Transportation Scenarios for the Economic Resource Assessment

Transportation of oil and gas production to market is a key component in the economic analysis. Typically, Alaska's remote petroleum provinces lack infrastructure and nearby markets, so transportation represents significant cost and logistical hurdles. Only Cook Inlet has existing facilities and a local market for oil and gas. Oil production is carried from the North Slope to outside markets by the Trans-Alaska Pipeline System (TAPS) and tankers from Valdez. In all other provinces future oil and gas production will have to be exported thousands of miles using infrastructure that does not exist today. Markets in Alaska might absorb a fraction of future production, but large-scale production could easily overwhelm small local demand.

For the 2006 assessment, the transportation assumptions are updated to provide realistic scenarios in the foreseeable future. We consider engineering feasibility, resource potential, and market demands. In previous assessments, natural gas production was either used on-site to increase oil production or exported to markets on the Asia Pacific Rim. In the current assessment we modeled natural gas production in all provinces with delivery to U.S. markets. A synopsis of the *transportation scenarios* is given in Table 1:

Each province has unique characteristics that could require different transportation systems for oil and gas production. The intent of this assessment is not to test all of the possible scenarios, or emerging technologies, but to base the analysis on established commercial technologies and delivery to existing markets. Oil is transported by pipelines and marine tankers. In many of the gas development scenarios the most practical option is to convert natural gas to Liquefied Natural Gas (LNG) for marine transport. We assume that LNG will be shipped to new receiving terminals built on the U.S. West Coast. Future gas production from Arctic Alaska is assumed to be transported to the U.S. Midwest through a new gas pipeline system from the North Slope. The *oil transportation routes* and *gas transportation routes* are shown in Figures 1 and 2.

Transportation costs were modeled using cost-of-service tariffs for the main export systems. Tariffs are bundled to include all charges associated with common-carrier pipelines, processing (separation; LNG conversion), storage, loading, shipping, and receiving terminals. Long distance pipelines and LNG facilities could cost billions of dollars and must be backed by large proven resource volumes (5-10 Tcf for a new LNG facility). To meet this requirement, we assumed that resources would be gathered from several provinces to centrally located processing and export facilities (e.g. St. Lawrence Island, Balboa Bay; see Fig. 2). The *transportation tariffs* are listed in Table 2.

The 2006 economic assessment provides insights into issues facing future resource development in offshore Alaska.

- Exploration, development, and production operations for oil and gas are combined in the economic model. Gas-prone provinces could have significant volumes of associated liquid petroleum resources. Likewise, oil development could recover associated gas and support later commercial gas production. Oil/gas co-

production scenarios provide the best opportunities for commercial success in these remote, high cost offshore provinces.

- Establishing new export facilities will be the key to unlocking Alaska's resource potential. The economic model assumes that tariffs will cover the costs of exporting Alaska's oil and gas, however practically none of the required infrastructure exists today. Widespread exploration to identify commercial-sized resources, large construction projects, and financing for tens of billions of dollars for plants, pipelines, ships, and terminals will be needed before Alaska's petroleum resources reach domestic markets. This will require unprecedented coordination of industry, government, and citizens. These practical aspects are taken for granted in the model, so the economic results should be regarded as very optimistic. Realistically, there will be long lead times (perhaps decades) between the discovery and delivery of new petroleum resources from offshore Alaska to markets.

- Most of Alaska's offshore provinces will be unable to support large-scale export operations at foreseeable prices using today's technology. This is particularly true for natural gas production that relies on LNG delivery systems. However, new technologies are available, but not yet commercially established, that could be designed to meet the needs of local markets. Gas-to-Liquids (GTL) is a technology that can convert natural gas to a variety of products including diesel fuel that will meet strict emission standards. Compressed-natural-gas (CNG) is a marine transportation technology that could be more cost effective than LNG over shorter distances (<2500 miles). With the exception of the resource-rich Arctic provinces, offshore development in other Alaska provinces will require new technologies and strategies to realize its potential.

Disclaimer: Transportation scenarios are generated to define economic inputs into the assessment model. They do not constitute official recommendations or preferences of the Department of the Interior. Other scenarios are plausible and perhaps equally viable.

