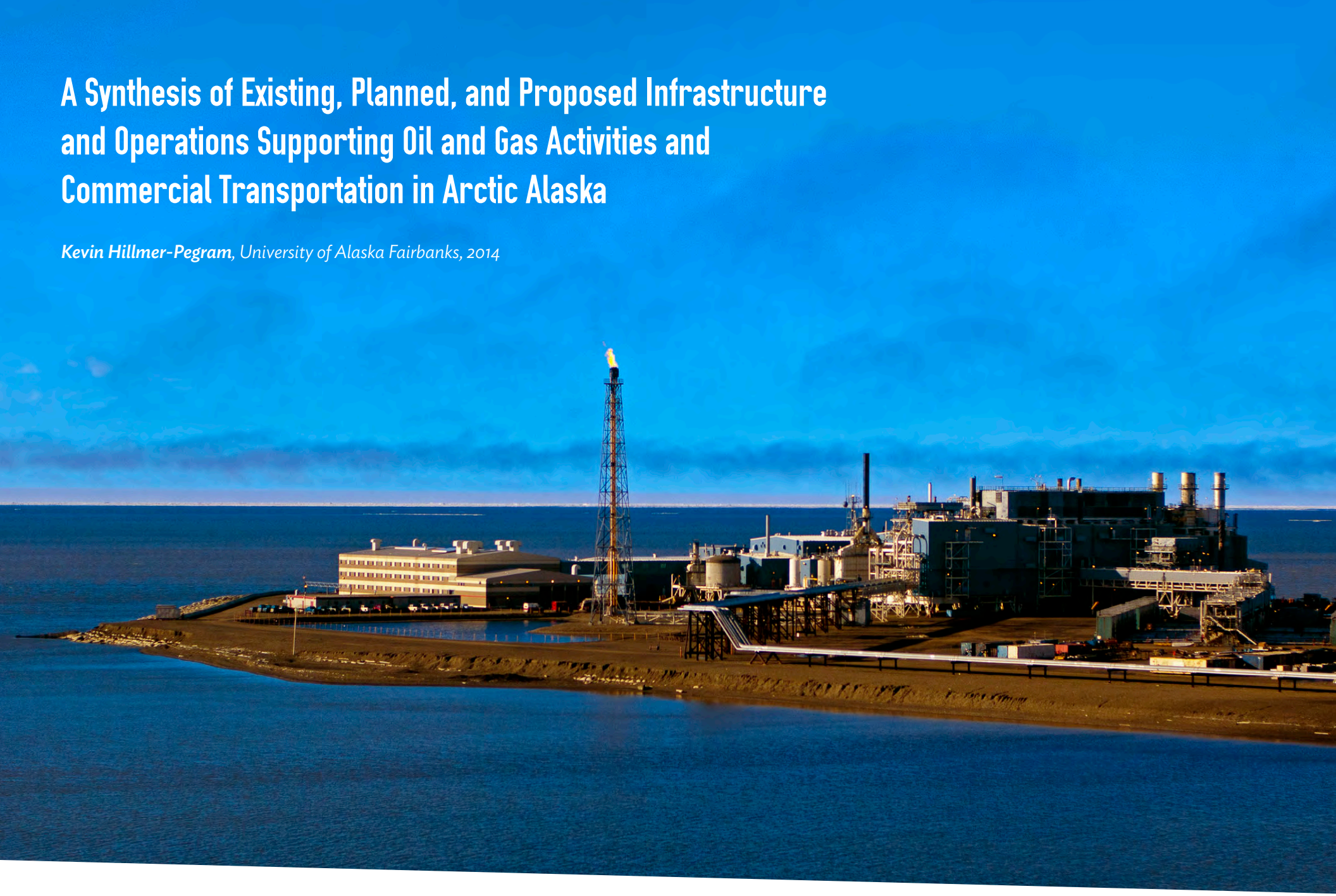
A Synthesis of Existing, Planned, and Proposed Infrastructure and Operations Supporting Oil and Gas Activities and Commercial Transportation in Arctic Alaska

***Kevin Hillmer-Pegram**, University of Alaska Fairbanks, 2014*



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On the cover: ***Lisburne Production Center****. ©Paul Andrew Lawrence, http://www.paulcolor.com.*

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Author Affiliation

Kevin Hillmer-Pegram is an Interdisciplinary PhD candidate at the University of Alaska Fairbanks. He is in the Resilience and Adaptation Program and housed in the Political Science Department.

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ADNR: Alaska Department of Natural Resources

ADOT&PF: Alaska Department of Transportation and Public Facilities

AIDEA: Alaska Industrial Development and Export Authority

ANCSA: Alaska Native Claims Settlement Act

ANWR: Arctic National Wildlife Refuge

AOGCC: Alaska Oil and Gas Conservation Commission

BLM: Bureau of Land Management

BOEM: Bureau of Ocean and Energy Management

BPXA: BP Exploration Alaska

BSEE: Bureau of Safety and Environmental Enforcement

DMTS: DeLong Mountain Transportation System

FIAP: Final Integrated Activity Plan

MMS: Minerals Management Service

NOAA: National Oceanic and Atmospheric Administration

NPR-A: National Petroleum Reserve - Alaska

NRC: National Research Council

OCS: Outer Continental Shelf

TAPS: Trans-Alaska Pipeline System

R2R: Road to Resources Initiative

US: United States of America

USACE: United States Army Corps of Engineers

USCG: United States Coast Guard

USFWS: United States Fish and Wildlife Service

USGS: United States Geological Survey

1. Introduction

1.1 Background and purpose of this report

This report builds on the National Research Council's (NRC) 2003 study entitled *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope* [1]. The authors of that study identify the need for information that can contribute to comprehensive planning of oil and gas activities in the region. Comprehensive planning, in their view, considers the effects of oil and gas activities cumulatively over the entire region, over long-range time frames, and from the perspectives of regional residents and other stakeholders. However, the NRC authors point out that, "Permitting decisions [for oil and gas activities] generally have been made one case at a time without a comprehensive plan to identify the scope, intensity, direction, or consequences of industrial activities that are judged appropriate and desirable [1, pg. 241]." When non-comprehensive planning occurs, the ecological and social consequences of a given development project—on other areas of Arctic Alaska and over time—can remain hidden from pre-development analysis.

Since the NRC report was published, efforts have been made to address the need for comprehensive planning, such as increasing participation of regional residents in planning and more effectively analyzing cumulative impacts in environmental assessments. Despite these efforts, however, the need for a more comprehensive and integrated approach to planning has been widely recognized. For example, a recent report to the United States (US) President calls for use of "integrated Arctic management," which is characterized as:

> *... a science-based, whole-of-government approach to stewardship and planning ... that integrates and balances environmental, economic, and cultural needs and objectives. It is an adaptive, stakeholder-informed means for looking holistically at impacts and sensitivities across the US Arctic and generating sustainable solutions [2, pg. 3].*

Unfortunately, there is a still a shortage of regional-level studies that present information about oil and gas development and other types of industrial activities in a usable manner for a wide audience of stakeholders and in support of an integrated approach to planning and management.

This report is designed to fill that gap by integrating a variety of data that have not been previously assembled. More specifically, the purpose of this report is to synthesize information about existing, planned, and proposed infrastructure and operations that support oil and gas exploration and production and commercial transportation over the whole of Arctic Alaska, compiling a region-wide vision of these industrial activities that has not previously existed.

This report is intended as a factual and unbiased reference for the wide range of stakeholders interested in such industrial activities. Chapters 4 through 9 summarize information related to specific geographic sub-regions of Arctic Alaska. Each chapter is preceded by a map of the geographic sub-region discussed in subsequent pages. These maps serve as vital visual companions to the report's text and tables. Chapter 10 provides a region-wide synthesis. The map accompanying Chapter 10 depicts infrastructure and commercial transportation for all of Arctic Alaska. Taken as a whole, the report provides readers with an overview of the history, current conditions, and potential future extent of industrial infrastructure in Arctic Alaska. The information in this report is scheduled to be used as background material for oil and gas and commercial transportation issues in two scenario building efforts in Arctic Alaska.[1]

1.2 Geographic scope

Different sources use multiple definitions of the word "Arctic." The Arctic Circle is bounded by the line of latitude at 66°33′ north and defines the region in which the sun is above the horizon in the summer and below the horizon in the winter for a period of 24 hours. However, other definitions of the term are more flexible and are based on the spatial extent of specific temperature ranges, the northern tree line, the presence of permafrost, or the boundary of sea ice coverage. For the purposes of this report, the term "Arctic Alaska" is used to denote a specific region of the state and of the state and federal waters that lie primarily within the Arctic Circle, but that also extend southward along the west coast of Alaska to Norton Sound, and inland in the northwest region of the state (Map 1 depicts Arctic Alaska divided into six sub-regions). Industrial activities that occur outside Arctic Alaska are beyond this report's scope.

The definition or Arctic Alaska used here is similar to the definitions used by international and national scientific entities, such as the Arctic Council Arctic Monitoring and Assessment Program and the US Arctic Research Commission.[2] Because Alaska constitutes the entire geographic extent of the US in the Arctic, Arctic Alaska has also been referred to as the US Arctic [2].

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1 *Scenario building is one approach to comprehensive planning that is rapidly gaining acceptance among a variety of stakeholders. The two scenario-building efforts are the* Northern Alaska Scenarios Project *(http://www.iarc.uaf.edu/en/NX2020/current-projects/NASP/) and the* North Slope Science Initiative Scenarios Project *(https://accap.uaf.edu/?q=Scenario_planning_NSSI). In very general terms, scenario building is a process whereby participants explore multiple plausible futures with the aid of a facilitator to help their communities and organizations prosper in the rapidly changing world. While there is a large and growing literature on scenario building as a tool for adapting to complex change, one particularly insightful book is James A. Ogilvy's* Facing the Fold: Essays on Scenario Planning.

2 *For other definitions of Arctic Alaska, see http://www.amap.no/about/geographical-coverage and http://www.arctic.gov/maps.html.*

1.3 Regional overview: ecosystems, humans, Arctic change, and the need for comprehensive planning

In terms of the natural environment, Arctic Alaska is made up of multiple ecoregions that are "large areas of land and waters containing vegetation communities that share species and ecological dynamics, environmental conditions, and interactions [3, pg. 26]." Ecoregions in Arctic Alaska range from Polar Arctic Tundra in the far north to Subarctic Tundra in the coastal west to Boreal Forest in the interior areas of the region. The marine ecosystems of the Beaufort Sea, Chukchi Sea, and Bering Strait are also part of Arctic Alaska. These regional ecosystems are in relatively pristine condition compared to many other parts of the world, partly because human activities in the Arctic have been historically restricted by harsh environmental conditions.

In addition to unique plant and animal species, Arctic Alaska is the homeland of multiple Alaska Native groups. According to the Alaska Native Language Center at the University of Alaska Fairbanks, these groups include speakers of the Koyukon, Tanana, and Gwich'in languages in the interior areas of the region, speakers of Inupiaq in the coastal and northern areas, and speakers of two types of Yupik in the Bering Strait area [4]. The 2013 US Census estimates that the four census areas fully or partially within Arctic Alaska are home to over 30,000 people and the Alaska Native portion of the four areas' populations ranges between 53% and 80% [5].

Many residents of Arctic Alaska are closely linked to regional ecosystems through their subsistence based life ways, whereby they draw at least a portion of their living directly from local landscapes and seascapes. The 2013 report to US President[3] explains that:

> *Reliance on subsistence approaches—hunting, fishing, and gathering of plants—is widespread in the US Arctic. Subsistence harvesting is not simply about calories and nutrition; it is culturally significant for Alaska Natives and other rural residents [2, pg. 14].*

In addition to the resources acquired through subsistence activities, many residents of Arctic Alaska also depend on the regional commercial economy for financial resources. Industrialized natural resource extraction, mainly for out-of-state markets, is the main source of activity for Arctic Alaska's commercial economy. The report cited above explains:

> *Revenue, employment, and personal income from ... industrial activities can improve the quality of life for local residents and support the ability of state and local governments to provide public services to communities [2, pg. 15].*

Striking a sustainable balance between subsistence-based life-ways and the commercial economy has been identified as a key goal for future comprehensive planning in Arctic Alaska [2]. However, regional stakeholders can have differing opinions about how to achieve a sustainable balance and how to define that term. Six key stakeholder categories have been identified in Arctic Alaska [2] (Table 1.1); within these categories, stakeholder opinions "reveal examples of both convergent and divergent views [2, pg. 34]," about what the future of the region should look like.

3 *The 2013 report cited here is authored by a US federal interagency working group. Many stakeholders in Arctic Alaska do not consider the US federal government to speak for them or represent their interests. The report is cited here, however, because it presents the views of many diverse regional stakeholders.*

Table 1.1. Stakeholders in Arctic Alaska

Stakeholder	*Additional information*
Tribal Governments and Alaska Native Organizations	Alaska Native interests are represented by: (1) tribal governments that operate within individual communities and regionally, (2) tribally authorized groups, and (3) Alaska Native Corporations established under the Alaska Native Claims Settlement Act
Industrial and Commercial Stakeholders	These include representatives from the following industries: oil and gas, renewable energy, mining, shipping, commercial fisheries, and tourism
State of Alaska	The Alaska Statehood Act of 1958 granted the state approximately 104 million acres of land, ownership of the submerged lands of navigable waterways and submerged lands up to 3 miles offshore under the Submerged Lands Act
Municipal Governments	These include cities, villages, and boroughs; they represent communities that are usually considered to be remote from large population centers
Conservation Organizations	These include non-governmental conservation and environmental organizations
Federal Government	More than 20 federal agencies play a role in management and research in Arctic Alaska

Arctic Alaska stakeholders are planning for the future and making decisions about how to promote regional sustainability in an atmosphere marked by rapid Arctic change, both environmentally and socially. [4] The 2013 report to the US President provides a succinct summary of Arctic change:

> *The US Arctic is experiencing rapid, sustained change, and those changes are expected to continue into the coming decades due to climate change, resource extraction, and increasing human activities. Terrestrial, freshwater, and marine ecosystems as well as broader environmental, cultural, and economic trends in the Arctic will be affected [2, pg. 8].*

When these changes are considered alongside the sometimes divergent opinions of stakeholders in Arctic Alaska, the need for comprehensive planning at the regional level that includes multi stakeholder participation becomes apparent. Without it, a sustainable balance between the subsistence-based life-ways of many regional residents and the growing commercial economy marked by increasing industrial activity may never be achieved.

1.4 Definition of key terms

To serve as an effective reference for stakeholders contemplating decision-making in Arctic Alaska, this report uses certain terms in specific ways.

The terms "industrial" and "commercial" are used interchangeably throughout this report to reference natural resource extraction that is primarily oriented toward exporting resources out of the region.

"Infrastructure" is used to describe human-made structures that appear in the landscapes and seascapes of Arctic Alaska and stem from oil and gas or other industrial activities. Infrastructure includes multiple types of buildings, roads, gravel islands, docks, causeways, airstrips, pipelines, power lines, wells, mines, and landfills. As a complement to infrastructure, this report uses the term "operations" to describe the industrial human activities that commonly accompany the construction and use of oil and gas and other industrial infrastructure, such as the trips made by trucks, tundra vehicles, fixed-wing aircraft, helicopters, and various types of ships.

For example, an offshore drilling platform is considered infrastructure while trips to and from the platform to bring construction materials, workers, supplies, maintenance items and so forth are considered operations. Infrastructure can be thought of as relatively permanent compared to operations, which are relatively impermanent activities that can recur. Taken together, the term "infrastructure and operations" captures the breadth of industrial activities related to oil and gas production that this report synthesizes.

In this report, "commercial transportation" comprises two areas of content. The first is the movement of natural resources for the primary purpose of export to non-regional markets. Examples include piping of oil from northern Alaska to ports in the south and potential trucking and shipping of coal or minerals from open-pit mines in western Alaska to distant markets. The second content area includes major conveyances of goods and materials—as distinct from day-to-day operations—that support industrial operations in Arctic Alaska, as well as maritime traffic that is primarily in support of industrial operations and that passes through the waters of Arctic Alaska. Examples include international shipping of cargo, including petroleum, chemicals, and raw materials; transport of oil field equipment, construction materials, or chemicals from outside the Arctic to support oil and gas development in the region; ice breaker operations or air freight deliveries for industrial projects; and tanker or barge traffic that moves refined petroleum products into the Arctic for distribution and use.

This report uses the term "existing" infrastructure and operations to mean industrial structures that have already been built and operations that have already occurred as of the time of writing (first quarter of 2014). "Planned" infrastructure and operations is a relatively narrow category and describes industrial structures and activities that have entered the initial permitting or development phase or are likely to occur within the next one to two years, but have not yet been completed as of this writing. "Proposed" infrastructure and operations defines those industrial structures and activities that neither exist today nor have entered the initial permitting phase, but have been quantitatively or qualitatively described in federal or state government planning documents and could plausibly occur in the future given current knowledge of industrial development trends. This report attempts to minimize the speculation inherent in the planned and proposed categories of infrastructure and operations by focusing on empirical data, such as government assessments and public statements of government agencies about their intentions for future industrial activities.

