** **	** **	** **		- -	- -	- -	- -	- -	- -
Trickle Cr.*	797.02	B/G, LWC	PS	- -	- -	** **	** **	** **		- -	- -	- -	- -	- -	- -
Solomon L. Outlet*	798.05	B/G, Bridge	CD; DS; DV; PS; SS	- -	- -	** **	** **	** **		- -	- -	- -	- -	- -	- -
Allison Cr.*	799.74	B/G, Blockpoint	CD; DS; DV; PS	- -	- -	** **	** **	** **		- -	- -	- -	- -	- -	- -

^a “**” indicates that the stream has been designated as an anadromous fish stream; “***” indicates proposed designation as anadromous fish stream.

^b Crossing mode and structure abbreviations are as follows:

A/G = aboveground

B/G = belowground

CMP = corrugated metal pipe (culvert)

LWC = low water crossing

Footnotes continued on next page.

TABLE 3.19-2 (Cont.)

^c Abbreviations are as follows:

“?” indicates that presence of species is suspected but not confirmed.

AB = Alaska blackfish (<i>Dallia pectoralis</i>)	KS = Chinook (king) salmon (<i>Oncorhynchus tshawytscha</i>)
AC = Arctic char (<i>Salvelinus alpinus</i>)	LC = Lake chub (<i>Couesius plumbeus</i>)
AL = Arctic lamprey (<i>Lampetra japonica</i>)	LS = Longnose sucker (<i>Catostomus catostomus</i>)
BB = Burbot (<i>Lota lota</i>)	LT = Lake trout (<i>Salvelinus namaycush</i>)
BL = American brook lamprey (<i>Lampetra</i> sp.)	LW = Lake whitefish (<i>Coregonus clupeaformis</i>)
BW = Broad whitefish (<i>Coregonus nasus</i>)	NP = Northern pike (<i>Esox lucius</i>)
CA = Arctic cisco (<i>Coregonus autumnalis</i>)	PS = Pink (humpback) salmon (<i>Oncorhynchus gorbuscha</i>)
CD = Sculpin (Family Cottidae)	PW = Pygmy whitefish (<i>Prosopium coulteri</i>)
CI = Cisco (<i>Coregonus</i> sp.)	RB = Rainbow trout (<i>Oncorhynchus gorbuscha</i>)
CN = Slimy sculpin (<i>Cottus cognatus</i>)	RS = Sockeye (red) salmon (<i>Oncorhynchus nerka</i>)
CS = Least cisco (<i>Coregonus sardinella</i>)	RW = Round whitefish (<i>Prosopium cylindraceum</i>)
DS = Chum (dog) salmon (<i>Oncorhynchus keta</i>)	SB = Stickleback (Family Gasterosteidae)
DV = Dolly Varden (<i>Salvelinus malma</i>)	S9 = Ninespine stickleback (<i>Pungitius pungitius</i>)
GR = Arctic grayling (<i>Thymallus arcticus</i>)	SH = Steelhead trout (<i>Oncorhynchus mykiss</i>)
HO = Pond smelt (<i>Hypomesus olidus</i>)	SK = Sucker (Family Catostomidae)
HW = Humpback whitefish (<i>Coregonus pidschian</i>)	SS = Coho (silver) salmon (<i>Oncorhynchus kisutch</i>)
IN = Inconnu (sheefish) (<i>Stenodus leucichthys</i>)	WF = Whitefish (<i>Coregonus</i> sp.)

^d Sensitivity designations as determined by BLM (1987a,b). Each month is divided in half, with a sensitivity ranking given for each half, if appropriate. “–” indicates that the stream is considered critically sensitive. Two dots “..” indicates that the stream is considered sensitive.

Sources: ADF&G (1999a-c); APSC (1993); BLM (1987a,b).

year-round because it may provide rearing and overwintering areas for all fish species. The main river is considered critically sensitive from May through June because of Arctic grayling spawning and from August through October because of anadromous Dolly Varden migration and spawning.

None of the streams or rivers from MP 95 to the Brooks Range (MP 170) is designated as anadromous fish habitat. In this segment, the pipeline crosses numerous tributary creeks from Spoiled Mary Creek (MP 75) to Oksrukuyik Creek (MP 103), all of which are classified as sensitive from May to October because they provide summer foraging habitat for a number of species, including Arctic grayling and Dolly Varden. Because of spawning by Arctic grayling and anadromous Dolly Varden, these tributaries are considered critically sensitive in spring and fall. As in the lower reaches, the portion of the Sagavanirktok River into which these tributaries empty is considered sensitive year-round and critically sensitive in spring (May-June) and fall (August-October). All of the streams crossed by the pipeline from Vanish Creek (MP 145) through the Atigun River floodplain (MP 157–165) are considered sensitive during the summer period, providing habitat for anadromous Dolly Varden, Arctic grayling, burbot, slimy sculpin, and round whitefish.

Arctic grayling and resident Dolly Varden occur during the summer (May through October) in several creeks along the ROW from Thieles Trickle (MP 113) to Galbraith Lake Tributary (MP 138). TAPS crosses the East Fork of the Kuparuk River at MP 124 and the Kuparuk River at MP 126. Although the portion of the Kuparuk River in the vicinity of the TAPS ROW is not designated as anadromous fish habitat, designated anadromous fish habitat does occur farther downstream (ADF&G 1999a). From MP 142 to MP 143, the pipeline crosses the Atigun River and several streams that enter Tea Lake. These waters contain anadromous Dolly Varden, Arctic grayling, burbot, lake trout, slimy sculpin, and round whitefish and are considered critically sensitive from May to October. They also provide overwintering habitat for some species and are considered sensitive from November through December.

3.19.1.1.2 Interior Alaskan Region. After crossing the Atigun Pass in the Brooks Range, the ROW enters Interior Alaska. Within this region (MP 170-605), the pipeline crosses or runs along several major streams and rivers, most of which are in the Yukon River drainage. At least 19 species of fish occur in the Yukon River drainage (Table 3.19-1). Arctic grayling; anadromous and resident Dolly Varden; and chum, coho, and chinook salmon are most important along the TAPS. Other common species along this portion of the ROW include whitefishes, slimy sculpin, longnose sucker, northern pike, and burbot.

Arctic grayling, slimy sculpin, and possibly resident Dolly Varden use the North Fork of the Chandalar River (MP 170–173), the first drainage crossed by the pipeline on the southern slope of the Brooks Range. The North Fork of the Chandalar River is considered sensitive habitat during the summer from May through October and critically sensitive in spring and fall because of spawning by Arctic grayling and possibly Dolly Varden.

South of the Brooks Range, the pipeline follows the course of the Dietrich River and the Middle Fork of the Koyukuk River from MP 175 to MP 247. Resident Dolly Varden, Arctic grayling, burbot, round whitefish, longnose sucker, and slimy sculpin inhabit the Dietrich River drainage. Known overwintering areas occur intermittently along the Dietrich River from MP 179 to MP 193 and are considered critically sensitive year round. The river's tributaries are considered sensitive habitat during periods of open water (typically May-October). Although none of the water bodies within the Dietrich River system is classified as anadromous, the Dietrich flows into the Middle Fork of the Koyukuk River, which is classified as an anadromous fish stream. The Middle Fork of the Koyukuk River and several of its tributaries from MP 205 to MP 247 support stocks of anadromous Dolly Varden, chum and chinook salmon, Arctic grayling, and other species. The Middle Fork of the Koyukuk River is considered critically sensitive rearing habitat year-round, and most of the tributaries and sloughs associated with it are considered sensitive from April through October. The pipeline crosses the mouths of two major anadromous-fish tributaries — Hammond River (MP 222) and

Slate Creek (MP 238) — which are considered sensitive during the open water period.

South of MP 226, the pipeline crosses several streams that provide habitat for chum and/or chinook salmon, including Minnie Creek (MP 226), Marion Creek (MP 233), the South Fork of the Koyukuk River (MP 256), Jim River (MP 268 and MP 271), Douglas Creek (MP 270), Prospect Creek (MP 277), and the Yukon River (MP 353). These streams are considered critically sensitive throughout the year. Other nonanadromous streams that support Arctic grayling and numerous minor species are classified as sensitive from April through October. Although few anadromous fish streams exist between Prospect Creek and the Yukon River, Bonanza Creek (MP 284, MP 286) and Fish Creek (MP 295) empty into the South Fork of the Koyukuk River, which is an anadromous fish stream. Chum salmon occur in Bonanza Creek downstream from the pipeline crossing, and the Kanuti River (MP 303) provides anadromous-fish habitat near its mouth.

Few anadromous fish streams occur along the 185 mi of the TAPS between the Yukon and Chatanika (MP 438) Rivers; chum salmon have been reported in Hess Creek (MP 379) and the Tolovana River (MP 399) (Table 3.19-2). Most streams in this area support Arctic grayling and numerous other species, including whitefishes, slimy sculpin, longnose sucker, northern pike, and burbot. These water bodies are considered sensitive from May through October. The Tolovana River (MP 399) supports anadromous fish about 25 mi downstream of the TAPS (ADF&G 1999b).

From Chatanika to Tanana Rivers, the pipeline crosses several major anadromous streams, including the Chatanika River (MP 438), Chena River (MP 460), Little Salcha River (MP 491), Salcha River (MP 496), Redmond Creek (MP 500), Shaw Creek (MP 520), and the Tanana River (MP 531). This area contains some of the most productive salmon spawning and rearing grounds in Interior Alaska and supports extensive commercial, sport, and subsistence fisheries. A major chum salmon spawning area is located just downstream of the MP 531 crossing at the confluence of the Tanana and Delta Rivers. The Chatanika, Chena, Salcha, and Tanana Rivers and Shaw

Creek provide critically sensitive year-round habitat for salmon and whitefish. Washington Creek (MP 432), Moose Creek (MP 471-473), and the Little Salcha River provide critically sensitive overwintering habitat from November through April and sensitive habitat the rest of the year.

No designated anadromous fish streams occur between the Tanana River (MP 531) and Isabel Pass (MP 605). However, most of the creeks crossed by the pipeline empty into the Delta River, which supports anadromous fish near its confluence with the Tanana River. The Delta River provides sensitive habitat for Arctic grayling and whitefish from May through October, and a year-round sensitive area is located at MP 592. The only stream with sensitive habitat that empties into the Delta River is Phelan Creek; perennial springs provide year-round habitat for Arctic grayling and whitefish. Both the Delta River and Phelan Creek are considered critically sensitive during spring and fall.

Commercial and subsistence fishing in the Yukon drainage is primarily for chinook, chum, and coho salmon. Along the pipeline, the heaviest fishing occurs in the Yukon River main stem and in the Tanana River around Fairbanks. Sport fishing north of the Yukon River is largely restricted to lakes and streams accessible from the Dalton Highway (Burr 2001) and is relatively light because of the region's isolation. Arctic grayling, inconnu, and northern pike are the most heavily harvested species, with small numbers of whitefish, lake trout, and burbot also taken. South of the Yukon River, the area around Fairbanks supports one of the largest sport fisheries in the state for Arctic grayling, accounting for over 50% of the annual take. Additional species taken include northern pike; inconnu; whitefish; burbot; lake trout; resident and anadromous Dolly Varden; and chinook, chum, and coho salmon (Burr 2001). Some of the heaviest sport fishing occurs in the Chena, Salcha, and Delta Rivers.

3.19.1.1.3 South of the Alaska Range. South of the Alaska Range, the ROW crosses streams and rivers that are primarily within the Copper River drainage (Map 3.19-1). Seventeen species of fish occur along the ROW

in the Copper River drainage (MP 606–800) (Table 3.19-1). Although all five species of Alaskan salmon are found in the drainage, sockeye, coho, and chinook salmon are dominant; by comparison, pink and chum salmon runs are very small (ADF&G 1986c). The Copper River is the major producer of sockeye and chinook salmon in the Prince William Sound region and also supports commercial and subsistence fisheries for eulachon in its lower reaches. Other important species include Arctic grayling, Dolly Varden, rainbow trout (steelhead), whitefish, sculpin, burbot, and smelt.

Gunn Creek (MP 608), Fish Creek (MP 613), and the Gulkana River (MP 655) are major anadromous fish streams and support large recreational fisheries. In addition to supporting stocks of chinook and sockeye salmon, Arctic grayling, and steelhead, the Gulkana River contains at least seven other species. The Gulkana River is considered sensitive year-round and critically sensitive for feeding and spawning from May through October. The Gulkana River Sockeye Salmon Enhancement Project hatchery area, crossed by the TAPS at MP 615 and MP 618, is considered critically sensitive during the incubation period from midsummer through spring (APSC 1993).

Between the Gulkana River (MP 655) and the Tonsina River (MP 723), the pipeline directly crosses only two designated anadromous fish streams: the Tazlina (MP 687) and Klutina (MP 697) Rivers. Both rivers provide migratory and spawning habitat for chinook and sockeye salmon and steelhead; coho salmon also occur in the Klutina River. Other species found in both streams include Arctic grayling, anadromous Dolly Varden, burbot, and whitefish. These rivers are considered sensitive from spring through late fall and critically sensitive during the open-water months from May to October. Along this stretch, the pipeline crosses or runs near 11 other streams, all of which support Arctic grayling. Bear Creek (MP 672), Dry Creek (MP 680), and Squirrel Creek (MP 717) are considered sensitive for Arctic grayling during the open-water feeding season and critically sensitive in May through June when Arctic grayling are spawning.

From the initial crossing of the Tonsina River (MP 723) until the final crossing of the Little Tonsina River (MP 734), the TAPS encounters a series of sensitive anadromous fish habitats. The Tonsina River supports stocks of chinook, coho, and sockeye salmon, Arctic grayling, anadromous Dolly Varden, and several other species. It is classified as sensitive from April through November and critically sensitive during the open-water migration, spawning, and rearing period from June through October. The ROW passes through the Little Tonsina Flats (MP 731–732), a large wetland area that provides foraging habitat for chinook and coho salmon, anadromous Dolly Varden, Arctic grayling, and slimy sculpin; however, Little Tonsina Flats is considered sensitive only in August and September. Slate Creek (MP 732) and the Little Tonsina River are anadromous fish streams that also support coho and chinook salmon, anadromous Dolly Varden, and Arctic grayling. The Little Tonsina also contains sockeye salmon, whitefish, and burbot. Both rivers are considered sensitive through most of the year and provide critically sensitive overwintering habitat from October through February.

No anadromous fish streams exist between the Little Tonsina River (MP 734) and MP 780, where the pipeline parallels the Lowe River. The streams and creeks along this length of the ROW contain resident Dolly Varden and are considered sensitive overwintering areas from January through March and critically sensitive during the spawning and overwintering period from August through December.

From the Lowe River crossing (MP 780) to the terminus of the pipeline at Port Valdez (MP 800), nearly all tributaries, streams, and creeks are considered anadromous fish habitat. They contain pink, sockeye, coho, and occasionally chum salmon and anadromous Dolly Varden. These anadromous species are dominant in these water bodies; other species are rare. All of these streams and tributaries are considered sensitive year round and are considered critically sensitive from late summer through much of the winter in conjunction with spawning and overwintering.

Commercial driftnet fisheries for sockeye, chinook, and coho salmon in the Copper River are some of the most productive fisheries within the Prince William Sound region (ADF&G 1986c). The fisheries occur in conjunction with the major runs for sockeye (May to late July), coho (early August to late September), and chinook (May through July) salmon. The Gulkana River Sockeye Salmon Enhancement Project, which is located along the pipeline in the upper Copper River drainage, is the only major sockeye hatchery in the region and is a dominant factor enhancing the commercial catch. The hatchery has been in operation since 1973 and has released between 179,000 and 30 million fry into the Gulkana River annually since opening. Annually, between 300 and 632,000 adults originating from the hatchery have returned to the Gulkana River during the same period. There is a minor sport fishery for steelhead in the area, with fishing being heaviest in the Gulkana River area. Sockeye, coho, and chinook salmon support extensive recreational fisheries throughout the Copper River drainage and in Prince William Sound. Recreational fisheries for Arctic grayling and Dolly Varden also exist in the area, particularly in the Gulkana River. Dolly Varden are also taken in other streams along the TAPS route, although most of the harvest is incidental to salmon fisheries (ADF&G 1986c). There is also a minor sport fishery for steelhead in some locations along the TAPS ROW, with fishing being heaviest in the Gulkana River area.

In addition to commercial and recreational fisheries, substantial recreational, personal use, and subsistence fisheries also occur in the Prince William Sound area and in the Copper River basin. A variety of gears are used to capture fish in these fisheries, including fish wheels and dip nets. The largest subsistence fishery in the area is in the upper Copper River, where 80,835 salmon (76,456 sockeye, 3,234 chinook, and 1,145 coho salmon) were reported taken in 1999 (ADF&G 2001a). About 87% of these were taken in fish wheels and 13% were taken in dip nets. By comparison, the

Copper River subsistence fishery, which occurs at the mouth of the Copper River near Cordova, is a relatively small portion of the overall salmon fishery in the Prince William Sound area. In 1999, 294 permits were issued for this fishery, and the estimated harvest was 2,528 salmon (1,422 sockeye, 729 coho, and 377 chinook salmon) (ADF&G 2001a). Through 1999, this harvest represented the second-highest on record for this fishery (ADF&G 2001a). Compared with the Copper River subsistence fisheries, subsistence fishing for salmon in other areas of Prince William Sound is considerably lower. Other species taken for subsistence purposes in the area include Arctic grayling, burbot, whitefish, and a variety of marine fish and shellfish species (ADF&G 2001a).

3.19.1.2 Beaufort Sea

Fish populations of the nearshore region of the Beaufort Sea provide an important subsistence resource for local residents (Craig 1989a) and support commercial and sport harvests (BLM and MMS 1998; Howe et al. 1998). Fish populations near existing and planned developments related to oil exploration and extraction, and the effects of these developments on fishes and fish habitat, have been extensively investigated since the mid-1970s.¹ Summaries of those studies are included in recent reviews and other documents, including the USACE (1980, 1984), ARCO Alaska et al. (1996), BLM and MMS (1998), and Truett and Johnson (2000).

Important fish species in the Beaufort Sea in the vicinity of oil production areas include anadromous Dolly Varden, Arctic cisco, least cisco, humpback whitefish, and broad whitefish. Although these species occur in the Beaufort Sea, they can include both anadromous and freshwater populations as identified in Section 3.19.1.1.

Anadromous Dolly Varden spawn in many of the mountain streams emptying into the Beaufort

¹ See, for example, Furniss 1975; Craig and McCart 1975; Bendock 1979; Craig and Haldorson 1981; Griffiths and Gallaway 1982; Critchlow 1983; Gallaway et al. 1983; Griffiths et al. 1983; Woodward-Clyde Consultants 1983; Craig 1984; Moulton et al. 1986; Envirosphere 1987; Fechhelm and Fissel 1988; Hemming 1988–1996; Hemming et al. 1989; Fechhelm and Griffiths 1990; Fechhelm et al. 1989, 1992, 1999; LGL 1990–1996.

Sea between and including the Colville and Mackenzie Rivers (Craig and McCart 1974, 1975; Smith and Glesne 1982; Craig 1977a,b; Daum et al. 1984; Craig 1984; Everett and Wilmot 1987). This species is not found in Arctic Coastal Plain streams west of the Colville, possibly because these drainages lack perennial springs (Craig 1984). The Sagavanirktok River is thought to contain the largest anadromous Dolly Varden populations on the North Slope (McCart et al. 1972). Juveniles remain in their natal streams for several years before their first seaward migration (Craig 1977a,b, 1989b).

Dolly Varden are powerful swimmers that migrate considerable distances along the coast during the summer. Although spawners are believed to maintain fidelity to their natal streams, nonspawners may overwinter in non-natal drainages (Glova and McCart 1974; Craig 1977a; DeCicco 1985, 1990, 1992, 1997).

Nearly all studies conducted in the nearshore zone in the summer found substantial numbers of large Arctic cisco (Craig and Mann 1974; Griffiths et al. 1975, 1977; West and Wiswar 1985; Wiswar and West 1987; Griffiths 1983; Fruge et al. 1989; Underwood et al. 1995). Arctic cisco found in the Alaskan Beaufort Sea are believed to originate from spawning grounds in the Mackenzie River system of Canada (Gallaway et al. 1983, 1989). In spring, newly hatched young-of-the-year (age 0) are flushed downriver into ice-free coastal waters adjacent to the Mackenzie Delta. Some young-of-the-year are transported west to Alaska by wind-driven coastal currents (Gallaway et al. 1983; Fechhelm and Fissel 1988; Moulton 1989; Fechhelm and Griffiths 1990; Schmidt et al. 1991; Underwood et al. 1995; Colonell and Gallaway 1997). In summers with strong and persistent east winds, enhanced westward transport can carry fish to Alaska's Colville River, where they take up winter residence. They remain in the Colville River until the onset of sexual maturity at about age 7, at which point they migrate back to the Mackenzie River to spawn (Gallaway et al. 1983).

The meteorologically driven recruitment process plays a major role in determining the age structure of Arctic cisco populations in Alaska. Summers with strong, persistent east winds are associated with strong year classes in

the Colville/Sagavanirktok region (Cannon et al. 1987; Moulton 1989; Glass et al. 1990; Reub et al. 1991; LGL 1992, 1994a; Griffiths et al. 1996). These year classes maintain a presence in the region that can be tracked as fish grow to ages harvested by the commercial and subsistence fisheries operating in the Colville River (Moulton et al. 1993; Moulton and Field 1988, 1991, 1994; Moulton 1994, 1995).

Least cisco have both migratory and freshwater resident populations on the Arctic Coastal Plain. Migratory populations have a discontinuous distribution in the coastal Beaufort Sea (Craig and McCart 1975; Craig 1984, 1989b). Western populations are associated with the Colville River and smaller rivers to the west, while eastern populations are associated mainly with the Mackenzie River. The large distance between these freshwater systems apparently isolates the migratory populations from each other.

Little is known about the westward dispersal of least cisco from the Colville River during summer, but adult fish that disperse eastward are known to travel considerable distances down the coast. Substantial numbers of large least cisco are typically collected in the Prudhoe Bay/Sagavanirktok Delta region. High abundance has also been reported in Foggy Island Bay (Cannon et al. 1987; Glass et al. 1990) and as far as Mikkelsen Bay (Fechhelm et al. 1996), about 100 mi east of the Colville River. Relatively few large least cisco reach Camden Bay, which is about 170 mi east of the Colville River (Underwood et al. 1995).

The eastward dispersal of juvenile least cisco during summer appears to be a function of wind-driven coastal currents (Fechhelm et al. 1994). West winds in early summer (primarily July) create easterly flowing currents in Simpson Lagoon that enhance the eastward dispersal of small fish. In summers of substantial west winds (about one out of every two years), large numbers of juvenile least cisco are collected in the Prudhoe Bay/Sagavanirktok Delta region (Griffiths et al. 1983; Moulton et al. 1986; LGL 1992, 1993). In years lacking substantial July west-wind events, few small least cisco reach the eastern end of Simpson Lagoon (Cannon et al. 1987; Glass et al. 1990;

Reub et al. 1991; Fechhelm et al. 1994; LGL 1994b; Griffiths et al. 1996).

As with least cisco, the anadromous broad whitefish has two population centers in the Beaufort Sea region — the Colville River and westward and the Mackenzie River drainage. Unlike the situation with least cisco and Arctic cisco, however, the Sagavanirktok River supports a spawning and overwintering population of broad whitefish.

Of the four dominant anadromous species, broad whitefish are the most restricted in terms of their summer dispersal from overwintering rivers. Young fish (age 2 and younger) from the Sagavanirktok River population tend to remain near the low-salinity waters of the delta for much of the open-water season (Gallaway and Fechhelm 2000). There has been speculation that salinity intolerance may be the reason for this limited summer distribution. Older broad whitefish (age 3 and older) disperse farther from their natal rivers (Gallaway and Fechhelm 2000), regularly moving between the Sagavanirktok and Colville Rivers (Moulton et al. 1986; Cannon et al. 1987; Moulton and Field 1994) through Simpson Lagoon. Broad whitefish catches reported for the eastern Alaskan Beaufort Sea have been low (Griffiths 1983; West and Wiswar 1985; Wiswar and West 1987; Fruge et al. 1989; Underwood et al. 1995).

Broad whitefish use a variety of habitats through their life cycle. Spawning occurs in deep portions of large rivers in fall. In the Mackenzie River, they spawn in the lower river just upstream of the marine influence. The anadromous population in the Colville River appears to show a similar pattern, with spawning in the main river upstream of the delta. Bendock and Burr (1986) identified a prespawning migration in August but did not know if the fish were freshwater residents or part of the anadromous population.

During the spring flood, subadult broad whitefish enter a variety of available habitats, including seasonally flooded lakes, lakes connected to stream systems, river channels, and coastal areas. Fish using perched lakes remain in the lake until they reach maturity, then return to the river in the spring of the year they will spawn. Broad whitefish that do not enter

perched lakes either enter the coastal region and adjacent small drainages to feed — thus assuming an anadromous pattern — or remain in the river system and feed in low-velocity channels, tapped lakes, or drainage lakes. In fall, they leave the shallow feeding areas and return to deep wintering areas in the main river or in lakes. Maturity is first reached at age 9, with most maturing at age 10 to 12 (Bendock and Burr 1984, 1986).

3.19.1.3 Prince William Sound

Prince William Sound supports large populations of marine and anadromous fish that form the basis of major commercial, subsistence, personal use, and sport fisheries. Sockeye, pink, coho, chinook, and chum salmon and Pacific herring have provided the greatest commercial harvest value in recent years (Morstad et al. 1999). Pacific halibut, sablefish, and other marine species are also harvested (Bechtol 1995). Sockeye salmon are the most harvested species in the subsistence and personal use fisheries, with other salmon species also providing important harvests (Morstad et al. 1999). Eulachon supports a smaller, but important, personal use and subsistence fishery during migration periods (April-May). Salmon and halibut also support a large sport fishery, with an estimated 130,000 person-days fished in 1997 (Howe et al. 1998).

Designated EFH for salmon fisheries in Alaska includes all estuarine and marine areas used by Pacific salmon of Alaska origin. The designated habitat would extend from the area of tidal influence in stream habitat and tidally submerged habitats to the oceanic limits of the Economic Exclusion Zone for the United States (North Pacific Fishery Management Council 1998). EFH has also been designated for scallops and Gulf of Alaska ground fish in Port Valdez.

Rice et al. (1996) and Wells et al. (1995) have described effects to fish populations in Prince William Sound from the 1989 Exxon Valdez oil spill. Studies on initial effects and subsequent recovery of fish populations following the spill have not resulted in consensus on the extent of damage and recovery rate. Studies conducted by the Exxon Valdez Oil Spill

Trustee Council indicated initial damage to Pacific herring, pink salmon, Dolly Varden char, and cutthroat trout (Rice et al. 1996). Pink salmon have continued to support commercial fisheries and anadromous Dolly Varden and cutthroat trout continue to support sport fisheries. After a record harvest in 1992, the Pacific herring population collapsed and has remained depressed, with reduced or no commercial harvest (Morstad et al. 1999).

Pink salmon are considered particularly vulnerable to contamination from the Valdez Marine Terminal and from oil spills in Prince William Sound because a large portion of the wild population spawns in the intertidal region of the spawning streams (Noerenberg 1963; Helle et al. 1964; Helle 1970). Pink salmon are the most abundant salmon species in Prince William Sound, with the production of wild salmon averaging about 9 million fish per year (range 2 million to 21 million) from 1977 to 1999 (Sharp et al. 2000). During this time, four major hatcheries added an annual average of 13 million fish (range <1 million to 39 million). Together, these populations have supported a commercial harvest averaging 27 million pink salmon over the same period. Following the Exxon Valdez oil spill in 1989, a marked drop was observed in population levels of pink salmon in Prince William Sound during 1992 and 1993. Population levels rebounded in subsequent years, most likely as a result of improved ocean survival rates for both wild and hatchery stocks. This pattern led to speculation that the spilled oil was responsible for the observed declines, although there are conflicting scientific views on this, and no direct connection has been conclusively established (Brannon et al. 2001; Rice et al. 2001).

On the basis of recent investigations, the Exxon Valdez Oil Spill Trustee Council (2002b) has determined that it is unlikely that oil from the Exxon Valdez oil spill is currently accumulating in pink salmon embryos and having any significant effects. Because of this determination and because pink salmon population levels and indicators (e.g., juvenile growth and survival) are within normal bounds, pink salmon are considered recovered from the effects of the oil spill (Exxon Valdez Oil Spill Trustee Council 2002b).

Three other species of Pacific salmon (sockeye, coho, and chum) also play an important role in the Prince William Sound ecosystem. Sockeye salmon enter a number of systems throughout Prince William Sound, with a small run entering Robe Lake near Valdez. Other systems with historically significant runs include Eshamy and Coghill Lakes located on the western side of Prince William Sound (Morstad et al. 1999). Coho salmon also enter the Robe Lake system and are spread widely throughout Prince William Sound. A hatchery run developed at the Solomon Gulch Hatchery at Valdez supports a large sport fishery in August and a directed commercial harvest in September. From 1988 to 1997, the sport coho harvest averaged 32,000 fish, with the annual average exceeding 50,000 fish since 1995 (Howe et al. 1998). Chum salmon are also widespread through the Sound and are important to the commercial harvest. The chum salmon harvest is also bolstered by a hatchery run. Chum salmon are now the second most numerous species in the salmon harvest (Morstad et al. 1999).

Dolly Varden support an important sport fishery in Prince William Sound, with an average harvest of over 3,000 fish from 1988 to 1997 (Howe et al. 1998). Dolly Varden in the Sound are considered anadromous and have a complex life cycle involving repeated annual migrations between freshwater rivers or lakes and the sea. Dolly Varden alevins (young fish after the yolk sac has been absorbed but before they emerge from the gravel) emerge from spawning stream gravel in May and remain in the stream for 2 to 4 years (Armstrong 1970). In

Life Cycle of Dolly Varden

Anadromous Dolly Varden have complex life cycles that involve repeated migrations between freshwater rivers or lakes and the sea. Young fish emerge from eggs laid in stream gravels and remain in the stream for 2 to 4 years before migrating to the sea to mature. After maturing at 7 to 9 years of age, Dolly Varden return to their natal stream to spawn. A proportion of the spawning fish (less than 50%) survive to return and spawn in subsequent years.

the Sound, most smolts (young salmonids that have undergone physiological changes to prepare them for leaving freshwater and entering seawater) leave spawning streams in May and June at ages 2, 3, and 4 to feed in saltwater and are generally thought to return to overwinter in freshwater streams in the fall. Differences in life history characteristics exist for fish spawned in watersheds with lakes and those without lakes (Armstrong and Morrow 1980); however, each spring, adult and immature fish migrate from freshwater systems to feed in saltwater. Mature fish return to their natal streams from age 7 to 9 to spawn in the fall. These migration patterns make management complex, because individual stocks are difficult to recognize and because each stream or lake system may contain mixed stocks of Dolly Varden that come from streams over a large area (Armstrong 1984). Additionally, recent analyses have shown that Dolly Varden contradict the accepted pattern of returning to lakes each fall. In tagging studies throughout south-central Alaska, including Prince William Sound, Bernard et al. (1995) found that 14 to 58% may spend the entire winter at sea.

Hepler et al. (1996) found that Dolly Varden that utilized oiled streams grew more slowly between 1989 and 1990 than Dolly Varden that used streams unaffected by the Exxon Valdez oil spill. However, these growth differences were no longer observed during the 1990-1991 winter. Hepler et al. (1996) hypothesized that the slower rate of growth in oiled streams could be the result of reduced food supplies or direct exposure to oil. Preliminary data that indicates that Dolly Varden from different locations across the sound are genetically similar suggest that the Dolly Varden population in Prince William Sound should have little difficulty in recovering from any initial growth-related effects (Exxon Valdez Oil Spill Trustee Council 2002c). Pending completion of the genetics work and absent additional growth data, the recovery status of Dolly Varden remains unknown according to the Exxon Valdez Trustee Council (2002c).

Sport fishing for both anadromous and resident freshwater cutthroat trout also occurs in Prince William Sound, especially in the vicinity of the Copper River drainage near Cordova. In this area, cutthroat trout are most abundant in Pipeline and McKinley Lakes and Alaganik

Slough and can also be found in most roadside streams and lakes. The population of cutthroat trout in Prince William Sound is maintained by spawning and recruitment of wild stocks. To protect spawning cutthroat trout, fishing for this species is not allowed from April 15 to June 14 in all waters of Prince William Sound.

Following the Exxon Valdez oil spill, cutthroat trout associated with oiled streams grew more slowly between 1989 and 1991 than those associated with unoiled streams, although these growth differences were no longer observed during the 1990-1991 winter (Hepler et al. 1996). Hepler et al. (1996) hypothesized that the slower rate of growth in oiled streams could be the result of reduced food supplies or direct exposure to oil. Additional preliminary research indicates that there is significant genetic variation among cutthroat trout from different locations in Prince William Sound and supports the hypothesis that natural factors could be responsible for the differences seen in the growth rates (Exxon Valdez Oil Spill Trustee Council 2002d). Pending completion of this research, the recovery status of the cutthroat trout remains unknown according to the Exxon Valdez Oil Spill Trustee Council (2002d).

Pacific herring also support a commercial fishery in Prince William Sound, targeting different aspects of the herring population through the year. Prior to spawning, a sac roe fishery harvests unspawned females for their eggs. After spawning, herring roe from free-ranging or impounded fish is harvested on kelp. In the fall, herring are harvested for food and bait (Morstad et al. 1999). The herring fisheries occur mainly along the eastern end of Montague Island, with the food and bait fishery also occurring near Knowles Head and Red Head north of Port Gravina (Sharp et al. 1996). The harvest has been highly variable in recent years, with all-time record harvests in 1991-1992 and complete fishery closures in 1994-1996. The stock collapsed in 1993 following an outbreak of viral hemorrhagic septicemia, and the fishery has been sporadic since (Sharp et al. 1996).

The Exxon Valdez oil spill resulted in oiling to a substantial portion of the shallow intertidal and subtidal areas that are used by spawning Pacific herring in Prince William Sound, and approximately 40-50% of the Pacific herring

eggs produced in 1989 were exposed to oil from the spill (Brown et al. 1996). Subsequent studies indicated a variety of effects attributable to the oil spill, including early hatching of eggs, low weights of hatched larvae, reduced larval growth rates, and genetic abnormalities to larvae (Brown et al. 1996). However, because of the large variability in the production of Pacific herring eggs and larvae and in the survival of larvae to become adults, the significance at a population level of such effects is unclear (Brown and Carls 1998). There appears to have been no long-term reproductive impairment of Pacific herring as a result of the Exxon Valdez oil spill, although population levels have remained low since 1992. A potential link between susceptibility to viral hemorrhagic septicemia and oil contamination remains uncertain. At the present time, the Exxon Valdez Oil Spill Trustee Council (2002e) has designated the Pacific herring as not recovered from the effects of the oil spill.

Rockfish are another group of fishes considered important to sport and commercial fisheries in Prince William Sound (Bechtol 1995; Howe et al. 1998). The rockfish group is actually composed of several species, all of which are long-lived and slow to mature. Many individual rockfish spend their entire lives in one area. This trait causes them to be especially vulnerable to over-harvest, and management strategies are frequently altered to avoid stock depletion (Bechtol 1995). The annual sport harvest of rockfish averaged over 13,000 fish between 1988 and 1997 (Howe et al. 1998), while the commercial harvest averaged about 215,000 pounds from 1988 to 1994 (Bechtol 1995) (average weight not available to convert pounds to number of fish).

Invertebrate organisms are extremely important to the ecosystem of Prince William Sound, serving as predators and prey for a variety of other organisms, including fish, birds, and mammals. Invertebrate communities within Prince William Sound can be subdivided into three basic groups, depending on where they are located relative to the shore and tidal influences: (1) intertidal zone, (2) subtidal zone, and (3) deep-water zone. The intertidal invertebrate community includes those invertebrates that live between low tide and high tide lines. Examples of such organisms include

barnacles, oligochaete worms, and mussels. Mussels are an especially important prey species in the nearshore ecosystem, and beds of mussels provide physical stability and habitat for other organisms in the intertidal zone. The subtidal zone in Prince William Sound extends from the lower elevation of the intertidal zone to about 20 m in depth. This zone sometimes includes dense stands of kelp or eelgrass and contains polychaete worms, snails, clams, abalone, and sea urchins. Important invertebrate species in the deeper-water zone include king, tanner, and Dungeness crabs and scallops.

Many invertebrate communities were also affected by the Exxon Valdez oil spill. In some areas, the intertidal zone was heavily oiled, leading to effects on invertebrates both from the oil and from oil cleaning operations. Differences were documented between invertebrate communities at oiled and unoiled intertidal zone sites during 1990 and 1991 (Hooten and Highsmith 1996). Following 1991, algal coverages and invertebrate abundances on rocky shorelines had returned to levels similar to those at reference sites (Exxon Valdez Oil Spill Trustee Council 2002f). However, some invertebrate communities, such as those on softer intertidal sediments, had apparently not yet recovered as of 1997 (Exxon Valdez Oil Spill Trustee Council 2002f).

The subtidal zone was also affected by the Exxon Valdez oil spill, with documented acute effects on kelp beds and some species of starfish (Peterson 2001). As of 1996, some suspected indirect effects of the Exxon oil spill on some species of sea urchins were still observed (Peterson 2001). Because it is unclear whether remaining differences in subtidal communities at oiled and referenced sites is due to the influence of natural factors, oil effects, or to a combination of these factors, the recovery status of subtidal communities is considered to be unknown by the Exxon Valdez Oil Spill Trustee Council (2002g).

No substantial effects of the Exxon Valdez oil spill were detected on the invertebrates in the deep-water zone (Peterson 2001). However, there was no evaluation of impacts on larval stages of these invertebrates, many of which are found in surface waters (Peterson 2001).

3.19.2 Reptiles and Amphibians

No reptiles occur in any of the areas related to the TAPS. Only two species of amphibians occur in the project area – the wood frog (*Rana sylvatica*) and the western toad (*Bufo boreas*). These two species are not discussed in detail in this section. The wood frog occurs in much of

Alaska south of the Brooks Range and is widespread along the TAPS ROW in habitats ranging from grassland, forest, muskeg, and tundra (Broderson 1994). The western toad occurs only in southeast Alaska; the northern limit of their range is the Prince William Sound area where they can be found in open nonforested areas near fresh water (Broderson 1994).

3.20 Birds

Up to 481 species of birds have been reported from Alaska. Because the pipeline and related facilities occur in such diverse and widespread areas, many of these species could occur in the vicinity of TAPS facilities. Of the birds reported in Alaska, 226 are known to breed within the state (Armstrong 2000; Gibson 1999; Gibson and Andes 2001). Many of the birds that occur in Alaska are migratory. Some of the migratory species that breed on the North Slope may overwinter in Prince William Sound and migrate through the TAPS ROW and adjacent areas (e.g., red-throated loon, yellow-billed loon, long-tailed duck, surfbird, and snow bunting) (TAPS Owners 2001a).

In the following subsections, descriptions of birds are presented separately for the TAPS ROW, Beaufort Sea, and Prince William Sound areas (Map 3.1-2). In reality, however, for many species, distinction among these areas (e.g., the northern portion of the TAPS ROW vs. Beaufort Sea and the southern portion of the TAPS ROW vs. Prince William Sound) is meaningless. The following discussions describe important groups of birds (e.g., waterfowl and raptors), as well as representative species within each group. The bird species addressed in more detail below are those that have one or more of the following characteristics: (1) have important habitats at or near TAPS, North Slope, or Prince William Sound; (2) are important for human use; and (3) use habitats common to other species (APSC 1993). Threatened, endangered, and protected bird species are addressed in Section 3.22.

Landbirds

Landbirds include bird species other than waterfowl, shorebirds, and seabirds that primarily inhabit terrestrial landscapes. These include the raptors, grouse and ptarmigan (see BPFWG 1999) and passerines (perching birds).

3.20.1 TAPS ROW

About 260 species of landbirds occur in Interior Alaska; 135 of these breed in the state. The most important habitats for the breeding species are coniferous and mixed forests at lower elevations, riparian areas, and deciduous shrublands and forests. Factors that can impact landbirds include timber harvest, insect outbreaks, fire management, development of transportation and utility corridors, oil and gas development, and mining (BPFWG 1999). Bird checklists (including species status and habitat preferences) for interior areas near the TAPS ROW can be found in Schauer (undated) for Dalton Highway; Sowl (1998) for Yukon Flats National Wildlife Refuge; Kessel (1986) for Interior Alaska near Fairbanks; BLM (1989b) for Copper River Basin and surrounding areas; U.S. Fish and Wildlife Service (USFWS undated-a) for Kanuti National Wildlife Refuge; and Isleib (1984) for Chugach National Forest.

3.20.1.1 Waterfowl, Seabirds, and Shorebirds

Four species of loons (yellow-billed, Pacific, common, and red-throated) breed near the ROW. Statewide population estimates for these species range from about 2,600 for the yellow-billed loon to about 70,000 for the Pacific loon (Groves et al. 1996). A few yellow-billed loons nest in the vicinity of the ROW (Sage 1971, 1974; McIntyre 1990; McIntyre et al. 1991). Common loons are uncommon breeders along the ROW. They nest primarily south of the Brooks Range on boreal lakes with generally one pair per lake (Gabrielson and Lincoln 1959; Groves et al. 1996). Pacific loons are common breeders in lakes at the northern end of the ROW and south of the Brooks Range (Gabrielson and Lincoln 1959; Johnson and Herter 1989). Red-throated loons are common breeders at the northern end of the ROW on the coastal plain and also can be found along the ROW between the Brooks Range and Chugach Mountains (Gabrielson and Lincoln 1959; Johnson and Herter 1989).

Both horned and red-necked grebes occur in the ROW area. Both species nest in Interior Alaska and are permanent residents in Prince William Sound. The red-necked grebe also nests in the North Slope (TAPS Owners 2001a). The horned grebe nests in freshwater ponds, sloughs, and lakes, while the red-necked grebe nests in freshwater lakes, marshes, and slow-moving rivers. Both species overwinter in inshore marine waters (Armstrong 2000).

Both tundra and trumpeter swans occur in the ROW area. Tundra swans usually nest near large ponds or lakes with emergent plant beds; trumpeter swans nest in undisturbed marshes adjacent to small lakes. About 10,000 tundra swans occur along the northern portion of the ROW and along the Arctic Coastal Plain (Rosenberg and Rothe 1994). Trumpeter swans breed along the ROW from south of the Brooks Range to the Valdez Marine Terminal (Gabrielson and Lincoln 1959). Several areas between MP 645 and MP 716 have been identified as nesting and brood-rearing concentration areas for trumpeter swans (APSC 1993). This region encompasses the drainages of the Gulkana, Copper, and Klutina Rivers. The 1995 statewide population of trumpeter swans was estimated at about 16,000. Approximately 59% of those were in the Gulkana and Lower Tanana land units, which encompass much of the southern ROW (Groves and Conant 1998).

Canada and greater white-fronted geese are common breeders around PS 1 and the northern end of the ROW, where they nest in isolated pairs on the tundra or on small islands in lakes and ponds (TAPS Owners 2001a). During spring migration, Canada, greater white-fronted, and snow geese aggregate in areas of early snowmelt that occur in the "dust shadows" along the Dalton Highway as far south as Atigun Pass. Brant (another type of goose) migrate to the oil fields from the west. During the spring migration, they stage along the Dalton Highway near PS 3 with greater white-fronted geese and snow geese (Montgomery 2002b). Areas of concentrated Canada goose and greater white-fronted goose nesting have been identified along the ROW between MP 0 and 78 (APSC 1993). The Canada goose is a common breeder south of the Brooks Range, in the Yukon and Tanana flats, and into the Copper River area (Gabrielson

and Lincoln 1959). Although the greater white-fronted goose is an uncommon breeder south of the Brooks Range, some do nest on the Yukon Flats and Minto Flats (Gabrielson and Lincoln 1959). As many as 325,000 snow geese congregate in the Arctic National Wildlife Refuge (ANWR) during September (Rothe 1994). (See Section 3.20.2 for a discussion of snow geese that breed in the Beaufort Sea area.)

Ducks that occur along the ROW can be divided into arctic-nesting, boreal-nesting, and Pacific coastal species. The arctic-nesting species include long-tailed duck (formerly known as oldsquaw); northern pintail; and common, king, spectacled, and Steller's eiders. Spectacled and Steller's eiders are both federally listed as threatened species (see Section 3.22). Boreal-nesting species include common dabbling ducks, such as mallard, northern pintail, and green-winged teal, and diving ducks, such as white-winged scoter, lesser scaup, bufflehead, goldeneye, and canvasback. An important Pacific coastal species is the harlequin duck (TAPS Owners 2001a).

Almost any stream, river, pond, or lake that occurs along the ROW can provide habitat for waterfowl. Diving ducks generally nest on larger and deeper inland water bodies, major rivers, and along the coast. Broad meandering and braided floodplains (e.g., Tanana River) with numerous nearby lakes and streams provide important waterfowl nesting habitat (APSC 1993). Table 3.20-1 lists important waterfowl nesting and migration areas that occur near the ROW.

The sandhill crane is a rare breeder at the northern end of the ROW but is a more common breeder between the Brooks Range and Chugach Mountains (Gabrielson and Lincoln 1959; Johnson and Herter 1989). It nests in wet tundra, marshes, and muskegs. The ROW intersects the major migration route of sandhill cranes along the Tanana River at Delta Junction (MP 543–559) (APSC 1993). As many as 200,000 to 300,000 cranes pass through this area during the spring and fall migrations (TAPS Owners 2001a). The sandhill crane is Alaska's largest game bird, although harvests are conservative because of the bird's low reproductive rate (Paul et al. 1994).

TABLE 3.20-1 Important Waterfowl Concentration Use Areas near the TAPS ROW^a

Milepost	Major Water Bodies	Use
135-150	Galbraith Lake	Migration
246-258	Wilson Creek/Chapman Creek/South Fork Koyukuk River	Nesting
261-276	Grayling Lake/Jim River	Nesting
302-309	Olson's Lake/Kanuti River	Nesting
336-351	Ray River/Yukon River	Nesting
369-371	Hess Creek	Nesting
377-379	Hess Creek/Fish Creek	Nesting
384-389	Erickson Creek	Nesting
392-393	Lost Creek	Nesting
397-401	Tolovana River	Nesting
412-413	Tatalina River	Nesting
437-439	Chatanika River	Nesting
458-460	Chena River	Nesting
462-520	Tanana River	Migration
520-526	Tanana River/Shaw Creek	Nesting, migration
525-535	Delta River	Migration
606-630	Summit Lake/Gulkana River/Paxson Lake	Nesting, migration
795-799	Lowe River, assorted creeks, Valdez Glacier drainages, Dayville Flats, Valdez Duck Flats	Nesting, migration

^a Areas listed are those with portions within 2 mi of the TAPS ROW.

Source: APSC (1993).

Alaska contains more than 95% of the breeding seabirds in the continental United States. About 100 million seabirds reside in the marine waters of Alaska during a portion of the year, with about 1,300 seabird colonies identified in the state (Hatch and Piatt 2001). However, seabirds are not common along the ROW except during migration. Nevertheless, several species of seabirds do regularly occur in the vicinity of the ROW, including jaegers, mew and glaucous-winged gulls, kittiwakes, terns, guillemots, and murrelets (Gabrielson and Lincoln 1959; Isleib and Kessel 1973; Johnson and Herter 1989). Seabirds are discussed in more detail in Sections 3.20.2 and 3.20.3.

The nesting abundance of shorebirds on the southern coastal plain of the North Slope is highest in the area from the coast to approximately 15.5 mi south of PS 1. From

there, shorebird abundance decreases rapidly toward the foothills of the Brooks Range. The most numerous breeding shorebirds in the foothills region are American golden-plover, pectoral sandpiper, and buff-breasted sandpiper (Hanson and Eberhardt 1981).

The shorebird community south of the Brooks Range differs markedly from that to the north. Shorebirds that dominate the tundra include several sandpiper species. Those that occur in the boreal forest zone include the semipalmated plover, lesser yellowlegs, and spotted sandpiper. These birds occur in and around small lakes, fens, or along rivers. Some arctic species, such as American golden-plover and whimbrel, occur in alpine tundra. The most widespread shorebirds along the entire ROW south of the Brooks Range are the lesser

yellowlegs and common snipe (TAPS Owners 2001a).

3.20.1.2 Raptors

A number of raptors (e.g., hawks, falcons, eagles, and owls) regularly occur along the ROW. The peregrine falcon (both the American and arctic subspecies), rough-legged hawk, gyrfalcon, and golden eagle are cliff-nesting species and may all nest in the same general areas (APSC 1993). The bald eagle and the northern goshawk have been identified as species sensitive to disturbance during ROW developments (TAPS Owners 2001a).

The arctic and American peregrine falcons are discussed in Sections 3.22.1.4 and 3.22.1.5, respectively. However, it should be mentioned that peregrine falcon use areas are identified as zones of restricted activity (ZRAs) to protect them and other raptors that often use these areas. The peregrine falcon ZRAs that occur close to the ROW include Franklin Bluffs (MP 15-36), Sagwon Bluffs (MP 57-61 and 59-68), Slope Mountain (MP 113-116), Yukon River (MP 350-355), and Grapefruit Rocks (MP 417-418) (APSC 1993).

The rough-legged hawk is among the most common hawk species, particularly in northern and western Alaska (Ritchie 2002). It nests along drainages in the northern foothills of the Brooks Range and regularly occurs along the TAPS from Franklin Bluffs to Galbraith Lake. Gyrfalcons occur in mountainous areas along the ROW, from north of the Brooks Range along the Sagavanirktok River to the Chugach Mountains. They nest on rock formations, hillside outcrops, river bluffs, and isolated rock outcroppings in open expanses of flat and gently rolling terrain (APSC 1993). Gyrfalcons have also been found to nest on a number of man-made structures, including on top of the pipeline's vertical support members (Ritchie 1991).

The bald eagle is more abundant in Alaska than elsewhere in the United States. The Alaska population is about 30,000 adults. Bald eagles occur along the Alaska coast, on offshore islands, and along interior rivers and lakes. They can be found along the ROW south of the Atigun

Pass (APSC 1993). Bald eagle nest sites occur near the ROW on the Yukon, Tanana, Gulkana, Copper, and Lowe Rivers and their tributaries (Ritchie and Ambrose 1996). More than 8,000 bald eagles nest and winter in the Gulf of Alaska and the Prince William Sound area (Bernatowicz et al. 1996). A few winter in interior Alaska near the confluence of the Tanana and Delta Rivers (Ritchie and Ambrose 1987). Resource use (e.g., logging, mining, and oil production and transportation) and human encroachment into remote areas are among the major threats to bald eagles in Alaska (Daum 1994).

Golden eagles occupy mountainous habitats similar to those of gyrfalcons, but they also regularly nest in other habitats, including cliffs along the Yukon and Tanana Rivers. They can be found along the TAPS ROW from as far north as MP 38 to the coastal mountains near Valdez (TAPS Owners 2001a; Montgomery 2002b). Loss of undisturbed habitat and increasing human disturbance are the major threats to golden eagles in Alaska (Daum 1994).

The northern goshawk and sharp-shinned hawk nest along the ROW. The northern goshawk nests in birch and aspen trees; the sharp-shinned hawk uses middle-aged spruce trees (Clarke 1994). Nesting activities and productivity of the northern goshawk are variable, reflecting the cyclic abundance of major prey (McGowan 1975). Ospreys rarely occur along ROW but are known to nest in the Tanana and Susitna valleys in Interior Alaska (Schempf 1989), and they may also nest in the Copper River Basin (Cooper et al. 1991). Other raptor species, such as northern harrier and American kestrel, occur along the ROW and are relatively common where nesting habitat is available.

Snowy owls are common on the Arctic Coastal Plain (Pitelka 1974; Johnson and Herter 1989). When their primary food (lemmings) is abundant, they can be found nesting near the ROW. Short-eared owls nest on the ground in tundra habitats along the ROW. Other owls in Alaska, such as the great horned owl, northern hawk owl, and the boreal owl, are primarily woodland species and commonly occur along the ROW in forest habitats south of the Brooks Range (Armstrong 2000; TAPS Owners 2001a).

3.20.1.3 Grouse and Ptarmigan

Forest-dwelling grouse (ruffed and spruce) occur along the TAPS ROW between the Brooks Range and the Chugach Mountains, and sharp-tailed grouse occur in more open, grassy habitats between Fairbanks and Glennallen (Gabrielson and Lincoln 1959). They occur in the valleys of the Yukon, Upper Koyukuk, Upper Kuskokwim, Tanana, and Upper Copper Rivers. Fires maintain the brushy grasslands preferred by the sharp-tailed grouse (Ellison 1994). A sharp-tailed grouse display area occurs near MP 653 to 685 along the TAPS (APSC 1993).

Three species of ptarmigan (rock, willow, and white-tailed) are residents along the ROW. The first two species are common from the Arctic Coastal Plain to the Chugach Mountains, whereas white-tailed ptarmigan are restricted primarily to the higher elevations in the Alaska Range and the Thompson Pass area of the Chugach Mountains (Gabrielson and Lincoln 1959; Kessel and Gibson 1978; Anderson 2002). Rock and willow ptarmigan commonly use open tundra in the dust shadows of the Dalton Highway during spring migration (TAPS Owners 2001a).

3.20.1.4 Passerines

More than 170 species of passerines (also known as perching birds or songbirds) have been recorded in Alaska (Gibson 1999). At least 70 species occur regularly along the TAPS ROW. Migrant passerines arrive in habitats along the ROW during late March through June (Ritchie 2002) and begin breeding soon after arrival. Most young fledge by August and begin their southward migration soon thereafter (TAPS Owners 2001a). Only a few species (e.g., common raven, redpolls, American dipper) are year-round residents at the northern end of the ROW. The common raven is closely associated with areas of human habitation (Johnson and Herter 1989).

The number of breeding passerine species is greater in the foothills of the Brooks Range than in the coastal plain of the North Slope because more shrub habitats are available (Johnson and Herter 1989). The most numerous passerines in the foothills of the Brooks Range

are savannah sparrow, yellow wagtail, American tree sparrow, Lapland longspur, and white-crowned sparrow (Gabrielson and Lincoln 1959).

In general, the number of resident and migrant breeding bird species increases in the more southern sections of the ROW, with upwards of 20 species breeding in some of the interior forest habitats (Spindler 1976; Benson 1999; Anderson et al. 2000). White-crowned sparrows and dark-eyed juncos are ubiquitous, occurring commonly in all regions south of the Brooks Range. Alder flycatcher, Swainson's thrush, and American robin are similarly widespread but are less numerous in the upper elevations of the Alaska Range (TAPS Owners 2001a). Other characteristic passerines by region are as follows: (1) interior forests – orange-crowned, yellow-rumped, and Wilson's warblers; (2) Alaska Range – American tree sparrow, cliff swallow, Wilson's and arctic warblers; (3) Copper Plateau – cliff swallow, yellow-rumped and Wilson's warblers; and (4) Pacific Coastal Mountains – orange-crowned, yellow-rumped, and Wilson's warblers and hermit thrush (TAPS Owners 2001a).

Changes in forest cover and conditions caused by timber harvest (e.g., for the logging industry or urban growth) and insect infestations likely have a negative effect on the distribution of a number of passerines and other landbird populations, particularly within south-central and southern coastal portions of Alaska. These changes have been beneficial to some species such as woodpeckers. However, no landbird species or their habitats are threatened with extirpation in Alaska (BPFWG 1999). Factors responsible for the status of the rare and endangered bird species are discussed in Section 3.22.

3.20.2 Beaufort Sea

About 240 species of birds occur throughout the North Slope, with about 180 of them breeding in the area (Johnson and Herter 1989). The total number of birds approaches 10 million. The only known regular winter residents are the common raven, snowy owl, glaucous gull, willow ptarmigan, and gyrfalcon (Johnson and Herter 1989). The barrier islands, reefs, spits, beaches, and shallow lagoons along the Beaufort Sea

provide shelter to thousands of molting birds (e.g., long-tailed duck, eiders, scaup, and brant) and nesting sites for gulls, eiders, terns, shorebirds, and passerines (see BLM 1972). Within the North Slope area, waterfowl nesting may occur on any pond or lake and, especially, within the Sagavanirktok River floodplain (APSC 1993).

Waterfowl, seabirds, and shorebirds are the most common breeding birds along the Beaufort Sea. The most abundant marine and coastal species are the red phalarope, long-tailed duck, glaucous gull, and common eider (ADNR 1999). Passerines and other birds are scarce (BPFWG 1999). For the most part, the birds found along the northern portion of the TAPS (as described in Section 3.20.1) are the same as those of the Beaufort Sea area. This section provides a brief overview of some of those species.

The yellow-billed loon is an uncommon breeder on the Arctic Coastal Plain, where it primarily breeds on the Colville River Delta and in the National Petroleum Reserve-Alaska west of the TAPS (Sjolander and Agren 1976; Johnson and Herter 1989). Tundra swans are common breeders across the Arctic Coastal Plain of Alaska and at the northern end of the ROW (Johnson and Herter 1989). Tundra swans nest in relatively low densities across the entire coastal plain but occur in highest densities on the major river deltas (Colville, Sagavanirktok, and Canning Rivers) (Johnson et al. 1998; Anderson et al. 1999). They are most sensitive to disturbance during nesting (May to early July) and during brood-rearing (July-September) (Bergman et al. 1977; Derksen et al. 1981). Potentially adverse influences on the productivity of swans in the oil-field region include the weather, predation, and oil-field activities (Ritchie and King 2000).

Four species of eiders nest on the coast of the Beaufort Sea. The spectacled and Steller's eiders are both listed as threatened and are addressed in Section 3.22. Common eiders nest in colonies along the coast, on barrier islands, sand spits, and tundra ponds near driftwood or clumps of grass. Harsh winters and lack of open water occasionally cause deaths of spring migrants. However, predation by foxes, ravens, and gulls on eggs and young is the major factor

regulating the abundance of common eiders in the oil-field production area (Johnson 2000b). King eiders are solitary breeders on islands and peninsulas in tundra lakes and ponds. More than one million eiders (mostly common and king) have been recorded passing Point Barrow in the late summer on their way to molting areas (Rothe and Arthur 2000).

Canada geese, greater white-fronted geese, snow geese, and brant nest on the Arctic Coastal Plain and in the northern section of the ROW (Johnson and Herter 1989, see Section 3.20.1). Brant and snow geese nest in colonies of a few to several hundred pairs at traditional coastal sites in the Prudhoe Bay area (Johnson 1991, 2000a; Murphy and Anderson 1993; Stickney et al. 1994; Sedinger and Stickney 2000). Canada geese are unevenly distributed across the Arctic Coastal Plain and reach their highest densities in the Prudhoe Bay area (Johnson and Herter 1989). They prefer to nest on small islands in ponds and lakes that provide safety from predators (Murphy and Anderson 1993). Greater white-fronted geese are the most common breeding geese on the Arctic Coastal Plain, declining in abundance to the east of Prudhoe Bay (Johnson and Herter 1989). This species nests on the tundra, often away from ponds or lakes. Brant are strongly associated with coastal habitats during nesting and brood-rearing. Brant colonies of 25 to 100 or more pairs are located near the coast in Prudhoe Bay and on Howe Island (Stickney et al. 1994). Snow geese nest primarily in a large colony of 300 to 500 pairs on Howe Island in the outer Sagavanirktok River delta. However, several small snow goose colonies have become established from the Colville River Delta to the Kukpowruk River Delta (west of the National Petroleum Reserve-Alaska) (Johnson 2000a; Ritchie et al. 2000), and a few nest in isolated pairs on the tundra (Johnson 1991, 2000a). During spring migration, snow geese regularly stage in the dust shadow of the Dalton Highway (TAPS Owners 2001a).

The long-tailed duck is the most common waterfowl species that nests in the Beaufort Sea area. They frequently nest in clusters or colonies, utilizing barrier island shorelines, lagoons, and nearshore areas during molting (ADNR 1999).

Glaucous gulls nest in colonies on barrier islands and drained lake basins on the tundra, as well as in isolated pairs on tundra ponds (Johnson and Herter 1989). They are scavengers and predators on waterfowl and other seabirds and also consume fish. Domestic and industrial developments along the North Slope have resulted in increases in juvenile gull survival (Patten 1994). However, current solid waste management practices now minimize the potential of this increase in gulls from becoming a problem along the TAPS and in the oil fields.

The Arctic Coastal Plain is an important breeding area for many species of shorebirds. At least 18 species breed in the Arctic Coastal Plain between the Colville and Canning Rivers, and approximately 20 other species occur as migrants or vagrants (Troy 2000). The most common shorebird species that nest in the area are the dunlin, pectoral sandpiper, semipalmated sandpiper, red phalarope, and red-necked phalarope (Hanson and Eberhardt 1981; BLM 1998a). Nest success strongly regulates shorebird population recruitment. A primary determinant of nest success is predation, especially by arctic fox. Other predators include arctic ground squirrel, lemmings, red fox, brown bear, short-tailed weasel, wolverines, jaegers, glaucous gulls, and common raven (Troy 2000). Shortly after spring migration, shorebirds and waterfowl disperse to nesting grounds on moist tundra and marshlands (ADNR 1999). Coastal tundra lakes, ponds, and river deltas are important areas for waterfowl and shorebird molting and for staging before and during fall migration (MMS 1996).

More than 30 species of passerines have been recorded on the coastal plain, and at least 8 species breed there (Johnson and Herter 1989). The most abundant breeding passerine on the coastal plain is the Lapland longspur (Johnson and Herter 1989; TERA 1993). Other common breeding species on the coastal plain are common and hoary redpolls, snow bunting, and savannah sparrow (Johnson and Herter 1989; Johnson et al. 2000). Snow buntings will nest in oil field structures and equipment in order to get their nests off the ground and away from predators (Montgomery 2002b). Ravens occasionally nest near the coast, primarily on buildings and other structures, including those in

the Prudhoe Bay and Kuparuk oil fields (Johnson and Herter 1989; Ritchie 1991; Day 1998).

River corridors contain most of the tall shrub stands in the North Slope (BLM 1998a). While these locations make up only a small percentage of the area, they contain the highest diversity of landbirds in northern Alaska (BPFWG 1999). The present distribution of most tundra birds is believed to reflect their various adaptations to arctic fox predation (see Burgess 2000).

3.20.3 Prince William Sound

Bird checklists for the Gulf of Alaska/Prince William Sound area can be found in Andrew et al. (1997) for Seward, Alaska; NPS (1997) for Kenai Fjords National Park; and USFWS (undated-b) for the Alaska Maritime Refuge. At least 278 species of birds have been reported from the Prince William Sound and the Gulf of Alaska (Gabrielson and Lincoln 1959; Isleib and Kessel 1973; DeGange and Sanger 1987). The Copper River Delta is an important migratory staging area for shorebirds and other species of waterfowl; more than 16 million migrate through the area each year (National Wildlife Federation 2002). Prince William Sound is an important overwintering area for seaducks, especially scoters, cormorants, harlequin ducks, Barrow's goldeneye, and mergansers. More than 20 species of raptors have also been recorded in Prince William Sound and the Gulf of Alaska (Gabrielson and Lincoln 1959; Isleib and Kessel 1973). The bald eagle is one of the most abundant raptors of this region.

At least 45 species of shorebirds and 45 species of seabirds occur in the Prince William Sound and Gulf of Alaska region (Armstrong 2000). A number of these species do not breed in the area, indicating the importance of the region for both migration and nesting (TAPS Owners 2001a; Anderson 2002). However, 28 species of seabirds do breed in the region (Isleib and Kessel 1973; Gould et al. 1982; DeGange and Sanger 1987). A significant portion of the world's population of both marbled and Kittlitz's murrelets occur in Prince William Sound (Agler et al. 1998). The region is especially important to nesting gulls and alcids (i.e., murres, guillemots, murrelets, and puffins),

particularly in Prince William Sound and on the Kenai Peninsula. The Barren Islands, located at the mouth of Cook Inlet, have the largest seabird colonies in the northern portion of the Gulf of Alaska (Boersma and Parrish 1996). The total population of seabirds in the Prince William Sound and Gulf of Alaska region may approach 2 million birds during summer, when the breeding number is added to the large number of nonbreeding albatrosses and sooty and short-tailed shearwaters summering from colonies

farther south and the nonbreeding northern fulmars, storm-petrels, gulls, and alcids from Alaska (Isleib and Kessel 1973).

Suitable nest sites and prey availability are the most important controlling factors governing seabird distribution and abundance (Hatch and Piatt 2001; Suryan and Irons 2001). Predators also have a controlling influence on the abundance of seabirds (Hatch and Piatt 2001).

3.21 Terrestrial Mammals

A total of 107 mammal species occur in Alaska; this section describes those terrestrial mammals that occur along the TAPS ROW and in the Beaufort Sea area. Terrestrial mammals that frequent the Prince William Sound area including river otter (*Lutra canadensis*), brown bear (*Ursus arctos*), black bear (*Ursus americanus*), red fox (*Vulpes vulpes*), Arctic fox (*Alopex lagopus*), gray wolf (*Canis lupus*), coyote (*Canis latrans*), mink (*Mustela vison*), wolverine (*Gulo gulo*), moose (*Alces alces*), mountain goat (*Oreamnos americanus*), and the Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) also occur within the southern portion of the TAPS ROW; therefore, a separate section on the Prince William Sound is not provided. The marine mammals that receive protection under either the Endangered Species Act or the Marine Mammal Protection Act and that occur in the Beaufort Sea or Prince William Sound are discussed in Section 3.22.

Alaska has been divided into Game Management Units (GMUs) for management of wildlife species. The TAPS ROW passes through portions of five GMUs — GMU 26 (North Slope), GMU 24 (Koyukuk River), GMU 20 (Tanana Valley), GMU 13 (Nelchina Basin), and GMU 6 (Prince William Sound). Two other game management units are near the ROW — GMU 25 (Upper Yukon) and GMU 11 (Wrangell Mountains) (Map 3.21-1).

3.21.1 TAPS Row

In the following discussion addressing mammal species that occur along the ROW, emphasis is placed on species that (1) have key habitats near the ROW, (2) can be affected by operation and maintenance of the TAPS, (3) are important to humans (e.g., sport and subsistence harvest), and/or (4) are representative of other species that share important habitats. Threatened, endangered, and protected mammal species are discussed in Section 3.22.

