Alaska Outer Continental Shelf

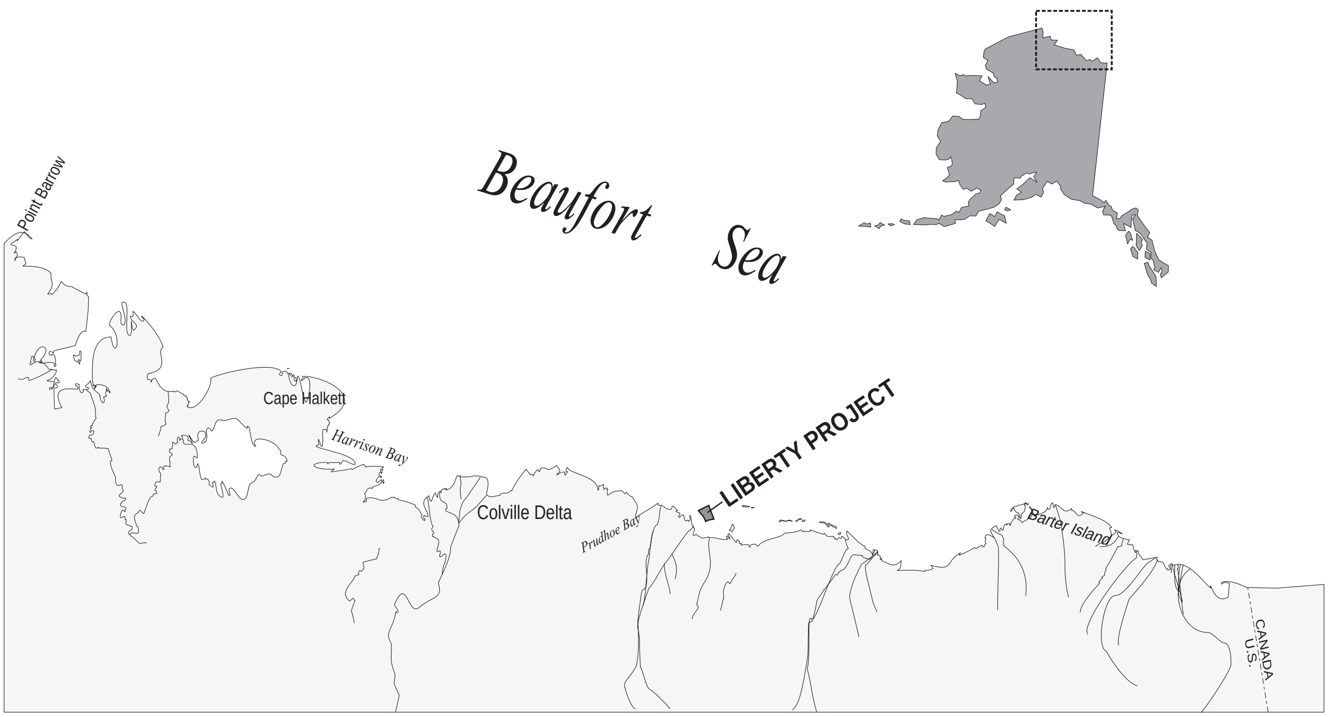
OCS EIS/EA
MMS 2002-019

Liberty Development and Production Plan

Final Environmental
Impact Statement

Volume III

(Tables, Figures, and Maps for Volumes I and II)



U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region

Liberty Development and Production Plan, Final Environmental Impact Statement,
OCS EIS/EA, MMS 2002-019, in 4 volumes:
Volume I, Executive Summary, Sections I through V,
Volume II Sections VI through IX, Bibliography, Index
Volume III, Tables, Figures, and Maps for Volumes I and II
Volume IV, Appendices

The summary is also available as a separate document:
Executive Summary, **MMS 2002-020.**

The complete EIS is available on CD-ROM (**MMS 2002-019 CD**) and on the Internet (**http://www.mms.gov/alaska/cproject/liberty/**).

This Environmental Impact Statement (EIS) is not intended, nor should it be used, as a local planning document by potentially affected communities. The exploration, development and production, and transportation scenarios described in this EIS represent best-estimate assumptions that serve as a basis for identifying characteristic activities and any resulting environmental effects. Several years will elapse before enough is known about potential local details of development to permit estimates suitable for local planning. These assumptions do not represent a Minerals Management Service recommendation, preference, or endorsement of any facility, site, or development plan. Local control of events may be exercised through planning, zoning, land ownership, and applicable State and local laws and regulations.

With reference to the extent of the Federal Government's jurisdiction of the offshore regions, the United States has not yet resolved some of its offshore boundaries with neighboring jurisdictions. For the purposes of the EIS, certain assumptions were made about the extent of areas believed subject to United States' jurisdiction. The offshore-boundary lines shown in the figures and graphics of this EIS are for purposes of illustration only; they do not necessarily reflect the position or views of the United States with respect to the location of international boundaries, convention lines, or the offshore boundaries between the United States and coastal states concerned. The United States expressly reserves its rights, and those of its nationals, in all areas in which the offshore-boundary dispute has not been resolved; and these illustrative lines are used without prejudice to such rights.

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Cooperating Agencies
U.S. Army Corps of Engineers
Alaska District Office

U.S. Environmental Protection Agency
Region 10

U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region

May 2002

Notice to Readers Regarding the Status of the Liberty Development and Production Plan (DPP)

In January 2002, BP Exploration (Alaska) Inc. (BPXA) publicly announced they were putting the Liberty Project on hold pending an ongoing re-evaluation of project configuration and costs. On March 5, 2002, BPXA sent a letter to Minerals Management Service (MMS) and others saying that pending completion of project re-evaluation, affected agencies should consider submitted permit applications incomplete and recommended processing of these applications be suspended. Also in March, BPXA indicated informally that submission of a modified DPP for the Liberty Project would likely take six months or more.

The MMS has decided to publish and file with Environmental Protection Agency (EPA) this final environmental impact statement (EIS) for the Liberty DPP because it includes substantial changes made in response to comments on the draft EIS. Also, MMS expects this final EIS will serve as a reference document for future projects.

The U.S. Army Corps of Engineers (Corps) and EPA, as cooperating agencies, had intended to use this final EIS as the NEPA document supporting permitting decisions by these agencies. The Corps and EPA hereby solicit comments on the adequacy of, and alternatives considered in, this final EIS.

Due to the applicant's re-evaluation of the project design, and the incomplete status of permit applications, the Corps and EPA are not soliciting comments on their permit decisions at this time. When revised permit applications are received with project changes, the Corps and EPA will issue public notices to request comments on the project proposal. Depending on the changes made, comments received, and any new information available, the three agencies will evaluate whether or not to use this final EIS as the primary NEPA documentation, issue a supplemental EIS or issue new environmental documentation to meet the agencies' respective NEPA compliance and permit evaluation requirements.

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TABLES

Table I-1 The Relationship Between the Component Alternatives and Combination Alternatives

Component Alternative	Combination Alternative A	Combination Alternative B	Combination Alternative C	Liberty DPP
Alternative Drilling Island Location and Pipeline Route				
Alt. I – Use Liberty Island Location and Pipeline Route (Liberty DPP)	✔	–	–	✔
Alt. III.A – Use Southern Island Location and Eastern Pipeline Route	–	✔	–	–
Alt. III.B – Use Tern Island Location and Pipeline Route	–	–	✔	–
Alternative Pipeline Design				
Alt. I – Use Single-Wall Pipe System (Liberty DPP)	–	–	–	✔
Alt. IV.A – Use Pipe-in-Pipe System	✔	–	✔	–
Alt. IV.B – Use Pipe-in-HDPE System	–	✔	–	–
Alt. IV.C – Use Flexible Pipe System	–	–	–	–
Alternative Upper Island Slope Protection System				
Alt. I – Use Gravel Bags (Liberty DPP)	–	✔	–	✔
Alt. V – Use Steel Sheetpile	✔	–	✔	–
Alternative Gravel Mine Sites				
Alt. I – Use Kadleroshilik River Mine (Liberty DPP)	–	✔	–	✔
Alt. VI – Use Duck Island Gravel Mine	✔	–	–	–
Alternative Pipeline Burial Depths				
Alt. I – Use a 7-Foot Burial Depth (Liberty DPP)	✔	*	–	✔
Alt. VII – Use a 15-Foot Pipeline Trench Depth	–	*	✔	–

* The burial depth for the HDPE system is a 6-foot minimal depth as designed by INTEC (2000)

Note: Each of the above component and combination alternatives is a complete project; each has all of the project elements needed to develop the Liberty Prospect and can be compared to each other on an equal footing.