1.5 Delimitations

As stated earlier, this report is designed to provide information about the extent of existing and plausible future industrial infrastructure and operations in Arctic Alaska that support oil and gas exploration and production and commercial transportation. It does not, however, attempt to analyze the environmental, social, and economic effects of the described industrial infrastructure and operations. Such analysis is beyond the scope of this report but is a crucial area for future research and discussion.[5]

This report also does not present non-industrial infrastructure, such as the roads, homes, structures, and operations of the numerous communities within Arctic Alaska. Similarly, it does not include former or active military sites, or infrastructure and activities related to natural resource extraction conducted for use within the communities of Arctic Alaska, such as the gas fields surrounding Barrow that provide natural gas for the community.

4 *For a more in-depth discussion of Arctic change than is possible here, see e.g., http://www.acia.uaf.edu/ and http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch15.html.*

5 *A follow up study to the 2003 NRC study referenced at the beginning of this chapter was published in 2014 (see reference cited [6]). The new study provides insight into some of the ecological impacts of continued industrial development on the North Slope.*

Multiple types of Alaska Native entities own land in Arctic Alaska. While there are important differences among these entities, this report does not, for the most part, distinguish different categories of Alaska Native land ownership. Instead, this report uses the term "Alaska Native lands" to reference all areas owned by any Native entity.[6]

The majority of the data presented are related to the oil and gas sector, because it is currently the largest and most important sector of industrial activity in Arctic Alaska. This report also touches on other important sectors: mining, international shipping, commercial fishing, and tourism. While this report focuses primarily on oil and gas, it is important to note that many sectors of industrial activities are related to and often influence one another. The influences can be reinforcing, as in the case of a new road or coastal port that facilitates oil and gas exploration, mining, and tourism. In other cases, the influence can be dampening. For example, the development of multiple offshore oil and gas platforms could negatively impact commercial fishing and tourism in an area. Such cross-sector influences, while not considered in depth here, are important and should be addressed through comprehensive planning.

Arctic Alaska is linked to the rest of Alaska, the continental US, the seven other Arctic nations, and increasingly the rest of the world via multiple social, political, economic, and environmental connections. While these connections to the broader world are important for understanding the possible futures of the region, they are largely beyond the scope of this document. Instead, this report focuses on synthesizing information about regional-level infrastructure and operations as a key ingredient of informed planning and decision making.

1.6 Organization of this report

The two chapters following this Introduction provide background information for readers who might be unfamiliar with the material covered in the rest of the document. Chapter 2 presents a description of the six main sub-regions in Arctic Alaska, including basic information about each sub-region's political jurisdictions and designations.

6 *The Alaska Native Claims Settlement Act of 1971 (ANCSA) established the basic framework for Native land ownership throughout most of Alaska. ANCSA largely resolved Native land claims by (1) creating for-profit Native corporations (i.e., 12 regional corporations, later increased to 13, and over 200 village corporations), (2) making Alaska Natives shareholders in the corporations, and (3) transferring rights to over 44 million acres of land to the corporations. Through the Act, the regional corporations generally gained ownership of both subsurface land rights (meaning rights to oil, gas, minerals, and other resources) and surface rights, while the village corporations retained only surface rights for their lands. Within Arctic Alaska, individual Alaska Natives also own lands. The text of ANCSA is available at http://www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate/legislation/alaska_legislation.Par.10664.File.tmp/PL92-1-203.pdf.*

Alpine Oil Field, North Slope, AK. *Creative commons licensed photo by Paxson Woelber: http://flickr.com/photos/paxson_woelber/9840005175.*

These jurisdictions and designations largely determine which set of rules (e.g., international, federal, State of Alaska, municipal, or Alaska Native), or combination of rule sets, control oil and gas activities and commercial transportation in a given area.

Chapter 3 describes five general phases of oil and gas production projects and briefly describes the infrastructure and operations associated with each phase. Understanding what each phase entails in terms of industrial activity will aid the reader in comprehending the subsequent chapters where the different phases are referenced but not described in detail.

Chapters 4 through 8 present the existing, planned, and proposed infrastructure and operations that support oil and gas production in Arctic Alaska, with each chapter focusing on one of the six sub-regions: the Central North Slope and State Waters, the National Petroleum Reserve - Alaska (NPR-A), the Chukchi Sea Outer Continental Shelf, the Beaufort Sea Outer Continental Shelf, the Arctic National Wildlife Refuge (ANWR), and Northwest Coastal and Interior Alaska. The chapters are presented in this sequence in order to reflect one possibility for how oil and gas infrastructure will expand in the future. The Central North Slope and State Waters sub-region currently has the most infrastructure, so that region is presented first. At the time of writing, infrastructure is expanding from the Central North Slope into the eastern part of NPR-A, so that sub-region is presented next. As this report shows, there are proposals to connect future NPR-A infrastructure to future infrastructure in the Chukchi Sea, and to connect future Beaufort Sea infrastructure to the Central North Slope, so those sections are presented subsequently.

The structure of the ANWR chapter differs from the other chapters. ANWR is a federally protected natural area where oil and gas activities and commercial transportation are currently prohibited, whereas industrial development is being actively pursued in portions of the other five sub-regions. Chapter 8 focuses on the purpose and status of ANWR and the State of Alaska's desire to pursue oil and gas exploration in ANWR's Coastal Plain. This report includes ANWR in order to provide readers with a complete vision of Arctic Alaska.

Chapter 9 presents the existing, planned, and proposed infrastructure and operations that support commercial transportation in the sixth sub-region—Northwest Coastal and Interior Alaska. The main projects covered in this chapter are the Roads to Resources Initiative proposed by the State of Alaska's Department of Transportation and Public Facilities (ADOT&PF) and the potential construction of a deep draft port along Alaska's western coast. The Red Dog mine and the associated DeLong Mountain Transportation System are also presented in Chapter 9. The report presents this sub-region last because there are few, if any, activities directly related to oil and gas production occurring therein, other than the transportation of oil and gas extracted from the more northern sub-regions.

Chapter 10 is the final chapter and provides a synthesis of the data presented in Chapters 4 through 9 via tables, maps, and text. It also offers a summary of the report's findings and some concluding ideas for how this report can be used to help readers think about and plan for future oil and gas activities and commercial transportation in Arctic Alaska. Chapter 10 is intended to serve as quick reference for stakeholders interested in these issues.

1.7 Methods and data notes

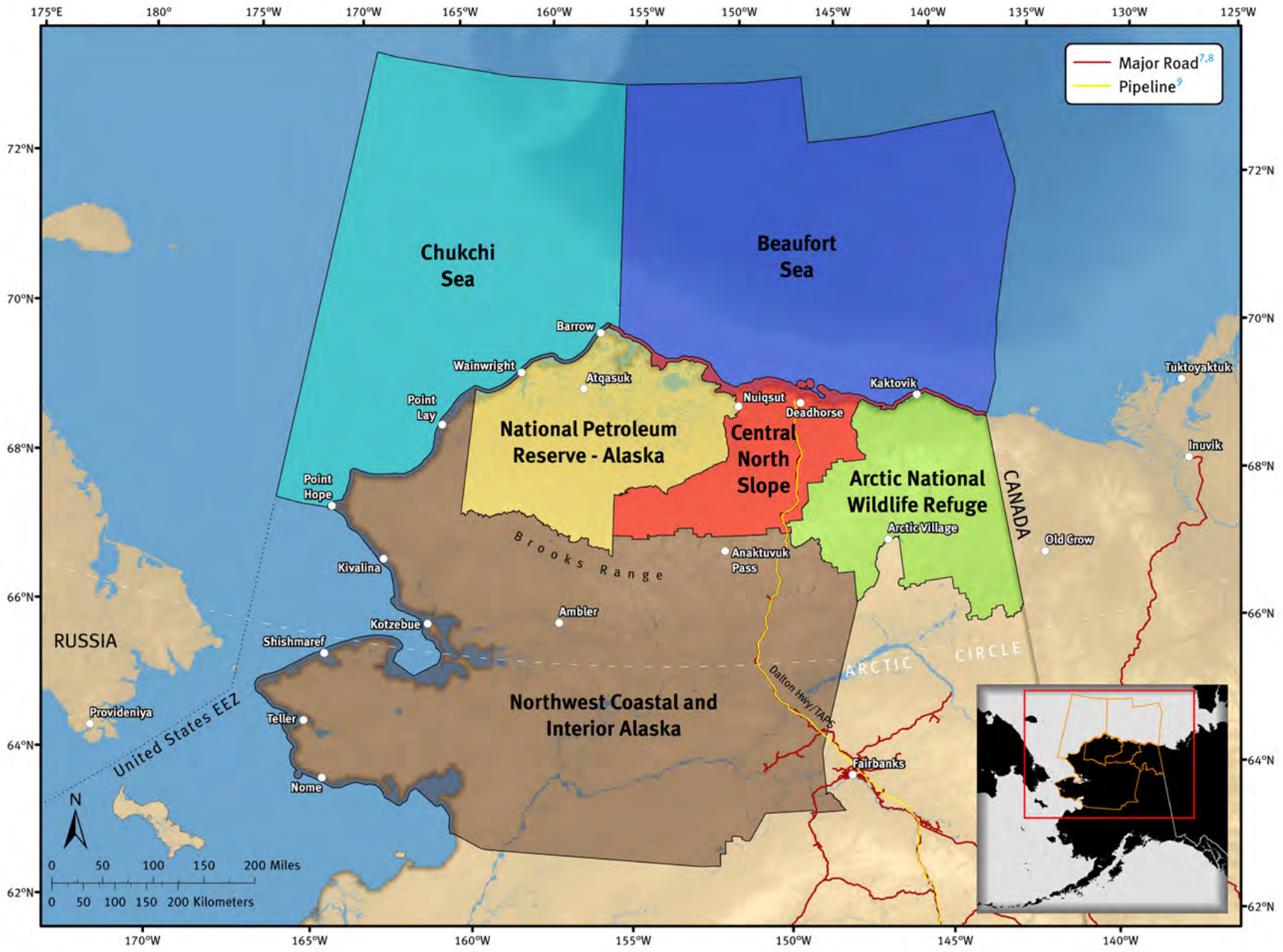
The information synthesized in this report was collected and assembled between January 2013 and March 2014 by the author with the aid of multiple reviewers and collaborators (see Acknowledgements). The author examined relevant documents and extracted pertinent data about industrial activities by adapting tables, text, and maps from the original sources cited throughout this report; a corresponding list of cited references appears at the end. Whenever possible, government planning documents—such as environmental impact statements, development permits, and other official reports—were used, as these sources are the most impartial and widely accepted quantifications and qualitative descriptions of industrial infrastructure and operations that are publicly available.

Until now the quantification of existing, planned, and proposed infrastructure in Arctic Alaska was largely piecemeal. To bridge the gaps in the existing data and build a regional synthesis, other sources, like the 2003 NRC report, were utilized when needed. Extensive efforts were taken to ensure the validity of all the sources used, including cross-referencing with other sources and consulting with experts. In addition to the citation of sources, explanations of the data presented in this report are provided as needed.

Many of the source documents synthesized here presented different types of infrastructure and operations (e.g., number of gravel pads versus number of facilities) and used different units of accounting (e.g., miles of pipeline corridor versus total acreage disturbed by pipeline) because of the requirements of different regulatory agencies and the methods of previous studies. While this can complicate comparisons among sub-regions and time frames, the last chapter of this report provides data in a more comparable format.

All original maps were made using a combination of publicly available data layers, geo-referenced data layers that were created specifically for this report, and the data holdings of Audubon Alaska. References for all map data sources are provided in the References Cited section. The mappers and the author worked in close collaboration to confirm correspondence between the information presented in written and graphic forms.

Map 1: Sub-regions of Arctic Alaska



2. SUB-REGIONS OF ARCTIC ALASKA

2.1 Introduction

The land and sea sub-regions that comprise Arctic Alaska exhibit a complex arrangement of political jurisdictions and legal designations for use. Authority over different areas is divided among federal, state, municipal, and Alaska Native entities, with multiple organizations sharing authority in many cases. The purpose of this chapter is to introduce the reader to Arctic Alaska by briefly describing the jurisdictions and designations for use in each sub region used by this report. The six sub-regions generally follow common geographic and political boundaries and should be recognizable to most readers.[7]

Many of the major political boundaries in Arctic Alaska, however, do not align with the boundaries of the ecoregions described previously. Accordingly, readers should not view the six sub-regions as independent, self-contained units. Rather the six sub-regions may be connected to other sub-regions through the movement of and interaction among not only plant and animal species, but also people, natural resources, and infrastructure. Indeed, the connectedness of the sub-regions is a significant factor in creating the need for comprehensive planning.

7 *This report uses political boundaries that correspond to previous studies of oil gas infrastructure in order to ease data analysis and presentation. The political boundaries of boroughs and census areas in Arctic Alaska are also important but not discussed here. North Slope Borough, Northwest Arctic Borough, Nome Census Area, and Yukon-Koyukuk Census Area can be seen at http://labor.alaska.gov/research/census/maps/AlaskaBorCA2013.pdf.*

2.2 Central North Slope and State Waters

The first sub-region is the Central North Slope and State Waters of the Beaufort Sea. The North Slope describes the terrestrial area between the northern foothills of the Brooks Range—which arcs across the northern portion of the state—and Alaska's northern coast. The Central portion of the North Slope is the area between the Colville River in the west and the Canning River in the east. As the Central North Slope extends southward from its coastal boundary, it is bordered by federal lands on all sides: NPR-A to the west, ANWR to the east, and Gates of the Arctic National Park and Preserve to the south. The Central North Slope is predominately State of Alaska land, with Alaska Native entities and the federal government holding title to smaller portions of the region [10].

The State of Alaska also holds authority over ocean waters between the coastline and a parallel line three nautical miles offshore (except for certain areas within NPR-A and ANWR). The state waters of Arctic Alaska extend from the maritime border with Canada in the east all the way west and south to the southerly limit of the study area. The state's nearshore oil and gas leasing area, however, is more limited in size. It extends from the Canadian border west to the boundary of the Chukchi Sea near Point Barrow. At present, state waters south of Barrow are not part of the state's oil and gas leasing areas [11].

Oil Production at Prudhoe Bay Oil Field, North Slope, AK. *©Paul Andrew Lawrence, http://www.paulcolor.com.*

The State of Alaska's Division of Oil and Gas, within the Department of Natural Resources, is responsible for scheduling and conducting oil and gas lease sales in the Central North Slope and State Waters sub-region. Oil and gas leasing has occurred on these lands since the 1960s, with the first nearshore Beaufort Sea leasing occurring in 1979. The sub-region is officially divided into three Areawide lease zones: the North Slope (5.1 million acres), the North Slope Foothills (7.6 million acres), and the Beaufort Sea (2 million acres) [12]. This report presents the Central North Slope and state waters in the same chapter because (1) prior efforts to quantify oil and gas infrastructure in the region, which this report cites, grouped the two area together in their accounting methods, (2) oil and gas leasing in both areas is largely under State of Alaska authority, and (3) nearshore development requires onshore infrastructure.

2.3 National Petroleum Reserve – Alaska

Existing, planned, and proposed infrastructure and operations supporting oil and gas development in NPR-A are presented in Chapter 5. The Bureau of Land Management (BLM), a federal agency within the US Department of the Interior, is responsible for scheduling and conducting oil and gas leasing in this sub-region. NPR-A is located in the northwestern corner of Alaska's North Slope. The eastern portion of NPR-A is bounded by the Beaufort Sea to the north and the Colville River to the east and the south. The western portion of NPR-A is bounded by the Chukchi Sea to the north, the Brooks Range and the Noatak National Preserve to the south, and a mix of federal, state, and Native lands to the west. Within the boundaries of NPR-A, there are Native land holdings around the villages of Atqasuk, Barrow, Nuiqsut, and Wainwright.

NPR-A was established in 1923 when President Harding set aside 22.8 million acres, known then as the Naval Petroleum Reserve No. 4, as an emergency source of oil for the US Navy [13]. BLM began administering the NPR-A as part of the Naval Petroleum Reserves Production Act of 1976, which, among other things, gave NPR-A its current name and authorized oil and gas exploration by the US Geological Survey (USGS). In 1980, Congress officially opened NPR-A to leasing and exploration by the oil industry and also established natural special areas within NPR-A boundaries. Since 1980, BLM has produced multiple management plans for NPR-A, with the most recent one reaching completion in 2012 [14]. Following from this planning effort, 11.8 million acres of NPR-A are available for oil and gas leasing, while the other 11 million acres have been designated unavailable for leasing in order to preserve environmental resources and surface uses.