Table 1: Transportation Scenarios

Province	Transportation Scenario
Beaufort Shelf	**Oil** production is gathered by onshore and offshore pipelines to TAPS and transported to Valdez. Oil is then carried by marine tankers to the U.S. West Coast. Gas production is gathered by pipelines to Prudhoe Bay and then carried by a new gas pipeline system through Canada to the U.S. Midwest.
Chukchi Shelf	**Oil** production is gathered by onshore and offshore pipelines to TAPS and transported to Valdez. Oil is then carried by marine tankers to the U.S. West Coast. Gas production is gathered by pipelines to Prudhoe Bay and carried by a new gas pipeline system through Canada to the U.S. Midwest.
Hope Basin	**Gas** and oil production is gathered by subsea pipelines to a new onshore facility near Kivalina. Gas is transported by a 380-mile subsea pipeline to a new LNG facility on St. Lawrence Island where it is converted to LNG and then transported by sea to the U.S. West Coast. Oil and gas liquids are separated and stored onshore, then transported by shuttle tankers to a new transshipment terminal (Balboa Bay or Valdez). Gas liquids are blended with oil and carried to the U.S. West Coast by tankers. Shuttle tankers could also carry petroleum to Cook Inlet.
Norton Basin	**Gas** production is gathered by subsea pipelines to a new onshore facility near Nome. Gas is transported by a 150-mile subsea pipeline to a new LNG facility on St. Lawrence Island where it is converted to LNG and then transported by sea to the U.S. West Coast. Gas liquids are separated and stored onshore and then transported by shuttle tankers to a new transshipment terminal (Balboa Bay or Valdez). Gas liquids are blended with oil and carried to the U.S. West Coast by tankers. Shuttle tankers could also go to Cook Inlet.
Navarin Basin	**Gas** and oil production is gathered to a new offshore facility/hub. Gas is transported by a 350-mile subsea pipeline into a new LNG facility on St. Lawrence Island where it is converted to LNG and then transported by sea to new West Coast receiving terminals. Oil and gas liquids are transported by shuttle tankers from the offshore hub to a new transshipment terminal (Balboa Bay or Valdez) then to the U.S. West Coast by tankers. Shuttle tankers could also go to Cook Inlet.
St. George Basin	**Gas** and oil production is gathered to an offshore facility/hub. Gas is transported by a 340-mile subsea and land pipeline to a new onshore facility at Balboa Bay where it is converted to LNG and then transported by sea to the U.S. West Coast. Oil and gas liquids are transported by shuttle tankers to a new transshipment terminal (Balboa Bay or Valdez) then to the U.S. West Coast by tankers. Shuttle tankers could also go to Cook Inlet.
North Aleutian Basin	**Gas** and oil production is gathered to an offshore facility/hub and then transported by 70-mile subsea and land pipelines to a new onshore facility at Balboa Bay. Gas is converted to LNG and then transported by sea to new West Coast receiving terminals. Oil and gas liquids are blended and transported by tankers from Balboa Bay to the U.S. West Coast. Shuttle tankers could also go to Cook Inlet.

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Table 1: Transportation Scenarios (continued)

Shumagin Shelf	**Gas** production is gathered to an offshore facility/hub and then sent through a 40-mile dense-phase subsea pipeline to a new onshore facility at Balboa Bay. Gas is converted to LNG and transported to new West Coast receiving terminals. Gas liquids are transported by tankers from Balboa Bay to the U.S. West Coast or to Cook Inlet.
Kodiak Shelf	**Gas** production is gathered to an offshore facility/hub. Gas is transported by a 200-mile dense-phase subsea pipeline to existing facilities in Cook Inlet. Gas liquids are separated at these onshore facilities. Gas and gas-liquids are sold in the Cook Inlet market.
Cook Inlet	**Oil** and gas production is transported by subsea pipelines to existing onshore facilities. Oil is refined and sold to the local market. Gas is delivered to industrial users and utilities.
Gulf of Alaska Shelf	**Oil** and gas production is gathered by subsea pipelines to a new LNG facility at Yakutat. Gas is converted to LNG and transported by sea to new West Coast receiving terminals. Oil and gas liquids are separated and stored onshore and then transported by shuttle tankers to Valdez. Oil is carried from Valdez to the U.S. West Coast by established tanker routes.