Table I-2 Scoping Issues Analyzed in This EIS

Issue	Section(s) Containing Information or Analysis
Oil Spills from Pipelines or Structures	
Risk of oil spills from buried pipelines	II.A.1.c, III.C.1, III.C.2, III.D.3, IV.C.1, IV.C.2, V, IX.A., Appendix A
Capability to detect oil spills from buried pipeline	II.A.1.b, IV.C.2
Effects of a potential oil spill on the various resources	III.A.2, III.C.2, III.D.3, , IV, V, IX
Effects of an extremely large (catastrophic) but unlikely oil spill	IX
Effects of an oil spill in broken ice	III.C.2, III.D.3, V, IX
Pipeline design (Pipe-in-Pipe, Pipe-in-HDPE, Flexible Pipe, Single-Wall Pipe)	II.C.2, IV.C.2
Oil-spill-response capabilities and contingency planning	II.A.2, II.A.3,II.A.4, III.C.1
Effects on Key Resources Resulting from Project-Related Disturbances	
Effects of potential oil spills, discharges, noise from industrial activities, and increased human interaction	III.A.2, III.C, III.D, V, IIX, Appendix A
Effects of the proposed activities on the Boulder Patch, including proposed pipeline construction (trenching and backfilling)	IIII.A.2.e, III.C.2.e, III.C.3.e, III.D.1.e, III.D.2.e, III.D.3.e, III.D.6.e, , IV, V.C.5, VI.A.5, IX.A.6.e
Effects on polar bears, especially denning bears, and concerns about having enough baseline information about polar bears	III.A.2.b, III.C.2.b, III.C.3.b, III.D.1.b, III.D.2.b, III.D.3.b, III.D.6.b, , IV,V.C.2, VI.A.2, IX.A.6.b
Effects of the proposed activities on birds, especially to long-tailed ducks, from helicopter flights during nesting and molting periods; potential risks to nesting birds by predators from increased activities	III.A.2.c, III.C.2.c, III.C.3.c, III.D.1.c, III.D.2.c, III.D.3.c, III.D.6.c, , IV,V.C.3, VI.A.3, IX.A.6.c
Effects on marine mammals, including bowhead and beluga whales; ringed, spotted, and bearded seals; and walruses	III.A.2, III.C.2, III.C.3, III.D.1, III.D.2, IV,V.C,VI.A, IX
Effects on caribou and other terrestrial species	III.A.2.d, III.C.2.d, III.C.3.d, III.D.1.d, III.D.2.d, III.D.3.d, III.D.6.d, , V.C.4,VI.A.4, IV, IX.A.6.d
Effects on fish, including proposed pipeline construction (trenching and backfilling)	III.A.2.f(1), III.C.2.f.(1), III.C.3.f.(1), III.D.1.f. (1), III.D.2.f.(1), III.D.3.f.(1), III.D.6.f. (1), IV, V.C.6.b,VI.A.6.a, , IX.A.6.f
Effects on essential fish habitat	III.A.2.f. (2), III.C.2.f.(2), III.C.3.f.(2), III.D.1.f.(2), III.D.2.f.(2), III.D.3.f.(2), III.D.4.b, III.D.6.f(2), III.D.7.f(2), III.D.9.f(2), V.C.6.b, VI.A.8
Effects on known archaeological sites in the area onshore and the impacts of silt from island construction to the area near Tigvarik Island	III.A.2.j, III.C.2.j, III.C.3.j, III.D.1.j, III.D.2.j, III.D.3.j, III.D.6.j, IV, V.C.10, VI.B.3, IX.A.6.j
Cumulative Effects on Biological and Physical Resources and Social Systems	
Cumulative effects of the Plan and activities, including pipelines, on the habitat and key species (particularly displacing bowhead whales) in the Beaufort Sea and people of the North Slope	V
Effects of future projects on the resources and people of the North Slope	V
Effects of the Plan compared to other ongoing and potential new activities	V
Petroleum-Development Activities and Effects on Subsistence Harvests	
How the Proposal affects subsistence hunting and gathering on the North Slope	III.A.2.h, III.C.2.h, III.C.3.h, III.D.1.h, III.D.2.h, III.D.6.h,, V.C.8, VI.B.1, IX.A.6.h
Effects of noise on the feeding and migration routes of marine mammals, especially the bowhead whale	III.A.2.a(1), III.C.3, IV, V.C.1.a
Effects of potential emissions from onshore construction (stacks) on whales' feeding and migration	III.A.2.m, III.D.1.a
Effects of onshore pipelines and how they may interfere with using traditional subsistence sites	II.A.1, III.A.2.h, III.C.1.c, III.C.2.h, III.C.3.h, , IV, V.C.8, IX.A.6.h, , Appendix A

Table I-2 Scoping Issues Analyzed in This EIS (continued)

Issue	Section(s) Containing Information or Analysis
Sociocultural and Economic Effects on Villages and Native Communities	
Include traditional knowledge in our analysis and as information for the decisionmaker	I.C.1, III.B, III.C, III.D, , IV, V, VI
Population growth (non-Native) and balance between traditional and modern lifestyles of the Inupiat people	III.A.2, III.C,2, III.C.3, III.D.1, III.D.2, III.D.3, III.D.6, , IV, V, IX
Timing and size of the project's workforce and how they will affect the community's economy	II.A.1.f, III.A.2, III.C.2.k, III.C.3.k, III.D.1.k, III.D.2.k, III.D.5, III.D.6.k, , IV, V.C.11IX.B.11
How well subsistence whalers will be accepted if they land on the island	II.A.1.b, III.C.3.i
Methods/locations for waste disposal and whether it will affect communities	II.A.1.3, III.D.1
Effects of the Pipeline and Gravel Island	
How pipeline construction may affect the Boulder Patch and nearby fish	II.A.1.c, II.A.4, III.C, III.D, , IV, V.C.5
How development may affect known archaeological sites	II.A.1.j, III.C.2.j, III.C.3.j, III.D.1.j, III.D.2.j, III.D.3.j, III.D.6.j, , IV, V.C.10, IX.B.10
How burying the pipeline may change the environment	II.A.1.c, II.A.4, III.C.3, III.D.6,., IV.C.5, V
What are the effects of dredging/excavation, placement of dredged material or fill, and what are the effects of disposing of the excess dredged material in the ocean.	II.A.1, III.C.3, III.D,1, III.D.2, , IV, V, VI., Appendix G and H
How gravel bags and the silt from island construction may affect the area near Tigvariak Island	I.D.2.c, III.C.3.e, , IV.C.1,IV.C.5, V.C.5
How pipeline design integrity reduces risks of a pipeline leak from rupturing	I.D.1., II.A.1.c, II.A.4, III.C.1.d, IV.C.2
How island facility design standards minimize risks of a blowout	II.A.1.c, II.A.4, III.C.1.d
How island design standards reduce risks of ice override	II.A.1.b, III.C.1.c
Effects on Air and Water Quality	
Emissions into the air	III.A.2.m, III.D.1.m, , IV, V.C.13, IX.B.13
Marine water discharges	III.A.2.l, III.C.2.l, III.C.3.l, III.D.1l, III.D.2.l, III.D.4, III.D.6.l, IV, V.C.12, IX.B.12
Discharges from the seawater treatment plants for seawater and domestic wastewater	III.D.1., III.D.4
Effects of Facilities Abandonment	
Effects of abandonment of the production facility at the end of the project's life	III.D.6
Effects of pipeline removal at abandonment	III.D.6
Other Agency Permits and Requirements	
What other Federal and State Agency permits are required	Appendix B – Table B-1