2.4 Chukchi Sea Outer Continental Shelf

The Chukchi Sea Outer Continental Shelf (OCS) is the subject of Chapter 6. The Chukchi Sea is located northwest of Alaska and is bordered by the Eastern Siberian Sea to the west, the Beaufort Sea to the east, the central Arctic Ocean to the north, and the Bering Strait to the south. The Chukchi Sea OCS describes that portion of the sea situated between Alaska state waters, which extend seaward three nautical miles from shore, the international high seas that begin 200 nautical miles offshore to the north—beyond the US exclusive economic zone (EEZ)— and the maritime border with the Russian Federation to the west.

The Chukchi Sea OCS is under federal jurisdiction. The US Department of the Interior manages most aspects of oil and gas operations in the Chukchi Sea OCS. Specifically, the Bureau of Ocean Energy Management (BOEM) is responsible for scheduling and conducting lease sales and conducting environmental analysis of oil and gas exploration and production, while the Bureau of Safety and Environmental Enforcement (BSEE) is charged with overseeing OCS drilling operations. The Chukchi Sea OCS planning area covers nearly 63 million acres [15]. Currently, approximately 2.7 million acres of the planning area have been leased by oil and gas companies. BOEM's most recent five-year oil and gas leasing program allows for the possibility of a new lease sale in the Chukchi Sea in 2016 [16]. The Chukchi Sea planning area excludes from leasing a deferral zone that extends 25 miles seaward from the coastline, plus additional subsistence-related deferral zones. The purpose of these deferral areas is to protect migratory birds, marine mammals, and subsistence activities from the potential impacts of oil and gas activities.

2.5 Beaufort Sea Outer Continental Shelf

Chapter 7 presents data on the Beaufort Sea OCS. The Beaufort Sea is located off the northern coast of Alaska and is bordered by the Chukchi Sea to the west and the central Arctic Ocean to the north; it also extends eastward beyond the disputed maritime border with Canada. Similar to the Chukchi Sea OCS, the Beaufort Sea OCS defines that portion of the sea located in US waters and beginning three nautical miles offshore—where State of Alaska jurisdiction ends—and extending to 200 nautical miles seaward from shore, beyond which the Beaufort Sea becomes international high seas. The Beaufort Sea OCS falls under federal jurisdiction, with BOEM and BSEE again acting as the lead regulatory agencies with regard to oil and gas activities.

The Beaufort Sea OCS oil and gas planning area covers approximately 65 million acres [15] with approximately 1.1 million acres currently leased. BOEM's most recent five-year oil and gas leasing program allows for the possibility of a new lease sale in the Beaufort Sea in 2017 [16]. The program also designates two leasing deferral zones around the villages of Barrow and Kaktovik due to their importance as subsistence whaling grounds.

2.6 Arctic National Wildlife Refuge

Although oil and gas activities and commercial transportation are prohibited in ANWR, Chapter 8 presents an overview of the ongoing debate about the status of this Arctic Alaska sub-region. ANWR was originally established in 1960 and then expanded in 1980 with President Carter's signing of the Alaska National Interest Lands Conservation Act (ANILCA). ANWR is federally administered by the US Fish and Wildlife Service in the US Department of the Interior. There are numerous, mostly small, Alaska Native land holdings within ANWR boundaries, with the largest being around the coastal village of Kaktovik.

Alaskan Oil Pipeline. *Creative commons licensed photo by faungg's photo: http://flickr.com/photos/44534236@N00/967880597.*

ANWR is located in the northeast corner of Alaska and, at 19.3 million acres, is the largest unit in the National Wildlife Refuge System [17]. The Brooks Range runs through the northern half of ANWR. The western border is defined by the Canning River and the Central North Slope, while Canada borders ANWR on the east; and a mix of state, Native, and federal lands—including the Yukon Flats National Wildlife Refuge—constitute the southern border. While the vast majority of ANWR is terrestrial, it also includes barrier islands, lagoons, and bays of the Beaufort Sea, with State of Alaska waters demarcating the Refuge's northern border.

2.7 Northwest Coastal and Interior Alaska

Chapter 9 diverges from the previous chapters by presenting infrastructure and operations data from a sub-region that is located partially south of the Arctic Circle and that pertains more to commercial transportation than to oil and gas activities. This sub-region is called Northwest Coastal and Interior Alaska. The Roads to Resources Initiative covered in this chapter begins near Fairbanks in the center of the state, and then extends toward the state's northwest coast and the NPR-A boundary. Similarly, the ports and commercial marine vessel activities covered in this chapter occur along the west coast of the state, both north and south of the Arctic Circle.

The lands and waters of the Northwest Coastal and Interior Alaska sub-region exhibit a complex patchwork of jurisdictions and designations for use, with authority split among federal, state, Native, and municipal entities. Numerous federal conservation units exist within the sub-region. This report considers the sub-region to be part of Arctic Alaska because the infrastructure and operations that occur there are related to those that occur above the Arctic Circle. This sub-region also includes the state waters in the Chukchi Sea that are offshore of NPR-A and south of Barrow. While these waters are not included in the State of Alaska's oil and gas leasing areas, they could potentially see development of industrial infrastructure from projects that bring oil and gas from federal offshore leases in the Chukchi Sea to existing onshore infrastructure.

3. PHASES OF OIL AND GAS ACTIVITIES IN ARCTIC ALASKA

3.1 Introduction

This report breaks down the activities associated with oil and gas production in Arctic Alaska into five main phases: (1) Leasing, (2) Exploration, (3) Development, (4) Production and Transportation, and (5) Decommissioning and Abandonment [1] [18] [19]. Each phase, described in detail below, involves a complex network of actors from the governmental, private, and civic spheres of society. The phases do not necessarily occur in sequential order, can overlap in time and geography, and can vary widely in terms of the amount of time they take and the government agencies that are involved. The purpose of this chapter is to familiarize the reader with each phase and its associated infrastructure and operations. This understanding will make the rest of this report more comprehensible and will supply readers with crucial information needed to participate effectively in regional comprehensive planning.

It is helpful to start with a note on permitting. While not a distinct phase itself, permitting is required in all phases of oil and gas activities. A wide range of federal, state, and local laws exist to protect the quality of the human and natural environment from potential negative impacts of oil and gas activities. Issuing permits under these laws can be straightforward, with applications quickly followed by issuance of a permit or other authorization. Alternatively, permitting can also be extremely involved; complex or controversial projects in remote Arctic areas can take multiple years and can require significant investment in baseline environmental and socioeconomic studies to assess potential impacts.

3.2 Leasing

The right to explore, extract, and develop subsurface resources can be conveyed by the owners of those resources to others, with leasing being the most common vehicle to execute these transactions. In Alaska, subsurface resources are primarily owned by either the state or federal governments, or by Alaska Native regional corporations. There has been limited exploration and development of subsurface resources on Alaska Native lands, with virtually all of the work since statehood occurring on state or federal lands. Both the state and federal governments have developed leasing processes and have sold leases to a number of individuals and companies. Even before a lease is issued, there is often an extensive planning process by which the leasing entity decides what areas to make available for lease. This preliminary phase can include environmental assessments, public comment periods, deliberation about lease prices, and elements of the exploration phase (e.g., input from the results of seismic surveys).

When rights are owned by the state or federal government, leasing is a public process whereby private companies enter competitive bids for lease tracts during a publicly announced lease sale. Both terrestrial and marine lease sale areas are divided into such tracts. The timing of lease sales has varied historically and depends on a wide range of political, economic, and environmental factors. Leases often expire after a certain number of years if the private entities that purchase them do not pursue development within the leased tract.

3.3 Exploration

In the exploration phase, lease tracts and other areas are investigated to determine whether commercially viable oil and gas resources exist. All exploration requires authorization from the resource managing entity, limiting how exploration can take place, who can explore, and the area that can be explored. Before any exploration actually begins, however, personnel and equipment must be transported to the exploration site—via land, sea, or air—and temporary facilities may have to be established.

Two common types of exploratory activity are large-scale seismic exploration and exploration drilling. Seismic surveys generate two- or three-dimensional images of the structure of the subsurface by projecting sound waves into the earth and recording their reflections. In Arctic Alaska, seismic surveying is generally conducted terrestrially by tundra vehicles during the winter and by large ships towing the appropriate sound equipment in marine environments during the summer. Large-scale seismic exploration is generally an intense industrial operation that produces air emissions, noise pollution, and, when conducted on land, can leave depressions in the tundra (called tundra scars), impact vegetation, and cause erosion [20]. Seismic exploration in marine areas can generate noise levels that can disturb marine mammals [20]. Seismic exploration is widespread in Arctic Alaska. For example, between 1990 and 2001, 15,499 miles of seismic lines were surveyed in the region, where a line is defined as the passing of a survey vehicle over land or water [1].

Exploration drilling often follows seismic exploration and is used to confirm or refine the findings of seismic surveys with regard to the quantity and quality of oil and gas resources. In Arctic Alaska exploration wells are usually drilled from seasonal ice pads in terrestrial environments and from ice islands, artificial gravel islands, natural islands, or drilling vessels and structures in offshore environments, depending on the water depth and distance to shore. In the nearshore environment of the State of Alaska waters, exploration drilling can sometimes be conducted from existing facilities or ice pads onshore [1]. Once a discovery has been confirmed through exploration drilling, appraisal wells can be drilled before development to further assess the discovery.

Oil Production, North Slope, AK. ©Paul Andrew Lawrence, http://www.paulcolor.com.

3.4 Development

When exploration operations are successful, they can lead to the next phase: development. Development is the process by which companies finalize their plans for producing viable quantities of oil and gas from a given site and construct the intricate infrastructure required for the extraction, initial processing, and transportation of resources. For new fields, development most often requires the siting and construction of relatively permanent and complex oil and gas infrastructure.

The development phase is often the most intense phase of oil and gas activities in terms of vehicular traffic coming and going from development sites. All construction materials, construction machinery, construction personnel, and oil and gas production personnel must be brought to the construction site by truck, barge, or plane. The construction of the Northstar project in the state waters of the Beaufort Sea, for example, required 35,000 surface trips by trucks and other vehicles [1].

Development of terrestrial production facilities in Arctic Alaska includes the construction of gravel well pads, production wells, drill rigs, processing facilities, roads, elevated pipelines, and numerous production facilities, including: oil and gas separation plants, gas processing plants, compressing plants, power plants, pump stations, and fresh and seawater water treatment plants. In addition to the actual oil and gas production infrastructure, the development phase includes the construction of support infrastructure such as personnel quarters, administrative offices, maintenance shops, warehouses, airstrips, landfills, docks, causeways, power lines, gravel mines, water reservoirs, sewage lagoons, and other storage and operation pads [1]. Some infrastructure may be shared by multiple oil and gas production projects, so construction of all the facilities listed above is not a part of every new development. For example, many of the individual production projects on the Central North Slope share the same processing and transportation facilities centered at the infrastructural complex contained within the Prudhoe Bay Unit.

Development of nearshore production facilities (in the shallow state and federal waters of the Beaufort Sea) is similar to the processes described above, including connections to the Prudhoe Bay Unit infrastructural complex. However, there are differences: the drill rigs, wells, and associated production infrastructure are constructed atop human-made gravel islands in the water, rather than atop gravel pads on the tundra. Also, the pipelines that transport extracted oil and gas to processing facilities are buried under the seafloor, rather than elevated above the tundra. Gravel causeways connect some nearshore gravel islands to the mainland, allowing trucks to drive to and from the islands.

In contrast to nearshore development, the development of an offshore facility in the federal waters of the Chukchi Sea or the deeper parts of Beaufort Sea would require the construction of a completely different type of support structure because the deeper water would make gravel islands impractical. For sustained production to occur at such depths (around 120 ft.), a deep-water production platform would be required [16], such as those used in other parts of the world. However, the performance of deep-water platforms in the sea ice regime of Arctic Alaska waters has yet to be demonstrated.

Northstar Offshore Island, Beaufort Sea. *Creative commons licensed photo by Joint Pipeline Office: http://www.jpo.doi.gov/Photo%20Gallery/index.htm.*

3.5 Production and Transportation

The production and transportation phase begins following construction of a functioning oil and gas facility (i.e., a facility connected to market). However, additional development may continue long after first production from a field has begun. Production is characterized by the processing, transport, and disposal of large volumes of fluids. Wells in Arctic Alaska typically extract both oil and gas from the subsurface due to the physical composition of regional reservoirs. Following extraction, the oil and gas are separated in a processing facility and a large portion of the gas is injected back into the ground to help maintain the well pressure required to push more oil upwards. Some of the gas, however, is used as a source of energy at the production facilities. Currently, almost all of the oil produced in Arctic Alaska is pumped through the 800-mile-long Trans-Alaska Pipeline System (TAPS) that runs from the Prudhoe Bay complex southward across the length of Alaska and ends at the Alyeska Valdez Marine Terminal on the state's southcentral coastline. The Valdez Marine Terminal temporarily stores and loads crude oil onto tankers for shipment to non-Alaskan refineries and markets.

The production phase also includes the creation and disposal of massive amounts of waste liquids that are generated during oil and gas exploration and production. Waste liquids include drilling muds and cuttings, crude oil, spill materials, test fluids, oily water, tank-bottom sludge, gas dehydration wastes, and produced water, which comes to the surface during oil extraction but must be removed before the oil is transported [1]. Some waste materials are classified by US law as hazardous, requiring them to be shipped to disposal facilities in the continental US.[8] The rest of the waste fluids are injected into subsurface formations through permitted disposal wells. As of 2003, over 1.5 billion barrels (63 billion gallons) of produced water and associated liquid wastes had been injected into subsurface disposal formations in the Central North Slope [1].

3.6 Decommissioning and Abandonment

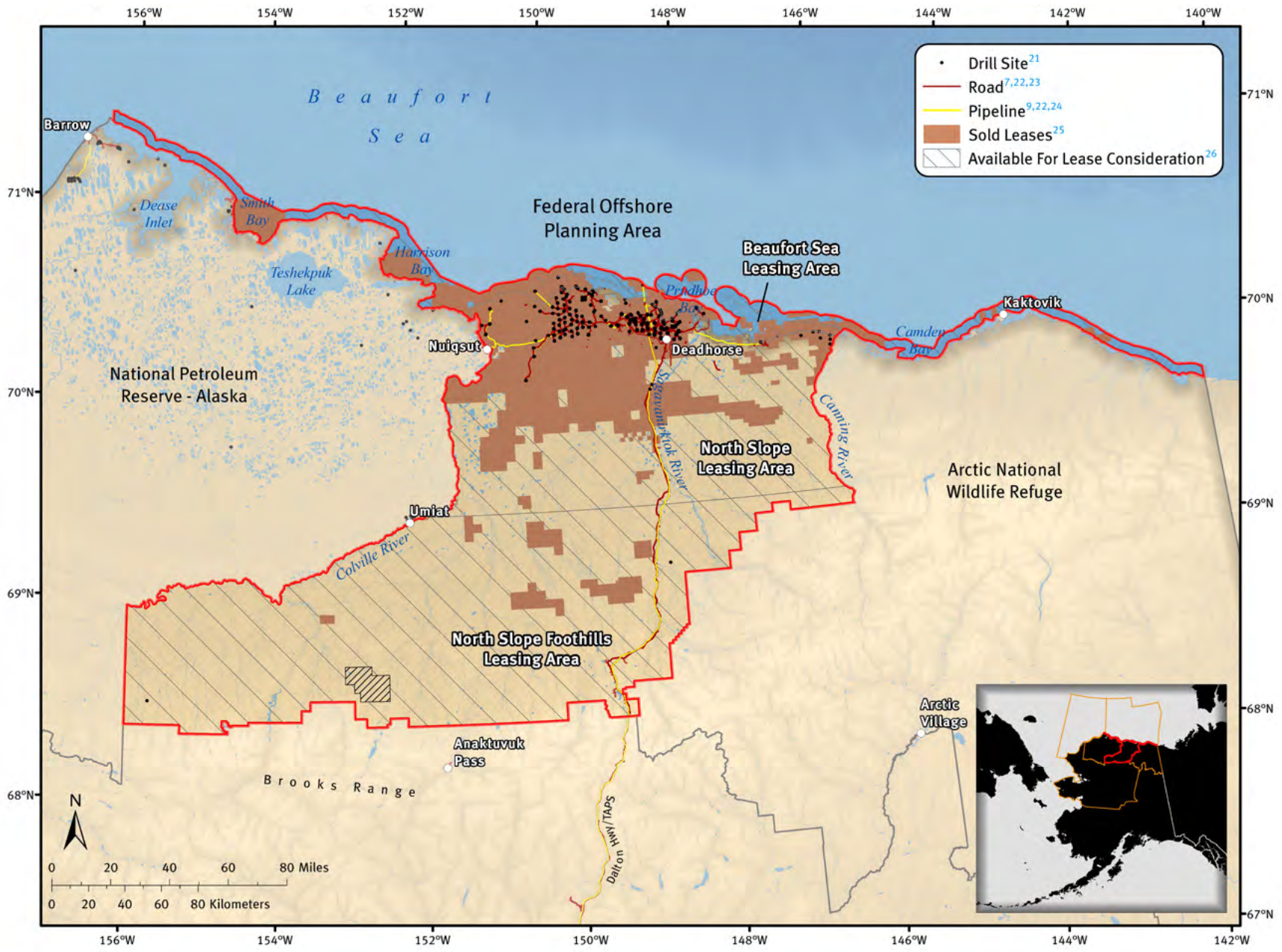
Decommissioning and abandonment take place when oil and gas infrastructure has reached the end of its productive life for the company that owns it. This can occur either because the reservoir it tapped has run dry and there is no other reasonably foreseeable use for the infrastructure, or because the infrastructure has become unsafe or unprofitable to operate. Both federal and state regulations require the plugging of abandoned wells, in addition to managing remaining waste products, securing infrastructure at the site, and removing and transporting infrastructure to a different location for reuse or disposal.