***Notes**: **Transportation scenarios are generated to define economic inputs into the assessment model. They do not constitute official recommendations or preferences of the Minerals Management Service.** Development economics are primarily driven by the commodity shown in bold. Oil production from gas-prone provinces could include light crude oil and gas-condensates. TAPS is the Trans-Alaska Pipeline System (Prudhoe Bay to Valdez) now carrying North Slope crude oil. The U.S. West Coast has several refineries that receive Alaska North Slope crude oil, however the destination for tankers is assumed to be Los Angeles.*

Table 2: Transportation Tariffs

Alaska OCS Provinces	Distance to Market (miles)	Tariffs ($/bbl) ($/Mcf)
Beaufort Shelf	3200 (oil) 3600 (gas)	$4.81 to $7.30 $2.46 to $2.87
Chukchi Shelf	3600 (oil) 4000 (gas)	$6.29 to $11.12 $2.92 to $4.11
Hope Basin	3900 (oil) 3900 (gas)	$6.17 to $9.81 $4.98 to $15.53
Norton Basin	3650 (oil) 3650 (gas)	$5.18 to $8.62 $4.24 to $8.96
Navarin Basin	3500 (oil) 3900 (gas)	$5.58 to $8.83 $4.65 to $10.07
St. George Basin	3000 (oil) 2940 (gas)	$3.85 to $5.21 $3.92 to $12.22
North Aleutian Basin	2670 (oil) 2670 (gas)	$2.05 to $3.41 $2.10 to $4.25
Shumagin Shelf	2640 (oil) 2640 (gas)	$2.05 to $3.41 $2.10 to $4.25
Kodiak Shelf	200 (oil) 200 (gas)	$0.70 to $1.00 $1.49 to $2.48
Cook Inlet	<100 (oil) <100 (gas)	$1.33 to $1.75 $0.15 to $0.45
Gulf of Alaska Shelf	2700 (oil) 2100 (gas)	$2.25 to $3.75 $2.00 to $3.85

Notes: Transportation scenarios are generated to define economic inputs into the assessment model. They do not constitute official recommendations or preferences of the Minerals Management Service. *Oil production from the North Slope and oil and gas production from Cook Inlet are delivered to markets at the present time. All other OCS provinces will rely on new transportation infrastructure. Distances are given in statute miles (1.0 nautical mile = 1.151 statute mile) from the provinces to likely market destinations. Routes from province to market are shown in Figures 1 and 2. West Coast oil and LNG deliveries are assumed to be Los Angeles. Midwest gas delivery is to Chicago. Tariffs are given as a range of bundled costs that include common-carrier pipelines, LNG plants, oil/gas processing, storage, shipping, and receiving terminal*