Source: USDOI, MMS, Alaska OCS Region

Table I-3 Measures BPXA Incorporated into Their Liberty Development and Production Plan (Alternative I–BPXA's Proposal) to Avoid or Minimize Potential Impacts to the Biological, Physical, and Sociocultural Resources Within the Study Area

Action	Benefit
Mitigation by Design	
Smaller facility size; reduced wellhead spacing to 9 feet; directional drilling.	Minimize impacts associated with size of the offshore island.
Designed facility for zero discharge of drilling wastes; no reserve pits.	Reduce island size and impacts to benthos; eliminate potential for contaminant release from reserve pits; avoid water-quality impacts; avoid impacts to fish and essential fish habitat.
Locate island as close to shore as possible.	Reduce length of pipeline necessary to reach shore, thereby minimizing disturbance to the marine environment and essential fish habitat.
Use filter fabric to reduce leaching of fine particulates downstream onto sensitive marine habitat.	Minimize redistribution of fine sediments from the gravel island following construction.
Process design incorporated measures to minimize carbon dioxide emissions by using natural gas and electrical power for drilling (long term).	Reduce emissions of greenhouse gases.
Mine gravel and construct island and pipeline during winter from ice roads.	Eliminate impacts to wildlife; reduce sediment input effects; eliminate dust effects; eliminate impacts to tundra wetlands from a permanent access road; minimize impacts to essential fish habita and subsistence; facilitate abandonment and reclamation of mine site.
Dispose of solid wastes onshore.	Minimize waste storage on the island. Reduce fox and polar bear encounters.
Impose restrictions to spring helicopter overflights of Howe Island.	Avoid disturbance to breeding and nesting snow geese and brant.
Route helicopter traffic to minimize effects to wildlife. Route vessel traffic inside the barrier islands.	Minimize disturbance to seals, bowhead whales, polar bear dens, and subsistence-whaling activities.
Consult with Alaska Eskimo Whaling Commission if bowhead whales are observed inside the Midway Islands barrier island group.	Minimize disturbance to migrating bowhead whales or subsistence-whaling activities.
Prohibit hunting by project personnel, and restrict public access.	Protect wildlife and cultural resources.
Train personnel in interactions with wildlife. Establish an environmental awareness program.	Reduce potential for disturbance to wildlife and essential fish habitat. Increase awareness of risks and means to reduce impacts on wildlife.
Train personnel to recognize and avoid cultural resources.	Ensure that cultural resources are preserved.
Develop Conflict and Avoidance Agreement with local subsistence users.	Avoid unreasonable conflicts to subsistence activities.
Use ice roads to access Liberty Project and resources.	Minimize impacts to the tundra.
Use sea ice to support island construction and pipeline placement. Install pipeline during winter, when water currents are low.	Avoid barge traffic in summer for gravel transport, reducing air emissions. Reduce sedimentation of disturbed materials from the pipeline trench on adjacent benthic environments and essential fish habitat. Reduce noise disturbance to marine mammals.
Minimize Island size.	Reduce footprint of island and impacts on benthic environment.
Coordinate with the Alaska Department of Fish and Game on studies of fish and brown bears within project area. Identify and avoid den locations.	Minimize interactions with bears. Identify important fish resources in project area.
Coordinate with the Fish and Wildlife Service on historic and recent locations of polar bear den sites.	Avoid actions that would disturb denning polar bears.
Archaeology surveys.	Avoid disturbance of potential archaeology sites.

Source: BPXA (2000a)

Table II.A-1 Key Project Component Summary for All Alternatives[1]

	I Proposal	III.A Southern Island	III.B Tern Island	IV.A Pipe-in- Pipe	IV.B Pipe-in-HDPE	IV.C Flexible Pipe	V Steel Sheetpile	VI Duck Island Gravel Mine	VII Bury Pipe Deeper
GRAVEL ISLAND									
a. Location	Liberty Island	Southern Island	Tern Island	Liberty Island	Liberty Island	Liberty Island	Liberty Island	Liberty Island	Liberty Island
b. Upper Slope Protection	Gravel Bags	Gravel Bags	Gravel Bags	Gravel Bags	Gravel Bags	Gravel Bags	Steel Sheetpile	Gravel Bags	Gravel Bags
c. Lower Slope Protection	17,000 Cement Mats	16,000 Cement Mats	18,000 Cement Mats	17,000 Cement Mats	17,000 Cement Mats	17,000 Cement Mats	22,500 Cement Mats	17,000 Cement Mats	17,000 Cement Mats
d. Amount of Gravel	797,600 cu yd	684,800 cu yd	599,500 cu yd	797,600 cu yd	797,600 cu yd	797,600 cu yd	855,000 cu yd	797,600 cu yd	797,600 cu yd
e. Maximum Footprint	835' * 1,170'	825' * 1,155'	850' * 1190'	835' * 1,170'	835' * 1,170'	835' * 1,170'	905' * 1,240'	835' * 1,170'	835' * 1,170'
f. Maximum Footprint Area	22.4 acres	21.9 acres	23.3 acres	22.4 acres	22.4 acres	22.4 acres	25.8 acres	22.4 acres	22.4 acres
g. Working Surface	345' * 680'	345' * 680'	345' * 680'	345' * 680'	345' * 680'	345' * 680'	345' * 680'	345' * 680'	345' * 680'
h. Water Depth at Island	22 feet	18 feet	23 feet	22 feet	22 feet	22 feet	22 feet	22 feet	22 feet
PIPELINE									
a. Pipe Design	1 Steel Pipe	1Steel Pipe	1 Steel Pipe	1 Steel Pipe in a Steel Pipe	1 Steel Pipe in an HDPE Pipe.	1 Flexible Pipe	1 Steel Pipe	1 Steel Pipe	1 Steel Pipe
b. Route	Liberty Route	Eastern Route	Tern Route	Liberty Route	Liberty Route	Liberty Route	Liberty Route	Liberty Route	Liberty Route
c. Average Trench Depth /Range in (Feet)	10.5 / (8 -12)	10.5 / (8-12)	10.5 / (8-12)	9 / (6.5-10.5)	10 / (7.5-11.5)	8.5 / (6-10)	10.5 / (8 -12)	10.5 / (8 -12)	15 feet
d. Quantity of Trench Dredge/ Excavation Material *	724,000 cu yds	499,025 cu yd	652,800 cu yd	557,300 cu yd	673,920 cu yd	498,960 cu yd	724,000 cu yd	724,000 cu yd	1,438,560 cu yd
e. Quantity of Trench Backfill Material *	724,000 cu yds	499,025 cu yd	652,800 cu yd	557,300 cu yd	673,920 cu yd	498,960 cu yd	724,000 cu yd	724,000 cu yd	1,438,560 cu yd
f. Minimum Burial Depth	7 feet	7 feet	7 feet	5 feet	6 feet	5 feet	7 feet	7 feet	11 feet
g. Surface Area Disturbed by Trench	59 acres	37 acres	59 acres	52 acres	57 acres	49 acres	59 acres	59 acres	81 acres
h. Offshore Length	6.1 miles	4.2 miles	5.5 miles	6.1 miles	6.1 miles	6.1 miles	6.1 miles	6.1 miles	6.1 miles
i. Onshore Length	1.5 miles	3.1 miles	3.1 miles	1.5 miles	1.5 miles	1.5 miles	1.5 miles	1.5 miles	1.5 miles
j. Construction Seasons	Winter	Winter	Winter	Winter	Winter	Winter	Winter	Winter	Winter
k. Leak-Detection System	MBLPC, PPA, LEOS or Equiv.	MBLPC, PPA, LEOS or Equiv.	MBLPC, PPA, LEOS or Equiv.	MBLPC, PPA, LEOS or Equiv.	MBLPC, PPA, LEOS or Equiv.	MBLPC, PPA, LEOS or Equiv.	MBLPC, PPA, LEOS or Equiv.	MBLPC, PPA, LEOS or Equiv.	MBLPC, PPA, LEOS or Equiv.
l. Engineering Calculation of Pipeline Failure Rate but no oil released	3.1%	3.1%	3.1%	2.1%	3.2%	4.6%	3.1%	3.1%	2.2%
m. Engineering Calculation of Pipeline Failure Rate with oil released (any size spill)	0.001%	0.001%	0.001%	0.01%	0.01%	0.1%	0.001%	0.001%	0.0003%
n. Engineering Calculation of Probability of a Spill Larger than 1,000 bbls during project life[2]	1.38%	1.38%	1.38%	0.234%	1.38%	1.38%	1.38%	1.38%	1.38%
GRAVEL MINE SITE									
a. Location	Kadleroshilik River	Kadleroshilik River	Kadleroshilik River	Kadleroshilik River	Kadleroshilik River	Kadleroshilik River	Kadleroshilik River	Duck Island Mine	Kadleroshilik River
b. Number of Haul Days	45-60	40-57	30-45	45-60	45-60	45-60	45-60	90-120 or use more equipment	45-60
c. Distance from Island	6 miles	5 miles	6 miles	6 miles	6 miles	6 miles	6 miles	20 miles	6 miles