Despite these regulations, the 2003 NRC report finds the legacy of abandoned oil and gas infrastructure on the North Slope to be a cause for concern. The authors note that as of 2003, only about 1% of the habitat on the North Slope affected by gravel fill from oil and gas activities had been restored, and conclude that "[t]he lack of clear state or federal performance criteria, standards, and monitoring methods governing the extent and timing of restoration has hampered progress in restoring disturbed sites [1, pg. 15]." The 2003 NRC report authors suggest that the high cost associated with this final stage of decommissioning and abandonment discourages oil and gas companies from accomplishing restoration.

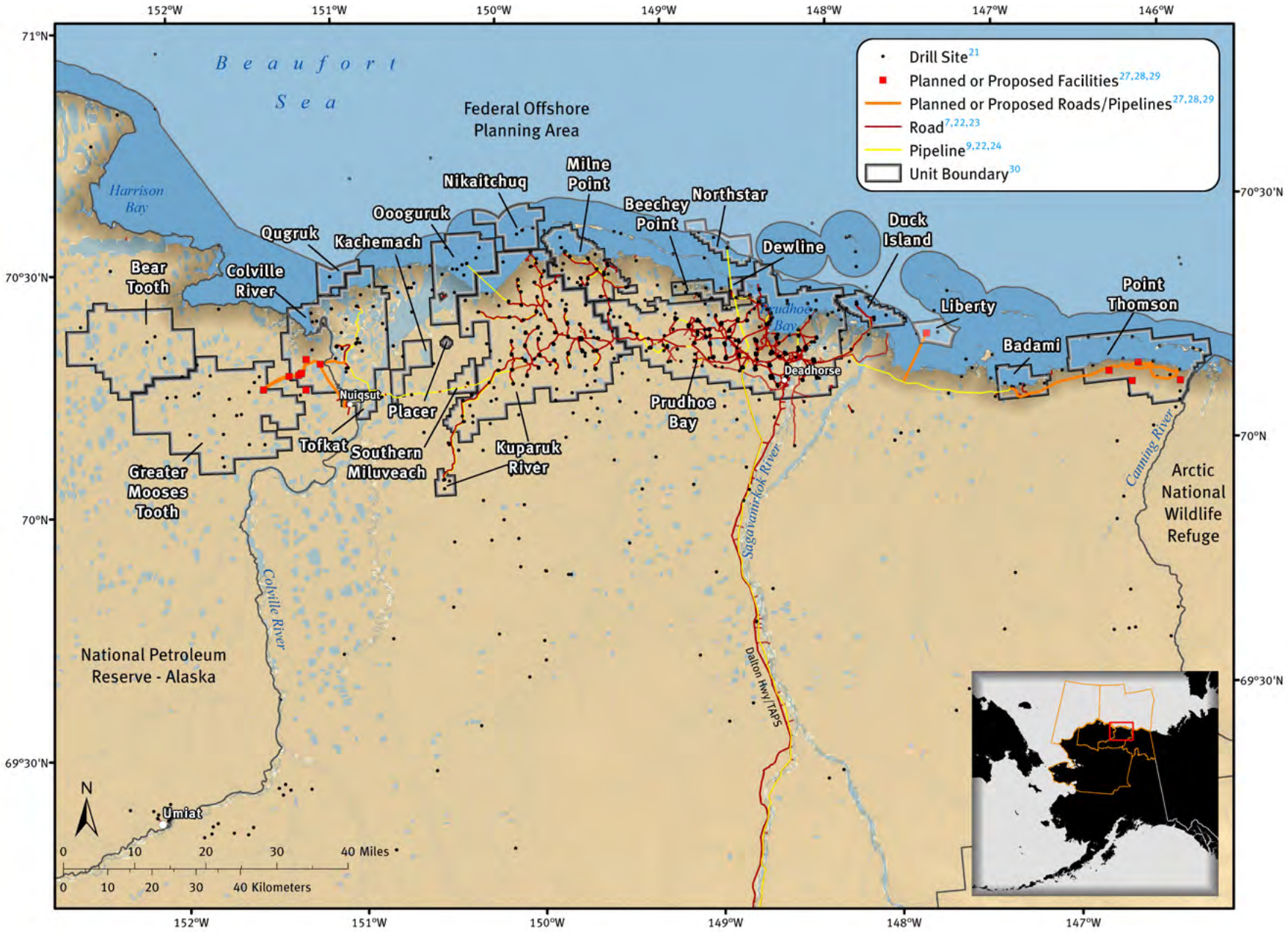
While most of Arctic Alaska's oil and gas facilities are still in the production phase, considering the end plan for the current and future industrial complex in the study area is an important component of thinking about and planning for the future of the region.

8 *For more information about the waste fluids associated with oil and gas production that are classified by the US Environmental Protection Agency as hazardous and those fluids that are exempt from regulation, see http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf.*

Map 2: Central North Slope and State Waters: State Leasing Areas and Existing Infrastructure



Map 3: North Slope Oil and Gas Units and Infrastructure



4. CENTRAL NORTH SLOPE AND STATE WATERS

4.1 Existing infrastructure and operations

Private companies began exploring the oil and gas production potential of Arctic Alaska in the early 1920s. The first development to successfully produce commercial quantities of oil in the region was at the Central North Slope's Prudhoe Bay field, which was discovered in 1968 and went online in 1977 following the completion of TAPS (discussed also in Chapter 3) [1].[9] The completion of TAPS was a necessary precondition for successful production in the region because it allowed for the economically efficient transport of oil from the far north of the state to an ice-free port in the south. Construction of the Dalton Highway was another infrastructure project that preceded North Slope oil and gas production. The highway, completed in 1974, is 414 miles long and runs from the Elliot Highway north of Fairbanks to the industrial support center of Deadhorse, adjacent to the Prudhoe Bay field [31]. The Dalton Highway, along with the construction of a major jet airport at Deadhorse, provided access to previously remote and roadless portions of Alaska and allowed the construction of TAPS and much of the oil and gas infrastructure on the North Slope.

Oil and gas infrastructure in the Central North Slope and State Waters sub-region expanded steadily from the initial development at Prudhoe Bay as additional commercially viable fields were discovered. Table 4.1 presents a timeline of some of the major oil and gas activities in the sub-region, such as the year that production began at many of the fields surrounding Prudhoe Bay, two major recent seismic surveys that occurred in the Beaufort Sea, and a recent effort along the Dalton Highway to explore for oil contained in shale deposits. In terms of industrial operations, note that production at each field was preceded by exploration and development activities. All producing fields involve year-round activities such as drilling and well work.

9 *Following the definitions used by the State of Alaska's Division of Oil and Gas, this report uses "field" to describe subterranean accumulations of oil and gas that consist of one or more pools, and "Unit" to describe the legally defined oil and gas activity areas that consist of one or more fields. Lease tracts and infrastructure and operations occur outside of Units as well as within them.*

Gathering Center 1 (GC1), Prudhoe Bay, AK. *Creative commons licensed photo by creative commons licensed photo by Jay DeFehr: http://flickr.com/photos/jay_defehr/6124733605.*

Table 4.1. Existing oil and gas activities in the Central North Slope and State Waters sub-region

Year(s)	Event
1963-67	First drilling of exploration wells by private companies [19]
1964	First State of Alaska lease sale [19]
1968	Discovery of Prudhoe Bay field, the largest in North America [19]
1977	Trans-Alaska Pipeline System operational [19], Beginning of production from Prudhoe Bay field (Prudhoe Bay Unit) [20]
1979	Initial leasing of Beaufort Sea state waters [19]
1981	Beginning of production from Lisburne field (Prudhoe Bay Unit) and Kuparuk field (Kuparuk River Unit) [20]
1985	Beginning of production from Milne Point field (Milne Point Unit) [20]
1987	Beginning of production from Endicott field (Duck Island Unit) [20]
1989	Beginning of production from Sag Delta North field (Duck Island Unit) [20]
1991	Beginning of production from Schrader Bluff field (Milne Point Unit) [20]
1993	Beginning of production from North Prudhoe Bay field and Pt. McIntyre field (Prudhoe Bay Unit) [20]
1994	Beginning of production from Niakuk field and West Beach field (Prudhoe Bay Unit) and Sag River field (Milne Point Unit) [20]
1996	Beginning of production from Cascade field (Milne Point Unit) [20]
1999	Beginning of production from Eider field (Duck Island Unit), Tabasco field, Tarn field, and West Sak field (Kuparuk River Unit), and Badami field (Badami Unit) [20]
2000	Beginning of production from Midnight Sun field (Prudhoe Bay Unit) [20]
2001	Beginning of production from Alpine field: CD-1 and CD-2 pads (Colville River Unit) [20]
2002	Beginning of production from Northstar field (Northstar Unit), Aurora field, Borealis field, and Polaris field (Prudhoe Bay Unit), and Meltwater field (Kuparuk River Unit) [20]
2003	Beginning of production from Palm field (Kuparuk River Unit) [20]
2005	Beginning of production from Orion field (Prudhoe Bay Unit) and Ugnu field (Milne Point Unit) [20]
2006	Beginning of production from Raven field (Prudhoe Bay Unit) [20], 3-D seismic survey in Harrison Bay (Beaufort Sea) [21]
2008	Beginning of production from Fiord: CD-3 pad and Nanuq: CD-4 pad (Colville River Unit) [20]
2010	3-D seismic survey in Smith Bay (Beaufort Sea) [22], Beginning of production from Kaparuk field (Oooguruk Unit) [23]
2011	Beginning of production from Nuiqsut field (Oooguruk Unit) [24]
2012	Beginning of production from Schrader Bluff field (Nikaitchuq Unit) [25]

The 2003 NRC report quantified infrastructure supporting oil and gas production on the North Slope [1]. In 2014, the NRC numbers were updated to include estimates of North Slope infrastructure as recent as 2011 [6]. Table 4.2 provides a summary of the 2011 estimates. Table 4.2 does not include the infrastructure and operations associated with oil and gas activities in the Central North Slope and State Waters sub-region for projects that have been brought into production since 2011. Nor does the table include data about the exploration activities that have occurred in the sub-region, as this data was not available.

The NRC and the follow up study did not tabulate the number of wells that have been drilled on the North Slope. However, the Alaska Oil and Gas Conservation Commission (AOGCC), which keeps well data, reports that as of March 2011 there were 6,011 wells on the terrestrial portion of the Central North Slope and 35 wells in state waters [40]. These numbers include all well types (e.g., exploration, production, injection).

Table 4.2. Existing Central North Slope and State Waters oil and gas infrastructure in 2011

Type	Amount
Gravel road and causeway	423 miles/3,100 acres [6]
Other travel ways (peat roads, tractor trail/tundra scar, and exploration road)	189 miles [6]
Dalton Highway (North Slope portion only)	170 miles/332 acres [1]
Facilities (production, processing, support, and exploration)	400 facility pads/5,793 acres [6]
Airstrips	13 airstrip pads/358 acres [6]
Gravel offshore islands	20 offshore island pads/202 acres [6]
Gravel mines in rivers	5,385 acres [6]
Gravel mines in tundra	1,378 acres [6]
Pipeline corridors (in-field)	491 miles [6]
Trans-Alaska Pipeline (North Slope portion only)	166 miles [1]
Culverts	2037 [6]
Bridges	27 [6]
Active Landfills	1 [6]
Power transmission lines	336 miles [6]
Total directly disturbed ground	18,357 acres [6]

4.2 Planned infrastructure and operations

In 2012, the United States Army Corps of Engineers Alaska District (USACE) completed an environmental impact statement (EIS) [29] and issued an activity permit [41] for the development of a planned hydrocarbon production facility at the Point Thomson field in the eastern portion of the Central North Slope.[10] Although the planned infrastructure is on state land, the need for federal assessments and permits was triggered by the fact that some of the development activities (including construction, dredging, and waste discharge) would affect waters and wetlands subject to the federal Clean Water Act. Taken together, the EIS and the permit present an estimate of some of the infrastructure and operations required for the development and production phases of Point Thomson. Table 4.3 presents a summary of the data from the two documents. Point Thomson infrastructure is under development at the time of writing. As of May 2013, the State of Alaska Department of Natural Resources (ADNR), Division of Oil and Gas suggests that Point Thomson production will begin in the winter of 2015-2016 [42].

There are many ongoing seismic explorations, incremental expansions of existing developments, and new developments in satellite areas of currently producing fields planned in the Central North Slope. Such relatively small developments and operations are difficult to track in detail, in part because they do not trigger major federal impact assessments. The North Slope Oil and Gas Activity Map produced by ADNR for December 2013 [43], however, provides some data about such planned infrastructure in this sub-region, which are summarized in table 4.4.

10 *For an explanation of how this report distinguishes between existing, planned, and proposed infrastructure, please see the* Definition of key terms *section of the Introduction chapter.*

Table 4.3. Planned Point Thomson infrastructure as of 2012

Type	*Amount*
Gravel pads	55.3 acre Central Pad [29][1] 20.9 acre East Pad [29] 20.6 acre West Pad [29] 6.81 acres of additional pads [29][2]
Airstrip and helipad	42.3 acres [29]
Gravel roads	10.1 miles [29]
Pipelines	12-inch export pipeline: 23 miles [28] 8-inch infield gathering pipelines: 10 miles [28] Vertical support members for pipelines: .13 acres [29]
Gravel mine	48.9 acres infield gravel mine [29] yielding 2.2 million cubic yards of gravel [28]
Other infrastructure	Pier: 120 feet by 30 feet, 5 mooring dolphins, and 1,500 cubic yards of dredging [28] Dredged material deposit: 1.4 acres [29] Emergency boat launch: .05 acres [29] Wildlife corridor: .25 acres [29] Electrical trenching: .41 acres [29] Culvert scour protection: .09 acres [29] Gravel stockpile: 5.2 acres [29]
Development phase operations and seasonal infrastructure	11,000 vehicle trips, including 300 barge trips [28] 129 miles of seasonal ice road for pipeline construction, equipment transport, and supplies (up to 3 years) [28] 23 miles of seasonal infield ice roads throughout production phase [28]

1 *This number includes 12.9 acres of existing pad (PTU-3)*
2 *This number includes 4.1 acres of existing pad (Alaska C-1 pad)*

Table 4.4. Planned infrastructure and operations in the Central North Slope and State Waters as of 2013

Infrastructure	Location	Activity Phase
22 wells	Mustang field (South Miluveach Unit)	Development, expect to begin production in late 2014
24 wells and pad, access road, gravel mine, pipelines, power lines	Shark Tooth field (Kupaurk River Unit)	Development, expect to begin production in late 2015
2 wells	Qugruk field (east of Colville River Unit)	Exploration
1 well	Southeast of Kuparuk River Unit	Exploration
3-D seismic survey of shale formations (mileage unknown)	Along Dalton highway, south of existing Units	Exploration
293 square miles of 3-D seismic survey	Schrader Bluff, south of Kupaurk River Unit	Exploration
280 square miles of 3-D seismic survey	Southeast of Badami Unit and south of Point Thomson Unit	Exploration
Up to 8 wells in 2014-2015 and surveys (mileage unknown)	Smith Bay in state waters offshore of NPR-A	Exploration

4.3 Proposed infrastructure and operations

As mentioned previously, oil and gas companies recently began exploring the potential of the Central North Slope to produce commercially viable oil and gas from formations of subterranean shale rock. Producing oil and gas from shale requires different techniques, infrastructure, and operations than production from the more conventional oil and gas fields in the Central North Slope. Hydraulic fracturing, commonly referred to as "fracking," is the primary technique for extracting oil and gas from shale. If shale production proves viable on the North Slope and fracking becomes a common activity in the region, it could trigger an expansion of industrial infrastructure and operations. In 2012 the United States Geological Survey (USGS) completed an estimate of recoverable oil and gas contained in the shale rocks of the Central North Slope and NPR-A [44]. However, a 2014 article from the oil and gas industry publication Petroleum News concludes that, "the feasibility of Alaska shale oil development remains an unknown [45]."