3.21.1.1 Moose

Moose have broad habitat requirements that include breeding (rutting) grounds, winter

feeding areas, calving grounds, and summer feeding areas (APSC 1993). Most moose make seasonal migrations between these areas; such migrations can range up to 60 mi. Moose are most common in open country (e.g., recently burned areas) that contains willow and birch shrubs, on timberline plateaus, and along major rivers of south-central and Interior Alaska (Rausch et al. 1994). Winter range includes climax willow stands in river valleys and shrub habitats. The peak calving period is mid-May to

Key Habitats

Key habitats are areas considered to be important for maintaining healthy terrestrial mammal populations. Examples of such areas are: concentration areas (general), calving concentration areas, caribou insect relief areas, Dall sheep lambing areas, mineral lick areas, migration corridors or movement zones, and winter use concentration areas (APSC 1993).

early June. Calving habitat includes open meadows interspersed with stands of black spruce, alder, willow, and sedges, or shallow lakes and ponds with emergent and aquatic vegetation. Calves are weaned by the fall breeding period (late September to early October) (APSC 1993). Important moose habitat areas near the TAPS ROW are listed in Table 3.21-1.

In fall and winter, moose consume willow, birch, and aspen twigs. Spring foods include sedges, horsetail, pond weeds, and grass. Summer foods include aquatic vegetation, forbs, and leaves of willows, birch, and aspen (Rausch et al. 1994).

Moose are widely distributed along the ROW from the Sagavanirktok River valley near PS 2 to the Valdez Marine Terminal. Winter concentration areas occur along much of the ROW, and calving concentration areas also occur on or near the ROW. Moose sometimes use the workpad or access roads as seasonal or daily travel corridors (APSC 1993). The elevated portion of the TAPS intercepts snow or forms a

TABLE 3.21-1 Important Moose Habitat Areas near the TAPS ROW^a

Habitat Area	TAPS Mileposts
Winter concentration areas	57-113, 271-279, 285, 295, 302-309, 349-394, 411-434, 436-471, 490-498, 518-526, 493-503, 535-574, 627-660, 691-714, 719-750
Calving areas	411-423, 436-439, 462-471, 490-503, 525-527, 719-728
Rutting areas	411-423, 436-439, 494-498, 627-646, 724-728

^a Areas listed are those that include portions within 2 mi or less from the TAPS ROW.

Source: APSC (1993).

windbreak, resulting in less snow and more exposed vegetation directly under the pipeline in some areas. This condition can attract moose in winter. Moose also frequent buried portions of the TAPS in the spring because snow melts earlier there (TAPS Owners 2001a).

Population increases of moose occur in response to mild winters, low predator numbers, relatively low harvest by humans, and events or activities (e.g., wildfires and tree harvesting) that favor the growth of browse (Ballard et al. 1987, 1991; Tobey 1996a). Moose declines occur as a result of severe winters, predation, fire suppression, and overharvest (TAPS Owners 2001a). Collisions with vehicles are an additional source of mortality. However, roadkills have not been identified as a significant factor on moose population size along the TAPS (TAPS Owners 2001a).

More people hunt moose than any other game species in Alaska (Rausch et al. 1994). The most important moose hunting areas are those with easy road access and proximity to human population centers. These include GMU 13 in south-central Alaska and GMU 20B. The latter includes the Fairbanks area and has extensive road systems (Ballard et al. 1991; Dale 1996; Tobey 1996a). Moose hunting in GMUs 24 and 26B (northern Alaska) is influenced by the presence of the Dalton Highway. The Dalton Highway Corridor Management Area (DHCMA) extends about 5 mi on each side of the Dalton Highway from the Yukon River north to the Prudhoe Bay Closed

Area. The DHCMA is closed to sport hunting with firearms, but game may be taken with bow and arrow. Residents of the DHCMA and six nearby villages are permitted to use firearms in the management area. No motorized vehicles, except aircraft, boats, and licensed highway vehicles, may be used to transport game or hunters within the DHCMA. All hunters traveling on the Dalton Highway must stop at check stations operated by ADF&G within the DHCMA (ADF&G 2002). Table 3.21-2 presents harvest summaries for moose (and other species except caribou). Additional information on subsistence is presented in Section 3.24.

3.21.1.2 Caribou

More than 857,000 caribou (*Rangifer tarandus*) are distributed among 32 separate herds in Alaska. A caribou herd is a group of caribou that establishes a calving area distinct from any other group and calves there repeatedly (Skoog 1968). Caribou undertake seven distinct phases of activities over the year: spring migration, calving, post-calving aggregation, dispersal, fall migration/prerut, rutting, and wintering (Jakimchuk et al. 1987). Generally, caribou migrate in a north-south direction, but in some areas (e.g., north slope of the Brooks Range, the Ray Hills, and upper Copper River basin) seasonal movements occur in an east-west direction that force the caribou to cross the pipeline and related facilities (APSC 1993). Calving is highly synchronized as an adaptation to predation (Bergerud and Page

TABLE 3.21-2 Harvest Summaries for Alaska Wildlife (except caribou) within the Game Management Units (GMUs) That Are Crossed by or Occur near the TAPS ROW^a

Species	GMU						State Total
	6	13	20	24	25	26	
American bison	0	0	74	0	0	0	104
Black bear	367	99	347	8	3	0	2,558
Brown bear	50	146	64	22	11	39	1,312
Sitka black-tailed deer	1,780	0	0	0	0	0	14,816
Moose	89	563	1,835	220	182	0	7,050
Mountain goat	72	4	0	0	0	0	453
Musk ox	0	0	0	0	0	9	137
Dall sheep	0	105	77	24	42	84	781
Gray wolf	13	269	309	75	48	48	1,574

^a Data do not include unreported harvest, which may equal or exceed the reported harvest for some species. Data are for harvest year 2000-2001. The reported harvest includes firearm and archery harvests, resident and nonresident harvests, and subsistence harvest (Schwartz 2002).

Source: ADF&G (undated-b).

1987). Caribou feed on sedges, grasses, fungi, lichens, mosses, and leaves and twigs of woody plants (such as willows and birches) (USFWS 1998a). Most caribou must migrate to find adequate food resources. Some of the larger herds may migrate up to 400 mi between summer and winter ranges, while the smaller herds may not migrate at all. Caribou prefer treeless tundra and mountains, although several herds winter in the boreal forest. Calving usually occurs in mountains or open, coastal tundra (Valkenburg 1999). During spring and fall migrations, caribou tend to move along or near major river drainages (ADNR 1999).

Caribou inhabit the arctic tundra, mountain tundra, and northern forests (Valkenburg 1999). The Nelchina, Delta, Central Arctic, and Western Arctic caribou herds regularly occur in the vicinity of the ROW, either during the summer or winter, or during migrations to seasonal ranges elsewhere. Several other herds also occur in the vicinity of the ROW and the Dalton Highway (i.e., the Ray Mountains and White Mountains herds) and may encounter the ROW. Table 3.21-3 presents population estimates for these caribou

herds. The traditional ranges of the Teshepuk Lake and Porcupine herds on the North Slope do not include the TAPS ROW, but they are near North Slope oil fields. Map 3.21-2 shows the distribution of caribou herds in the vicinity of the TAPS ROW. Herds are not totally independent and are not reproductively isolated. They have some overlap in summer, fall, or winter ranges, where some exchange of animals between herds occurs (Skoog 1968; Cameron and Whitten 1979; Bergerud et al. 1984; Cronin et al. 1997, 1998a).

Factors influencing herd size include hunter harvests, predation, weather conditions, and forage availability (Table 3.21-3). Results of long-term research on the Delta and adjacent caribou herds suggest that adverse weather can cause decreased production of calves and increased vulnerability to predation over a wide range of caribou densities. The absolute numbers and proportion of the western segment of the Central Arctic caribou herd that use the Kuparuk Oil Field area for calving has decreased from the 1980s through the early 2000s (Murphy and Lawhead 2000; Lawhead and Pritchard

TABLE 3.21-3 Caribou Herd Size, Harvest Summaries, and Limiting Factors for Herds Occurring near the TAPS ROW^a

Herd	Herd Size in 2000	Harvest Summary ^b	Limiting Factors
Nelchina	30,000	1,084/3,209	Forage availability, weather, predation, hunter harvest
Delta	3,200	24/36	Weather, predation
Ray Mountains	2,000	4/2	Predation
White Mountains	700	49/26	Not known
Central Arctic	27,000	495/411	Not fully investigated
Western Arctic	430,000	18,327/21,803	Predation, starvation, disease, accidents, hunter harvest
Teshekpuk Lake	27,000	2,250/2,065	Similar to Western Arctic herd
Statewide	857,345	32,294/34,582	

^a Herd size estimates from ADF&G (undated-a), harvest summaries from ADF&G (undated-b), and limiting factors from TAPS Owners (2001a) and references cited therein.

^b 2000-2001 harvest year/five-year average harvest (1996-1997 through 2000-2001). Data do not include unreported harvest, which may equal or exceed the reported harvest. The reported harvest includes firearm and archery harvests, resident and nonresident harvests, and subsistence harvest (Schwartz 2002).

2002). However, it cannot be definitively concluded that the distributional shift in calving to areas south of the oil field is a disturbance-caused displacement related to oil field development and operation (Murphy and Lawhead 2000). Nevertheless, the Kuparuk Oil Field is still used annually by several hundred cows that have a high level of calf production that does not differ significantly in its calves/cows ratio from that in the nondeveloped areas south of the oil field (Lawhead and Pritchard 2002). To date, evidence does not suggest that caribou populations have been adversely affected by the oil industry in Alaska (Boertje et al. 1996; Valkenburg 1997; Cronin et al. 1998a,b, 2000).

Harvest summaries for the caribou herds are also provided in Table 3.21-3. The Nelchina herd has historically been one of the most important caribou herds in the state for hunting because of its proximity to large population centers and because the herd is easily accessible by road (Lieb 1989). In contrast, the Ray Mountains herd is lightly hunted because few people know about the herd, and it is largely inaccessible during the hunting season (Osborne 1995). Harvest from the Ray Mountains herd has averaged fewer than 10 caribou per year over the last 10 years (Woolington 1997a; Nowlin 1998). The BLM (1989a) indicates that most of the reported harvest of Ray Mountains herd caribou occurred along the Dalton Highway. In the northern portion of Alaska, most caribou harvesting by nonlocal hunters (those who do not live within

northern Alaska) occurs between late August and late October, when caribou may be in the vicinity of the Dalton Highway. Subsistence harvest occurs throughout the year (TAPS Owners 2001a).

The distribution of the various caribou herds is summarized as follows:

- *Nelchina Herd:* Migration movements between spring/summer and fall/winter ranges require crossing the Richardson Highway and the TAPS ROW (Eide et al. 1986). APSC Security flight data indicate that the caribou continue to use their traditional migration route while transecting the ROW and Richardson Highway (TAPS Owners 2001a). Calving areas near the ROW occur between MP 627 and 660 (APSC 1993), a winter concentration area occurs from MP 659 to 693, and a migration area occurs from MP 602 to 680 (APSC 1993).
- *Delta Herd:* Although most of the Delta caribou herd occurs west of the ROW, a small portion of the herd occurs east of the Delta River, TAPS ROW, and the Richardson Highway in the areas of Iowa Creek and Donnelly Dome (APSC 1993; Eagan 1995; Valkenburg 1997; Valkenburg et al. 1999) (Map 3.21-2). A winter concentration area occurs near the ROW between MP 520 and 555 (APSC 1993).
- *Ray Mountains Herd:* During fall and winter, the herd moves to the northern side of the Ray Mountains, primarily in the Kanuti-Kilolitna drainage (Woolington 1997a). During autumn, Ray Mountains herd caribou occasionally have been observed in the vicinity of the TAPS ROW near PS 5 (APSC 1993), the Dalton Highway at Old Man, and near Caribou Mountain (Woolington 1997a).
- *White Mountains Herd:* All seasonal White Mountains herd habitats and ranges are east (approximately 20 mi at a minimum from about MP 520) of the ROW and Dalton Highway (Map 3.21-2). White Mountains herd caribou have not been reported crossing the pipeline or the highway. However, as illustrated by other Alaskan caribou herds, if this population increases, seasonal ranges may expand, and the White Mountains herd may then encounter the ROW and the Dalton Highway (TAPS Owners 2001a).
- *Central Arctic Herd:* Among the four caribou herds in the North Slope area (see Map 3.21-2), the Central Arctic herd is routinely exposed to oil and gas development facilities. This herd ranges from the Brooks Range to the Beaufort Sea, and from the Colville River east to the Canning River (Lawhead 1997). The primary calving areas for the Central Arctic herd lie between the Sagavanirktok and Canning Rivers in the area south of Bullen Point and in and around the Kuparuk and Milne Point oil fields. (Ballard et al. 2000; Murphy and Lawhead 2000). Lesser-used calving areas occur between the Eastern Channel and the Nechelik Channel of the Colville River and in the foothills of the Brooks Range south of the Colville River delta (ADNR 1999). Calving near the ROW occurs between MP 0 and 26, a winter concentration area occurs between MP 0 and 145, and migration areas occur from MP 100 to MP 105, 133 to 145, MP 146 to 156, and MP 173 to 243 (APSC 1993). The principal times when the Central Arctic herd encounters oil and gas field developments are during the periods of calving, post-calving aggregation, and dispersal (late May to mid-August) (TAPS Owners 2001a).
- *Western Arctic Herd:* During September and October, the Western Arctic herd caribou migrate as far south as the Seward Peninsula onto winter range and as far east as the TAPS ROW (APSC 1993; Woolington 1997b).
- *Teshkepuk Lake Herd:* Caribou from the Teshekpuk Lake herd winter over a wide range from the Arctic Coastal Plain to the Seward Peninsula, south of the Brooks Range (Philo et al. 1993; Carroll 1995). In some years, a portion of the herd winters on the Arctic Coastal Plain (Philo et al. 1993). The calving grounds and summer range of the herd are on the Arctic Coastal Plain (Philo et al. 1993; Carroll 1995). The principal calving grounds are located around Teshekpuk Lake, and the summer range

extends across the coastal plain west of the Colville River delta (Philo et al. 1993; Carroll 1995). The calving and summer ranges of the herd are overlapped by recent oil and gas exploration leases in the northeastern part of the National Petroleum Reserve—Alaska (BLM and MMS 1998).

3.21.1.3 Musk Ox

Musk ox (*Ovibos moschatus*) were extirpated from Alaska by the early 1900s (Woolington 1997c; Reynolds 1998). They were reestablished in the state when musk ox from Greenland were introduced in 1935-1936 to Nunivak Island off Alaska's west coast (Reynolds 1998). The total number of musk ox on the Arctic Coastal Plain has increased steadily since reintroduction, and at least 800 musk ox now inhabit the North Slope, generally within the ANWR area (Reynolds 1998; Woolington 1997c). Factors influencing musk ox population size include dispersal of mixed-sex groups into other regions (which can initially affect calf production), predation by brown bears and gray wolves, declining forage availability from intraspecific competition, and weather (TAPS Owners 2001a).

Westward dispersal of the musk ox across the North Slope began in the early 1980s, with individual bulls and small numbers of mixed-sex groups being observed as far west as the Kuparuk and Prudhoe Bay oil fields (BLM and USACE 1988; USACE 1997; Reynolds 1998). In 1986, as many as 18 musk ox were repeatedly observed along the Sagavanirktok River north of Franklin Bluffs (BLM and USACE 1988). In addition, musk ox have been seen near the Dalton Highway and as far south as PS 3 (Thompson 1999; Stephenson and Hunter 1999). At present, the total distribution of musk ox on the Arctic Coastal Plain covers a linear distance of approximately 300 mi extending from the Colville River west of Prudhoe Bay to beyond the Babbage River in northwest Canada (Reynolds 1998). A breeding population has become established in the Itkillik-Colville Rivers area (Johnson et al. 1996). No geographical barriers to range expansion exist along the arctic coast, and the potential range for musk ox is extensive (Smith 1984). For musk ox to have expanded their range from ANWR to the Colville

River, some animals had to cross the TAPS ROW or travel through the oil fields on the North Slope (TAPS Owners 2001a). However, no habitats important to musk ox are crossed by or occur near the TAPS ROW (APSC 1993). Only three musk ox were harvested in GMU 26 in 1999/2000 (Table 3.21-2).

During the snow-free season, musk ox generally use moist habitats and associated lush meadow and riparian vegetation (Klein 2000; BLM 1988). The most important summer habitats on the Arctic Coastal Plain are riparian, upland shrub, and moist sedge-shrub meadows, which provide preferred willow, forb, and sedge vegetation (Robus 1984; Johnson et al. 1996; BLM and MMS 1998). Musk ox use upland tussock areas and riparian drainages as calving habitat between late April and late June (Reynolds 1984; APSC 1993; USACE 1997).

Between late November and the end of February, musk ox frequently use riparian and dry tundra habitats such as ridges and bluffs. Winter forage depends largely on snow depth and hardness (Klein 2000). In late winter, musk ox feed on windblown vegetated bluffs that have shallow snow cover (Wilson and Klein 1991; Klein et al. 1993; USACE 1997). On the coastal plain, these areas are distributed in narrow bands along creeks, rivers, and the coastline. During winter, musk ox reduce their movements and activity; once they move to a winter area, they seldom leave it unless disturbed (Wilson and Klein 1991). Musk ox forage on the TAPS ROW in winter between PS 2 and 3 and also just south of PS 3. They concentrate on the workpad, perhaps because there is less snow cover, more grassy plants, or possibly more concentrated forage because of fertilization done in the course of revegetation (Montgomery 2002a).

3.21.1.4 American Bison

The Delta and Copper River herds of the American bison (*Bison bison*) occur in the vicinity of the ROW. The Delta herd ranges from Donnelly Dome to Big Delta in GMUs 20D and 20A, and the Copper River herd is distributed east of the Copper River in the northwestern portion of GMU 11 (APSC 1993). Good bison range is limited in Alaska, thus large numbers cannot be sustained (Griffin and Johnson 1994).

Most bison have predictable, periodic movements. Seasonal movements are associated with the search for food, calving and rutting areas, and mineral licks. Bison also move daily to obtain water. Weather, especially high winds, may also necessitate short-term movements. Summer range habitats can include upland dry meadows with open forests, margins of wet areas with forest, and areas with well-drained alluvial soils. Winter range includes bogs, stream banks, and margins of sloughs and ponds (see APSC 1993).

The most recent precalving herd estimate for the Delta herd was 361 bison (Hicks 1998). The most important limiting factor for this herd is harvest by humans (Taylor 1994; DuBois and Rogers 1999). Table 3.21-2 provides bison harvest summaries. There are no records of predation on Delta bison, although wolves, brown and black bears, and coyotes occur in the area. Drowning, hunting-wounding losses, and accidents are other potential limiting factors on bison numbers. Winter severity is not considered a major mortality factor (Taylor 1994; DuBois and Rogers 1999). The greatest potential for nonhunting mortality to bison in the Delta herd is disease transmitted from domestic livestock in the area (Taylor 1994). Kiker and Fielder (1980) reported that fewer than 10 bison in the Delta herd are killed annually in vehicle collisions.

Calving habitat in the lower and middle Delta River area is the only key bison habitat close to the TAPS ROW (MP 548 to 578). A major area for bison movement also occurs in this area (MP 545 to 566) (APSC 1993). The Delta herd is migratory; the bison move alone or in groups of up to 50 animals (DuBois 1995; DuBois and Rogers 1999). The herd normally travels to the floodplain of the Delta River from mid-February to March, crossing the Richardson Highway and the TAPS ROW. In early spring (April-May), cows move to secluded meadows near the Delta River to give birth (Hemming and Morehouse 1976; APSC 1993; DuBois and Rogers 1999). This area is west of the ROW between PS 9 and 10. During summer, the herd ranges along the Delta River floodplain and adjacent uplands, southwest of Delta Junction between Black Rapids Glacier and the mouth of the river (DuBois and Rogers 1999). During this period, bison are frequently visible from the Richardson

Highway (TAPS Owners 2001a). In July, August, or September, the herd migrates from the Delta River, again crossing the ROW and the Richardson Highway, onto the Delta Junction bison range and private agricultural lands, where they stay for most of the fall and winter (DuBois and Rogers 1999).

Bison are grazing animals, and in the Delta area only limited amounts of preferred foods, such as grasses and sedges, are available along rivers and in recent burns (Campbell and Hinkes 1983; Berger 1996; DuBois and Rogers 1999). The availability of winter forage was an important limiting factor for the Delta bison (ADF&G 1976), but agriculture (e.g., barley production) has augmented natural forage for bison.

The Copper River herd population estimates range from 75 to 87 individuals (McDonald 1998a; Tobey 1994, 1998). The management objective for this herd is to maintain a minimum of 60 overwintering adults (Tobey 1998). Limiting factors for this herd include winter severity (i.e., snow depth) and the potential for winter starvation; accidental death (e.g., falling off steep bluffs that border the Copper River); drowning (due to winter ice conditions and/or crossing attempts); and harvest by humans (Tobey 1998). Predation by wolves, black bears, and brown bears is likely; however, no research has been conducted on predation rates on Copper River herd bison (TAPS Owners 2001a).

The current range for the Copper River herd is bounded by the Dadina River on the north, the Kotsina River to the south, the Copper River on the west, and the Wrangell Mountains to the east. Most of the range consists of black spruce forest, with bison frequenting swamps, sedge openings, grass bluffs, and river bars (Tobey 1998). Before 1990, there were very few reports of Copper River bison crossing the river, and observations of animals along the west bank of the Copper River in GMU 13 were infrequent. Recently, however, bison have been reported grazing in hay and crop fields in the Kenny Lake area west of the Copper River and just east of the ROW (Tobey 1998).

3.21.1.5 Dall Sheep

Dall sheep (*Ovis dalli*) occur in the vicinity of the TAPS ROW in the Chugach Mountains (GMUs 11 and 13D), the Alaska Range (Delta Controlled Use Area in GMUs 13B, 20A, and 20D), and the Brooks Range (GMUs 24 and 26B). Dall sheep are generally nonmigratory, but may make extensive movements between summer and winter ranges. They will remain in some areas (e.g., Atigun River Valley) throughout the year (APSC 1993). Factors that can potentially limit Dall sheep populations include winter severity and predation by wolves, coyotes, bears, wolverines, and golden eagles (Sinnott 1996a). Harvest summaries for Dall sheep are presented in Table 3.21-2.

In GMU 13D, Dall sheep are most abundant between the Nelchina and Klutina glaciers west of the ROW, and are also present in the Tonsina Controlled Use Area adjacent to the ROW. Dall sheep occur in the mountainous areas below about 9,800 ft in elevation, although concentrations vary among drainages. During the winter, Dall sheep in the Chugach Mountains are found in relatively snow-free areas and on windblown ridges above 2,950 ft in elevation. Lambing areas are often found in steep terrain with southern exposures (TAPS Owners 2001a).

Within the Delta Controlled Use Area, lambing and mineral lick areas occur adjacent to and within 9.3 mi of the ROW. These areas occur both east and west of the pipeline, north of PS 10 (APSC 1993). Winter range for the Dall sheep is provided by the area's moderate climate, including high winds, warm temperatures, and low snow depths. The greatest threats to Dall sheep habitat in the Delta Controlled Use Area are mining activities and military exercises on state lands (DuBois 1996a).

In the eastern Brooks Range, the highest densities of Dall sheep occur in the northern drainages that provide favorable weather and habitat conditions during winter (Stephenson 1996). Drainages such as the Junjik, East Fork Chandalar, and Hulahula Rivers may also inhibit Dall sheep movements, resulting in discrete subpopulations in the Brooks Range. Several lambing areas and mineral licks occur between PS 4 and 5. These areas occur both east and

west of the pipeline (less than 8 mi), and overlap the ROW in some areas. Dall sheep movement zones associated with lambing areas have been identified west of the ROW near Chandalar and Atigun Pass. The sheep may cross the Dalton Highway in these areas (APSC 1993). Rare instances of mortality from vehicles have been reported (Jakimchuk et al. 1984).

A number of lambing areas occur less than 2 mi from the ROW (MP 114–115, MP 142–146, MP 144–147, MP 148–166, MP 173–179, MP 182–185, MP 187–200, MP 202–205, MP 206–109, MP 214–221, MP 568–588, and MP 719–712) (APSC 1993). Following lambing, ewes, lambs, and yearlings tend to concentrate around mineral lick areas. A number of mineral licks also occur within 2 mi of the ROW (MPs 115, 140, 145, 154, 158, 162, 164, 166, 169, 173, 176, and 218) (APSC 1993). Several special areas near the ROW have been established, in part, to protect Dall sheep habitat (e.g., lambing areas) and mineral licks (BLM 1989a). These areas include the Snowden Mountain Area of Critical Environmental Concern (ACEC) (east of the ROW and Dalton Highway at MP 190–200); Nugget Creek ACEC (north of the ROW at MP 216–221); and Poss Mountain ACEC (about 4 mi east of the ROW at MP 217–219) (APSC 1993). These areas are in the Brooks Range near the ROW and the Dalton Highway and are used year-round by Dall sheep (BLM 1989a).

3.21.1.6 Sitka Black-Tailed Deer

Sitka black-tailed deer occur throughout GMU 6, which is at the northern limit of their range and at the southern end of the TAPS ROW. When climatic conditions favor expansion, these deer can be found more than 30 mi inland along the Copper River corridor (APSC 1993). The deer population in GMU 6 is stable (Griese 1989a; Nowlin 1997). Highest deer densities occur on islands, and the lowest densities occur on the mainland in areas surrounding Prince William Sound. Deer density decreases rapidly with distance inland from Prince William Sound (Nowlin 1997). Population estimates are not available for GMU 6 or for areas in the vicinity of the ROW (TAPS Owners 2001a).

Factors that limit deer distribution, habitat use, and population numbers include snow depths and duration; wolf predation; availability of mature conifer-forest habitat, which provides deer wintering areas; clear-cutting and selective timber management practices; parasites; and hunting. During periods of high deer densities, a number of deer under 2 years of age often become infested with lungworm (Merriam et al. 1994). Harvest summaries are presented in Table 3.21-2. Although deer may be present in the vicinity of the southern end of the ROW, this area has not been identified as being important deer habitat (APSC 1993).

3.21.1.7 Mountain Goat

Mountain goats are found near the TAPS ROW south of the Alaska Range in GMUs 6, 11, and 13D. In south-central Alaska, they are generally confined to the Chugach and Wrangell Mountains. Mountain goats stay in or near steep, broken terrain (Johnson 1994b). Mountain goats in Subunit 6D, which is bisected by the ROW, have increased to the west of the ROW and the Richardson Highway, yet have declined to the east (Nowlin 1996a). They occur near Thompson Pass, where they are found in very rugged and broken terrain with cliffs, ledges, pinnacles, and talus slopes. No habitats important to mountain goats occur near or are crossed by the ROW (APSC 1993).

Old-growth forest provides important winter habitat for mountain goats (Schoen and Kirchhoff 1982; Fox et al. 1989; Nowlin 1996a). During the summer, goats frequent high alpine mountains, where they eat grasses, sedges, and low shrubs (APSC 1993). Although female goats seek isolated areas to give birth, the availability of winter habitat is the most important seasonal requirement for the species (TAPS Owners 2001a). Mountain goat populations are limited by winter severity and snow depths (Adams and Bailey 1982; Swenson 1985), predation (Nowlin 1996a), and availability of winter habitats (Fox et al. 1989). Natural causes of mortality (e.g., predation) primarily affect yearlings and goats over 8 years old; goats in their prime are more prone to hunting mortality (Smith 1986). Harvest summaries are provided in Table 3.21-2.

Near the ROW in GMU 11, mountain goats are distributed south of the Chitina River in that portion of the Chugach Mountains from the Copper River east to the Canadian border (Tobey 1996b). This area directly east of and adjacent to the ROW may provide the most suitable goat habitat in GMU 11 (Tobey 1996b). Goats from GMU 11 east of the ROW sometimes cross the pipeline and mix with goats from GMU 13D (TAPS Owners 2001a). In GMU 13D, mountain goats are primarily found in the Chugach Mountains adjacent to and west of the ROW (Sinnott 1996b). The population in GMU 13D is limited by winter weather and predation (Sinnott 1996b). The northernmost range of the mountain goat in Alaska is in the Talkeetna Mountains north of the Chugach Range (Ballard and Whitlaw 2002).

3.21.1.8 Brown Bear

Brown (grizzly) bears occur throughout most of Alaska except for several island groups (Eide et al. 1994). They are present in all GMUs crossed by the TAPS ROW and occur across the North Slope (TAPS Owners 2001a). Brown bear concentration areas (i.e., areas of higher densities) include the Sagavanirktok and Atigun River valleys. A brown bear concentration area also occurs between MP 613 and 621 (Summit Lake-Gulkana River-Paxson Lake area) (APSC 1993). More than 31,000 brown bears occur in Alaska (ADF&G 2000b). Brown bear abundance depends upon productivity of the environment. In areas of low production, such as the North Slope, brown bear densities are as low as one bear per 300 mi². In areas north and south of the Alaska Range (central Alaska), brown bear densities are intermediate at one bear per 15 to 23 mi². Highest densities of one bear per square mile have been reported for Admiralty Island, where food is readily available (Miller et al. 1997).

Brown bears are omnivorous. They feed on berries, grass, sedges, horsetails, roots, insects, fish, ground squirrels, and ungulate neonates (newborns). Brown bear spring and berry concentration areas occur between MP 182 and 247 and between MP 561 and 574 (APSC 1993). In some areas they also prey on domestic animals, carrion, and garbage (Eide et al. 1994). Brown bears feed on salmon from mid-May

through August and use both salmon and berries from September through early November. Denning begins in late October, with most bears denning by mid-December (APSC 1995a). Ballard et al. (1982) reported that brown bears in the Nelchina Basin entered dens in late October. Bears generally emerge from dens in late March (depending on weather conditions). From mid-April to late July they can be found in grassland areas, such as grass flats, sedge meadows, and saltwater bogs (APSC 1995a), and old-growth upland forests (Schoen and Beier 1990). In late summer, they occur within old-growth riparian areas (Schoen and Beier 1990).

After emergence from dens, most brown bears (except females with newborn cubs) move to river bottoms to feed on sprouting plants, remaining berries, and ungulate neonates; and to scavenge the carcasses of animals such as moose and caribou that have died during the winter (Ballard et al. 1982; Miller 1987; Tobey 1995; Ballard and Whitlaw 2002). During the spring, females with cubs remain at higher elevations to reduce contact with other bears (TAPS Owners 2001a). Adult male brown bears have been implicated as a cause of cub mortality (see Shideler and Hechtel 2000). During summer and fall, bear distribution and movements are determined by the presence of salmon and by moose and caribou distributions (Miller 1987; Tobey 1995).

Sources of brown bear mortality include legal and illegal harvests, kills in defense of life and property, accidents, and nonhunting and natural causes (e.g., predation by other bears) (Nowlin 1995; McDonald 1998b; Tobey 1995). Harvest summaries for brown bears are presented in Table 3.21-2. Habitat disturbance (e.g., logging) in valley bottoms and riparian areas used as travel corridors are also detrimental to brown bears (USFWS 1995a).

3.21.1.9 Black Bear

Black bears occur throughout most of the forested portions of Alaska (Johnson 1994a). They are present in all GMUs crossed by the TAPS ROW. However, they are infrequent in the northern third of the state (i.e., GMUs 24 and 26B) (TAPS Owners 2001a). Black bears are widely distributed along the pipeline in

forested areas south of the Atigun Pass (e.g., MP 306–463, MP 627–660, and MP 691–800); with black bear concentration areas occurring between MP 226–237, MP 397–403, MP 412–418, and MP 778–800 (APSC 1993). They prefer open forests. Highest population densities generally occur in mixed habitats of semiopen forests with herbaceous plants, lush grass, succulent forbs, and fruit-bearing shrubs (APSC 1993). Black bears use coniferous forest and alder-dominated mountain slopes during the nondenning period. During spring and fall they use shrub zones to feed on berries and succulent vegetation (Miller 1987; Tobey 1996c). They are also associated with settlement areas such as Coldfoot, Livengood, and Valdez (APSC 1993). Rugged terrain and dense shrubs are used for escape cover and den sites. Black bears often use streams with dense riparian shorelines as travel corridors to feeding areas (USFWS 1995b). Home range can vary from 1 to 100 mi². Black bears are omnivorous. They consume freshly sprouted vegetation, carrion, ungulate neonates, fish, berries, and insects (Johnson 1994a; Ballard and Whitlaw 2002).

Factors that influence black bear numbers include harvest by legal and illegal kills (including kills in defense of life and property), food abundance, adverse weather, habitat quality and quantity, and competition and predation by brown bears (Alt 1984; Boudreau 1996; DuBois 1996b; USFWS 1995b; Giese 1989b; Nowlin 1996b). Harvest summaries for the black bear are presented in Table 3.21-2.

3.21.1.10 Gray Wolf

The gray wolf is present in all GMUs crossed by the TAPS ROW (TAPS Owners 2001a), with more than 7,500 wolves occurring throughout Alaska (ADF&G 2000b). In 1994-1995, there were about 7,500 to 10,000 wolves in 700 to 900 packs (ADF&G 2001c). Wolf populations fluctuate over time in response to the availability of prey and to wolf-control activities (Woolington and McNay 1997). Predator-control projects have occurred in the past in an effort to increase the number of moose and caribou (see TAPS Owners 2001a). Causes of wolf mortality can include hunting and trapping, predation by other wolves, accidents, injuries, starvation, drowning,

and rabies (Ballard et al. 1987; Ballard and Krausman 1997; Zarnke and Ballard 1987). Harvest summaries are provided in Table 3.21-2.

Ballard et al. (1987) determined that distribution and movement patterns of wolves in GMU 13 were dependent on prey availability. They also found that wolf territory size was primarily a function of moose density, with an average pack territory of about 600 mi². Generally, wolves do not follow migrating caribou out of pack territory (Ballard et al. 1987; Stephensen and Boertje 1994). A number of wolf territories in GMU 13 are bisected by the ROW and the Richardson Highway (Ballard et al. 1987). Several wolf packs maintain territories near the ROW in GMU 20A (Ballard and Gipson 2000).

Wolves are found throughout GMU 24 in all habitat types and near human settlements (Woolington and McNay 1997). Highest wolf densities are found in the northern and southern portions of the unit rather than in the central area, which has the lowest density of resident ungulates (hooved mammals such as caribou and moose) (Woolington and McNay 1997).

Highest wolf densities in GMU 26B are found in the Brooks Range and its foothills. On the coastal plain, wolves seasonally prey on the most available ungulate species: caribou during spring and summer, and moose and Dall sheep during winter (Garner and Reynolds 1986). Two wolf-den sites have been documented near the ROW within the foothills of the Brooks Range and the Arctic Coastal Plain. One occurs at Atigun Pass and the other just north of PS 3. Both sites occur in river drainages adjacent to the ROW and the Dalton Highway (APSC 1993).

3.21.1.11 Other Species

Thirty-nine native species of furbearers (e.g., species that are of primary economic importance for their fur rather than as a food resource) and small mammals (species of rodents, shrews, bats, and other mammals that are generally not of a size large enough to be readily used for their fur or meat) occur along the TAPS ROW (TAPS Owners 2001a). Several of the species are harvested for fur or, less commonly, food. These species include

snowshoe hare (*Lepus americanus*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), coyote, Arctic fox, red fox, marten (*Martes americana*), ermine (*Mustela erminea*), least weasel (*Mustela nivalis*), mink, wolverine, river otter, and lynx (*Lynx canadensis*). Some other species (e.g., marmots) are used by Alaska Natives for food and fur (Curby 1994). The ADF&G manages the harvest of furbearers through both hunting and trapping regulations. Small mammals in Alaska that may occur in areas that the ROW crosses include 10 species of shrews, 7 species of voles, and 4 species of mice (Osborne 1994a,b; Jarrell et al. 2001). These species are important food resources for a number of carnivorous birds and mammals.

Beavers have blocked culverts or otherwise modified drainages across or near the pipeline that have led to flooding and washouts (APSC 1993; Trudgen 1999). Nevertheless, beavers are an ecologically important species that dramatically alter drainage patterns, which can enhance aquatic productivity, provide overwintering habitat for fish, create waterfowl habitat, and increase wetland and riparian vegetation. However, beaver dams may block stream access to anadromous fish such as salmon (Shepherd 1994).

3.21.2 Beaufort Sea

For this FEIS, the terrestrial portion of the Beaufort Sea is considered to be the Arctic Coastal Plain north of the foothills of the Brooks Range. This area encompasses most of the North Slope oil fields, ANWR, and NPR-A. A portion of the TAPS (primarily from MP 0 to 58 [PS 2]) occurs within this area.

About 15 species of terrestrial mammals occur within the North Slope area (Gilders and Cronin 2000). Terrestrial mammal species numbers that occur along the Beaufort Sea are limited because of habitat constraints associated with long, harsh winters. The most abundant or predominant mammal species that occur in this area include the Arctic shrew (*Sorex arcticus*), brown lemming (*Lemmus sibiricus*), Arctic fox, brown bear, caribou, moose, and musk ox. The following discussion highlights pertinent information on these mammal species as it relates to their occurrence along the Beaufort

Sea. More detailed information on several of these species is presented in Section 3.21.1.

A breeding population of moose became established in the North Slope in the 1940s and 1950s (Carol 2002), and their habitat use and distribution are seasonal. During some years, moose range to the coast during the summer (Noel and Olsen 1999a,b). In winter they are limited to inland riparian and shrub habitats (Coady 1980). In some years, habitat use is limited primarily to riparian areas on a year-round basis (Mould 1979). Within the North Slope, moose may occasionally disperse across the tundra, but usually are found in varying elevations in the Brooks Range foothills.

The moose population within the North Slope increased to more than 1,500 individuals in 1991 (Carol 2002). From 1991 through 1996, the population decreased by about 75%. It is speculated that this decline was due to a combination of factors (e.g., exceeding carrying capacity, a harsh winter and competition from hares, copper deficiency, physiological stress from insects following a harsh winter, and high predator densities). The moose population has been increasing in the past several years because of such factors as an increase in available browse and the physiological condition of the moose (Carol 2002).

The caribou is an important component of the arctic landscape because of its high value to subsistence and sport hunters, indigenous Native cultures, the general public, and the functioning of terrestrial ecosystems (Murphy and Lawhead 2000). Four caribou herds occur across the North Slope: the Western Arctic herd, the Teshekpuk Lake herd, the Central Arctic herd, and the Porcupine herd (Map 3.21-2). These herds have distinct calving areas, but sometimes overlap during other times of the year (Cronin et al. 1998a). Herd size and harvest summaries for the Western Arctic, Teshekpuk Lake, and Central Arctic herds are presented in Table 3.21-3. The size of the Porcupine herd was estimated at 130,000 in 2000, and the reported Alaskan harvest for the 1999-2000 year was 388 (ADF&G undated-a, 2000b). All four herds have increased in numbers since the mid-1970s. The Porcupine herd was 105,000 in 1977 (Cronin et al. 1998a). The Western Arctic herd has grown from 64,000 in 1976 to 430,000 in

2000; the Teshekpuk Lake herd from 3,500 in 1978 to 27,000 in 2000; and the Central Arctic herd from about 5,000 in 1975 to 27,000 in 2000 (Cronin et al. 1998a; ADF&G undated-a).

Calving areas for these herds are mostly within 30 mi of the coast. Caribou often wander great distances during seasonal migrations (Bergerud and Page 1987). In mid-summer, caribou are often harassed by mosquitoes, warble flies, and nose bot flies. In response to this harassment, caribou will move from inland feeding areas to windswept, vegetation-free coastal areas (particularly river deltas), gravel drilling pads and roads, on river bars and bluffs, and even into the Beaufort Sea, where these insect pests are less abundant. Caribou will move to the coast and back to inland feeding areas within a matter of hours or days, depending on the level of insect harassment (Ballard and Whitlaw 2002).

During their spring and fall migrations, caribou tend to move along or near major river drainages. Generally, the winter ranges for all four herds include the northern foothills of the Brooks Range (ADNR 1999). The winter range for the Porcupine herd also includes the Yukon Territory and the south side of the Brooks Range, while the Western Arctic herd winters over much of northwest Alaska (Cronin et al. 1998a). Movement and distribution of caribou over their winter range reflect their need to avoid predators or their response to strong winds or snow conditions (which influence availability of forage) (BLM and MMS 1998).

Caribou of the Central Arctic herd migrate north each spring from their winter range in the Brooks Range and its northern foothills to calving grounds and summer range on the Arctic Coastal Plain between the Canning and Colville Rivers. Small numbers of the Central Arctic herd spend the winter on the coastal plain (e.g., less than 10 per 40 mi²) (Carruthers et al. 1987); thus, the region encompassing the existing oil fields is not considered important winter range (Carruthers et al. 1987; Murphy and Lawhead 2000). Census data indicate that about half of the Central Arctic herd tends to spend the calving and insect seasons west of the Sagavanirktok River, including the area with existing oil-field development, and the other half of the herd ranges east of the Sagavanirktok

River (Lawhead 1988). Regular interchange of animals probably occurs between the east and west ranges (Cronin et al. 1997, 2000).

Mosquito-harassed caribou on the coastal plain coalesce into large groups and move upwind (generally northward) to reach relief habitats, which include cool and windy coastal beaches, low bluffs, sparsely vegetated river bars and deltas, and oil field gravel roads and pads (White et al. 1975; Roby 1978; Dau 1986; Lawhead 1988; Pollard et al. 1996). Caribou in the western range of the herd frequently encounter oil field infrastructure during these movements (White et al. 1975; Curatolo and Murphy 1986; Murphy and Curatolo 1987; Pollard et al. 1996; Cronin et al. 1998b). The location of mosquito-relief habitat varies with weather conditions (primarily air temperature and wind speed), and mosquito-harassed caribou apparently move only as far as necessary to reach insect-free locations on any given day (Lawhead 1988). When mosquito harassment abates, caribou move from the coast to inland areas with better forage (Smith 1996).

Before oil-field development, bears were uncommon on the North Slope. However, by 1997 their numbers increased to 60 to 70 bears within the oil production areas (density of nearly one bear per 100 mi²) (Shideler and Hechtel 2000). However, densities as high as six bears per 100 mi² occur in some habitats such as barrier islands and nearshore coastal areas. Brown bears have large home ranges (e.g., up to 5,200 mi²) and can travel over 30 mi per day (ADNR 1999). Brown bears travel along major drainages on the North Slope and feed extensively in riparian areas. They also frequently den along riverbanks (see ADNR 1999). Relatively high densities of arctic ground squirrels, relatively abundant denning habitat, and access to human garbage apparently have allowed the bear population to increase to relatively high densities in oil development areas in comparison with other Arctic Coastal Plain habitats. Most of the brown bears in the oil field complex use natural dens, but some use man-made structures (Shideler and Hechtel 2000). The bears in the oil field areas are not an isolated population, and there is movement of animals among different areas of the North

Slope (Cronin et al. 1999 and references cited therein).

Brown bears with access to garbage and human foods in oil fields have relatively large average litter sizes and low cub mortality compared with other bear populations on the Arctic Coastal Plain (Shideler and Hechtel 2000). However, relatively high subadult and adult mortality offset these benefits. Shideler and Hechtel (2000) suggested that oil field bears that had become habituated to the presence of humans were consequently more vulnerable to harvests by humans when they moved away from oil fields.

Shideler and Hechtel (2000) indicated that agency and industry regulations (such as prohibition of hunting and firearms within the oil fields, education about bear safety, training in how to handle bear problems, and strict regulations against the feeding of bears) have successfully reduced the effects related to the oil fields on bears. Bear-proof garbage containers are currently being installed in the oil field complex, and access to the North Slope Borough garbage landfill has been eliminated with chain link and electric fencing. Shideler and Hechtel (2000) anticipated short-term increases in mortality of bears habituated to anthropogenic food sources, but in the long term they expected the bear population would be characteristic of natural populations not exposed to oil fields.

Riparian areas are the preferred habitat for musk ox in summer. In winter and spring, musk ox occur in uplands adjacent to river drainages (including the Sagavanirktok) that provide forage of tussock sedges and have less snow cover than the riparian areas. Calving occurs in the southern portion of the Arctic Coastal Plain on windblown banks with riparian areas and in upland sites in the foothills (see ADNR 1999).

Several furbearers, including the Arctic fox, gray wolf, and wolverine, occur within the coastal plain area of the Beaufort Sea. The Arctic fox occurs in the treeless coastal areas of Alaska from the Aleutian Islands north to Point Barrow and east to the Canadian border (Stephenson 1994). Dense aggregations of Arctic foxes can occur in winter in the vicinity of large marine-mammal carcasses and at village dumps, where garbage is available (Chesemore

1975). Arctic foxes are highly adaptable and readily habituate to human activities when not harassed. They readily consume human foods or garbage and quickly learn to exploit these resources (Burgess et al. 1993). However, primary foods are small mammals, such as brown lemmings and tundra voles (*Microtus oeconomus*), and birds (particularly ptarmigans). Being omnivorous, they also consume berries. Arctic fox predation is considered to be the main cause of nest loss for noncolonial shorebirds and passerines in the North Slope (see Burgess 2000). They will venture out into the Beaufort Sea ice during winter to feed upon the remains of polar bear (*Ursus maritimus*) kills (Stephenson 1994; Tannerfeldt 2001). Food scarcity is the most significant population-limiting factor for Arctic foxes (Underwood and Mosher 1982). Fox numbers in the Beaufort Sea area often vary in response to cyclic changes in the size of lemming and vole populations (see ADNR 1999).

Arctic fox dens are typically excavated into low mounds on the tundra. The foxes prefer sites that have a history of use. However, they are capable of denning under skirted buildings, in abandoned human structures, in utility corridor structures, and even in abandoned vehicles (Burgess 2000). The density of Arctic fox dens in the Prudhoe Bay area (one primary den per 4.6 to 5.0 mi²) is higher than in adjacent areas on the North Slope (about one primary den per 11.6 to 15.4 mi²) (Burgess 2000). The number of young produced varies considerably from year to year and is highly correlated with lemming density. Arctic foxes are the main vectors of

rabies in the Arctic (Winkler 1975; Crandell 1975). Rabies outbreaks are often associated with periods of high-density Arctic fox populations (TAPS Owners 2001a). The Arctic fox is the most important terrestrial furbearer species in the Arctic because of its numbers and circumpolar distribution (Tannerfeldt 2001).

Although they have high birth rates, gray wolves also have high mortality rates, and they are seldom abundant within the Arctic Coastal Plain. Hunting and trapping are the major controlling influences on wolf numbers; with secondary influences being disease, malnutrition, accidents, and predation by other wolves. The primary prey of wolves are moose and caribou. However, they are opportunistic and will also prey on small mammals, fish, and birds (see ADNR 1999).

Wolverines are found primarily in the more remote areas of Alaska. They occur throughout the North Slope, but primarily in the Brooks Range and foothills (see BLM and MMS 1998). They frequent all types of terrains and will often utilize rivers as territorial boundaries. Wolverines will travel great distances in search of food. They generally feed on medium and small mammals, birds, and carrion of moose and caribou. Only rarely will they kill a moose or caribou (see ADNR 1999).

The river otter has recently been reported as far north on the Sagavanirktok as MP 83. They use overwintering fish resources and travel northward on the river ice (Montgomery 2002a).

3.22 Threatened, Endangered, and Protected Species

Designated species receive protection under a variety of federal regulations. Regulations pertinent to the TAPS ROW renewal include the Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), Bald and Golden Eagle Protection Act, Migratory Bird Treaty Act, and Magnuson-Stevens Fishery Conservation and Management Act. In addition, the State of Alaska maintains lists of endangered species (5 Alaska Administrative Code [AAC] 93.020) and species of special concern (ADF&G 1998). Species protected under the ESA and MMPA and species listed by the state that could occur in the vicinity of the TAPS or in areas of potential cumulative impact (Beaufort Sea and Prince William Sound) are listed in Table 3.22-1. The following text describes those species that are currently listed, proposed for listing, recently delisted, or considered candidates for listing under the ESA; protected under the MMPA; or listed by the state as endangered or as a species of special concern. Essential fish habitat protected under the MSFCMA is discussed in Section 3.19, migratory birds and bald and golden eagles are discussed in Section 3.20.

3.22.1 TAPS Row

Three species of animals listed as threatened or endangered under the ESA may occur along the TAPS ROW: spectacled eider (threatened), Steller's eider (threatened), and Eskimo curlew (endangered). Both the Arctic peregrine falcon and American peregrine falcon, formerly listed as threatened and endangered, occur along the TAPS ROW. The Arctic and American peregrine falcons were delisted in 1994 and 1999, respectively (59 FR 50796; 64 FR 46542), but are still being monitored to ensure that their populations are secure. During this monitoring period, peregrine falcons are treated similarly to candidates for listing. No ESA-listed plant species are found along the ROW.

Special Terms Applicable to Protected Species

Endangered species: Any species that is in danger of extinction throughout all or a significant portion of its range (ESA).

Threatened species: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range (ESA).

Candidate species: A species for which the USFWS currently has substantial information on hand to support the biological appropriateness of proposing to list the species as endangered or threatened (ESA).

Critical habitat: Specific areas on which are found those physical and biological features essential to the conservation of a listed species (ESA).

Depleted stock: A species or population that is below its optimum sustainable population (MMPA).

Species of Special Concern: Any species or subspecies of fish or wildlife or population of mammal or bird native to Alaska that has entered a long-term decline in abundance or is vulnerable to a significant decline due to low numbers, restricted distribution, dependence on limited habitat resources, or sensitivity to environmental disturbance (5 AAC 93.020).

Listed Species Most Likely to Occur along the TAPS Row

Spectacled eider: ESA listed as threatened.

Steller eider: ESA listed as threatened.

Both occur in wetland areas along the coast of the Beaufort Sea.

TABLE 3.22-1 Threatened, Endangered, and Protected Species That Could Occur in the Vicinity of the TAPS or in the Beaufort Sea or Prince William Sound

Common Name	Species	Status ^a	Occurrence in Project Area			Comments
			TAPS	Beaufort Sea	Prince William Sound	
Birds						
Spectacled eider	<i>Somateria fischeri</i>	ESA-T AK-SC	Yes	Yes	No	Nests in coastal arctic and subarctic wetlands with shallow ponds and lakes. Areas of highest abundance are more than 100 mi west of the TAPS ROW, but species is found at relatively low densities in the northernmost portions of ROW. Winters in the Bering Sea. Areas of designated critical habitat are located on the western coast of Alaska and in the Bering Sea.
Steller’s eider	<i>Polysticta stelleri</i>	ESA-T AK-SC	Yes	Yes	Yes	Nests in arctic coastal wetlands, mostly on the western North Slope near Barrow. Occurs in very low density in the Prudhoe Bay area near the northern portion of the ROW. Winters in Alaska from the eastern Aleutian Islands to Cook Inlet but occasionally found in Prince William Sound. Areas of designated critical habitat are located on the western coast of Alaska and the Alaska Peninsula.
Eskimo curlew	<i>Numenius borealis</i>	ESA-E, AK-E	Former	No	Former	Probably extinct. Previously nested in arctic tundra of Alaska and Canada. Wintered in South America.
American peregrine falcon	<i>Falco peregrinus anatum</i>	ESA-DM AK-SC	Yes	No	Yes	Nests throughout interior forested areas of Alaska, mainly on cliffs along rivers or near lakes. Winters in southern United States south to Argentina.
Arctic peregrine falcon	<i>Falco peregrinus tundrius</i>	ESA-DM AK-SC	Yes	Yes	Yes	Nests in treeless tundra areas of northern Alaska, Canada, and Greenland, mostly along rivers. Winters in southern United States south to Argentina and Chile.

TABLE 3.22-1 (Cont.)

Common Name	Species	Status ^a	Occurrence in Project Area			Comments
			TAPS	Beaufort Sea	Prince William Sound	
Olive-sided flycatcher	<i>Contopus borealis</i>	AK-SC	Yes	No	Yes	Nests in coniferous forest of Alaska south of Brooks Range, usually near openings and water. Winters in South America.
Gray-cheeked thrush	<i>Catharus minimus</i>	AK-SC	Yes	No	Yes	Nests in predominantly coniferous forests and mixed forests of Alaska south of Brooks Range. Winters in northern South America.
Townsend's warbler	<i>Dendroica townsendi</i>	AK-SC	Yes	No	Yes	Nests in coniferous forest of Yukon River valley and southern Alaska. Winters from Mexico to Nicaragua.
Blackpoll warbler	<i>Dendroica striata</i>	AK-SC	Yes	No	Yes	Nests in predominantly coniferous forests and mixed forests of Alaska south of Brooks Range. Winters in South America.
Mammals						
Bowhead whale	<i>Balaena mysticetus</i>	ESA-E MMPA-D AK-SC	No	Yes	No	Winters in the Bering Sea, migrates north in spring, and summers in the eastern Beaufort Sea. Number of bowhead whales in the Alaska portion of the Beaufort Sea is relatively low except during migration. Population has been increasing over the last several decades.
Gray whale	<i>Eschrichtius robustus</i>	ESA-D MMPA-P	No	Yes	Yes	Spends summer feeding in the northern Bering, Chukchi, and Beaufort Seas. Winters mainly along coast of Baja California.
Fin whale	<i>Balaenoptera physalus</i>	ESA-E MMPA-D	No	No	Yes	Found seasonally off the coast of North America and Hawaii. In Alaska, they are found in the summer in the Bering Sea and Gulf of Alaska and as transients during migration in Prince William Sound.

TABLE 3.22-1 (Cont.)

Common Name	Species	Status ^a	Occurrence in Project Area			Comments
			TAPS	Beaufort Sea	Prince William Sound	
Beluga whale	<i>Delphinapterus leucas</i>	MMPA-P (Chukchi and Beaufort Sea stocks); MMPA-D (Cook Inlet stock)	No	Yes	Yes	Five stocks in Alaskan waters. Beaufort Sea and eastern Chukchi Sea stocks occur in Beaufort Sea area in summer; Cook Inlet stock occurs in Prince William Sound area in winter. Number of beluga whales in Alaska portion of Beaufort Sea is relatively low except during migration. Population is stable or increasing.
Minke whale	<i>Balaenoptera acutorostrata</i>	MMPA-P	No	No	Yes	In North Pacific, occurs from Bering and Chukchi Seas south to near the equator. Relatively common, but not abundant, in the Bering and Chukchi Seas and in the inshore waters of Gulf of Alaska. Migratory in northern portion of range.
Humpback whale	<i>Megaptera novaeangliae</i>	ESA-E MMPA-D AK-E	No	No	Yes	Occurs worldwide in all oceans but less common in Arctic waters. Winters in temperate and tropical waters of the North and South Hemispheres. In Alaska, occurs in Bering Sea and Gulf of Alaska. Feeding aggregations occur in Prince William Sound during the summer.
Killer whale	<i>Orcinus orca</i>	MMPA-P	No	Possible	Yes	Found in all oceans of the world but prefers the colder waters of both hemispheres. In Alaska, occurs along entire coast from Chukchi Sea, Bering Sea, along Aleutian Islands, Gulf of Alaska, and southeast Alaska.
Pacific white-sided dolphin	<i>Lagenorhynchus obliquidens</i>	MMPA-P	No	No	Yes	Found throughout temperate North Pacific Ocean. In east North Pacific, occurs from Gulf of California north to Gulf of Alaska and rarely in the southern Bering Sea.
Harbor porpoise	<i>Phocoena phocoena</i>	MMPA-P	No	Possible	Yes	Frequents coastal waters of the Chukchi Sea, Bering Sea, Gulf of Alaska, and west coast of North America.

TABLE 3.22-1 (Cont.)

Common Name	Species	Status ^a	Occurrence in Project Area			Comments
			TAPS	Beaufort Sea	Prince William Sound	
Dall's porpoise	<i>Phocoenoides dalli</i>	MMPA-P	No	No	Yes	Widely distributed across entire North Pacific Ocean over continental shelf and deep oceanic waters. In Alaska, found in Gulf of Alaska and off coast of Bering Sea.
Steller sea lion	<i>Eumetopias jubatus</i>	ESA-E MMPA-D AK-SC	No	No	Yes	Ranges along North Pacific Rim from northern Japan to California, with centers of abundance in Gulf of Alaska. In Alaska, found in Bering Sea, Gulf of Alaska, and southeastern Alaska. Three haulout areas in Prince William Sound have been designated as critical habitat.
Harbor seal	<i>Phoca vitulina</i>	MMPA-P	No	No	Yes	Inhabits coastal and estuarine waters off Baja California, north along west coasts of North America, Gulf of Alaska, Aleutian Islands, and southern Bering Sea.
Spotted seal	<i>Phoca largha</i>	MMPA-P	No	Yes	No	Occurs in continental-shelf waters of the Beaufort, Chukchi, and Bering Seas. Occupies coastal habitats as ice retreats in summer. In Beaufort Sea, most common in western and west-central portions from July to October.
Ringed seal	<i>Phoca hispida</i>	MMPA-P	No	Yes	No	Occurs in all seas of the Arctic Ocean, where it occupies ice-covered waters year-round. Common in the Beaufort Sea but at lower densities than in other portions of their range.
Ribbon seal	<i>Phoca fasciata</i>	MMPA-P	No	Possible	No	Inhabits North Pacific Ocean and adjacent portions of Arctic Ocean. In Alaska, ranges from Bristol Bay into the Chukchi and western Beaufort Sea; found on pack ice and rarely on shorefast ice.
Bearded seal	<i>Erignathus barbatus</i>	MMPA-P	No	Yes	No	Occurs over the continental shelves of the Bering, Chukchi, and Beaufort Seas. Year-long resident of Beaufort Sea, but less common in winter or in areas of fast ice. Rarely hauls out onto land.

TABLE 3.22-1 (Cont.)

Common Name	Species	Status ^a	Occurrence in Project Area			Comments
			TAPS	Beaufort Sea	Prince William Sound	
Pacific walrus	<i>Odobenus rosmarus</i>	MMPA-P	No	Yes	No	Inhabits continental-shelf waters of Bering and Chukchi Seas. Found occasionally in Beaufort Sea as stragglers in summer.
Sea otter	<i>Enhydra lutris</i>	MMPA-P	No	No	Yes	Occurs in nearshore waters from Aleutian Islands to California. More than 90% of the world's population occurs in Alaskan waters from the Aleutian Islands to southeastern Alaska. The Aleutian Island distinct population segment is considered a candidate for listing, and the Alaskan stock has been petitioned for listing as depleted under the MMPA.
Polar bear	<i>Ursus maritimus</i>	MMPA-P	No	Yes	No	Ranges widely year-round across entire Beaufort Sea area on land, fast ice, and pack ice. Occurs at low population density throughout its range.

^a Notation: ESA = listed under the Endangered Species Act with the following qualifiers, E = endangered, T = threatened, D = delisted, DM = delisted but being monitored; MMPA = listed under the Marine Mammal Protection Act, with the following qualifiers, D = depleted, P = protected; AK-SC = Alaska species of special concern.

Sources: Angliss et al. (2001); Ferrero et al. (2000); Hall (1979); USFWS (1999a,c, 2001a,b); Page and Gill (1994); Ambrose et al. (1988); Cade (1960); Armstrong (1995).

3.22.1.1 Spectacled Eider

Spectacled eiders are diving ducks that nest in arctic Russia and western and northern Alaska and winter in the Bering Sea; they spend most of their year in marine waters (USFWS 1999a). This species was listed under the ESA as threatened throughout its range in 1993 (58 FR 27474). Reasons for decline of the spectacled eider are not well understood, but lead poisoning from the ingestion of spent shot; subsistence hunting; predation by foxes, gulls, and ravens whose populations are enhanced near human settlements; contaminants; commercial fishing; and complex changes in the food web of marine wintering areas have been suggested as possible contributing factors or obstacles to recovery (USFWS 1996, 1999a). The spectacled eider is the ESA-listed species that is most likely to occur in the vicinity of the TAPS (only along the northernmost segment on the Arctic Coastal Plain).

The USFWS recently designated critical habitat for the spectacled eider in Alaska (66 FR 9146). These areas include (1) breeding areas of the Yukon–Kuskokwim Delta (1,078 mi²), (2) molting areas of Norton Sound (4,087 mi²), (3) molting areas of Ledyard Bay (5,390 mi²), and (4) wintering areas in the Bering Sea adjacent to St. Lawrence Island (28,436 mi²). The spectacled eider was originally listed because of drastic declines (96%) on breeding areas in the Yukon–Kuskokwim Delta. It is not known if such a decline has occurred on the North Slope, but this portion of the population is relatively stable at present (Larned et al. 2001). The breeding population on the North Slope is currently the largest breeding population of this species in North America, but because the area is much larger than that of the Yukon–Kuskokwim Delta, population density is lower (USFWS 2001a).

Spectacled eiders nest in low-lying, coastal arctic and subarctic wetlands dominated by grasses and sedges with numerous shallow ponds and lakes (USFWS 1999b). Nests are located near water. On their nesting grounds, spectacled eiders feed primarily by dabbling in shallow fresh or brackish ponds or flooded tundra (USFWS 1999b). Foods taken include mollusks, insects, crustaceans, and seeds,

especially those of pondweed. The winter diet is less well known but apparently includes amphipods, mollusks, and crabs (USFWS 1999b).

Spectacled eiders return from their wintering grounds to northern Alaska in late May or early June. Males leave in mid- to late June at the onset of nesting, while females leave from late June through mid-September, depending on their breeding success. After leaving the coastal plain, spectacled eiders molt in a few locations in eastern Russia or Ledyard Bay in northwestern Alaska before continuing on to staging areas near St. Lawrence Island and wintering areas in the central Bering Sea (Petersen et al. 1999; TERA 1999). Spectacled eiders from all three main breeding areas (Yukon–Kuskokwim Delta, North Slope, and arctic Russia) congregate during the winter in a 3,000-mi² area of the Bering Sea (USFWS 2001a). Additional information on breeding biology and status of the spectacled eider is summarized in reports by the USFWS (1996, 2001a).

The abundance of spectacled eiders decreases from west to east across the Arctic Coastal Plain of Alaska. Most high-density areas are over 100 mi west of PS 1, and relatively few spectacled eiders occur east of the Shaviovik River to the east of TAPS (Larned et al. 1999). About 100 pairs of spectacled eiders occur in the Prudhoe Bay area (TERA 1997). Larned et al. (2001) summarized spectacled eider abundance across the Arctic Coastal Plain. Approximately 40 mi of the ROW is in the region surveyed, and spectacled eider abundance in the ROW area was considered relatively low. Larned et al. (2001) indicated that the best habitats for spectacled eiders along the TAPS were at the northernmost end, near PS 1. Surveys of the TAPS region south to approximately MP 7 from 1991 to 1997 (TERA 1996, 1997) found a few spectacled eiders near the TAPS ROW but none within 0.6 mi. Spectacled eiders may occur farther south than the areas covered by current surveys, although densities probably are low. Along the TAPS, the southernmost report of a spectacled eider is at MP 12 (Hohenberger et al. 1981).

3.22.1.2 Steller's Eider

The Steller's eider is a diving duck that occurs in three distinct breeding populations — two in Russia (Atlantic and Pacific) and one in Alaska. Most of the world's population of Steller's eider nest in arctic Russia and winter in waters adjacent to the Alaska Peninsula (USFWS 2001b). These ducks spend most of the year in shallow, nearshore marine waters (USFWS 1999c). The Alaska population breeds along the western and northern coast of the state.

The Alaska breeding population of the Steller's eider was listed as threatened in 1997 (59 FR 35896) because of a substantial population decline (Kertell 1991; Quakenbush and Cochrane 1993). Reasons for that decline are not known, but possible factors include lead poisoning from the ingestion of spent shot, especially in the Yukon–Kuskokwim Delta; hunting; predation by ravens, gulls, and foxes in breeding areas; increased shipping traffic and disturbance of feeding flocks in marine areas; and contaminants affecting food availability in the Bering Sea (USFWS 1999c). Disturbance and loss of nesting habitat from oil and gas development may have occurred in Siberia (USFWS 1999c).

Critical habitat for the Steller's eider was recently designated by the USFWS (2001b) in the following areas: (1) breeding areas of the Yukon–Kuskokwim Delta (989 mi²); (2) molting and staging areas of Kuskokwim Shoals (1,472 mi²); (3) molting and staging areas of Seal Islands (24 mi²); (4) molting and wintering areas of Nelson Lagoon (206 mi²); and (5) molting and wintering areas of Izembek Lagoon (140 mi²). All of these areas are in southwestern Alaska on the coast of the Bering Sea, away from the TAPS. The TAPS ROW and facilities are east of this area.

The historic breeding range of the Steller's eider was discontinuous from the Aleutian Islands, the Alaska Peninsula, the Yukon–Kuskokwim Delta, and the Seward Peninsula; in northwestern Alaska from Point Lay to Barrow; across most or all of the Arctic Coastal Plain of northern Alaska; and across most of arctic Russia (Kertell 1991; Quakenbush et al. 2000). Currently, most Steller's eiders in Alaska breed

primarily near Barrow, but the total breeding range probably extends from Point Lay to near the Colville River Delta (Day et al. 1995; Quakenbush et al. 1995).

Steller's eiders spend most of the year in shallow, nearshore marine waters where they feed by diving and dabbling for benthic organisms (USFWS 1999b). Foods of the Steller's eider include amphipods, crabs, mussels, clams, snails, insects, and some plant material. Information on their preferred nesting habitat is sparse. On the Yukon–Kuskokwim Delta, they historically nested in the vegetated intertidal zone of the central delta (King and Dau 1981). In arctic Alaska, they nest in low-centered polygons and shallow ponds with emergent grasses and sedges, wet meadows, lakes, and drained lake basins (Quakenbush and Cochrane 1993; Quakenbush et al. 2000; Obritschkewitsch et al. 2001). After the breeding season, Steller's eiders migrate to sheltered estuaries along the coast of the Bering Sea, where they molt (USFWS 1999b). Most of the world's Steller's eider population spends the winter in shallow, nearshore, marine habitats along the Alaska Peninsula and from the eastern Aleutian Islands to Kodiak Island and lower Cook Inlet (USFWS 1999b,c, 2001b).

The Steller's eider has been recorded occasionally in the Prudhoe Bay area, and a female with young was seen in that area in 1993 (USFWS 1998b). During the summer, Steller's eiders are likely to occur only at the northernmost end of the TAPS near Prudhoe Bay. In winter, small groups are occasionally found in the Gulf of Alaska and Prince William Sound (USFWS 1998b) and are regularly found during annual Christmas Bird Counts near Kodiak Island and in lower Cook Inlet (USFWS 1998b). A few individuals have been seen near Prince William Sound (near Seward and Cordova) but not in any other areas of the Sound (USFWS 1998b).

3.22.1.3 Eskimo Curlew

Once numerous, the Eskimo curlew is now either extinct or on the verge of extinction (Page and Gill 1994). Although it was observed regularly in northern Alaska, nesting was never documented (Gabrielson and Lincoln 1959).