1 Unless otherwise noted all information in this table is from INTEC (2000)
2 Information from Fleet (2000)

Shading indicates components or quantities that are different from Alternative I-Proposal

Table II.A-2 Pipeline Trench Excavation and Backfill Quantities for Alternatives I, III, IV, and VII

	I Proposal-Liberty Island and Single-Wall Pipe	III.A Southern Island	III.B Tern Island	IV.A Steel Pipe in Steel Pipe	IV.B Steel Pipe in HDPE	IV.C Flexible Pipe	VII Bury Pipe Deeper
PIPELINE TRENCH							
a. Length							
Island to 3-mile limit	8,000 feet	2,376 feet	11,616 feet	8,000 feet	8,000 feet	8,000 feet	8,000 feet
3-mile limit to shoreline	24,400 feet	19,900 feet	17,524 feet	24,400 feet	24,400 feet	24,400 feet	24,400 feet
Total	32,400 feet	22,276 feet	29,140 feet	32,400 feet	32,400 feet	32,400 feet	32,400 feet
b. Width	61-132 feet	61-132 feet	61-132 feet	53-115 feet	53-115 feet	50-110 feet	120-152 feet
c. Fill Area							
Island to 3-mile limit	18.2 acres	5.3 acres	25.8 acres	15.4 acres	17.0 acres	14.7 acres	24.9 acres
3-mile limit to shoreline	55.4 acres	44.1 acres	38.9 acres	47.1 acres	51.8 acres	44.9 acres	76.1 acres
Total	73.6 acres	49.4 acres	64.7 acres	62.5 acres	68.8 acres	59.6 acres	101.0 acres
d. Onshore Transition Zone							
Length and width	150 x 25 feet	205 x 25 feet	205 x 25 feet	150 x 25 feet	150 x 25 feet	150 x 25 feet	150 x 25 feet
Area	0.3 acres	0.41 acres	0.41 acres	0.3 acres	0.3 acres	0.24 acres	0.4 acres
e. Quantity of Dredged/ Excavated Material							
Island to 3-mile limit	(179,000 cu yd)	(53,225 cu yd)	(260,200 cu yd)	(137,600 cu yd)	(166,400 cu yd)	(123,200 cu yd)	(355,200 cu yd)
3-mile limit to shoreline	(545,000 cu yd)	(445,800 cu yd)	(392,600 cu yd)	(419,700 cu yd)	(507,520 cu yd)	(375,760 cu yd)	(1,083,360 cu yd)
Total	(724,000 cu yd)	(499,025 cu yd)	(652,800 cu yd)	(557,300 cu yd)	(673,920 cu yd)	(498,960 cu yd)	(1,438,560 cu yd)
f. Quantity of Backfill							
Select backfill							
Island to 3-mile limit	17,000 cu yd	5,800 cu yd	24,250 cu yd	None	17,000 cu yd	17,000 cu yd	17,000 cu yd
3-mile limit to shoreline	50,000 cu yd	40,800 cu yd	36,050 cu yd	None	50,000 cu yd	50,000 cu yd	50,000 cu yd
Total select backfill	67,000 cu yd	46,600 cu yd	60,300 cu yd	None	67,000 cu yd	67,000 cu yd	67,000 cu yd
Native backfill							
Island to 3-mile limit	162,000 cu yd	47,425 cu yd	235,950 cu yd	137,600 cu yd	149,400 cu yd	106,200 cu yd	338,200 cu yd
3-mile limit to shoreline	495,000 cu yd	405,000 cu yd	356,550 cu yd	419,700 cu yd	457,520 cu yd	325,760 cu yd	1,033,360 cu yd
Total native backfill	757,000 cu yd	452,425 cu yd	592,500 cu yd	557,300 cu yd	606,920 cu yd	431,960 cu yd	1,371,560 cu yd
Total native and select backfill	724,000 cu yd	499,025 cu yd	652,800 cu yd	557,300 cu yd	673,920 cu yd	498,960 cu yd	1,438,560 cu yd

Source: BPXA (2000a)

Table II.A-3 Oil-Spill Volumes BPXA Estimates for Planning Spill Response and Cleanup

Spill Source	Regulatory Reference	Spill Volume
Pipeline	U.S. Department of Transportation 49 CFR 194.105(b)(1)	1,764 barrels
Diesel storage tank	State of Alaska, Dept. of Environmental Conservation 18 AAC.75.432	5,000 barrels
Tanks, flowlines, pipeline, and daily production	Minerals Management Service 30 CFR 254.47	36,123 barrels
Well blowout	State of Alaska, Dept. of Environmental Conservation 18 AAC 75.434	178,800 barrels
Pipeline Leak (offshore)	State of Alaska, Dept. of Environmental Conservation 18 AAC 75.436	1,764 barrels
Pipeline Leak (onshore)	State of Alaska, Dept. of Environmental Conservation 18 AAC 75.425 (e)(2)(c)	1,142 barrels

Source: USDOI, MMS, Alaska OCS Region

Table II.A-4 Guidance for Preparing Marine On-Water Response Scenarios

VARIABLE	VALUE TO BE USED FOR SPILL-RESPONSE PLANNING
1. Blowout oil lost to evaporation from wells producing more than 5,500 barrels per day	20% applied to atomized well blowout, where evaporation occurs before impact to land or water. Adjusted RPS volume is not to decline below 5,500 barrels/day.
2. Blowout-discharge rate from existing production wells	Annual average daily oil production for the maximum producing well (rounded to nearest thousand barrels), as reported by the Alaska Oil and Gas Conservation Commission (AOGCC).
3. Blowout-discharge from new reservoirs	16,500 barrels for the first 72 hours. If rate is higher after initial production, use AOGCC data and submit c-plan amendment. ADEC condition of c-plan approval will specify timing of submission of production data.
4. Duration of planning period for a blowout	15 days, based on consideration of historical duration of blowouts. This does not mean response to a blowout ends after 15 days. C-plan will include ability to sustain response indefinitely.
5. Out-of-region resources	ADEC will consider use of limited out-of-region resources, including off-shift in-state specialists and specialists from other response organizations, to meet 72-hour adjusted RPS based on verifiable contracts and sharing agreements. Out-of-region supplement beyond RPS demonstration is to be fully described. The c-plan will include mobilization plan, equipment list, and phone numbers. (Reference Prince William Sound Regional Citizens Advisory Council out-of-region report).
6. Realistic maximum wind speed	20 knots (based on 95th percentile of wind speed for season).
7. Realistic directional persistence	First 24 hours: wind from southwest (based on historical data). Next 48 hours: wind from northeast (based on historical data).
8. Realistic maximum wave height in mature fetch	1.5 meters (based on historical data for Northstar, NOAA atlas, and assumed 4-mile fetch for wave height.
9. Ice coverage during broken-ice periods	Simulated ice movement and changes in ice percentage cover rather than constant percentage.
10. Oil-to-water ratio of emulsion for storage purposes	60 parts oil to 40 parts water (i.e., oil volume x 1.67). Based on Prince William Sound c-plan and S.L. Ross* report.
11. Portion of oil entering open water	S.L. Ross* (1997) blowout model's prediction of oil falling to water on site map *plus* oil falling to other surfaces in quantities greater than 0.5 gallon per square foot. Existing on-site containment such as gravel berms can reduce the volume entering open water.
12. Slick size	Fallout footprint based on S.L. Ross* (1998) blowout model using a blowout well with an open orifice. Width of downwind zone of scattered oil = 0.25 x length. Farfield zone contains windrows of oil.
13. On-water trajectory	Vector sum of local current (speed and direction) and wind (direction and 3% of speed).
14. Safety zone boundary (permissible exposure limit)	5 milligrams of oil particulate per cubic meter of air.
15. Encounter rate	Use the Anvil model in lieu of the MEC model.
16. Derated oil-recovery rate for skimmers	(a) 20% of pump's nameplate capacity based on State DEC guidelines, except for rates specified in (b) below. (b) Skimmer-specific rates: LORI SCS-3: 80% x 271 barrels/hr = 217 barrels/hr. Foxtail: 30% x nameplate pump capacity (based on CISPRI test). Vikoma 30K: 10barrels/hour.
17. Throughput efficiency (boom containment)	Marine open water: 100%. River system: minimum of 3 control sites with open-water marine backup.
18. Advancing skimmer speed	0.7 knots.
19. Barge-storage capacity	95% of rated capacity.
20. Utilization time of recovery systems	10 hours in each 12-hour shift; 2 shifts per day. Utilization time in first 72 hours = 60 hours minus time to deploy.
21. Minibarge fill time (with weir skimmer and 2 decants)	1 hour (based on ACS field tests with DOP 250 pump and 249-barrels barge, Prince William Sound c-plan, and S.L. Ross* [1998]).
22. Minibarge transit time	5 knots laden and unladen (based on USCG and ACS field tests).
23. Minibarge offload time	1.5 hours to hook, pump, and unhook (based on ACS field tests).
24. Decant from barges	Large recovery and storage barges: 80% of free water. Mini-barges: 60% of free water. Based on Prince William Sound c-plan and ADEC guidelines.
25. Delivery mixture from 249-barrel minibarge coupled with weir skimmer	79 barrels oil, 53 barrels water-in-oil emulsion, and 104 barrels free water (2 decants required). Based on Prince William Sound c-plan.