Since the 1970s, stakeholders such as State of Alaska government agencies, US government agencies, and private companies have been proposing development plans to build a natural gas pipeline and processing facilities that could bring the North Slope's gas reserves to market in an economically viable manner.[11] However, nothing has been built to date. A 2013 report from the Alaska Natural Gas Transportation Projects Office of the Federal Coordinator presents the main proposals that have recently emerged for commercializing the gas on Alaska's North Slope [46]. Table 4.5 summarizes the main proposals. The infrastructure and operations associated with proposed natural gas projects and shale oil and gas activities could fall within the boundaries of both the Central North Slope and of other sub-regions of Arctic Alaska.

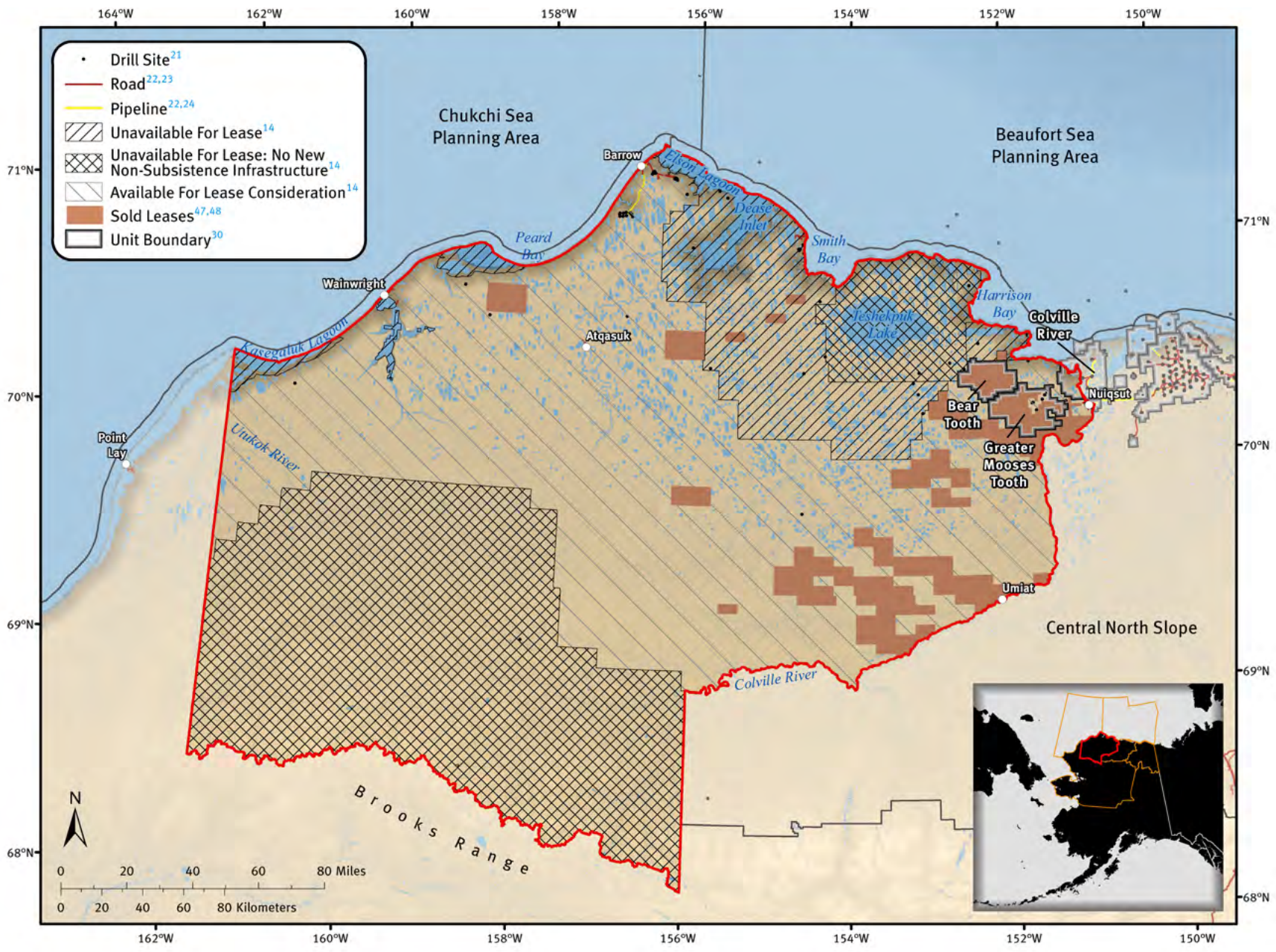
11 *Natural gas must be piped at a low temperature because of its physical properties, while oil must be piped at a higher temperature so it flows readily. Thus, the existing TAPS cannot be used to transport economically viable quantities of natural gas and a dedicated gas pipeline or trucking operation would be required for production.*

Table 4.5. Recent proposed projects for commercializing North Slope natural gas

Main concept	*Infrastructure and operations*	*Project status*
Pipe gas to Nikiski, Alaska where it would be processed for sale to Asian markets via shipping	800 mile long pipeline, mostly buried, paralleling TAPS from Prudhoe Bay to Fairbanks, then cutting south to Nikiski on the Kenai Peninsula, a processing plant	Being assessed for feasibility
Pipe gas to Alberta, Canada where it would enter an existing pipeline system for sale to US markets	1,700 mile long pipeline, buried, paralleling TAPS from Prudhoe Bay to Delta Junction (southeast of Fairbanks) and then cutting southeast to Alberta	On hold
Pipe gas to southcentral Alaska where it would be processed and sold to the Alaskan market	737 mile long pipeline, buried, paralleling TAPS from Prudhoe Bay to the Big Lakes area (north of Anchorage), a processing plant	Being actively pursued
Truck gas to Fairbanks, Alaska where it would be sold to markets in the state's interior	A processing plant on the North Slope, storage tanks in Fairbanks, and a fleet of trucks operating continuously along the Dalton Highway	Being actively pursued

Deadhorse and the Prudhoe Bay industrial complex for oil & gas exploration and production. *©Paul Andrew Lawrence, http://www.paulcolor.com.*

Map 4: National Petroleum Reserve – Alaska



5. NATIONAL PETROLEUM RESERVE – ALASKA

5.1 Existing infrastructure and operations

Despite its name, NPR-A has seen relatively little oil and gas infrastructure and operations compared to the Central North Slope and State Waters sub-region. AOGCC reports that there were 122 hydrocarbon wells (of all types combined) in NPR-A as of March 2011 [40]. However, BLM reports that 136 test holes were drilled in NPR-A before official leasing began in 1982. These older wells are known as legacy wells [49]. The degree of overlap between the legacy wells reported by BLM and wells reported by AOGCC is not known. Aside from the non-exporting oil and gas production facilities around the village of Barrow, there are no producing developments inside NPR-A at the time of writing. Some of the major oil and gas activities that have occurred in NPR-A are presented in table 5.1. These events include formation of the first two federal Units, beginning in 2008, and completion of the most recent NPR-A management plan in 2012.

Table 5.1. Existing oil and gas activities in NPR-A

Year(s)	Event
1950	Beginning of production from South Barrow field (non-export) [20]
1976	Naval Petroleum Reserve No. 4 becomes NPR-A managed by BLM, USGS launches major exploration efforts in NPR-A [19]
1981	Beginning of production from East Barrow field (non-export) [20]
1982	Beginning of leasing in NPR-A [19]
1985	First industry exploration well drilled in NPR-A [19]
1993	Beginning of production from Walakpa field (non-export) [20]
2008	Formation of first federal oil and gas Unit (Greater Mooses Tooth) in NPR-A [22], first discoveries and wells drilled in Greater Mooses Tooth Unit [36], continued seismic survey activities around Umiat on southeast border of NPR-A [22]
2009	Formation of Bear Tooth Unit in NPR-A (adjacent to Greater Mooses Tooth Unit) [37]
2010	USGS finishes an updated assessment of oil and gas reserves in NPR-A [38]
2012	Completion of most recent NPR-A comprehensive management plan and EIS
2013	First discoveries and wells drilled in Bear Tooth Unit [30]

5.2 Planned infrastructure and operations

The boundary of the Colville River Unit (introduced in Chapter 4) extends across the eastern border of NPR-A. There are plans to expand the existing infrastructure in this Unit westward into NPR-A boundaries. Permits have been issued to build industrial crossings of the Colville River, which constitutes NPR-A's border with the Central North Slope. Construction of a production facility called CD-5 is scheduled to begin in the first part of 2014, according to ADNR [43]. ADNR reports that planned infrastructure and operations in NPR-A for 2014 also include drilling up to three additional appraisal wells at Umiat and 280 square miles of seismic surveying south of the Colville River and Greater Mooses Tooth Units [43]. Additionally, initial permitting has begun for a 33-well gravel pad (called GMT-1) in the Greater Mooses Tooth Unit that will be connected to the CD-5 facility by a gravel road [53].

5.3 Proposed infrastructure and operations

BLM's 2012 Final Integrated Activity Plan/Environmental Impact Statement (FIAP/EIS) provides an estimate of the infrastructure and operations that could be needed for exploration, development, and production of the estimated known oil and gas reserves within NPR-A [14]. The plan states that BLM's figures "provide realistic and conservative estimates for impact analysis that make it very unlikely that this FIAP/EIS will underestimate the impacts [14, pg. 71]." Table 5.2 presents a summary of the estimate from the FIAP/EIS for BLMs preferred development alternative B-2. The estimate includes proposed activities for the Greater Mooses Tooth Unit, the Bear Tooth Unit, and Umiat.

Proposed offshore oil and gas developments discussed in the following two chapters (Chukchi Sea OCS and Beaufort Sea OCS respectively) could affect the amount of infrastructure and operations that eventually occur within NPR-A. Offshore developments in federal waters could require the construction of connecting pipelines and roads that cut across portions of NPR-A in order to transport oil and gas from offshore production facilities to the existing infrastructure and TAPS at the Prudhoe Bay field. However, such infrastructure and operations were not estimated by BLM's 2012 FIAP/EIS. In addition, the State of Alaska's Roads to Resources Initiative, specifically the Foothills West Transportation Access project, could spur industrial development in NPR-A by providing increased terrestrial access to the sub-region. This issue is covered in greater detail in Chapter 9.

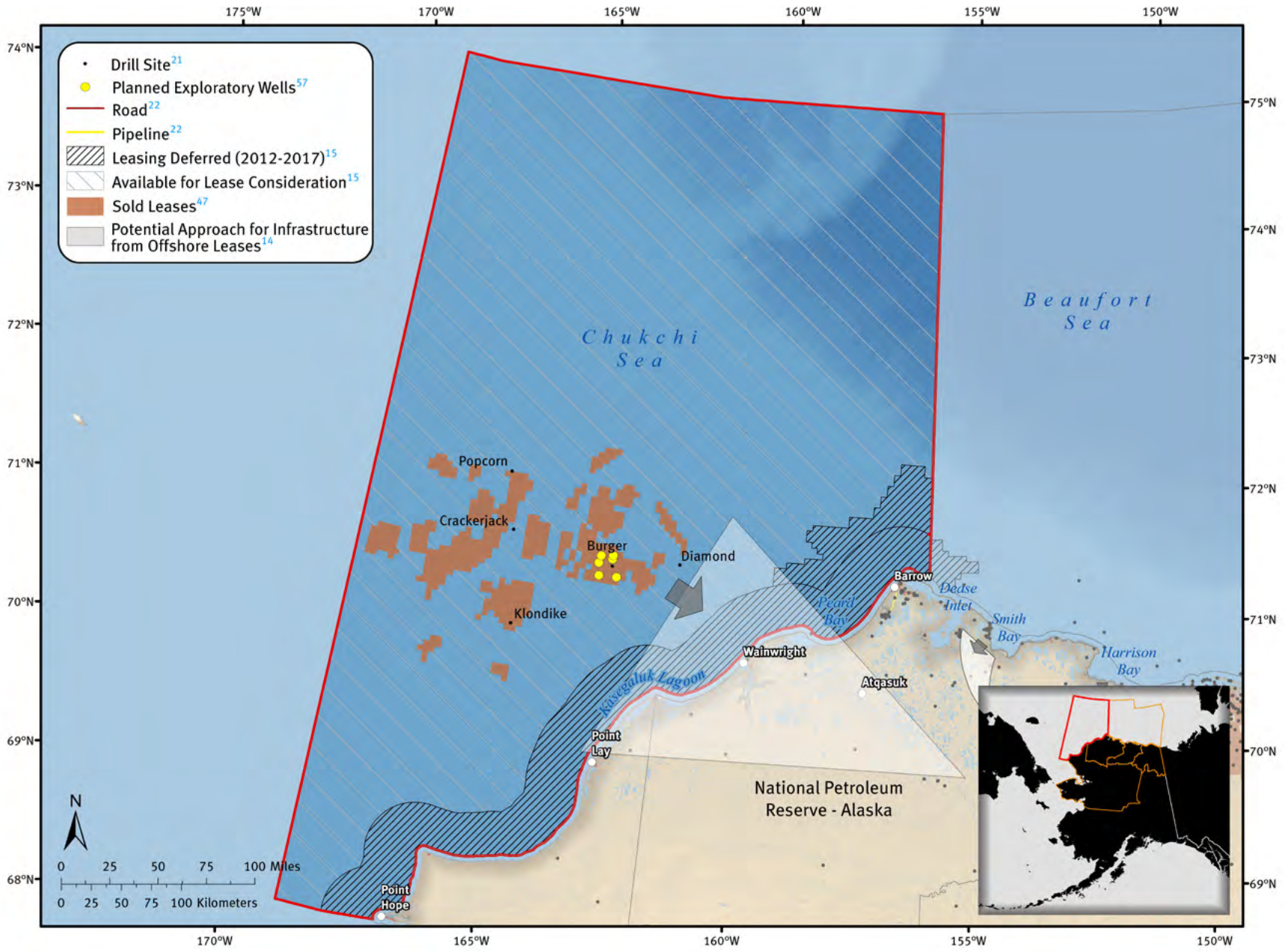
Trans-Alaska Oil Pipeline

Table 5.2. Proposed infrastructure and operations supporting oil and gas production in NPR-A

Type	***Amount[1]***
Wells (oil and gas exploration)	152 wells/912 acres (short term)[2]
Central processing facilities	8 /320 acres (long term)
Gravel production pads (oil and gas)	82/580 acres (long term)
Wells (oil and gas production)	705 wells (no additional acreage) [42]
In-field gravel roads	566 miles/4,245 acres (long term)
Gravel runways	27/297 acres (long term)
Pipelines	1,520 miles/8002 acres (short term), 1,653 acres (long term)
Pump stations and staging bases	5 /160 acres (long term)
Gravel pits	≤ 31/1,125 acres (long term)
Ice roads/snow packed trails	59,342 miles/249,246 acres (short term)
Ice air strips	65/715 acres (short term)
Surveying (2-D and 3-D) and camp train	61,093 miles/581,397 acres (short term) [41]
Total short term disturbed land area	846,661 acres[3]
Total long term disturbed land area	8,402 acres

1 *Data from [40] unless marked otherwise*
2 *[40] explains, "Short-term activities are commonly associated with the footprint during winter exploration or construction, while the long-term acreage figures reflect the gravel footprint of the development [pg. 71]."*
3 *Combined total of seismic surveying from [41] and exploration from [40]*

Map 5: Chukchi Sea Outer Continental Shelf Oil and Gas Planning Area



6. CHUKCHI SEA OUTER CONTINENTAL SHELF

6.1 Existing infrastructure and operations

To date, there are five decommissioned and abandoned exploration wells in the Chukchi Sea OCS, which were drilled between 1989 and 1991 [15], and the top hole of one well that was drilled in 2012 at the Burger prospect [58]. The existing wells are spread around five oil and gas prospects called Burger, Klondike, Crackerjack, Popcorn, and Diamond. Table 6.1 presents a timeline for selected existing oil and gas infrastructure and operations in the sub-region.

6.2 Planned infrastructure and operations

In recent years, oil and gas companies have submitted applications for industrial activities in this sub-region, and Shell conducted limited drilling activities in the Chukchi Sea OCS in 2012. At the time of writing, however, there are no active plans to conduct oil and gas activities in the Chukchi Sea OCS. The next potential lease sale is scheduled for 2016 [15].

6.3 Proposed infrastructure and operations

BOEM and its predecessor agency, the Minerals Management Service (MMS), have generated multiple estimates of proposed infrastructure and operations in the Chukchi Sea OCS over the years. BOEM's most recent estimate, the 2012 *Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017 Final Programmatic Environmental Impact Statement* [16], presents estimates for (1) the infrastructure that could be built over the next 40-50 years specifically as a result of the 2012-17 program and (2) infrastructure that could be built over the next 40-50 years in the cumulative case scenario, which includes all past and potential oil and gas infrastructure from all past and potential lease sales in the sub-region, within the given time frame. Regarding the estimates, BOEM states, "It should be noted that the cumulative case scenario ... reflects inherent uncertainty about the future of OCS oil and gas activities. ... [F]uture activity is unpredictable and could span a considerable range [pg. 4-660]." Table 6.2 provides a summary of the cumulative case data and includes the pipeline that could be required to connect offshore production facilities to existing infrastructure by cutting across NPR-A.