Potential breeding habitat occurs in a narrow band along the northern foothills of the Brooks Range (Gill et al. 1998).

In the mid 1800s, huge flocks of Eskimo curlews migrated between nesting areas in the Arctic and wintering grounds in South America. The Eskimo curlew population had already declined to low numbers before its distribution or much of its breeding biology was described (Gollop et al. 1986). The last documented sighting of an Eskimo curlew was in Texas in 1962 (Ambrose 2002). The cause of the Eskimo curlew's decline is unknown, but over-hunting, habitat change through conversion of wintering and staging areas to agriculture, changes in prey availability, and climate change have been suggested as factors (Faanes and Senner 1991). Of these, the only factor that may have operated on the breeding grounds was climate change, including colder conditions (perhaps resulting in poor reproduction) during the period of decline.

3.22.1.4 Arctic Peregrine Falcon

The Arctic peregrine falcon, formerly listed as endangered and then reclassified as threatened, was delisted on October 5, 1994 (59 FR 50796). For a 5-year period after delisting, the USFWS monitors populations to ensure that the species is secure. During the monitoring period, the species is treated similarly to a candidate for listing. The USFWS identifies the Arctic peregrine falcon as a delisted species that is undergoing monitoring.

Arctic peregrine falcons nest in northern Alaska from the U.S.-Canada border to Norton Sound on the Bering Sea. They occur along the TAPS ROW on the Sagavanirktok River and its tributaries between late April and mid-September. Incubation of eggs begins in late May, hatching occurs in early July, and young fledge in late August (Cade 1960; Ritchie 1987). Arctic peregrine falcons winter mainly in South America (Hickey and Anderson 1969). Peregrines are primarily cliff-nesters and regularly use river bluffs and cliffs in the northern foothills of the Brooks Range (Cade 1960). They occasionally use lower-quality habitats, such as low coastal bluffs and banks of lakes and rivers

on the Arctic Coastal Plain. They prey mainly on birds.

Nesting Arctic peregrine falcons have been recorded on the Sagavanirktok River within 1 mi of the TAPS ROW. The Colville River and its tributaries and the Sagavanirktok River are the core breeding areas for peregrines in northern Alaska. Concentration areas for nesting peregrines include Franklin and Sagwon bluffs, but nesting also has been documented as far south as Slope Mountain (Wright and Bente 1999; APSC 1993). During the 1970s, peregrines in northern Alaska were reduced to about 35% of the 1950s breeding population because of pesticides (Ambrose et al. 1988). Fewer than five pairs nested along the Sagavanirktok River in the mid-1970s (Roseneau et al. 1976), but by 1998, the number of nesting pairs along the river had increased to more than 25 pairs (Wright and Bente 1999).

3.22.1.5 American Peregrine Falcon

The American peregrine falcon, formerly listed as endangered and reclassified as threatened, was delisted on August 25, 1999 (64 FR 46542). For a 5-year period after delisting, the USFWS will monitor populations to ensure that the species is secure. During the monitoring period, the species is treated similarly to a candidate for listing. The USFWS identifies the American peregrine falcon as a delisted species that is undergoing monitoring.

The American peregrine falcon occurs throughout much of North America from the subarctic boreal forests of Alaska and Canada south to Mexico. In Alaska, their range is restricted primarily to the interior portions of the state (Ambrose et al. 1988). They occur along the TAPS ROW south of the Brooks Range and nest in the Yukon River basin along the Yukon, Koyukuk, and Tanana Rivers and their tributaries. Nesting has not been documented south of the Alaska Range along the TAPS, although suitable habitat appears to be present (Cade 1960). Most birds that breed in Alaska winter in South America.

American peregrine falcons are present in Alaska from late April to late September.

Incubation begins in mid-May; young hatch in late June and fledge in August. American peregrine falcons nest on riparian cliffs and dirt bluffs in the area, but occasionally use rock outcrops in uplands adjacent to major rivers (Ritchie and Rose 1999). Peregrine falcon nesting areas near the TAPS ROW include the middle Yukon River, the Tanana River between Fairbanks and Delta Junction, and some tributaries in the Tanana-Yukon uplands (White et al. 1977). Nesting habitat for peregrines and other raptors includes Grapefruit Rocks near the pipeline at MP 417–418 between Livengood and Fairbanks.

Between the late 1960s and 1985, the American peregrine falcon population in Interior Alaska declined to at least 55% of historical numbers (Ambrose et al. 1988). The lowest levels occurred in the 1970s, and numbers began to increase by the late 1970s. The population has continued to increase and presently exceeds the population size of the 1960s (Haugh 1976; Ritchie et al. 1998).

3.22.2 Beaufort Sea

Although the Beaufort Sea is not in the direct region of influence of the TAPS, listed and protected species that occur there are discussed in this section because they could be affected by the cumulative impact of the TAPS and other activities on the North Slope (Table 3.22-1). The Beaufort Sea supports several marine mammals that are listed under the ESA or that are protected by the MMPA. These species are the focus of this section. The spectacled eider, Steller's eider, and Arctic peregrine falcon, listed under the ESA (or in the case of the peregrine falcon, recently delisted), could occur on the coast of the Beaufort Sea. They are discussed in Section 3.22.1.

Marine mammals that occur regularly in the Beaufort Sea include the bowhead whale, gray whale, beluga whale, Pacific walrus, spotted seal, ringed seal, bearded seal, and polar bear. Each of these species is discussed in this section. In addition, the harbor porpoise, killer whale, and ribbon seal reach the northern limit of their summer distribution in the northeastern Chukchi Sea, occurring irregularly and in low numbers in the extreme western part of the

Listed Species Most Likely to Occur in Beaufort Sea

Spectacled eider: ESA listed as threatened.

Steller's eider: ESA listed as threatened.

Bowhead whale: ESA listed as endangered; MMPA listed as depleted.

Ten additional species of marine mammals are known to occur or could occur in the Beaufort Sea and are protected under the MMPA.

Beaufort Sea near Point Barrow. Others, such as the Pacific walrus and spotted seal, occur regularly in the western Beaufort Sea and decrease markedly farther east, the former mainly as individual stragglers east of Pitt Point and the latter as stragglers east of Oliktok Point. Ringed seals, bearded seals, and polar bears, all of which move extensively, are present year-round. Bowhead and beluga whales are normally present from late April to mid-October. Bowhead whales, bearded seals, ringed seals, and polar bears are important subsistence species for hunters from Barrow, Nuiqsut, and Kaktovik. Beluga whales are taken sporadically when available.

3.22.2.1 Bowhead Whale

Bowhead whales are found in seasonally ice-covered areas of the Arctic and near-Arctic (Angliss et al. 2001). Five stocks are recognized; the Bering Sea (Western Arctic) stock is the largest of the five designated stocks of this species and the only stock found in U.S. waters. The Western Arctic stock is classified under the ESA as endangered and under the MMPA as depleted. A recent analysis indicates that delisting of the Western Arctic stock is warranted (Shelden et al. 2001).

The Western Arctic stock was estimated at 10,400 to 23,000 whales before decimation by the commercial whaling industry in the last half of the 19th century, and perhaps 3,000 when whaling ended in 1914 (Woodby and Botkin 1993). This stock has slowly increased since then and in 1993 was estimated at 8,000 whales

(Zeh et al. 1994). The estimated rate of increase from 1978 to 1993 was 3.2% (Zeh et al. 1996) and occurred despite continued harvest and industrial activity in the Beaufort Sea. The bowhead whale continues to be an important subsistence resource, and 44 to 66 bowheads have been harvested annually in Alaska since 1993.

Bowhead whales winter in the Bering Sea, migrate north in spring, and summer in a broad area from Amundsen Gulf and the eastern Beaufort Sea to the eastern part of the East Siberian Sea. The spring migration begins in late March to early April, depending on ice conditions. The first bowhead whales usually arrive near Barrow in mid-April, but ice cover can affect the date of arrival (Krogman et al. 1989). From there, bowhead whales travel to the eastern Beaufort Sea, where they spend the summer feeding on zooplankton. An unknown portion of the population migrates along the Russian coast to feeding grounds in the western Chukchi Sea (Bogoslovskaya et al. 1982). Whales that summer in the eastern Beaufort Sea begin the first part of the fall migration in late August or early September and are usually out of the Beaufort Sea by late October (Treacy 1988-1998; Moore and Reeves 1993). The number of bowhead whales in the Alaskan portion of the Beaufort Sea is relatively low except during spring and fall migration.

Increased oil and gas exploration and development in the Arctic will increase the risk of adverse effects on bowhead whale populations (Angliss et al. 2001). Bowhead whales appear to be sensitive to noise from offshore drilling platforms and seismic survey operations (Angliss et al. 2001; Richardson et al. 1995) and actively avoid seismic operations during their fall migration (Angliss et al. 2001). The fact that the bowhead whale population has increased in size over the last several decades suggests that the impacts of the oil and gas industry on individual survival and reproduction are likely to be minor (Angliss et al. 2001).

3.22.2.2 Gray Whale

The gray whale occurs as two stocks in the North Pacific Ocean — the western North Pacific

(“Korean”) stock, which breeds off the coast of eastern Asia, and the eastern North Pacific stock, which breeds along the west coast of North America. All populations of the gray whale were formerly listed as endangered under the ESA, but the eastern North Pacific population was delisted in 1994 (59 FR 31094) because it had recovered to its historic size (USFWS 1994a). Although protected by the MMPA (as are all whale species), the gray whale in the eastern North Pacific is not considered depleted. The most recent stock assessment indicated that the eastern North Pacific population has been increasing in recent years and is neither in danger of extinction nor likely to become endangered in the foreseeable future (Angliss et al. 2001).

Most of the eastern North Pacific stock of the gray whale spends the summer feeding in the northern Bering, Chukchi, and Beaufort Seas (Angliss et al. 2001). Gray whales feed primarily on benthic amphipods, but they also eat other benthic and pelagic invertebrates (Rice and Wolman 1971; Nerini 1984). Starting in October or November, these whales migrate from Alaska to their primary wintering and calving area along the west coast of Baja California. Their summer distribution is mainly limited to shallow waters of the continental shelf. During the summer, gray whales are abundant in the northeastern Chukchi Sea but occur irregularly in the Beaufort Sea. During annual whale surveys of the Beaufort Sea from 1987 to 1997, Treacy (1988-1998) saw gray whales in only 2 years. In 1988, a carcass washed on shore east of Deadhorse, and three animals were entrapped in newly formed shore ice at Point Barrow. In October 1997, three groups totaling nine whales were seen near Point Barrow. On occasion, gray whales occur farther east. Alaska Native hunters near Cross Island killed a gray whale in 1933; 30 were seen near Cooper Island, 21 mi east of Point Barrow, in October 1972; one was seen near Barter Island in September 1975; and three were reported off Tuktoyaktuk, Canada, in August 1980 (Maher 1960; Marquette and Braham 1982). These more recent sightings may reflect the increase and recovery of this once-depleted species, now estimated to number about 26,600 (Angliss et al. 2001).

3.22.2.3 Beluga Whale

Beluga whales are distributed throughout seasonally ice-covered Arctic and sub-Arctic waters of the Northern Hemisphere (Angliss et al. 2001). Five stocks are recognized in Alaskan waters — Beaufort Sea, Eastern Chukchi Sea, Eastern Bering Sea, Bristol Bay, and Cook Inlet. Only the Cook Inlet beluga whale stock is considered depleted. They are not listed as threatened or endangered under the ESA.

Beluga whales may occur in both offshore and coastal areas, depending on season (Angliss et al. 2001). In summer, concentrations are found in Cook Inlet, Bristol Bay, Norton Sound, Kasegaluk Lagoon, and the Mackenzie Delta. Most beluga whales from these areas overwinter in the Bering Sea, but those from Cook Inlet overwinter in the Gulf of Alaska. In winter, belugas occur offshore and in association with pack ice. In spring, they migrate to warmer coastal estuaries, bays, and rivers for molting and calving. Annual migrations can cover more than 1,000 mi.

Beluga whales are usually found in the Beaufort Sea from April to November, but they rarely overwinter there. Most beluga whales spend the summer in the eastern Beaufort Sea and Amundsen Gulf, but they are present in low numbers across the entire region. During early summer, they are common in the warm waters of Mackenzie, Kugmallit, and Liverpool Bays. Others occur in open water and in the distant pack ice (Harwood et al. 1996). Most young are born from mid-June to mid-July and nurse for 12 to 18 months (Burns and Seaman 1985). When migrating to wintering areas in the Bering Sea, most belugas travel in or near the front zone of the pack ice, but also through open water from the offshore ice margin to the coast (Burns and Seaman 1985; Treacy 1988-1998).

The Beaufort Sea stock, identified on the basis of where they spend the summer, is estimated to number about 39,000 whales (Angliss et al. 2001). The population is considered stable or increasing. Estimated annual subsistence take from the Beaufort Sea stock in Alaska and Canada is 184.

Belugas of the Eastern Chukchi stock, estimated at about 3,700 animals (Small and

DeMaster 1995; Angliss et al. 2001), now summer mainly in and near the 170-km-long Kasegaluk Lagoon system near the settlement of Point Lay (Frost et al. 1993). At least some, and perhaps all, of these whales move north into the Beaufort Sea during late July to early August (Burns and Seaman 1985), at about the same time animals of the Beaufort Sea stock begin migrating west.

The responses of beluga whales to noise and disturbance are highly variable. Responses appear to be related to such factors as experience of the whales, activities of the whales, and type of disturbance. They have frequented areas near Anchorage port facilities in which small boat traffic was heavy. In Bristol Bay, they feed among the salmon fishing boats. In other areas they continue to return to favored bays and river mouths in spite of extensive hunting pressure. In deep ice-covered waters during spring, they swam away from large ships and icebreakers as far away as 35 to 50 km. In general, belugas are more tolerant of disturbance in open water than when their movements are constrained by sea ice (Burns and Seaman 1985; Cosens and Dueck 1993; Richardson et al. 1995).

3.22.2.4 Pacific Walrus

Pacific walrus mainly inhabit the continental shelf waters of the Bering and Chukchi Seas, where they feed on benthic organisms. They occasionally move into the eastern East Siberian Sea and the western Beaufort Sea (Ferrero et al. 2000). During the late winter breeding season, walrus occur in two major concentration areas of the Bering Sea (one in the Gulf of Anadyr and one in the southeastern Bering Sea). During the summer, most of the population migrates into the Chukchi Sea; however, thousands of animals, primarily adult males, congregate on or near terrestrial haulouts in the Gulf of Anadyr and in Bristol Bay.

All Pacific walrus are thought to belong to a single stock (Ferrero et al. 2000). Population estimates vary from year to year but have consistently been about 200,000 to 250,000 animals. The current population trend is not known, but the population has increased from a low of about 100,000 in the 1950s. The

walrus is an important subsistence resource. An estimated 7,300 walrus were killed annually over the past four decades, but this number decreased in the 1990s. Although protected by the MMPA, the Pacific walrus is not considered depleted and is not listed as threatened or endangered under the ESA.

The usual eastern distribution limit of the Pacific walrus is in the vicinity of Point Barrow (Brooks 1954), although small numbers do move farther east. In most years, a relatively few walruses enter the Beaufort Sea and stay for a short period of time because the pack ice recedes north, well beyond the narrow continental shelf on which they forage. In the central Beaufort Sea, walruses are beyond the margin of their normal range and occur only occasionally and usually as individuals. In years when sea-ice remains near shore in summer, small herds occur as far east as Cape Simpson; individual stragglers have been observed as far east as the Yukon Territory in Canada (Bee and Hall 1956; Harington 1966; Youngman 1975).

3.22.2.5 Spotted Seal

Spotted seals occur along the continental shelf of the Beaufort, Chukchi, Bering, and Okhotsk Seas and south to the northern Yellow Sea and Sea of Japan (Angliss et al. 2001). Spotted seals migrate from the Chukchi Sea in October and pass through the Bering Strait in November. They overwinter in the Bering Sea along the ice edge. During spring, they are found along the southern margin of the ice and move into coastal habitats as the ice retreats.

All spotted seals are thought to belong to a single stock (Angliss et al. 2001). Reliable population estimates are not available; however, earlier estimates indicated that the Bering Sea population was about 200,000 to 250,000 animals. Spotted seals are an important species for Alaskan subsistence hunters, and estimated annual harvests range from 850 to 3,600 seals. They are not listed as a depleted stock under the MMPA, nor are they listed as threatened or endangered under the ESA.

Spotted seals occur in the coastal zone of the Beaufort Sea every summer, especially in the western and west-central portions. Spotted

seals arrive after ice has cleared from the bays (usually July), and they depart with the onset of freezeup in early October. These far-ranging seals feed at sea, in coastal bays and lagoons, and in rivers during periods of high fish concentrations. They haul out on islands and sandbars. Haulout areas that are used regularly include Oarlock Island in Dease Inlet; areas of Smith Bay near the mouth of the Ikpikpuk River; and in the Colville River Delta. A few regularly ascend the Colville River as far upstream as the confluence of the Itkilik River.

3.22.2.6 Ringed Seal

Ringed seals have a circumpolar distribution and occur in all seas of the Arctic Ocean (Angliss et al. 2001). They are found in ice-covered waters and remain in contact with ice most of the year. They give birth on the ice in late winter and early spring. Ringed seals occur throughout the Beaufort, Chukchi, and Bering Seas as far south as Bristol Bay in years of extensive ice covering. An apparent overall northward movement occurs as the ice retreats in the spring and summer.

The entire ringed seal population in U.S. waters is considered one stock (Angliss et al. 2001). A reliable population estimate is currently not available, but rough estimates indicate the population is between 1 million and 3.6 million animals. Current population trends are not known, although there is no indication that the population is declining. Ringed seals are not listed as depleted under the MMPA or as threatened or endangered under the ESA.

Ringed seals are abundant and present year-round in the Beaufort Sea. They are most evident when floating sea ice is present. From autumn to early summer, the highest densities of ringed seals occur in fast-ice habitat. Pups are born from late March to May and are nursed for 4 to 6 weeks (Smith and Stirling 1975; Smith and Hammill 1981; Kelly 1988). Starting in late April, seals of all ages begin to haul out on top of the ice and snow to bask during the annual molt. Basking seals are most numerous in late May-June. Compared with other areas in Alaska, in the Beaufort Sea the density of ringed seals is low and varies annually.

Ringed seals are an important subsistence resource in the Beaufort Sea region (Angliss et al. 2001). Overall, annual harvests have been declining. An estimated 7,000 to 15,000 seals were harvested annually from 1962 to 1972, but by 1979 this number had dropped to about 2,000 to 3,000 in 1979 and 3,000 during the mid-1980s. A current reliable estimate of the annual harvest is not available.

3.22.2.7 Bearded Seal

Bearded seals have a circumpolar distribution that extends from the Arctic Ocean to Hokkaido in the western Pacific and generally in relatively shallow waters that are seasonally ice covered (Angliss et al. 2001). In Alaskan waters, bearded seals are found over the continental shelves of the Bering, Chukchi, and Beaufort Seas. Many of the seals that winter in the Bering Sea migrate north from late April through June and spend the summer along the ice edge in the Chukchi Sea. Bearded seals rarely haul out onto land.

The entire bearded seal population is considered one stock (Angliss et al. 2001). A reliable population estimate for the bearded seal is currently not available, but estimates from the 1970s indicated that the Alaskan population ranged from 250,000 to 300,000. Current population trends are not known, although there is no indication that the population is declining. Bearded seals are not listed as depleted under the MMPA or as threatened or endangered under the ESA.

Bearded seals are present year-round in the Beaufort Sea. They are considered common although not abundant during late spring through early autumn; relatively fewer occur during the months of heavier ice cover. Bearded seals are found in areas of moving ice where it overlies waters less than about 500 to 650 ft deep. In winter, they occur infrequently in the areas of fast ice (Burns and Harbo 1972; Frost et al. 1989; Frost and Lowry 1999). Bearded seals are benthic feeders.

Bearded seals are an important resource for Alaskan subsistence hunters (Angliss et al. 2001). The estimated average annual harvest from 1966 to 1977 was 1,784 seals. Reliable

information on the current average annual harvest is not available. Relatively few are taken in the Beaufort Sea, except near Point Barrow.

3.22.2.8 Polar Bear

Polar bears have a circumpolar distribution in the Northern Hemisphere (Angliss et al. 2001). Two stocks are recognized in Alaska — the Beaufort Sea stock and Chukchi/Bering Sea stock. The Beaufort Sea stock ranges from Point Hope in the west to Bailie Islands, Canada, in the east. An area of overlap between the Beaufort Sea stock and the Chukchi/Bering Seas stock occurs between Point Barrow and Point Hope, centered near Point Lay. Polar bears occur at low densities throughout their range and range widely over large areas.

Accurate estimates of the size of the Beaufort Sea population have been difficult to obtain, but the current estimate is 1,765 bears (Ferrero 2000). This stock has increased at an estimated annual rate of 2% or more since passage of the MMPA in 1972 and is thought to now be at or near carrying capacity (Amstrup 1995; USFWS 1995). The average density in the region from Point Barrow to Cape Bathurst was estimated to be one bear per 141 to 269 km² in 1986 (Amstrup et al. 1986). Subsistence hunting results in an average annual take of about 32 animals (1.9% harvest rate) (Ferrero 2000). The polar bear is not listed as depleted under the MMPA or as threatened or endangered under the ESA.

In the Beaufort Sea, polar bears are present year-round, although their distribution shifts seasonally. Polar bears are widely distributed, occurring on land, fast ice, and pack ice. They are most abundant in areas where their principal prey (ringed seals) is most available. In summer, they are found mainly on the distant pack ice, although they are occasionally seen on land or swimming in open water at a considerable distance from the ice. In autumn, as the ice comes closer to the coast, some polar bears swim to shore and scavenge beached carcasses or the remains of bowhead whales taken by subsistence hunters.

Polar bears do not hibernate, but are active all winter. Pregnant females make dens in deep

snowdrifts during late October to November. Of 90 dens in the Beaufort Sea region reported by Amstrup (1995), 48 were on drifting pack ice, 38 were on land, and 4 were on shoreline ice. Each female usually produces two cubs annually in December or January. Mother and cubs emerge from dens in late March to early April, and those that were on land go to sea. There has been continuing concern about the effects of anthropogenic disturbances on bears in maternity dens, but Amstrup (1995) reported that disturbances associated with capture and marking of study animals did not affect litter sizes or the growth and condition of cubs.

3.22.3 Prince William Sound

The Valdez Marine Terminal is located at the southernmost end of the TAPS on the coast of Port Valdez, an arm of Prince William Sound. Listed and protected species that are known to occur or could occur on Prince William Sound are listed in Table 3.22-1. Prince William Sound supports several marine mammals that are listed under the ESA or that are protected by the MMPA. Those species are discussed in this section. The Steller's eider, Arctic peregrine falcon, and American peregrine falcon, listed under the ESA (or in the case of the peregrine falcons, recently delisted) are discussed in Section 3.22.1.

Listed Species Most Likely to Occur in Prince William Sound

Steller's eider: ESA-listed as threatened.

Humpback whale: ESA-listed as endangered; MMPA-listed as depleted.

Fin whale: ESA-listed as endangered; MMPA-listed as depleted.

Steller sea lion: ESA-listed as endangered; MMPA-listed as depleted.

Nine species of marine mammals are abundant or common in Prince William Sound; other species are uncommon or rare in the Sound and are not discussed here. Species of

marine mammals that inhabit marine waters outside Prince William Sound include blue whale, right whale, sei whale, sperm whale, and fur seal (USACE 1999). Several stocks of chinook salmon, sockeye salmon, and steelhead that spawn in rivers and streams of Washington, Oregon, and Idaho are listed under the ESA as threatened or endangered. As adults, these fish occupy oceanic habitats that include Alaskan waters. Green, loggerhead, leatherback, and Olive Ridley sea turtles are also ESA-listed and occasionally enter Alaskan waters. These fish and turtle species are unlikely to enter Prince William Sound and are not discussed here.

Killer whales are found worldwide in all major oceans but favor the colder waters of both the Northern and Southern Hemispheres (Matkin et al. 1997; Angliss et al. 2001). Of four species of whales common to Prince William Sound, the killer whale is the only toothed whale and feeds primarily on marine mammals and fish (Calkins 1986). Killer whales are abundant and present year-round, but the migratory pattern in and out of the Sound probably varies among pods (Dahlheim and Matkin 1994). Of more than 14 pods identified in Prince William Sound, 8 are regularly found there (Matkin et al. 1994).

Four baleen whales occur seasonally in Prince William Sound. Fin, humpback, and gray whales are the largest species to visit the Sound and are migratory. Minke whales are small migratory whales that occur there year-round (Calkins 1986). Fin and humpback whales are listed as endangered under the ESA and depleted under the MMPA. Gray whales migrate to and from the Bering and Chukchi Seas and occur in the Sound in late spring and early fall (Calkins 1986). (A more detailed description of the gray whale is provided in Section 3.22.2.2.) Minke whales summer in the Gulf of Alaska and mostly are seen closer to shore to waters 650 ft deep (Consigliari and Braham 1982). Minke whales generally feed on krill and fish (Tamura et al. 1998).

Dall's and harbor porpoises both are abundant and widespread in Prince William Sound. The Dall's porpoise is the more common species (Calkins 1986; Harvey and Dahlheim 1994). Both species feed on fish and crustaceans (Calkins 1986). Dall's porpoises occur on the continental shelf and slope and

prefer straits, passes between islands, and areas of merging currents (Scheffer 1949; Cowan 1944). Harbor porpoises frequent bays, harbors, and river mouths (Calkins 1986). Both porpoises are more abundant in Prince William Sound in summer than winter (Hall 1979).

3.22.3.1 Humpback Whale

The humpback whale occurs worldwide in all ocean basins but is less common in Arctic waters (Angliss et al. 2001). Historically, the feeding range of humpback whales in the north Pacific included coastal and inland waters around the Pacific Rim from California north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk. In winter, most humpback whales are found in the temperate and tropical waters of the Northern and Southern Hemispheres. In the North Pacific, humpback whales are seasonal migrants and feed on zooplankton and small fish (Kawamura 1980). Commercial harvesting in the 20th century reduced the humpback whale population across much of its range. This species is currently listed as endangered under the ESA and depleted under the MMPA.

Humpback whales are probably the most abundant whales in Prince William Sound, and 60 to 100 individuals feed there during the summer (von Ziegesar et al. 1994). These whales are considered to be part of the Central North Pacific humpback whale stock, which spends winter and spring near the Hawaiian Islands (Angliss et al. 2001). This stock consists of feeding aggregations along the northern Pacific Rim from British Columbia to the far eastern coasts of Russia.

In a 3-year study of humpback whales in Prince William Sound, von Ziegesar (1994) found whales primarily in Knight Island Passage, the southern end of Chenega Island, and the entrances of Icy and Whale Bays. These areas are all in the southwestern portion of Prince William Sound and away from the action area (Port Valdez). These observations are consistent with those of Hall (1979). Humpback whale distributions within Prince William Sound appeared to be determined by abundance of prey and perhaps other factors rather than being

habitual (von Ziegesar 1994). Records of humpback whales in Port Valdez are not available, and use of Port Valdez by humpback whales may be limited or not occur because of its distance from known occupied areas and the open waters of the Gulf of Alaska and because it is at the end of an arm of the Sound.

The overall population estimate for the Central North Pacific stock is about 4,000 individuals, and there is some indication that the population may be increasing (Angliss et al. 2001). Although subsistence hunters in Alaska have not been reported to take humpback whales, an average of 3.5 humpback whales are estimated to be killed annually incidental to commercial fisheries activities (Angliss et al. 2001). Mortality resulting from collisions with ships unrelated to commercial fisheries is estimated to average 0.8 per year (Angliss et al. 2001).

3.22.3.2 Fin Whale

The fin whale occurs in all ocean basins of the world, but it is not common in tropical waters or polar seas with ice. In the North Pacific, fin whales are found from above the Arctic Circle to lower latitudes of approximately 20°N (Angliss et al. 2001). During summer, fin whales occur along the Pacific coast of North America from the Bering Sea to as far south as central Baja California. Their migratory status is unclear, but fin whales have been found during the winter in the area of the Hawaiian Islands and off the California coast (Angliss et al. 2001). Commercial harvesting of fin whales in the 1940s through 1960s greatly reduced the worldwide population and led to listing the species as endangered under the ESA and depleted under the MMPA. Fin whales feed on krill, other crustaceans, and various species of small fish (Nowak 1991).

Fin whales occur in deep water portions of Prince William Sound for a few days each year from April to June during their summer migration to their Bering Sea feeding grounds (Hall 1979). Their distribution in Prince William Sound appears to be limited to the area near the Hinchinbrook Entrance. Although fin whales are transient in Prince William Sound, they are normally relatively abundant and visible (Hall

1979). These whales are considered part of the Northeast Pacific stock, which is distributed along the North Pacific Rim from British Columbia to the far eastern coasts of Russia.

Reliable estimates of the size of the Northeast Pacific stock are not available, but approximately 15,000 individuals have been estimated for the entire North Pacific (Angliss et al. 2001). Subsistence hunters in Alaska have not been reported to take fin whales, and few fin whales have been reported killed incidental to commercial fisheries or other activities (estimated average of 0.6 per year) (Angliss et al. 2001).

3.22.3.3 Steller Sea Lion

Steller sea lions occur along the North Pacific Rim from northern Japan to California, with a center of abundance in the Gulf of Alaska (Angliss et al. 2001). The species is not known to migrate, but individuals disperse widely outside of the breeding season (late May to early June). Two stocks — eastern and western — are recognized in U.S. waters. Rookeries of the eastern stock occur in southeast Alaska, while those of the western stock range from Prince William Sound through the Aleutian Islands (Kruse et al. 2001).

The two stocks have shown very different population trends, with the eastern stock increasing at a rate of 5.9% annually from 1979 to 1997 (Kruse et al. 2001). Over a similar time span, the western stock has declined precipitously (90% at some sites). The western stock of the Steller sea lion is listed as endangered under the ESA and depleted under the MMPA. Although the eastern stock is listed as threatened, its population is at the highest level of recorded abundance, and delisting may be warranted (Kruse et al. 2001). Subsistence hunting results in an annual take of 353 Steller sea lions from the western stock (Angliss et al. 2001).

Male and female Steller sea lions congregate on rookeries from May through July. Older males (at least 9 years of age) defend territories on rookeries to attract females. A single pup is born during mid-May to mid-July, with the peak in mid-June. Steller sea lions

consume a wide range of food items, including fish, squid, octopus, and crustaceans (Hoover 1988). Haulout areas are rocky shorelines, which are used by sea lions for resting. Designated critical habitat for the Steller sea lion includes three haulout areas (Perry Island, Point Eleanor, and the Needle) in Prince William Sound. None of the critical habitat areas for the Steller sea lion occur in Port Valdez, where the Valdez Marine Terminal is located. No Steller sea lion rookeries occur within Prince William Sound.

The minimum population size of the western U.S. stock of Steller sea lion is estimated to be 34,600 animals (Angliss et al. 2001). There are an estimated 3,500 to 4,000 Steller sea lions in and near Prince William Sound (Merrick et al. 1991). From 1986 to 1989 an estimated population decline of 63% occurred in the area from the central Gulf of Alaska, including Prince William Sound, to the central Aleutian Islands (NMFS 1992). At Sugarloaf Island near the Sound the decline from 1956-1957 to 1990 was from 11,963 to between 1,319 and 1,513 animals, or 87 to 89% (Merrick et al. 1991).

The observed population decline resulted first in an emergency listing of the Steller sea lion and then in a reclassification of the western stock of the Steller sea lion from threatened to endangered. The decline continues and there is no indication that it has slowed (Angliss et al. 2001). A team of scientists and stakeholders was convened to review the status of the Steller sea lion in Alaska and possible causes for its decline. The primary cause of the original decline (1970s to 1980s) is thought to have been low survival and birth rates because of undernutrition (Kruse et al. 2001). The cause of undernutrition is not known, but possible explanations include (1) competition for prey with large-scale commercial fisheries; (2) changes in prey abundance, composition, and distribution resulting from climatic change; and (3) ecosystem-level changes resulting from the commercial harvest of predators such as whales and certain fishes (Kruse et al. 2001). The team concluded that declines in the 1990s could not be attributed to humans. They identified two management goals for restoration of the sea lion population: (1) prevent human disturbance of sea lions on land, and

(2) preclude adverse impacts to the composition, density, spatial distribution, and size distribution of prey populations. To achieve these goals, the team recommended establishment of no-approach zones around rookeries and haulout areas and experimental establishment of no-fishing zones (Kruse et al. 2001).

The effect of the Exxon Valdez oil spill on the Steller sea lion is not fully understood. There were a number of indications that sea lions had been exposed to oil from the spill, including (1) observations of sea lions swimming in and near oil slicks, (2) oil observed near numerous haulout sites, (3) fouling of rookeries at Seal Rocks and Sugarloaf Island, and (4) the presence of hydrocarbon metabolites in sea lion tissues (Calkins et al. 1994). However, Calkins et al. (1994) concluded that a population-level effect could not be demonstrated. They found that after the spill, the predicted number of pups and total sea lions on rookeries and haulouts were not significantly different from the actual counts (i.e., the observed numbers were not lower than expected on the basis of long-term trends). They hypothesized that the effects on Steller sea lion may have been less than for other species (e.g., harbor seals and sea otters) because oil did not persist on sea lion rookeries and haulouts since they are located in areas of steep slopes and high surf activity.

3.22.3.4 Harbor Seal

Harbor seals occur in coastal and estuarine waters off Baja California, north along the western coast of the United States, British Columbia, and southeast Alaska, west through the Gulf of Alaska and Aleutian Islands and in the southeastern Bering Sea (Angliss et al. 2001). They haul out on rocks, reefs, beaches, and drifting glacial ice. They are generally nonmigratory. In Alaska, three stocks are recognized — the southeast Alaska, Gulf of Alaska, and Bering Sea stocks (Angliss et al. 2001). The harbor seal is not listed as depleted under the MMPA or as threatened or endangered under the ESA.

Harbor seals are abundant year-round in Prince William Sound, and seals move into and out of the Sound regularly. Although seals use haulouts throughout the year, the highest

numbers of seals occur on haulouts during pupping (mainly May-June) and molting (mainly August-September). The largest concentrations of seals occur at haulouts around the perimeter of the Sound, including the Copper River Delta and the mainland glacial fjords of the Sound's northern and western portions. Harbor seals eat a variety of foods, including fish, crustaceans, squid, and octopus (Calkins 1986; Hoover 1988).

The number of harbor seals in the Gulf of Alaska decreased steadily from the mid-1970s to the 1990s (Angliss et al. 2001). In Prince William Sound, harbor seal numbers declined by 57% from 1984 to 1992. This decline began before the 1989 Exxon Valdez oil spill, was greatest in the year of the spill, and may have been less pronounced afterward. Surveys indicate that the long-term decline of harbor seal numbers in Prince William Sound has not yet ended (Angliss et al. 2001). The current population of the Gulf of Alaska stock is estimated at about 29,200 seals. Subsistence harvest of seals from the Gulf of Alaska stock is common and results in an annual take of 791 seals (Angliss et al. 2001).

In 1989, an estimated 302 seals were "missing" from haulouts that were oiled by the Exxon Valdez oil spill, and 14 dead seals (including 11 newborn pups) were recovered in the Sound following the spill (Williams et al. 1994). That estimate was based primarily on statistical analyses of counts from surveys done during August-September 1988-1992. The missing seals were presumed to have died from the spill (Frost et al. 1994). Indeed, many seals were exposed to the oil (Lowry et al. 1994) and to the massive influx of people and equipment involved in cleanup. Haulouts were oiled, treated, inspected, and studied. Seals were coated with oil, incorporated volatile hydrocarbon compounds into their tissues, and metabolized them, as shown by biochemical indicators (Frost et al. 1994).

The survey-based impact study of Frost et al. (1994) was based on assumptions that molting seals have 100% fidelity to sampled haulouts and that cleanup and other human activities did not displace seals. A review of that study by Hoover-Miller et al. (2001) indicates that the single-year reduction in seals at oiled haulouts could not be used as an estimator of spill-caused mortality. Hoover-Miller et al. (2001)

concluded that fewer seals probably died as a result of the spill, and that the effects of the spill were limited and transitory and were overshadowed by the overall continuing decline in the harbor seal population.

3.22.3.5 Sea Otter

In North America, sea otters occur from the Aleutian Islands to California, with much of the world's population occurring in Alaskan waters (Angliss et al. 2001). They are distributed in Alaska from the Aleutian Islands to southeast Alaska, but there are certain portions of the Aleutian Islands, Kodiak Archipelago, northern Gulf of Alaska, and southeastern Alaska where they are relatively uncommon.

Sea otters occupy shallow coastal areas (less than 180 ft deep) (Kenyon 1969). They are gregarious, but adult males defend territories within female-dominated areas. Groups of more than 1,000 individuals have been observed (USFWS 1994b). Reproductive activity can occur throughout the year, but pupping tends to be concentrated in late spring and early summer. Females usually give birth to a single pup annually. In Prince William Sound, sea otters feed on a variety of bivalves, crustaceans, and other invertebrates in the nearshore area (Calkins 1978; Garshelis 1983; Doroff and Bodkin 1994; Johnson and Garshelis 1995).

Those otters that occur in Alaska are currently managed as a single stock, but multiple stocks may exist (Angliss et al. 2001). Alaskan sea otters are members of a northern sea otter subspecies. Within this subspecies, the USFWS considers the Aleutian population to be a distinct population segment, which it currently considers a candidate for listing under the ESA (66 FR 54808). The Center for Biological Diversity recently petitioned the USFWS to add the Aleutian population of sea otters to the ESA list of endangered species and to list the Alaska stock of the sea otter as depleted under the MMPA (Center for Biological Diversity 2000).

Calkins and Schneider (1985) estimated the 1976 Alaskan sea otter population at 100,000 to 150,000 individuals. The current population is estimated to be in that range, with a minimum population of 100,000 (Angliss et al. 2001). In 1994, the number in Prince William Sound was estimated at 14,352 (Angliss et al. 2001). The Alaska sea otter population generally has grown and expanded since commercial harvesting stopped in 1911. Subsistence harvest continues in Prince William Sound and other portions of southcentral Alaska; the mean annual subsistence take was 297 otters from 1996-2000 (USFWS 2002). Population growth in Prince William Sound was disrupted by the earthquake in 1964 and the Exxon Valdez oil spill in 1989 (Estes 1991; Johnson and Garshelis 1995; Garshelis and Johnson 2001).

Activities associated with oil and gas exploration, development, and transportation can adversely affect sea otters and their habitat (Angliss et al. 2001). It is estimated that approximately 2,650 sea otters were killed in Prince William Sound as a result of the Exxon Valdez oil spill; 3,905 otters were estimated to have been killed as a result of the spill in Alaska as a whole (Angliss et al. 2001). By 1993, chronic effects to sea otters may have been subsiding, and recovery of the affected population appeared to be underway (Angliss et al. 2001). The overall population in western Prince William Sound has increased over the 1990s (Monson et al. 2000), and various indicators suggest the sea otter population in spill-affected areas was recovering a few years after the spill (Johnson and Garshelis 1995). The Exxon Valdez Trustee Council (2002a) considers the sea otter population to still be recovering from effects of the oil spill, because the number of otters in heavily oiled bays of the Western Sound has not returned to prespill numbers. Concerns continue over demographic effects from the initial exposure to the oil spill and over the toxicological effects of residual oil several years after the spill (Monson et al. 2000; Dean et al. 2000) in areas that were heavily oiled.

3.23 Economics

Although the TAPS can be physically identified as a separate part of the oil production and transportation system for North Slope oil, such a distinction is not easily made from an economic standpoint. Oil production, pipeline operation, and marine transportation all function as interconnected elements of the North Slope oil production and delivery system, and the economic impacts of each element are not easily separated. The system as a whole provides benefits to the economies of the state and the nation and fiscal benefits to state and local governments.

Given the relative importance of the North Slope oil production and transportation system to the Alaskan economy, the economic and fiscal benefits of the TAPS are experienced throughout the state. This description of the economic affected environment therefore focuses on describing existing economic and fiscal conditions in the state as a whole, with less emphasis placed on the pipeline corridor region through which the TAPS transports oil from the North Slope oil fields to the Valdez Marine Terminal.

The following description of the affected economic environment for the TAPS is intended to establish the appropriate baseline conditions for analyzing the impacts of (1) renewing the Federal Grant for the ROW for 30 years (proposed action alternative), (2) the time-dependent alternative (less-than-30-year renewal alternative), and (3) the nonrenewal alternative (no-action alternative) and for analyzing cumulative impacts. For the national economy, this section describes trends in the contribution of North Slope oil to domestic oil production, reduced foreign oil dependency, the balance of trade, federal tax revenues, and the marine transportation sector. For the state economy, this section describes of the state, trends in population, gross state product, employment, personal incomes, and state and local government revenues and expenditures over the current Federal Grant period, 1978–2003. For the pipeline corridor region, which consists of the six boroughs and census areas in which the TAPS is located as well as Anchorage (Map 3.23-1), this section describes

trends in population, employment, and personal income. Since movements in each of these indicators of economic activity in the state follow closely the fortunes of the oil industry in the state, the next section provides a brief description of trends in North Slope oil production and world oil prices.

3.23.1 North Slope Oil Production and World Oil Prices

Oil production in Alaska is dominated by production from the North Slope fields. Minor production also occurs in Cook Inlet, which averaged 2.5% of total Alaska oil production between 1990 and 2000 (Alaska Department of Revenue 2002). Production from the North Slope oil fields and the transportation of crude to Valdez through the TAPS began in 1977, with a peak of 2.038 million bbl/d in 1988. Production has subsequently declined, with average daily production currently at 1.045 million bbl/d, 51% of its 1988 peak level (Table 3.23-1). After peaking in early 1981 at \$70/bbl in 2000 dollars (\$37/bbl in 1981 dollars), oil prices have fluctuated, reaching an all-time low of \$13/bbl (in 2000 dollars) in 1998 (\$12/bbl in 1998 dollars), 18% of the 1981 peak level (Table 3.23-1) (DOE 2001a). Prices have rebounded slightly since 1998 and currently stand at \$27/bbl (October 2002).

3.23.2 National Economic Issues

Oil production from the North Slope fields has made a significant contribution to the national economy through its contribution to producing domestic oil, reducing dependency on foreign oil, and generating substantial tax revenues and royalties for the federal government. In addition, North Slope oil has benefited specific sectors of the economy, notably marine tanker transportation, since the vast majority of Alaskan oil is delivered to U.S. West Coast ports for refining and distribution.

TABLE 3.23-1 Trends in North Slope Oil Production and World Crude Prices

Year	North Slope Production (million bbl/d)	Oil Prices (\$/bbl)	Oil Prices (2000 \$/bbl)
1980	1.522	34	71
1985	1.782	27	43
1990	1.793	22	29
1995	1.523	17	19
2000	1.045	28	28
2001	0.991	22	21

Sources: DOE (2001b,c); Alaska Department of Revenue (2001a).

3.23.2.1 Domestic Oil Production and National Energy Security

The United States was able to satisfy domestic demand for oil from domestic supplies until 1950, when the country became a net oil importer. Dependency on foreign oil has continued to grow, and the country now imports more than 60% of domestic demand from other countries (DOE 2001c). Dependency on oil from outside the United States can create significant foreign policy issues if the countries supplying oil are politically and/or economically unstable. Without the production of North Slope oil, the nation's dependency on foreign oil would be even greater.

North Slope production has regularly constituted more than 15% of U.S. domestic crude production. Throughout the late 1980s, the fields contributed more than 20%, peaking at approximately 25% in 1988 (DOE 2001c).

3.23.2.2 Balance of Trade

Dependency on foreign oil also has implications for the nation's balance of trade with the rest of the world, and North Slope oil has reduced the U.S. balance of trade deficit in each year of North Slope production. Trade deficits contribute to federal government budget deficits and can lead to domestic economic problems if they are sufficiently large to require additional

government borrowing, which could mean less money available for investment, higher interest rates, slower economic growth, and higher unemployment. As a result of North Slope production, the deficit in crude oil has been reduced by an average of 21% over the period 1977–2001, reducing the overall trade deficit by an average of 12%, with approximately \$446 billion (in 2000 dollars) saved on the overall U.S. oil bill over this period (DOE 2001c). In addition, when the cost of domestic production is less than the price of imported oil, there are also cost savings to U.S. consumers and to the federal government.

3.23.2.3 Federal Tax Revenues

The federal government obtains revenues from North Slope production through corporate income taxes paid by the TAPS pipeline owners and oil producers, and through federal royalties on oil developments. In addition, windfall profits taxes were levied on oil producers between 1980 and 1988. It has been estimated that North Slope and the TAPS contributed almost \$64 billion (2000 dollars) to federal government revenues over the period 1977–1998, an average of almost \$2.9 billion (2000 dollars) annually (ECA 1999).

3.23.2.4 Marine Transportation

North Slope oil production provides benefits to U.S. companies transporting the oil from Alaska to the West Coast. Under the stipulations of the Jones Act of 1920, all shipping between U.S. ports must use ships built and registered in the United States and employ U.S. seamen.

Transport of North Slope oil has provided a steady source of employment directly for seamen and indirectly for shipbuilding workers since 1977. In 1999, there were about 100 U.S.-flagged tankers. In 1993, 32 tankers were used on a full-time basis for North Slope oil transportation from Valdez to West Coast ports (DOE 1994). In 1988, the year of maximum TAPS throughput, tankers transporting North Slope oil employed an estimated 2,600 seamen (DOE 1994). More than 50 tankers were built

during the 1970s and 1980s to transport North Slope oil (GAO 1999). Construction of each tanker required approximately 1,000 U.S. shipyard workers, with additional jobs created at U.S. ship repair and overhaul facilities (GAO 1999). While the number of tankers required for North Slope oil has been steadily declining with falling North Slope oil production, double-hulled tankers are gradually replacing the older single-hulled tankers for North Slope transportation, providing more U.S. shipyard employment (GAO 1999).

3.23.3 State Economic Issues

3.23.3.1 Population

More than half (51.2%) of Alaskan residents (626,932 in 2000) live in the urban areas of Anchorage (population 260,283 in 2000), Juneau (30,711), and Fairbanks (30,224). In 2000, 113,145 people resided in the pipeline corridor region, including 82,840 people living in the Fairbanks North Star Census Area, 10,195 residing in the Valdez Cordova Census Area, and 7,385 in the North Slope Borough (Table 3.23-2).

Population in the state has grown rapidly since the early 1960s, particularly during the 1970s with the development of the North Slope oil fields and the construction of the TAPS, and during the 1980s in conjunction with oil production and expenditures in the state. Growth rates have varied somewhat over the period 1970-2000, with annual growth averaging 2.9% during the 1970s, and 3.2% during the 1980s. Growth in the state slowed during the 1990s, reaching a relatively modest annual average rate of 1.3% (Table 3.23-2).

A key component to Alaskan population growth has been the migration that has occurred in association with the various phases of oil industry-related economic development in the state over the last 30 years. Compared with the average natural increase in population in the state since 1970 of 1.7%, growth due to net migration, primarily in the civilian population, has been significant. Net in-migration constituted 88% of total population growth in the state in 1975 during the peak year of the construction of the TAPS. This growth was followed by a substantial net out-migration of population between 1978 and 1980 following completion of the pipeline. A similar cycle in net in-migration occurred in the early 1980s as production from the North Slope began to impact the state economy as a whole, with 74% of the growth in population resulting from in-migration in 1982. This period of growth was followed by net out-migration of population in the mid and late 1980s; out-migration also occurred in the late 1990s.

3.23.3.2 Gross State Product

Gross state product (GSP), or the sum of value added in the production of all goods and services in the state in a year, is a general measure of the level of economic activity in the state. GSP can be presented in terms of current or constant dollars, with constant dollars used to take into account general inflation in the economy and fluctuations in natural resource prices when comparing GSP values over time. Table 3.23-3 summarizes changes in Alaska GSP over the period 1970-1998, together with changes in GSP over the same period in key industries, in terms of 2000 dollars.

TABLE 3.23-2 Alaska Population Statistics, 1970–2000

1970	1980	Growth Rate, ^a 1970–1980 (%)	1990	Growth Rate, ^a 1980–1990 (%)	2000	Growth Rate, ^a 1990–2000 (%)
302,583	401,851	2.9	550,043	3.2	626,932	1.3

^a Annual average rate.

Sources: U.S. Bureau of the Census (1994, 2001f).

TABLE 3.23-3 Alaska Gross State Product by Industry (millions of 2000 dollars)

Industry	1970	1980	Growth Rate ^a (%), 1970–1980	1990	Growth Rate ^a (%), 1980–1990	1998	Growth Rate ^a (%), 1990–1998
Alaska	7,985	22,361	10.8	24,752	1.0	22,652	-0.9
Oil and Gas	823	6,999	23.9	7,490	0.7	4,397	-5.2
Mining	48	40	-1.8	216	18.3	718	12.8
Seafood	319	695	8.1	791	1.3	979	2.2
Forest Products	266	365	3.2	539	4.0	236	-7.9
Construction	604	846	3.4	884	0.4	1,120	2.4
Manufacturing	48	109	8.5	130	1.8	172	2.
Transportation	503	573	1.3	656	1.4	837	2.
Air Cargo	1	1	0.0	56	49.3	172	11.7
Public Utilities	118	252	7.9	527	7.7	583	1.0
Trade	562	1,083	6.8	1,734	4.8	2,155	2.2
Finance	461	1,238	10.4	1,519	2.1	1,777	1.6
Services	478	1,198	9.6	1,972	5.1	2,529	2.5
Tourism	56	205	13.8	450	8.2	676	4.2
Federal Civilian	1,276	1,703	2.9	1,831	0.7	1,587	-1.4
State and Local Government	967	1,885	6.9	2,628	3.4	2,779	0.6
Military	1,481	1,498	0.1	1,922	2.5	1,267	-4.1

^a Annual average rate.

Source: Goldsmith (1999); U.S. Department of Labor (2001).

GSP growth in Alaska sharply declined over the period 1970-1998, with an average annual growth rate of 10.8% during the 1970s giving way to a much smaller average rate of 1.0% during the 1980s, followed by negative average annual growth during the 1990s (Table 3.23-3). Changes in the Alaskan economy as a whole reflect declining growth and contraction in the petroleum sector, with growth rates falling from an annual average of almost 11% during the 1970s to 1.0% during the 1980s. The oil and gas sector declined during the 1990s, reflecting falling world oil prices and declining oil production in the state. The relative contribution of the petroleum sector to GSP has also

declined, falling from about 31% of GSP in 1980 and 1990 to less than 20% in 1998, while still remaining the largest contributor to GSP in the state.

The fortunes of the oil and gas industry in the 1980s and 1990s were offset to a certain extent by rapid growth in other basic sectors (see Appendix A, Section A.8) in the state's economy that are not related to oil production, notably mining, air cargo, and tourism. Air cargo grew at annual rate of more than 29% over the period, mining at 15.5% and tourism at 6.1%. Solid annual average growth rates were also experienced in the 1990s by the manufacturing

(2.8%), transportation (2.5%), construction (2.4%), and seafood (2.2%) sectors of the economy. Forest products, a significant source of growth in 1980s with an average growth rate of 4%, suffered a major decline during the 1990s. Despite the decline in the petroleum sector, the contribution of the key growth sectors in the basic nonpetroleum economy in the state — air cargo, mining, and tourism — to GSP in 1998 was still fairly small at 6.9%. The nonbasic sectors (see Appendix A, Section A.8) trade; finance; services; federal, state, and local government; and the military each contributed more to GSP than air cargo, mining, and tourism. These nonbasic sectors also showed moderate growth in the 1990s.

3.23.3.3 Employment and Unemployment

3.23.3.3.1 Employment by Industry. Total employment in Alaska increased markedly over the period 1970–1998, growing at an average annual rate of 4.7% during the 1970s and at 3.0% during the 1980s. Growth in recent years has slowed somewhat, with annual growth rates during the 1990s averaging only slightly more than 1% (Table 3.23-4). Although the number of employees in mining, which includes oil and gas, increased rapidly during the 1970s (8.4%) and 1980s (5.5%), other parts of the economy still have more employees than the oil and gas sector. A number of these sectors experienced relatively high rates of growth during the 1970s and 1980s. Services (19%), trade (16%), and state and local government (17%) each currently have a significantly larger share of total employment in the state than does oil and gas, with tourism, mining, and air cargo growing substantially over much of the period 1970–1998.

Employment statistics significantly understate the importance of the oil and gas industry in the state. A large number of additional jobs are created in other sectors of the Alaska economy, notably construction, transportation, wholesaling and business services, through the effect of large oil and gas industry procurement and capital spending in these sectors (Goldsmith 1997). Employment in

many of the remaining sectors of the economy is also closely related to the oil and gas industry itself, notably transportation, or on the overall level of economic activity resulting from the large-scale development of oil and gas, notably federal civilian and state and local government, and public utilities.

3.23.3.3.2 Unemployment. Over the last 30 years, unemployment rates in Alaska have been higher than the national rates, with higher than average rates occurring during the 1980s during the first years of North Slope oil production and TAPS operation (Table 3.23-5). The average unemployment rate for Alaska fell during the 1990s, but with the national rate also falling, rates in Alaska remained higher than in the nation as a whole. The current unemployment rate in Alaska, 5.8%, is slightly higher than the national rate of 5.7%.

It is likely that unemployment data underestimate the number of people who would like to work because the unemployment rate includes only persons registering for unemployment benefits. In many Alaskan communities, the number of employment opportunities is limited, meaning that some people may no longer be actively searching for employment.

3.23.3.4 Personal Income

Over the period 1970–1999, real personal income in the state (adjusted for the effects of inflation) more than doubled (Table 3.23-6), with an average annual growth rate of 4%. Growth was particularly rapid (6.1%) during the 1970s with the construction of the TAPS. Over the same period, per capita income increased from \$19,250 to \$29,111 per person, an annual average increase of 1.4%. In the latter part of this period, however, growth rates in total incomes slowed from an annual rate of 4.2% during the 1980s to 1.3% during the 1990s. Growth in per capita incomes also slowed, from an average annual rate of 1.0% in the 1980s to an average rate of 0.1% in the 1990s, primarily as a result of the shift in the Alaskan economy away from higher-paying oil industry employment to lower-paying trade and service industry jobs (Goldsmith 1997).

TABLE 3.23-4 Total Employment in Alaska by Industry^a

Industry	1970	1980	Growth Rate ^b (%), 1970–1980	1990	Growth Rate ^b (%), 1980–1990	1998	Growth Rate ^b (%), 1990–1998
Alaska	133,400	211,360	4.7	283,580	3.0	317,350	1.1
Mining (incl. Oil and Gas)	2,990	6,690	8.4	11,480	5.5	10,450	-0.9
Seafood	120	220	6.2	460	7.7	350	-2.7
Forest Products	0	660	NA ^c	1,320	7.2	1,450	0.9
Construction	6,890	10,640	4.4	10,500	-0.1	13,430	2.5
Manufacturing	7,840	13,980	6.0	17,180	2.1	14,390	-1.8
Transportation	6,130	10,180	5.2	12,790	2.3	15,550	2.0
Air Cargo	400	600	4.1	900	4.1	2,000	8.3
Communications	1,850	4,380	9.0	3,350	-2.6	4,320	2.6
Public Utilities	820	1,360	5.2	2,390	5.8	2,560	0.7
Trade	14,760	27,070	6.3	41,770	4.4	50,500	1.9
Finance	3,100	7,650	9.5	9,170	1.8	11,330	2.1
Services	10,830	27,380	9.7	45,630	5.2	60,950	2.9
Tourism	1,530	5,800	14.3	10,470	6.1	15,230	3.8
Federal Civilian	17,110	17,720	0.4	18,730	0.6	17,180	-0.9
State and Local	18,440	36,290	7.0	51,000	3.5	54,230	0.6
Military	31,430	22,000	-3.5	23,130	0.5	18,020	-2.5
Proprietors	9,510	19,340	7.4	24,220	2.3	27,420	1.2
Fisheries	4,630	7,400	4.8	8,380	1.3	8,730	0.4

^a Total civilian and military employment, including proprietors' primary source of employment.

^b Annual average rate.

^c NA = not applicable.

Source: Goldsmith (2000).

TABLE 3.23-5 Unemployment Rates (%)

Entity	Average, 1971–1980	Average, 1981–1990	Average, 1991–2000	Current ^a
Alaska	8.8	9.4	7.5	5.7
United States	6.4	7.1	5.6	5.6

^a Rates for August 2002.

Sources: Goldsmith (2000); Bureau of Labor Statistics (2002).

A significant and growing portion of personal income in Alaska has come from income transfers made by the state to individuals. These transfers are payments for retirement and disability benefits, income maintenance, unemployment benefits, and public assistance. The contribution of these payments has grown from less than 6% of personal income in 1970 to almost 18% in 1997. Annual growth in the contribution of these payments was particularly rapid during the 1980s.

Another growing portion of income for many Alaskan families (particularly large, low-income families) is the Alaska Permanent Fund Dividend, an annual per capita payment from a savings account established in 1976 (see text box). Dividends were first paid in 1982 and, adjusting for inflation, grew at an annual average rate of almost 11% over the period 1983–1990, and at a rate of 4.5% during the 1990s. The annual payment has become a growing portion of per capita personal income in the state during the 1990s, increasing from 4.2% of per capita income in 1990 to 6.2% in 1999 (Table 3.23-6).

3.23.3.5 State and Local Government Revenues and Expenditures

3.23.3.5.1 State Revenues. The fiscal health of Alaska is closely tied to the fortunes of the oil industry in the state, although that dependence is declining. Revenues for the state general fund are generated from various taxes collected from the oil industry, including a severance tax based on the value of oil

produced; property taxes; income taxes; and royalties, bonuses, and lease payments based on the value of oil production on state land. The balance of general fund revenues comes from corporate income taxes, fees, and licenses. Currently no state income tax or sales tax is levied in Alaska.

General purpose expenditures by state government have tended to exceed revenues collected from the various sources available,

Alaska Permanent Fund

The Alaska Permanent Fund was established in 1976 as a means of converting depletable North Slope oil resources into sustainable financial assets — assets that could be managed in such a way as to insulate Alaskans from fluctuations in natural resource production. A portion of annual royalties paid to the state from oil production on state land are put into the Permanent Fund, and then those revenues are invested in the stock market. While the fund principal is constitutionally protected from being spent, a portion of the earnings from the fund is used for the Permanent Fund Dividend, an annual per capita payment made to eligible state residents, with the balance of earnings reinvested in the Fund. Although it has not been necessary to date, earnings from the fund could also be used to offset annual shortfalls in the state budget.

meaning that the state has had to draw on cash surpluses accumulated from oil revenues in earlier years (TAPS Owners 2001a). As revenues from oil production fell with declining

TABLE 3.23-6 State Personal Income and Alaska Permanent Fund Dividend

Category	1970	1980	Growth Rate ^a (%), 1970–1980	1990	Growth Rate ^a (%), 1980–1990	1999	Growth Rate ^a (%), 1990–1999
Total (2000 \$ million)	5,856	10,593	6.1	15,988	4.2	18,035	1.3
Per capita (2000 \$)	19,250	26,133	3.1	28,906	1.0	29,111	0.1
Transfer payments (2000 \$ million)	324	835	9.9	2,217	10.3	3,053	4.7
Transfer payments per capita (2000 \$)	1,071	2,079	6.9	4,030	6.8	5,011	2.7
Transfer payments share of personal income (%)	5.6	8.0	3.6	13.9	5.8	17.9	3.6
Permanent Fund Dividend (2000 \$)	NA ^b	1,549 ^c	NA	1,212	10.9 ^d	1,800	4.5
Permanent Fund Dividend share of per capita personal income (%)	NA	3.1 ^e	NA	4.2	3.9	6.2	4.4

^a Annual average rate.

^b NA = not applicable.

^c Dividend payments were first made in 1982 with an appropriation by the state legislature. Subsequent dividend payments have been based on Permanent Fund Dividend earnings.

^d Growth rate for the years 1983–1990.

^e 1983 data.

Sources: U.S. Department of Commerce (2001); Alaska Permanent Fund Corporation (2001); U.S. Department of Labor (2001).

production and lower world oil prices, the state established the Constitutional Budget Reserve Fund (CBRF) in 1991 to cover year-to-year deficits. The CBRF consists of settlements from oil and gas tax and royalty disputes.

Oil and gas revenues have fallen at an average annual rate of -2.9% over the period 1980–2000, reflecting the overall decline in oil production and TAPS throughput. Falling revenues have meant that the contribution of the oil and gas industry to state tax revenues has fallen from 82 to 34% over this period (Table 3.23-7). Nonetheless, petroleum revenues still remain a significant source of

income for the state. Helping to offset the loss of oil and gas revenues to the state has been the contribution of earnings from the investment of oil revenues. These investment earnings have grown at an average of almost 15% each year since 1980 and have become more important than oil revenues to the state budget. Also offsetting the loss of oil revenues has been the growth in federal grants to Alaska, which increased at an annual average rate of 3.1% between 1980 and 2000, and nonoil revenues, which increased at an annual rate of 2.2% over the same period. Overall, the state budget grew at an annual rate of 1.4% between 1980 and 2000.

TABLE 3.23-7 State Government Revenues (millions of 2000 dollars)

Item	1980	1990	2000	Growth Rate ^a (%), 1980–2000
Oil revenues				
Severance taxes	894	1,274	703	-1.2
Property taxes	298	114	45	-9.0
Corporate income taxes	966	149	163	-8.5
Royalties (including bonuses, rents, and settlements)	1,592	767	732	-2.5
Constitutional Budget Reserve (CBR) revenues	NA ^b	NA	448	1.2 ^c
Royalties to the Permanent Fund	608	340	307	-3.4
Total oil revenues	4,359	2,645	2,397	-2.9
Earnings from investment of oil revenues	156	1,062	2,477	14.8
Nonoil revenues (excluding federal grants)	263	275	409	2.2
Federal grants	667	793	1,217	3.1
Total state revenues	5,314	6,161	6,984	1.4
Oil and gas revenue share of total state revenues	82%	43%	34%	

^a Annual average rate.

^b NA = not applicable; CBR was established in 1991.

^c Data for the period 1991-2000.

Sources: Goldsmith (2000); Alaska Department of Revenue (2001a).

3.23.3.5.2 Local Revenues. A significant portion of revenues generated locally comes from property taxes, and revenues from oil company property play a major role in property tax revenues in a small number of communities (see Section 3.23.4.4). In 1996, as an example, nearly 40% of property taxes in the state were levied on real assets owned by the petroleum sector (Table 3.23-8). In all Alaskan communities, the oil and gas industry plays an important part in the funding of local government services and programs through the role of state transfers to local communities, a large portion of

which came from state oil revenues. In 1996, almost 35% of local government revenues came in the form of transfers from the state, primarily in the form of direct state funding of local education programs, and the federal government. Annual average growth in state transfers, especially in state funding of education, was fairly high between 1980 and 1996, but state funding of local programs fell in the 1990s. Federal funding has remained constant, and overall local revenues have grown slightly over the period at 1.8%.

TABLE 3.23-8 Local Government Revenues (millions of 2000 dollars except where noted)

Item	1980	1990	1996	Growth Rate ^a (%), 1980–1996
Property taxes	337	663	668	3.5
Petroleum	118	316	267	4.2
Nonpetroleum	219	347	401	3.1
Petroleum percentage of total	34.9	47.7	39.9	
Other taxes	83	122	167	3.6
State transfers	524	1,036	842	2.4
For education	395	812	805	3.6
Federal transfers	93	115	115	1.1
Charges and miscellaneous revenues	472	770	663	1.7
Total general revenues	1,509	2,802	2,447	2.4

^a Annual average rate.

Sources: Goldsmith (2000); Alaska Department of Revenue (2001a).

3.23.3.5.3 State Expenditures.

Including debt service, capital programs, and transfers, state expenditures grew at an average rate of 1.9% over the period 1980–2000, although overall expenditures fell in the 1990s. Expenditures per capita have fallen significantly since 1990 and are currently lower than they were in 1980, as population growth in the state has outpaced the ability of the state to fund expenditure programs. Nevertheless, state expenditures per capita still are currently the highest in the nation, primarily because the harsh climate, low population density, and the inaccessibility of many communities make the services provided by state agencies very costly. The largest component of state government expenditures is social services, which grew at an average rate of 11.0% between 1980 and 2000 and now constitutes 45% of overall state expenditures (Table 3.23-9). Expenditures in other areas, such as public safety, have grown fairly rapidly, while state funding of other areas, such as transportation and environment and housing, have fallen.

3.23.3.5.4 Local Expenditures.

Local expenditures have shown moderate growth over the period 1980–2000 at 2.0%, reflecting the relatively slow growth in the state budget at 2.4% (Table 3.23-10). Expenditures since 1990 have not kept pace with population growth in the state, however, with per capita expenditures falling slightly from 1990 levels by 1996. Almost a third of local government expenditures in 1996 were for education programs.

3.23.3.6 Public Services

In 2000, more than 23,000 full-time employees were working for the state (Table 3.23-11). Almost half of state employees were in general government, and more than a third were employed in education. The current student/teacher ratio is 16.7 in Alaska schools compared with 16.0 for the United States as a whole (U.S. Department of Education 2002). Alaskan per capita education expenditures of

TABLE 3.23-9 State Government Expenditures (millions of 2000 dollars except where noted)

Item	1980	1990	2000	Growth Rate ^a (%), 1980–2000
General government	200	301	204	0.1
Education	648	664	877	1.5
Social services	293	1,096	2,363	11.0
Transportation	402	637	156	-4.6
Public safety	105	220	468	7.8
Environment and housing	243	309	170	-1.8
Capital outlay and debt service	667	1,139	585	-0.7
Subtotal	2,556	4,367	4,823	3.2
Transfers	660	1,247	417	-2.3
Total state expenditures	3,588	5,964	5,240	1.9
Expenditures per capita (\$)	8,928	10,843	8,358	-0.3

^a Annual average rate.

Sources: Goldsmith (2000); Alaska Department of Revenue (2001b).

TABLE 3.23-10 Local Government Expenditures (millions of 2000 dollars except where noted)

Item	1980	1990	1996	Growth Rate ^a (%), 1980–1996
Education	0	849	857	0.1 ^b
Other expenditures	0	922	898	-0.3 ^b
Capital outlay and debt service	600	682	618	0.2
Utility expenditures	203	322	NA ^c	2.3 ^d
Total expenditures	1,816	2,786	2,682	2.0
Expenditures per capita (\$)	4,518	5,065	4,433	-0.1

^a Annual average rate.

^b Rates for 1990–1996.

^c NA = not applicable.