*S.L. Ross Environmental Research Ltd., D.F. Dickins and Assocs. Ltd., and Vaudrey and Assocs., 1998

Table II.C-1 Comparison of Gravel Islands—Maximum Dimensions, Number of Concrete Blocks, Total Fill Volume, and Area Among EIS Alternatives

EIS Alternative	Maximum Dimensions of Gravel Island (feet)	Number of Concrete Blocks - Slope Protection	Fill Volume for Gravel Island (cubic yards)	Fill Volume for Gravel Bags in Slope Protection (cubic yards)	Fill Volume Gravel for Concrete Blocks (cubic yards)	Total Fill Volume (cubic yards)	Fill Area of Gravel Island (acres)
Alternatives I , IV.A, IV. B, IV.C, VI, and VI Proposed Liberty Island	835 x 1,170	17,000	773,000	17,000	7,600	797,600	22.4
Alternative III.A - Southern Island	825 X 1,155	16,000	661,000	17,000	6,800	684,800	21.9
Alternative III.B. - Tern Island	855 X 1,185	18,000	574,500	17,000	8,000	599,500	23.3
Alternative V - Use Steel Sheetpile	905 X 1,240	18,000	845,000	N/A	10,000	855,000	25.8

Source: BPXA (2000a)

Table II.C-2 Pipeline Construction

Activity	Alternative I Single-Wall Pipe	Alternative IV.A Pipe-In-Pipe System	Alternative IV.B Pipe-In-HDPE System	Alternative IV.C Flexible Pipe
Mobilizing Equipment, Material, and Workforce				
Mobilization time (days)				
Liberty Pipeline Route	3	6	6	
Eastern Pipeline Route	3	6	6	
Tern Pipeline Route	3	6	6	
Constructing the Ice Road and Thickening the Ice				
Pipe weight (pounds/foot)	90	210	104	85
Required ice thickness (feet)	8 – 9	10 – 11	8 – 9	8 – 9
Ice-road construction (days)				
Liberty Pipeline Route	47	56	47	47
Eastern Pipeline Route	32	39	32	32
Tern Pipeline Route	42	50	42	42
Ice Slotting				
Ice slotting (days)				
Liberty Pipeline Route	11	14	11	11
Eastern Pipeline Route	8	10	8	8
Tern Pipeline Route	10	13	10	10
Trenching				
Minimum cover (feet)	7	5	6	5
Trench depth (feet)	10.5	9	10	8.5
Preparing a Site for Making Up Pipeline Strings				
Size (square yards)	426,500	566,000	533,000	416,500
Time (days)				
Liberty Pipeline Route	37	47	47	37
Eastern Pipeline Route	26	33	33	26
Tern Pipeline Route	42	42	42	42
Making Up Pipeline Strings				
Nondestructive examination of welds	Yes	Yes	Yes	NA
Sandblasting and FBE coating of welds	Yes	Yes	Yes	NA
Installing sacrificial anodes	Yes	Yes	NA	NA
Crew days				
Liberty Pipeline Route	17	47	34	NA
Eastern Pipeline Route	12	33	24	NA
Tern Pipeline Route	15	42	31	NA
Transporting Strings to the Ice Slot and Tying In				
Transporting and welding (days)				
Liberty Pipeline Route	10	33	22	9
Eastern Pipeline Route	7	23	15	6
Tern Pipeline Route	9	30	20	8
Installing the Pipeline				
Installation time (days)				
Liberty Pipeline Route	35	29	33	26
Eastern Pipeline Route	24	20	23	18
Tern Pipeline Route	32	26	30	23
Backfilling the Trench				
Backfilling time (days)				
Liberty Pipeline Route	36	30	44	38
Eastern Pipeline Route	25	21	30	26
Tern Pipeline Route	32	27	40	34
Trench footprint size (acres)				
Liberty Pipeline Route	73.6	62.5	68.8	59.6
Eastern Pipeline Route	49.4	41.9	46.2	40.0
Tern Pipeline Route	64.7	54.9	60.5	48.3
Demobilizing Equipment				
Demobilization time (days)				
Liberty Pipeline Route	2	4	4	2
Eastern Pipeline Route	2	4	4	2
Tern Pipeline Route	2	4	4	2

Source: INTEC (1999a) and MMS Calculations

Table II.C-3 Comparison of Trench Excavation and Backfill for Different Pipeline Designs and Routes