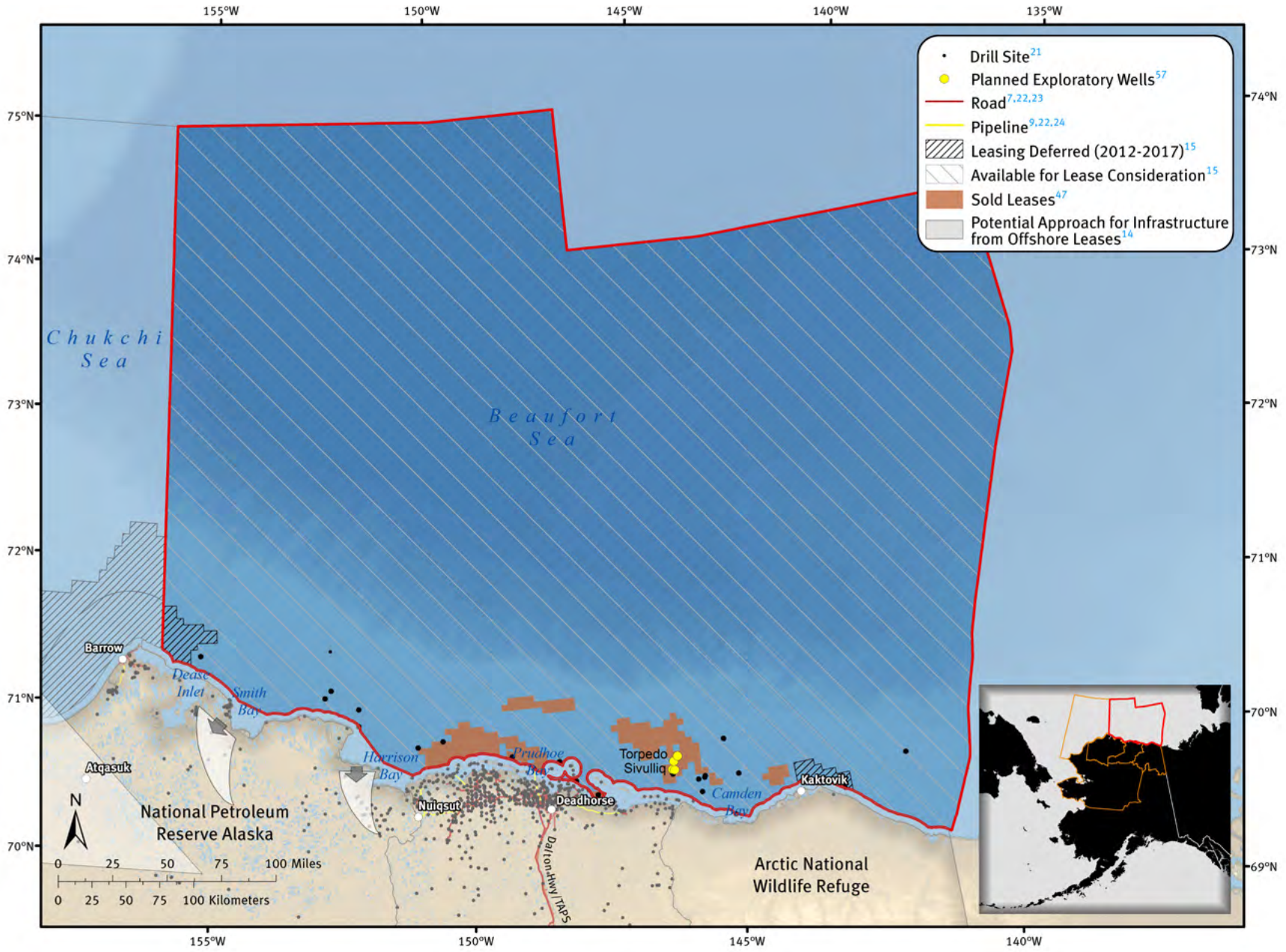
Table 6.1. Existing oil and gas activities in the Chukchi Sea OCS

Year(s)	*Event*
1989-1991	First five exploration wells drilled [15]
2008	Lease sale 193 (most recent lease sale)
2012	BOEM completes most recent five year plan covering 2012-2017 [15], Drilling of top hole at Burger-A prospect [58]
2016	Next potential lease sale [43]

Table 6.2. Proposed infrastructure and operations supporting oil and gas production in the Chukchi Sea OCS

Type	*Amount*
Production platforms	3-16 structures
Exploration wells	12-54
Production wells	234-1,115
New offshore pipeline	150-1,000 miles
New onshore pipeline	250-500 miles
New waste facilities	2-4
New gas processing facilities	2-4
Dock/causeways	2-4
Vessel trips per week (service and helicopter)	6-96
Total offshore bottom area disturbed	10-60 acres (platform footprint), 518-3,459 (pipeline construction)
Total terrestrial area disturbed	4,510-9,019 acres (pipeline construction)

Map 6: Beaufort Sea Outer Continental Shelf Oil and Gas Planning Area



7. BEAUFORT SEA OUTER CONTINENTAL SHELF

7.1 Existing Infrastructure and operations

To date, there are 30 decommissioned and abandoned exploration wells in the Beaufort Sea OCS, which were drilled between 1981 and 2002 [15], and the top hole of one well that was drilled in 2012 at the Sivulliq prospect [58]. The Northstar production island and its buried pipeline to land are located in state waters but the facility produces from oil and gas fields that are covered by both state and federal leases. Table 7.1 provides a timeline of selected oil and gas activities in the Beaufort Sea OCS.

7.2 Planned infrastructure and operations

Shell conducted limited drilling activities in the Beaufort Sea OCS in 2012, and there have been a number of proposals to drill specific wells in the recent past. At the time of writing, none of these existing proposals is active, and there are no planned oil and gas activities in the Beaufort Sea OCS. The next potential lease sale is scheduled for 2017 [15].

7.3 Proposed infrastructure and operations

In 2002, MMS completed an EIS for the proposed development of an oil production facility at the Liberty Unit, which is located in federal waters eight miles east of the Endicott field [28]. The 2002 EIS assessed a proposal that centered on the development of an offshore island that would house the production facilities and connect to existing infrastructure via buried pipelines, similar to the Northstar project. This proposal, however, was later rejected in favor of a proposal that centered on ultra extended reach drilling from the existing Endicott facilities (in state waters) to access the oil in the Liberty field. The second proposal for developing the Liberty Unit, however, was also rejected due to feasibility issues. The most recent proposal again calls for the construction of an offshore island in federal waters with buried pipelines connecting to shore. At the time of writing, BSEE has required that the newest proposal be submitted by the end of 2014 [59].

In addition to the potentially forthcoming proposal for developing the Liberty Unit, the EIS for BOEM's most recent five year program [16] estimates some of the infrastructure and operations that would be required for developing the known estimated oil and gas reserves in the Beaufort Sea OCS. As was the case for the Chukchi Sea OCS, the five-year program presents estimates for (1) the infrastructure that could be built over the next 40-50 years specifically as a result of the 2012-2017 program and (2) infrastructure that could be built over the next 40-50 years in the cumulative case scenario, which includes all past and potential oil and gas infrastructure from all past and potential lease sales in the sub-region, within the given time frame. Once again, BOEM cautions that "the cumulative case scenario ... reflects inherent uncertainty about the future of OCS oil and gas activities. ... [F]uture activity is unpredictable and could span a considerable range [pg. 4-660]." Table 7.2 presents a summary of the data from the cumulative case, which includes BOEM's estimates for development of the Liberty Unit and pipeline to connect to existing infrastructure.

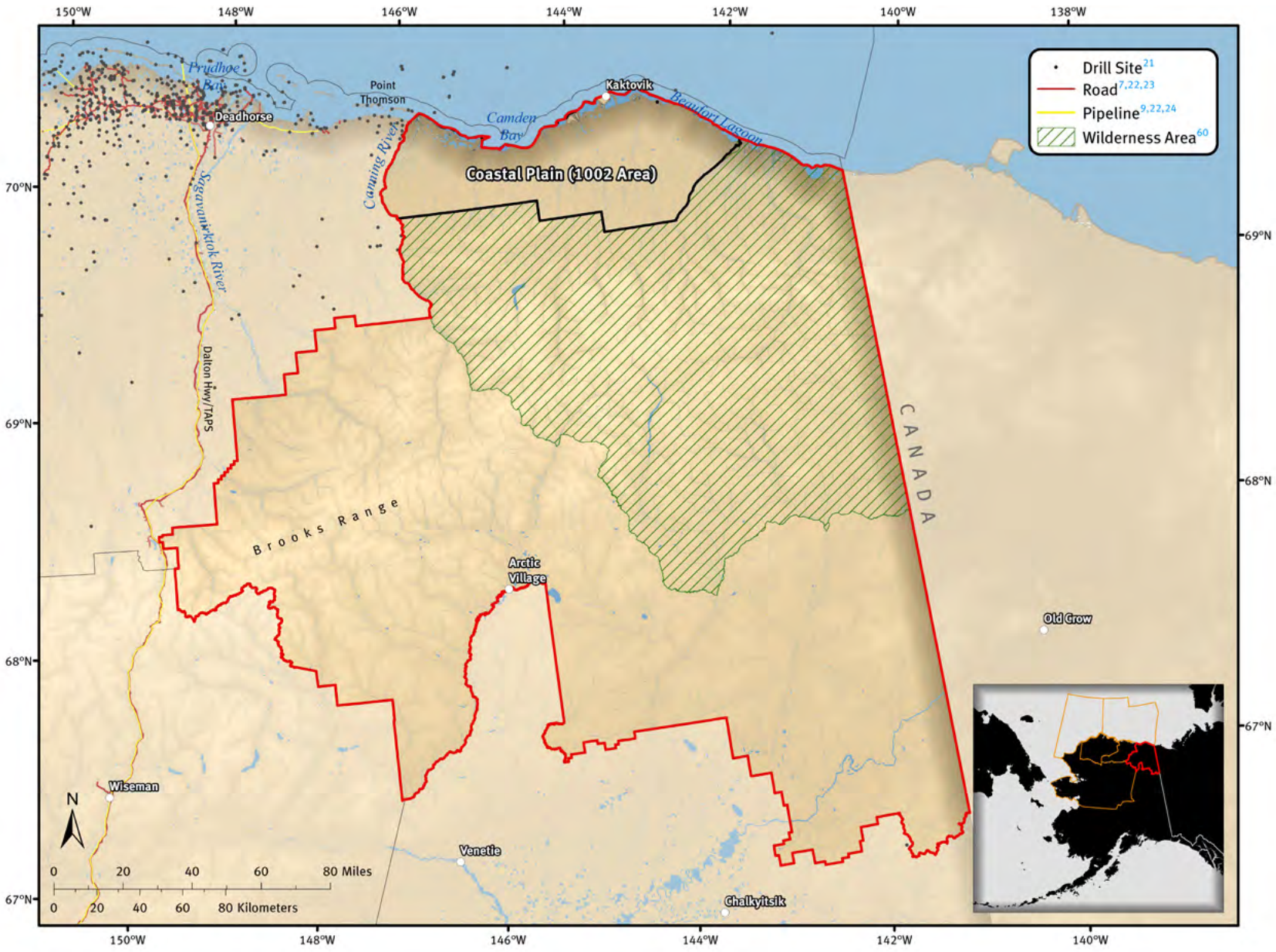
Table 7.1. Existing oil and gas activities in the Chukchi Sea OCS

Year(s)	*Event*
1979	Initial leasing of Beaufort Sea OCS federal waters [15]
1981	First exploration well drilled [15]
2007	Lease sale 202 (most recent lease sale)
2008	Seismic survey in Beaufort Sea Outr Continental Shelf, including around Liberty Unit [36]
2012	BOEM completes most recent five year plan, covering 2012-2017, drilling of top hole for well at Sivulliq prospect (north of Point Thomson Unit) [58]
2017	Next potential lease sale [43]

Table 7.2. Proposed infrastructure and operations supporting oil and gas production in the Chukchi Sea OCS

Type	*Amount*
Production platforms	2-10 structures
Exploration wells	12-40
Production wells	110-335
New offshore pipeline	50-423 miles
New onshore pipeline	40-290 miles
New waste facilities	2-4
New gas processing facilities	2-4
Dock/causeways	2-4
Vessel trips per week (service and helicopter)	4-60
Total offshore bottom area disturbed	7.4-37 acres (platform footprint), 173-1,470 (pipeline construction)
Total terrestrial area disturbed	717-4,510 acres (pipeline construction)

Map 7: Arctic National Wildlife Refuge



8. ARCTIC NATIONAL WILDLIFE REFUGE

8.1 Summary of current status

The US National Wildlife Refuge System promotes conservation, management, and restoration of the Nation's wildlife, fish, and plant species for the enjoyment of current and future generations of Americans. The Arctic National Wildlife Refuge (ANWR) was originally set aside for refuge purposes in 1957, prior to Alaska statehood, and then officially established in 1960. ANWR was expanded in size and acquired many of its current features in 1980 with President Carter's signing of ANILCA [46].[12] ANILCA's stated purposes for the Arctic Refuge include:

> *(i) to conserve fish and wildlife populations and habitats in their natural diversity...;*
> *(ii) to fulfill the international fish and wildlife treaty obligations of the United States;*
> *(iii) to provide the opportunity for continued subsistence uses by local residents; and*
> *(iv) to ensure water quality and necessary water quantity within the refuge [section 303].*

In addition to defining these purposes for ANWR, ANILCA designated eight million acres of the existing refuge as Wilderness, which guarantees the highest level of protection within the National Refuge System. However, a 1.5 million acre area between the refuge's northern coastline and the foothills of the Brooks Range (i.e., the Coastal Plain) was excluded from the Wilderness designation.

Section 1002 of ANILCA called for a comprehensive assessment of the Coastal Plain area, which is commonly referred to as the "1002 area." The assessment was to provide Congress with information about the area's fish and wildlife resources, the potential impacts of oil and gas activities on those resources, and an estimate of the area's oil and gas resource potential.

8.2 History of oil and gas activity

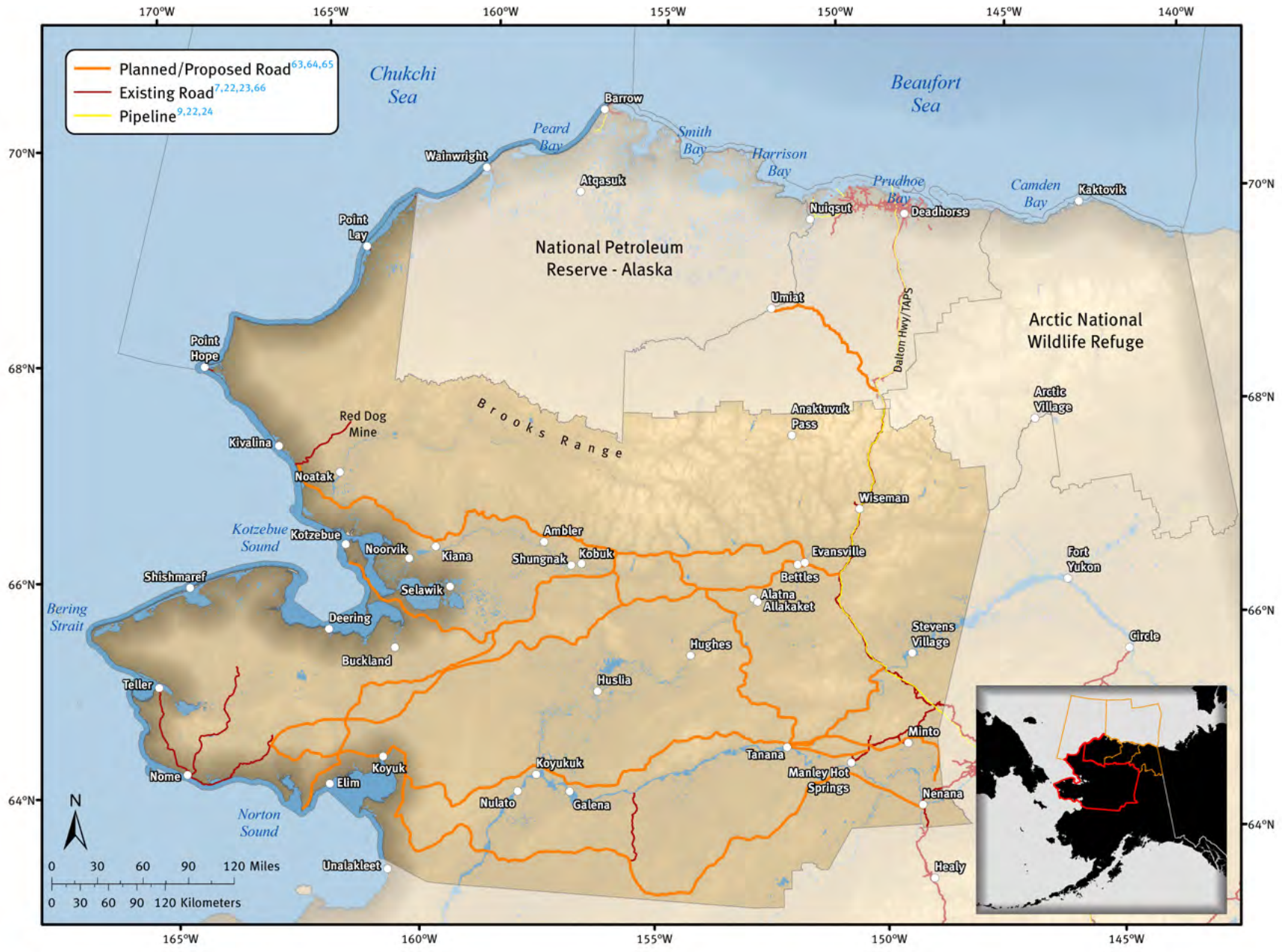
An oil and gas seismic exploration program for the 1002 area was conducted between 1983 and 1985 [17]. One exploration well was also drilled by oil companies on Native lands within ANWR boundaries but its results are proprietary. The data from seismic exploration have received multiple interpretations over the years and have led some stakeholders to conclude that the area could produce economically viable oil and gas. However, section 1003 of ANILCA states, "production of oil and gas from the Arctic National Wildlife Refuge is prohibited and no leasing or other development leading to production of oil and gas from the [Refuge] shall be undertaken until authorized by an act of Congress [61]."