^d Rate for 1980–1990.

Sources: Goldsmith (2000); Alaska Department of Revenue (2001b).

TABLE 3.23-11 State Public Service Employment Data, 2000

Category	Number of Employees
Public safety	397
Transportation	726
General government	11,341
Firefighters ^a	1,100
Teachers ^b	8,869
Judicial and legislative	976
Total	23,409

^a Does not include volunteers.

^b Includes elementary and secondary schools in both Regional Educational Attendance Areas (REAAs) and in cities and boroughs.

Source: Alaska Department of Revenue (2001b).

\$2,554 in 1996 were appreciably higher than in any other U.S. state and far exceeded the national average of \$1,504 (U.S. Department of Education 2002), reflecting the costs associated with maintaining educational services among often extremely widely geographically dispersed communities.

3.23.4 Alaska Regional Economic Issues

3.23.4.1 Population

In the pipeline corridor, annual average population growth has mirrored growth rates in the state as a whole (Table 3.23-12). Growth in the pipeline region has been most significant in the Fairbanks North Star Borough, in the North Slope Borough, and in Anchorage, particularly during the 1980s. The Valdez Cordova Census Area experienced moderate growth during the 1970s. During the 1990s, growth slowed in each part of the corridor region, with the Yukon-Koyukuk Census Area losing population during that period.

3.23.4.2 Employment and Unemployment

3.23.4.2.1 Employment by

Industry. A large portion (47%) of employment in Alaska is concentrated in Anchorage, with 128,295 wage and salary employees in 1999 (Alaska Department of Labor and Workforce Development 2001). Elsewhere, in the pipeline corridor, employment is concentrated in the Fairbanks North Star Borough, with much smaller employment totals in the North Slope Borough and in the Valdez Cordova Census Area (Table 3.23-13).

Employment in the oil and gas sector is concentrated in Anchorage and in the North Slope Borough, with smaller numbers of employees in the Fairbanks North Star Borough. Employment in Anchorage and Fairbanks is dominated by trade, services, and public sector jobs (local, state and federal government), with a smaller number of jobs in the transportation and construction sectors. In the North Slope Borough, the oil and gas industry accounts for almost 40% of all direct employment. (Many employees in the oil and gas sector are not residents of the North Slope Borough; the vast majority of state and local government positions and a large number of construction jobs in the borough depend on oil revenues.) In the remainder of the corridor area, employment is concentrated in the Valdez Cordova Census Area, where state and local government, services, and, to a lesser extent, transportation employment at the Valdez Marine Terminal are the major activities.

3.23.4.2.2 Unemployment. A marked variation in unemployment rates exists in the pipeline corridor region. During the 1990s, unemployment was particularly high in the Yukon-Koyukuk Census Area, with relatively high rates also in the Southeast Fairbanks Census Area (Table 3.23-14). The current rates in each part of the region, with the exception of the North Slope Borough, are lower than average rates for the period 1991–2000.

TABLE 3.23-12 Pipeline Corridor Region Population

Entity	1970	1980	Growth Rate ^a (%), 1970–1980	1990	Growth Rate ^a (%), 1980–1990	2000	Growth Rate ^a (%), 1990–2000
Pipeline corridor region total	192,030	254,510	2.9	334,380	2.8	373,428	1.1
Anchorage	126,385	174,431	3.3	226,338	2.6	260,283	1.4
Fairbanks North Star Borough	45,864	53,983	1.6	77,720	3.7	82,840	0.6
North Slope Borough	3,451	4,199	2.0	5,979	3.6	7,385	2.1
Southeast Fairbanks Census Area	4,308	5,676	2.8	5,913	0.4	6,174	0.4
Valdez Cordova Census Area	4,977	8,348	5.3	9,952	1.8	10,195	0.2
Yukon-Koyukuk Census Area	7,045	7,873	1.1	8,478	0.7	6,551	-2.5

^a Annual average rate.

Sources: U.S. Bureau of the Census (1994, 2001f).

It is likely that unemployment data underestimate the number of people who would like to work, particularly in more isolated Alaska Native communities, because the unemployment rate includes only persons registering for unemployment benefits. In many Alaskan communities, the number of employment opportunities is limited, meaning that some people may no longer be actively searching for employment.

3.23.4.3 Personal Income

Real personal incomes (adjusted for inflation) in the pipeline corridor are concentrated in Anchorage and in the Fairbanks North Star Borough, both of which have seen fairly rapid personal income growth, especially during the 1970s and 1980s (Table 3.23-15). Real per capita incomes in Anchorage grew

moderately during the 1980s and have only grown relatively slowly during the 1990s. In the Fairbanks-North Star Borough real per capita incomes fell during the 1980s and only grew slowly during the 1990s.

Elsewhere in the pipeline corridor region, total personal incomes grew at a moderate pace during the 1980s. Growth continued during the 1990s in the North Slope Borough and in Southeast Fairbanks, but declined in Valdez Cordova and Yukon-Koyukuk. With the exception of the Southeast Fairbanks Census Area and Valdez Cordova during the 1980s, per capita incomes have stagnated, or fallen, as has been the case in the North Slope Borough, particularly during the 1980s.

Total incomes in the Yukon-Koyukuk and Southeast Fairbanks Census Areas are the lowest in the pipeline corridor region. Data for

TABLE 3.23-13 Pipeline Corridor Region Employment^a by Industry, 1999

Industry	Anchorage	Fairbanks North Star	North Slope	Southeast Fairbanks	Valdez- Cordova	Yukon- Koyukuk
Total	128,295	32,538	7,439	1,660	4,632	1,998
Oil and Gas	3,392	428	2,922	0	0	0
Mining	123	393	0	0	0	26
Agriculture	681	116	0	0	5	2
Seafood	0	0	0	0	81	0
Forest Products	10	0	0	0	1	0
Construction	7,081	1,757	624	44	156	79
Manufacturing	2,160	604	8	23	518	15
Transportation	7,427	1,769	178	94	648	44
Air Transportation (incl. Air Cargo)	5,872	913	119	33	48	26
Public Utilities	1,006	388	108	105	177	26
Trade	30,873	6,586	474	351	599	188
Finance	6,829	1,085	172	16	182	44
Services	35,427	8,094	846	319	1,048	368
Federal Government	9,850	3,277	24	309	125	95
State and Local Government	17,432	7,086	1,966	358	1,027	1,084

^a Nonagricultural wage and salary employment, excluding proprietors and active duty military employment.

Source: Alaska Department of Labor and Workforce Development (2001).

these areas most closely reflect trends in personal incomes in Alaska Native villages, with a large number of small Alaska Native communities in both areas. In 1999, per capita incomes in Yukon-Koyukuk were only 57% of those in Anchorage, and in Southeast Fairbanks were only 67% of those in Anchorage.

The Permanent Fund Dividend makes a larger contribution to personal incomes in the Fairbanks-North Star Borough and in the Southeast Fairbanks and Yukon-Koyukuk Census Areas than it does in the state as a whole. Almost 7% of per capita income in the

pipeline corridor region as a whole comes from the annual payment.

3.23.4.4 Local Government Revenues and Expenditures

3.23.4.4.1 Revenues. Five local jurisdictions in the pipeline corridor collect local taxes, primarily in the form of property taxes and sales taxes. These jurisdictions are Anchorage,

TABLE 3.23-14 Pipeline Corridor Region Unemployment Rates^a

Area	Average Rate (%), 1991–2000	Current Rate ^b (%)
Anchorage	5.5	4.4
Fairbanks North Star	7.7	4.7
North Slope	5.4	12.5
Southeast Fairbanks	12.3	8.3
Valdez Cordova	9.8	6.6
Yukon-Koyukuk	16.0	13.7

^a Rates include only those individuals registering for unemployment benefits. In some communities in each area, unemployment rates may be higher than the average for the area or borough as a whole.

^b Rates for August 2002.

Source: Bureau of Labor Statistics (2002).

North Slope Borough, City of Valdez, Fairbanks North Star Borough, and Fairbanks.

With only a small number of communities and little local manufacturing not related to natural resource production, the North Slope Borough and the City of Valdez rely heavily on the oil and gas industry as a source of local revenues, primarily through property taxes. In the North Slope Borough, 98% of property tax revenues, and 66% of all local revenues, come from the oil and gas sector (Table 3.23-16). In the City of Valdez, 78% of property taxes, and 63% of total revenues, come from oil and gas. Both areas are relatively independent of federal and state transfers, with 76% of expenditures in the North Slope Borough and 75% in the City of Valdez coming from local sources. Both jurisdictions also have a Permanent Fund for oil revenues, providing an additional source of locally generated funds (TAPS Owners 2001a).

In contrast, Fairbanks and Fairbanks North Star Borough, with comparatively little oil and gas property to tax, receive only 30 and 40% of their revenue from local sources respectively, with the remainder coming from state assistance. State assistance is mainly in the form of transfers, revenue sharing of locally

generated taxes, assistance for specific programs (such as primary and secondary education), and general aid (TAPS Owners 2001a). In Anchorage, relatively little revenue comes directly from oil and gas, meaning that state assistance constitutes a significant share of total revenues.

3.23.4.4.2 Expenditures. The character of expenditures by the five local jurisdictions in the pipeline corridor region collecting taxes varies considerably. Excluding debt service and capital projects, 91% of expenditures in Fairbanks North Star are on education and social services, with 76% of the budget spent on education alone (Table 3.23-17). In the North Slope Borough, expenditures on general government are a more significant component of total expenditures, with education and social services together constituting 71% of the budget (with education making up 26% of expenditures). A major variation exists between total per capita expenditures in the North Slope Borough and elsewhere in the pipeline corridor region. Excluding capital expenditures, more than \$25,000 is spent per person by local government in the North Slope Borough, compared with \$2,700 in Anchorage, \$2,539 in Fairbanks North Star, \$2,325 in Valdez, and \$873 in Fairbanks.

3.23.4.5 Education

The level of education provision in the four pipeline corridor areas generally reflects the level of overall expenditure per capita in each area. The student/teacher ratio in the North Slope Borough is relatively low at 10.2, compared with slightly higher ratios for Fairbanks, Fairbanks North Star, Valdez, and Anchorage (Table 3.23-18).

3.23.5 Village Economies

Personal incomes in Alaska Native villages are lower than those in the state as a whole, and unemployment, especially in smaller villages, is high, particularly during the winter when there is little alternative market-based activity. Because of the key role of subsistence in many village economies, economic data that are collected for

TABLE 3.23-15 Pipeline Corridor Region Personal Income

Entity	1970	1980	Growth Rate (%) 1970–1980	1990	Growth Rate ^a (%), 1980–1990	1999	Growth Rate ^a (%), 1990–1999
<i>Pipeline Corridor Total</i>							
Total (2000 \$ million)	3,727	7,031	6.6	10,340	3.9	11,858	1.5
Per capita (2000 \$)	20,678	25,214	2.0	26,643	0.6	26,927	0.1
Permanent Fund	– ^b	5.6 ^c	–	4.6	-2.5	6.7	4.4
Dividend share of per capita personal income (%)							
<i>Anchorage</i>							
Total (2000 \$ million)	2,856	5,012	5.8	7,597	4.2	8,864	1.7
Per capita (2000 \$)	22,404	28,510	2.4	33,380	1.6	34,383	0.3
Permanent Fund	–	4.8 ^c	–	3.6	-3.5	5.2	4.1
Dividend share of per capita personal income (%)							
<i>Fairbanks North Star Borough</i>							
Total (2000 \$ million)	870	1,398	4.9	1,971	3.5	2,237	1.4
Per capita (2000 \$)	18,952	25,627	3.1	25,231	-0.2	26,521	0.6
Permanent Fund	–	5.4 ^c	–	4.8	-1.4	6.8	3.9
Dividend share of per capita personal income (%)							
<i>North Slope Borough</i>							
Total (2000 \$ million)	0	145	–	186	2.5	209	1.3
Per capita (2000 \$)	0	34,186	–	30,689	-1.1	29,514	-0.4
Permanent Fund	–	4.0 ^c	–	4.0	0.0	6.1	4.9
Dividend share of per capita personal income (%)							
<i>Southeast Fairbanks Census Area</i>							
Total (2000 \$ million)	0	97	–	126	2.6	134	0.7
Per capita (2000 \$)	0	16,890	–	21,822	2.6	23,010	0.6
Permanent Fund	–	8.3 ^c	–	5.6	-4.9	7.8	3.9
Dividend share of per capita personal income (%)							
<i>Valdez Cordova Census Area</i>							
Total (2000 \$ million)	0	231	–	305	2.8	294	-0.4
Per capita (2000 \$)	0	27,192	–	30,390	1.1	28,686	-0.6
Permanent Fund	–	5.5 ^c	–	4.0	-4.0	6.3	5.2
Dividend share of per capita personal income (%)							

TABLE 3.23-15 (Cont.)

Entity	1970	1980	Growth Rate (%) 1970–1980	1990	Growth Rate ^a (%), 1980–1990	1999	Growth Rate ^a (%), 1990–1999
<i>Yukon-Koyukuk Census Area</i>							
Total (2000 \$ million)	0	148	–	155	0.5	120	-2.8
Per capita (2000 \$)	0	18,878	–	18,348	-0.3	19,448	0.6
Permanent Fund	NA ^c	7.9 ^d	NA	6.6	-2.1	9.3	3.8
Dividend share of per capita personal income (%)							

^a Annual average rate.

^b – = data not recorded for 1970, so growth rate cannot be determined.

^c NA = not applicable; Permanent Fund was created after 1970.

^d 1982 data.

Sources: U.S. Department of Commerce (2001); Alaska Permanent Fund Corporation (2001).

TABLE 3.23-16 Pipeline Corridor Region Local Government Tax Revenues, 2000 (millions of dollars except where noted)

Item	Anchorage	Fairbanks	Fairbanks North Star	North Slope	City of Valdez
Property tax	290.1	11.2	63.3	201.2	18.8
Oil and gas share ^a (%)	1	30	8	98	78
Other revenues	222.7	4.0	18.5	52.2	7.9
Total local revenues	512.8	15.2	81.8	253.4	26.7
Oil and gas share ^a (%)	0	25	7	66	63
Federal, state, and other revenues	314.7	2.2	123.5	41.7	7.9
Total operating revenues	827.5	17.4	205.3	331.3	34.6
Capital projects	11.4	9.0	7.4	36.2	1.0
Total revenues	838.9	26.4	212.7	331.3	35.6
Local share (%)	61	58	38	76	75

^a Based on 1998 data.

Sources: ADCED (2001a); TAPS Owners (2001a).

TABLE 3.23-17 Pipeline Corridor Region Local Government Expenditures, 2000 (millions of dollars except where noted)

Item ^a	Anchorage	Fairbanks	Fairbanks North Star	North Slope	City of Valdez
General government	33.3	2.8	11.0	38.0	1.8
Public safety	97.3	9.9	4.1	15.8	2.2
Public services	212.6	9.3	26.6	81.2	10.1
Education	359.5	0	129.0	47.6	9.6
Debt service	73.0	0.6	14.3	147.0	1.9
Total operating expenditures	775.7	22.6	185.0	329.6	25.6
Capital projects	161.7	3.8	25.3	141.0	9.0
Total expenditures	937.4	26.4	210.3	470.6	34.6
Expenditures per capita (\$)	3,601	873	2,539	63,724	3,394

^a Depreciation and internal service funds, such as trust accounts, are not included.

Source: ADCED (2001a).

TABLE 3.23-18 Pipeline Corridor Region Local Education Data, 1999

Item	Anchorage	Fairbanks	Fairbanks North Star	North Slope	City of Valdez
Teachers (number)	2,723	932	932	182	55
Student/teacher ratio	17.6	17.1	17.1	10.2	14.7
Percent Alaska Native (%)	12.6	13.4	13.4	81.3	15.7

Source: ADCED (2001a).

these communities may not fully represent their economic well being. For example, many transactions between individuals involving the exchange of subsistence products that would otherwise provide income if they took place in the marketplace are not reflected in personal income statistics. Similarly, unemployment data may not reflect the extent to which additional economic activity may be required if subsistence activities provide a sufficient alternative to participation in the marketplace. In addition, the large differences in prices between urban and rural Alaska may exaggerate the corresponding differences in economic well being, depending on the extent to which local community members

in rural areas have to participate in the local market economy for key consumer items, such as food, clothing and energy, and the extent to which these items can be obtained through participation in subsistence activities. Because of these considerations, the analysis did not estimate the impacts of renewal and nonrenewal for areas and villages below the level of the census area or borough.

3.23.6 Subsistence

Subsistence fishing and hunting are an important part of the economies of rural Alaskan

communities, providing food, clothing, and employment. While the subsistence harvest of wild food (fish, terrestrial and marine mammals, birds, shellfish) only represents 2% of the fish and game harvested annually in Alaska (commercial fishing represents 97% and sport fishing and hunting 1%), that harvest contains about 35% of the caloric requirements of the rural population (ADF&G 2000a). In some areas of Alaska, notably the interior and western areas, subsistence products provide more than 50% of the daily requirement. Approximately 2% of the daily requirement of the urban population is met through subsistence activities.

Although it is difficult to establish the relative economic importance of subsistence harvests because the consumption and exchange of subsistence products do not occur in the marketplace, estimates of their importance have been made on the basis of the dollar value of replacing subsistence products in the market. Using a replacement value of \$3 per pound, the replacement value of subsistence harvests in rural Alaska has been estimated by the ADF&G (2000a) to be \$131 million annually; at \$5 per pound the replacement value of these products would be \$219 million. In Alaska as a whole, the replacement value of subsistence products is estimated to be between \$160 million and \$267 million (ADF&G 2000a).

3.23.7 Alaska Native Corporations

A substantial portion of Alaskan land is owned by Alaska Native corporations, set up under the 1971 Alaska Native Claims Settlement Act (ANCSA) (see Section 3.25). Under ANCSA, Alaska Natives were given \$462.5 million and 2% of the value of federal and state leasable mineral revenues (Ervin 1976). Regional and village corporations have been organized, with 13 regional corporations administering per capita cash payments from the settlement and subsurface land rights, and 168 village/urban corporations receiving surface rights. These corporations undertake a variety of economic development activities, in particular the development and sale of natural resources (including mining, forestry, timber and fisheries) and tourism. Investments in real estate and private companies also provide benefits to corporation members. A significant number of Alaska Natives are shareholders in at least one of these corporations. A number of corporations provide contracting services to the TAPS. Over the period 1996–2001, for example, out of total TAPS contracting expenditures of \$1.9 billion, \$0.759 billion (39%) was awarded to Alaska Native corporations (TAPS Owners 2002b).

In addition to their economic role, Alaska Native corporations also play important cultural and social roles in the daily lives of Alaska Natives, providing shareholders with homesites and benefits for elders, promoting traditional tribal culture, and managing cultural resources.

3.24 Subsistence

3.24.1 Introduction

In Alaska, the term subsistence refers to “the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption” (Federal Subsistence Board 1999). Subsistence activities can involve hunting, fishing, trapping, and collecting. Uses of resources acquired through subsistence include food, clothing, transportation, construction, art, crafts, exchange, and customary trade.

Subsistence is extremely important in many rural Alaskan communities because of three key roles that it plays. One is economic — that is, it provides a means of obtaining important resources particularly food. Resources acquired through subsistence activities are used to meet a range of demands that are both central for survival and, in many parts of Alaska, either difficult to obtain by other means or quite costly in monetary terms (MMS 1988; Wolfe and Bosworth 1994; Wolfe and Walker 1987). Coupled with the high cost of many commodities in rural Alaska is a general tendency for high unemployment, increasing the importance of subsistence as an economic activity.

Although the economic role of subsistence in many rural localities is undeniably important, one must remember that in Alaska it is not the sole function of this activity. Moreover, rural communities rely on both subsistence production as well as goods and services obtained through the monetized, national economy. The term “mixed, subsistence-based economy” is often used to describe the economic systems of these localities.

A second role of subsistence is sociocultural. The sociocultural function of subsistence is particularly important to Alaska Native groups, for whom subsistence provides a crucial link between modern sociocultural systems and their roots, and for whom the acquisition and exchange of subsistence resources helps knit together cohesive societal units (Berger 1985; Worl 1982; see also Beetus and Beetus 1992; Brower and Opie 1997; Schmitz 1992; Solomon 1986). The act of

Subsistence

Subsistence is the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption (Federal Subsistence Board 1999).

Subsistence resources are used for food, clothing, transportation, construction, art, crafts, exchange, and customary trade. The roles of subsistence include the following:

- Economic: Provides necessary resources.
- Sociocultural: Important component of Alaska Native and rural non-Native sociocultural systems.
- Ceremonial: Subsistence and subsistence resources often play an important role in Alaska Native ceremonial activities.

Although the State of Alaska does not limit subsistence to rural residents, the federal government does; this document uses the rural criterion.

harvesting subsistence resources in many cases requires cooperation by several individuals, particularly during times of resource abundance, such as salmon runs and caribou migrations. The shared labor of producing and processing subsistence foods creates and maintains enduring bonds within kin groups, between men and women, and between elders, adults, and younger people.

In many communities, a small number of families (or households) in a village ultimately harvest the vast majority of subsistence resources (Magdanz and Utermohle 1998). A survey of selected communities in the mid-1980s showed that about 30% of households generated about 70% of the total community subsistence production (Wolfe 1987). These resources are distributed widely to other households

throughout a community, establishing or further defining the relations of mutual aid and obligation among components of a society, as well as providing increased security in a very challenging natural setting (ADF&G 1990).

A third role of subsistence is ceremonial. Once again, this function is particularly important in Alaska Native groups, for whom subsistence activities and resources incorporate a set of religious and spiritual beliefs about proper relations between humans and the spirits of the natural world. Subsistence foods are often central components of important indigenous ceremonial events. Examples of such ceremonies include the messenger feasts of the Nunamiut and potlatches of the various Athabascan groups. The first, firmly rooted in tradition, serves to establish relationships between Nunamiut communities through sharing food at large ceremonies (Spencer 1984). Potlatches are multiday feasts to commemorate an important day (including Christmas), as well as the memory of a recently deceased member of a community (see Clark 1981; Simeone 1995). In such ceremonial events subsistence resources play a central role, representing at once the generosity of the spirits of the natural world, and the spiritual maturity of the hunter who has found favor with these spirits and who expresses appreciation for these gifts by sharing freely with others.

This section contains the main discussion of the subsistence affected environment in this EIS. However, other portions of the document also contain information relevant to this topic. A more detailed presentation and discussion of subsistence data appears in Appendix D. Certain sociocultural and ceremonial aspects of subsistence also are discussed in Section 3.25, primarily providing evidence for the continuing ties of modern subsistence activities to traditional sociocultural systems. Human health issues associated with the consumption of foods harvested through subsistence activities are discussed in Section 3.17, and environmental justice issues associated with subsistence are examined in Section 3.29.

Subsistence in Alaska is a complex topic. Some of this complexity is due to factors related to the act of subsistence itself, including (1) the large array of subsistence resource types

available and the intricate cycle of seasonal availability in discrete portions of the traditional use area, (2) the flow of subsistence resources through (primarily) Native sociocultural systems via several exchange mechanisms, (3) the mixture of modern technology and traditional ecological knowledge enabling highly efficient subsistence harvests, (4) the wide range of uses for subsistence resources, and (5) the tendency for different cultural groups to use different resources in different parts of the state. Much of the complexity associated with subsistence, however, also stems from the current laws surrounding subsistence, particularly the legal division between subsistence on federal lands and subsistence on state lands. Alaska became a state in 1959, adopting a constitution that reserved fish and wildlife resources for "common use" by Alaskans. The first Fish and Game Code following statehood recognized subsistence fishing, although this was not limited to rural residents, and there was no statutory definition of subsistence hunting (Kelso 1987). In 1978, Alaska lawmakers enacted legislation that recognized and protected subsistence uses of both fish and game, in part to comply with anticipated federal legislation. As implemented in regulations adopted by the Alaska Joint Boards of Fisheries and Game, the state statute required that individuals engaged in subsistence activities be rural residents, and it gave subsistence uses of any resource priority over other uses (AS 16.05.940).

In 1980, Congress passed the Alaska National Interest Lands Conservation Act (ANILCA), in which Title VIII established a rural definition of subsistence, a priority for subsistence over other uses, and a requirement for local participation in subsistence management decisions through advisory bodies. The state subsistence program was determined to meet the requirements of the federal statute, and so the state was authorized to implement a unified subsistence management program on federal as well as state and private lands.

However, in December 1989, the Alaska Supreme Court ruled that the rural residency provision of the subsistence law violated the state's constitution, removing the ability of state agencies to enforce a rural preference. Federal

law (Title VIII of ANILCA, 16 USC §3111 et seq.) provided for direct implementation of the federal statutes on federal public lands in the event that the state could no longer comply with the federal standards. Thus, subsistence in Alaska has been defined in several different ways over the past 25 years, and it currently is treated differently on state and federal public lands (and certain navigable waters). In an attempt to avoid some of this confusion, this FEIS uses the current federal definition of subsistence and its central requirement of rural residency, although some urban residents also benefit from harvesting wild resources for uses consistent with subsistence.

Subsistence involves a large number of people, with more than 123,000 persons eligible in 1999 on the basis of rural residency (Wolfe 2000). Harvest patterns and amounts vary considerably by location and resource availability, although for the entire state, the most important subsistence food by weight is fish (about 60%), followed by land mammals (20%), marine mammals (14%), birds (2%), shellfish (2%), and plants (2%). Commercial fishing far outstrips subsistence and recreational harvests, accounting for about 97% of the total fish and game harvest during the 1990s by weight, compared with 2% taken for subsistence by rural residents and 1% taken through recreational hunting and fishing (Wolfe 2000; see also ADF&G 2001a). This figure aggregates all fish and wildlife harvests, which are dominated by the large commercial fisheries. A similar figure on wildlife alone would show that a far higher percentage of wildlife, particularly moose and caribou, is taken for subsistence purposes. Harvest ticket data for moose taken from 1983 through 2000 indicate that rural residents harvested 39%, while urban residents took 58% (residency for the remaining 3% was unknown) (Office of Subsistence Management 2002).

Subsistence harvest techniques frequently involve a combination of traditional techniques, traditional ecological knowledge, and modern technology. For example, people often will arrange their activities to exploit a particular resource at a particular place and time, as they have done for generations, although harvesting may involve modern firearms and mechanized

transportation. Subsistence harvests tend to be part of a “mixed, subsistence-based economy” that also involves varying amounts of wage labor — with the subsistence resources, combined with cash, providing the means of survival.

3.24.2 Community Harvest Patterns

The examination of subsistence in this EIS focuses on the topic from primarily a community perspective, organized within four broad geographical zones. These geographic zones share a common ecology, and some common patterns result for communities within each zone. The decision to examine subsistence at the level of individual communities was based in part on data availability. The ADF&G, which collects the most detailed information on subsistence, compiles and presents this information at the level of individual communities (Fall 1990). However, focusing on particular

The Evolution of Subsistence Regulation in Alaska

Prior to 1978, there was no statutory distinction between subsistence and other fish and game harvests did not exist. Local managers exercised some discretion to recognize local needs and traditions. In 1978, legislation and regulations enacted by the State of Alaska (AS 16.05.940) identified subsistence as an activity undertaken by *rural* residents, with subsistence given priority over commercial and sport harvests. In 1980, the Alaska National Interest Lands Conservation Act similarly identified subsistence as an activity undertaken by *rural* residents, with priority over other harvests. However, in December 1989, the Supreme Court of the State of Alaska ruled that the rural preference violates the state constitution, prohibiting the state from using rural residency for subsistence eligibility. Therefore, from December 1989 until the present, the State of Alaska regulations apply to state and private lands, and federal regulations (maintaining the rural eligibility requirement and subsistence priority) apply to federal lands.

places also has an important analytical correlate: a community-specific examination makes it possible to focus this subsistence analysis on a geographic region that is proximal to the TAPS and, thus, potentially affected by it. Moreover, because subsistence resources and harvest patterns can vary dramatically between different locations in rural Alaska, a community-specific perspective emerges as the most useful when examining the complex issues surrounding subsistence. The communities of interest include the homes of the 21 federally recognized tribes identified by the BLM as those that would be potentially directly affected by renewing the TAPS ROW (see BLM 2001a). This EIS also examines subsistence in five other rural communities in proximity to the TAPS — a subset of the 23 largely non-Native communities defined elsewhere in the FEIS (see Section 3.29) for which subsistence data exist. Eleven of the 23 communities defined by geographic proximity to the TAPS (College, Ester, Fairbanks, Fox, Harding Lake, Moose Creek, North Pole, Pleasant Valley, Salcha, Two Rivers, and Valdez) would have been excluded from this analysis anyway because of their location in nonrural portions of Alaska as defined by the Federal Subsistence Board (Office of Subsistence Management 2001). The remaining seven (Big Delta, Coldfoot, Copperville, Deadhorse, Delta Junction, Livengood, and Prudhoe Bay) never have been the subject of systematic subsistence studies. In all, then, the evaluation of potential impacts on subsistence in this document considers all communities of interest that are eligible for subsistence because of rural locations for which reliable subsistence data exist (i.e., the 26 communities that are discussed in this section).

Brief descriptions of community harvest patterns and any subsistence concerns that residents or researchers have identified are provided in the following subsections. Apart from the incomplete coverage of all rural communities, the information examined is, in many cases, several years old and likely suffers from inaccuracies such as underreporting. Moreover, subsistence is by its very nature a collection of flexible and strategic behaviors that vary both seasonally and between years in response to fluctuations in resource availability. Such variability over time requires caution when

examining quantitative characterizations of subsistence activities and particularly in relying on harvest patterns for a *representative year* (identified for many communities by researchers at ADF&G). Similarly, maps of geographic patterns or traditional use areas are typically based on the past 10 to 20 years and provide a relatively accurate depiction of contemporary harvest patterns. However, these use areas are not fixed and could see adjustments as people respond to the inherent variability in the timing, location, and abundance of subsistence resources (see Nelson 1992). Information from interviews and testimonies on subsistence concerns (a form of traditional ecological knowledge) is offered both to help fill gaps in more conventional data and because subsistence practitioners tend to develop intimate understandings of the resources they pursue.

The data presented in this EIS are drawn from historic ethnographies, over two dozen intensive community studies conducted primarily by the ADF&G Division of Subsistence, and on-going data series from subsistence fishing harvest calendars and permits, sport fishing surveys, and wildlife harvest tickets. This is the best available data on subsistence at the community level and provides reliable documentation of the array of important subsistence resources, the levels of participation in various types of subsistence harvest, harvest levels, and traditional use areas. These data typically describe a baseline pattern in the mid-to late 1980s, with a limited number of cases in which update studies were conducted during the 1990s. Although some trend information is available from permit and ticket data, these data are limited. As a result, one must be cautious in using them to extrapolate and predict patterns for the early 21st century. Additional information on these communities appears elsewhere in this EIS. Sociocultural characteristics of the main communities of the 21 directly affected federally recognized tribes and 23 other communities in proximity of the TAPS are addressed in Section 3.25 (see Tables 3.25-1 and 3.25-3), and selected demographic characteristics for all 44 settlements are addressed in Section 3.29 (see Table 3.29-1). Subsistence and community harvest patterns are discussed in greater detail in Appendix D, while subsistence impacts under

ANILCA Section 810 are discussed in Appendix E.

The EIS arranges the following brief overviews of community subsistence patterns in four geographic groupings of communities: North Slope, Yukon River Drainage, Copper River Basin, and Prince William Sound and Lower Cook Inlet. This approach groups communities with similar ecological, sociocultural, and (hence) subsistence characteristics in an attempt to provide an improved understanding of subsistence in the vicinity of the TAPS.

3.24.2.1 North Slope

In this document, the term “North Slope” refers to that portion of north-central Alaska north of the Brooks Range. Alaska Natives in this region comprise two Iñupiat sociocultural systems, the Nunamiut and the Tareumiut (see Section 3.25). The Tareumiut live along the north coast of Alaska. Although they use terrestrial resources, it is their use of marine resources — notably whales — that one often associates with Tareumiut subsistence. The Nunamiut live inland from the coast in the Brooks Range. Subsistence harvests in this region are generally among the highest in the state (ADF&G 2000a), with Nuiqsut residents taking more than 740 lb per person in 1993 (Table 3.25-1). Nunamiut adaptation relied heavily on caribou for subsistence, supplemented by a number of other (primarily) terrestrial resources, and trade for sea mammal products with the coastal Tareumiut.

Subsistence harvests for North Slope coastal communities involve relatively equal reliance on large land mammals (mainly caribou), marine mammals, and fish, as displayed in Figure 3.24-1 for an example community. These resources are harvested at different times of the year, in some cases requiring temporary relocation or aggregation of residents from a particular community (Figure 3.24-2).

This EIS discusses one village representative of both of the above sociocultural (and subsistence) systems: Anaktuvuk Pass, a Nunamiut settlement, and Nuiqsut, a (largely) Tareumiut village. In addition to the brief

descriptions of subsistence in both of those communities presented in the following paragraphs, further details are provided in Appendix D.

3.24.2.1.1 Anaktuvuk Pass. Located in the central Brooks Range approximately 49 mi west of the TAPS, the community of Anaktuvuk Pass is the last remaining settlement of the Nunamiut (Interior North Alaska Eskimo) (see Map 3.24-1) (Alaska Department of Community and Economic Development [ADCED] 2001b). As discussed in greater detail in Section 3.25.1.1.6, Anaktuvuk Pass was resettled in the late 1940s following abandonment earlier in the century. By 2000, its population had risen to 282, the majority Native (mostly Nunamiut – see Tables 3.25-1 and 3.29-1). In part because of geographic isolation and economic pressures, and in part because of cultural reasons, subsistence remains important in this community. Seasonal wage employment (e.g., trapping, handicraft production) plays a role in the mixed economy of Anaktuvuk Pass, supplementing the resources acquired through subsistence activities (including those received in sharing and trade) (see North Slope Borough 1999).

Subsistence hunting and fishing involves a large number of species throughout the year (Spearman et al. 1979). However, caribou are traditionally the dominant resource and the only resource reported in the ADF&G survey data (Table 3.24-1). Hunting other land mammals, large and small, and fishing help supplement caribou hunting (ADCED 2001b). Data from 1993 (the representative year) indicate that 43% of the households in Anaktuvuk Pass hunted caribou for subsistence (Table 3.24-2), and that caribou alone provides more than 200 lb of food per capita. If quantitative data were available for other species, higher rates of participation and harvest levels would result — consistent with the wider range of resources documented by research on subsistence with a broader focus conducted in Anaktuvuk Pass during the 1970s (Spearman et al. 1979). Subsistence harvest surveys for 3 years in the early 1990s indicate fluctuating caribou harvests, ranging from fewer than 220 lb per capita to nearly 250 lb (Figure 3.24-3).

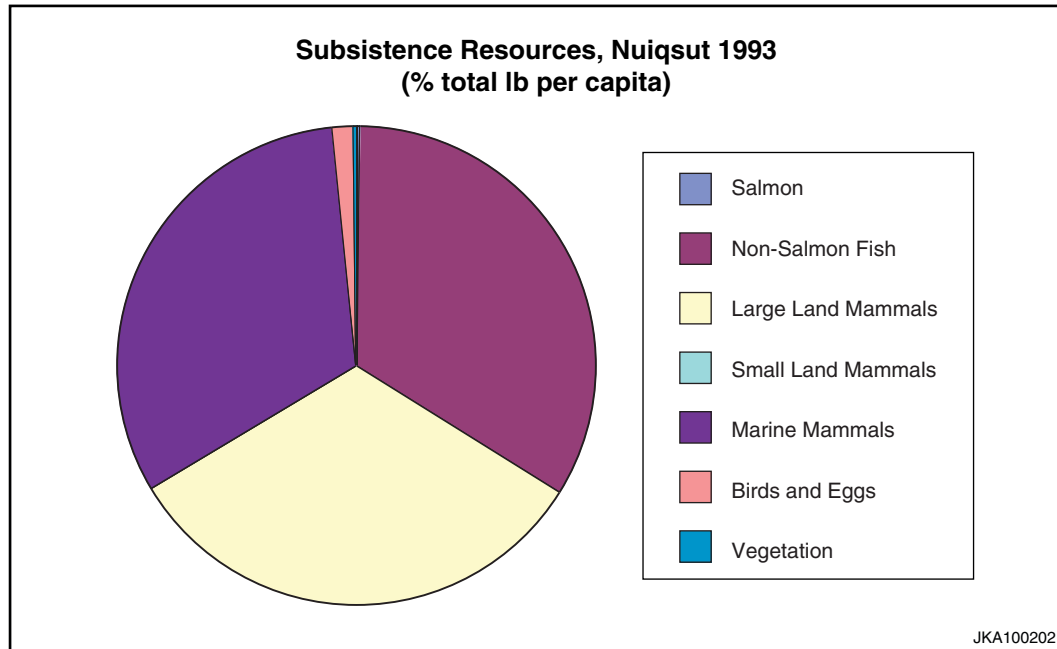


FIGURE 3.24-1 Example Combination of Subsistence Resources on the North Slope (Nuiqsut) (Source: ADF&G 2001b)

Resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Moose					-----	-----	-----	-----	-----	-----		
Brown Bear					-----	-----	-----	-----	-----	-----		
Polar Bear	-----	-----	-----	-----	-----					-----	-----	-----
Seals	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Walrus					-----	-----	-----	-----	-----			
Caribou	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bowhead Whale				-----	-----	-----			-----	-----	-----	
Birds, Eggs	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Freshwater Fish						-----	-----	-----	-----	-----	-----	-----
Marine Fish	-----	-----			-----	-----	-----	-----	-----	-----	-----	-----
Marine Invertebrates						-----	-----	-----	-----	-----	-----	-----
Small Mammals					-----	-----	-----	-----	-----	-----		
Furbearers	-----	-----	-----	-----	-----				-----	-----	-----	-----

Berries							-----	-----				
Plants/Roots					-----	-----	-----	-----				

JKA100223

----- Intermittent

FIGURE 3.24-2 Example of the Seasonality of the Subsistence Harvest on the North Slope (Barrow) (Source: Wolfe et al. 1986)

TABLE 3.24-1 Subsistence Resource Pounds Harvested per Capita in Directly Affected and Other Selected Rural Communities, Selected Recorded Year

[Click here to view Table 3.24-1, page 1](#)

TABLE 3.24-1 (Cont.)

[Click here to view Table 3.24-1, page 2](#)

TABLE 3.24-2 Percent Households in Directly Affected and Other Selected Rural Communities Participating in Subsistence Harvest, Selected Recorded Year

[Click here to view Table 3.24-2, page 1](#)

TABLE 3.24-2 (Cont.)

[Click here to view Table 3.24-2, page 2](#)

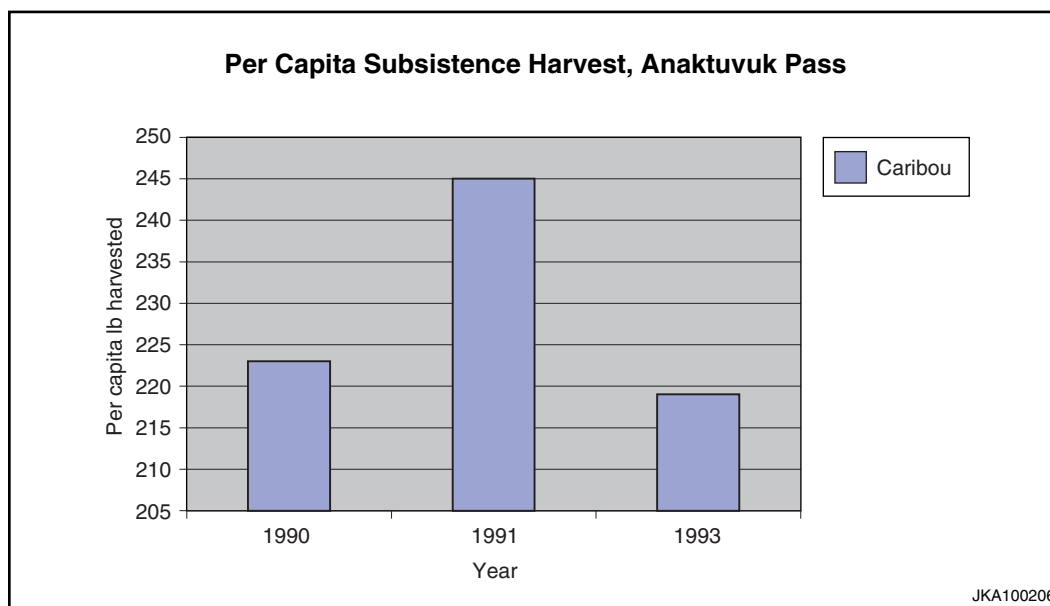


FIGURE 3.24-3 Variability in Anaktuvuk Pass Caribou Harvest Over Time (Source: ADF&G 2001b)

The subsistence use area for Anaktuvuk Pass extends generally east to west along the central Brooks Range. The area used for caribou hunting is particularly extensive. On the eastern boundary, the subsistence use area for Anaktuvuk Pass overlaps with a section of the TAPS (see Map 3.24-1).

Subsistence concerns of local residents identified during the early 1990s revolved around the lack of caribou migration through the pass in 1989 because of nonlocal subsistence and sport hunting (ADF&G 2001b). Concerns also included the increased difficulty in subsistence hunting within Gates of the Arctic NPP because of regulations on this activity in the park itself (Mekiana 1992).

3.24.2.1.2 Nuiqsut. Nuiqsut is an incorporated community on the western bank of the Nechelik Channel of the Colville River Delta, about 57 mi west of the TAPS (see Map 3.24-1) (ADCED 2001b). Originally the location of a Native village called Itquippaa, the old community was abandoned in the 1940s and resettled in 1973 by 27 Tareumiut families from Barrow who originally had lived in the area (Galginaitis 1990). The population of Nuiqsut was 433 in 2000, more than 88% of whom were

Natives (mostly Tareumiut) (see Tables 3.25-1 and 3.29-1).

Although some wage employment is available in nearby oil fields and with North Slope Borough and state governments, subsistence remains extremely important to the residents of Nuiqsut for economic, sociocultural, and ceremonial reasons (North Slope Borough 1999). Subsistence harvests are large in Nuiqsut at 742 lb per person annually. The composition of the total harvest is relatively balanced among marine mammals (notably whales), large land mammals (especially caribou), and fish (notably whitefish), with each of these resource categories contributing more than 230 pounds per capita to the Nuiqsut economy during the reference year of 1993 (see Table 3.24-1) (see also Galginaitis 1990). Hunting large land mammals and fishing involved 74% and 81%, respectively, of the Nuiqsut households in 1993 (see Table 3.24-2). Even larger percentages of households gave or received these (and other) resources, providing evidence of the considerable exchange that continues in the community (ADF&G 2001b).

Evidence for earlier periods suggests that similar harvest patterns, in the sense of species mix and level of importance, occurred over time

in Nuiqsut, although detailed quantitative data are lacking (Libbey et al. 1979; North Slope Borough Planning Commission and Commission on History and Culture 1979; see also ADF&G 1986a). Subsistence data from 1994-1995, the year following the representative year presented in Tables 3.24-1 and 3.24-2, indicate similar breadth in subsistence species and in their emphasis, with caribou being particularly important (Brower and Opie 1997). Subsistence harvest surveys for 1985 and 1993 reveal considerable variability, the per capita harvest in the latter year much higher than in the former with a particular distinction in marine mammal harvest (Figure 3.24-4). The primary cause of this difference is the failure of whaling in 1985. Local hunters attributed this to disturbance of whales by seismic exploration activities, which drove the migrating animals farther offshore (Pedersen et al. 2000).

The Nuiqsut subsistence use area encompasses a large, generally circular area, extending north to the Beaufort Sea coast and south to the foothills of the Brooks Range. A portion of the use area, focused on caribou hunting, reaches into the Brooks Range to Anaktuvuk Pass. Part of the Nuiqsut subsistence harvest area overlaps with a section of the TAPS in the vicinity of Prudhoe Bay and Deadhorse (see Map 3.24-1).

Subsistence concerns identified by local residents during 1985 and 1993 included habitat destruction resulting from increasing oil and gas development, growing competition for subsistence resources because of larger populations and improved access by nonlocal hunters, and oil exploration activities noted above (ADF&G 2001b; Pedersen et al. 2000). Subsistence problems identified in 1995-1996 included aircraft scaring caribou, musk oxen affecting caribou movements, absence of caribou, lack of access to key equipment (such as a working snowmachine) to enable hunting, and the possibility that modern activities may be poisoning game (Brower and Opie 1997). Subsistence concerns expressed by Nuiqsut residents during public scoping for this EIS included vehicles on the Dalton Highway disturbing wildlife; a general decline in caribou population near Nuiqsut (no reason given); altered caribou migration patterns because of TAPS infrastructure and operation, as well as other oil-related infrastructure and activities; bowhunter wounding of caribou near the TAPS; modifications of subsistence harvest schedules, in part because of spill response training and in part because of oil and gas development activities; spills in the Sagavanirktok River headwaters that have reduced fish populations; and spills and other impacts related to the oil

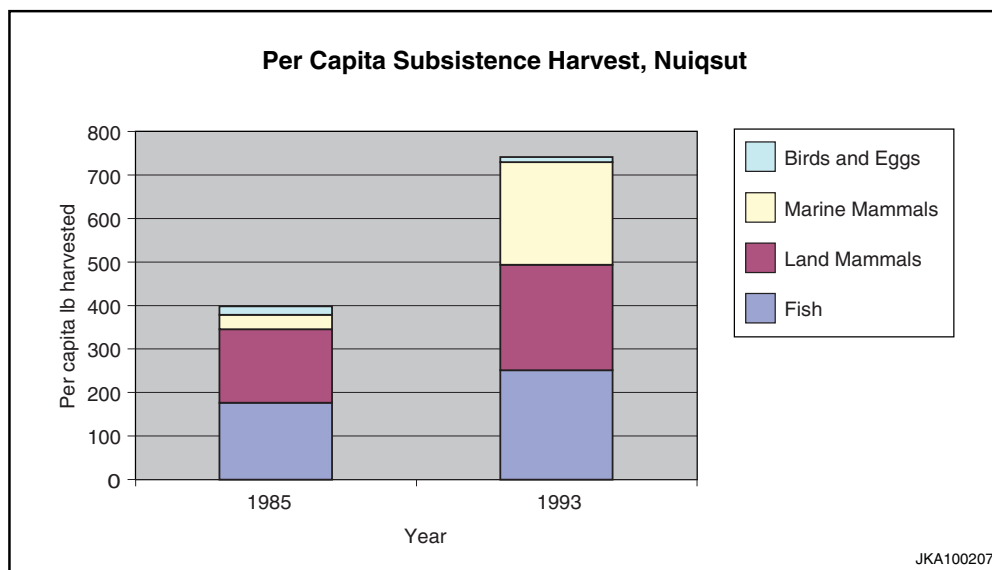


FIGURE 3.24-4 Variability in Nuiqsut Subsistence Harvest Over Time (Source: ADF&G 2001b)

industry that have altered the taste and general quality of fish.

3.24.2.2 Yukon River Drainage

The Yukon River Drainage comprises a broad expanse of the interior Alaska Plateau between the Brooks Range and the Alaska Range drained by the Yukon River and its tributaries. The Alaska Native sociocultural systems of this region comprise several Athabascan peoples, including Gwich'in, Koyukon, and Tanana (see Section 3.25.1). Adaptive strategies of these peoples, as well as rural non-Native sociocultural systems, emphasize combinations of terrestrial mammals and both anadromous and resident fish (supplemented by other resources in smaller amounts, as available). Salmon harvests represent a particularly large portion of total subsistence foods in this region. Harvesting these resources during both traditional and modern times often involves carefully timed, short-term relocations to places where certain resources are abundant. Figure 3.24-5 shows the main subsistence resources harvested in the Yukon River Drainage for an example community from this region — in terms of per capita pounds of salmon combined with lesser amounts of other types of fish and large land mammals. The timing of resource harvests indicates the importance of certain months for key resources (Figure 3.24-6). Per capita harvest levels in the Interior are very high, second in the state only to western Alaskan villages (ADF&G 2000a). Among the Interior villages examined in this EIS, harvests range from about 900 to 1,200 lb per capita, with the exception of much lower levels for Evansville (see Table 3.24-1). For the upper Yukon River villages, the high values include a significant amount of fish harvested for sled dog food, estimated at 62% of the harvest for chum and coho salmon (Andersen 1992).

This EIS discusses 10 communities that lie in the Yukon River Drainage: Alatna, Allakaket, Evansville, Hughes, Manley Hot Springs, Minto, Rampart, Stevens Village, Tanana, and Wiseman. As the data presented reveal, subsistence varies among these localities, although it plays an important economic, sociocultural, and (except for Wiseman)

ceremonial role in each. The EIS groups these communities primarily because the salmon upon which all to a degree rely spend part of their lives in the ocean west of Alaska — subjecting them to different impacts than salmon associated with waters south of Alaska. In addition to the brief descriptions of subsistence in these communities presented in the following paragraphs, further details may be found in Appendix D.

3.24.2.2.1 Alatna. Alatna is a small village on the northern bank of the Koyukuk River about 56 mi west of the TAPS (Map 3.24-1) (ADCED 2001b). The population of Alatna in 2000 was 35, and although the village is located in a part of Alaska inhabited predominantly by Athabascan peoples, most of the Alatna inhabitants in 2000 were Kobuk River Iñupiat, a reflection of the long history of trading relations between the Iñupiat of the Kobuk River region and the Koyukon Athabascans (see Tables 3.25-1 and 3.29-1).

Subsistence is important to this small community, serving as the main economic activity (supplemented by a small amount of seasonal wage labor), as well as playing key cultural roles. Subsistence activities involve harvesting a variety of land mammals, birds, and fish that contribute a considerable amount of food and other resources (Marcotte and Haynes 1984; see Table 3.24-1). Note that data on Alatna subsistence activities in the referenced table also appear in the Allakaket column, because information on these two neighboring communities has often been joined in projects collecting subsistence data. Most recent available data for Alatna combined with Allakaket indicate that a large percentage of the village households were involved with subsistence in 1982 (see Table 3.24-2, Allakaket column). For example, 70% of households harvested moose, 80% of households harvested small mammal species of marten and hare, while 66% of households harvested beaver, and at least 70% of households harvested fish and 80% took waterfowl. A more limited survey in the late 1990s, indicated that 70% percent of households harvested large mammals, such as caribou or moose, while 100% of households used these species, indicating that sharing enables all households to have access to these important

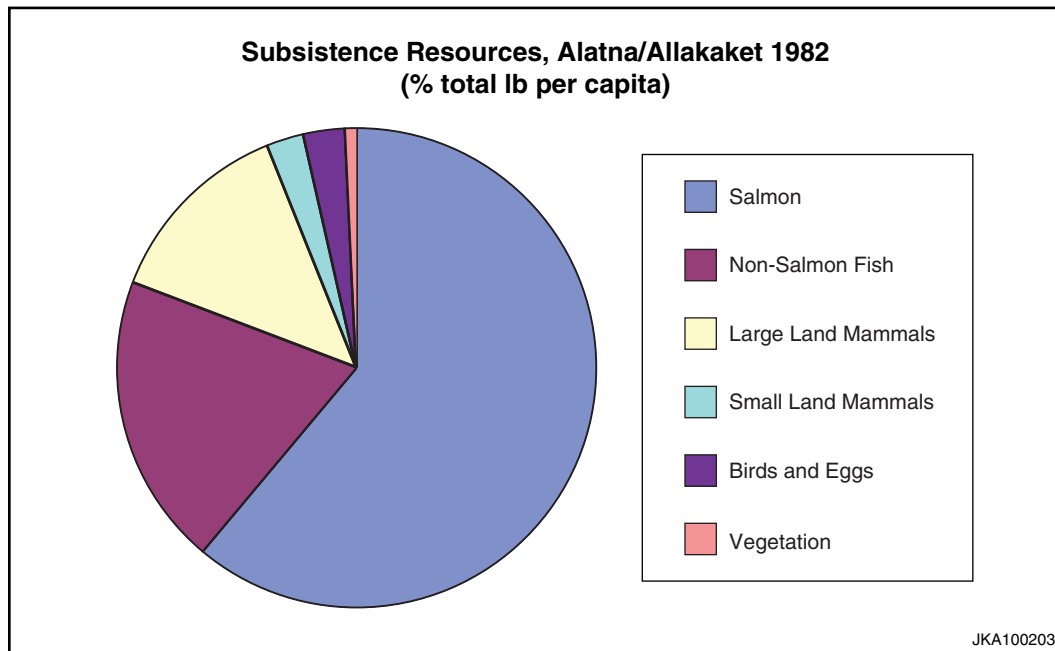


FIGURE 3.24-5 Example Combination of Subsistence Resources in the Yukon River Drainage (Alatna/Allakaket) (Source: ADF&G 2001b)

resources (ADF&G 2001b). Subsistence harvest surveys for Alatna and neighboring Allakaket in the early 1980s indicate declining subsistence harvests, with much of the decrease accounted for by reduced salmon harvest (Figure 3.24-7). Subsistence levels for large mammals during the 1980s and late 1990s, in contrast, do not reveal a clear trend, with per capita pounds harvested for two of the three years in the late 1990s higher than their early 1980s counterparts (Figure 3.24-8).

The subsistence use area for Alatna is a large zone running along the Koyukuk River near the village, extending east along the Kanuti River, and northwest up the Alatna River and associated uplands. The zone includes an area in the Brooks Range, northwest of the community. Although the subsistence use area for Alatna does not intersect the TAPS, it does include part of the Koyukuk River downstream from the pipeline (see Map 3.24-1).

Concerns identified during the late 1990s by local residents included both competition from nonlocal hunters and declining numbers of moose and caribou; the latter problem was

blamed on hunting competition and predation by wolves (ADF&G 2001b).

3.24.2.2.2 Allakaket. Allakaket is located on the southern bank of the Koyukuk River about 55 mi west of the TAPS (see Map 3.24-1) (ADCED 2001b). The village population in 2000 was 97, with most of the inhabitants Alaska Natives (primarily Koyukon Athabascans) (see Tables 3.25-1 and 3.29-1).

Subsistence is important in Allakaket, with both land mammals and fish harvested in large amounts (Marcotte and Haynes 1984; see Table 3.24-1; see also Brannian and Gnath 1988). Data from 1982, the year specified by the ADF&G as being representative of subsistence activities in Allakaket, indicate a very large per capita harvest at 906 lb, and very high rates of household participation (see Table 3.24-2). As in Alatna, in the early 1980s, 70% of households took large mammals, especially moose, 80% of households harvest small mammals, 66% of households took furbearers, at least 70% of households harvested fish, and 80% took waterfowl. By the late 1990s, data only on subsistence harvests of large land mammals

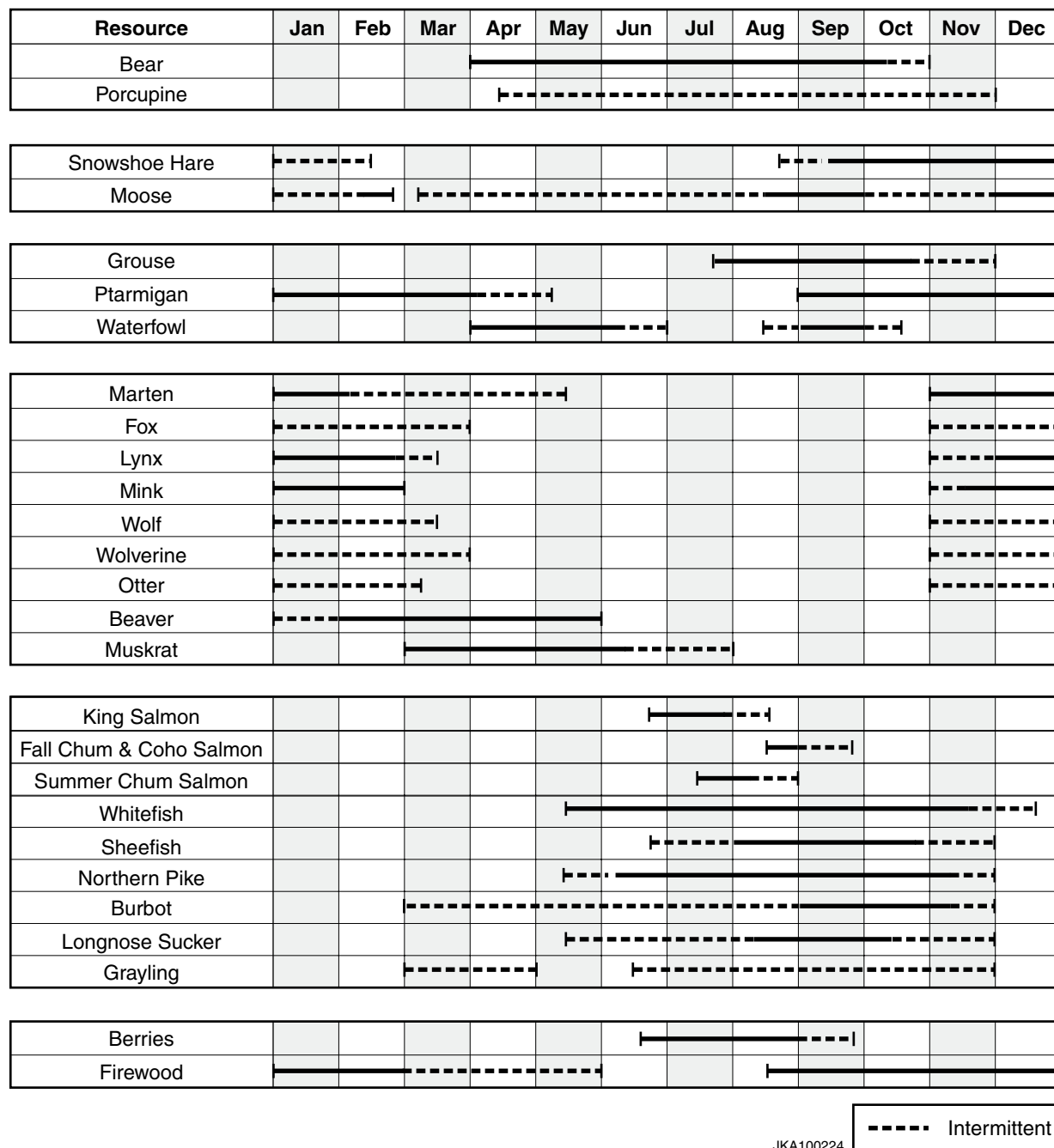


FIGURE 3.24-6 Example of the Seasonality of the Subsistence Harvest in the Yukon River Drainage (Stevens Village) (Source: Sumida 1988)

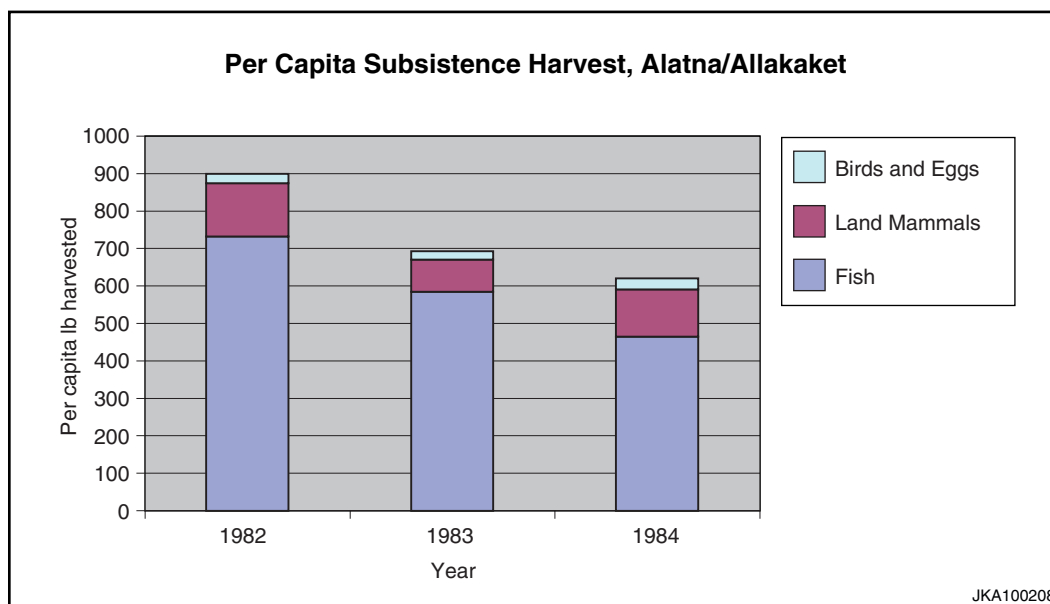


FIGURE 3.24-7 Variability in Alatna/Allakaket Subsistence Harvest Over Time (Source: ADF&G 2001b)

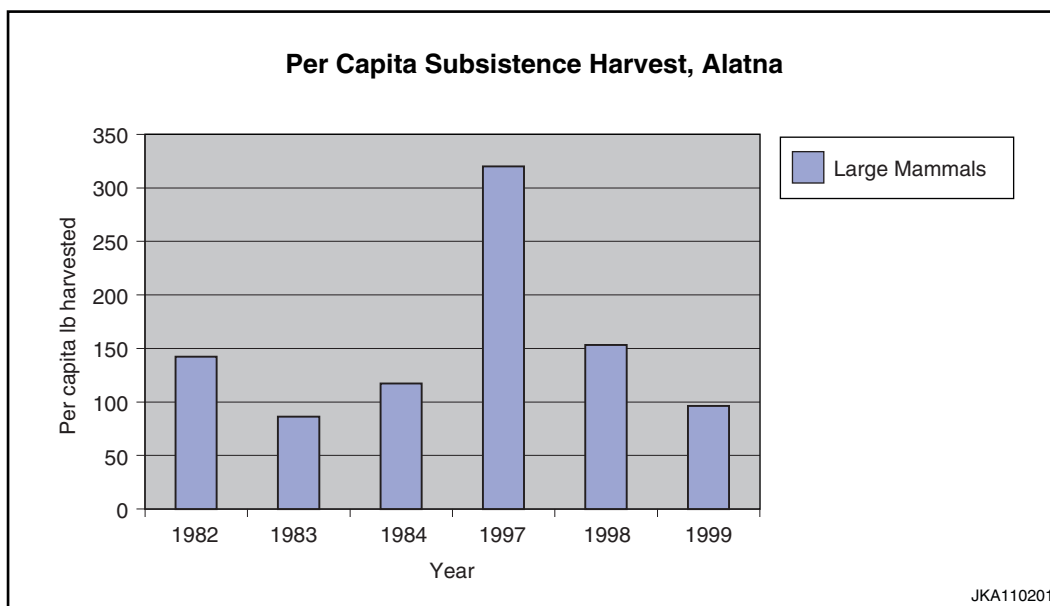


FIGURE 3.24-8 Variability in Alatna Subsistence Harvest of Large Mammals Over Time (Source: ADF&G 2001b)

indicate that nearly all households who successfully hunt these species give them to other households (ADF&G 2001b). Thus, although only slightly more than half the community households harvest these resources, all households use them. This is evidence of continuing social interaction through subsistence activities. Subsistence harvest surveys for Allakaket and neighboring Alatna in the early 1980s indicate declining subsistence harvests, with much of the decrease accounted for by reduced salmon harvest (see Figure 3.24-7). Harvest data for large animals for subsistence during the early 1980s and late 1990s indicate fairly constant harvest levels, with some reduced harvests for the early 1980s (Figure 3.24-9).

The subsistence use area for Allakaket is a large zone running along the Koyukuk River near the village, extending east along the Kanuti River, and northwest up the Alatna River and association uplands. The zone include an area in the Brooks Range, northwest of the community. Although the subsistence use area for Allakaket does not intersect the TAPS, it does include part of the Koyukuk River downstream from the pipeline (see Map 3.24-1).

Subsistence concerns identified during the late 1990s included both competition from nonlocal hunters and declining numbers of moose and caribou; the latter problem was blamed on hunting competition and predation by wolves (ADF&G 2001b). Subsistence concerns expressed by Allakaket residents during public scoping for this EIS included TAPS impacts on caribou migration patterns (both the presence of the pipeline and vehicle movement along the Dalton Highway causing them not to come near Allakaket as they did in the past); competition from nonlocal hunters and fishermen (including TAPS employees); airboats disrupting fish spawning grounds; and tourism disrupting the subsistence process (interrupting harvest activities). In the recent past, residents also expressed concerns that the influx of outsiders has led to the imposition of new rules and regulations that unnecessarily constrain subsistence activities (Beetus and Beetus 1992), and (again) that declines in local caribou since the 1970s are due to changing migration patterns caused by the TAPS (Moses 1993).

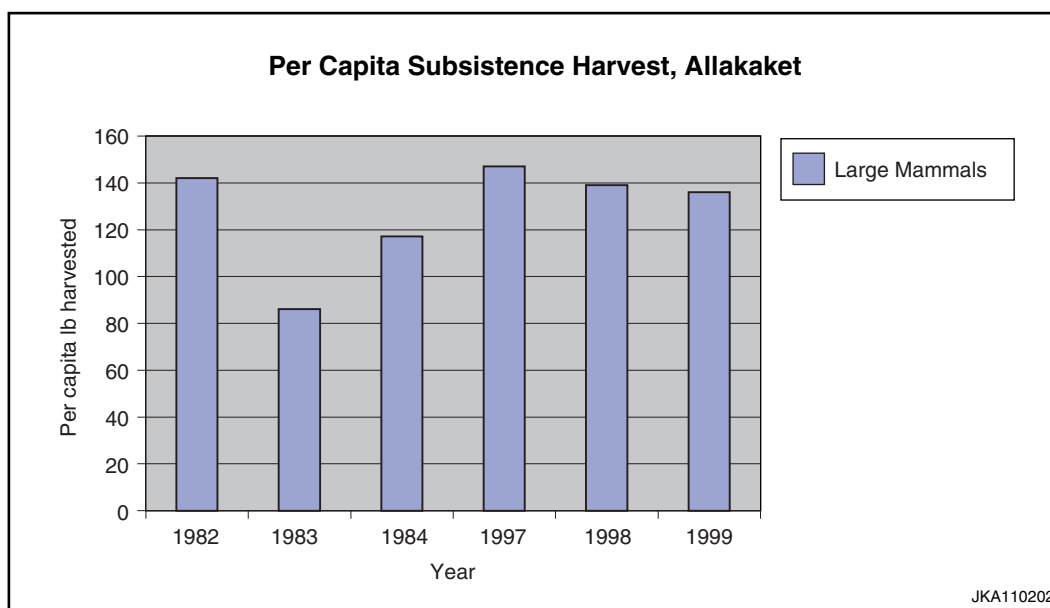


FIGURE 3.24-9 Variability in Allakaket Subsistence Harvest of Large Mammals Over Time (Source: ADF&G 2001b)

3.24.2.2.3 Evansville. Evansville is an interior village about 180 air mi northwest of Fairbanks and 22 mi west of the TAPS (see Map 3.24-1) (ADCED 2001b). In 2000, the decennial census recorded 28 people in Evansville, half of them Native (Athabascan and Iñupiat) (see Tables 3.25-1 and 3.29-1). In contrast to most rural communities in Alaska, many Evansville residents are employed in wage-producing jobs — the majority associated with air transportation, visitor services, and government.