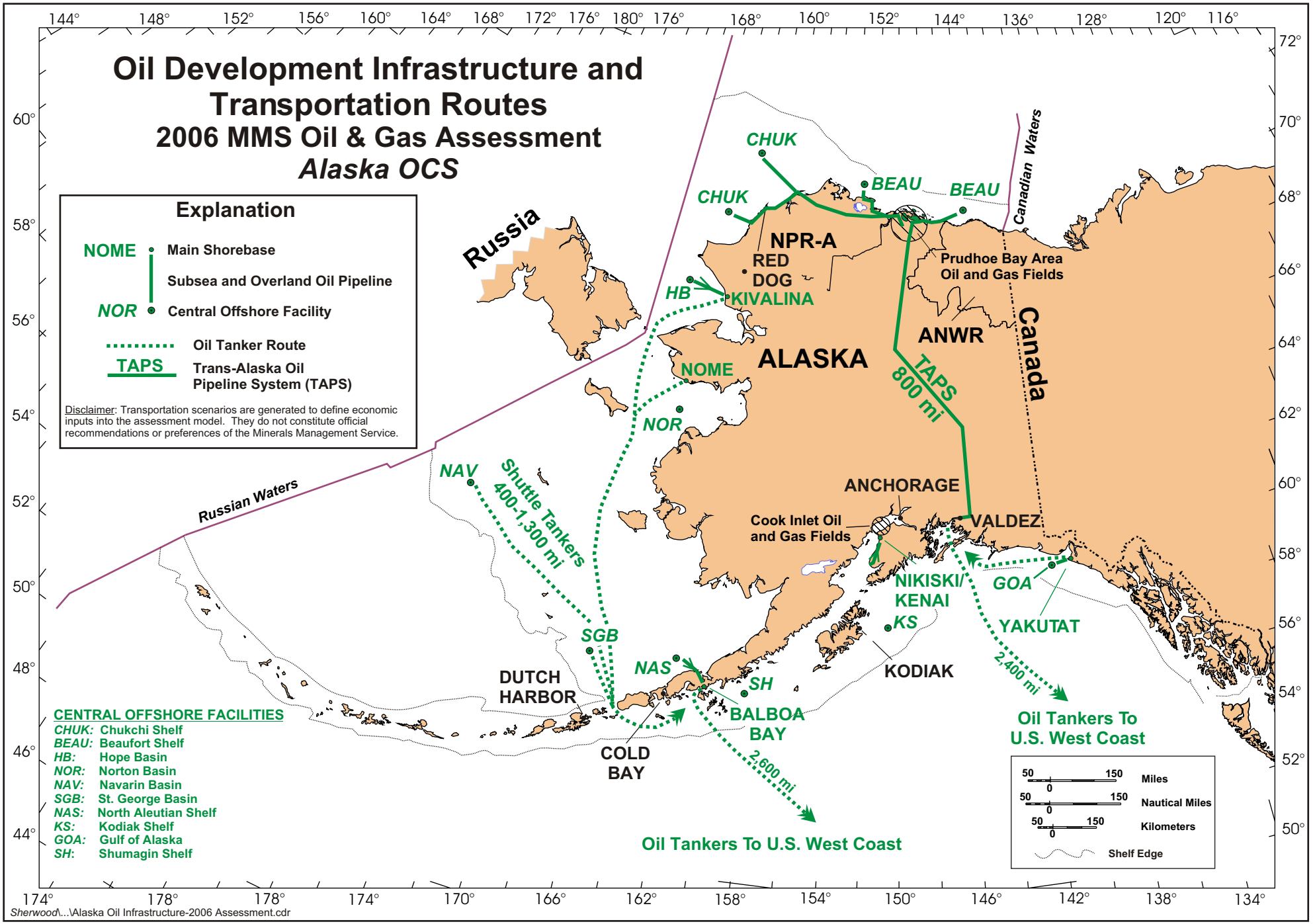
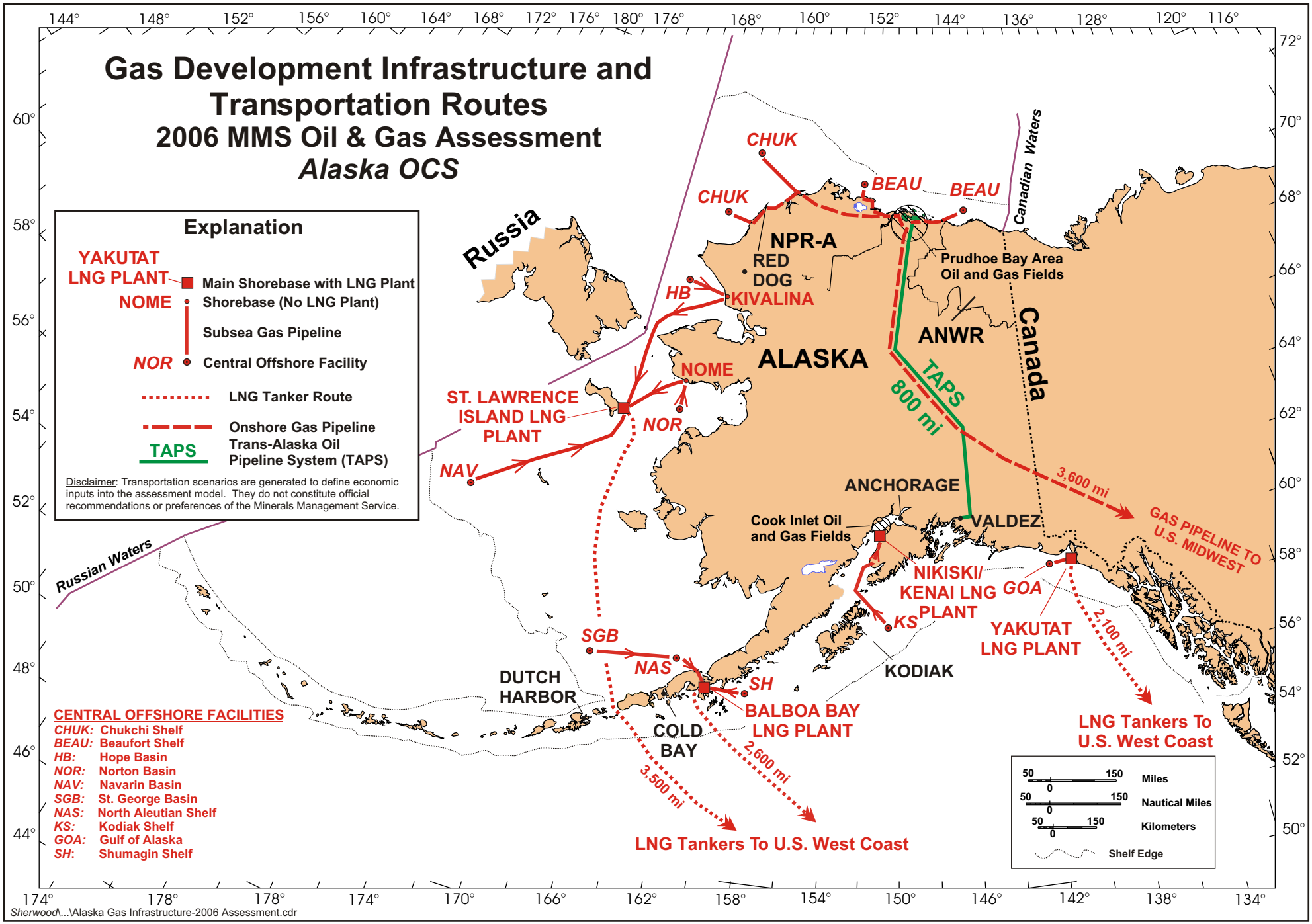