Pipeline Design	Trench Characteristic	Island Location and Pipeline Route								
		Alternative I Liberty Island/Liberty Pipeline			Alternative III.A Southern Island/Eastern Pipeline Route			Alternative III.B Tern Island/Tern Pipeline Route		
		Gravel Island to 3-Mile Limit	3-Mile Limit to Shoreline	Onshore Transition Pipeline	Gravel Island to 3-Mile Limit	3-Mile Limit to Shoreline	Onshore Transition Pipeline	Gravel Island to 3-Mile Limit	3-Mile Limit to Shoreline	Onshore Transition Pipeline
Alternative 1 Single-Wall Pipe	**a.** Trench Length (ft)	8,000	24,400	150	2,376	19,900	205	11,616	17,524	205
	b Trench Width (ft)	61'-132'	61'-132'	25	61'-132'	61'-132'	25	61'-132'	61'-132'	25
	c. Trench Excavation (yd^3)	(179,000)	(545,000)	(2,200)	(53,225)	(445,800)	(3,000)	(260,200)	(392,600)	(3,000)
	d. Select Backfill (yd^3)	17,000	50,000	2,500	5,800	40,800	3,450	24,250	36,050	3,450
	e. Native Backfill (yd^3)	162,000	495,000	400	47,425	405,000	550	235,950	356,550	550
	f. Total Trench Backfill (yd^3)	179,000	545,000	2,900	53,225	445,800	4,000	260,200	392,600	4,000
	g. Trench Fill Area (acres)	18.2	55.4	0.3	5.3	44.1	0.41	25.8	38.9	0.41
	h. Trench Depth (ft)	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Alternative III.A Pipe-in-Pipe	**a.** Trench Length (ft)	8,000	24,400	150	2,376	19,900	205	11,616	17,524	205
	b. Trench Width (ft)	53'-115'	53'-115'	25	53'-115'	53'-115'	25	53'-115'	53'-115'	25
	c. Trench Excavation (yd^3)	(137,600)	(419,700)	(1,875)	(40,900)	(342,300)	(2,570)	(200,000)	(301,500)	(2,570)
	d. Select Backfill (yd^3)	none	none	2,160	none	none	2,950	none	none	2,950
	e. Native Backfill (yd^3)	137,600	419,700	345	40,900	342,300	470	200,000	301,500	470
	f. Total Trench Backfill (yd^3)	137,600	419,700	2,505	40,900	342,300	3,420	200,000	301,500	3,420
	g. Trench Fill Area (acres)	15.4	47.1	0.3	4.6	38.4	0.36	22.4	33.8	0.36
	h. Trench Depth (ft)	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Alternative III.B Pipe-in-HDPE	**a.** Trench Length (ft)	8,000	24,400	150	2,376	19,900	205	11,616	17,524	205
	b. Trench Width (ft)	59'-126'	59'-126'	25	59'-126'	59'-126'	25	59'-126'	59'-126'	25
	c. Trench Excavation yd^3	(166,400)	(507,520)	(2,090)	(49,420)	(413,920)	(2,850)	(241,615)	(364,500)	(2,850)
	d. Select Backfill (yd^3)	17,000	50,000	2,400	5,800	40,800	3,275	24,250	36,050	3,275
	e. Native Backfill (yd^3)	149,400	457,520	385	43,620	373,120	525	217,365	328,450	525
	f. Total Trench Backfill (yd^3)	166,400	507,520	2,785	49,420	413,920	3,800	241,615	364,500	3,800
	g. Trench Fill Area (acres)	17.0	51.8	0.3	5.1	42.3	0.39	24.7	37.2	0.39
	h. Trench Depth (ft)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Alternative III.C Flexible Pipe	**a.** Trench Length (ft)	8,000	24,400	150	2,376	19,900	205	11,616	17,524	205
	b. Trench Width (ft)	50'-110'	50'-110'	25	50'-110'	50'-110'	25	50'-110'	50'-110'	25
	c. Trench Excavation (yd^3)	(123,200)	(375,760)	(1,770)	(36,590)	(306,460)	(2,425)	(178,890)	(269,870)	(2,425)
	d. Select Backfill (yd^3)	17,000	50,000	2,035	5,800	40,800	2,790	24,250	36,050	2,790
	e. Native Backfill (yd^3)	106,200	325,760	325	30,790	265,660	445	154,640	233,820	445
	f. Total Trench Backfill (yd^3)	123,200	375,760	2,360	36,590	306,460	3,235	178,890	269,890	3,235
	g. Trench Fill Area (acres)	14.7	44.9	0.24	4.4	36.6	0.33	21.4	32.3	0.33
	h. Trench Depth (ft)	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Alternative VII Bury the Pipe Deeper	**a.** Trench Length (ft)	8,000	24,400	150	2,376	19,900	205	11,616	17,524	205
	b. Trench Width (ft)	120'-152'	120'-152'	25	120'-152'	120'-152'	25	120'-152'	120'-152'	25
	c. Trench Excavation (yd^3)	(355,200)	(1,083,360)	(3,125)	(105,500)	(883,560)	(4,275)	(515,750)	(778,070)	(4,275)
	d. Select Backfill (yd^3)	17,000	50,000	3,590	5,800	40,800	4,920	24,250	36,050	4,920
	e. Native Backfill (yd^3)	338,200	1,033,360	575	99,700	842,760	785	491,500	742,020	785
	f. Total Trench Backfill (yd^3)	355,200	1,083,360	4,165	105,500	883,560	5,705	515,750	778,070	5,705
	g. Trench Fill Area (acres)	24.9	76.1	0.4	60.6	62.0	0.59	36.2	54.6	0.59
	h. Trench Depth (ft)	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0

Source: BPXA (2000a)

Table II.C-4 Pipeline Corrosion and Leakage into the Annulus

Alternative IV.A Pipe-in-Pipe System	Alternative IV.B Pipe-in-HDPE System	Alternative IV.C Flexible Pipe
Corrosion of either the inner or outer pipeline is the most probable cause of this type of damage. If only the inner pipe corrodes, oil would be released into the annulus area between the pipes. If only the outer pipe corrodes, then seawater could enter the annulus between the pipes. If both pipes corrode, oil could be releases into the environment. The table in Section II.A.1.e(4) provides the engineering failure rate for each of the above failure states.	Corrosion of the inner pipeline is the most likely cause for this type of damage. The outer pipe cannot corrode, so a release of oil to the environment would not occur. The table in Section II.A.1.e(4) provides the engineering failure rate for this pipeline to release oil into the environment.	This type of damage, although theoretically possible, is extremely unlikely to occur. Because the pipeline is made of layers of plastic and stainless steel, it is very unlikely that the pipeline would be damaged by corrosion. The exception would be at the connectors between the sections of flexible pipe; however, at this location the pipeline would not be able to provide secondary containment. The flexible pipe acts much more like a single pipe than either of the other multiwall pipeline systems. Because of this, it is highly unlikely or either the inner or outer fluid-containment barrier to fail by itself. The table in Section II.A.1.e(4) provides the engineering failure rate for each pipeline design to release oil into the environment.

Source: INTEC (1999a). **Note:** The single-wall pipe in the Proposal is not included in this table, because it does not have an annulus.

Table II.C-5 Pipeline Failure Rate and Expected Spill Volume

	Alternative I Single-Wall Pipe	Alternative IV.A Pipe-In-Pipe System	Alternative IV.B Pipe-In-HDPE System	Alternative IV.C Flexible Pipe	INTEC's 7-Foot Burial Depth Pipe-In-Pipe System
Damage Category	**Pipeline Failure Probability by Pipeline Design [1]**				
1–Pipeline displacement but no leak	0.031	0.02	0.03	0.04	0.022
2–Pipeline buckle but no leak	0.0012	0.001	0.002	0.006	0.00012
3–Small/medium leak into the environment	0.000013	0.0001	0.0001	0.001	0.00000028
3–Oil leaks into the annulus	NA	0.0001	0.001	NA	0.0001
3–Water leaks into the annulus	NA	0.0001	NA	NA	0.0001
4–Large leak/rupture	0.0000003	0.0001	0.000001	0.00001	0.00000021
	"Expected" Spill Volume—Life of the Pipeline [1]				
	0.0021 bbl (0.088 gal)	0.028 bbl (1.18 gal)	0.014 bbl (0.59 gal)	0.14 bbl (5.88 gal)	0.00034 bbl (0.014 gal)
	"Expected" Spill Volume—Life of the Pipeline [2]				
	28 bbl (1176 gal)	8 bbl (336 gal)	24 bbl (1008 gal)	29 bbl (1218 gal)	13 bbl (546 gal)
	Probability of Spill Larger Than 1000 barrels Occurring During Project Life [2]				
	0.0138	0.00158	0.0138	0.0138	0.00234

[1] Summary information from INTEC pipeline alternatives report (INTEC, 2000).
[2] Summary information from Fleet risk evaluation report (Fleet, 2000).