Many Evansville residents continue to practice subsistence hunting, fishing, and trapping, along side the economic alternatives of wage employment. The level of participation and the amount harvested in 1982 vary widely by subsistence resource (Marcotte and Haynes 1984; see Tables 3.24-1 and 3.24-2), with moderate rates of household participation in most forms of harvest, but high production in moose, salmon, and other fish. The annual per capita level of harvest was 260 lb. Subsistence data collected on large land mammals in the late 1990s indicate that the exchange of subsistence

resources helps ensure that individuals who do not harvest these animals still have access to them while reaffirming social networks (ADF&G 2001b). Subsistence harvest surveys for Evansville (and neighboring Bettles) in the early 1980s indicate declining subsistence harvests, with much of the decrease accounted for by reduced fish harvest (Figure 3.24-10). Subsistence harvest data for large mammals in the early 1980s and late 1990s also indicate a general trend towards decline over time (Figure 3.24-11).

The subsistence use area for Evansville, (shared with neighboring Bettles) extends along the Koyukuk River and associated lowlands from Alatna/Allakaket up into the Brooks Range to the north. The zone extends east-west along the lower reaches of the Brooks Range, including the John River and other river headwater valleys. Part of the subsistence area for Evansville overlaps with a sector of the TAPS to the east (see Map 3.24-1). In addition, the use area for this community includes part of the Koyukuk River downstream from the pipeline.

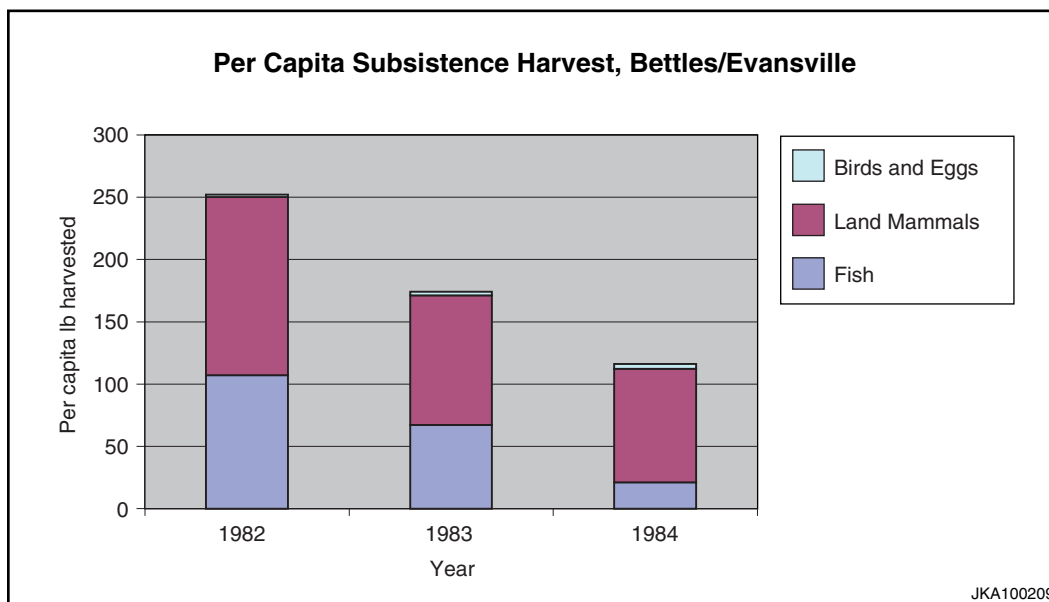


FIGURE 3.24-10 Variability in Evansville/Bettles Subsistence Harvest Over Time (Source: ADF&G 2001b)

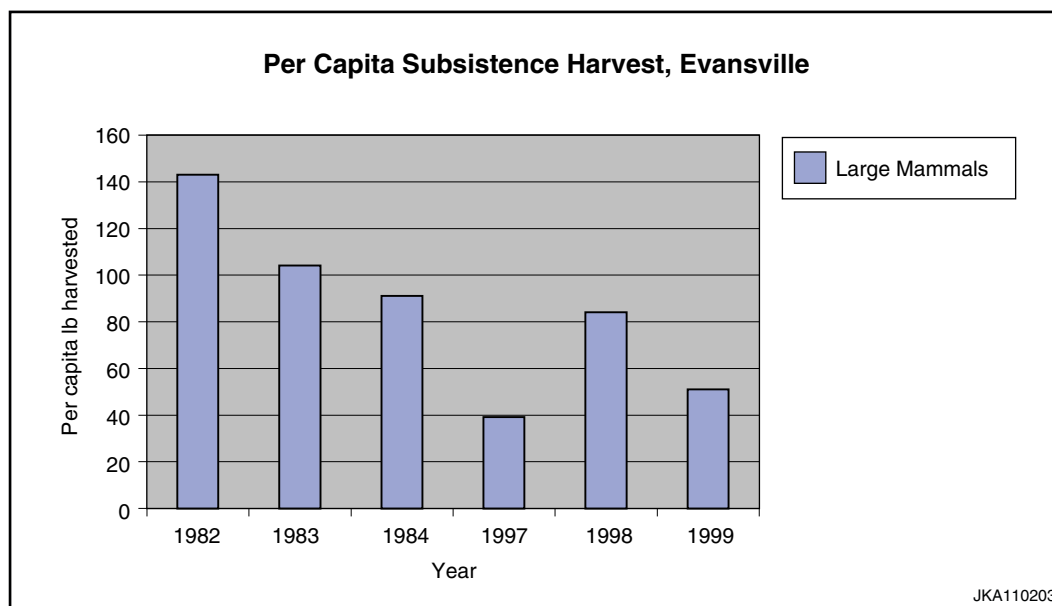


FIGURE 3.24-11 Variability in Evansville Subsistence Harvest of Large Mammals Over Time (Source: ADF&G 2001b)

Subsistence concerns identified by local residents during the early 1980s included increased competition for subsistence resources due to improved access and restrictions on nonsubsistence hunting in Gates of the Arctic NPP, sporadic caribou migration (no reason proposed), and low moose populations (in 1987, again with no reasons proposed) (ADF&G 2001b; Holly 1992).

3.24.2.2.4 Hughes. Hughes is located on a tall bluff on the eastern bank of the Koyukuk River, roughly 210 air mi northwest of Fairbanks and about 105 mi west of the TAPS (see Map 3.24-1) (ADCED 2001b). In 2000, the population of Hughes was 78, the vast majority of whom were Native (primarily Koyukon Athabascans) (see Tables 3.25-1 and 3.29-1).

Subsistence involves much of the population of Hughes. A detailed community survey in 1982 recorded average per capita harvest of 1,492 lb. Subsistence remained important to Hughes residents into the 1990s based on more limited data from annual harvest tickets and subsistence salmon surveys. Residents of Hughes harvested a broad range of land mammals, birds, and fish in the reference year of 1982, although moose and salmon by far dominated the weight

harvested (Marcotte and Haynes 1984; see Table 3.24-1; see also Brannian and Gnath 1988). Several subsistence resources, including moose and salmon, were harvested by more than 60% of the community households (see Table 3.24-2). The limited data available on exchange indicate that many households also received subsistence resources, preserving a key sociocultural function of subsistence while extending access to key resources (ADF&G 2001b). Because ADF&G did not collect subsistence harvest data for multiple years, evidence on harvest variability over time is unavailable.

The subsistence use area for Hughes extends for more than 100 mi along the Koyukuk River valley, including upland zones to both the north and the south. Although the subsistence area for Hughes does not intersect the TAPS, it does include part of the Koyukuk River downstream from the pipeline (see Map 3.24-1).

Subsistence concerns identified by local residents during the early 1980s included increased competition for subsistence resources resulting from improved access for nonlocal hunters and fishermen, sporadic caribou migration (no reason proposed), and low moose

populations (in 1987, again with no reasons proposed) (ADF&G 2001b).

3.24.2.2.5 Manley Hot Springs.

Manley Hot Springs is a small community located on Hot Springs Slough about 5 mi north of the Tanana River at the end of the Elliott Highway and 65 mi west of the TAPS (see Map 3.24-1) (ADCED 2001b). The Manley Hot Springs population in 2000 was 72, the majority of whom were non-Native (see Tables 3.25-1 and 3.29-1).

The economy of Manley Hot Springs is diverse, including employment in small businesses, government, and commercial fishing. Alongside the availability of these other economic options, subsistence remains important in this small village. Gardening, hunting, and fishing play important roles in providing food, with salmon and moose particularly important (see Betts 1997, Brannian and Gnath 1988). Specific data on harvest levels, participation rates, and subsistence concerns are unavailable from the ADF&G for this community. However, subsistence data collected recently for an environmental assessment of road construction indicate a range of subsistence resources similar to that found in nearby Alaska Native villages, such as Rampart and Stevens Village, except for a virtual absence of caribou from subsistence because of the lack of that resource locally (Betts 1997).

The subsistence use area for Manley Hot Springs extends along a large portion of the Tanana River, with significant upland zones both north and south of the river. The use area does not intersect the TAPS; it does, however, include parts of the Tanana and Yukon Rivers and associated drainages as close as 6.5 mi downstream from the pipeline (see Map 3.24-1).

Subsistence concerns primarily consist of competition from nonlocal hunters (Betts 1997). Additional concerns expressed during public scoping included competition from nonlocal hunters made possible by increased access.

3.24.2.2.6 Minto. Minto is located on the western bank of the Tolovana River, about 47 mi south of the TAPS and about 130 mi

northwest of Fairbanks (see Map 3.24-1) (ADCED 2001b). In 2000, Minto contained 258 people, nearly 92% of whom were Native (mainly Tanana Athabascan) (see Tables 3.25-1 and 3.29-1). The village economy of Minto is mixed. Wage employment is predominantly seasonal, although some is year-round. Subsistence remains important for economic, sociocultural, and ceremonial reasons, involving most of the village population (Andrews 1988; see Table 3.24-1).

Minto residents harvest a wide array of resources, with particularly high reliance on fish (notably salmon, but also pike and grayling) as documented in the reference year of 1984. Large land mammals, particularly moose, also were important. The annual per capita harvest for Minto residents was 1,015 lb in 1984. Nearly all Minto households were involved in subsistence activities, with nearly 90% of all households fishing (often traveling to fish camps during the summer) and over 80% of households participating in large land mammal, small land mammal, and bird harvests (see Table 3.24-2). Because ADF&G did not collect subsistence harvest data for multiple years, evidence on harvest variability over time is unavailable.

The subsistence use area for Minto extends throughout the Minto Flats, along a large portion of the Tanana River, and into a large upland zone generally north of the village. Part of the subsistence area for Minto intersects the TAPS, while other sections include part of the Tanana River and associated drainages downstream from the pipeline (see Map 3.24-1) (Andrews 1988).

Subsistence concerns identified by local residents in 1984 included habitat destruction resulting from mining; excessive constraints of certain hunting regulations; competition for moose, waterfowl, furbearers, and pike (exacerbated by low populations of moose and pike) from nonlocal hunters and fishermen; and disruption of fish and game by airboats used by nonlocal hunters and fishermen (ADF&G 2001b; Betts 1997). Subsistence concerns expressed by Minto residents during public scoping included competition by nonlocal hunters.

3.24.2.2.7 Rampart. Rampart is located on the southern bank of the Yukon River, about 75 mi upstream from its intersection with the Tanana River and 33 mi south-southwest of the TAPS (see Map 3.24-1) (ADCED 2001b). In 2000, the population of Rampart was 45, with most of its inhabitants Koyukon Athabascans (see Tables 3.25-1 and 3.29-1). Subsistence is extremely important in this small village. In addition to its sociocultural and ceremonial roles, subsistence fuels much of the economy in this geographically isolated community, supplemented by a small amount of primarily seasonal wage labor (including a small amount of commercial fishing).

Rampart residents harvest particularly large quantities of fish, mainly salmon and whitefish, and large game, particularly moose and caribou (Brannian and Gnath 1988). Limited harvest data are available from the ADF&G (see Table D-12 in Appendix D), but these data do not include information on per capita harvest levels or participation in subsistence activities comparable to that presented in Tables 3.24-1 and 3.24-2 for other communities. Subsistence data collected recently for an environmental assessment of road construction indicate a range of subsistence resources similar to that in nearby Stevens Village, although an analysis of available information suggested a decline in subsistence over the past few decades (Betts 1997).

The subsistence use area for Rampart runs along the Yukon River from near the confluence with the Tanana River to a point upstream of the TAPS. It includes upland zones generally south of the Yukon River, near the village. The subsistence use area for Rampart intersects the TAPS and includes several miles of the Yukon River and associated drainages downstream from the pipeline (see Map 3.24-1).

Subsistence concerns include predation of game and competition from nonlocal hunters and commercial fishing (Betts 1997).

3.24.2.2.8 Stevens Village. Stevens Village is located on the northern bank of the Yukon River, upstream from where it crosses the Dalton Highway and about 20 mi north of the TAPS (see Map 3.24-1) (ADCED 2001b). The

Stevens Village population in 2000 was 87, most of whom were Koyukon Athabascans (see Tables 3.25-1 and 3.29-1). A few Stevens Village residents participate in a small amount of primarily seasonal wage labor in the village. In contrast, the majority of residents in Stevens Village participate in subsistence activities as a means of providing necessary resources for economic, sociocultural, and ceremonial purposes.

Stevens Village residents rely on a broad range of subsistence resources, together yielding a per capita harvest of 1,139 lb in 1984 (Sumida 1988) (see Table 3.24-1). Available data indicate that a large percentage of the village population harvested subsistence resources in the mid-1980s (Table 3.24-2), with over 80% of households involved in subsistence fishing, 90% in bird harvest, and 73% in small land mammal and furbearer harvests. A smaller portion of households, 46%, participated in large land mammal hunting, but harvesting households shared foods with others, providing wider access to these resources and helping to define and maintain exchange networks (ADF&G 2001b). In 1984, the most representative year for which detailed harvest data exist, fishing (notably for salmon) was particularly important, with per capita harvest more than one-half ton. Note that more than half of the fish harvested was used to feed sled dogs (Sumida 1988). Hunting small and large game also contributed to subsistence. Because ADF&G did not collect subsistence harvest data for multiple years, evidence on harvest variability over time is unavailable.

The Stevens Village subsistence use area encompasses the western portion of the Yukon Flats, from approximately the point where the Dalton Highway crosses the Yukon River, up to the village of Beaver, a distance of well over 100 river miles. The use area ranges north of the Yukon, especially in the Dall River area, and south of the Yukon into the drainages of Waldron and Rogers Creeks. Part of the subsistence harvest area for Stevens Village overlaps with a section of the TAPS (see Map 3.24-1) (Sumida 1988).

Subsistence concerns identified by local residents during 1984 included habitat destruction associated with the TAPS,

competition for resources by nonlocal residents, particularly in the Dall River area, and low moose populations (with no reason proposed) (Sumida 1988; ADF&G 2001b).

3.24.2.2.9 Tanana. The village of Tanana is about 2 mi west of the junction of the Tanana and Yukon Rivers in Interior Alaska, approximately 83 mi southwest of the TAPS (Map 3.24-1) (ADCED 2001b). In 2000, the decennial census recorded 308 inhabitants in this community, the majority of whom were Alaska Natives (primarily Athabascan) (see Tables 3.25-1 and 3.29-1). The economy of Tanana is mixed. Several wage labor positions exist, both full-time (with the city, village council, or school district) and seasonal (fire fighting, construction, and commercial fishing) jobs.

Subsistence remains important in Tanana dominated by salmon fishing, but also including fishing for other species, hunting large and small land animals, and hunting and collecting birds and eggs (see Table 3.24-1; see also Betts 1997). Tanana residents harvested 2,157 lb per capita in 1987. Data from the most representative harvest year (1987) indicate that more than 91% of the households participated in

subsistence harvests, with salmon fishing again registering the highest harvest rate (Case and Halpin 1990) (see Table 3.24-2). Subsistence fishing has been exceptionally productive in this community, amounting to nearly 2,000 lb per capita, although as much as 75% of the chum and coho salmon taken is used for dog food. Exchange patterns for subsistence resources incorporate the remaining households that do not harvest resources themselves, in the process helping to redefine patterns of social interaction (ADF&G 2001b). For example, in 1987 just over a third of households harvested moose, but all households report using this resource. Data collected on large mammal harvests in Tanana during the late 1990s indicate a substantial decline in per capita pounds harvested between 1997 and 1999 (Figure 3.24-12), although it is uncertain if this is representative of a longer-term trend.

The subsistence use area for Tanana consists of a long section of the Yukon River, roughly centered at its confluence with the Tanana River, and extending up this important tributary to Manley Hot Springs. South of the Yukon River, the Nowitna River drainage also constitutes an important portion of the Tanana

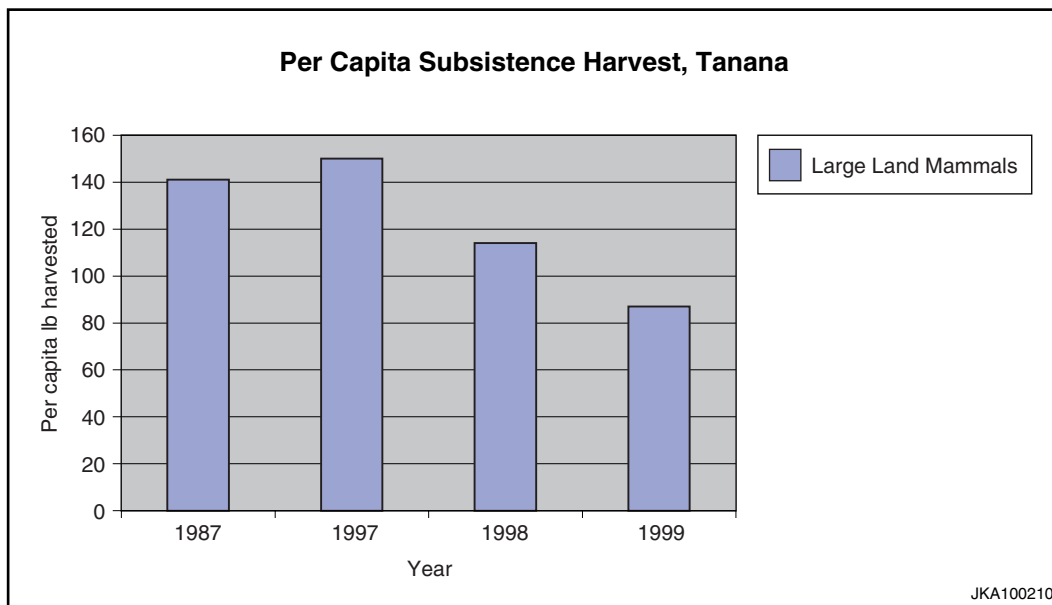


FIGURE 3.24-12 Variability in Tanana Subsistence Harvest of Large Mammals Over Time (Source: ADF&G 2001b)

use area. Although the subsistence use area for Tanana does not intersect the TAPS, it does include part of the Yukon and Tanana Rivers downstream from the pipeline (see Map 3.24-1).

Subsistence concerns identified by local residents during the late 1980s and late 1990s included habitat destruction caused by mining; competition from nonlocal fishermen, hunters, and trappers for salmon, moose, and fur-bearing animals; low moose population because of hunting competition and high wolf predation; and varying seasonal availability of caribou (ADF&G 2001b; Betts 1997). Additional concerns expressed during public scoping included competition from nonlocal hunters (especially for caribou) made possible through increased access.

3.24.2.2.10 Wiseman. Wiseman is a small community located a few miles west of the Dalton Highway and about 1 mi west of the TAPS. In 2000, the population of Wiseman was only 21 persons, 19% of whom were Alaska Native (see Table 3.29-1). Although a few sources of wage labor exist — primarily in providing road services on the Dalton Highway, mining, government employment, and commercial fishing — subsistence plays an important role in the economy of this small community (Johnson 1992; Reakoff 1992; Scott 1998).

During the 1990s, most households participated in subsistence, with hunting and fishing providing key resources according to the study by Scott (1998). Because the information obtained in that study employed different methods than those used by the ADF&G, results are not strictly comparable and thus are not included in Tables 3.24-1 and 3.24-2.

Available data indicate that the subsistence use area used by Wiseman residents intersects the TAPS (Scott 1998). Part of this area includes a length of the middle fork of the Koyukon River and its tributaries, exploited primarily for fishing. It also includes a broad portion of the southern Brooks Range in the vicinity of Wiseman, extending east to incorporate a large portion of the TAPS ROW.

Subsistence-related concerns expressed by Wiseman residents included competition by nonlocal hunters (especially) and fishermen whose access has been facilitated by the opening of the Dalton Highway, constraints placed on subsistence activities by government management agencies, and declining resource levels (Scott 1998).

3.24.2.3 Copper River Basin

The Copper River Basin refers to that portion of the Alaskan interior plateau that is drained by the Copper River and its tributaries. The region includes Alaska Native villages as well as rural communities that are inhabited largely by non-Natives (see Section 3.25). The Alaska Natives who inhabited this region at the time of Euro-American contact were Ahtna Athabascans, the people whose sociocultural presence continues to dominate much of the region. Subsistence in the Copper River Basin emphasizes a combination of fish (particularly salmon) and land mammals (with caribou and moose often the most important in terms of amount harvested). Other resources, including non-salmon fish, birds and their eggs, and marine invertebrates from the mouth of the Copper River also play a role in Copper River Basin community subsistence, although in much lesser amounts than the other categories.

Figure 3.24-13 shows the main subsistence resources harvested in the Copper River Basin for an example community from this region. The data reveal that salmon and large land mammals contribute the vast majority of pounds per capita harvested. The timing of resource harvests indicates the importance of summer and early fall for much of the volume of subsistence resources harvested, with other parts of the year providing important supplemental resources (Figure 3.24-14). Harvest levels in the Copper River Basin communities generally are 25% to 33% those for Interior and Arctic villages (ADF&G 2000a). Among the villages examined in this EIS, reported values range from about 100 to 200 lb per capita, the harvest for Paxson higher at 289 lb per person (see Table 3.24-1).

The EIS discusses subsistence in nine Copper River Basin communities: Chitina, Copper Center, Glennallen, Gakona, Gulkana, Kenny Lake, Paxson, Tazlina, and Tonsina. With

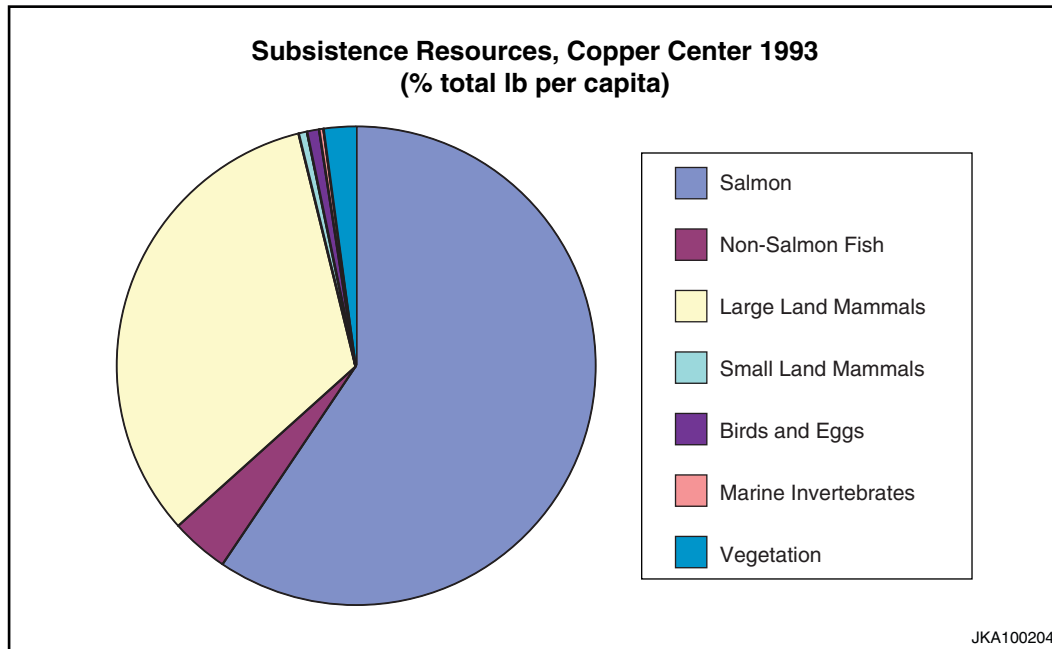


FIGURE 3.24-13 Example Combination of Subsistence Resources in the Copper River Basin (Copper Center) (Source: ADF&G 2001b)

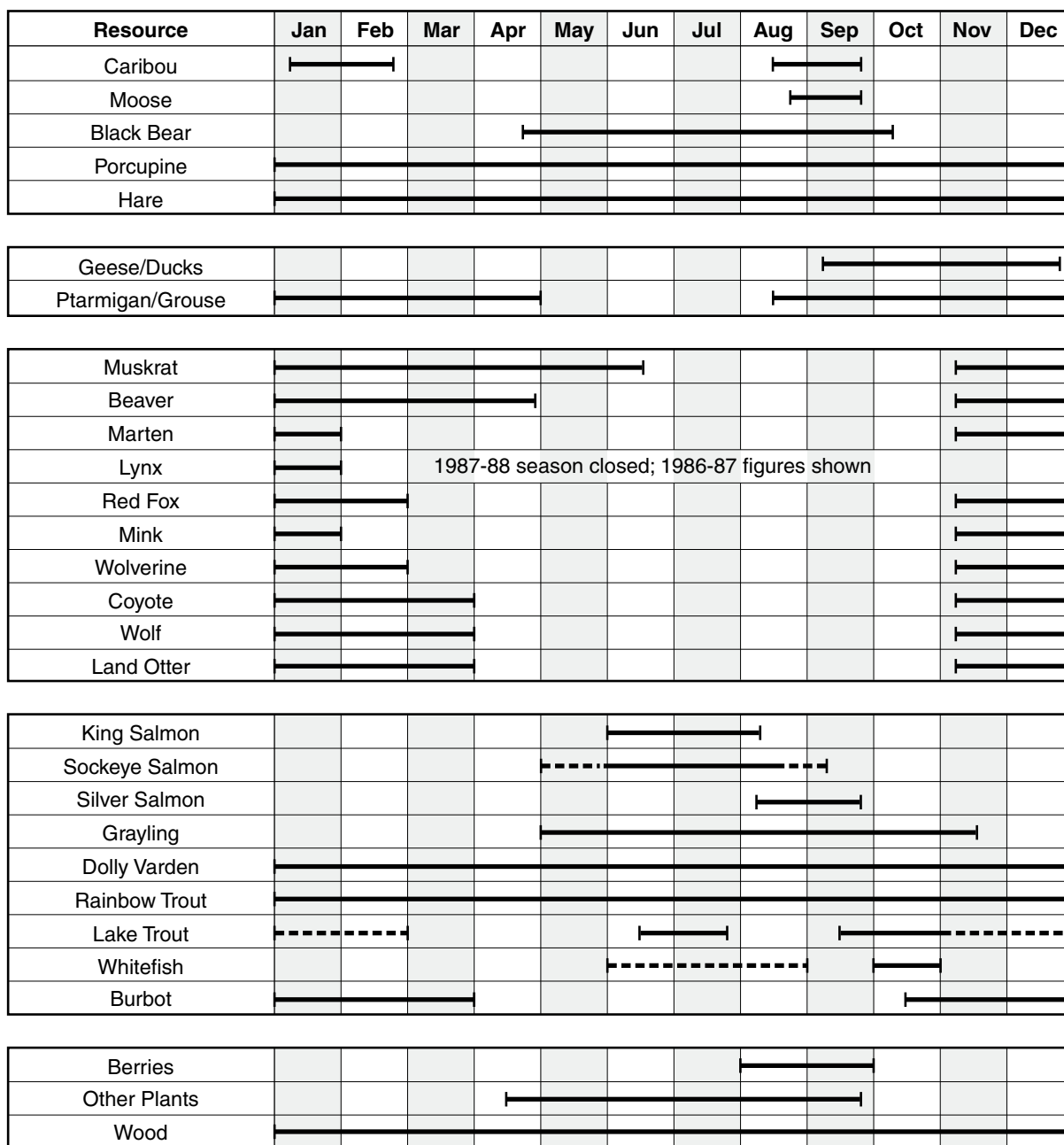
the exceptions of Glennallen, Kenny Lake, and Paxson, federally recognized Tribal governments are important local institutions. Although residents of these communities generally pursue subsistence through harvesting terrestrial and riverine resources found elsewhere in interior Alaska, they rely heavily on salmon runs in the Copper River and its tributaries. These salmon spend much of their lives in the ocean waters south of Alaska, subjecting them to different conditions than their western Alaska counterparts. As a consequence, subsistence in this region also is subject to the population cycles and management of these salmon runs. In addition to the brief descriptions of subsistence in these nine communities presented in the following paragraphs, further details are provided in Appendix D.

3.24.2.3.1 Chitina. Chitina is located about 21 mi east of the TAPS on the western bank of the Copper River at its confluence with the Chitina River (see Map 3.24-1) (ADCED 2001b). The population of Chitina was 123 in 2000, with most of its inhabitants Ahtna Athabascan (see Tables 3.25-1 and 3.29-1). The village economy is mixed, with both year-round

and seasonal wage employment along with subsistence activities.

Subsistence remains important in Chitina, with an average per capita harvest of 191 lb in 1982 (McMillan and Cuccarese 1988) (see Table 3.24-2). Large percentages of village households harvest a range of resources, while considerable exchange of these resources provides access to food resources for more of the community and reaffirms patterns of social interaction and obligation (ADF&G 2001b). Fishing played a particularly important role in Chitina subsistence through the late 1980s, with salmon the dominant resource by weight (see Table 3.24-1). Subsistence harvest data from 1982 and 1987 indicate a large increase in per capita pounds harvested in the latter year, primarily accounted for by an increase in salmon harvest (Figure 3.24-15).

The subsistence use area for Chitina residents is centered at the confluence of the Copper River and the Chitina River, where the village is located. It extends up the Copper River to the vicinity of Kenny Lake, and down the Richardson Highway to nearly Thompson Pass. Rugged uplands in the Wrangell-St. Elias



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FIGURE 3.24-14 Example of the Seasonality of the Subsistence Harvest in the Copper River Basin (Source: National Park Service 1995)

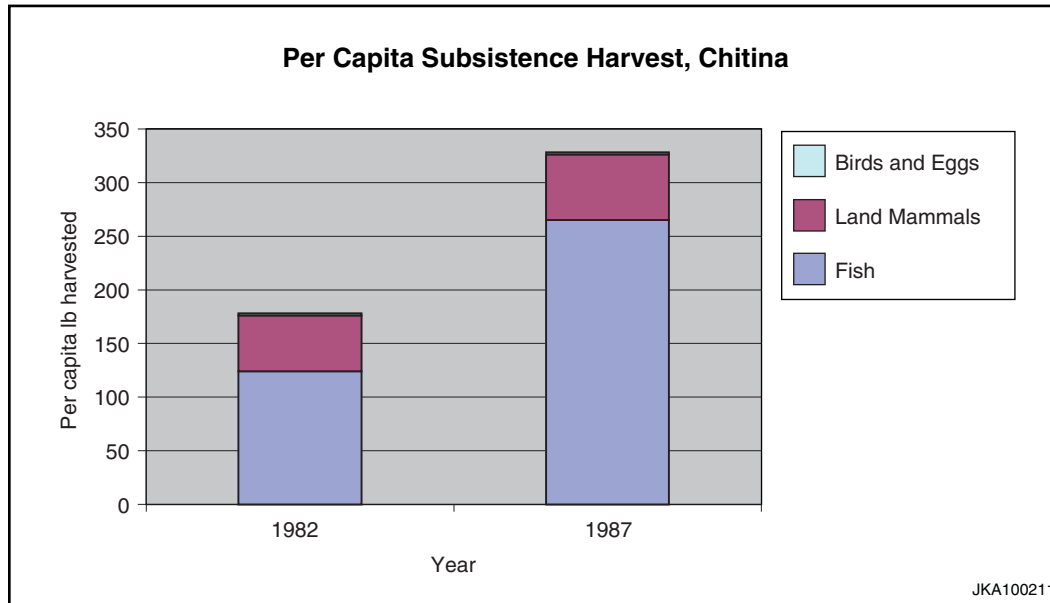


FIGURE 3.24-15 Variability in Chitina Subsistence Harvest Over Time (Source: ADF&G 2001b)

Mountains to the north and the Chugach Mountains to the south of the Chitina River are included in this use area. Part of the subsistence use area for Chitina overlaps with a section of the TAPS (see Map 3.24-1). In addition, the use area for this community includes part of the Copper River downstream from the pipeline.

Subsistence concerns identified by local residents during the 1980s included hunting and fishing bag limits (particularly for caribou and salmon) as well as both the potential increased competition for resources and habitat destruction resulting from development in the area (ADF&G 2001b).

3.24.2.3.2 Copper Center. Copper Center lies on the western bank of the Copper River at its confluence with the Klutina River, about 0.6 mi east of the pipeline (see Map 3.24-1) (ADCED 2001b). Slightly fewer than half of its 2000 population of 362 were Alaska Natives (mainly Ahtna Athabascan) (see Tables 3.25-1 and 3.29-1). Proximity to Glennallen, the TAPS, and the Richardson Highway provides a range of economic options, including wage employment in local businesses, such as those associated with the highway and tourism, the Copper River Native Association (a

regional Tribal consortium), and the National Park Service.

Over 75% of Copper Center households participate in subsistence harvest activities, particularly subsistence fishing. Salmon, caribou, and moose provide the largest amounts of harvested meat by weight, together contributing an average per capita harvest of 174 lb in 1987 (McMillan and Cuccarese 1988) (see Tables 3.24-1 and 3.24-2; see also Simeone and Fall 1996). Sharing of subsistence food is widespread, as indicated by the example that just under 20% of households harvested moose, but 53% of households reported utilizing moose for food. Such exchange ensures that virtually all households have access to the resources obtained (ADF&G 2001b). Subsistence harvest data from the 1982 and 1987 indicate an increase in per capita pounds harvested in the latter year, a consequence of increased salmon and (especially) large mammal harvests (Figure 3.24-16).

The Copper Center use area runs generally along the Richardson Highway, north and south of the village, and extends through a wide zone to the west of the road. Many extensions along river valleys into the Wrangell-St. Elias Mountains are also included. Part of the

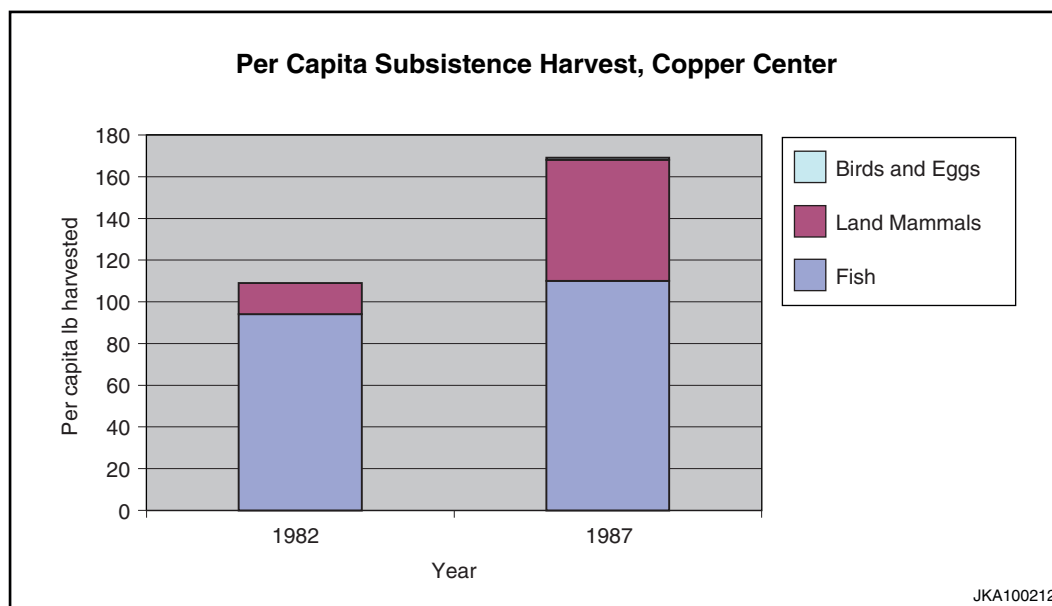


FIGURE 3.24-16 Variability in Copper Center Subsistence Harvest Over Time (Source: ADF&G 2001b)

subsistence use area for Copper Center overlaps with a section of the TAPS (see Map 3.24-1). In addition, the use area for this community includes part of the Copper River downstream from the pipeline.

Subsistence concerns identified by local residents during the 1980s included hunting and fishing bag limits (particularly on caribou and salmon), as well as both the potential increased competition for resources and the habitat destruction resulting from non-TAPS-related development in the area (ADF&G 2001b). By the late 1990s, the Nelchina caribou herd was at low population levels, so that harvest restrictions and allocational conflicts were severe. Increased nonlocal participation in moose hunting and the Chitina dip net fisheries also frustrated local subsistence users.

3.24.2.3.3 Gakona. Gakona is a small community at the confluence of the Copper and Gakona Rivers, at mile 2 of the Tok Cutoff to the Glenn Highway and about 6 mi east of the TAPS (see Map 3.24-1) (ADCED 2001b). The Gakona population in 2000 was 215, about 13% of whom were Native (mainly Ahtna Athabascan) (see Tables 3.25-1 and 3.29-1). The economy of

Gakona relies largely on local businesses and seasonal tourist travelers.

Many residents participate in subsistence activities; caribou, moose, and salmon contribute similar amounts in terms of weight (McMillan and Cuccarese 1988; Stratton and Georgette 1984) (see Table 3.24-1; see also Simeone and Fall 1996). The average per capita harvest was 95 lb in 1987. Available data indicate that as many as 70% of the community residents harvested fish for subsistence in 1987 (see Table 3.24-2). Widespread sharing provided nearly all households in the village with access to subsistence resources, in the process helping to maintain patterns of social interaction (ADF&G 2001b). Subsistence harvest data from 1983 and 1987 indicate a substantial decrease in per capita pounds harvest in the latter year, primarily accounted for by a large decline in salmon harvest (Figure 3.24-17).

The Gakona subsistence use area is generally located north of the village and includes significant zones both east and west of the Richardson Highway, along with additional areas located in the Wrangell Mountains north of Chitina and in the Chugach Mountains west of Tonsina. Part of the subsistence use area for Gakona overlaps with a section of the TAPS

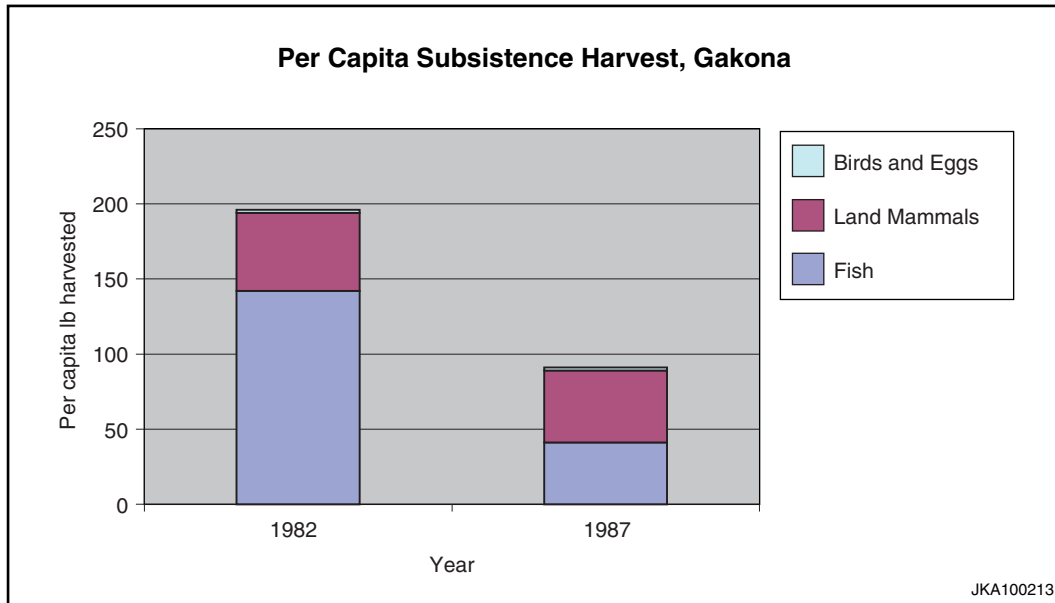


FIGURE 3.24-17 Variability in Gakona Subsistence Harvest Over Time
(Source: ADF&G 2001b)

(see Map 3.24-1). In addition, the use area for this community includes part of the Copper River downstream from the pipeline.

Subsistence concerns identified by local residents during the 1980s included hunting and fishing bag limits (particularly on caribou and salmon), as well as both the potential increased competition for resources and habitat destruction resulting from non-TAPS-related development in the area (ADF&G 2001b).

3.24.2.3.4 Glennallen. Glennallen is a small community on the Glenn Highway near its intersection with the Richardson Highway, about 3.5 mi west of the TAPS (see Map 3.24-1) (ADCED 2001b). Glennallen's population in 2000 was 554, 5.1% of whom were Native (primarily Athabascan) (see Table 3.29-1). Largely because of its location near the intersection of two highways and its proximity to Wrangell-St. Elias NPP, residents of Glennallen have more economic options than most rural Alaskans. Wage labor provides most of the livelihood in Glennallen, primarily through working for local businesses or government agencies.

Subsistence, nevertheless, remains an important activity in Glennallen, with an average

per capita harvest of 99 lb in 1987. Hunting (notably for moose and caribou) and fishing (particularly for grayling and salmon) provided most of the meat obtained through noncommercial means in the representative year of 1987 (see Table 3.24-1) (McMillan and Cuccarese 1988; Simeone and Fall 1996). About 71% of the households fished in 1987 (see Table 3.24-2). Exchange patterns made fish and other subsistence resources available to all households while helping to redefine social networks (ADF&G 2001b). Subsistence harvest data from 1983 and 1987 indicate an increase in per capita pounds harvested in the latter year, the growth due to increased harvests of salmon and land mammals (Figure 3.24-18).

The Glennallen subsistence use area is particularly large, reflecting the tendency of newer residents to travel along area highways to access the hunting range. Part of the subsistence use area for Glennallen overlaps with a section of the TAPS (see Map 3.24-1). In addition, the use area for this community includes part of the Copper River downstream from the pipeline.

Subsistence concerns identified by local residents in 1987 included habitat destruction and potentially increased competition for

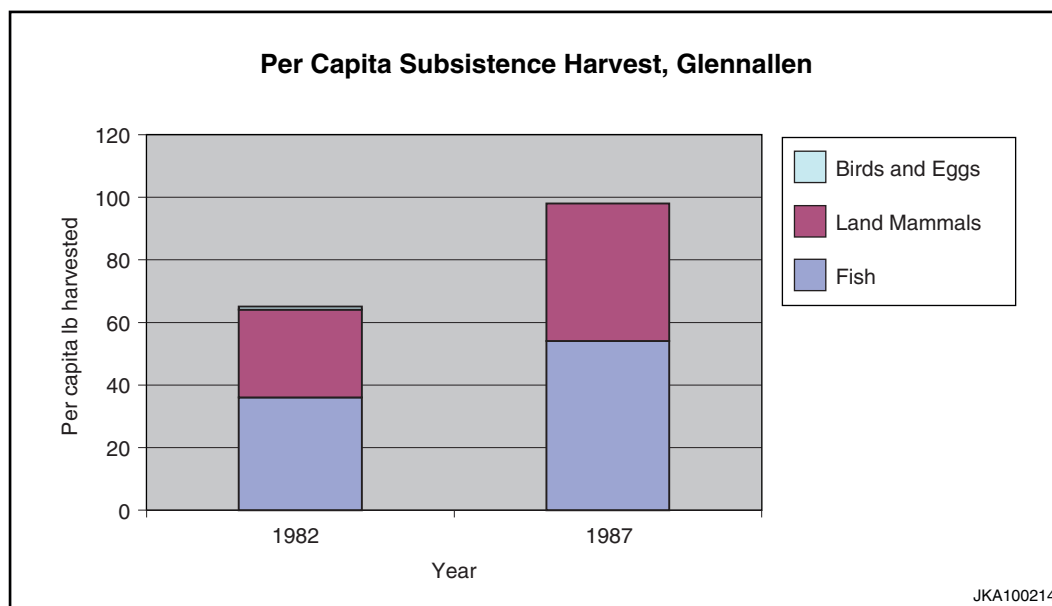


FIGURE 3.24-18 Variability in Glennallen Subsistence Harvest Over Time (Source: ADF&G 2001b)

subsistence resources because of non-TAPS-related development in the area (ADF&G 2001b).

3.24.2.3.5 Gulkana. Gulkana lies on the eastern bank of the Gulkana River where it joins the Copper River, approximately 3 mi east of the TAPS (Map 3.24-1) (ADCED 2001b). The population of Gulkana in 2000 was 88, about 72% of whom were Alaska Natives (primarily Ahtna Athabascan — see Tables 3.25-1 and 3.29-1).

The village economy of Gulkana is mixed, with subsistence hunting, fishing, gathering, and trapping providing key resources along with limited year-round and seasonal wage employment. Gulkana residents harvested an average 153 lb per capita in 1987 (McMillan and Cuccarese 1988; see Table 3.24-1; see also Simeone and Fall 1996). Fishing, particularly for salmon, contributes the greatest amount of subsistence resources by weight. Similarly, the largest percentages of households harvested fish compared with other subsistence activities, although hunting of land mammals also involved relatively large percentages of village residents (see Table 3.24-2). The exchange of subsistence resources helped to ensure that

nearly all households in the village had access to these materials, while reestablishing patterns of giving and receiving (ADF&G 2001b).

The Gulkana subsistence use area is concentrated to the north and west of the village, but extends south along the Richardson Highway to Thompson Pass and to the northwest along the upper Copper River toward Nabesna. A discontinuous portion of this use area is also found in the Wrangell-St. Elias Mountains north of Chitina. Part of the subsistence use area for Gulkana overlaps with a section of the TAPS (see Map 3.24-1). In addition, the use area for this community includes part of the Copper River downstream from the pipeline. Subsistence harvest data from 1983 and 1987 indicate an increase in per capita pounds harvested in the latter year, primarily accounted for by larger amounts of salmon and land mammals (Figure 3.24-19).

Subsistence concerns identified by local residents during the 1980s included hunting and fishing bag limits (particularly on caribou and salmon), as well as both the potential increased competition for subsistence resources and habitat destruction resulting from non-TAPS-related development in the area (ADF&G 2001b).

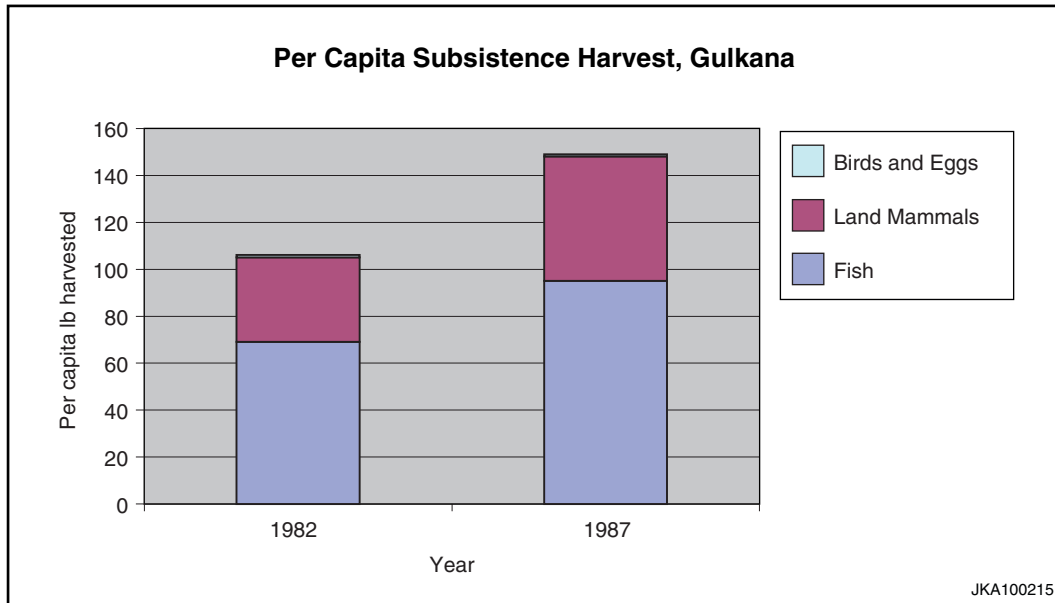


FIGURE 3.24-19 Variability in Gulkana Subsistence Harvest Over Time (Source: ADF&G 2001b)

3.24.2.3.6 Kenny Lake. Kenny Lake is a small community located about 7 mi east of the TAPS in the central Copper River Basin (ADCED 2001b) (see Map 3.24-1). The total population of Kenny Lake was 410 in 2000, with slightly more than 10% of the residents Alaska Natives (see Table 3.29-1). Although the area in and around Kenny Lake was inhabited for centuries by Athabascans, the community itself was founded in the 1960s by people homesteading agricultural land.

The economy of Kenny Lake is mixed, although wage labor is the main economic activity, with the majority of employment in commercial agriculture and small businesses. Subsistence, primarily hunting and fishing, also is conducted by residents of the community, producing an average per capita harvest of 136 lb in 1987. During 1987, the year designated by ADF&G as representative, subsistence contributed more than 130 edible pounds per person (McMillan and Cuccarese 1988) (see Table 3.24-1). Salmon accounted for nearly 83 edible pounds per person, with most of the remainder coming from moose and caribou. ADF&G survey data indicate that all households in Kenny Lake harvested at least one subsistence resource in 1987 (see

Table 3.24-2). Despite this high rate of participation in harvesting, exchange of subsistence resources also occurred in this small community, reaffirming patterns of social interaction (ADF&G 2001b). Subsistence harvest data from 1983 and 1987 indicate a large increase in per capita pounds harvested in the latter year, accounted for by increased large mammal and (especially) salmon harvests (Figure 3.24-20).

The Kenny Lake subsistence use area encompasses a wide zone to the west and east, generally south of the village, including both the Copper River and the Chitina River basins. Extensions along the Richardson and Glenn Highways are also important. Part of the subsistence use area for Kenny Lake overlaps with the TAPS (see Map 3.24-1). In addition, the use area for this community includes part of the Copper River downstream from the pipeline.

Subsistence concerns identified by local residents during the late 1980s included both potential increased competition for subsistence resources and possible habitat destruction resulting from non-TAPS-related development in the area (ADF&G 2001b).

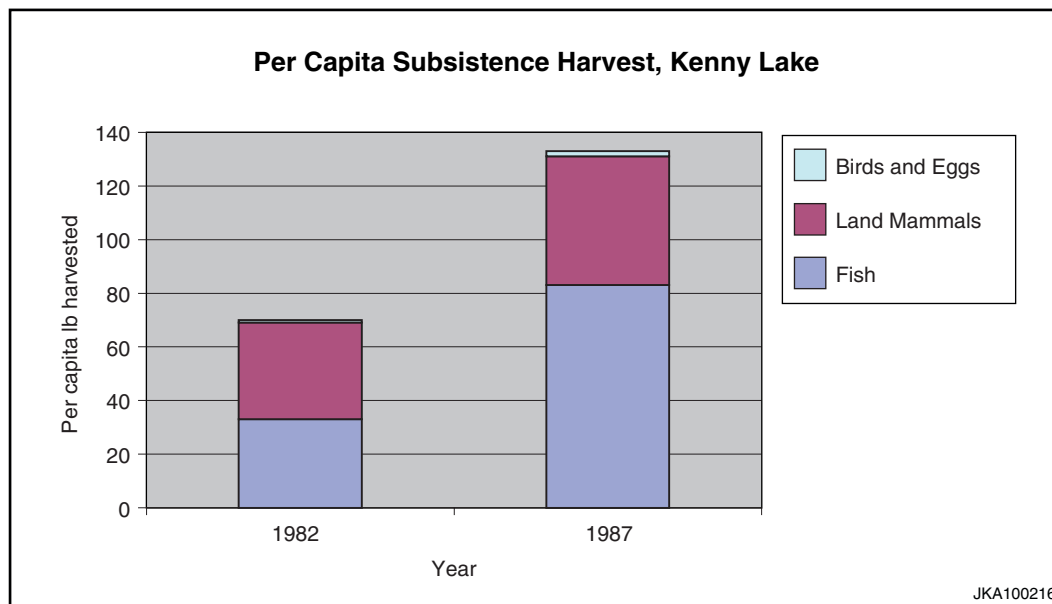


FIGURE 3.24-20 Variability in Kenny Lake Subsistence Harvest Over Time (Source: ADF&G 2001b)

3.24.2.3.7 Paxson. Paxson is located about 4 mi west of the TAPS in the Copper River Basin, at the intersection of the Richardson and Denali Highways (ADCED 2001b) (see Map 3.24-1). Paxson's total population was 43 in 2000, with no residents either Native or of any other minority (see Table 3.29-1). Paxson began in the early 1900s as a small roadhouse in the vicinity of the modern community.

Although the economy of Paxson is mixed, wage labor is the dominant component as residents take advantage of their proximity to two major highways to work in small local businesses that provide services to travelers, or for the government (primarily in highway maintenance). Nevertheless, subsistence activities provide considerable resources to community residents, in excess of 280 edible pounds per person in 1987 (McMillan and Cuccarese 1988) (see Table 3.24-1). Nearly every household harvested subsistence resources in the late 1980s. Despite higher participation in fishing that year, the largest amount of resources was contributed by land mammals, mainly moose and caribou (see Table 3.24-2). Although evidence exists for the exchange of subsistence resources, the receipt of resources did not generally increase the

percentage of households using these resources (ADF&G 2001b).

The Paxson subsistence use area covers a wide area centered on the village, including the and extending west along the Denali Highway, and south. Part of this area for Paxson overlaps with a section of the TAPS (see Map 3.24-1).

Subsistence concerns identified by local residents during the late 1980s included both potential increased competition for resources and possible habitat destruction from non-TAPS-related development in the area (ADF&G 2001b).

3.24.2.3.8 Tazlina. Tazlina is a small community located along the Richardson Highway on the Tazlina River near its juncture with the Copper River, about 2 mi northeast of the TAPS (see Map 3.24-1) (ADCED 2001b). Its population in 2000 was 149, about a quarter of whom were Native (primarily Ahtna Athabascan) (see Tables 3.25-1 and 3.29-1).

Largely because of its location on a major highway and its proximity to a large community (Glennallen), residents of Tazlina have more economic options than most rural Alaskans.

Wage labor, primarily for local businesses or government agencies, provides most of the livelihood in Tazlina. Nevertheless, subsistence continues as an important activity for many village residents. Hunting (notably for moose and caribou) and fishing (particularly for grayling and salmon) provide most of the meat obtained through noncommercial means (McMillan and Cuccarese 1988) (see Table 3.24-1; see also Simeone and Fall 1996). In 1987, the representative year for Tazlina, per capita harvests for all resources reached 107 lb. About 63% of the households harvested fish, while 29% took large land mammals (mostly moose and caribou), 23% took small mammals and furbearers, and 40% took birds, mostly grouse and ptarmigan (see Table 3.24-2). Considerable exchange of subsistence resources also occurred in 1987, providing access to these resources for households that do not harvest them, as well as further defining distribution networks. For example, although 63% of households fished, 94% of households were able to use this food source because of sharing (ADF&G 2001b).

The Tazlina subsistence use area is particularly large, reflecting the tendency of residents to travel along area highways to access the hunting range. Part of the subsistence use area for Tazlina overlaps with a section of the TAPS (see Map 3.24-1). In addition, the use area for this community includes part of the Copper River downstream from the pipeline.

Subsistence concerns identified by local residents in 1987 included habitat destruction by non-TAPS-related development and potentially increased competition for subsistence resources resulting from non-TAPS-related development in the area (ADF&G 2001b).

3.24.2.3.9 Tonsina. Tonsina is a small settlement in the central Copper Basin, located about 2 mi east of the TAPS in the vicinity of PS 12 (ADCED 2001b; see Map 3.24-1). The total population of Tonsina in 2000 was 92, about 10% of whom were Alaska Natives (mainly Ahtna Athabascan) (see Tables 3.25-1 and 3.29-1). In 1902, the U.S. Army established a telegraph station at the location of the modern community. The majority of growth experienced

in Tonsina, however, has been related to construction and continued operation of the TAPS.

Most adults in Tonsina work for wages, with employment at PS 12 and work on road maintenance crews providing much of their income. Nearly all households also harvested some sort of subsistence resource in 1987, the representative year for the community, testimony to the continuing importance of this activity (McMillan and Cuccarese 1988) (see Table 3.24-2). Rates of household participation in subsistence are high, with 83% of households fishing, 70% hunting for large land mammals, primarily caribou and moose; and about 40% taking small land mammal, furbearers, and birds (mostly grouse and ptarmigan). Tonsina residents harvested 156 lb of subsistence resources per capita in 1987. About half of the per capita subsistence harvest by weight was fish, primarily salmon, with most of the remainder being caribou and moose (see Table 3.24-1). Exchange of subsistence resources also occurred, with moose and salmon shared most widely. This sharing provides some households who did not harvest resources themselves access to those resources as well as further defining exchange networks (ADF&G 2001b). Subsistence harvest data from 1983 and 1987 indicate a substantial increase in per capita pounds harvested in the latter year, primarily accounted for by a larger harvest of land mammals (Figure 3.24-21).

The Tonsina subsistence use area extends through a large portion of the Copper Basin from Paxson to Thompson Pass, into the Chugach Mountains south of the community, and through much of the Chitina River valley. Part of the subsistence harvest area for Tonsina overlaps with a section of the TAPS (see Map 3.24-1). In addition, the use area for this community includes part of the Copper River downstream from the pipeline. Subsistence concerns identified by local residents during the late 1980s included both the potential increased competition for subsistence resources and possible habitat destruction from non-TAPS-related development in the area (ADF&G 2001b).

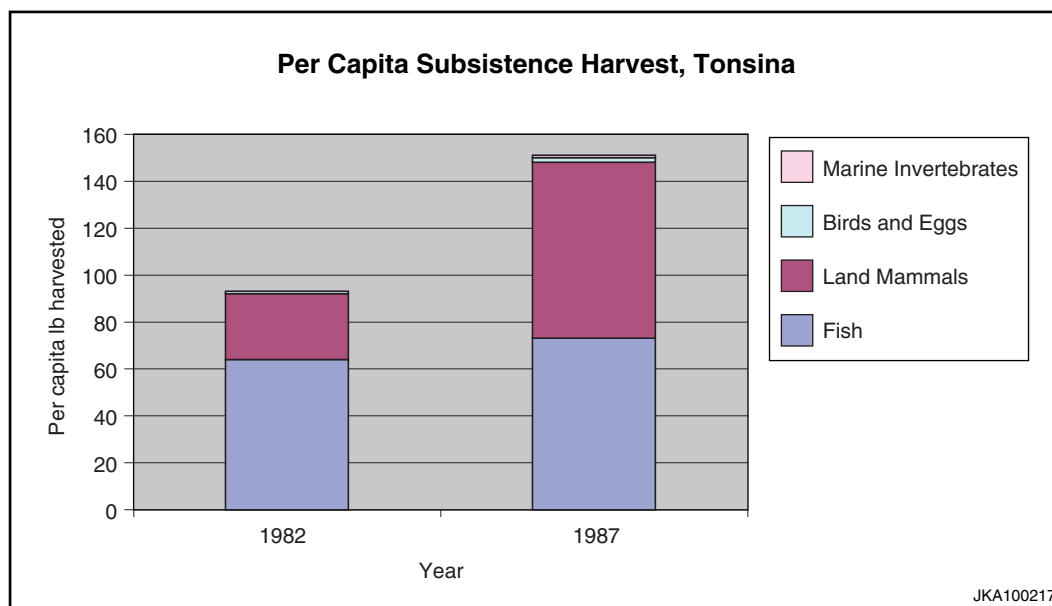


FIGURE 3.24-21 Variability in Tonsina Subsistence Harvest Over Time
(Source: ADF&G 2001b)

3.24.2.4 Prince William Sound and Lower Cook Inlet

Prince William Sound is the body of water along the coast of south-central Alaska extending from Cape Puget in the west to Cape Hinchinbrook in the east (see Map 3.1-2). The lower Cook Inlet, in turn, refers in the present context to the marine setting south of Kachemak Bay, on the Kenai Peninsula's most southern reaches. The focus here is on human settlements located near the shores of both of these bodies of water — communities having traditional affiliations with Chugach Alutiiq, Eyak, and (more recently) non-Native sociocultural systems (see Section 3.25). Subsistence in these south-central Alaska coastal communities typically involves a broad range of marine, riverine, and terrestrial animals — marine mammals, marine invertebrates, fish, land mammals, and birds — many in relatively large amounts. However, resources from water environments tend to be most important in terms of total pounds harvested. Figure 3.24-22 graphically presents the relative contribution of various subsistence resources harvested in Prince William Sound in per capita pounds for an example coastal community. The data reveal a heavy reliance on fish within a subsistence

strategy that includes a broad range of marine and terrestrial resources. Harvests occur throughout the year, carefully timed in a complex series of activities based on the availability of a large number of resources (Figure 3.24-23). Harvest levels in the Prince William Sound-Lower Cook Inlet region are about 25% to 33% of those in Interior and Arctic villages, and nearly double those of the Copper River Basin communities. Among the villages of interest in this EIS, reported values range from about 250 lb per capita to 400 lb per capita. The exception is Cordova, where per capita harvest for 1997 was about 180 lb per person.

The EIS discusses subsistence in three Prince William Sound communities — Chenega Bay, Cordova (which includes the Native Village of Eyak), and Tatitlek. It also examines subsistence in Nanwalek and Port Graham, neighboring communities on the coast of the lower Cook Inlet. These communities all share broadly common ecological locations, providing them access to both terrestrial and marine subsistence resources. As a consequence, they all harvest and use the broad range of animals and plants from both ecological settings characteristic of coastal adaptive strategies. Although the sociocultural composition of these five communities varies (see Section 3.25), and

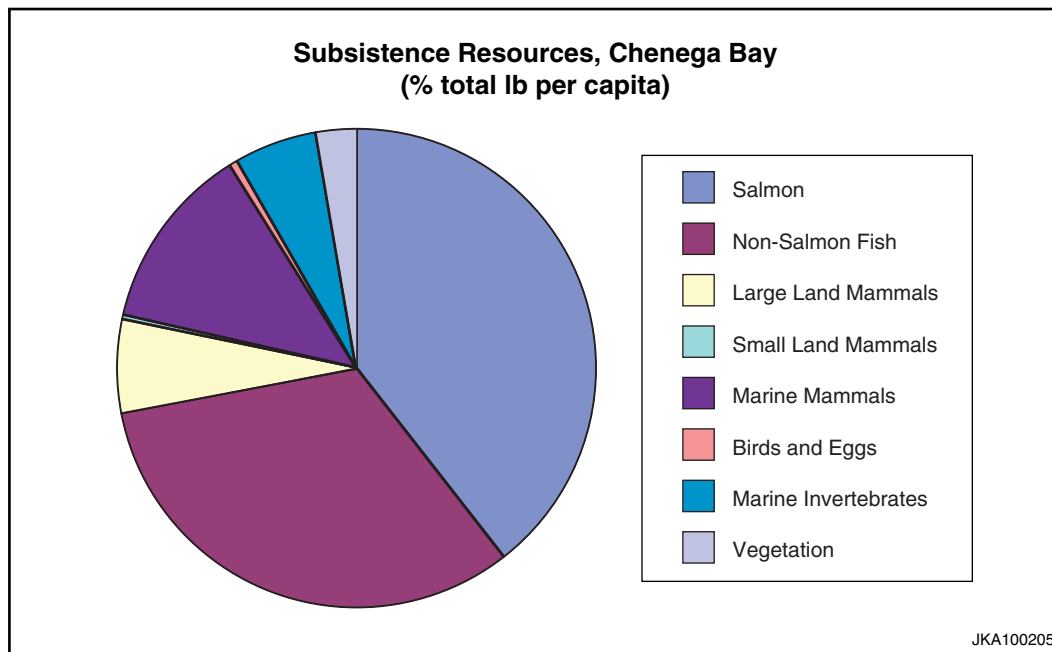


FIGURE 3.24-22 Example Combination of Subsistence Resources in Prince William Sound (Chenega Bay) (Source: ADF&G 2001b)

specifics of their geographic locations also vary, for present purposes certain shared subsistence characteristics and locations with respect to the TAPS provide justification for their grouping. In addition to the brief descriptions of subsistence in these five communities presented below, further details are provided in Appendix D.

3.24.2.4.1 Chenega Bay. Chenega Bay is a small, unincorporated community located on Evans Island in Prince William Sound, about 85 mi southwest of the Valdez Marine Terminal (see Map 3.24-1) (ADCED 2001b). The original village of Chenega, a Chugach Alutiiq settlement, was destroyed by the 1964 earthquake, and the current location was settled in 1984. The 2000 census recorded 86 people in Chenega Bay, nearly 74% of them Alaska Native or Native American (see Tables 3.25-1 and 3.29-1). The Chenega Bay economy is mixed, combining commercial fishing, small-scale oyster farming, and subsistence (Tomrdle and Miraglia 1993).

The residents of this small community harvest a wide range of land and marine

mammals, fish, birds, and marine invertebrates for subsistence purposes (Fall and Utermohle 1999; Stratton and Chisum 1986) (see Table 3.24-1). Chenega Bay residents harvested 275 lb of subsistence resources per capita in 1993. Harvest participation rates vary by resource category, with nearly 80% involved in subsistence fishing in the reference year, and 40-50% of households involved in hunting marine mammals (primarily seals), land mammals (mostly deer) and birds (both waterfowl and upland species) (see Table 3.24-2). The exchange of subsistence resources involved many of the village households, expanding access to these materials while further establishing social networks and patterns of obligation (ADF&G 2001b). Figure 3.24-24 shows per capita pounds harvested for several resources in the 1980s and 1990s. Harvest data have changed over time, declining considerably in 1989 and 1990 as a consequence of the Exxon Valdez Oil Spill and followed by a resurgence in harvests to levels higher than pre-spill amounts.