Oil Development Infrastructure and Transportation Routes
2006 MMS Oil & Gas Assessment
Alaska OCS
Explanation
NOME
Main Shorebase
Subsea and Overland Oil Pipeline
NOR
Central Offshore Facility
Oil Tanker Route
TAPS
Trans-Alaska Oil Pipeline System (TAPS)
Disclaimer: Transportation scenarios are generated to define economic inputs into the assessment model. They do not constitute official recommendations or preferences of the Minerals Management Service.
Russia
Canadian Waters
CHUK
BEAU
NPR-A
RED DOG
KIVALINA
HB
Prudhoe Bay Area Oil and Gas Fields
ANWR
Canada
ALASKA
NOME
NOR
TAPS 800 mi
NAV
Shuttle Tankers 400-1,300 mi
Russian Waters
ANCHORAGE
Cook Inlet Oil and Gas Fields
VALDEZ
NIKISKI/ KENAI
KS
GOA
YAKUTAT
SGB
NAS
SH
DUTCH HARBOR
KODIAK
BALBOA BAY
COLD BAY
2,600 mi
2,400 mi
Oil Tankers To U.S. West Coast
Oil Tankers To U.S. West Coast
CENTRAL OFFSHORE FACILITIES
CHUK: Chukchi Shelf
BEAU: Beaufort Shelf
HB: Hope Basin
NOR: Norton Basin
NAV: Navarin Basin
SGB: St. George Basin
NAS: North Aleutian Shelf
KS: Kodiak Shelf
GOA: Gulf of Alaska
SH: Shumagin Shelf
Miles
Nautical Miles
Kilometers
Shelf Edge
Sherwood\...\Alaska Oil Infrastructure-2006 Assessment.cdr

Figure 1


Gas Development Infrastructure and Transportation Routes
2006 MMS Oil & Gas Assessment
Alaska OCS
Explanation
YAKUTAT LNG PLANT
Main Shorebase with LNG Plant
NOME
Shorebase (No LNG Plant)
Subsea Gas Pipeline
NOR
Central Offshore Facility
LNG Tanker Route
Onshore Gas Pipeline
TAPS
Trans-Alaska Oil Pipeline System (TAPS)
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CENTRAL OFFSHORE FACILITIES
CHUK: Chukchi Shelf
BEAU: Beaufort Shelf
HB: Hope Basin
NOR: Norton Basin
NAV: Navarin Basin
SGB: St. George Basin
NAS: North Aleutian Shelf
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Russia
Russian Waters
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Canada
ALASKA
NPR-A
RED DOG
KIVALINA
HB
CHUK
BEAU
BEAU
Prudhoe Bay Area Oil and Gas Fields
ANWR
TAPS 800 mi
3,600 mi
GAS PIPELINE TO U.S. MIDWEST
NOME
ST. LAWRENCE ISLAND LNG PLANT
NOR
NAV
ANCHORAGE
Cook Inlet Oil and Gas Fields
VALDEZ
NIKISKI/ KENAI LNG PLANT
KS
GOA
YAKUTAT LNG PLANT
2,100 mi
KODIAK
SGB
NAS
SH
DUTCH HARBOR
COLD BAY
BALBOA BAY LNG PLANT
2,600 mi
3,500 mi
LNG Tankers To U.S. West Coast
LNG Tankers To U.S. West Coast
Miles
Nautical Miles
Kilometers
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Sherwood\...\Alaska Gas Infrastructure-2006 Assessment.cdr

Figure 2