While the federal status of ANWR with regard to oil and gas activities is clear, the State of Alaska is promoting exploration in the Coastal Plain (1002 area). In 2013, for example, ADNR, Division of Oil and Gas released a document called The Oil and Gas Resource Evaluation and Exploration Proposal for the Arctic National Wildlife Refuge 1002 Area [62]. The state's proposal urges the US Congress to open the 1002 area to exploration and lays out a seven-year exploration plan that includes, among other things, 3 D seismic survey of 3,305 square miles and the drilling of up to 16 exploration wells. While it is important to understand what ADNR has in mind for the future of ANWR, this report does not include the activities described above in the proposed category of infrastructure and operation because oil and gas activities are currently prohibited within the borders of ANWR.

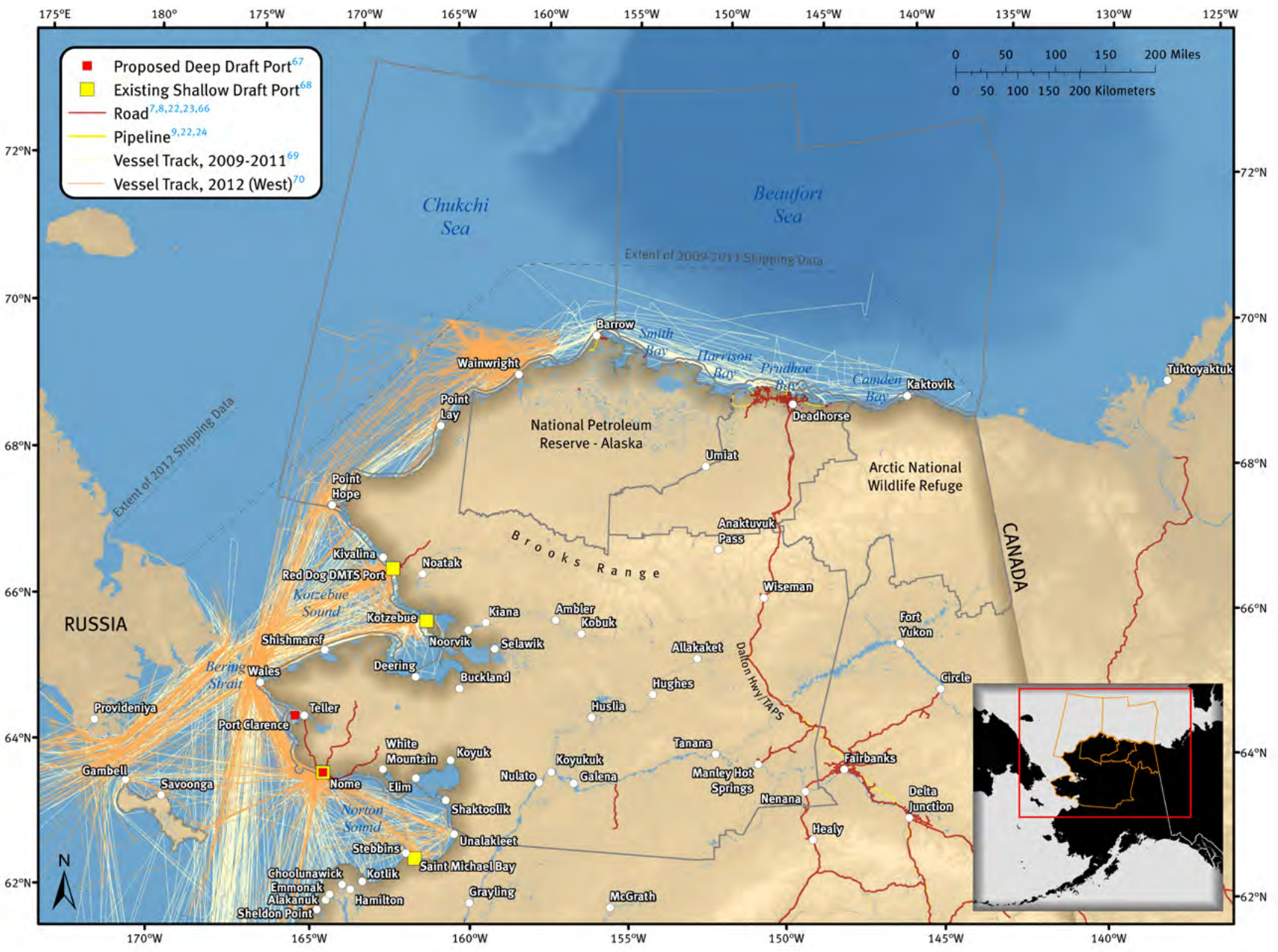
12 *ANILCA designated 18 million acres as part of ANWR, another one million were added in 1983, and 325,000 more acres in 1988 [41].*

Alaska Oil Tanker, Valdez, AK.

Map 8: Northwest Coastal and Interior Alaska



Map 9: Marine Vessel Traffic (2009-2012) and Deep Draft Ports in Arctic Alaska



9. NORTHWEST COASTAL AND INTERIOR ALASKA

9.1 Existing infrastructure and operations

According to the AOGCC database, a small number of abandoned oil and gas exploration wells are scattered around the Northwest Coastal and Interior Alaska sub-region [40]. However, neither the State of Alaska nor the federal government holds oil and gas lease sales in this region at this time. Infrastructure and operations in the sub-region related to commercial transportation, rather than oil and gas, is the focus of this chapter. Table 9.1 provides a timeline of some major activities that have occurred to date related to commercial transportation in the lands and waters of Northwest Coastal and Interior Alaska.

Table 9.1. Existing commercial transportation activities in Northwest Coastal and Interior Alaska

Year(s)	*Event*
1974	Completion of Dalton Highway [18]
1989	Beginning of operations at Red Dog mine main pit [48]
2011	Beginning of EIS for Roads to Resources Initiative [49] (suspended in 2013 because of changes made to project proposals) [31]
2012	Red Dog mine ends main pit production and begins production at Aqqaluk pit [48]
2013	Release of first year report for current assessment of deep draft port locations [50]

In addition to portions of TAPS and the Dalton Highway located south of the North Slope, there are three other major gravel roads in this sub-region. These roads originate near the city of Nome on the Seward Peninsula. Some of the roads around Nome were constructed in order to facilitate gold mining in the area (which began in the early 1900s and largely ended in the 1960s), while others serve primarily to connect existing communities [73].

Commercial transportation in this sub-region is driven in part by the Red Dog mine, located about 52 miles inland between the coastal villages of Kotzebue and Kivalina [71]. Red Dog mine extracts zinc and lead ore from open-pit sites. Lead and zinc concentrates are trucked from the mine site to a coastal port facility and then shipped to markets. The road from the mine to the port and the port itself are called the DeLong Mountain Transportation System (DMTS), owned by the Alaska Industrial Development and Export Authority (AIDEA). Because the waters surrounding the DTMS port are relatively shallow, long distance ore carriers have to anchor offshore in deeper waters, with shallow-draft barges being used to transfer materials into the carriers in a process called lightering. In addition to the port at Red Dog mine, the other primary ports in the region are shallow draft ports (<30 feet) at Kotzebue and Nome [74].

Marine vessel traffic is another component of transportation in the Northwest Coastal and Interior Alaska sub-region. Maritime activity in the area includes vessels engaged in commercial transportation (e.g., cargo ships. tankers, and ice breakers), scientific research vessels, pleasure vessels, and other boats. Annually there are over 400 transits of marine vessels through the Bering Strait, a number that includes both commercial vessels and non-commercial vessels, such as military, research, and law-enforcement vessels [67]. The number of large commercial vessels passing through the Bering Strait annually has been estimated at closer to 150 (excluding fishing vessels which are usually smaller) [74].

The Marine Exchange of Alaska monitors marine vessel traffic in Alaska's waters. Table 9.2 presents a summary of Marine Exchange data for the years 2009, 2010, and 2011 [67]. The numbers in the table represent non-fishing vessels over 100 feet in length for the regions of the North Slope, Bering Strait, and Norton Sound combined. Table 9.2 also presents data on the Red Dog Mine and the gravel roads around Nome discussed above.

9.2 Planned infrastructure and operations

New commercial transportation in the Northwest Coastal and Interior Alaska sub-region is proposed by the Roads to Resources Initiative (R2R), led by the Alaska Department of Transportation and Public Facilities (ADOT&PF), which works with interested parties to "design and build projects that support development of natural resources in the oil and gas, alternative energy, mining, timber, fisheries, and agriculture industries [76]." While R2R is an ongoing program, as of early 2014 construction had begun on a new road that will eventually connect the western terminus of the Elliot Highway (near Manley Hot Springs) to an area of the Yukon River near the village of Tanana [77]. The Road to Tanana, as the project is named, is planned to be 36 miles long [78]. According to the 2010 state-sponsored *Western Alaska Access Planning Study*, the road is viewed as the first segment of a more extensive road project (described below), which will eventually connect to the roads around Nome on the Seward Peninsula. The larger project is intended to provide increased access to remote villages and promote the development of natural resources in the southern part the sub-region [79].

Table 9.2. Existing commercial transportation infrastructure and operations in Northwest Coastal and Interior Alaska

Type	Amount
Dalton Highway (south of North Slope)	244 miles[1]
TAPS (south of North Slope to end of Dalton Highway)	244 miles[2]
Roads around Nome [51]	72 miles: Teller Highway 86 miles: Kougarok Road 72 miles: Nome-Council Road
Red Dog mine [53][3]	1,531 acres disturbed (open-pits, waste areas, support facilities) 52 miles/616 acres disturbed: DMTS road and port 406.5 additional acres disturbed by Aqqaluk extension preferred alternative 48.9 vehicle trips per day on DMTS 27 ore carriers per year anchor in deep water offshore of the port 327 round trips for barges and tugs per year to load ore carriers 12 barges per year to supply mine Up to 11 fixed wing flights per week (between mine and other Alaska locations)
Marine vessel trips of non-fishing vessels over 100 feet [50]	602 in 2009 986 in 2010 678 in 2011
Bering Strait transits of all vessel types [50]	>400 per year

1 *This number was calculated by subtracting the number of miles on the North Slope presented in [1] from the total length of the Dalton Highway as reported in [18].*

2 *This is a very rough estimate made by this report based on the fact that TAPS runs roughly parallel to the Dalton Highway in this sub-region.*

3 *Estimates in [53] use data from 2006 (acres), 2003 (DMTS road trips), 2005 (marine vessel trips) and 2008 (fixed wing trips).*

Offshore Oil Rig, Cook Inlet, AK. ©Paul Andrew Lawrence, http://www.paulcolor.com.

9.3 Proposed infrastructure and operations

While the Road to Tanana is under construction at the time of writing, there are three additional R2R projects that fall in the proposed category. Table 9.3 presents ADOT&PF's description of the projects and their estimated lengths in miles.

Proposed infrastructure in the sub-region also includes an 11.2 mile two-lane gravel road between the village of Kotzebue and the coastal area of Cape Blossom to the south [81]. A 1983 feasibility study commissioned by the State of Alaska recommended Cape Blossom as the best location around Kotzebue to construct a deep-draft port in anticipation of the increased vessel traffic expected to accompany development of coal mining in the area. While coal mining around Kotzebue has not materialized to date, ADOT&PF reports that the EIS for the road to Cape Blossom has been completed and that the road project is currently in the design phase [81].

Another assessment of potential locations for a deep-draft port to serve Arctic Alaska is currently underway, and much of the assessment's study area falls within the Northwest Coastal and Interior Alaska sub-region. In 2013, ADOT&PF and USACE released their first-year report for the assessment [67]. Regarding the need for the assessment and the subsequent construction of a new port, the report states, "Marine Vessel traffic in the Arctic Ocean is growing dramatically with the thinning and retreat of the Arctic Ocean ice pack. This creates the potential for conflict, accidents, and incidents [67, pg. 9]." Accordingly, they contend that a deep-draft port is needed in the sub-region to enhance economic development, oil spill response capacity, community resupply, the US presence in the Arctic, and search and rescue capability in the region. While the study is not scheduled to conclude until late 2014, the first-year report recommended the Nome/Port Clarence area as the best location for a deep-draft port to serve Arctic Alaska. However, there presently are no quantified estimates of possible infrastructure or operations related to the proposed port system.

Proposed commercial marine vessel traffic in the Arctic that could affect Northwest Coastal and Interior Alaska is qualitatively summarized by the Arctic Council's 2009 Arctic Marine Shipping Assessment:

> *Arctic natural resource development (hydrocarbons, hard minerals and fisheries) and regional trade are the key drivers of future Arctic marine activity. ... Future Arctic marine activity will include many non-Arctic stakeholders [and] multiple users in Arctic waterways ... Offshore hydrocarbon developments may lead to increased marine traffic in the Bering Strait region [74, pg. 5].*

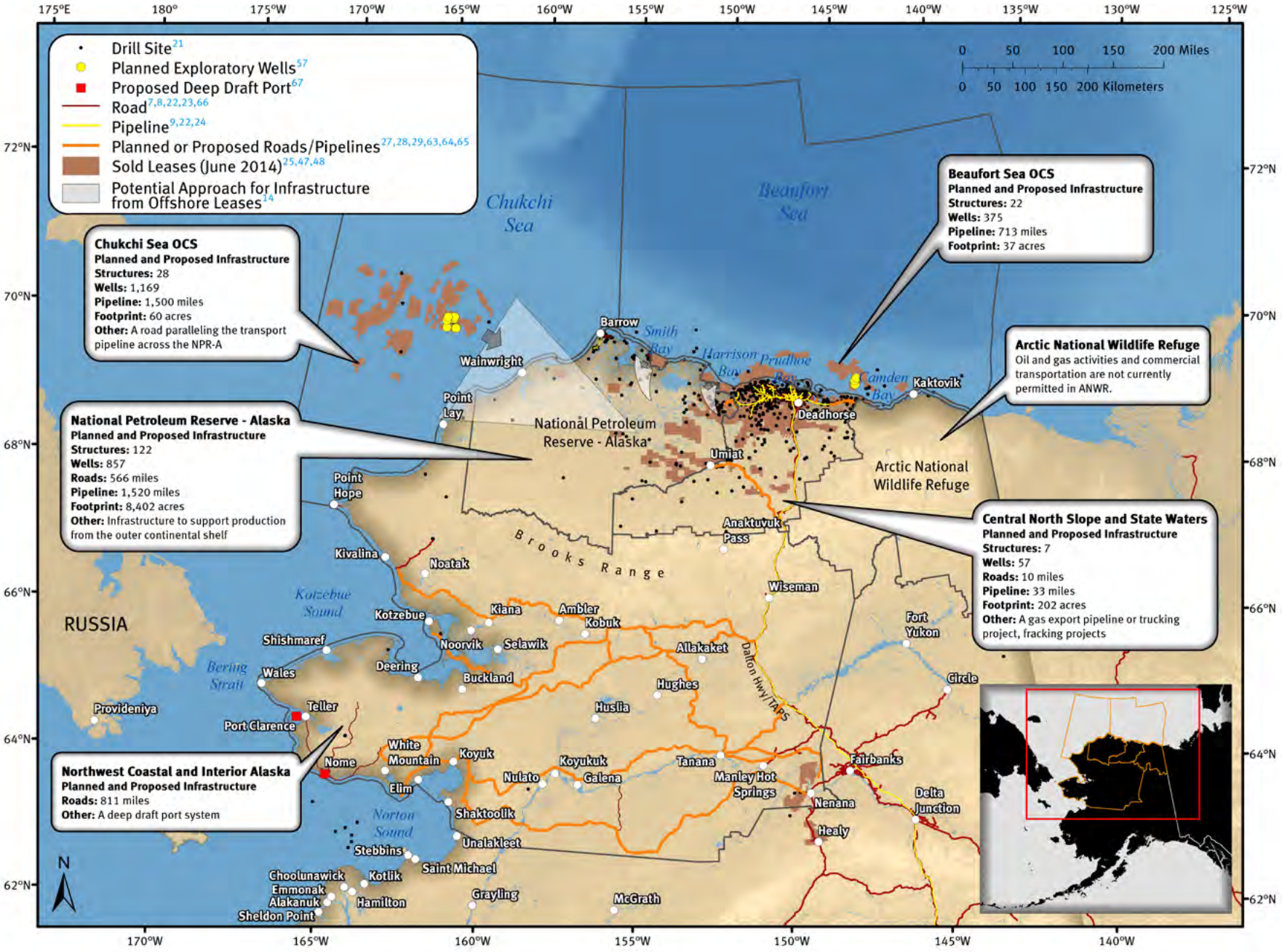
It has also been proposed that trans-Arctic shipping, i.e., shipping that uses the Arctic Ocean to link the Pacific Ocean with the Atlantic Ocean, will increase as sea ice decreases along the Northern Sea Route (north of the Russian Federation), the Trans-Arctic Sea Route (across the North Pole), and the Northwest Passage (north of Canada). Increased shipping and vessel activity along the Northern Sea Route has already been observed [74]. While there are no quantitative estimates of how further increases in trans-Arctic shipping could impact the industrial infrastructure and operations in Arctic Alaska, recent projections suggest that substantial increases to shipping will be possible for certain types of ships by 2050 [82].