The contemporary Chenega Bay subsistence use area encompasses the lands

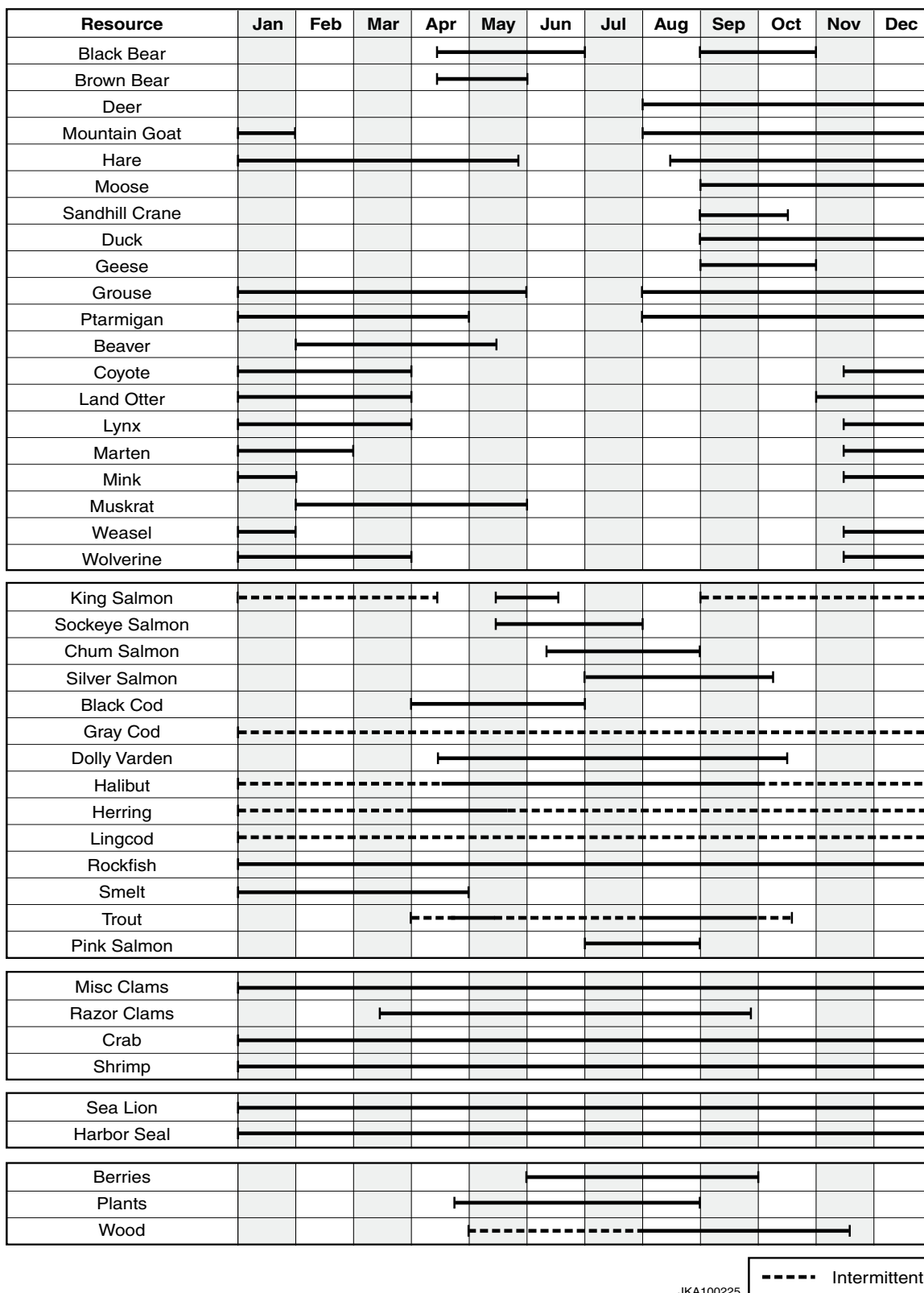


FIGURE 3.24-23 Example of the Seasonality of the Subsistence Harvest in Prince William Sound (Cordova) (Source: Stratton 1992)

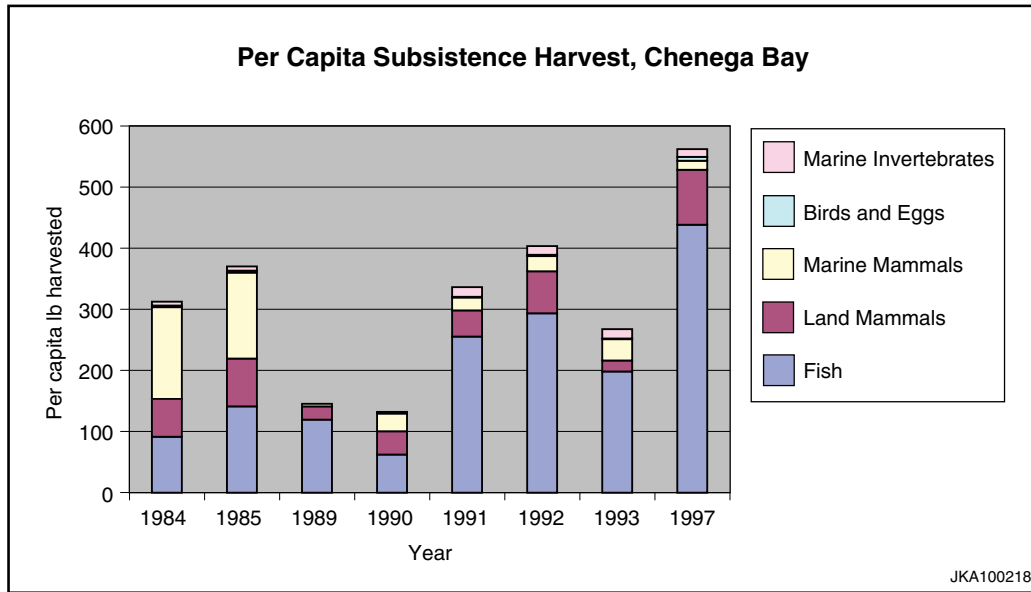


FIGURE 3.24-24 Variability in Chenega Bay Subsistence Harvest Over Time (Source: ADF&G 2001b)

and surrounding waters of Evans Island, where the village is located, nearby LaTouche Island and Elrington Island to the southeast, and Bainbridge Island to the west. A portion is also found to the north, in the vicinity of Chenega Island, the site of the historic community of Chenega, destroyed in the 1964 earthquake. Although the subsistence use area generally lies well west of the TAPS, small localities occur close to the south and west of the Valdez Marine Terminal (see Map 3.24-1) (see also Ganley and Wheeler 2000; Ganley 2001).

Due in part to the community's relatively recent settlement in its current location, subsistence concerns in the Chenega Bay area are still emerging (ADF&G 2001b). On the basis of 1984-1986 data (collected before the Exxon Valdez spill), per capita harvests appear to have declined substantially (42%) from levels in the 1960s. Reasons for the decline proposed by local residents included changing regulations and reduced resource levels (Stratton and Chisum 1986). Data collected after the Exxon Valdez spill support local concerns about subsistence impacts as a consequence of that event, indicating declines (an estimated 57% reduction in Chenega Bay) in the first year following the 1989 spill (Fall et al. 1996). Residents generally attributed this decline to

actual and feared contamination of resources. Subsistence harvests rebounded in the following years, although some residents reported increased effort and costs to achieve desired harvest levels, which they attributed to scarcity of resources. Subsistence harvest participation and production showed substantial recovery into the late 1990s (Fall 1999; Fall and Utermohle 1999). Persisting effects of contamination from the Exxon Valdez oil spill; shortages of seals, sea lions, clams, octopus, and some ducks; certain regulations affecting subsistence harvests of salmon; and competition for deer by nonlocal or recreational hunters all have been cited as subsistence concerns. Section 4.7.8.1 discusses subsistence levels in Chenega Bay and other communities directly affected by the Exxon Valdez spill before and after the spill.

3.24.2.4.2 Cordova (and Eyak).

Cordova is a small community in the eastern part of Prince William Sound, about 35 mi south-southeast of the TAPS (see Map 3.24-1) (ADCED 2001b). The population of Cordova was 2,454 in 2000, 10.4% of whom were Alaska Natives (ethnically Eyak, Chugach Alutiiq, Tlingit, and other peoples) (see Table 3.29-1). The Native Village of Eyak is a politically

separate entity representing Alaska Natives who reside in Cordova and along the Copper River Highway east of town (see Section 3.25.1.1.8). The Native Village of Eyak is one of the 21 directly affected Tribes examined in this EIS. Because Eyak Tribal members live throughout the Cordova area, not in a geographically distinct location, and because the ADF&G reports Eyak subsistence data aggregated with those from Cordova, the following discussion focuses on the latter community.

Although Cordova is relatively remote from major Alaska population centers and transportation arteries, wage labor dominates the community's economy, with most employment associated with commercial fishing or fish processing. Most residents also are involved in subsistence. Fishing for a variety of species, hunting (particularly deer, moose, and hare), and collecting marine invertebrates provide most of the meat obtained through noncommercial means in Cordova, although as with most coastal communities residents pursued a broad range of subsistence resources (see Table 3.24-1) (Fall and Utermohle1999). Cordova residents harvested approximately 179 lb of subsistence resources per capita in 1997, the representative year for Cordova. Nearly 80% of the households in Cordova fished for subsistence that year, with another 47% hunting large land mammals (see Table 3.24-2). Sharing of both fish and land mammal subsistence resources is widespread. For example, just under 50% of households harvest large land mammals, but 77% report using these foods; 75% of households harvest subsistence fish, while 94% reporting using them. Giving and receiving the resources harvested helped to make them available to households not involved in the actual harvest, at the same time reaffirming patterns of exchange and social obligation (ADF&G 2001b). Figure 3.24-25 shows per capita pounds harvested by Cordova residents for several resources during the 1980s and 1990s. Harvest data indicate a decline for several years following the Exxon Valdez Oil Spill (1989), with data for 1997 indicating what appears to be a resurgence towards pre-spill amounts.

The Cordova subsistence use area extends across Prince William Sound from near Cape Suckling in the east to Port Wells and the

eastern shore of the Kenai Peninsula in the west. This area includes marine waters and upland areas along the coast and on a number of islands (see Map 3.24-1).

Subsistence concerns identified by local residents during public scoping for this EIS and during the late 1990s included both contamination and environmental damage associated with the Exxon Valdez oil spill in 1989 (Fall and Utermohle1999). Data collected after the Exxon Valdez spill indicated declines in subsistence harvests following the 1989 spill, with recovery continuing into the late 1990s (Fall 1999; Fall and Utermohle1999). Residents attributed the sharp decline to contamination and fear of contamination of resources. Although harvest levels subsequently rebounded, residents reported increased efforts and cost to obtain desired levels due to resource scarcity. Cordova residents expressed concerns during public scoping about continued contamination in the water column, persisting low herring stocks, and restrictions to areas important for crab harvests because of oil tanker lanes whose definition expanded following the events of September 11, 2001. Section 4.7.8.1 discusses subsistence levels in Cordova and other communities directly affected by the Exxon Valdez oil spill before and after the spill.

3.24.2.4.3 Nanwalek. Nanwalek is located at the southern tip of the Kenai Peninsula, approximately 252 mi southwest of the TAPS on the lower Cook Inlet (see Map 3.24-1) (ADCED 2001b). The population of Nanwalek in 2000 was 177, nearly 90% of whom were Alaska Natives (mainly Unegkurmiut Alutiiq) (see Tables 3.25-1 and 3.29-1). Some wage employment is available, mainly seasonal work at the Port Graham Cannery.

Subsistence remains extremely important to many Nanwalek residents for economic, sociocultural, and ceremonial reasons. One of the more notable characteristics of subsistence in Nanwalek is the broad range of marine and terrestrial resources harvested, with fishing for and gathering marine invertebrates especially important (see Table 3.24-1). Nanwalek residents harvested an average of 254 lb per person in 1997. All Nanwalek households harvested fish and marine invertebrates, while

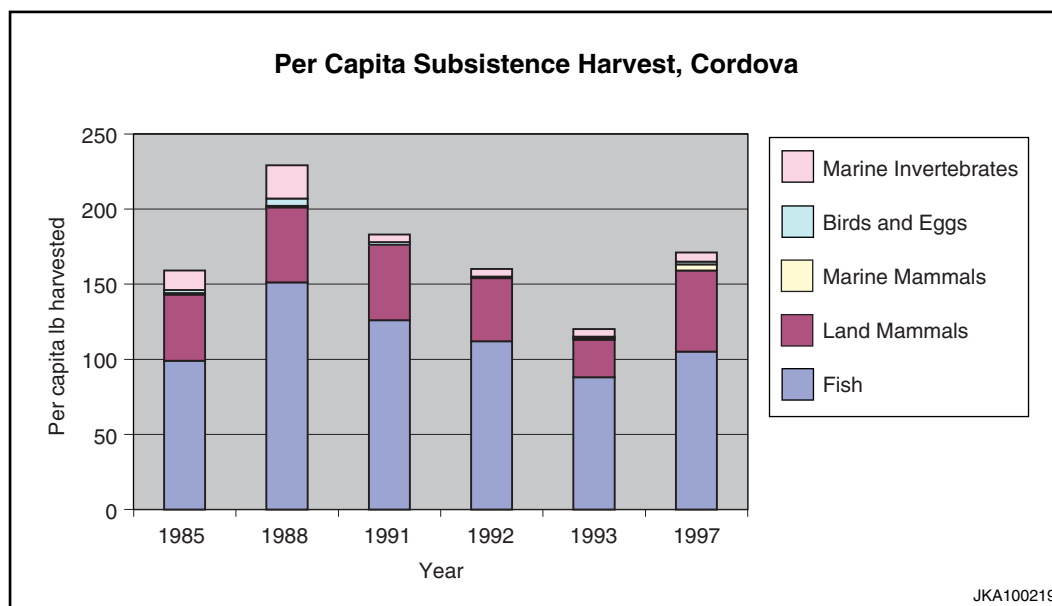


FIGURE 3.24-25 Variability in Cordova Subsistence Harvest Over Time (Source: ADF&G 2001b)

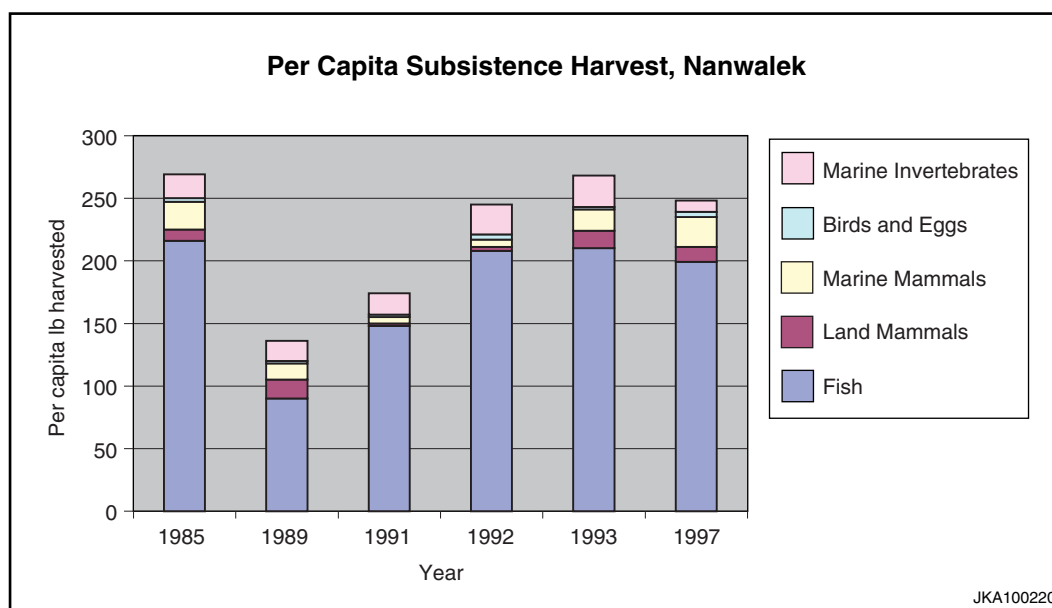


FIGURE 3.24-26 Variability in Nanwalek Subsistence Harvest Over Time (Source: ADF&G 2001b)

marine mammals involved 34% of households, land mammals about 14%, and birds and their eggs about 45% during the reference year of 1997 (see Table 3.24-2). In addition, resource exchange involved nearly all households in Nanwalek, helping to reaffirm patterns of social interaction and obligation (ADF&G 2001b). Figure 3.24-26 shows per capita pounds harvested for several resources in the 1980s and 1990s. These data indicate changing harvests over time, declining considerably in 1989 and 1991 as a consequence of the Exxon Valdez oil spill and increasing thereafter similar to levels recorded prior to the spill (Fall 1999; Fall and Utermohle 1999).

The Nanwalek subsistence use area lies on the southwesternmost tip of the Kenai Peninsula in the vicinity of the village, and also in the Fox River area at the head of Kachemak Bay to the northeast. The use area for Nanwalek lies well west of the TAPS (see Map 3.24-1) (see also Ganley 2001; Ganley and Wheeler 2000).

Subsistence concerns identified by Nanwalek residents during the late 1980s and early 1990s included persistent problems resulting from the Exxon Valdez oil spill; low populations of seals, sea lions, some waterfowl, sockeye salmon, and a number of marine invertebrates; and competition with nonresidents for black bear, moose, goats, salmon, and halibut (ADF&G 2001b). Section 4.7.8.1 discusses subsistence levels in Nanwalek and other communities directly affected by the Exxon Valdez spill before and after the spill.

3.24.2.4.4 Port Graham. Port Graham is located at the southern end of the Kenai Peninsula on the shore of Port Graham, about 223 mi southwest of the Valdez Marine Terminal (see Map 3.24-1) (ADCED 2001b). Originally a Russian settlement in the mid-19th century, in 2000 the settlement of Port Graham contained 171 people, nearly 85% of whom were Native (largely Unegkurmiut Alutiiq) (see Tables 3.25-1 and 3.29-1). The economy of Port Graham is mixed (Stanek 1985). Wage employment is available in the nearby cannery and hatchery, and 15 residents held commercial fishing licenses in 2000.

Subsistence remains an important activity in Port Graham, with a harvest level of 253 lb per person in 1997. Fishing was by far the dominant activity, accounting for 220 lb per capita that year (see Table 3.24-1). Subsistence harvests involved large percentages of Port Graham households, with more than 90% harvesting fish in the same reference year, while 27% took marine mammals, about 5% took large land mammals (black bears), and 25% took birds (see Table 3.24-2). In addition to high levels of harvesting, many households exchanged subsistence resources — providing access to those resources for those who had not obtained fish and game themselves, while reaffirming patterns of social interaction and exchange (ADF&G 2001b). Figure 3.24-27 shows per capita pounds harvested for several resources in the 1980s and 90s. Harvest data have changed over time, declining considerably in 1989 as a consequence of the Exxon Valdez oil spill but apparently recovering shortly thereafter to pre-spill levels (Fall 1999; Fall and Utermohle 1999).

The Port Graham subsistence use area lies on the southwesternmost tip of the Kenai Peninsula in the vicinity of the village, and also in the Fox River area at the head of Kachemak Bay to the northeast. The use area for Port Graham lies well west of the TAPS (see Map 3.24-1) (see also Ganley 2001; Ganley and Wheeler 2000).

Subsistence concerns identified by local residents during the late 1980s and early 1990s included persisting problems because of the Exxon Valdez oil spill; habitat destruction from logging; low populations of seals, sea lions, some waterfowl, sockeye salmon, and a number of marine invertebrates; and competition with nonresidents for black bear, moose, goats, salmon, and halibut (ADF&G 2001b). Section 4.7.8.1 discusses subsistence levels in Port Graham and other communities directly affected by the Exxon Valdez oil spill before and after the spill.

3.24.2.4.5 Tatitlek. Tatitlek is located on the shore of Prince William Sound in an area called the Tatitlek Narrows, about 17 mi southwest of the Valdez Marine Terminal (see Map 3.24-1) (ADCED 2001b). It is located on the site of a historic Alutiiq village. The 2000 census

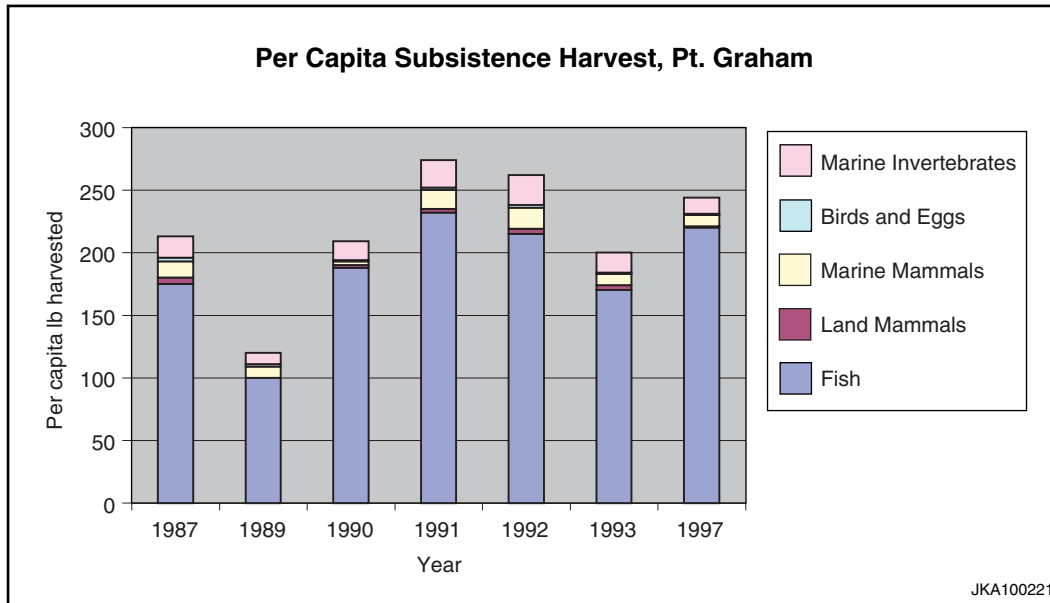


FIGURE 3.24-27 Variability in Port Graham Subsistence Harvest Over Time (Source: ADF&G 2001b)

recorded 107 people living in Tatitlek, more than 84% of whom were Alaska Natives (primarily Chugach Alutiiq) (see Tables 3.25-1 and 3.29-1). The village economy relies on both cash income and subsistence. Seasonal wage employment is available in fish processing and oyster farming, and in 2000 three residents held commercial fishing licenses.

Subsistence remains extremely important in Tatitlek, among other functions providing most of the food items and other resources used by the community. Subsistence harvest reached 406 lb per capita in 1997. As is the case in many coastal communities, a large variety of subsistence resources are exploited, including marine mammals and invertebrates, fish, large and small land mammals, and birds (Fall and Utermohle 1999) (see Table 3.24-1). This information on breadth of resources harvested is consistent with earlier research on the same community, although data for different years point to the considerable variability possible even between successive harvest years (Tomrdle and Miraglia 1993; see also Stratton 1992). Data from 1997, the representative year designated for Tatitlek, indicate that 75% of households harvest fish and marine invertebrates, 69% take birds (particularly ducks), 63% take land mammals (mostly deer),

and 50% harvest marine mammals (mostly seals) (see Table 3.24-2). Sharing subsistence resources involves most households of the village. For example 50% of households take seals, but 94% of households report using this food resource; 63% of households take deer, while 94% of households use this species. Sharing provides access to resources while reaffirming patterns of exchange and social interaction (ADF&G 2001b). Figure 3.24-28 shows per capita pounds harvested for several resources in the 1980s and 1990s. Harvest data have changed over time, declining considerably in 1989 and 1990 as a consequence of the Exxon Valdez oil spill and resurging in later years (although remaining well below the exceptionally high levels recorded for 1988).

The subsistence use area for Tatitlek spreads to islands and coastal marine waters in much of eastern Prince William Sound, near the village. Although this area does not intersect the TAPS, it does include several parts of Prince William Sound in the immediate vicinity of the Valdez Marine Terminal (see Map 3.24-1) (see also Ganley 2001; Ganley and Wheeler 2000).

Subsistence concerns identified by local residents during the late 1980s through the late 1990s included persistent problems resulting

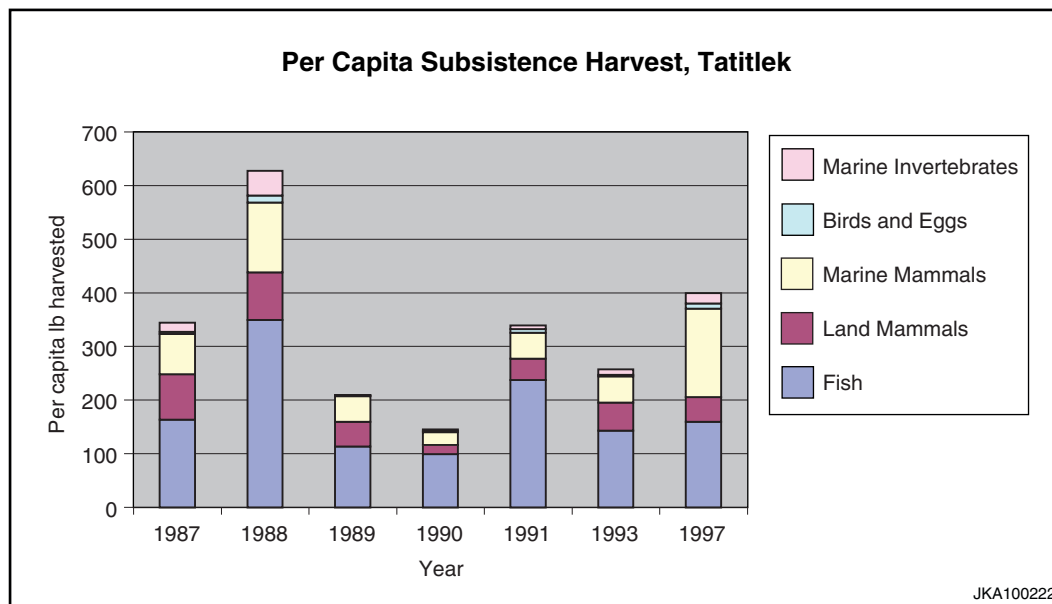


FIGURE 3.24-28 Variability in Tatitlek Subsistence Harvest Over Time (Source: ADF&G 2001b)

from the Exxon Valdez oil spill; low populations of seals, sea lions, some waterfowl, herring, sockeye salmon, a number of marine invertebrates, and deer; and competition for salmon and herring roe with nonresidents or commercial operations (ADF&G 2001b) (Stratton 1990). Studies focusing on subsistence changes following the Exxon Valdez spill indicate declines (an estimated 56% reduction in Tatitlek) in the first year following the 1989 spill (Fall et al. 1996). Residents generally attributed these rapid declines to actual and feared contamination of resources. Subsistence harvests rebounded in the following years, although some residents reported the need for increased effort and costs to achieve desired harvest levels, which they attributed to scarcity of resources. Subsistence harvest participation and production showed recovery continuing into the late 1990s (Fall 1999; Fall and Utermohle 1999). Section 4.7.8.1 discusses subsistence levels in Tatitlek and other communities directly affected by the Exxon Valdez oil spill before and after the spill.

3.24.3 Access to Subsistence Resources

Subsistence inevitably requires access to the resources targeted for harvest. During traditional times, Alaska Natives moved through an annual seasonal round of locations to harvest resources efficiently, relocating to new areas in response to longer-term changes in resource abundance and availability. More recently, increasingly sedentary settlement by Natives and non-Natives alike has changed certain aspects of this access — such as the use of more frequent trips from a central locality. Moreover, modern transportation technology has had an important affect on geographic patterns of subsistence exploitation, often making it possible to continue harvest throughout the traditional range, and occasionally in a larger area than was traditionally used. This section briefly describes access in modern subsistence activities.

For several reasons, access to subsistence resources varies widely among communities

examined in this EIS. One reason is geographic location of a particular resource. For example, the challenge of gaining access to marine subsistence resources, and the combination of knowledge, equipment, and personnel involved, differs from access to riverine resources, which, in turn, differs from access to terrestrial resources. Another reason is the geographic distribution and behavior patterns of subsistence resources. For example, access to more widely occurring terrestrial mammal resources located in specific areas, such as hares, might differ from access to terrestrial mammals that migrate and whose geographic availability is more limited, such as caribou. A third reason for differing access to subsistence resources is density. Resources such as moose and whales tend to be sparsely distributed, thus often requiring more effort and travel over greater distances than for resources available in higher density.

Modern technology has had enormous impacts on subsistence harvest activities, affecting access as well as means of harvest. During traditional times and, indeed, extending well into the 1960s in many parts of rural Alaska, pursuit of subsistence resources often required considerable effort — rowing or paddling boats in marine and riverine environments and walking or traveling by dogsled on land. In pre-contact and early contact times, indigenous peoples roamed over extremely large areas in search of subsistence resources. Sedentary settlements and mechanized travel have resulted in many changes. Boats with motors, off-road vehicles, snowmachines, and (infrequently, because of high cost) airplanes all play key roles in modern subsistence activities. Modern transportation technology in subsistence has offset some effects of sedentary settlement in modern communities. Traditional use area patterns persist, in part because traditional place names and traditional ecological knowledge about resources anchor identity and aid in hunter effectiveness. In some instances, new transportation technologies have resulted in expansion of feasible harvest areas beyond those traditionally used.

Access to marine subsistence resources now primarily involves travel by shallow-draft boats with engines when there is open water and

snowmachines when ice forms. Although both means of transport have sustained, or in some cases increased, the size of geographic areas exploited, engine-powered boats have also made certain previously inaccessible places now available for subsistence activities.

Access to riverine resources often involves boats with engines, if any river travel is required, in both rivers near the coasts and interior rivers. Access to terrestrial resources usually involves travel by some type of motorized vehicle, including off-road vehicles (trucks and all-terrain vehicles) when snow depth is not a hindrance, snowmachines when sufficient snow exists, and airplanes during much of the year (although their use for subsistence activities is limited by high cost). Access to terrestrial resources can also involve travel by boat, particularly in coastal areas, and, in some cases (notably parts of the northern interior) travel by dogsleds. Similarly, access to marine and riverine resources in some settings can involve travel over land. The importance of improved transportation technology in the context of subsistence is substantial; lack of access to such technology is occasionally given as a reason for not engaging in subsistence activity (e.g., Brower and Opie 1997). Similarly, highly productive households have secure access to transportation technology and money to cover operating costs (Wolfe 1987). The impacts of transportation extend beyond traveling to harvest sites to the exchange of subsistence resources, of particular importance to Alaska Natives for economic as well as sociocultural (including ceremonial) reasons.

Travel to harvest locations tends to follow routes and involve destinations established over many generations. Although the terrestrial harvest areas depicted in Map 3.24-1 are often composed of large parcels of land, access is usually by trails linked to topographic features, such as valleys, shorelines, lakes, and geologic formations (TAPS Owners 2001a). Fishing, both in marine environments and on rivers, often focuses on places that have been used for centuries. Development that has interrupted these access routes or restricted access to desired harvest areas, such as certain localities associated with North Slope Oil development, is viewed by people pursuing subsistence as

having an adverse effect on their activities (e.g., Haynes and Pedersen 1989).

Finally, access to subsistence resources involves not only travel to those resources, but also the ability to obtain them. Modern technology again plays an important role, as it has with transportation adapted to what may be centuries-old activities. For example, Alaska Native whaling crews off the northern coast of Alaska use global positioning units, which rely on signals from satellites orbiting the earth, to help relocate key areas for whales (TAPS Owners 2001a). Modern firearms, harpoons, and fishing technology, as well as implements introduced many decades ago (such as fish wheels), contribute to the act of harvesting — improving the amount harvested and, in certain situations, making harvesting possible when older technology would not.

The topic of access is important to the analysis of subsistence in this EIS, in part because of the geographic patterns of subsistence practices and the possibility that various alternatives considered in the EIS might affect these patterns. The topic of access is also important in understanding modern subsistence in Alaska, because in addition to benefits of modern technology there also are costs. Snowmachines, boats with engines, rifles, and so on all play central roles in subsistence activities in 21st century Alaska. But all require money for purchasing, maintaining, and obtaining necessary components (such as fuel and ammunition), and money is often in short supply in rural settings. Just as the use of dogsleds in the Alaska of the past required increased harvests of fish for dog food, modern technology requires sufficient cash to acquire, maintain, and operate the equipment.

3.24.4 Sport Harvests Versus Subsistence

A recurring concern regarding subsistence in Alaska is the impact of sport or recreational hunting and fishing over the past two to three decades. This issue appeared repeatedly in the summary presented above on subsistence issues at the community level (Section 3.24.2), as well as during public scoping. In the case of

the TAPS, the increased access via the Dalton Highway and access roads, and the introduction of relatively large numbers of people to northern and Interior Alaska, have been seen by many as providing the foundations for competition with regard to subsistence activities.

One means of evaluating the relationship between subsistence and sport harvests is to examine data on harvest tickets compiled by the ADF&G (see Haynes 2000). These data are available for several species, with information on most available annually beginning in the early 1980s. Two characteristics of these data make them particularly useful for present purposes. First, they are compiled by location of harvest, with the maximum level of precision the uniform coding unit. Uniform coding units are geographic subdivisions of the game management units that the State of Alaska uses for wildlife management purposes. This spatial component of the data enables one to focus on harvests in particular parts of the state, such as the subsistence use areas presented in Map 3.24-1 (see also Appendix D), thereby making selected data of particular relevance for this study.

A second important characteristic of the harvest ticket data is that they record the address of the hunter filing each ticket. These data do not distinguish between subsistence and sport harvests, due in part to dual federal-state management of hunting (which define sport and subsistence harvests differently) and to the changing definition of subsistence over time, as discussed in Section 3.24.1. However, as this study relies on the federal definition of subsistence based on rural residency, it is possible to *approximate* subsistence versus sport harvests on the basis of the town where the harvesting party resided. It is important to note that this is very much an approximation. Harvests on state lands that this study records as sport harvests because of nonrural residency, for instance, may well have been subsistence harvests under state definition (which technically would have applied to a harvest on state land). However, applying the rural residency criterion enables the application of a single principle for purposes of examining the relationship between sport and subsistence harvests over time.

Before we examine the data, some brief cautionary notes are required. In general, these

data are based on self-reporting — that is, submitting a harvest ticket to the ADF&G with accurate information. Underreporting and erroneous reporting always are possible problems. In an examination of similar data for a slightly different region, Haynes (2000) also noted the general concern that older data and data from rural settings tend to be less reliable than other information because of unsystematic or incomplete reporting.

The present study examines harvest ticket data for more than 600 uniform coding units that lie at least partially within the subsistence use areas shown in Map 3.24-1. Although data exist for several species, four are particularly important for sport and subsistence uses: caribou, mountain goat, moose, and Dall sheep.

As noted in Section 3.24.2, caribou is an important subsistence resource for most of the communities examined that lie in the Copper River Basin, in the Yukon River Drainage, and on the North Slope. Amidst considerable variability, harvests declined in the mid-1980s before generally recovering, showing a marked increase in the mid-1990s (Figure 3.24-29). This surge in harvests occurred immediately after opening of the Dalton Highway to public use, although this analysis did not focus solely on areas accessible from that road. Two changes are particularly marked with regard to the sport-subsistence distinction related to both absolute and relative subsistence harvests. Although the end points of the data reveal extremes, they provide a sense of trends in the data. Subsistence harvests accounted for 500 animals in 1983, nearly 37% of the total harvest; by 2001, subsistence users harvested fewer than 130 animals, slightly more than 11% of the total harvest for the uniform coding units of interest. Subsistence harvests generally have accounted for an increasingly small percentage of total Caribou harvests in the area examined. Total subsistence harvest was relatively high for many years in the middle of the time period considered, before declining back to levels seen in the mid-1980s.

Mountain goat harvest data reveal more variability, and less of a developing trend, than do the caribou data (Figure 3.24-30). An increase in combined subsistence and sport harvests in the early 1990s was followed by a

slight decline in the middle of that decade. The relative importance of subsistence generally grew over time, reaching nearly half of the total harvest near the middle of the period considered before declining in the later 1990s. As with caribou, mountain goat harvest levels in the early 21st century were comparable to those seen in the early 1980s, following two periods of increase and subsequent decline.

Moose also play an important role in subsistence for many of the rural communities examined in this EIS (see Section 3.24.2). Overall moose harvest generally grew from 1983 to 1999, before declining slightly in the final two years examined. Subsistence harvests remained fairly constant over the period examined, while much of the overall harvest variability is accounted for by shifts in sport harvest levels (Figure 3.24-31). Sport harvests accounted for a larger percentage of the total from 1993 onward than they had previously.

Dall sheep harvests in the geographic area of interest increased twice over the nearly two decades examined — in the late 1980s and the late 1990s (Figure 3.24-32). Harvests once again varied considerably over time, with the 2001 harvest similar to that recorded in 1983. The subsistence share of harvests varied, but for all the years considered generally increased its relative role over time.

The approximations of subsistence and sport harvests for the uniform coding units near rural communities examined in this EIS do not reveal particularly strong trends throughout. In part this is due to variability seen to some degree in data for all four species examined. However, this conclusion is also in part due to declines in harvests over the past few years. Focusing on the period from 1983 through the late 1990s, total animals taken increased considerably for all animals examined except Dall sheep — with growth in sport harvests of caribou and moose particularly strong. Moreover, for caribou and moose, the data presented reveal increasing percentages of harvests by sport hunters compared to subsistence hunters. Such harvest trends for these most important terrestrial subsistence resources provides support for many of the concerns voiced by rural Alaskans in this area regarding growing competition. That stated, the

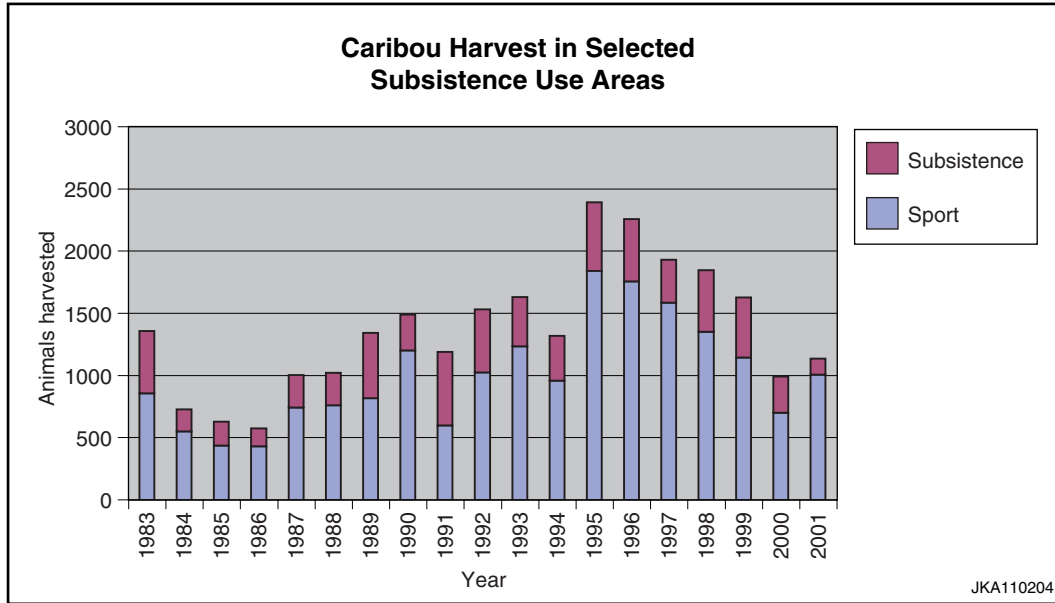


FIGURE 3.24-29 Approximated Sport and Subsistence Harvests of Caribou in Uniform Coding Units that Intersect Subsistence Use Areas of Rural Communities Examined in this EIS (Data Source: Lieb 2002)

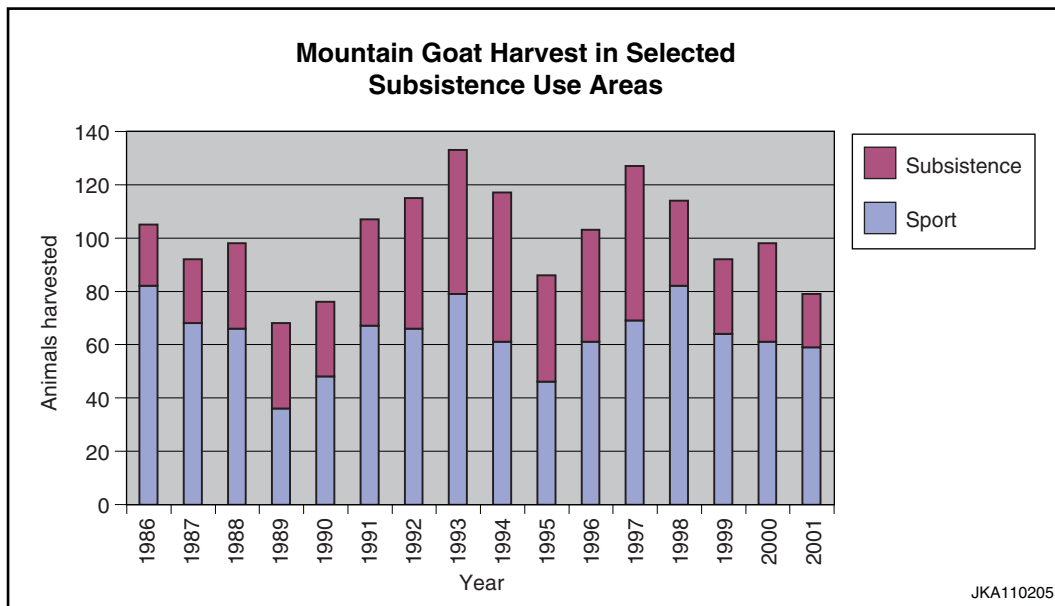


FIGURE 3.24-30 Approximated Sport and Subsistence Harvests of Mountain Goats in Uniform Coding Units that Intersect Subsistence Use Areas of Rural Communities Examined in this EIS (Data Source: Lieb 2002)

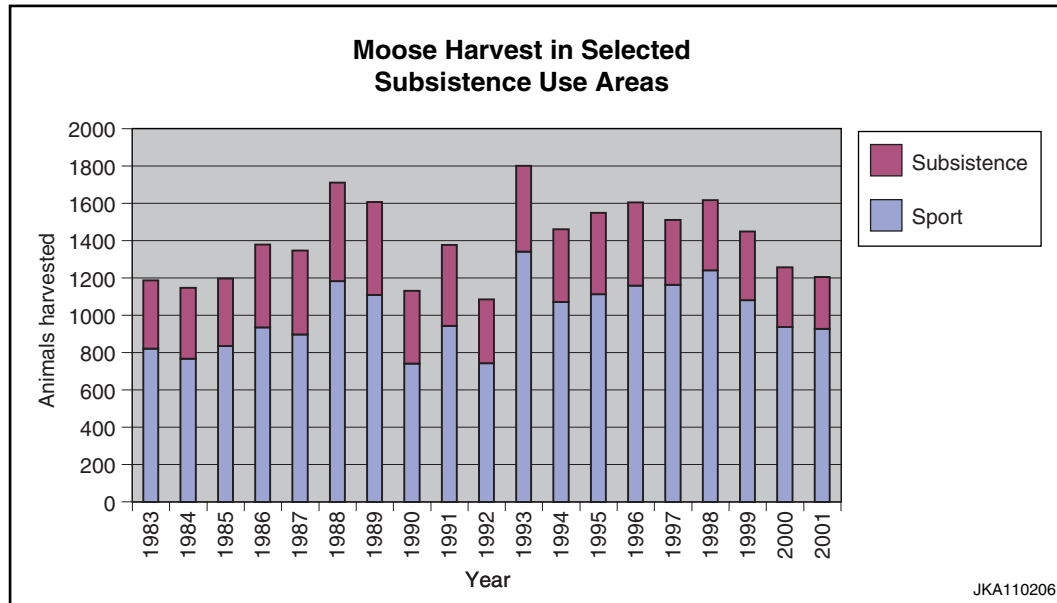


FIGURE 3.24.31 Approximated Sport and Subsistence Harvests of Moose in Uniform Coding Units that Intersect Subsistence Use Areas of Rural Communities Examined in this EIS
(Data Source: Lieb, 2002)

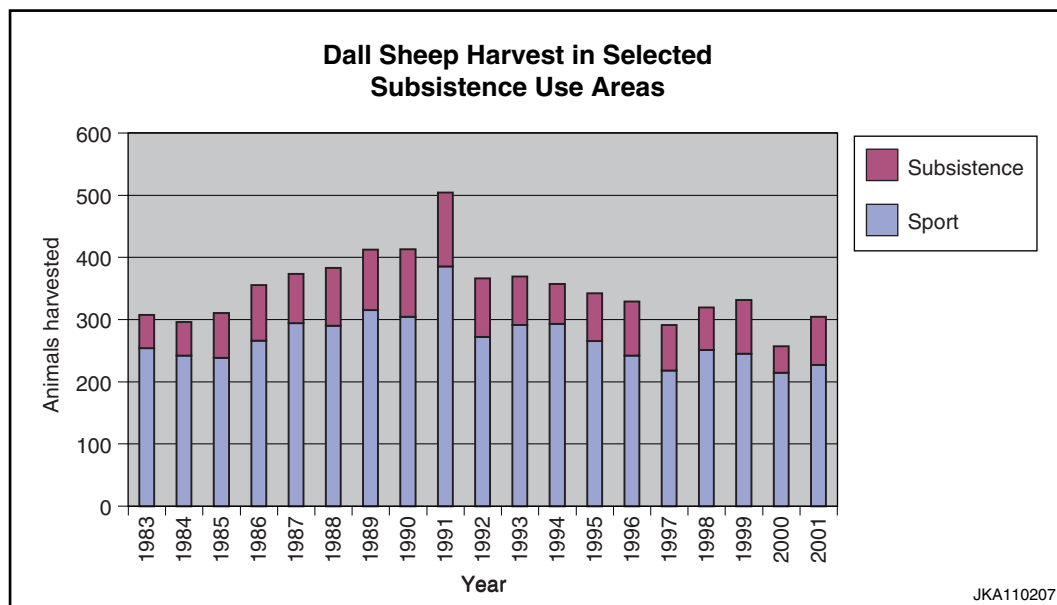


FIGURE 3.24.32 Approximated Sport and Subsistence Harvests of Dall Sheep in Uniform Coding Units that Intersect Subsistence Use Areas of Rural Communities Examined in this EIS
(Data Source: Lieb, 2002)

reasons for harvest increases in general and sport harvests in particular through the late 1990s is not necessarily associated with the TAPS, but instead is likely a consequence of several other causes, including general population growth.

Subsistence fishing provides an important source of food for many rural Alaskans. Although recreational fishing is one source of competition for fishing resources, by far the greatest competition comes from commercial fishing — an estimated 97% of fish and game harvests by weight for the state (Wolfe 2000). Nevertheless, the TAPS has long been considered a *possible* source of impact on subsistence fisheries. In 1974, the ADF&G closed several rivers and streams in the Haul Road corridor to subsistence fishing (Haynes 2000). In addition to citing limited biological knowledge of fish stocks in these waterways, the agency also cited the need to protect the fish from nontraditional subsistence fisheries by people associated with the North Slope oil fields and the TAPS. Parts of this area were subsequently reopened to subsistence fishing in the mid-1980s, and the entire area was reopened in 1988.

Data on recreational fishing are available for certain sections of the northern part of the TAPS corridor beginning as early as the 1980s (Haynes 2000). Access by those engaged in recreational fishing along the corridor again appears to be important. Sport fishing was closed along the Dalton Highway corridor briefly during the late 1970s and reopened in 1981. Opening the highway to public traffic as far north as the Dietrich River in 1981 and north to Prudhoe Bay in 1994 provided new access to fishing areas in previously remote areas. Evidence published in the late 1980s indicated that for areas accessible to anglers, individual fish of interest to anglers were less numerous and smaller after construction and opening of the TAPS Haul Road (Dalton Highway) (BLM and USACE 1988). The ADF&G responded to possible impacts of increased access by restricting sport fishing bag limits (northern pike and arctic grayling) for this area and by implementing a catch-and-release-only requirement for lake trout within the Dalton Highway corridor. Data for sport fishing, both in terms of angler-days and catches, indicate a

slight increase for certain indicators (within a considerable amount of variability) north of Atigun Pass from 1983 through the late 1990s (Figure 3.24-33). Data for sport fishing between Atigun Pass and the Yukon River are more limited temporally, although they indicate a general increase from 1995 through 1999 (Figure 3.24-34). Data for subsistence fishing reveal a varying reliance on fish by communities near the TAPS north of the Yukon River (ADF&G 2001a).

Data on subsistence salmon fisheries are available for individual communities over time — the years of data availability varying with the fishery involved. Figure 3.24-35 shows how subsistence salmon harvests varied over time for three of the four regions considered in this EIS: the Yukon River Drainage, Copper River Basin, and Prince William Sound-Lower Cook Inlet (presented separately in the figure). The importance of salmon to communities in the Yukon River Drainage immediately becomes obvious, although many of the chum and coho salmon harvested by rural villages in that region are used for dog food. The failure of the Yukon River salmon runs in 1990s also is clear in the graph, after particularly large harvests in the mid-1990s. Copper River Basin subsistence salmon fisheries also are highly productive, as indicated by the descriptions of those communities in Section 3.24.2.3. Management of these fisheries is challenging, particularly in light of commercial fishing pressures coupled with high demands of the Chitina dip-net fishery (see Simeone 1998). The total subsistence salmon produced by Prince William Sound and the Lower Cook Inlet are less than the other two regions. The data presented in Figure 3.24-35 is for salmon only. Other species of fish for which data are not presented are of varying importance in the subsistence of south-central Alaska communities (Fall and Utermohle 1999).

As was the case with harvests of terrestrial mammals, available evidence on subsistence fishing does not reveal particularly clear trends, largely because of variability over time. Low subsistence harvests for certain years, particularly for entire fisheries such as the Yukon River in the late 1990s, has had an important impact on the economies and sociocultural systems of the communities affected. That

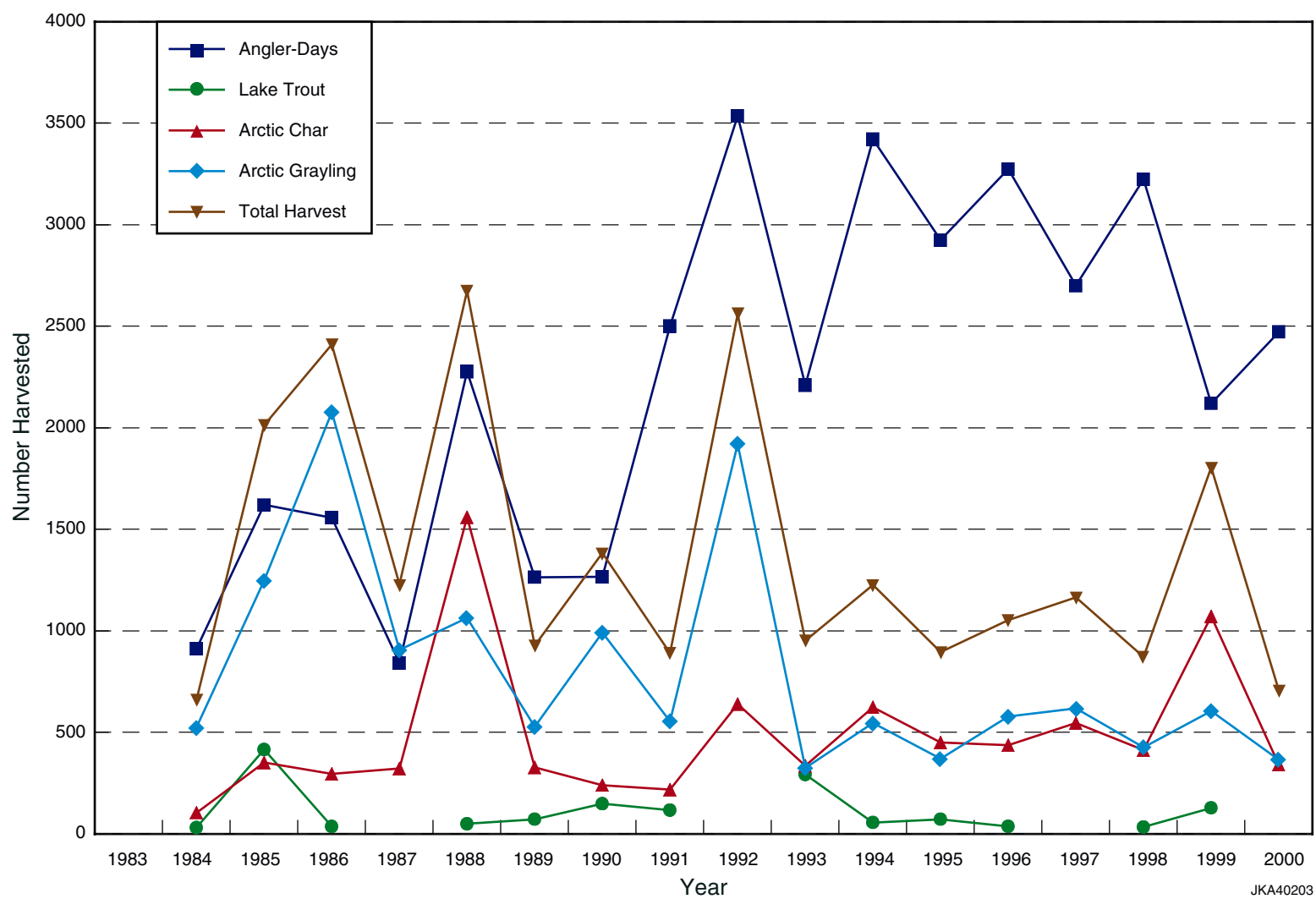


FIGURE 3.24-33 Sport Fishing Indicators North of Atigun Pass, 1983-1999 (Source: Based on ADF&G data reported in Haynes 2000)

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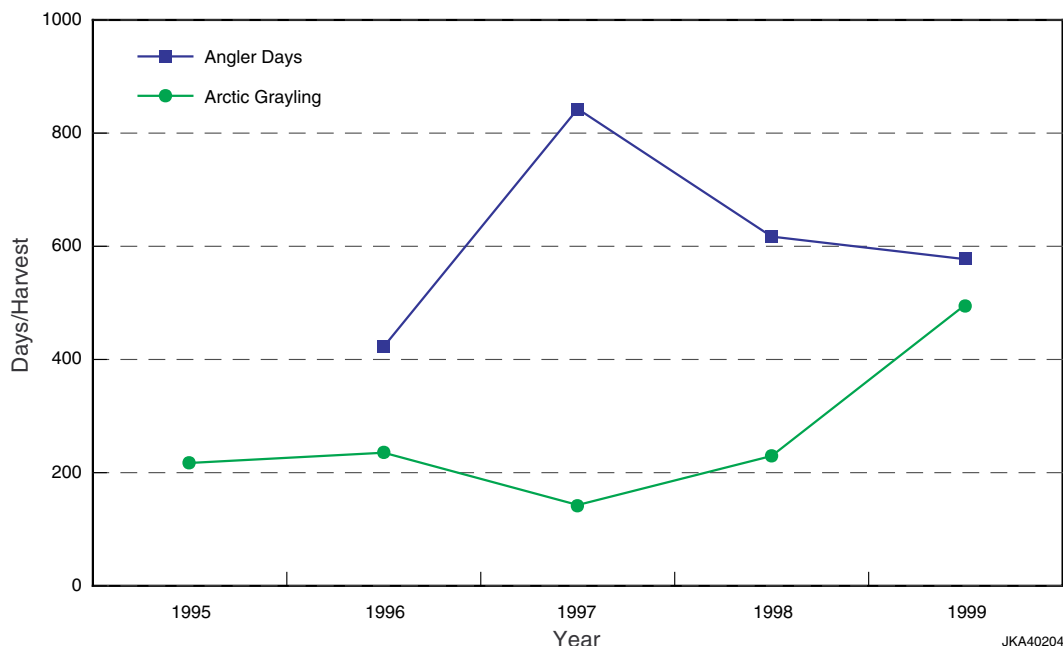


FIGURE 3.24-34 Sport Fishing Indicators between Atigun Pass and the Yukon River, 1995-1999 (Source: Based on ADF&G data reported in Haynes 2000)

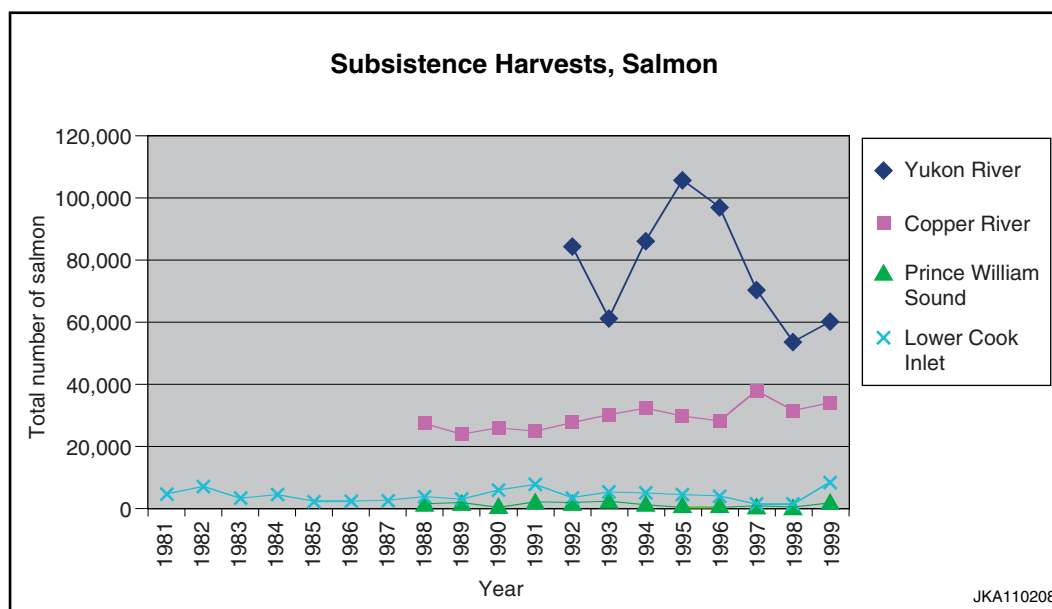


FIGURE 3.24-35 Variability in Subsistence Harvests of Salmon in Communities Examined in the EIS, Grouped by Region (Data source: ADF&G 2000c)

stated, the reasons for such fluctuations tend to involve factors other than sport fishing, with commercial fishing and environmental variables of particular concern. A review of available data on fisheries (presented in Section 4.3.16)

indicates that monitoring and the subsequent establishment of regulations to manage fisheries along the TAPS ROW largely have been successful.

3.25 Sociocultural Systems

Sociocultural systems comprise the collection of beliefs, ideas, behavioral patterns, and tools that humans use to adapt to their physical and social surroundings. Although all humans are affiliated with one sociocultural system or another, this section focuses primarily on selected groups of indigenous people of Alaska, known collectively as *Alaska Natives*. It also examines the sociocultural system of non-Native rural Alaskans, people who generally share common roots in Euro-American society, but who have chosen a remote, rural Alaskan existence leading to behavioral patterns and activities much different from those of most Americans.

Sociocultural Systems

Sociocultural systems consist of the beliefs, ideas, behavioral patterns, and tools that humans use to adapt to their physical and social surroundings. The discussion of sociocultural systems presented here focuses on the Alaska Natives and rural, non-Native Alaskans living in areas in the vicinity of the TAPS. Alaska Natives have a different sociocultural heritage than most Americans. Eight different Alaska Native sociocultural systems are considered. Most rural, non-Native Alaskans have their sociocultural foundation in Euro-American society, but are now following a way of life much different from the majority of Americans.

3.25.1 Alaska Native Sociocultural Systems

Alaska Native sociocultural systems continue to occupy and use their traditional lands, maintaining many traditions in social organization, cultural beliefs, and religious activities into the 21st century. The reasons for this persistence are a complex mix of ecological possibilities, contact history, and the enduring commitment of Alaska Native communities to retain their culture and identity. European and, later, American contact with Alaska Natives was driven by exploitation of resources such as fur,

Alaska Native Sociocultural Systems Whose Traditional Occupation Included Areas near or Transected by the TAPS (Listed North to South)

- Iñupiat
 - Nunamiut
 - Tareumiut
- Athabascan
 - Gwich'in
 - Koyukon
 - Tanana
 - Ahtna
- Alutiiq
 - Chugach Alutiiq
- Northwest Coast
 - Eyak

whales, gold, and salmon. These resources had limited geographic distributions, and so intensive contact generally was localized or regionalized through the late 19th century. When it occurred, contact with Euro-Americans often had severe consequences for Alaska Native sociocultural systems — such as Russian displacement of Alaska Natives from traditional fishing territories. Even more widespread in their effects were waves of epidemic disease that took a terrible toll on Native populations in parts of Alaska during the 19th and early 20th centuries, in many cases removing entire organizational components of Native societies. Despite such disruption, Alaska Native sociocultural systems persisted. One interpretation suggests that isolation and limited direct contact with non-Natives helped limit the impact of introduced diseases, which often decimated Native populations (and cultures) elsewhere, and slowed the adoption of non-Native cultural characteristics (see Fortune 1992). An alternative view, increasingly asserted in the Alaska Native community, is that epidemic disease had drastic effects, causing the abandonment of entire communities and leaving traumatized survivors to aggregate in new settlements (sometimes in new areas) to

continue their lives without the benefit of the cultural guidance of elders who had perished (Napoleon 1991; Alaska Natives Commission 1994). Directed culture change through missionary efforts began with the Russian Orthodox Church in the late 18th century, but impacts were more widespread as American denominations accelerated such work in the late 19th century. Also of fundamental importance in the dynamics of sociocultural change in Alaska are the movements of political self-assertion and cultural renewal initiated by Alaska Natives themselves. To be sure, the sociocultural systems of modern Alaska Natives are considerably modified from those that existed prior to contact. However, parts of the earlier systems persist, yielding modern sociocultural systems that to one degree or another blend Euro-American and traditional characteristics.

Initial contact between Alaska Natives and non-Natives began in 1741 with Chirikov's landing on the panhandle near Cross Sound. However, frequent contact in most of the geographic area of present interest did not begin until the second half of the 18th century or later (VanStone 1984). Confined initially to the western and southern coasts, Euro-Americans eventually moved into Interior Alaska by the mid-19th century to pursue fur trade and missionary activities, and to the north coast later that century for whaling (Hosley 1981; Spencer 1984). With increased exposure to non-Natives came sociocultural change — including a slowly growing reliance on introduced goods, a shift in Native settlement and economic activities in some areas to improve access to those goods, and the gradual (and variable) integration of non-Native language, religion, and behavior into traditional societies. Such changes succeeded in greatly modifying Alaska Native sociocultural traditions but did not completely replace them. As of the 2000 census of population and housing, 15.6% of the state's population (98,043 individuals) identified themselves as Alaska Native or American Indian (mostly the former); another 21,102 individuals claimed at least partial Alaska Native heritage, bringing the total to 119,145, or 18.7% of the state population (U.S. Bureau of the Census 2001a). Many of these people continue to live in rural communities that consist largely of Alaska Natives, rely heavily on harvesting available

resources for subsistence, anchor their identity in traditional sociocultural heritage, and have maintained participation in contemporary Alaska Native lands claims, cultural revival, and sobriety movements.

In traversing 800 mi of Alaska, the TAPS crosses areas associated with several major Alaska Native sociocultural systems. The natural environment crossed by the TAPS varies widely. Alaska Native sociocultural systems, the primary means by which people adapt to natural (and social) surroundings, vary widely as well. To help organize this overview of sociocultural diversity, this EIS follows the *Handbook of North American Indians* in defining eight regional sociocultural systems (though updating their names), listed from north to south as follows: Tareumiut (North Alaska Coast Eskimo), Nunamiut (Interior North Alaska Eskimo), Gwich'in, Koyukon, Tanana, Ahtna, Chugach Alutiiq (formerly called Pacific Eskimo), and Eyak, (Damas 1984; Helm 1981; Suttles 1990) (Map 3.25-1). These may be seen as parts of the larger Eskimo (northern and northwestern Alaska), Athabascan (Interior Alaska), Alutiiq (southcentral and southwestern Alaska), and Northwest Coast (southeastern Alaska, extending from the northwest coast of the United States) sociocultural traditions.

Brief descriptions of these eight regional sociocultural systems follow, each covering certain key topics — social organization, cultural values, institutional organization, modern settlements, and demographics. These descriptions all begin with overviews of each system shortly after the onset of contact with Euro-Americans, providing some documentation of the systems in question (usually) before great amounts of culture change occurred. Far from being exclusively of historic interest, traditional Alaska Native sociocultural systems continue to contribute much to Alaska Native society in the early 21st century. Moreover, these brief historic summaries help one to appreciate how much these systems have changed over the past century or two.

Discussions of certain other important characteristics of Alaska Native sociocultural systems appear elsewhere in this EIS. Subsistence, a topic of considerable importance to Alaska Natives, as well as many rural

non-Native Alaskans, is discussed in Section 3.24, although an examination of certain sociocultural aspects of traditional subsistence appears below. Cultural resources, including prehistoric and historic archaeological sites, as well as sacred sites (traditional cultural properties), are discussed in Section 3.26. Issues associated with environmental justice, important to Alaska Natives both because of their minority status and because of their frequent low-income status, are presented in Section 3.29. Finally, Section 3.23 describes the modern economy of Alaska, which has an increasing influence on (and is increasingly influenced by) Alaska Native sociocultural systems of the 21st century.

3.25.1.1 Major Alaska Native Sociocultural Systems along the TAPS

Alaska Natives along the TAPS ROW are characterized by a broad range of sociocultural diversity, and it would be a gross oversimplification to treat them otherwise even in a brief overview such as this. However, in the interest of orienting this summary there are some important characteristics that many Alaska Native groups share, the most important of which include the following:

- *Hunting and gathering:* None of the Alaska Native groups discussed below traditionally produced their own food through agriculture, relying instead on hunting, gathering, fishing, and trapping, with nearly all of the food consumed being animal flesh. Successful exploitation of these Alaskan ecosystems required intimate knowledge of animal habitats, distribution, and reactions to weather. This traditional ecological knowledge would remain important even as new technologies were adopted.
- *Mobile bands* of varying composition: In large part determined by the availability of subsistence resources, most groups consisted of small bands that frequently relocated in search of food, sometimes fragmenting into smaller groups (as small as individual nuclear families in times of little

food) and other times forming larger aggregations. Coastal peoples often had more substantial settlements occupied for longer periods of the year.