Table II.C-6 Pipeline Repair Techniques: Overview

	Season	Applicable Zone	Diving Requirements	Level of Excavation	Temporary or Permanent	Comments
Welded Repair with Cofferdam	***winter***	0-6 feet	Not Required	Moderate	Permanent	This repair is performed in a dry environment.
		7-22 feet	Minimal			
	open water	0-22 feet	Minimal			
Hyperbaric Weld Repair	***winter***	7-22 feet	Extensive	Moderate	Permanent	This is for repairs of minor damage.
	open water	0-22 feet	Extensive			
Surface Tie-in Repair	***winter***	0-6 feet	Not Required	High	Permanent	
		7-22 feet	Moderate			
	open water	0-22 feet	Moderate			
Tow Out of Replacement String	***winter***	0-6 feet	Not Required	High	Temporary	This is a permanent repair if a spool piece is welded, and a temporary repair if mechanical connectors are used.
		7-22 feet	Extensive			
	open water	0-22 feet	Extensive			
Rigid Spool Piece with Mechanical Connectors	***winter***	0-6 feet	Not Required	Moderate	Temporary	This is used only if there is insufficient time to carry out permanent repair.
		7-22 feet	Extensive			
	open water	0-22 feet	Extensive			
Split-Sleeve Repair Method	***winter***	0-6 feet	Not Required	Low	Temporary	This is used for stopping leaks and for lowering the potential for rupture when external dents or bulges have been detected in the pipeline.
		7-22 feet	Moderate			
	open water	0-22 feet	Moderate			

Source: INTEC (1999a)

Table II.C-7 Pipeline Repair Techniques: Excavation, Repair Time, Integrity

	Alternative I Single-Wall Steel System	Alternative IV.A Pipe-In-Pipe System	Alternative IV.B Pipe-In-HDPE System	Alternative IV.C Flexible Pipe
WELDED REPAIR WITH COFFERDAM				
Sediment Excavated	**1,150 yd^3**	**1,034 yd^3**	**1,150 yd^3**	**1,150 yd^3**
Repair Time	**35 days**	**41 days**	**37 days**	**37 days**
Integrity	Once completed, this repair would return the pipeline to its original integrity.	Once completed, this repair would return the inner pipe to its original integrity but would require sleeves to repair the outer pipe and, therefore, would reduce the integrity of the outer pipe.	Once completed, this repair would return the inner pipe to its original integrity but would require sleeves to repair the outer pipe and, therefore, would reduce the integrity of the outer pipe.	Once completed, this repair would return the pipeline to its original integrity.
HYPERBARIC WELD REPAIR				
Sediment Excavated	**1,150 yd^3**	**1,034 yd^3**	**NA**	**1,150 yd^3**
Repair Time	**35 days**	**42 days**	**NA**	**37 days**
Integrity	Once completed, this repair would return the pipeline to its original integrity.	Once completed, this repair would return the inner pipe to its original integrity but would require sleeves to repair the outer pipe and, therefore, would reduce the integrity of the outer pipe.	**NA**	Once completed, this repair would return the pipeline to its original integrity.
SURFACE TIE-IN REPAIR				
Sediment Excavated	**6.490 yd^3**	**8,500 yd^3**	**6.490 yd^3**	**2,926 yd^3**
Layover Area	**3,150 yd^3**	**4,000 yd^3**	**3,150 yd^3**	**1,528 yd^3**
Excavation Time	**10 - 15 days**	**15 - 20 days**	**10 - 15 days**	**5 - 10 days**
Total Repair Time	**35 days**	**47 days**	**39 days**	**42 days**
Integrity	Once completed, this repair would return the pipeline to its original integrity and a zero-stress condition.	Once completed, this repair would return the inner pipe to its original integrity but would require sleeves to repair the outer pipe and, therefore, would reduce the integrity of the outer pipe.	Once completed, this repair would return the inner pipe to its original integrity and, although it would require sleeves to repair the outer pipe, this would not reduce the integrity of the outer pipe.	Once completed, this repair would return the pipeline to its original integrity.
TOW-OUT OF REPLACEMENT STRING				
Sediment Excavated	**6,480 yd^3**	**6,480 yd^3**	**6,480 yd^3**	**6,480 yd^3**
Total Repair Time	**40 days**	**46 days**	**42 days**	**46 days**
Integrity	Once completed, this repair would return the pipeline to its original integrity, if the end connections were welded.	Once completed, this repair would return the inner pipe to its original integrity but would require sleeves to repair the outer pipe and, therefore, would reduce the integrity of the outer pipe.	Once completed, this repair would return the inner pipe to its original integrity and, although it would require sleeves to repair the outer pipe, this would not reduce the integrity of the outer pipe.	Once completed, this repair would return the pipeline to its original integrity.

Source: INTEC (1999a:Appendix E).

Table III.B-1 Environmental Studies Sponsored by MMS Applicable to the Beaufort Sea Area

	Fiscal Year of Funding		
Title	**1999 or earlier**	**2000**	**2001**
Physical Oceanography			
Synthesis and Collection of Meteorological Data in the Nearshore Beaufort Sea		x	
Coupled Ice-Ocean Modeling of the Arctic Ocean	x	x	
Evaluation of Sub-Sea Physical Environmental Data for Beaufort Sea		x	
Alaska Sea Ice Atlas	x		
The Circulation, Thermohaline Structure, and Cross Shelf Transport in AK Beaufort Sea		x	
Beaufort and Chukchi Sea Seasonal Variability for Two Arctic Climate States	x		
Beaufort Sea Nearshore Under-Ice Currents: Science, Analysis and Logistics	x	x	
Fate and Effects			
Alternative Oil Spill Occurrence Estimators for Beaufort/Chukchi Sea OCS		x	x
Environmental Sensitivity Index Shoreline Classification in the Beaufort Sea		x	
Revision of the OCS Oil Weathering Model: Implementation	x		
The Role of Zooplankton in the Distribution of Hydrocarbons	x		
Kinetics and Mechanisms of Slow PAH Desorption From Lower Cook Inlet and Beaufort Sea Sediments	x		
A Nowcast/Forecast Model for the Beaufort Sea Ice-Ocean-Oil Spill System		x	
Petroleum Hydrocarbon Degrading Microbial Communities in Beaufort Sea Sediments	x	x	x
Historical Changes in Trace Metals and Hydrocarbons, Beaufort Sea Inner Shelf	x		
Biological			
Feeding Ecology of Maturing Sockeye Salmon in Nearshore Waters of Kodiak Arch.	x		
The Alaska Frozen Tissue Collection and Electronic Database	x		
Seabird Samples as Resources for Marine Environmental Assessment	x		
Alaska Marine Mammal Tissues Archival Project	x	x	
Modeling Recovery Rates for Avian Populations			x
Protected Species			
Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Science and Traditional Knowledge	x	x	
Monitoring Key Marine Mammals, Arctic: Beaufort Sea Ringed Seals	x		
Monitoring the Distribution of Arctic Whales	x	x	x
Satellite Tracking of Eastern Chukchi Sea Beluga Whales in the Beaufort Sea and Arctic Ocean		x	
Correction Factor for Ringed Seal Surveys in Northern Alaska	x		
Polar Bear Den Survey: Workshop	x		x
Monitoring Beaufort Sea Waterfowl and Marine Birds	x	x	x
Simulation Modeling of Effects of Oil Spills on Polar Bear Population Dynamics	x		
Analysis of Covariance of Human Activities and Sea Ice in Relation to Fall Migrations of Bowhead Whales			x
Use of Sea Ice Habitat by Polar Bears in the Southern Beaufort Sea			x
Social Science and Economics			
Collection of Traditional Knowledge of the Alaskan North Slope	x	x	
Synthesis/Book of Information on the Socioeconomic Effects of O&G Industry Activity, AK OCS	x		
Sociocultural Consequences of Alaska OCS Activities: Data Analysis and Integration	x		
EVOS Oil Spill, Cleanup and Litigation: Collection of Social Impacts Information and Analysis	x		
Update of Oil Industry Labor Factors for Alaska Manpower Model		x	
Subsistence Economies and North Slope Oil Development	x		
Traditional Knowledge/Western Science Bowhead Whale Migration Seasonal Report			x
Quantitative Description of Potential Impacts of OCS Activities on Bowhead Whale Hunting/Subsistence			x
Multidisciplinary			
Reference Manual and GIS Overlays, Oil Industry and Other Human Activity (1970-1995) Beaufort Sea	x		
ANIMIDA - Arctic Nearshore Impact Monitoring in Development Area	x	x	x
Estimation of Oil Spill Risk from the Alaska North Slope, Trans-Alaska Pipeline, and Canadian Spill Data Sets	x		
Alternative Oil Spill Occurrence Estimators for Beaufort/Chukchi Sea OCS		x	
Conference Management and Reports on MMS Results	x	x	x

Source: USDOI, MMS, Alaska OCS Region
For the most current status of ongoing studies, please see http://www.mms.gov/eppd/sciences/index.htm.
For completed studies, see the Environmental Studies Program Information System (ESPIS) at http://mmpub.mms.gov/.