Table 9.3. Proposed projects of the Roads to Resources Initiative

Name	Description	Estimated road length
Road to Nome (proposed expansion of the planned Road to Tanana)	"Overland access from Interior Alaska to the Seward Peninsula has long been a key element of Alaska's transportation planning ... to address national security, for economic development, and to improve community access to goods and services." [79]	500 miles [57]
Foothills West Transportation Access[1]	"This project will provide access to known gas and oil reserves on the north side of the Brooks Range, about 100 miles west of the Dalton Highway, [around Umiat]." [77]	100 miles [55]
Ambler Mining District Access	"This project is to provide an all-season transportation access road to promote exploration, development, and production of known mineral resources in the Ambler mineral belt." [77]	200 miles [58]

1 *This project would likely fall in the Central North Slope and State Waters sub-region, rather than the Northwest Coastal and Interior Alaska sub-region. However, it is presented here in order to keep all of the R2R projects in the same chapter.*

Map 10: Existing, Planned, and Proposed Infrastructure Supporting Oil and Gas Activities and Commercial Transportation in Arctic Alaska



10. ARCTIC ALASKA INFRASTRUCTURE SYNTHESIS

10.1 Introduction

This chapter provides readers with a quick reference guide to "what is" and "what could be" with regard to the industrial infrastructure in Arctic Alaska that supports oil and gas activities and commercial transportation. The chapter synthesizes the existing, planned, and proposed infrastructure that the previous six chapters present separately. Existing, planned, and proposed *operations*, however, are not presented here. While it would be ideal to include such a synthesis, the inconsistent and incomplete operations data contained in the source documents do not lend themselves to a reasonable comparative synthesis. Readers are nonetheless urged to consider operations when thinking about infrastructure and the future of Arctic Alaska (see Chapter 3 for a description and examples of the basic operations that accompany each stage of oil and gas production).

10.2 Synthesis Table

Table 10.1 shows comparable infrastructure data for the Arctic Alaska region as a whole and for the six sub-regions independently. Infrastructure is divided into existing, planned and proposed timeframes. Some potentially significant proposed infrastructure projects have not yet been quantified and cannot be included in the comparison. This is the case for (1) gas pipeline and trucking projects, (2) development of shale oil and gas, (3) a potential road that may parallel a future pipeline cutting across NPR-A to support OCS development in the Chukchi Sea, and (4) construction of a deep-draft port. These projects are described in the Comments column of the table and must be considered when analyzing different futures for the region.

Infrastructure data have been grouped into five main categories and rounded to the nearest whole number for ease of comparison. Data sources are provided in brackets. Data adhere to the following descriptions unless noted otherwise:

- **Structures:** indicates the number of structures and includes gravel pads, gravel islands, gravel airstrips, gravel helipads, bridges, and facilities (e.g., pump stations).
- **Wells:** indicates the number of oil and gas wells and includes all types (e.g., exploration, production, injection, abandoned).
- **Roads:** indicates miles of road, causeway, and tundra scar.
- **Pipeline:** indicates miles of pipeline.
- **Footprint:** indicates the acreage covered by infrastructure and, where available, gravel-borrow sites; excludes acres that are temporarily disturbed (e.g., by exploration activities that do not disturb the environment in continuing ways).[13]

13 *There is an ongoing debate in the scientific community over how to categorize the impacts of some oil and gas activities. This report reproduces the terminology used by the cited references to describe impacts.*

Conoco Phillips Oil Field. *©Paul Andrew Lawrence, http://www.paulcolor.com.*

Table 10.1. Synthesis of existing, planned, and proposed infrastructure for Arctic Alaska and each sub-region

Entire Region

	Existing Infrastructure		Planned Infrastructure		Proposed Infrastructure		Comments
Arctic Alaska	Structures	460	Structures	7	Structures	349	Acres of temporarily disturbed land and sea (from industrial activities such as oil and gas exploration) are not represented in this table.
	Wells	6,215	Wells	57	Wells	2,401	
	Roads	1,138 miles	Roads	21 miles	Roads	1,365 miles	
	Pipeline	901 miles	Pipeline	33 miles	Pipeline	3,733 miles	
	Footprint	18,454 acres	Footprint	202 acres	Footprint	8,499 acres	

Sub-regions

	Existing Infrastructure		Planned Infrastructure		Proposed Infrastructure		Comments
Central North Slope and State Waters	Structures	460 [6]	Structures	7 [29] [31]	Structures	-	These numbers do not include the proposed gas pipeline (ranging from 737 miles to 1,700 miles, but not all in this sub-region) or the proposed shale developments. The State of Alaska does not provide comprehensive projection of additional infrastructure for incremental expansion within existing Units or new development from current leases.
	Wells	6,046 [27]	Wells	57 [31]	Wells	-	
	Road	612 miles [6]	Road	10 miles [29]	Road	-	
	Pipeline	657 miles [6] (pipeline corridor)	Pipeline	33 miles [29]	Pipeline	-	
	Footprint	15,900 acres (this is a projection for 2012 from [11])	Footprint	202 acres [29]	Footprint	-	
NPR-A'	Structures	-	Structures	-	Structures	122 [11]	These numbers only include production from within NPR-A and do not include estimates for infrastructure supporting proposed OCS production from federal offshore waters.
	Wells	122 [27]	Wells	-	Wells	857 [11]	
	Road	-	Road	-	Road	566 miles [11]	
	Pipeline	-	Pipeline	-	Pipeline	1,520 miles [11]	
	Footprint	-	Footprint	-	Footprint	8,402 acres [11]	

Sub-regions, cont.

	Existing Infrastructure		Planned Infrastructure		Proposed Infrastructure		Comments
Chukchi Sea OCS[2]	Structures	-	Structures	-	Structures	28 [13]	These numbers do not include a road that could run parallel to the proposed onshore pipeline that would cross NPR-A to connect proposed offshore infrastructure to existing onshore infrastructure [5].
	Wells	5 [12] (does not include top hole drilled in 2012 [43])	Wells	-	Wells	1,169 [13]	
	Road	-	Road	-	Road	-	
	Pipeline	-	Pipeline	-	Pipeline	1,500 miles [13]	
	Footprint	-	Footprint	-	Footprint	60 acres [13]	
Beaufort Sea OCS	Structures	-	Structures	-	Structures	22 [13]	These numbers assume that any infrastructure from the proposed Liberty project is included in the estimates from [7].
	Wells	30 [12] (does not include top hole drilled in 2012 [43])	Wells	-	Wells	375 [13]	
	Road	-	Road	-	Road	-	
	Pipeline	-	Pipeline	-	Pipeline	713 miles [13]	
	Footprint	-	Footprint	-	Footprint	37 acres [13]	
ANWR	Structures	-	Structures	-	Structures	-	Oil and gas activities and commercial transportation are not permitted in ANWR.
	Wells	1 [8]	Wells	-	Wells	-	
	Road	-	Road	-	Road	-	
	Pipeline	-	Pipeline	-	Pipeline	-	
	Footprint	-	Footprint	-	Footprint	-	
Northwest Coastal and Interior Alaska	Structures	-	Structures	-	Structures	-	These numbers do not include the acres impacted by the proposed deep-draft port.
	Wells	11 [27]	Wells	-	Wells	-	
	Road	526 miles (see table 9.2 for references)	Road	11 miles [56]	Road	800 miles (see table 9.3 for references)	
	Pipeline	244 miles (see table 9.2 for references)	Pipeline	-	Pipeline	-	
	Footprint	2,554 acres (includes Red Dog mine open pits [53])	Footprint	-	Footprint	-	

1 *Planned NPR-A data (including the GMT-1 development that is the permitting phase) were omitted from this table in order to avoid double counting. The NPR-A proposed estimates cover that infrastructure that would be in the planned category.*

2 *Proposed infrastructure in the Chukchi Sea OCS and Beaufort Sea OCS represent the high-end of BOEM's estimated ranges.*

10.3 Summary

Industrial infrastructure in Arctic Alaska related to oil and gas production and commercial transportation has expanded substantially since the first commercial wells were drilled in the early 1960s. Today, the existing estimated footprint of oil and gas infrastructure totals well over 18,000 acres. At the time of this writing, expansion of oil and gas infrastructure continues as the industry develops specific projects located at the outer edges of the existing infrastructural complex. For example, infrastructure is expanding to the east in the form of the Point Thomson project and to the west through the ongoing development of the Colville River and Greater Mooses Tooth Units within NPR-A. Simultaneously, oil and gas exploration activities continue to the north (in multiple offshore environments) and to the south of existing infrastructure (in the foothills of the Brooks Range). Commercial transportation infrastructure is also expanding, as construction crews build the road from the Manley Hot Springs area to Tanana. These construction projects and others are categorized as "planned infrastructure" in this report. They are relatively modest in scope and size, adding to the extent of existing infrastructure by only a few percent. Nonetheless, these projects represent the latest stages of a long-term trend of incremental expansion of industrial infrastructure in the region.

If the projects captured in the "proposed infrastructure" category proceed, it would result in a considerably larger expansion of industrial infrastructure. As mentioned throughout this report, there is a high degree of uncertainty about the future of industrial infrastructure in Arctic Alaska. For that reason, it is impossible to predict which projects will go forward, what they will look like, and when they will be developed. However, if "proposed infrastructure" projects develop in the manner described in state and federal analyses, the extent of Arctic Alaska's industrial infrastructure would increase significantly. The number of structures would almost double, from 460 to 816. The number of wells would increase by around one third, from 6,215 to 8,673. Miles of road would more than double, from 1,138 to 2,503. Miles of pipeline would more than quadruple, from 901 to 4,667. Lastly, the infrastructure footprint would increase by about half, with over 27,000 acres of Arctic Alaska ultimately being directly covered or excavated for industrial development. The area and resources affected by that infrastructure footprint—what the NRC refers to as "zones of influence"—would be considerably greater [1, pg. 9].

Importantly, the numbers in the preceding paragraph do not take into account potential infrastructure from a number of significant proposed projects. For example they do not include a North Slope gas pipeline or trucking project, development of unconventional resources in the Central North Slope, a road across NPR-A to support OCS production, construction of a deep-draft port along the west coast, or a rapid boom in trans-Arctic shipping. If some or all of those proposed projects go forward, it would further increase the expansion of infrastructure in Arctic Alaska.

10.4 Conclusion

Expansion of oil and gas infrastructure, commercial transportation, and related industrial operations in Arctic Alaska will generate a variety of reactions from different stakeholders, who have diverse perspectives. Recalling the six categories of stakeholders described in the Introduction (tribal governments and Alaska Native organizations, industrial and commercial stakeholders, the State of Alaska, municipal governments, conservation organizations, and the federal government), it is easy to imagine areas of converging and conflicting opinions about increased industrial activity in Arctic Alaska. Given the range of stakeholders, multiple voices and positions will influence the future trajectory of commercial development in the region.

To achieve sustainable solutions that are fair to all stakeholders, decision-making processes must be inclusive and must be founded on a common set of information. To that end, this document can help advance sustainable solutions in Arctic Alaska by disseminating information about industrial expansion in a format that is useful for all stakeholders and decision-makers. By identifying past, present, and potential infrastructure supporting oil and gas activities and commercial transportation in Arctic Alaska, this report can serve as a shared starting point for discussion and a foundation for further analysis. Ultimately, it is hoped that this report—and the scenario projects it is meant to inform—can facilitate comprehensive and integrated Arctic planning that is more effective and leads to wise decisions.

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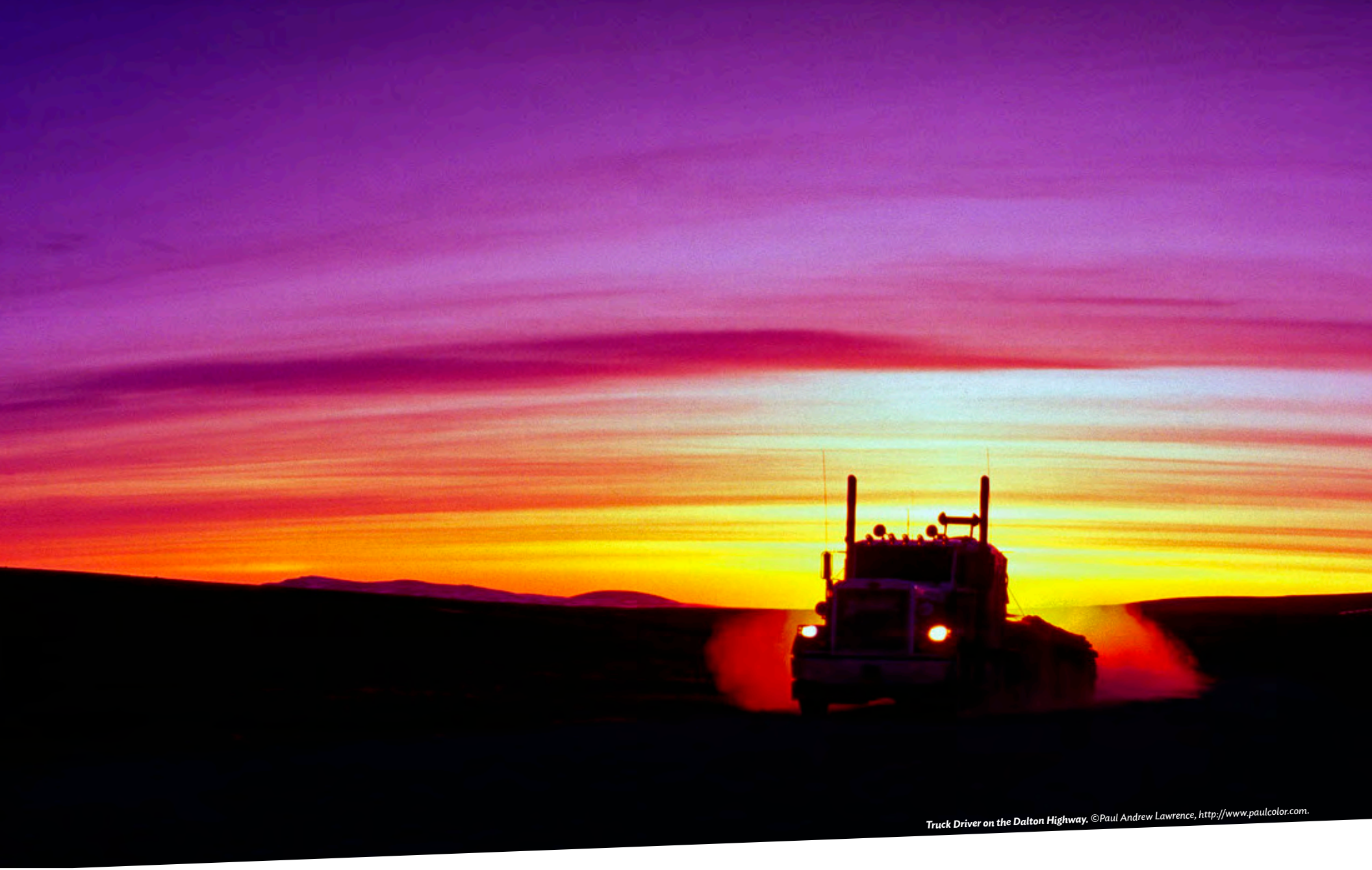

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