- *Egalitarian or Simple Ranked Societies:* Most of the groups examined in this EIS were fundamentally egalitarian in social structure and political organization. Leaders were acknowledged on the basis of their personal abilities or accomplishments. Along the Pacific Coast, sociocultural systems had more formal and elaborate systems of clan ranking, and even class systems, with nobles, commoners, and slaves.
- *Strong kin-based systems:* The main social units for most sociocultural systems examined in this section were nuclear or extended families, with bands often comprising collections of related family units. Clans that crosscut kinship were recognized among the Athabaskan and Eyak sociocultural systems.

Many of the common characteristics discussed above are consequences of Alaska Natives adapting to available resources, which occurred in different amounts at different times of the year in different localities. For example, prior to contact, interior Athabascans might have lived along streams in temporary camps of several families during early summer to capitalize on the salmon run, dispersed as smaller groups of families in the uplands during late summer to hunt sheep and gather berries, and aggregated into large groups in autumn near mountain passes to collaborate on large-scale hunts of migrating caribou. Most of these patterns of behavior are primarily of historical interest. However, certain aspects of traditional subsistence-settlement systems persist — notably the desire to exploit key subsistence resources at certain times of the year (after relocating temporarily to do so). Moreover, Alaska Natives continue to recognize the importance of kinship, which persists as an important consideration in social and economic relationships.

Contemporary Alaska Natives live primarily in permanent communities, some occasionally relocating temporarily at a certain time of year to pursue subsistence activities. As a result, when

examining modern Alaska Natives, this study focuses on selected *villages* (federally recognized tribes), emphasizing 21 that were judged likely to experience direct effects of renewing the TAPS ROW (BLM 2001a) (see Map 3.25-1). Five main criteria contributed to the selection of these groups:

- Potential impacts on subsistence, including both direct impacts (e.g., TAPS reducing access to subsistence areas) and indirect impacts (e.g., TAPS-associated roads enabling access by recreational hunters);
- Potential impacts on employment, primarily in providing TAPS-related employment;
- Potential impacts on culture, such as the change brought about by wages earned from the oil industry;
- Impacts on land selection, notably during ANCSA negotiations when certain land was not claimed to facilitate TAPS construction; and
- Impacts through ANCSA corporation earnings, ANCSA7(i) redistributions, and Section 29 of the current ROW agreement, in the form of increased income from oil revenues and wages.

These criteria led to the original selection of 16 rural *directly affected* villages, which increased to 21 upon further review (Table 3.25-1).

The following sections contain compressed descriptions of the main sociocultural systems whose traditional areas are intersected by (or, in one case, lies near) the TAPS. The information presented includes overviews of each system about the time of Euro-American contact as well as modern characteristics — to provide a sense of how these sociocultural systems have changed over time. These overviews are arranged north-to-south, both to group similar sociocultural systems and to provide an organization parallel to the discussion of subsistence found in Section 3.24.

3.25.1.1.1 Tareumiut (North Alaska Coast Eskimo). The Iñupiat of northern Alaska share a common language,

Iñupiaq. However, speakers of this language may be divided into two regional groups — the Nunamiut, living in interior Alaska, and the Tareumiut, living on or near the north Alaska coast. The Tareumiut traditionally are associated with the north coast of Alaska, primarily between Point Barrow and Point Hope to the west (Spencer 1984). Although possessing an intricate sociocultural system, the hallmark of the Tareumiut is whaling (Table 3.25-2). This activity contributed (and continues to contribute) not only to the economy of these peoples but also to their social fabric and religious practices. Whaling was an activity pursued by small, organized groups led by a highly respected individual, the whaling captain (“umialik”). Following a successful hunt, parts of the whale were shared among residents of the village (and guests) where the whaling crew lived and with selected individuals outside the village. Although the Tareumiut also hunted or otherwise pursued other animals in both the past and present, their emphasis was on hunting sea mammals.

The Tareumiut had only limited and sporadic contact with Euro-Americans prior to the 1850s, when whaling ships from New England arrived and began intensive commercial whaling in the area (Kruse 1982). Crews introduced diseases, alcohol, and the hiring of Natives for whaling crews, all of which took their toll on Tareumiut society. Outsiders introduced additional changes throughout much of the 20th century, including wage labor, a cash economy, and various economic pursuits (e.g., commercial fur trapping and reindeer herding) that differed greatly from traditional subsistence activities. Missionaries introduced not only Christianity, but also modern Western education and important cultural changes (such as insistence that children stop speaking Iñupiaq). Additional changes occurred following World War II, largely associated with a surge in activities by Euro-Americans related to oil exploration and development (Kruse 1982). The discovery of large oil reserves on traditional Tareumiut land ultimately led to ANCSA. As discussed in Section 3.23.6, the Arctic Slope Regional Corporation, which formed to manage Iñupiat land and compensation funds, has been extremely successful.

Ranked as the most successful business in Alaska in 1999 (Association of ANCSA Regional

TABLE 3.25-1 Directly Affected Villages in the Vicinity of the TAPS

Village Name	Sociocultural Affiliation ^a	Basic Village Economy	Area (mi ²) ^b
<i>North Slope</i>			
Anaktuvuk Pass	Mainly Iñupiat (primarily Nunamiut)	Subsistence hunting and fishing; little wage labor	4.9
Nuiqsut	Mainly Tareumiut	Subsistence hunting; some wage labor (mainly in oil industry)	9.2
<i>Yukon River Drainage</i>			
Alatna	Mainly Kobuk River Iñupiat	Subsistence fishing and hunting; crafts; some seasonal wage labor	36.5
Allakaket	Mainly Koyukon Athabascan	Subsistence fishing and hunting; crafts; some wage labor (usually part-time or seasonal)	4.3
Evansville	Athabascan and Iñupiat	Wage labor and subsistence hunting and fishing	22.4
Hughes	Mainly Koyukon Athabascan	Subsistence fishing and hunting; limited wage labor (local government, seasonal construction, firefighting)	3.1
Manley Hot Springs	Mainly Euro-American; Alaska Natives are Athabascan and Iñupiat	Range of small businesses generating cash income; also commercial fishing; some subsistence fishing and hunting to complement other activities	54.3
Minto	Mainly Tanana Athabascan	Subsistence hunting and fishing; wage labor (school, local government); crafts	138.7
Rampart	Mainly Koyukon Athabascan	Subsistence fishing and hunting; some wage labor (e.g., fire fighting, commercial fishing)	168.8
Stevens Village	Mainly Koyukon Athabascan	Subsistence; some wage labor (e.g., fire fighting, working in school)	11.0
Tanana	Mainly Koyukon Athabascan with some Iñupiat; also relatively large Euro-American population	Emphasis on subsistence; some wage labor (e.g., fire fighting, trapping, construction, and commercial fishing), often seasonal	15.6
<i>Copper River Drainage</i>			
Chitina	Mainly Ahtna Athabascan	Wage labor (local, state, and federal government); also subsistence fishing and hunting	95.7
Copper Center	Mainly Ahtna Athabascan	Subsistence fishing and hunting; wage labor (local businesses, tourism-related)	13.7
Gakona	Mainly Ahtna Athabascan (in Native village portion of community)	Wage labor (local businesses, tourism-related); some subsistence fishing and hunting.	61.3

TABLE 3.25-1 (Cont.)

Village Name	Sociocultural Affiliation ^a	Basic Village Economy	Area (mi ²) ^b
Gulkana	Mainly Ahtna Athabascan	Subsistence fishing and hunting; limited wage labor (local government, seasonal construction)	36.5
Tazlina	Mainly Ahtna Athabascan	Subsistence fishing and hunting; some wage employment in small service businesses	7.5
Prince William Sound and Lower Cook Inlet			
Chenegá	Mainly Chugach Alutiiq	Mainly subsistence fishing and hunting; also commercial fishing	31.1
Eyak	Eyak, Chugach Alutiiq, and several other groups, including those from coastal (e.g., Tlingit) and Interior (e.g., Athabascan) Alaska	Wage labor, primarily associated with commercial fishing (local businesses); considerable involvement in subsistence fishing, hunting, and collecting	13.5
Nanwalek	Mainly Unegkurmiut Alutiiq	Wage labor (mostly Port Graham cannery, some commercial fishing); subsistence fishing and hunting	8.5
Port Graham	Mainly Unegkurmiut Alutiiq	Wage labor (fish cannery, commercial fishing); subsistence fishing and hunting	5.9
Tatitlek	Mainly Alutiiq, some Iñupiat	Mainly subsistence fishing, hunting, and collecting; some wage employment (mainly commercial fishing)	7.3

^a Refers to Alaska Native sociocultural group; villages tend to be associated with one major sociocultural group, although members of other groups also may be present.

^b Refers to total area of land and (when appropriate) water under jurisdiction of the community.

Source: ADCED (2001b).

Corporation Presidents/CEOs 2001), the Arctic Slope Regional Corporation's total revenues exceeded \$1 billion in 2000 (Arctic Slope Regional Corporation 2001). The North Slope Iñupiat also led in another form of political self-assertion with the formation in 1972 of the North Slope Borough. To an unprecedented degree, the borough has successfully used its taxing authority on energy development to generate revenues with which to launch ambitious programs in capital improvements, land use regulation, wildlife management, and cultural programs (McBeath and Morehouse 1980).

The North Slope Borough also formed to represent the interests of the North Slope

Iñupiat. One directly affected village examined in this EIS, the Native Village of Nuiqsut, consists largely of Tareumiut from Barrow (and their descendants) who resettled a previously abandoned village (ADCED 2001b) (see Table 3.25-1). Pursuit of subsistence, emphasizing both marine mammals and terrestrial resources, continues to play an important role in Nuiqsut, although increasing numbers of residents have access to wage labor associated with the oil industry. Exchange and social interaction rely heavily on traditional kinship lines, and many Tareumiut continue to speak their native Iñupiaq.

TABLE 3.25-2 Selected Characteristics of Regional Sociocultural Systems, Shortly after Contact, in the Vicinity of the TAPS

Name	Area	Socio-political Organization ^a	Subsistence-Settlement	Demography
Tareumiut (North Alaska Coast Eskimo)	Primarily along north coast from Point Barrow west to Point Hope, but with limited activity along the coast east of Point Barrow	Core of society was bilateral extended families, any given village being a grouping of these units; regional tribal recognition was absent; generally egalitarian, with political organization absent beyond the hunt (crew) leaders, who rose to authority due to personal skills, wealth, and ability to recruit and lead crews.	Semisedentary, residing in villages; whaling played a key role in subsistence and in cultural definition, emphasized in the spring as crews left from villages (more sporadic whaling occurring during the fall whale migration), with some walrus and caribou hunting also conducted in groups during late spring and summer; travel to trading centers in late summer; in fall and winter people returned to villages to hunt individually, make or repair hunting tools, and engage in social activities.	Approximately 1,850 in the mid- to late 19th century.
Nunamiut (Interior North Alaska Eskimo) ^b	Brooks Range, and Colville, Ikpikpuk, Meade, and Utukok River valleys	Nuclear family was main structural unit, although people usually lived in egalitarian bands of 6 to 12 extended families (the main unit of production and consumption); trading partners helped establish extra-band relations while friendships were important within and between bands; band headman was an individual of material wealth and respect, coordinator of key caribou hunts in fall and spring.	Caribou constituted more than 90% of diet and greatly influenced settlement; spring and fall aggregations in mountain passes to hunt migrating caribou; winter settlement comprised dispersed extended families; summer aggregation in Nigalik for trading fair (crucial opportunity to interact with other bands, establish/maintain trade relations).	1,000–2,000 is likely a good estimate for pre-contact total, although estimates vary widely; virtually all remaining Nunamiut presently residing in Anaktuvuk Pass, resettled mid-20th century, with population of 249 Natives in 2000.

TABLE 3.25-2 (Cont.)

Name	Area	Socio-political Organization ^a	Subsistence-Settlement	Demography
Gwich'in	Northeastern Alaska (middle Yukon River drainage) and northwestern Yukon Territory (lower Mackenzie River drainage), extending north to the edge of the Brooks Range and Cordillera	Nine to 10 regional bands at contact; basic component of society was the nuclear family, which occasionally aggregated into semisedentary local groups or larger groups, the latter for economic or ritual purposes; three matrilineal clans cross-cut all of the Gwich'in; hierarchically ordered, with leaders often coming from the highest ranking clan present; wealth and age also helped determine local and large group leadership, although hereditary leaders occasionally occurred.	Seminomadic, with relocations and size of settlements determined by economic (usually) or ritual activities; perhaps 15% of population organized in largely sedentary local groups that occupied and exploited range of resources from a particular area; remainder of population moved throughout the year, with larger group aggregations occurring at summer fish camps and spring and fall caribou hunts; Gwich'in viewed themselves as caribou hunters, and although caribou contributed much to meet their needs, survival demanded exploitation of fish (freshwater and anadromous) and other game (particularly hares, beaver, muskrats, squirrels, and porcupine) available.	Estimated 4,600–5,400 in the 18th century (early contact), declining to fewer than 1,000 by mid-19th century; by 1968, population had rebounded to about 2,150.
Koyukon	Middle Yukon River valley, Kantishna and Koyukuk River valleys; lower Tanana River valley; three main divisions, based largely on linguistics	Loosely ranked, seminomadic bands of about 50 persons, matrilineal extended family forming the core of society; leaders were <i>rich men</i> or <i>big traders</i> known for personal accomplishment, leading bands (or parts of bands) and organizing communal subsistence efforts (caribou fences, fish weirs); originally three matri-clans; little regional tribal recognition, although intermarriage among bands created social/kinship network beyond the immediate band.	Seminomadic, with movements and settlement based on seasonal subsistence activities; fall aggregations at stream outlets of large lakes to combine fishing (grayling, whitefish) and hunting (main activity being large-scale caribou hunting); winter residence in villages near fall camps, fishing until ice became too thick; spring hunting and trapping camps until ice breakup, at which time they aggregated for spring feast and then dispersed to fishing camps (salmon, traps and weirs); late summer hunting in hinterlands while women, children, and older people collected.	Population likely totaled 1,100–1,800 for most of known history (mid-19th century to present).

TABLE 3.25-2 (Cont.)

Name	Area	Socio-political Organization ^a	Subsistence-Settlement	Demography
Tanana	Majority of Tanana River watershed — uppermost tributaries to Tolovana River	Areas of about 12 bands can be distinguished; egalitarian to loosely ranked, with chiefs determined largely by ability (loose inheritance through family lines) the main coordinators of collaborative efforts (e.g., construction of fish weirs and caribou fences, hunt coordination); three main matrilineal descent groups cross-cutting bands and providing a basis for social integration.	Seminomadic, with movements and settlement based on seasonal subsistence activities; fall aggregations in uplands for main caribou hunt at caribou fences; winter villages near caribou fences as well (near caches of meat); spring fishing camps, to build or repair weirs for summer fishing (whitefish, salmon); late summer sheep hunting and collecting camps in mountains; caribou were of paramount importance; considerable change in settlement and band structure 1920s-1960s, accompanying increased sedentary lifestyle.	Population probably never greater than 700 following contact; census of 1910 recorded 415, although probably included some neighboring Koyukon.
Ahtna	Copper River valley, excluding delta, covering about 23,000 mi ²	Three regional groupings, based on linguistics; basis was 8-10 matrilineal clans organized into two exogamous moieties; egalitarian-ranked society, with three social classes recognized; chiefs selected on basis of accomplishment and leadership ability; authority largely confined to one's own clan, but organized collaborative hunting and fishing activities involved leadership at large scales.	Seminomadic, with movements and settlement based on seasonal subsistence activities; spring and summer fish (salmon) camps along Copper River and key tributaries; late summer upland meat camps (hunting caribou, moose, and smaller mammals); fall camps near waterways (fishing, trapping, and hunting range of animals); winter aggregation in villages; late January/February dispersal to exploit any resources available; movements and settlement keyed to local environmental conditions and amount of food present in previously established caches.	Population probably never more than 1,000; decimated by disease (smallpox 1837-1839; tuberculosis about 1900).

TABLE 3.25-2 (Cont.)

Name	Area	Socio-political Organization ^a	Subsistence-Settlement	Demography
Chugach Alutiiq	Coastal Prince William Sound, east nearly to Cordova	Eight local groups, although with no cultural recognition beyond village cluster; three nonrigid classes in what appears as an egalitarian-ranked society; chiefs hereditary, or at least from chiefly class, but position had to be maintained through personal actions; some chiefs led several villages; little is known of the basis for early social organization.	Primarily a marine-littoral adaptation, with an emphasis on marine mammals and halibut throughout the year, other fish (salmon, cod, herring, and eulachon) during summer, and mountain goat, harbor seal, and bear during the winter; summer villages/fish camps occurred at the mouth of salmon streams, winter villages in protected areas (e.g., small embayment), with all settlement tied to the coast and seasonal relocations tied to subsistence.	278 at the time of the first U.S. census in 1880 (likely numbered many more at one time), in addition to 600–800 of mixed descent; by 2000, 63 in Chenega Bay, and 90 in Tatitlek (most probably Chugach); and 255 Natives in Cordova (consisting primarily of Chugach Alutiiq and Eyak). Note that 2000 figures do not reflect mixed descent (e.g., for Cordova, total number claiming some Native heritage is 368).
Eyak	As recently as late 18th century, along 300-mi length of Gulf of Alaska coast (about 15 mi wide), northern extent was Prince William Sound	Four regional groupings, the eastern three with strong ties to Tlingit; basis was two matrilineal clans/moieties; ranked society, with three social categories, chiefs selected on basis of heredity, but leadership largely confined to own clan/moiety rather than entire village.	Combined marine (smaller mammals, fish, shellfish, seaweed), riverine (fish), and terrestrial (caribou, moose, range of smaller mammals, berries) adaptive pattern; exploitation was highly seasonal; semisedentary villages and temporary resource-exploitation sites.	Wide-ranging estimates, never more than 450; decimated by disease (e.g., smallpox epidemic of 1837–1838) and warfare and largely incorporated into Tlingit. Estimates based on language and blood quantum suggested as few as 5 Eyak remained by 1985. However, the Tribal government of the Native Village of Eyak reports a multi-ethnic membership of 500, of which 100 are said to be descendants of aboriginal Eyak. The 2000 census reported 368 residents of Cordova and 14 of Eyak claiming at least partial Native heritage.

See footnotes on next page.

TABLE 3.25-2 (Cont.)

^a General terms of band and tribe in the sense of Service (1971), and egalitarian and ranked in the sense of Fried (1967).

^b Virtually all information from Anaktuvuk Pass, because Nunamiut had long since left their original river valleys by the time systematic recording had begun.

Sources: Table compiled from information in Birket-Smith (1953); Birket-Smith and De Laguna (1976); Burch (1980); A.M. Clark (1974, 1981); D.W. Clark (1984); Davis (1984); De Laguna (1990); De Laguna and McClellan (1981); Gubser (1965); Hall (1984); Heinrich 2002; McKennan (1959, 1981); Osgood (1936b); Slobodin (1981); Spencer (1959, 1984); U.S. Bureau of the Census 2001c.

3.25.1.1.2 Nunamiut (Interior North Alaska Eskimo). The Nunamiut differ from their northern neighbors in geographic location, living primarily in the Brooks Range and along several rivers flowing out of those mountains, and in their heavy reliance on caribou for food during traditional times (Hall 1984; Hall and Associates 1985) (see Table 3.25-2). Before the arrival of Euro-Americans, the Nunamiut lived in a series of mobile bands in the mountains and foothills south of the Arctic Ocean coast. However, during the second half of the 19th century, widespread depopulation from introduced disease, starvation due to declining caribou herds, and migration to the coast decimated the interior groups. Shortly after 1920, the Nunamiut abandoned their lands. Although a few families returned in the late 1930s to pursue a traditional life, they did not resettle the area permanently until people began living in the village of Anaktuvuk Pass in the early 1950s (Hall and Associates 1985; Gubser 1965). Most of the people living in Anaktuvuk Pass are Mountain Nunamiut from the Brooks Range. Because most ethnographic research on the Nunamiut has been conducted with people from this community, anthropological understanding of this sociocultural system in early contact times is biased. Additional insights on inland Iñupiat groups are available from studies in the Noatak and Kobuk River areas to the west (Burch 1998).

The Village of Anaktuvuk Pass is one of the federally recognized Tribes directly affected by the TAPS (see Table 3.25-1). The population of this community in 2000 was 282, with 249 (88.3%) Alaska Natives, most presumably Nunamiut. In 1971, the Nunamiut became eligible to enroll as shareholders in the Arctic Slope Regional Corporation, which was created to manage the money and 5 million acres of land granted to the Iñupiat under ANCSA (Arctic Slope Regional Corporation 2001).

Despite close corporate association with oil industry activities on the north slope of the Brooks Range, Native residents of Anaktuvuk Pass continue to pursue traditional subsistence activities, notably caribou hunting. Much of community life revolves around organizing and pursuing subsistence activities. Exchanging subsistence resources and other forms of social

interaction emphasize kin ties both within the community and beyond.

3.25.1.1.3 Gwich'in. The Gwich'in are a northern Athabaskan people occupying the Yukon flats and the southeastern slopes of the Brooks Range in what is now Alaska and the lower Mackenzie River drainage in Canada's Yukon Territory (Slobodin 1981) (see Table 3.25-2). The Gwich'in consisted of 9 or 10 regional bands at contact, each likely speaking a slightly different dialect and occupying a separate river drainage within the main drainages mentioned above. Traditional social organization balanced certain sociocultural guidelines with flexibility and opportunism, the latter two principles enhancing survival in a challenging natural environment. Although the majority of Gwich'in followed a seminomadic life characteristic of most Athabascans, as many as 15% lived in local groups consisting of six to eight related households that occupied a fixed area for a number of years. As interaction with Euro-Americans began, the Gwich'in gradually became more sedentary, participated heavily in the fur trade and wage economy, and in many cases converted to Christianity (Osgood 1936b).

The modern Gwich'in sociocultural system represents a mix of indigenous and Euro-American culture. Although their relative geographic isolation has contributed to the persistence of key cultural features, such as the Gwich'in language, a number of traditional cultural characteristics have disappeared (Slobodin 1981). The Gwich'in of Arctic Village and Venetie responded to new opportunities under the Indian Re-Organization Act, as extended to Alaska in 1936, applying for and receiving the largest Executive Order Reservation (at 1.8 million acres) in Alaska. Culture change has been particularly rapid since the 1950s, with the Department of Northern Affairs and National Resources in Canada facilitating the development of local schools in Canada, and Alaska statehood introducing a number of changes in Alaska. Organizations such as the Tanana Chiefs Conference and Doyon, Ltd. emerged to address selected key issues for the Gwich'in and other interior Athabascans.

The Tanana Chiefs Conference re-emerged in the 1960s out of the land claims movement, drawing on the tradition of the first meeting of the Chiefs in 1915. The Tanana Chiefs Conference is the largest of the regional Tribal Associations, also termed regional non-profit corporations. The Tanana Chiefs Conference provides a “unified voice advancing tribal governments, economic and social development, educational opportunities and protecting traditional and cultural values” (Tanana Chiefs Conference undated; Nelson 1986). With the signing of ANCSA, interior Athabascans were given the opportunity to enroll in Doyon, Ltd., the Alaska Native regional corporation associated with peoples of the Interior. With stock issued initially to nearly 9,100 shareholders in 1971, the approximately 12.5 million acres of land owned by Doyon makes it the largest private landholder in North America (Doyon, Ltd. 2001). Presently the number of Doyon, Ltd., stockholders approaches 14,000, its total revenues in 1999 ranking it 22nd among all Alaska corporations (Association of ANCSA Regional Corporation Presidents/CEOs 2001). The five businesses affiliated with Doyon, Ltd., cover a broad range of modern economic activities.

Under the terms of ANCSA, the Venetie Indian Reservation was converted to land owned by the Venetie and Arctic Village corporations. Total Gwich'in population in their former homeland was about 2,150 in the late 1960s, about 750 of whom lived in the Alaskan communities of Arctic Village, Chalkyitsik, Circle, Fort Yukon, and Venetie. All of these communities lie well to the east of the TAPS, and none has been identified as likely to experience TAPS-related impacts directly (see Table 3.25-1).

3.25.1.1.4 Koyukon. Among the northernmost Alaska Athabascans, the Koyukon are traditionally associated with the middle Yukon River valley (along with local tributaries) and the lower Tanana River valley (Clark 1984) (see Table 3.25-2). The entry of Euro-Americans into Koyukon territory occurred relatively early for Interior Alaska (beginning in the late 1830s), although interaction was not frequent until the gold rush at the end of the 19th century. Differences among regional divisions in the amount and type of contact with outsiders

remained evident into the 1970s, its consequences including differences in the traditional sociocultural behavior that remains.

The greatest changes in the Native sociocultural system seemed to begin in the 1940s, when Koyukon men who had served in the military returned home to share their experiences and increased knowledge of the outside world (Clark 1984). During that decade, or slightly before, the Koyukon had completed the shift from seminomadic to sedentary village life, settling on main waterways in communities that have electricity, running water, and other modern amenities. With sedentary life came formal education and health facilities, as the agencies providing such services could establish schools and health centers in fixed locations. Opportunities for wage labor also increased after World War II, although it often was tied to particular projects and frequently was (and continues to be) seasonal.

With the concentration of people in sedentary villages came concentrated political awareness and influence. The Tanana Chiefs Conference and Doyon, Ltd., serve the Koyukon and other Interior Alaska Athabascans (see Section 3.25.1.1.3). Koyukon Athabascans continue to reside in several interior villages, including several federally recognized Tribes examined in this EIS: Evansville Village, Hughes Village, Manley Hot Springs Village, Rampart Village, Native Village of Stevens, and Native Village of Tanana (see Table 3.25-1). Despite the considerable sociocultural changes experienced among the Koyukon, inhabitants of these six villages continue to rely heavily on traditional subsistence resources; the importance of kinship, respect for elders, and traditional spiritual beliefs similarly persist (Nelson 1983).

3.25.1.1.5 Tanana. Coined by Osgood (1936a) in his assessment of northern Athabascan peoples, the term “Tanana” refers to the collection of hunting and gathering bands that occupied the Tanana River watershed as far downstream as the Kantishna River (McKenna 1981) (see Table 3.25-2). As with most Interior Alaska Natives, the Tanana had little interaction with Euro-Americans until the late 19th century, with widespread interaction accompanying the

gold rush in the Fairbanks area beginning in 1902. The appearance of large numbers of non-Natives brought many changes to the Tanana, including the introduction of diseases that decimated the Native population and fur and meat trading that substantially changed the Native economy. With these economic shifts and the decline of caribou herds early in the 20th century, settlement became sedentary, and permanent villages emerged, changing the former nomadic way of life and many aspects of traditional social structure.

Many of the changes experienced by the Athabascan peoples of Interior Alaska, including the Tanana, are discussed in the recent history of the community of Minto (Olson 1981). Substantial shifts in the Native economy and settlement occurred in Minto during the 20th century — indeed, the community itself even relocated, first established on the Tanana River and subsequently (“New Minto,” the present village site) on a tributary of the Tanana. Tanana Athabascans from the surrounding area came to live in Minto. Families with no prior relationships were brought into close proximity. People began to grow food in small gardens and purchase food in stores; formal education was introduced; the village began to operate under a village council (1937); and localized exposure to Christianity began. Minto, which, in many ways is a microcosm of interior Athabascan sociocultural systems, has experienced significant shifts in social organization, political organization, education, religion, and economy. Nevertheless, key elements of the traditional sociocultural system persist — including the importance of subsistence, both as a means of acquiring resources and as a basis for economic and social exchange, and an emphasis on kinship as a basis for social organization and obligation.

As with other interior Athabascans, the modern Tanana sociocultural system represents a mix of old and new. The Tanana Chiefs Conference and Doyon, Ltd., play important roles in the lives of many Tanana — the former focusing more on general political issues and Tribal programs, the latter on managing assets conveyed under ANCSA (see Section 3.25.1.1.3). But tradition also plays an important role in the lives of most modern Tanana Athabascans. Many continue to follow traditional

A Shift in Settlement, A Shift in Culture

Traditionally, Ahtna and other Athabascans were highly nomadic, moving seasonally throughout a traditional range to exploit available subsistence resources. With the arrival of Euro-Americans, many Athabascans began to redefine their seasonal mobility — namely by (1) prolonged settlement around trading posts, to enhance trading and access to selected parts of Euro-American goods and technologies, and (2) prolonged settlement around gold mining communities, often providing meat and other key resources to those communities in exchange for Western material culture.

The emergence of public expenditures during the mid- to late-20th century led to a further increase in sedentary settlement, under government pressure for mandatory school attendance and to gain access to key services such as health care. Settlement in communities introduced key changes in sociocultural systems:

- Change in subsistence activities, with changed mobility, and hence shifts in adaptation and economy.
- Frequent interaction with relatively large numbers of nonkin members.
- Need for administrative principals to organize and lead multi-kin-group, and often multi-ethnic (in some villages different Alaska Native tribes), sedentary communities.

ways — placing a continuing importance on subsistence resources, kin relations, and cooperation within villages and kin groups. Many Tanana continue to live in their interior Alaska homeland, including the Native Village of Minto (a federally recognized Tribe) and the city of Fairbanks. As noted above, Minto was designated as one of the villages directly affected by the TAPS (see Table 3.25-1).

3.25.1.1.6 Ahtna. The people known as Ahtna, southernmost of the Athabascans, occupied most of the Copper River valley at the time of initial Euro-American contact (De Laguna

and McClellan 1981) (see Table 3.25-2). Widely dispersed in seminomadic bands, the central role of subsistence was particularly evident in traditional Ahtna culture — determining the locations and sizes of settlements and providing the impetus for collaboration and the basis for political leadership. With the introduction of fur trade, settlement patterns and other key characteristics of traditional culture changed to accommodate this shift in economic emphasis. As with many interior groups, interaction with Euro-Americans intensified notably in the early 20th century and led to an increasingly sedentary life, which in turn contributed to several other sociocultural changes as people from different local and regional bands came into constant contact with one another in larger, year-round aggregations.

The Ahtna persist today, as do many key aspects of their culture — such as the basic clan structure and reliance on subsistence. The total population is uncertain because of the lack of data for the Ahtna as a demographic unit. Recorded numbers never exceeded 600 for any part of their geographic area, and the actual total probably was fewer than 1,000. Following the adoption of Alaska statehood in 1959, indigenous people residing in the Copper River valley founded the Copper River Native Association (Ahtna Tannah Ninnan Association) (De Laguna and McLennan 1981). This organization remains active in offering Tribal programs and services for the Ahtna villages, including natural resources, health, and behavioral health. After passage of ANCSA in 1971, Ahtna, Inc., was formed to receive and manage lands and compensation funds for Alaska Native shareholders in the Copper River valley. Currently, the approximately 1,200 shareholders of Ahtna, Inc., benefit from about 1,528,000 acres of land owned by the corporation, along with the operations of nine subsidiaries and seven joint ventures (Ahtna, Inc. 2001). Most Ahtna Athabascans continue to live in the Copper River valley, primarily as federally recognized Tribes. Several of these were designated as likely to experience direct effects from the TAPS: Chitna Traditional Village, Native Village of Kluti-Kaah (Copper Center), Native Village of Gakona, Gulkana Village, and Native Village of Tazlina (see Table 3.25-1).

3.25.1.1.7 Chugach Alutiiq. The Chugach Alutiiq are part of a larger grouping of peoples, traditionally linked to the mainland coast and related islands (e.g., Kodiak Island), known collectively as *Alutiiq* (and previously as Pacific Eskimos) (Birket-Smith 1953, De Laguna 1956, Clark 1984; Simeone and Miraglia 2000). A summary of what is known of main traditional sociocultural characteristics appears in Table 3.25-2, based on documentation in the mid-19th century. Archeological evidence indicates that by this time, the sociocultural system already had changed considerably from its precontact form (Wooley 1995). The Chugach Alutiiq historically inhabited Prince William Sound east to Cordova. It is likely that the Chugach at one time numbered well into the thousands, many more than the 286 documented in the first census of the area in 1880. Both population decline and the absence of detailed information on the traditional Chugach sociocultural system are due to earlier and more prolonged contact with Euro-Americans along the coast, a characteristic not shared by the other Alaska Native groups examined in this study.

Today, the Chugach Alutiiq in the vicinity of the TAPS reside primarily in Cordova, Chenega Bay, and Tatitlek. All three communities have federally recognized Tribes in residence (Native Village of Eyak, Chenega Bay, and Native Village of Tatitlek, respectively), and have been identified as possibly experiencing TAPS-related impacts, as have other Alutiiq (Unegkurmiut) villages of Nanwalek and Port Graham (and the federally recognized Tribes of the Native Village of Nanwalek and Port Graham Village) on the Kenai Peninsula (BLM 2001a; see also Davis 1984). Chugach Natives, Inc., was formed in 1971 under the ANCSA (43 USC 1601 et seq.) to manage lands and compensation funds conveyed under the settlement and to engage in business on behalf of the Chugach and Unegkurmiut shareholders. The Corporation initially enrolled more than 1,900 persons and received \$24 million (Chugach Alaska Corporation 2001). More recently adopting the name Chugach Alaska Corporation, in 2000 this corporation had revenues exceeding \$200 million through business activities that included six subsidiaries and several joint

ventures. Many Chugach Alutiiq today earn livings primarily through wage labor, working for businesses in Cordova and other communities or pursuing commercial fishing. However, the importance of Chugach Native heritage persists, primarily in the continued pursuit of subsistence to supplement wage-based economy and the maintenance of social interaction through traditional kinship and obligation networks. Since the mid-1980s the Chugach region has also seen a variety of cultural revival activities, including initiatives by the Tribal governments, the school district, and regional and national museums. As an example, an Alutiiq language curriculum has been integrated in varying degrees in Chenega Bay and Tatitlek (Simeone and Miraglia 2000).

3.25.1.1.8 Eyak. Before the arrival of Euro-Americans, the Eyak were the northernmost sociocultural system of a region that most anthropologists commonly associated with the Pacific Northwest Culture Area (Suttles 1990), although they spoke a language related to Athabaskan (Birket-Smith and De Laguna 1976, De Laguna 1990). Inhabiting a 300-mi coastal strip along the Gulf of Alaska, the Eyak lived in semisedentary villages and pursued primarily a coastal-marine adaptation (see Table 3.25-2) (Birket-Smith and De Laguna 1976; De Laguna 1990). The Eyak occupied an area between other sociocultural systems that had important effects on them. The Tlingit to the south had a strong influence on the sociocultural system of the Eyak, whose original system eventually become increasingly similar to that of the Tlingit. The Chugach Alutiiq, to the west, were the main enemies of the Eyak, and warfare between these two contributed to depopulation of both. Contact with Athabascans in Interior Alaska was more limited, in part because of fundamentally different adaptations (coastal for the Eyak, riverine and terrestrial interior for the Athabascans), coupled with geographic barriers (mountains) beyond the Copper River valley separating the coast from the interior.

According to academic scholarship, the Eyak currently occur only in very small numbers, and little of their traditional sociocultural system persists. This assessment of cultural affiliation and continuity highlights blood quantum (or genealogy) and language ability. Within this

perspective, a discussion of Eyak culture in the 21st century is problematic. ANCSA led to the formation of a village corporation called Eyak in 1971, an organization that included very few Eyak people — of the 319 shareholders in 1985, only 2 could actually claim Eyak heritage (De Laguna 1990). The contention that only one full-blooded Eyak remained as of 1992 is also asserted by some Eyak themselves (interview with Lankard and Jones, in *Essential Information* 1993). Although sociocultural traditions are not transmitted genetically, kin ties to cultural mentors in the home make the consistent transmittal of traditions more likely.

An alternative perspective on membership and cultural continuity is asserted by the Native Village of Eyak, the federally recognized Tribe based in Cordova. The Tribe reports a membership of about 500 in Cordova, and states that elders recognize more than 100 of these individuals as Eyak descendents. The remainder of the Tribe consists of individuals with Alutiiq, Tlingit, Athabaskan, Haida, and Iñupiat heritage (Heinrichs undated-a, 2002). The Tribe has emerged in recent years as an ambitious political and services organization, with significant programs in environmental protection, resource monitoring, spill response, health care, and cultural revitalization. Beginning in 1994, the Tribe sponsored a Sobriety Celebration to advocate cultural identity as a foundation for sobriety. (Native Village of Eyak, undated-b).

3.25.1.2 Alaska Native Claims Settlement Act

The Alaska Native world changed dramatically on December 18, 1971, with the passing of ANCSA. Rooted in federal commitments to address Native land rights, the Statehood Act, and the discovery of oil at Prudhoe Bay, ANCSA was a comprehensive settlement of Native claims to aboriginal title for virtually the entirety of Alaska. ANCSA extinguished aboriginal title claims (including aboriginal hunting and fishing rights) to more than 325 million acres of land, clearing land title and removing barriers to continued state land selections and creation of a transportation corridor for development of the Prudhoe Bay oil reserves. In exchange, ANCSA conveyed

Alaska Native Regional Corporations

Under provisions of the Alaska Native Claims Settlement Act (ANCSA), 12 for-profit corporations with land entitlement were formed in 1971 for Alaska Natives residing in the state. A 13th corporation, which has no land entitlement, represents Alaska Natives elsewhere. At the time of original enrollment, shareholders had to be at least 25% Alaska Native. In 1999, 10 of the 36 most successful Alaskan businesses were Alaska Native regional corporations, with 5 of these corporations among the top 10 businesses in the state (Association of ANCSA Regional Corporation Presidents/CEOs 2001).

44 million acres of land (which excluded the TAPS Corridor and land to be used for the Valdez Marine Terminal), provided for \$962.5 million in monetary compensation, and established regional and village corporations to manage these assets. ANCSA did not terminate Alaska Native tribes nor eligibility for national programs intended to fulfill the federal constitutional trust responsibility to Native Americans. Although silent on specific protections for subsistence, the legislative history for ANCSA indicated that Congress expected the Secretary of the Interior and the Governor of Alaska to use existing authorities to protect Alaska Native hunting and fishing (Arnold et al. 1978; Burch 1984; McNabb 1992).

The evolution of Alaska Native political self-assertion began in the early 20th century, but gathered its current momentum in the movement leading to ANCSA (Philp 1981; Haycox 1986/87; McBeath and Morehouse 1980; Mitchell 2001). With passage of the Alaska Statehood Act of 1958, Alaska Native land claims grew in intensity to become an area of dispute that gained national attention as the state claimed land that Alaska Natives considered their own (Berry 1975). With the discovery of large oil and mineral deposits in the 1960s, including the Prudhoe Bay oil fields that ultimately led to the construction of the TAPS, disputes increased. In response, Alaska Natives began to organize themselves — first into local organizations and then regional organizations (Lantis 1973). Eight

of these regional organizations combined to form the Alaska Federation of Natives, the organization that conducted much of the lobbying for ANCSA.

ANCSA divided Alaska into 12 regions, providing the basis for forming 12 regional for-profit corporations (Map 3.25-2). (A 13th corporation also was formed to represent nonresident Alaska Natives, although it had no geographic base nor land entitlement.) These regional corporations had four primary responsibilities (Burch 1984):

- Receive all cash payments made under ANCSA and invest or distribute the money to village corporations and individuals;
- Become owners of the surface estate of some land and the subsurface estate of all land selected under ANCSA;
- Supervise the creation of village corporations and assist those corporations in the selection of land and development of business ventures; and
- Invest and operate businesses on a for-profit basis.

Village corporations, in turn, emerged as local counterparts to the regional corporations, selecting and managing the surface title to land around villages (often chosen for value as subsistence lands), initially dispersing cash and title to existing homesites to individuals, and subsequently dispersing dividends from corporate activities. The main difference between village and regional corporations was the ability of the former to organize on a for-profit or nonprofit basis, although the regional corporations have proven by far the most successful (Mitchell 2001). As is the case with regional corporations, the advent of village corporations also introduced new concerns to Alaska Native sociocultural systems — such as the availability of shares to Natives born after corporate formation and struggles with bankruptcy faced by some corporations.

ANCSA and the resulting emergence of two layers of corporate structure introduced additional change to Native peoples who had witnessed considerable changes since the

arrival of Euro-Americans centuries before. Virtually all groups examined here initially consisted of seminomadic egalitarian or ranked bands with achieved political leadership and limited political ties outside of local extended kin units. Settlement in permanent villages brought more people into single, permanent communities and required the emergence of a leadership structure. Extension to Alaska in 1936 of the Indian Reorganization Act of 1934 provided for Alaska Natives with a “common bond of occupation, or association, or residence within a well-defined neighborhood or rural district” to organize a self-governing Tribal council with a written constitution and by-laws (Berger 1985). The Indian Reorganization Act, as amended, thus extended legal recognition to formally elected tribal councils as governing bodies separate from federal, state, and local municipal governments in the United States treating Alaska Native Tribes the same as Tribes in the rest of the United States. ANCSA represented a significant departure from earlier Indian policies, conveying land and compensation funds to Alaska Native corporations rather than Tribes. However, ANCSA did not terminate Tribes, and in the early 1990s the U.S. Department of the Interior formally recognized 227 Alaska Native Tribes. The result is a complex network of local and regional corporations and federally recognized Tribal governments.

Alaska Native peoples whose ancestors often were seminomadic hunter-gatherers today live in sedentary settlements where they have adapted many elements of their traditional sociocultural systems to new conditions. Most Alaska Natives are associated with a federally recognized Tribe as well as a village and a regional corporation. These three entities may or may not share common goals and objectives. The emergence of Alaska Native political awareness, helping to support pursuit of their own interests, has had many positive consequences for the Native population of Alaska. For most Alaska Natives, these changes represent a selective incorporation of new opportunities while maintaining important cultural traditions. The results are a series of adapted sociocultural systems that strive to preserve key components of the past while they develop increasing abilities to respond to

challenges of the natural and human environment of modern Alaska.

3.25.1.3 Overview of Modern Alaska Native Sociocultural Concerns and Benefits

As is the case with many indigenous groups in the United States, Alaska Natives today struggle with many social problems. It is difficult to identify single causes of these problems. As discussed throughout Section 3.25.1.1, many of the sociocultural systems considered here face the ongoing challenge of striking the right balance between the traditional world of their aboriginal ancestors and the world of modern America. Moreover, the socioeconomic reality of most Alaska Natives finds them with limited financial resources — resources that might provide options in life that lead to fewer social problems, or a range of assistance to help address such problems. The final report of the Alaska Natives Commission in 1994 describes Alaska Natives as peoples at risk of permanently becoming part of America’s underclass (Alaska Natives Commission 1994). Despite ANCSA, the success of certain Alaska Native regional corporations, growing pride and connection with their sociocultural heritage, and increased political awareness and influence, Alaska Natives experience high levels of violence, substance abuse, and behavior leading to personal and social dysfunction.

One of the greatest problems facing Alaska Natives in 2002 continues to be substance abuse, particularly alcohol abuse. Problems with alcohol have a long, grim history in Alaska Native sociocultural systems, having frequently accompanied early interaction with Euro-Americans. The consumption of alcohol by Natives, occasionally involving alcohol production as well, often occurred during the emergence of commercial fur trapping, commercial whaling, and the various gold rushes. However, it became a significant problem shortly after Alaska statehood in the late 1950s, seemingly increasing with the emergence of government programs to help the

underprivileged in the fledgling state (Alaska Natives Commission 1994). By the early 1970s, excessive alcohol consumption by Alaska Natives had become a major problem in many places (e.g., Kruse et al. 1981), emerging statewide as the leading cause of death among Alaska Natives (Alaska Natives Commission 1994). The problem continued to grow. During the 1980s, one Alaska Native died directly as a result of alcohol consumption every 12 days — a rate three-and-one-half times that of non-Natives in Alaska.

Another social problem that occurs at alarming rates among Alaska Natives is suicide. This problem also can be traced back to the 1950s, when the steady growth in suicide rate began (Alaska Natives Commission 1994). Once again, the data largely tell the story. By 1981, the suicide mortality rate for Alaska Natives had reached 42 per 100,000 people, well above the national average. By 1986, the rate had increased to 58 per 100,000 people, and in 1989 it had grown even further to 69 per 100,000. During the 1980s, one Alaska Native died every 10 days from suicide. The problem appears to be prevalent particularly among males, notably young men aged 20–24 years. In 1982–1984, the suicide mortality rate for Alaska Natives aged 20–24 was 228 per 100,000 population (Alaska Federation of Natives statistics, cited in Alaska Natives Commission 1994). By 1989, the rate for these young men had increased to 403 per 100,000 people, in excess of 30 times the national rate. Fortunately, suicides among Alaska Natives have declined slightly in recent years. Although the basic pattern of suicide has persisted — more prevalent in males than females and in persons aged 20–24 years — the overall rate for all Alaska Natives had fallen by about 30% to 48.4 per 100,000 people in 1998, compared with 23.7 for the state of Alaska as a whole (Alaska Bureau of Vital Statistics 1999). This decline coincides with increased efforts to help reduce suicides in Alaska, in both urban and rural settings. Despite these improvements, the suicide rate of Alaska Natives remains more than double that of non-Natives in the state and in the rest of the United States.

In contrast, modern Alaska Native sociocultural systems also have experienced many positive developments in recent years.

Among the most important of these developments is the dramatic growth in Alaska Native Tribal administration of health care, behavioral health, and substance abuse prevention programs. Initiatives for cultural renewal as a foundation in prevention and treatment are now widespread in what is often termed the *sobriety movement*. Federal funds to the Tribal sector have grown significantly during the 1990s to support such activities. Economic opportunities alongside the subsistence lifestyles have generally increased over the past several decades even in rural communities. Such economic options can add convenience and security to the traditional activities that many value so highly (see Section 3.24-2). In conjunction with state and federal funded programs and associated employment, the Permanent Fund Dividend, and economic benefits through regional and village corporations, such opportunities for wage employment have provided Alaska Natives with more cash than in the past — enabling them to purchase many modern amenities. A number of state-funded programs, public services, and infrastructure improvements also are contributing to the improvement of Alaska Native lives — such as the General Fund Community Support Programs (ADCBD 2002a,b). Such funds help provide and maintain schools, health care facilities, and transportation infrastructure (roads, rural airports) to much of rural Alaska (North Slope Bureau 1999). The APSC also financially supports various community programs; although these programs do not necessarily have a rural focus, they certainly contribute to the lives of Alaska Natives. Local financial resources also have contributed to the development of key infrastructure and services that have benefited Alaska Native sociocultural systems, such as occurred during the 1980s and 1990s in the North Slope Borough (Strohmeyer 1997). Federal funds to Alaska Native Tribal governments and regional Tribal associations have grown significantly during the 1990s. The EPA has been particularly active in funding Tribal environmental programs. Finally, the financial success of certain Native regional corporations has provided additional resources to shareholders, again providing important economic options in a state where wage employment in rural settings can be difficult to

find (Association of ANCSA Regional Corporation Presidents 2001).

3.25.2 Non-Native Rural Alaskan Sociocultural Systems

In addition to Alaska Natives, the alternatives considered in this EIS have important implications for non-Natives in Alaska as well. For most non-Natives, sociocultural systems are essentially those found throughout most of the modern United States — allowing for variations on this general theme due to differing ethnic composition and other characteristics. Although these sociocultural systems have evolved over the years as well, they have experienced considerably less change than their Alaska Native counterparts. Many of the most important impacts on Alaska non-Natives are considered within the economic analysis, with the existing conditions described in Section 3.23. A sector of non-Native society in Alaska that may also experience impacts but is not specifically covered in the economic analysis is rural Alaskans.

Rural Alaskans, Native and non-Native alike, usually live differently than their urban counterparts. Apart from the obvious contrasts in their physical settings, the most notable distinction is the isolation in rural Alaska and the tradition (and necessity) of both self-reliance and community cooperation that has developed there. This combination of self-reliance and mutual support is consistent with the history of many Alaska non-Natives, who have either descended from individuals who came to the remote frontier to earn a living trading furs, mining gold, or the like, or who themselves came to pursue such endeavors (Haycox 2002). In many ways, it is consistent with the need to survive in harsh natural surroundings where assistance beyond one's self or neighbor was far

away. One of the most noteworthy differences between urban and rural non-Natives in Alaska appears in the rural economy, which relies heavily on subsistence. This topic is examined in Section 3.24, which focuses specifically on subsistence as a rural endeavor, and as a result will not be examined here.

A number of communities located in the vicinity of the TAPS qualify as rural, both according to the U.S. Bureau of the Census definition, namely a population of fewer than 2,500 persons, and according to federal subsistence regulations, which designate rural areas for the harvesting of fish and game (Office of Subsistence Management 2001). By virtue of geographic proximity to the TAPS, reliance at least partially on a subsistence harvest area that includes the TAPS, or some combination of these factors, these communities may experience impacts from the continued operation of the pipeline and related facilities.

Several of these communities, such as Wiseman in Interior Alaska, share a broadly similar history tied to gold prospecting in the early 20th century and provide examples of the sociocultural conditions that seem to characterize survival strategies of small non-Native settlements in rural Alaska (Scott 1998). Others, such as Moose Creek and North Pole, appear by virtue of their relatively small populations and proximity to the TAPS to be sociocultural settings similar to Wiseman. However, these latter communities are, in fact, part of greater Fairbanks — that is, they are not rural by federal subsistence standards and are included in this discussion largely because of their geographic proximity to the TAPS. Table 3.25-3 lists the non-Native rural communities in the vicinity of the TAPS and presents selected characteristics. Demographic data on these communities are presented in Table 3.29-1 and thus are not repeated here.

TABLE 3.25-3 Non-Native Rural Communities in the Vicinity of the TAPS

Name ^a	Background	Basic Community Economy	Area (mi ²) ^b
<i>North Slope</i>			
Deadhorse	Founded in the mid-1970s as the land base for Prudhoe Bay offshore oil drilling; exists as a base, providing housing and services for about 5,000 transient workers associated with offshore drilling and the TAPS.	Wage employment, primarily in the oil industry or as indirect jobs providing goods and services to oil industry employees.	NAC ^c
Prudhoe Bay	Developed in 1970s to support oil-drilling operations; origin of TAPS.	Wage employment associated with the oil industry.	558.1
<i>Yukon River Drainage</i>			
Big Delta	Originally a road house established in 1903 at the junction of Delta and Tanana Rivers; later benefited from highway and TAPS construction and state-funded agricultural projects.	Mainly wage labor, although many businesses and individuals rely on Ft. Greely (slated to close); also agriculture, government employment, and tourism.	61.1
Coldfoot	Founded by gold prospectors in 1900, largely abandoned by 1912; survives mainly as location for services to travelers along Dalton Highway.	Wage employment in government and private sector (services to travelers).	37.0
Delta Junction	Founded in 1903 at a key intersection of trails in Interior Alaska, becoming the nearest civilian community to what would become Ft. Greeley in 1942; currently the main town in an important agricultural area of Alaska.	Wage employment primarily at the nearby military installation, in commercial agriculture, in state or local government, or in private industry (largely APSC).	17.3
Ester	Began as gold mining camp in early 1900s, which continued through mid-1900s.	Wage employment at University of Alaska and businesses in Fairbanks and its suburbs.	64.7
Fox	Began as gold mining camp in early 1900s.	Primarily wage employment in small local businesses and in nearby Fairbanks.	13.6
Harding-Birch Lakes	Founded primarily as summer recreation site for Fairbanks residents.	Some wage labor, although mostly seasonal associated with summer recreation.	233.6
Livengood	Began as gold mining camp in 1914.	Limited wage employment, mainly in providing roadside services along Dalton Highway.	267.9
Moose Creek	Suburb of Fairbanks that has grown primarily due to proximity of Eielson Air Force Base and North Pole.	Wage labor, primarily at Eielson Air Force Base and a range of businesses in Fairbanks and its suburbs.	1.7

TABLE 3.25-3 (Cont.)

Name ^a	Background	Basic Community Economy	Area (mi ²) ^b
North Pole	Homesteaded in 1944; has grown primarily due to proximity to Fairbanks and Eielson Air Force Base.	Primarily wage employment for a range of businesses and government agencies in Fairbanks and at Eielson Air Force Base.	4.2
Pleasant Valley	Largely has developed as suburb of Fairbanks.	Primarily wage employment for a range of Fairbanks businesses and government agencies.	30.3
Salcha	As late as the early 20th century, an Alaska Native village; evolved into a small non-Native community of occasional-use homes owned by residents of nearby Fairbanks.	Primarily wage labor for businesses in Fairbanks, in commercial fishing, and construction.	74.2
Two Rivers	Community has grown primarily with expansion of Fairbanks.	Range of wage employment both local and in Fairbanks.	28.5
Wiseman	Began as supply center for miners in the vicinity in 1911.	Subsistence plays central role; some wage labor providing roadside services and working for North Slope Borough; also commercial fishing.	78.1
<i>Copper River Basin</i>			
Copporville	Developed during TAPS construction.	Primarily wage labor, mainly government and small businesses; subsistence, particularly by Alaska Native residents.	1.4
Glennallen	Founded as small community along Glenn Highway near its intersection with Richardson Highway.	Primarily wage employment for government agencies and small businesses serving commuters and tourists along Glenn and Richardson Highways (including visitors to Wrangell-St. Elias National Park and Preserve).	114.9
Kenny Lake	Originally homesteaded in 1960s for agricultural purposes; much property subsequently subdivided and sold for residential use.	Primarily wage labor in commercial agriculture and small businesses; some employment in tourism.	195.2
Paxson	Began as a road house in the early 20th century; subsequently grew as small area for services at intersection of Denali and Richardson Highways.	Primarily wage labor, servicing travelers along the two highways (most seasonal); also government employment; some subsistence.	318.3
Tonsina	Began as U.S. Army telegraph station in 1902; several lodges followed, but most growth has followed TAPS development.	Some wage labor at roadhouses, highway maintenance camp, and TAPS PS 12; subsistence supplements wage income.	148.0

TABLE 3.25-3 (Cont.)

Name ^a	Background	Basic Community Economy	Area (mi ²) ^b
<i>Prince William Sound and Lower Cook Inlet</i>			
Cordova	Town founded in 1909, as terminus for Copper River and Northwestern Railroad (copper ore loaded at Cordova for shipping to smelters); evolved into fishing community beginning in the 1940s.	Primarily wage employment in commercial fishing, housing both a large fishing fleet and fish processing plants; also several sources of government employment.	75.7

^a Excludes College, Fairbanks, and Valdez, all of which have populations in excess of 2,500, the cut-off used by the U.S. Bureau of the Census to define rural communities.

^b Refers to total area of land and (when appropriate) water under jurisdiction of the community.

^c NA = information not available.

Sources: ADCED (2001b); Scott (1998).

3.26 Cultural Resources

Cultural resources include archaeological sites and historic structures and features that are protected under the National Historic Preservation Act of 1966, as amended; the Archaeological Resources Act of 1979; and the Antiquities Act of 1906. Cultural resources also include traditional cultural properties (TCPs) that are important to a community's practices and beliefs and that maintain a community's cultural identity. Cultural resources that meet the eligibility criteria for listing on the *National Register of Historic Places* (NRHP) are considered "significant" resources and, when present, must be taken into consideration during the planning of federal projects. Federal agencies also are required to consider the effects of their actions on sites, areas, and other resources (e.g., plants) that are of religious significance to Native Americans and Alaska Natives, as established under the American Indian Religious Freedom Act. Native American and Alaska Native graves, burial grounds, and associated funerary objects are protected by the Native American Graves Protection and Repatriation Act.

The following discussion presents an overview of information on known cultural resources along the TAPS corridor. Because the pipeline traverses a broad range of environmental settings along its 800-mi route, this overview groups cultural resources into three main geographic regions on the basis of environmental characteristics and the broadly similar cultural remains found in each. These regions, from north to south, are the North Slope, Central Region, and Valdez/Prince William Sound (see Map 3.26-1). The North Slope area consists of the northernmost 145 mi of the pipeline, from Prudhoe Bay to about Galbraith Lake. The Central Region from MP 145 to 775 contains the Brooks Range, the Interior Forest Region, the Alaska Range, the Copper Plateau, and the Pacific Coastal Mountains. The final region, Valdez/Prince William Sound, consists of the final 25 mi of the pipeline extending to the Pacific Coast.

Cultural Resources

The term *cultural resources* refers to surviving physical links to our cultural past. Included are archaeological sites, historic structures and features, and other remnants of past societies and lifestyles. The term also encompasses properties that have played important roles in the cultural traditions of specific social or ethnic groups. These features, called traditional cultural properties, include such things as sacred locations and land features, burial sites, or other revered locations or features important in defining cultural and religious traditions.

Cultural resources are important for scientific reasons because they can help us understand how former societies functioned and how ancient people lived. They are also important for less tangible reasons, providing links to our histories and our cultural and social ancestors.

3.26.1 Archaeological Context

The archaeological context of Alaska provides a framework for understanding the types and ranges of sites that have been found within the project area. The prehistoric, ethnohistoric (cultures that existed at the time of first contact with Euro-Americans), and historic contexts for the project area are summarized in Tables 3.26-1 and 3.26-2. The presentation in the referenced tables focuses on current information for the TAPS ROW area.

3.26.2 Known Cultural Resources

A number of cultural resource surveys and investigations have been conducted within the TAPS corridor (Cook 1970, 1971, 1977; Haggarty et al. 1991; Hall and Gal 1988; Lobdell 1986; Workman 1970, 1972). These surveys, in

TABLE 3.26-1 Prehistoric Context for Areas along the TAPS ROW^a

Zones and Periods	North Slope, MP 0–145	Central Region, MP 145–775	Valdez/Prince William Sound, MP 775–800
Ecozones	<i>Arctic Coastal Plain</i> : nearly level plain underlain by permafrost with tundra vegetation. Arctic Foothills: ridges, mesas, and plateaus underlain by thick permafrost.	<i>Brooks Range Mountains Interior Forest</i> : boreal forest with wide river channels. Alaska Range Mountains, Copper Plateau Mountains, Pacific Coastal Mountains.	<i>Western Hemlock-Sitka Spruce Forest</i> : steep footslopes, outwash plains, floodplains, river terraces, and river deltas.
Periods			
Ethnohistoric	<i>Taremiut and Nunamiut</i> (Post A.D. 1880) Dwellings: khelik (skin tent) and ivrulik (winter moss house).	<i>Gwich'in, Koyukon, Tanana, and Ahtna</i> (Post A.D. 1800) Dwellings: bark-covered huts and skin-covered dome lodges.	<i>Chugach, Alutiiq, Eyak, and Tlingit</i> (Post A.D. 1700) Dwellings: plank houses and semisubterranean houses.
Prehistoric	<i>Birnirk/Thule</i> (A.D. 900-1880) Key material culture elements: toggle harpoon heads, sealing darts, pottery, boats, and sleds. Dwellings: rectangular and semisubterranean houses with entrance tunnels. <i>Arctic Small Tool Tradition</i> (2,000 B.C.-A.D. 1000) Key material culture elements: small stone-end blades, side blades, microblades, bifacial burins, and bifaces. Alt. Designation: Denbigh Flint Complex. Norton Tradition, Choris Tradition, and Ipiuktak Tradition. Dwellings: elliptical and rectilinear houses in latter half of tradition. <i>Northern Archaic Tradition</i> (2,500 B.C.-A.D. 900) Key material culture elements: side-notched projectile points. Settlement: removed from coast. <i>Paleoarctic Tradition</i> (8,500-5,000 B.C.) Key material culture elements: microblade technology. <i>Northern Paleoindian Tradition</i> (10,000-6,800 B.C.) Key material culture elements: lanceolate points.	<i>Athabaskan Tradition</i> (A.D. 1-1800) Key material culture elements: stemmed points and nonlithic artifacts of bone, antler, birch bark, and copper. Dwellings: semisubterranean houses. <i>Late Microblade Complex or Late Denali</i> (1,500 B.C.-A.D. 500) Key material culture elements: microblades and possibly side-notched points. <i>Northern Archaic Tradition</i> (4,000-2,000 B.C.) Key material culture elements: side-notched projectile points and microblade technology. <i>American Paleoarctic Tradition or Denali Complex</i> (10,000-5,000 B.C.) Key material culture elements: microblade technology. <i>Beringian Tradition</i> (13,000-11,000 B.C.) Key material culture elements: microblade technology and wedge-shaped microblade cores.	<i>Chugach Phase</i> (A.D. 1000-1700) Key material culture elements: splitting adzes and stone lamps. Dwellings: plank houses. <i>Palugvik Tradition</i> (400 B.C.-A.D. 1100) Key material culture elements: slate blades, ulu-shaped scrapers, adzes. <i>Uqciuvit Tradition</i> (4,000 B.C.-A.D. 1) Key material culture elements: slate blades. <i>American Paleoarctic Tradition</i> (10,000-4,000 B.C.) Key material culture elements: microblade technology.

^a Compiled from information in Giddings (1967); Baudi (1969); Dumond (1987); Bockstole (1979); Davis et al. (1981); Anderson (1984); Naske and Slotnick (1987); Bowers et al. (1995); TAPS Owners (2001a); West (1996).

TABLE 3.26-2 Alaska Historic Time Line^a

Dates	North Slope	Central Region	Valdez/Prince William Sound
1977	TAPS construction is completed from Prudhoe Bay to Valdez.		
1973	Congress passes the Trans-Alaska Pipeline Authorization Act.		
1968	Oil is discovered in Prudhoe Bay.		
1959	Alaska becomes 49th state.		
1950s	Military buildup occurs during Cold War.		
1939-1943	Military establishes several bases to protect Alaska during World War II.		
1912	Alaska is named a territory.		
1897-1900		Klondike Gold Rush	
1878			First fish canneries are established.
1872-1881	Commercial whaling.	Gold discoveries in southeastern Alaska.	
1868	United States places Alaska under military and Treasury Department control.		
1867	United States purchases Alaska from Russia.		
1853-1865		Mining begins in southern Alaska.	
1847		Fort Yukon is established by Hudson Bay Company.	
1826	First non-Natives sight Point Barrow.		
1824		Russians begin exploring the Interior. Later, missionaries and fur trappers follow the explorers' route.	
1797			First Russian exploration up Copper River occurs.
1795			First Russian Orthodox Church is established on Kodiak Island. ^b
1793			First Russian settlement is established on Prince William Sound.
1784			First Russian settlement is established on Kodiak Island. ^b
1741	Russian Vitus Bering is the first European to reach Alaska, ^c quickly followed by English and Spanish explorers.		

^a Compiled from information presented in Hosley (1981); Van Stone (1984); Saleeby (2000); U.S. Army (1969); Gibson (1976); Grinev (1997); Fairbanks North Star Borough Public Library (2001).

^b West of Valdez/Prince William Sound.

^c East of Valdez/Prince William Sound.

conjunction with other smaller efforts, identified 1,062 cultural properties within 1/2 mi of the TAPS (State Historic Preservation Office [SHPO] 2001). Three archaeological districts and three historic districts also occur within this area. Of the known sites, 3% are located within the pipeline ROW (Table 3.26-3). Twenty-eight percent of known sites are prehistoric or have a prehistoric component, and 71% are historic or fall into the later historic period and other categories (e.g., Cold War, multi-component). Prehistoric sites identified within 1/2 mi of the pipeline include raw material collection sites, hunting camps, campsites, villages, house pits, caches, a caribou drive fence, quarry sites, a pictograph, and a rock shelter (SHPO 2001; TAPS Owners 2001a). Historic sites include Alaska Native traditional land use sites, roadhouses, cabins, homesteads, telegraph line stations, trading posts, cemeteries and individual grave sites, a steamboat, military sites, historic trails, Gold Rush towns, mining sites, dredges, railroad features, aircraft wreckage, and other historical structures.

Details on several archaeological sites in the vicinity of TAPS have been obtained through excavations. The Gallagher Flint Station, located less than 1/2 mi from the TAPS in the North Slope, shows evidence of numerous occupations

and has National Landmark Status (Dixon 1975; Bowers 1983; Ferguson 1997). Other important sites found on the North Slope include the Putu and Bedwell sites (Alexander 1974; Reanier 1995), the Hilltop site (Reanier 1995), the Mosquito Lake site (Cook 1977), and the Aniganigaruk site (Corbin 1971, 1975). Key sites in the Central Region include the Healy Lake site (Cook 1969, 1975; Holmes and Cook 1999), Broken Mammoth site (Yesner 1994), Swan Point site (Holmes et al. 1996), and the Chugwater site (Maitland 1986; Lively 1988). Two sites identified in the Prince William Sound/Valdez area are the Palugvik site and the Uqciuvit site (Yarborough and Yarborough undated). Information from these excavated sites has provided researchers with much of their understanding of prehistoric Alaska along the TAPS, as presented in Table 3.26-1.

Although a relatively large number of archaeological sites have been identified in the vicinity of the TAPS, several key issues remain unresolved. Many of these issues concern the early surveys for cultural resources, including those immediately preceding pipeline construction. The exact areas surveyed and the actual locations of the sites identified in many cases remain unclear (Cook 2001; Potter et al. 2001). In some cases, it appears that sites were

TABLE 3.26-3 Cultural Resources Located along the TAPS^a

Proximity to Pipeline ^b	Total Number of Cultural Resources	Archaeological Sites	Historic Structures and Cemeteries	Eligible for NRHP Listing	Not Eligible for NRHP Listing	Eligibility Not Yet Determined
Within 52 ft of the TAPS	33	27	6	2	2	29
Within 600 ft of the TAPS	274	131	143	7	16	251
Within 1/2 mi of the TAPS	1,062	294	768	97	119	846

^a Excluding traditional cultural properties.

^b The three distances used here represent the width of the ROW (104 ft) on state lands, the maximum distance of a known site that extends under the ROW (600 ft), and the distance considered for sensitive items in Stipulation 2.3.1.1 of the Federal Grant (1/2 mi). Based on current data.

identified but never officially recorded (Breiby 2001; Dale 2001). Also, on the earliest surveys, which covered the bulk of the pipeline corridor, historic archaeological sites often were not recorded (TAPS Owners 2001a). Determination of significance for cultural resources also remains a problem. Thirteen archaeological sites within a 1-mi corridor have been determined eligible for listing on the NRHP, and three archaeological sites have been determined ineligible. However, the eligibility of the remaining 278 known archaeological sites in the corridor remains undetermined. This lack of eligibility determination is an important information gap in evaluating the effects of the proposed action on cultural resources.

Regulations are in place to protect and monitor cultural resources. Stipulation 1.9.1 of the Federal Grant requires surveillance and inspection of the TAPS for archaeological values. Stipulation 1.9.2 states that if any archaeological or historical sites are discovered, APSC must report the information to the Authorized Officer and an archaeologist. Section 106 of the NHPA requires consultation with the SHPO and any affected Tribes as appropriate to ensure the consideration of cultural resources during a federal undertaking (expansion of ROW, development of new material sites, etc.).

To apply the Section 106 requirements more effectively to the complex task of operating and maintaining the TAPS, the BLM, the Alaska SHPO, and the Advisory Council on Historic Preservation are in the process of developing a programmatic agreement for the TAPS. The 21 federally recognized Tribes and the public are being provided an opportunity to comment on the agreement prior to its enactment. This agreement clarifies the procedures for considering cultural resources along the TAPS and formalizes the relationships between the various agencies.

APSC has general procedures to ensure that cultural resources are taken into consideration. Before any activity is started, the APSC “permitted activity initiator” (generally the person in charge of a planned project or activity in the ROW) consults the *Environmental Atlas of the Trans-Alaska Pipeline System* (APSC 1993). The atlas includes information on known cultural

resource site locations. APSC must obtain permits to conduct projects in areas that contain any known cultural resource material. Section 5.5 of APSC Environmental Protection Manual (EN-43-1) states that if any cultural material is discovered during activities relating to the operation or maintenance of the TAPS that work will stop immediately and a Field Environmental Generalist, the Environment Team, or the Land Section in the Fairbanks Business Unit Support Management Group will be contacted (APSC 1998). The Section 106 process is followed for areas inside and outside the ROW.

3.26.3 Traditional Cultural Properties

Information on TCPs, which often include localities that are sacred to a particular indigenous group, frequently is not made available to parties outside the group. Few TCPs are currently listed in the site files of the Alaska SHPO. However, scarcity of such sites in the database does not necessarily indicate that only a few TCPs actually exist. As discussed in Section 4.3.22, procedures will be followed and tribal consultations about areas that might be disturbed will be conducted on a case-by-case basis. Such action will ensure compliance with Section 106 of the NHPA, the American Indian Religious Freedom Act, and Executive Order 13007, which provides Alaska Natives with access to sacred sites on federally held lands.

3.26.4 Historic Structures

Historic structures along the TAPS include roadhouses, mining and related sites, cemeteries, and military buildings. Historic building surveys have been conducted at Fort Greely and Eielson Air Force Base (Denfield 1998; Tetra Tech, Inc. 1999). Ninety historic structures located within a half-mile of the TAPS have been determined eligible for listing on the NRHP. The majority of the eligible properties are military buildings, others include early 20th century roadhouses, cemeteries, and mining-related structures. Two historic districts also have been identified.

One historic structure worth noting is the TAPS itself. The construction of the TAPS occurred following the discovery of large oil deposits in Prudhoe Bay on Alaska's North Slope in 1968. A pipeline was judged as the best method for moving oil from the North Slope to tankers bound for the lower 48 states. Numerous legal controversies involving land rights, Alaska Native rights, and environmental issues delayed pipeline construction. The controversy over whether the pipeline would be constructed ended with passage of the Trans-Alaska Pipeline Authorization Act in November of 1973. Construction of the TAPS began in March 1975, and the pipeline began carrying oil in June 1977. The TAPS consists of 800 mi of pipeline (about

420 mi of which is elevated and the remainder is belowground), 11 pump stations, and the Valdez Marine Terminal, where the oil is transferred to tankers. Pipeline operation has continued uninterrupted since 1977, with only minor shutdowns for repairs.

An historical evaluation of the TAPS has not been conducted. However, because of its place in history as an example of remarkable engineering and construction over a short period of time, its central role in the economy of Alaska, and its contribution to the domestic oil industry, the TAPS infrastructure could be considered potentially eligible for listing on the NRHP.

3.27 Land Uses and Coastal Zone Management

This section discusses current land ownership and land use patterns along the TAPS ROW and coastal zone management activities in the North Slope Borough and Valdez coastal zones.

3.27.1 Land Ownership and Uses

TAPS and its associated facilities are located primarily on federal and state public lands. Land uses along the TAPS corridor include recreational, wildlife habitat and other natural resource conservation, commercial, municipal, residential, agricultural, Native corporations, subsistence activities, and military reservations.

3.27.1.1 Land Ownership

Most of the pipeline and its associated facilities are on public lands. As of November 1999, 47% of the TAPS ROW was on federal lands and 43% was on state lands. Some state lands have been conveyed to municipalities and boroughs with the TAPS ROW reserved (TAPS Owners 2001a). The remaining 10% of the ROW is on private lands owned by Alaska Native corporations (under ANCSA), individual Alaska Natives (under the Alaska Native Allotment Act),

and other private landowners, including the TAPS Owners. Most privately owned parcels are in the Fairbanks, Delta Junction, Copper River Basin, and Valdez areas. In addition, the TAPS Owners have acquired property at PS 1, 8, 9, the Nordale Yard, the North Pole Metering Station, both sides of the Tanana River crossing, the Valdez Marine Terminal, the Fox area (including Engineer Creek), and five other small parcels. With the exception of one parcel currently under negotiation (see below), valid rights-of-way for construction and operation of TAPS exist on all parcels, public or private (TAPS Owners 2001a) (Map 1-2). In addition, the BLM retained administration of the TAPS ROW on all lands conveyed to Alaska Native corporations.

Major changes in land ownership have occurred since the TAPS owners acquired the ROW. Federal lands have been conveyed to ANCSA corporations and to the state, state lands to municipalities and boroughs, and municipal and borough lands to private individuals. All privately owned parcels are subject to perpetual right-of-way agreements acquired by the pipeline owners (TAPS Owners 2001a).

Federal lands have also been conveyed to Native regional corporations, subject to the TAPS ROW. In addition, six Alaska Native allotments within the TAPS ROW have been

Land Ownership and Use along the TAPS ROW

The right-of-way for the TAPS consists of federal (47%), state (43%), and private (10%) land. Private landowners include the TAPS Owners, Alaska Native corporations, individual Alaska Natives, and other private owners.

North of the Yukon River, the area through which the pipeline passes is largely undeveloped, and principal land uses include mining, recreation, wildlife habitat and other natural resource conservation, and subsistence activities. Limited commercial land use occurs at three locations along the Dalton Highway: Yukon River Crossing, Coldfoot, and Deadhorse.

Land use is more varied south of the Yukon River. Although most of the land is not developed, several communities are located along the southern portion of the TAPS. Included are Fairbanks, North Pole, Delta Junction, Glennallen/Copper Center, and Valdez. Three military reservations also occur near the ROW. Commercial enterprises and residential areas exist in the vicinity of these communities, and some agricultural activities occur near the TAPS, particularly near Delta Junction.

conveyed to individual owners pursuant to the Alaska Native Allotment Act. The pipeline owners have acquired easements for the TAPS ROW across all parcels except one, which is currently under negotiation (Hansen 2002).

3.27.1.2 Land Uses

The vast majority of land along the TAPS ROW from the Yukon River north to Prudhoe Bay is undeveloped. Mining, recreation, wildlife habitat and other natural resource conservation, and subsistence are the primary land uses. A number of conservation system units have been designated and are discussed in Section 3.27.1.3. Commercial facilities that provide food, lodging, fuel, and vehicle repair services are clustered at three development nodes along the Dalton Highway: Yukon River Crossing, Coldfoot, and Deadhorse (BLM 1991; Dalton Highway Advisory and Planning Board 1998).

Although most recreational activities are permissible on state and federal lands, restrictions exist along the Dalton Highway. AS 19.40.210 prohibits the use of off-road vehicles (ORVs) within 5 mi of the Dalton Highway right-of way (Dalton Highway Advisory and Planning Board 1998). AS 16.05.789 prohibits hunting with firearms within 5 mi of either side of the highway between the Yukon River and the Arctic Ocean (Alaska Legal Resource Center 2001).

South of the Yukon River, land use is more varied, although most land remains undeveloped and recreation remains a major land use. Several cities and communities with outlying residential development exist along the southern half of the pipeline: Fairbanks, North Pole, Delta Junction, Glennallen/Copper Center, and Valdez. Some agriculture occurs on private lands in the vicinity of the TAPS, particularly near Delta Junction. Scattered commercial logging and wood harvesting for personal use occur on BLM lands and state lands (Mushovic 2001; Mylius 2001). Lands owned by native corporations and allottees are used primarily for subsistence activities (Hansen 2001), although subsistence activities also occur on public lands.

Three military reservations exist along the ROW. Fort Wainwright and Eielson Air Force Base (AFB) are south and east of Fairbanks, respectively; and Fort Greely is southwest and southeast of Delta Junction (TAPS Owners 2001a). The pipeline crosses all three reservations (USACE 2002).

Although historical land use conflicts due to TAPS have been few and temporary along the vast majority of the pipeline's length, some access and use conflicts have occurred (and are continuing) on Native lands owned by the Ahtna and Chugach Corporations along the southern half of the pipeline. The Ahtna Corporation, which owns land south of Paxson, has experienced trespassing on their land that they believe is due to pipeline-related access near a heavily-used snowmachine and ORV use area (Hart 2002). The Chugach Corporation, which owns the land in the Valdez area, is concerned that the existence of TAPS on their land precludes other uses (Rogers 2002). APSC's access policy is discussed in Section 3.28.1.

State-leased airports are located near or within the TAPS corridor and adjacent to the Dalton Highway at Prospect Creek, Coldfoot, Dietrich Camp, Chandalar Camp, and Galbraith Lake. In addition, APSC owns an airport at 5-Mile Camp near the Yukon River. The public is allowed to use that field by permission. Other airstrips under state or private maintenance also exist along the ROW (BLM 1989a; TAPS Owners 2001a).

The federal TAPS ROW is generally 54 ft wide and the state ROW is about 100 ft wide. Both expand to incorporate TAPS-related facilities, including pump stations, river training structures, communication sites, and a fuel gas line. Other structures include an airstrip, construction camps, access roads, material sites, disposal sites, and other specific-use sites. Although the ROW is a nonexclusive use on public lands, other uses must be compatible (TAPS Owners 2001a).

A number of federal, state, and local land use plans are in effect along the 800-mi TAPS corridor. Federal land use plans include the Utility Corridor Proposed Resource Management

Plan, the Dalton Highway Recreation Area Management Plan, the Southcentral Planning Area Management Framework Plan, the Delta and Gulkana Wild and Scenic River Management Plans, and the Fort Greely Resource Management Plan. State land use plans include the Dalton Highway Master Plan and the Copper River Basin, Tanana Basin, and Prince William Sound Area Plans for state lands. Existing local land use plans are the North Slope Borough Comprehensive Plan, the North Star Borough Comprehensive Plan, and the Valdez Comprehensive Plan. In addition, coastal management program enforceable policies are in effect for the North Slope Borough and Valdez coastal zones (see Section 3.27.2).

3.27.1.3 Special Land Uses

Several conservation system units have been designated in the vicinity of the TAPS. They include national parks; national wildlife refuges; a federally designated wilderness area; BLM lands, including a national recreation area (NRA); and state lands, including recreation sites, areas, and parks. North of the Yukon River, BLM lands near the ROW include ACECs, which were established to identify and manage BLM lands requiring special management to protect historical, cultural, scenic, fish, and wildlife resources; other natural systems and processes; and human life and property from natural hazards. The conservation system units (including the ACECs) are depicted in Map 3.27-1 and listed in Table 3.27-1.

3.27.2 Coastal Zone Management

Activities in Alaskan coastal zones are regulated by federal and state legislation. The Federal Coastal Zone Management Act (CZMA) was enacted in 1972 and was last amended in 2001. The Alaska Coastal Management Act (ACMA) was enacted in 1977 and was last amended in 1994. It provides for coastal zone management in Alaska as envisioned in the national CZMA. Both statutes guide land use in coastal zones to provide a balance between development and protection of coastal resources (BLM and MMS 1998; State of Alaska 2001).

The Alaska Coastal Management Program (ACMP), approved in 1979, was developed to implement the ACMA. The ACMP encourages coastal districts to develop and adopt district coastal management programs (CMPs) that become part of the ACMP once they are fully approved. CMPs include enforceable policies, and all activities that occur within a coastal zone or that may affect coastal resources must be consistent with an approved CMP. Activities must also be consistent with applicable statewide ACMP standards. The Alaska Department of Governmental Coordination (DGC) and State of Alaska resource agencies conduct consistency reviews on proposed and existing projects within coastal zones (BLM and MMS 1998; State of Alaska 2001).

Coastal Zone Management and the TAPS

In coastal areas of Alaska, development activities are subject to both federal and state laws designed to maintain a balance between development and coastal resource protection. The ACMP also encourages coastal districts to establish coastal management programs. Both the northern and southern ends of the TAPS pass through coastal management zones.

At the northern end, about 110 mi of the pipeline and associated facilities are in the North Slope Borough Coastal Zone. At the southern end, about 25 mi of the pipeline and associated facilities, including the Valdez Marine Terminal, are in the Valdez Coastal Zone. The pipeline and associated activities are subject to provisions established for those zones, as well as applicable statewide ACMP standards.

The TAPS begins in the North Slope Borough Coastal Zone, which includes about 110 mi of the pipeline and related structures, including PS 1 (Map 3.27-2). The pipeline ends in the Valdez Coastal Zone, which encompasses about 25 mi of the pipeline and the Valdez Marine Terminal (Map 3.27-3). Both coastal zones have fully approved CMPs that include enforceable policies. The North Slope Borough CMP requires that development activities not substantially interfere with subsistence activities

or jeopardize subsistence resources in the borough. Most development activities in the North Slope Borough are related to hydrocarbon exploration, development, and transportation. Subsistence activities include hunting and fishing, and subsistence resources include both terrestrial wildlife and fisheries. The Valdez CMP allows for a variety of development activities but prioritizes approval of activities that

are water-related and/or water-dependent. Existing activities include utility corridors, industrial and commercial facilities, and public recreation and tourism. The operation and maintenance of the TAPS and related facilities have been found to be consistent with the North Slope Borough and Valdez CMPs (Laughlin 2002; North Slope Borough 1988; Valdez 1987).

TABLE 3.27-1 Conservation System Units in the Vicinity of TAPS

Pipeline Milepost	Name of Unit ^{a,b}	Approximate Distance ^c and Direction from TAPS
122-140	Toolik Lake ACEC/Research Natural Area	Crossed by pipeline
136-145	Galbraith Lake ACEC	About 1 mi east
139-162	Arctic National Wildlife Refuge	¼ mi east
139-266	Gates of the Arctic National Park	2-3 mi west
156-163	West Fork Atigun ACEC	3 mi west
190-200	Snowden Mountain ACEC	1 mi east
207-211	Sukakpak Mountain ACEC	½ mi east
216-221	Nugget Creek ACEC	1 mi west
238-355	Yukon Flats National Wildlife Refuge	2 mi east
257-274	Jim River ACEC	2-3 mi east
302-309	Kanuti National Wildlife Refuge	8 mi west
429-515	Tanana Valley State Forest	About 2 mi east
420-429	White Mountains National Recreation Area	1-3 mi east
438	Lower Chatanika State Recreation Area	3 mi east
465-470	Chena River State Recreation Site	2 ½ - 3 mi east
495-496	Harding Lake State Recreation Area	8 mi west
491	Salcha River State Recreation Site	8 mi west
525-531	Quartz Lake State Recreation Area	1 mi east
531	Big Delta State Historic Park	½ mi west
540	Delta State Recreation Site	2 mi west
569	Donnelly Creek State Recreation Site	½ mi west
577-602	Delta Wild and Scenic River	1 mile west
602-613	Fielding Lake State Recreation Site	1 ½ mi south
682	Dry Creek State Recreation Site	1 mi east
630-654	Gulkana Wild and Scenic River	Crossed by pipeline
674-710	Wrangell St. Elias National Park and Preserve	2-5 mi east
719	Squirrel Creek State Recreation Site	1 mi east
771-773	Worthington Glacier State Recreation Site	Crossed by pipeline
775	Blueberry Lake State Recreation Site	2 mi southeast
NA	Sawmill Bay State Marine Park	18 mi southwest
NA	Shoup Bay State Marine Park	8 mi southwest
NA	Jack Bay State Marine Park	15 mi southeast
VMT	Chugach National Forest	¼ mi southwest

^a Units are listed geographically from north to south.

^b Notation: ACEC = Area of Critical Environmental Concern; VMT = Valdez Marine Terminal.

^c Distance from the closest boundary of the unit to the TAPS.

Sources: APSC (1993); ADNR (2001).

3.28 Recreation, Wilderness, and Aesthetics

Recreation, wilderness, and aesthetics are important resources near the TAPS ROW corridor. Recreational activities are abundant and popular on the public lands in the vicinity of the TAPS. The third largest federally designated Wilderness Area in the United States is within a few miles of the pipeline and offers unique opportunities for solitude. The aesthetics along the majority of the pipeline are outstanding.

3.28.1 Recreation

A variety of recreational opportunities exist on the public lands in the vicinity of the 800-mi ROW corridor. Some common activities include hiking, sightseeing, car-camping, backpacking, bow hunting, trapping, sport fishing, river floating, kayaking, canoeing, wildlife viewing, berry picking, dog mushing, snowmachining, skiing, and mountain biking. Recreational areas near the pipeline include national parks; national wildlife refuges; national Wild and Scenic Rivers; a federally designated Wilderness Area; BLM lands, including a national recreation area; and state lands, including a state forest and state recreation sites, areas, and parks. These conservation system units are depicted in Map 3.27-1 and listed in Table 3.27-1 (in Section 3.27.1 - Land Use). Access is via roads, overland travel by foot or animal, waterways, and air (TAPS Owners 2001a; BLM 1989a).

Recreational areas north of Fairbanks in the vicinity of the TAPS include Gates of the Arctic National Park and Preserve (NPP), which encompasses a 7.2-million-acre Wilderness Area – the only federally designated wilderness within a few miles of the pipeline (Ulvi 2001). Three national wildlife refuges (NWRs) are also located within several miles of the northern half of the TAPS – the Arctic NWR (over 19 million acres), Yukon Flats NWR (13.2 million acres), and Kanuti NWR (1.6 million acres) (Patterson 2001). BLM lands are adjacent to, or within a few miles of, the ROW and are largely undeveloped. The BLM-managed White Mountains National Recreation Area (NRA) is a one-million-acre semiprimitive area within 1 mi of the TAPS accessible via the Elliott and Steese Highways (Goodwin 2002). State lands within a few miles

of the pipeline also have minimal recreational development.

Primary road access to recreational areas in the northern vicinity of the pipeline is via the 416-mi all-weather graveled Dalton Highway. The Dalton Highway, formerly called the Haul Road, was constructed in 1974 to support construction of the TAPS. Initially, the highway was closed to the public; however, the state gradually allowed increased access to the north. In 1995, the highway was opened to Deadhorse (TAPS Owners 2001a).

Recreational Opportunities along the TAPS

Numerous recreational opportunities exist on the state and federal public lands near the TAPS. Common activities include hiking, sightseeing, car-camping, backpacking, bow hunting, sport fishing, river floating, kayaking, canoeing, wildlife viewing, dog mushing, snowmachining, skiing, and mountain biking. Federal lands include National Parks, National Wildlife Refuges, a federally designated Wilderness Area, two National Wild and Scenic Rivers, and BLM lands. State recreation sites, areas, and parks are also plentiful near the southern half of the TAPS.

BLM visitor data show that increased public access to the Dalton Highway has resulted in increased recreational use of areas along the highway near the ROW. Most use occurs between May and September. Sightseeing and car-camping are the primary activities along the highway. Visitation is by privately owned vehicles and tour buses. In 2001, 67% of visitors arrived by privately owned vehicles (BLM 1989a, 2001c).

The BLM compiles visitation statistics for three development nodes along the Dalton Highway: Coldfoot Visitor Center, Marion Creek Campground, and Yukon Crossing Contact Station. Statistics compiled at these points from 1991 to 2001 show that visitation along the Dalton Highway has increased steadily during the past decade. At Coldfoot Visitor Center, the

number of visitors has increased from 3,107 in 1991 to 4,629 in 2001. At Marion Creek Campground, 480 user nights were counted in 1994 (the first year for which data were compiled); by 2001, the number of user nights rose to 826. At the Yukon Crossing Contact Station, visitor statistics have been compiled since 1992. In that year, the number of visitors was 2,246; in 2001, 8,767 persons visited this point (BLM 2001c).

Although increased recreation has occurred along the Dalton Highway, the BLM estimates that the majority of visitors never leave the highway right-of-way. Very few secondary roads are available off the Dalton Highway for recreationists who desire remote access. Some abandoned mining roads do exist, such as one that leads close to the southeastern boundary of Gates of the Arctic NPP. However, no roads lead directly to the park – or the Wilderness Area within it – and no roads lead to any of the national wildlife refuges near the ROW. Consequently, recreationists who desire access to these remote recreation areas commonly park their vehicles along the Dalton Highway and then travel by foot, dogsled, snowmachine, horse, or all-terrain vehicle (ATV). Entrance by floating, boating, or kayaking on waterways is also common. However, small aircraft are most often used for remote access, and the construction of several small airports along the TAPS ROW has

enhanced this method of access (see Section 3.27.1) (BLM 1989a; Delaney 2001a; TAPS Owners 2001a).

Because of the remoteness of the area and the extremely limited road access available, recreational use in areas north of the Yukon River along the Dalton Highway is widely dispersed. Qualitative assessments by federal and state public land managers indicate that recreational areas in the northern vicinity of the TAPS are minimally used and have experienced very little increase in recreational use in the last 25 years. However, quantitative recreational data are very limited. Such data are not available for Gates of the Arctic NPP, including the wilderness area within it, or for any of the NWRs. Very limited use estimates are available for some state lands. Limited data are available from the BLM (and presented herein) (Delaney 2001a; Edgerton 2001; Huer 2001; Mylius 2001; Panarese 2002; Schultz 2001; Ulvi 2001).

Recreational areas south of Fairbanks in the vicinity of the TAPS that are accessed via the Richardson Highway include Wrangell-St. Elias NPP. The park boundary ranges from 2 to 5 mi from the TAPS at its closest points; however, the majority of the park is substantially farther from the pipeline. No documented increase in recreational use has occurred since the construction of the TAPS (Snitzler 2001).

Recreation Opportunity Spectrum (ROS) Classes

To optimize the management of recreational resources on the public lands it administers, the BLM has developed recreational opportunity spectrum (ROS) classes with accompanying management zones and objectives. Recreation resources on BLM lands along the Dalton Highway are categorized into the following ROS classes, which have not changed in the last 25 years (BLM 1989a, 1991):

- *Roaded natural*: Resource modification harmonizes with the natural environment; opportunities for motorized and nonmotorized recreation; equal opportunities for interaction with others and for isolation from the sights and sounds of man; low to moderate concentration of users; rustic visitor facilities.
- *Roaded modified*: Significant modification of the landscape; both motorized and nonmotorized recreation possible; little opportunity for isolation; visitor facilities may or may not be available.
- *Rural*: Substantially modified natural environment; little opportunity for isolation with human sights and sounds readily evident; moderate to high concentrations of users; readily available facilities, sites, and trails.

Another recreation area near the southern half of the pipeline is within the Chugach National Forest (NF). A small (several hundred acre) area of the NF juts north to within about 2 mi of the Valdez Marine Terminal. The vast majority of the Chugach NF is several miles from the Valdez Marine Terminal and the pipeline, and no change in recreational use levels or opportunities have been noted by the U.S. Forest Service (USFS) in the last 25 years (Behrends 2002). No other national forests are in the vicinity of the pipeline.

The remaining recreation areas near the TAPS and south of Fairbanks are administered by the BLM or the ADNR. The BLM lands are largely undeveloped and include two Wild and Scenic Rivers (WSRs) and a few campgrounds and boat launching sites, all of which have experienced an increase in use since the construction of the pipeline (see below). Lands administered by the ADNR are discussed in more detail below and include a number of campgrounds. Quantitative data on use levels are estimates only and are limited for these state lands; however, a general increase in recreational use has been noted in the past 25 years (Panarese 2002).

The BLM uses ROS classes to manage recreation areas along the southern half of the pipeline, just as it does along the northern half of the TAPS. Three ROS classes have been in effect along the Richardson Highway since the mid-1970s (Overbaugh 2001):

- *Roaded natural*: see text box on previous page.
- *Semi-primitive motorized*: Essentially unmodified environment; some opportunity for isolation from human sights and sounds; low concentrations of users; limited facilities.
- *Semi-primitive nonmotorized*: Essentially unmodified environment; some opportunity for isolation from the sights and sounds of man; low user concentrations; limited facilities; motorized use is limited to airplanes.

In 1980, segments of the Delta and Gulkana Rivers within or adjacent to the TAPS corridor were designated as components of the National

Wild and Scenic Rivers System pursuant to the Wild and Scenic Rivers Act of 1968 (BLM 1983a,b). Section 1281 of the Act mandates that each component of the "... system... be administered... to protect and enhance the values which caused it to be included" in the system (16 USC §1281(a)). The Act also mandates that WSRs be managed by the federal agency administering the land the river flows through – in this case, the BLM.

Three levels of designation are possible under the Act – wild, scenic, and recreational – and river segments must be managed according to their classification. Wild rivers must remain free of impoundments and generally accessible only by trail, with primitive watersheds or shorelines and unpolluted waters. Scenic rivers must also remain free of impoundments with largely primitive watersheds and undeveloped shorelines; however, some road access may exist. Recreational rivers may have had some impoundments or diversions in the past, are readily accessible by road or railroad, and may have some development along shorelines.

The Wild and Scenic Rivers Act of 1968

"It is hereby declared to be the policy of the United States that certain selected rivers of the Nation which, with their immediate environments, possess outstanding remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations..."

The Delta National WSR has all three levels of classification (Map 3.28-1) and was designated to protect its outstanding scenery and natural and cultural values. Twenty miles of the river are classified as wild, 18 mi as recreational and 24 mi as scenic. The Delta National WSR corridor is also protected. It contains about 37,000 acres and excludes most of the TAPS ROW corridor. However, a portion of the WSR corridor boundary overlies the ROW between MP 577 and 596. The Delta is

designated as recreational within this segment, and the pipeline is mostly below ground. At MP 596, the TAPS veers east and exits the boundary of the Delta River WSR corridor (BLM 1983a; TAPS Owners 2001a).

Recreational opportunities on and along the Delta River include rafting, kayaking, canoeing, powerboating, fishing, hunting, wildlife viewing, and nature photography (BLM 1983a; TAPS Owners 2001a). Recreational use of the Delta River has increased steadily since 1970, with river floating especially popular. The BLM counted 300 user days of river floating on the Delta in 1970 and 1,555 in 1998 (BLM 1983a, 1998b). In addition to the recreation occurring on the river, the BLM estimates that thousands of people use the area around the Delta River for other recreational activities, such as berry picking, plant collecting, scenic viewing, nature study, and ORV use (BLM 1983a, 1998b).

About 181 mi of three forks of the Gulkana National Wild River were designated as a wild river because of its "primitive character, abundant fish and wildlife, and geologic, cultural and recreational values" (Map 3.28-2) (BLM 1983b). The protected river corridor contains about 91,000 acres (BLM 1993). The corridor boundary overlies the ROW between MP 653 and 655 (TAPS Owners 2001a).

The Gulkana River provides excellent opportunities for white-water rafting (floating) and kayaking, wildlife viewing, fishing, and solitude (BLM 1983b). Two popular put-in and take-out points for river floating are within 0.5 to 2 mi of the ROW – Paxson Lake Campground at MP 629 and Sourdough Campground at MP 654 (APSC 1993; BLM 1983b). Sourdough Campground is also a popular put-in point for powerboat users. The TAPS crosses the Gulkana River on an overhead bridge upstream of Sourdough Campground (BLM 1983b).

Recreational use of the Gulkana National Wild River and adjacent areas has been increasing. About 5,480 people floated or powerboated on the Gulkana in 1999, compared with 3,600 in 1981 (BLM 1983b; Whittaker et al. 2000). In addition, the number of visitors to Paxson Lake Campground increased from 7,667 in 1975 to 14,526 in 1993. Visitation to

Sourdough Campground also increased, from 12,998 in 1975 to 20,000 in 1993 (BLM 1993).

Recreational opportunities on state land along the pipeline are plentiful and similar to the types of opportunities available on federal land. The ADNR maintains numerous state recreational areas and sites along the pipeline from just north of Fairbanks south to the City of Valdez, where several state marine parks are located. A variety of recreational opportunities are also available at Tanana Valley State Forest, which extends in noncontiguous segments from about Fairbanks to Delta Junction, primarily east of the TAPS (ADNR 2002).

Recreational opportunities in and around Valdez included viewing marine and terrestrial wildlife, ocean cruises, sea kayaking, nature photography, hunting, sport fishing, camping, backpacking, glacier viewing, boating, and back-country skiing. In addition to recreational opportunities available on state land, a number of commercial recreational guides and tour companies operate in the Valdez area (ADNR 2001; TAPS Owners 2001a).

The primary access for recreation areas south of Fairbanks is via the paved Richardson Highway. Secondary roads are also uncommon along the Richardson Highway near the southern half of the pipeline, just as they are north of Fairbanks. However, some recreational areas, such as Wrangell-St. Elias NPP, are accessible by unimproved road. The methods used for remote access in the north are also common in the south (BLM 1991; TAPS Owners 2001a).

Prior to September 11, 2001, recreation along the entire 800-mi length of the pipeline included visits to TAPS facilities, which have been a major tourist attraction in Alaska since their construction. In 1996, about 200,000 persons visited established APSC visitor sites, such as visitor centers, pump stations, and the Valdez Marine Terminal. Nine viewing stations that provide information on the history and engineering of the pipeline have been readily accessible from the Alaska highway system (TAPS Owners 2001a). In addition, recreational use of the ROW was allowed for such activities as hiking, jogging, mountain biking, and snowmachining. These activities were considered generally compatible with safe

pipeline operations and were accommodated under APSC's pre-September 11 access policy, summarized below (TAPS Owners 2001a):

- The rights of the landowners, both public and private, owning the property under the TAPS ROW must be respected.
- Perpendicular pipeline crossings with vehicles under 1,500 lb gross vehicle weight or with nonvehicular, low-impact modes of transportation may proceed without APSC permission.
- Linear use of small portions (generally under 1 mi) of the pipeline workpad or of the numerous TAPS access roads can proceed via any mode of transportation after obtaining a letter of nonobjection from APSC and permission from the pertinent landowner.
- Depending on TAPS work activities and seasonal conditions, the workpad is closed at times to all traffic, including APSC and its contractors. Blocking the APSC access road is not allowed under any circumstances.
- Hunting, trapping, or shooting across, from, or on the pipeline right-of-way is not allowed.

Since the events of September 11, 2001, APSC has heightened security measures and changed their access policy. Non-business-related public tours have been discontinued indefinitely at PS 9, the Valdez Marine Terminal, and the SERVS. In addition, the viewing station across from PS 12 will be closed during 2002 and all signs will be removed (Stearns 2002).

Access to the ROW has also been restricted since October 1, 2001, when the JPO directed APSC to lock all access road gates. This closure is in effect at least until November 2002, although it could be extended beyond that date. Recreational use of the ROW has been discontinued since September 11, 2001, and will remain discontinued indefinitely (Stearns 2002).

3.28.2 Wilderness

No federal or state designated or proposed Wilderness Areas exist within or adjacent to the

ROW corridor (ADNR 2001; APSC 1993; Delaney 2001b). The only federally designated Wilderness Area within a few miles of the TAPS is within Gates of the Arctic NPP. The eastern boundary of the Wilderness Area is within 2 to 3 mi of the TAPS at its closest point (Ulvi 2001).

Although the Wilderness Act of 1964 prohibits the use of motorized vehicles in federally designated Wilderness Areas, the ANILCA of 1980 exempts wilderness in Alaska from that prohibition. Specifically, ANILCA states that snowmachines, motorboats, and airplanes are permitted for traditional activities and travel to and from homes and villages.

Most of Gates of the Arctic NPP is wilderness — about 7.2 million acres — making it the third largest Wilderness Area in the United States. Recreational opportunities are similar to other areas in the vicinity of the TAPS, with increased opportunities for solitude. Only a minor increase in the amount of recreational use in the eastern portion of the Wilderness Area (near the TAPS) has occurred in the past 25 years (Ulvi 2001).

The Wilderness Act of 1964

Federal wilderness, as defined by the Wilderness Act of 1964, is "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. ...an area of underdeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed...to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value" (16 USC §1131(c)).

3.28.3 Aesthetics (Visual Resources)

Visual resources are defined as the land, water, vegetation, animals, and structures that are visible on the land. The ROW passes through areas that contain outstanding visual resources, many of which are listed in Table 3.28-1. These areas include the vast treeless tundra of the Arctic Coastal Plain, the mountains of the Brooks and Alaska Ranges, the Delta and Gulkana Wild and Scenic Rivers, and the coastal region of Prince William Sound. Other visual features along the ROW include the pipeline and its associated facilities; the cities of Fairbanks, North Pole, Delta Junction, and Valdez; and the communities of Glennallen and Copper Center (TAPS Owners 2001a).

With the exception of the TAPS and parallel roads, most of the area is pristine and natural, particularly north of the Yukon River. South of the Yukon, man's impacts are localized, with the pipeline, highways, and population centers near or adjacent to each other. Along the entire pipeline corridor, most background views are untouched by human activity (BLM and USACE 1988).

Scenic views are an important resource in Alaska. According to Alaska's Outdoor Recreation Plan, sightseeing is a very popular activity among residents and is the most popular recreation activity of visitors to Alaska (BLM and MMS 1998). The BLM rates sightseeing as a primary activity along the Dalton Highway (BLM 1989a).

All portions of the ROW corridor that pass through BLM-administered land are managed in accordance with Class IV visual resource management objectives, except for small portions of the Wild and Scenic River corridors (see below). Consequently, major modifications to the existing landscape are allowed for activities related to energy transportation. However, every effort is made to minimize visual impacts (BLM 1989a; Overbaugh 2001). Stipulations in the Federal Grant also minimize visual impacts (see below).

Special attention is given to protect visual resources on BLM land designated as ACECs (Section 3.27). The Galbraith Lake, Sukakpak

Visual Resource Management (VRM) Classes

The BLM uses a visual resource management (VRM) system to classify visual resources according to scenic quality, visual sensitivity, and distance zones. The VRM classification determines the management objectives for the area. Four VRM management class objectives exist (BLM 2001d):

- *Class I Objective:* Preserve the existing character of the landscape by allowing only a very low level of change that must not attract attention.
- *Class II Objective:* Retain the existing character of the landscape and allow a low level of change.
- *Class III Objective:* Partially retain the existing character of the landscape with a moderate level of change.
- *Class IV Objective:* Provide for management activities that require major modification of the existing character of the landscape by allowing a high level of change.

Mountain, and Jim River ACECS all contain outstanding scenery (Table 3.27-1) (BLM 1989a). In addition, the Delta National WSR corridor is a VRM Class I, as is the Gulkana National Wild River corridor. Both corridors include a small portion of the ROW corridor (Maps 3.28-1 and 3.28-2). The management objective within these corridors is to preserve the existing character of the landscape (BLM 1989a; Liska 2001).

Viewing TAPS facilities is also a major tourist attraction. In 1996, about 200,000 persons visited established APSC visitor sites, such as visitor centers, pump stations, and the Valdez Marine Terminal. Nine viewing stations that provide information on the history and engineering of the pipeline are readily accessible from the Alaska highway system. The highest visitor counts occur at the Steese Highway site near Fox and PS 12 at milepost 64 of the Richardson Highway (TAPS Owners 2001a).

TABLE 3.28-1 Visual Resources, Viewpoints, and Overlooks along the TAPS ROW Corridor^a

Milepost	Description
5	Former Dalton Highway checkpoint to Prudhoe Bay: Prudhoe facilities visible on the horizon
15-36	Franklin Bluffs
64	Overlook of the Coastal Plain
73	Overlook of Sagwon Bluffs
106	View of highway, gas line, and PS 3 to the north
112	View of highway, gas line, and PS 3 to the north
118	Overlook of Slope Mountain
125	Special big game crossing of the pipeline
129	Potential BLM overlook of Toolik Lake
136-144	Views of Atigun River, Galbraith Lake, PS 4, and pipeline
139-175	Galbraith Lake, overlooks of Atigun and Chandalar valleys
176	Potential BLM overlook of the Chandalar Shelf
197	Potential BLM overlook of A/Loon ponds
207-211	Sukapak Mountain
245	Atigun Pass (Brooks Range)
246	Panoramic view of the Middle Fork Koyukuk River Valley
247	BLM Cathedral Lake overlook
253	Overlook of Chapman Lake
262	Grayling Lake
278	Gobblers Knob; view of Prospect Creek/Jim River drainage, and PS 5
306	Potential BLM Olson's Lake overlook
311	Wayside and overlook facility
312	Finger Rock
319	Viewpoint of pipeline
323	Potential BLM overlook of Yukon Flats
339	Overlook of Ray River and Ray Mountains
347	Overlook of Dalton Highway, pipeline, Yukon, and PS 6
353-354	View of the pipeline crossing of Yukon River
388	Overlook of Erickson Creek and pipeline
417	Globe Creek and Grapefruit Rocks viewpoint
420	Pipeline viewpoint
448	Pipeline viewpoint
531	Viewpoint of pipeline crossing Tanana River
550	Viewpoint of PS 9
562	Viewpoint of pipeline and the Alaska Range
577-602	Delta Wild and Scenic River
578	View of Black Rapids Glacier and Delta River
584	Viewpoint of PS 10
588	Viewpoint of special designs for fault crossings
599	Photo point of pipeline
607	View of Gulkana Glacier and summit of Isabel Pass
614	Viewpoint of Summit Lake and pipeline
625	Overlook of Paxson Lake
630-654	Gulkana Wild and Scenic River
642-645	Overlooks from highway on Hogan Hill west and south

TABLE 3.28-1 (Cont.)

Milepost	Description
687	Overlook of Copper River and Wrangell Mountains
711	Overlook of pipeline, APSC interpretation signs
770	Photo site for Worthington Glacier National Natural Landmark
774-776	Thompson Pass
780-785	Keystone Canyon, historic railroad tunnel, Bridal Veil Falls, and Horsetail Falls

^a Representative list only.

Source: TAPS Owners (2001a).

About half the 800-mi length of the TAPS is above ground and clearly visible from the air. The majority of the aboveground components also are visible from adjacent public roads, including where the pipeline is suspended above the Tanana and Gulkana Rivers.

Temporary visual impacts have occasionally occurred during tank-vent flaring at PS 1 (TAPS Owners 2001a). The incomplete combustion of fuel results in the release of carbon particles to the atmosphere, causing opacity (a cloud that blurs or partially obscures the landscape, including scenic views).

The potential visual impacts of the TAPS were considered in the design, and stipulations were included in both the federal and state ROW agreements. Stipulation 2.10.1 in the Federal Grant mandates that “permittees...consider aesthetic values in planning, construction and operation of the Pipeline System. Where the Right-of-Way crosses a State highway in forested terrain, the straight length of the Pipeline Right-of-Way visible from the highway shall not exceed six hundred (600) feet in length, unless otherwise approved in writing by the Authorized Officer. The Authorized Officer may impose such other requirements as he deems necessary to protect aesthetic values.”

3.29 Environmental Justice

On February 11, 1994, President Clinton issued Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (59 FR 7629). This Executive Order, along with its accompanying cover memo, calls on federal agencies to incorporate environmental justice considerations as part of their missions. It directs them to address, as appropriate, the disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations. The cover memo specifically mentions the NEPA twice, providing opportunities to incorporate environmental justice as part of the NEPA process. In addition, Section 4-4 of Executive Order 12898 identifies subsistence issues as a particular concern for environmental justice populations, since these populations frequently rely on food that they grow, hunt, collect, or otherwise obtain through noncommercial means.

In response to Executive Order 12898, both the Council on Environmental Quality (CEQ) and the EPA developed general guidelines for the evaluation of environmental justice under NEPA (CEQ 1997; EPA 1998). The CEQ guidelines provide an overview of Executive Order 12898 with respect to NEPA; in particular, they discuss environmental justice in terms of specific phases of the NEPA process. The EPA guidelines provide information similar to the CEQ guidelines but in greater detail, in an effort to establish guidance for EPA staff to use both in preparing environmental impact assessments and in evaluating such assessments prepared by other agencies. The EPA guidelines also discuss effects in particular impact areas, including ecological, human health, and socioeconomic analyses. The evaluation of environmental justice in this EIS is consistent with these two sets of guidelines, both in terms of integrating environmental justice within the NEPA process and complying with the spirit or intention of the executive order.

Both the CEQ and EPA guidelines discuss the use of spatial representation and analysis of data pertinent to environmental justice and focus specifically on geographic information system

Environmental Justice

Environmental justice is defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including a racial, ethnic, or socioeconomic group, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies (EPA 1998).

Environmental justice was officially identified by Executive Order 12898 in 1994 as an issue that all federal agencies must consider.

The attention to environmental justice is intended to ensure that all communities and persons in the United States can live in safe, healthful environments.

The approach used in environmental impact analysis is to examine impacts to the general population as well as to minority and low-income populations, both to identify high and adverse impacts and to determine whether the two subgroups experience negative impacts differently than does the population as a whole.

technology (CEQ 1997; EPA 1998). However, different analytical settings demand guidelines designed to address the specific issues encountered in each – particularly in terms of defining affected areas and pertinent geographic units of analysis. The referenced guidelines lack the type of specific direction necessary for this or any other EIS. In lieu of clearer CEQ and EPA guidance, the following analysis has defined minority and low-income populations for two different spatial units: (1) individual *census block groups* across the entire state of Alaska and (2) 45 *communities* that may experience impacts as the result of continued operation of the TAPS. The latter are defined in part by using the BLM

approach to identifying directly affected communities (BLM 2001a), and in part on their geographic proximity to the TAPS (see Map 3.24-1).

A block group is the second smallest geographic unit used by the U.S. Bureau of the Census for data presentation (U.S. Bureau of the Census 1991, 2001a). Consisting of clusters of census blocks containing 250 to 550 housing units (the ideal being about 400 units), block groups tend to provide a level of geographic detail useful for identifying environmental justice populations. Moreover, because the analysis of human health impacts also considers population distributed by block groups (see Section 3.17.2), using these geographic units provides consistency among areas of particular concern for environmental justice issues within this FEIS.

Ultimately, the evaluation of environmental justice in environmental impact analyses relies on consequences in other issue areas, each of which may affect a different geographic area. To guarantee coordination with several other disciplines considered in this document, the geographic area examined for environmental justice concerns at the block group level comprises the entire State of Alaska. Examining such a large area enables coordination with the evaluation of economic impacts, which in many cases affect the entire state. The examination of selected census block groups enables a more geographically focused analysis close to the TAPS and geographically commensurate with analyses of other issue areas.

Considering environmental justice issues at the level of individual communities supports an evaluation that focuses on directly affected places. Many of these communities are largely inhabited by Alaska Natives, and as is discussed in Section 3.25, were selected because of the likelihood that they would experience impacts from the continued operation of the TAPS. Moreover, the examination of impacts on sociocultural systems and subsistence largely focuses on the 45 directly affected communities, thus bringing the evaluation of environmental justice impacts in line with analyses in these two other closely related impact areas.

3.29.1 Minority Populations

This FEIS used data from the 2000 census to evaluate the environmental justice implications of both the proposed action and the no-action alternative. The CEQ guidelines recommend that “minority” be defined as members of American Indian or Alaska Native, Asian or Pacific Islander, Black non-Hispanic, and Hispanic populations (CEQ 1997). The earliest release of detailed 2000 census data that included information necessary to identify minority populations enumerated individuals both according to race and Hispanic origin (U.S. Bureau of the Census 2001a). It also reported individuals claiming multiple racial identities, up to six races. For consistency with the CEQ guidelines, in this document the term “minority populations” includes persons who identified themselves as partially or totally Black (including Black or Negro, African American, Afro-American, Black Puerto Rican, Jamaican, Nigerian, West Indian, or Haitian), American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, or “Other Race.” All individuals claiming more than one race similarly were considered minority. The minority category also includes “White” individuals who are Hispanic in origin, the latter technically an ethnic category. To avoid double-counting, tabulations included only White Hispanics; the above racial groups already account for non-White Hispanics. In sum, then, the minority population considered under environmental justice consists of all non-White persons (including those of multiple racial affiliations) plus White persons of Hispanic origin.

Minority Populations

Minority populations are identified on the basis of U.S. Bureau of the Census racial and (selected) ethnic categories:

- Racial: Black, American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, “Other Race,” or multiple races.
- Ethnic: White Hispanic (non-White Hispanics covered under racial categories).

To identify *disproportionately high* minority populations, this FEIS uses the percentage of minorities for the state of Alaska as a reference point. Block groups or communities with minority populations in excess of the percentage for the state as a whole thus are identified as disproportionately high with respect to their minority composition. Using the entire state to identify disproportionality acknowledges both the unique minority situation in Alaska compared with other states (with a comparatively high population of indigenous people), as well as the geographic extent of the TAPS, which crosses the entire state north to south. In 2000, 32.4% of the state population was minority, on the basis of the criteria outlined above (U.S. Bureau of the Census 2001b). Of the 533 block groups defined for Alaska in 2000, 218 had minority populations in excess of 32.4% – a total of 133,772 minority persons in all (Map 3.29-1). Of the 29 block groups intersected by or adjacent to the TAPS, 7 contained populations in excess of 32.4% minority, a total of 2,702 minority persons. Nineteen of the 45 communities likely to experience effects from continued operation of the TAPS contained minority populations in excess of 32.4% of their total inhabitants (Table 3.29-1).

3.29.2 Low-Income Populations

As recommended by the CEQ guidelines, this environmental justice analysis identifies low-income populations as those falling below the statistical poverty level identified annually by the U.S. Bureau of the Census in its Series P-60 on income and poverty. The Census Bureau defines poverty levels on the basis of a statistical threshold that considers for each family both overall family size and the number of related children less than 18 years old. For example, the poverty threshold annual income for a family of three with one related child under 18 was \$13,410, while the poverty threshold for a family of five with one related child under 18 years was \$21,024 in 1999 (U.S. Bureau of the Census 2000). The 2000 census used 1999 thresholds

Low-Income Populations

Low-income populations are defined on the basis of U.S. Bureau of the Census income criteria, as discussed in Series P-60 publications. The poverty line is defined on the basis of a combination of income, family size, and number of family members younger than 18 years – the income threshold thus varying by family composition. Each census relies on income data from the previous year, so the 1990 census relied on income data from 1989.

because 1999 was the most recent year for which annual income data were available when the census was conducted. If a family fell below the poverty line for its particular composition, the census considered all individuals in that family to be below the poverty line.

To identify census block groups with *disproportionately high* presence of low-income populations, this FEIS used the percentage of low-income persons living in the state of Alaska as a reference point. The rationale for using state-level statistics to define disproportionality low-income populations was that the TAPS crosses the entire state and, as a result, requires reference to an equally broad range of economic settings. In 1999, 9.4% of the state population was low-income, as defined on the basis of the criteria outlined above (U.S. Bureau of the Census 1992). Of the 533 block groups defined for Alaska in 2000, 286 had low-income populations in excess of 9.4% – a total of 37,134 low-income persons in all (Map 3.29-2). Of the 29 block groups defined in the 2000 census that are intersected by the TAPS, 11 contained populations in excess of 9.4% low-income, a total of 1,057 low-income persons.

Low-income statistics for the 45 directly affected communities considered in this document are also summarized in Table 3.29-1. Twenty-five of the 45 contained low-income populations in excess of 9.4% (low-income data were unavailable for two of the communities).

TABLE 3.29-1 Minority and Low-Income Percentages for the State of Alaska, 29 Block Groups Intersecting the TAPS, and 45 Communities Likely To Be Affected Directly by Continued TAPS Operation, 2000

Area	Total Population	Percentage Minority	Percentage Native ^a	Percentage Low Income ^b
State of Alaska	626,932	32.4	15.6	9.4
Alatna	35	97.1	94.3	9.1
Allakaket	97	95.9	95.9	12.9
Anaktuvuk Pass	282	90.4	88.3	4.4
Big Delta	749	4.5	1.5	30.0
Chenega	86	77.9	73.3	15.6
Chitina	123	48.8	33.3	12.7
Coldfoot	13	— ^c	—	—
College	11,402	22.2	8.9	8.2
Copper Center	362	51.9	46.7	18.8
Copperville	179	22.9	14.0	7.1
Cordova	2,454	28.9	10.4	7.5
Deadhorse	—	—	—	NA ^d
Delta Junction	840	8.6	4.0	19.4
Ester	1,680	12.6	4.6	8.1
Evansville	28	53.6	50.0	4.3
Eyak	168	10.7	1.2	NA ^d
Fairbanks	30,224	33.3	9.9	10.5
Fox	300	12.3	8.0	8.7
Gakona	215	24.7	12.1	10.8
Glennallen	554	14.8	5.1	8.0
Gulkana	88	73.9	71.6	40.7
Harding-Birch Lakes	216	6.5	—	—
Hughes	78	89.7	78.2	28.0
Kenny Lake	410	17.3	10.2	25.9
Livengood	29	17.2	6.9	15.4
Manley Hot Springs	72	26.4	23.6	9.7
Minto	258	92.3	91.9	26.4
Moose Creek	542	11.6	2.2	9.4
Nanwalek	177	93.2	89.3	17.5
North Pole	1,570	19.0	3.6	8.7
Nuiqsut	433	89.8	88.2	2.4
Paxson	43	—	—	—
Pleasant Valley	623	12.0	4.8	7.0
Port Graham	171	88.9	84.8	18.8
Prudhoe Bay	5	80.0	20.0	—
Rampart	45	93.3	88.9	17.9

TABLE 3.29-1 (Cont.)

Area	Total Population	Percentage Minority	Percentage Native (2000) ^a	Percentage Low Income (1990) ^b
Salcha	854	12.2	3.9	3.9
Stevens Village	87	96.6	95.4	61.2
Tanana	308	82.1	79.9	23.0
Tatitlek	107	86.0	84.2	24.2
Tazlina	149	30.9	24.8	8.1
Tonsina	92	15.2	9.8	6.7
Two Rivers	482	11.4	2.7	—
Valdez	4,036	16.4	7.2	6.2
Wiseman	21	19.0	19.0	10.5

^a "Native" includes Alaska Natives and Native Americans, the former presumed to contribute most, if not all, to the total Native population in each geographic unit reported in the table. Percentages do not include individuals identifying themselves as mixed-heritage Native (who would appear under "Percentage Minority".)

^b Although low-income data come from the 2000 census, low-income data are for 1999.

^c A dash indicates 0.0 or a percentage that rounds to 0.0.

^d NA = data not available.

Sources: Table compiled from U.S. Bureau of the Census (2001c-d, 2002) data.

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TABLE 3.24-1 Subsistence Resource Pounds Harvested per Capita in Directly Affected and Other Selected Rural Communities, Selected Recorded Year^a

Subsistence Resource	Alatna ^b	Allakaket ^c	Anaktuvuk Pass	Chenega Bay	Chitina	Copper Center	Cordova	Evansville	Gakona	Glennallen	Gulkana	Hughes	Kenny Lake	Manley Hot Spgs	Minto	Nanwalek	Nuiqsut	Paxson	Port Graham	Rampart	Stevens Village ^b	Tanana	Tatitlek	Tazlina	Tonsina
Reference year	'98	'82	'93	'93	'82	'87	'97	'82	'87	'87	'87	'82	'87	ND ^d	'84	'97	'93	'87	'97	'93	'84	'87	'97	'87	'87
All Resources	153	906	219	275	191	174	179	260	95	99	153	1,492	136	ND	1,015	254	742	289	253	ND	1,139 ^e	2,157 ^f	406	107	156
Marine mammal	- ^g	-	-	35	-	-	4	-	-	-	-	-	-	-	-	24	236	-	9	-	-	-	165	-	-
Polar bear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-
Porpoise	-	-	-	0	-	-	0	-	-	-	-	-	-	-	-	0	-	-	0	-	-	-	4	-	-
Seal	-	-	-	25	-	-	0	-	-	-	-	-	-	-	-	18	23	-	9	-	-	-	116	-	-
Sea otter	-	-	-	0	-	-	4	-	-	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-	-
Steller sea lion	-	-	-	10	-	-	0	-	-	-	-	-	-	-	-	6	-	-	0	-	-	-	46	-	-
Walrus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-
Whale	-	-	-	0	-	-	0	-	-	-	-	-	-	-	-	0	213	-	0	-	-	-	0	-	-
Large land mammal	153	118	-	18	43	58	52	134	48	43	45	212	47	-	90	12	242	139	1	-	73	141	46	42	74
Bison	-	-	-	-	0	0	0	-	0	0	0	-	0	-	-	-	-	14	-	-	-	-	-	3	0
Black bear	-	9	-	1	0	0	1	6	0	0	1	11	5	-	15	4	-	0	1	-	19	11	0	1	3
Brown bear	-	-	-	0	0	0	1	3	0	0	0	0	0	-	-	0	2	0	0	-	0	3	0	1	0
Caribou	53	5	219	2	6	26	1	28	22	18	15	0	17	-	-	0	228	33	0	-	-	11	0	15	33
Dall sheep	-	2	-	0	0	2	0	3	3	1	0	0	0	-	-	0	0	8	0	-	-	-	0	0	2
Deer	-	-	-	15	0	0	25	-	0	0	0	-	2	-	-	0	-	0	0	-	-	-	41	0	0
Elk	-	-	-	0	-	-	2	-	-	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-	-
Goat	-	-	-	0	0	1	1	-	0	0	0	-	0	-	-	0	-	0	0	-	-	-	5	0	0
Moose	100	102	-	0	37	28	21	96	22	23	30	201	23	-	76	8	12	84	0	-	54	116	0	23	37
Muskox	-	-	-	-	-	0	-	-	0	0	0	-	0	-	-	-	0	0	-	-	-	-	-	0	0
Small land mammal	-	24	-	0	9	1	2	9	1	1	8	16	1	-	31	0	0	25	0	-	21	39	0	2	1
Beaver	-	0	-	0	0	0	0	2	0	0	2	11	0	-	22	0	-	22	0	-	2	33	0	0	0
Coyote	-	-	-	0	0	0	0	0	0	0	0	-	0	-	-	0	-	0	0	-	-	-	0	0	0
Fox	-	15	-	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	-	0	0	0	0	0
Hare	-	9	-	0	7	0	2	7	1	1	2	6	1	-	6	0	-	1	0	-	5	5	0	1	1
Land otter	-	-	-	0	0	0	0	0	0	0	0	0	0	-	0	0	-	0	0	-	0	0	0	0	0
Lynx	-	-	-	0	2	0	0	0	0	0	0	0	0	-	0	0	-	0	0	-	3	0	0	0	0
Marmot	-	-	-	-	0	0	0	-	0	0	0	-	0	-	-	0	0	0	0	-	-	-	0	0	0
Marten	-	-	-	0	0	0	0	0	0	0	0	0	0	-	0	0	-	0	0	-	0	0	0	0	0
Mink	-	-	-	0	0	0	0	-	0	0	0	-	0	-	0	0	0	0	0	-	0	0	0	0	0
Muskrat	-	-	-	0	0	0	0	0	0	0	4	0	0	-	2	0	-	0	0	-	11	0	0	0	0
Porcupine	-	-	-	0	0	0	0	-	0	0	0	-	0	-	1	0	-	2	0	-	0	0	0	1	0
Squirrel	-	-	-	0	0	0	0	-	0	0	0	-	0	-	-	0	0	0	0	-	-	-	0	0	0
Weasel	-	-	-	0	0	0	0	-	0	0	0	-	0	-	0	0	0	0	0	-	-	-	0	0	0
Wolf	-	-	-	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	-	0	0	0	0	0
Wolverine	-	-	-	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	-	0	0	0	0	0

TABLE 3.24-1 (Cont.)

Subsistence Resource	Alatna ^b	Allakaket ^c	Anaktuvuk Pass	Chenega Bay	Chitina	Copper Center	Cordova	Evansville	Gakona	Glennallen	Gulkana	Hughes	Kenny Lake	Manley Hot Spgs	Minto	Nanwalek	Nuiqsut	Paxson	Port Graham	Rampart	Stevens Village ^b	Tanana	Tatitlek	Tazlina	Tonsina
Fish	-	732	-	198	124	110	105	107	41	54	95	1,234	83	-	860	199	251	107	220	-	1,023	1,958	159	56	73
Salmon	-	554	-	109	116	104	63	66	29	41	86	1,162	67	-	687	158	3	45	144	-	922	1,600	93	38	65
Non-salmon	-	177	-	89	8	7	43	42	12	13	19	72	16	-	174	42	248	63	76	-	102	358	66	18	8
Marine invert.	-	-	-	14	-	-	6	-	0	0	0	-	0	-	-	9	-	0	13	-	-	-	19	1	1
Bird and egg	-	25	-	1	2	1	2	2	2	0	1	24	2	-	26	4	12	15	1	-	20	16	10	1	2
Crane	-	-	-	0	-	0	0	-	0	0	0	-	0	-	-	0	-	3	1	-	1	0	1	0	0
Duck	-	9	-	1	1	0	1	1	0	0	1	9	0	-	11	2	3	7	0	-	7	3	4	0	0
Goose	-	14	-	0	0	0	0	1	0	0	0	14	0	-	13	0	6	0	0	-	9	7	1	0	0
Seabird and loon	-	-	-	0	-	-	0	-	-	0	-	-	-	-	-	0	-	-	0	-	-	-	0	-	-
Shorebird	-	-	-	0	-	-	0	-	-	0	-	-	-	-	-	0	-	-	0	-	-	-	0	-	-
Swan	-	-	-	-	-	0	0	-	0	0	0	-	0	-	-	0	0	0	0	-	-	-	0	-	0
Upland bird	-	1	-	0	1	1	1	0	2	0	0	1	2	-	2	0	2	5	0	-	2	6	0	1	2
Bird egg	-	-	-	-	-	-	0	-	-	0	-	-	0	-	-	1	-	0	0	-	-	-	5	-	0

a When data were available for more than one year, figures shown are those for “representative year” (if designed).

b No representative year designated.

c Data presented represent “Allakaket/Alatna.” Data may not equal sums for major categories, due to rounding error.

d “ND” = no data available.

e More than half of the fish harvested was used to feed sled dogs.

f As much as 75% of the chum and coho harvested was used to feed sled dogs.

g A dash indicates no data presented, which could mean that they were not applicable, applicable but zero, or not collected; “0” indicates that zero was reported.

Source: ADF&G (2001b).

TABLE 3.24-2 Percent Households in Directly Affected and Other Selected Rural Communities Participating in Subsistence Harvest, Selected Recorded Year^a

Subsistence Resource	Alatna ^b	Allakaket ^{c,d}	Anaktuvuk Pass	Chenega Bay	Chitina	Copper Center	Cordova	Evansville ^d	Gakona	Glennallen	Gulkana	Hughes ^d	Kenny Lake	Manley Hot Spgs	Minto	Nanwalek	Nuiqsut	Paxson	Port Graham	Rampart	Stevens Village ^b	Tanana	Tatitlek	Tazlina	Tonsina
Reference year	'98	'82	'93	'93	'82	'87	'97	'82	'87	'87	'87	'82	'87	ND ^e	'84	'97	'93	'87	'97	ND	'84	'87	'97	'87	'87
All Resources	70	NA	43	96	87	100	90	NA	86	92	90	NA	100	ND	96	100	90	93	98	ND	100	92	88	69	92
Marine mammal	-	-	-	44	-	-	5	-	-	-	-	-	-	-	-	35	37	-	27	-	-	-	50	-	-
Polar bear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Porpoise	-	-	-	0	-	-	0	-	-	-	-	-	-	-	-	0	-	-	0	-	-	-	13	-	-
Seal	-	-	-	9	-	-	4	-	-	-	-	-	-	-	-	7	-	-	11	-	-	-	19	-	-
Sea otter	-	-	-	39	-	-	4	-	-	-	-	-	-	-	-	35	36	-	21	-	-	-	50	-	-
Steller sea lion	-	-	-	26	-	-	0	-	-	-	-	-	-	-	-	7	-	-	0	-	-	-	19	-	-
Walrus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-
Whale	-	-	-	0	-	-	0	-	-	-	-	-	-	-	-	0	5	-	0	-	-	-	0	-	-
Large land mammal	70	-	-	48	13	52	47	-	62	39	35	-	61	-	53	14	74	50	5	-	47	54	63	29	69
Bison	-	-	-	-	0	0	0	-	0	0	0	-	0	-	-	-	-	7	-	-	-	-	-	2	0
Black bear	0	37	-	9	0	0	5	5	0	3	5	53	11	-	20	14	-	0	5	-	40	14	0	4	4
Brown bear	-	0	-	0	0	0	2	0	1	0	0	0	0	-	-	0	8	0	0	-	7	2	0	1	1
Caribou	60	6	43	4	9	48	1	5	45	33	30	0	37	-	-	0	74	43	0	-	-	12	0	22	64
Dall sheep	-	11	-	0	0	5	1	5	16	2	0	0	0	-	-	0	0	29	0	-	-	-	0	2	11
Deer	-	-	-	48	0	0	41	-	0	1	0	-	11	-	-	0	-	0	0	-	-	-	63	0	2
Elk	-	-	-	0	-	-	2	-	-	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-	-
Goat	-	-	-	0	0	5	4	-	0	0	0	-	0	-	-	0	-	0	0	-	-	-	19	0	1
Moose	30	77	-	0	13	19	11	35	14	14	20	79	17	-	40	7	10	43	0	-	20	35	0	14	25
Muskox	-	-	-	-	-	0	-	-	0	0	0	-	0	-	-	-	0	0	-	-	-	-	0	0	0
Small land mammal	-	-	-	13	52	27	27	-	46	8	50	-	28	-	84	7	42	57	7	-	73	41	13	23	40
Beaver	-	66	-	0	0	1	3	0	3	2	10	63	2	-	36	0	-	36	0	-	13	13	0	1	10
Coyote	-	-	-	0	13	1	3	0	10	1	5	-	13	-	-	0	-	14	0	-	-	-	0	6	1
Fox	-	34	-	0	0	6	0	0	20	1	5	53	8	-	22	0	26	29	0	-	30	12	0	7	6
Hare	-	80	-	0	48	7	22	0	26	6	30	90	19	-	60	0	-	29	0	-	57	33	0	15	23
Land otter	-	6	-	9	0	0	4	0	1	0	5	11	0	-	11	3	-	21	0	-	3	3	0	2	2
Lynx	-	54	-	0	9	0	0	30	0	0	5	53	0	-	7	0	-	0	0	-	27	9	13	0	0
Marmot	-	-	-	-	0	0	0	-	0	0	0	-	0	-	-	0	0	0	0	-	-	-	0	0	1
Marten	-	80	-	0	13	5	5	25	29	3	10	84	8	-	47	0	-	36	0	-	47	21	0	4	8
Mink	-	-	-	0	13	0	4	-	10	0	5	-	5	-	13	0	0	7	0	-	10	6	0	1	2
Muskrat	-	31	-	0	0	0	2	15	9	1	10	42	0	-	40	0	-	14	0	-	53	5	0	1	1
Porcupine	-	-	-	4	-	19	1	-	0	0	20	-	0	-	18	3	-	14	0	-	10	4	0	10	11
Squirrel	0	0	-	-	0	1	2	-	7	0	0	-	2	-	-	3	16	0	7	-	-	-	0	2	0
Weasel	-	-	-	0	4	6	2	-	13	2	5	-	8	-	9	7	3	14	2	-	-	-	0	1	2
Wolf	-	6	-	0	4	0	0	0	3	0	5	0	3	-	2	0	11	7	0	-	0	4	0	2	4
Wolverine	-	11	-	0	4	0	1	15	1	0	5	21	3	-	-	0	16	0	0	-	3	3	0	0	1

TABLE 3.24-2 (Cont.)

Subsistence Resource	Alatna ^b	Allakaket ^{c,d}	Anaktuvuk Pass	Chenega Bay	Chitina	Copper Center	Cordova	Evansville ^d	Gakona	Glennallen	Gulkana	Hughes ^d	Kenny Lake	Manley Hot Spgs	Minto	Nanwalek	Nuiqsut	Paxson	Port Graham	Rampart	Stevens Village ^b	Tanana	Tatitlek	Tazlina	Tonsina
Fish	-	-	-	78	65	78	75	-	70	71	90	-	89	-	89	100	81	79	91	-	83	77	75	63	83
Salmon	-	60	-	70	48	68	66	24	58	60	60	68	57	-	78	100	36	43	86	-	73	67	69	38	64
Non-salmon	-	71	-	57	57	58	59	62	58	42	70	84	83	-	73	90	79	79	64	-	80	64	63	15	67
Marine invert.	-	-	-	74	-	0	29	-	10	1	0	-	0	-	-	79	-	0	75	-	-	-	63	12	2
Bird and egg	-	-	-	44	39	34	30	-	52	21	20	-	44	-	84	45	76	71	25	-	90	86	69	40	43
Crane	-	-	-	0	-	5	2	-	0	0	0	-	0	-	-	3	-	14	0	-	13	3	19	2	0
Duck	-	80	-	26	9	6	23	15	9	3	10	79	5	-	82	31	39	43	21	-	70	37	44	7	10
Goose	-	77	-	9	0	5	6	10	0	0	5	74	0	-	64	0	73	14		-	73	45	31	2	1.4
Seabird and loon	-	-	-	0	-	-	0	-	-	-	-	-	-	-	-	14	-	-		-	-	-	0	-	-
Shorebird	-	-	-	0	-	-	3	-	-	-	-	-	-	-	-	0	-	-		-	-	-	0	-	-
Swan	-	-	-	-	-	0	0	-	0	0	0	-	0	-	-	0	8	0		-	-	-	0	0	0
Upland bird	-	46	-	26	39	34	23	25	52	19	20	68	44	-	73	17	45	71		-	77	77	13	38	42
Bird egg	-	-	-	-	-	-	2	-	-	0	-	-	0	-	-	31	-	0		-	-	-	56	-	0

^a When data were available for more than one year, figures shown are those for “representative year” (if designated).

^b No representative year designated.

^c Data presented represent “Allakaket/Alatna.”

^d In cases where original data did not include household participation figures for the categories shown in this table but include figures for subcategories, the largest figure in a subcategory was used to show household participation.

^e ND = no data available.

^f A dash indicates no data presented, which could mean that they were not applicable but zero, or not collected; “0” indicates that zero was reported.