Table III.C-1 Derated Skimmer Capacity

Description and Model	Quantity	Name Plate Capacity (gal/min)	Derating Factor*	Total Recovery (gal/20-hr day)
Disc				
MI-11/24	7	28	0.2	47,040
12KMkII	9	52	0.2	112,320
MI-2*	1	4	0.2	960
MI-30*	6	7	420 g/h	50,400
30k	9	7	420 g/h	75,600
Mini	1	77	0.2	18,480
Seaskimmer 50	1	132	0.2	31,680
Ocean	1	220	0.2	52,800
T-54	3	238	0.2	171,360
Drum				
Drum/Brush	3	97	0.2	69,840
TDS-118	4	50	0.2	48,000
TDS-136	1	90	0.2	21,600
Brush				
Lori	8	190	0.8	1,459,200
TransVac				
Diesel	3	350	0.2	252,000
Rope Mop				
Foxtail	1	174	0.3	62,640
MW62	2	20	0.2	9,600
Z14-E	37	10	0.2	88,800
Weir				
Desmi 250 Ocean	1	440	0.2	105,600
Desmi 250 Harbor	3	308	0.2	221,760
Destroil	2	110	0.2	52,800
Fasflow	2	440	0.2	211,200
Mini-Fasflow	4	100	0.2	96,000
Manta Ray rigid	12	24	0.2	69,120
Manta Ray flexible	73	38	0.2	665,760
Slurp	10	44	0.2	105,600
Alum	1	100	0.2	24,000
Seavac	1	656	0.2	157,440
Walosep W-1	1	175	0.2	42,000
Walosep W-4	1	396	0.2	95,040
Totals	**204**			**3,689,040**

Source: Alaska Clean Seas (1998:Vol. I, Tactic L-6, 3/1/99)
*Derating factor from Guidance for Preparing Marine Response Scenarios, Alaska Clean Seas (1998:Vol. I, Assumptions)

Table III.C-2 Comparison of Relative Island Design Parameters

	Liberty	Tern	Mukluk	Endicott Main Production Island	Northstar
Water depth	22 feet	21.5 feet	48 feet	6 feet	39 feet
Elevation of the working surface	12-15 feet	12 feet	21 feet	12 feet	
Height of gravel bag berm around perimeter of the working surface	5 feet	7 feet	4 feet	4-foot concrete splash wall on northwest side	N/A
Slope armor	Concrete mat and 4-cubic-yard gravel bags	2- and 4-cubic-yard gravel bags	2- and 4-cubic-yard gravel bags	Concrete mat and 4 cubic yard gravel bags	Steel sheetpile and concrete mat
Slope angle	1:3	1:3		1:3	1:3

Source: USDOI, MMS, Alaska OCS Region

Table III.C-3a Exposure Variables, Location of Oil-Spill from Historical Data, Product, Time Period, and Size Class Used to Estimate the Chance of an Oil Spill Occurring

	MMS OCS	Alaska North Slope	Trans-Alaska Pipeline	CONCAWE	S.L. Ross OCS	U.S. DOT
Exposure variable	Volume produced in billion barrels	Volume produced in billion barrels	Volume produced in billion barrels Pipeline miles in mile/years	Pipeline miles in mile/years	Pipeline miles in mile/years and wells in well/years	Pipeline miles in mile/years
Location of oil spills	Gulf of Mexico and Pacific OCS	Alaska North Slope	Alaska, Trans Alaska Pipeline	European onshore pipelines and estuary crossings	Gulf of Mexico and Pacific OCS	U.S. onshore and State offshore pipelines
Products	Crude, Diesel and Condensate	Crude and Condensate	Crude Oil	Crude and Petroleum Products	Crude, Diesel and Condensate	Crude and Petroleum Products
Time Period	1964-1999	1985-2000	1985-2000	1991-1995	1964-1995	1986-2000
Size Class	≥1,000	≥500	≥500	≥1,000	≥1,000	≥1,000

Table III.C-3b Spill Rates Used to Estimate the Chance of an Oil Spill Occurring from Historical Data

Source	Infrastructure	**MMS OCS**	**Alaska North Slope**	**Trans Alaska Pipeline**	**CONCAWE**	**S.L. Ross OCS**	**U.S. DOT**
Spills/Bbbl	Gravel Island	0.32	0.53				
Spills/Well Year	Gravel Island					0.000036	
Spills/Bbbl	Pipeline	1.33	0.11	0.11	0.87		
Spills/Mile/Year	Pipeline			0.00007[1]	0.00018[2]	0.00025	0.00023

Notes **1 The spill rate for 1977-2000 for ≥1,0000 is 0.00027. 2 This spill rate was used for consistency with the Northstar final EIS. The CONCAWE spill rate from 1971-1999 is 0.00024.**

Table III.C-3c MMS OCS Spill Rates ≥1,000 Barrels for Offshore Pipelines and Gravel Island Based on Volume

Source	Oil Reserve Volume Billion Barrels	Spills per Billion Barrels	Mean Number of Spills	Probability of No Spills	Probability of One or More Spills
Gravel Island	0.12	0.32	0.04	0.95	0.04
Pipeline	0.12	1.33	0.16	0.85	0.15

Table III.C-3d Alaska North Slope Spill Rates ≥500 Barrels for Pipelines and Gravel Island Based on Volume

Source	Oil Reserve Volume Billion Barrels	Spills per Billion Barrels	Mean Number of Spills	Probability of No Spills	Probability of One or More Spills
Gravel Island	0.12	0.53	0.06	0.94	0.06
Pipeline	0.12	0.11	0.01	0.99	0.01

Table III.C-3e Trans Alaska Pipeline Spill Rates ≥500 Barrels for Pipelines Based on Volume

Source	Oil Reserve Volume Billion Barrels	Spills per Billion Barrels	Mean Number of Spills	Probability of No Spills	Probability of One or More Spills
Pipeline	0.12	0.11	0.01	0.99	0.01

Table III.C-3f Trans-Alaska Pipeline Spill Rates ≥500 Barrels for Pipelines Based on Mile/Year

Alternative		Miles of Pipeline	Mile/Years	Spills Per Mile/Year	Mean Number of Spills	Probability of No Spills	Probability of One or More Spills
I	**Offshore Pipeline**	6.1	91.5	0.00007	0.006	0.994	0.006
	Onshore Pipeline	1.5	22.5	0.00007	0.002	0.998	0.002
	System	7.6	114	0.00007	0.008	0.992	0.008
II	**No Action**	0	0	0.00007	See	Table	III.C-3k
III.A	**Offshore Pipeline**	4.2	63	0.00007	0.0044	0.996	0.004
	Onshore Pipeline	3.1	46.5	0.00007	0.0033	0.997	0.003
	System	7.3	109.5	0.00007	0.0077	0.992	0.008
III.B	**Offshore Pipeline**	5.5	82.5	0.00007	0.0058	0.994	0.006
	Onshore Pipeline	3.1	46.5	0.00007	0.0033	0.997	0.003
	System	8.6	129	0.00007	0.0090	0.991	0.009
IV, V, VI, VII	**Offshore Pipeline**	6.1	91.5	0.00007	0.0064	0.994	0.006
	Onshore Pipeline	1.5	22.5	0.00007	0.0016	0.998	0.002
	System	7.6	114	0.00007	0.0080	0.992	0.008

Table III.C-3g CONCAWE Spill Rates ≥1,000 Barrels for Pipelines Based on Mile/Year

Alternative		Miles of Pipeline	Mile/Years	Spills Per Mile/Year	Mean Number of Spills	Probability of No Spills	Probability of One or More Spills
I	**Offshore Pipeline**	6.1	91.5	0.00018	0.016	0.984	0.016
	Onshore Pipeline	1.5	22.5	0.00018	0.004	0.996	0.004
	System	7.6	114	0.00018	0.021	0.980	0.020
II	**No Action**	0	0	0.00018	See	Table	III.C-3k
III.A	**Offshore Pipeline**	4.2	63	0.00018	0.011	0.989	0.011
	Onshore Pipeline	3.1	46.5	0.00018	0.008	0.992	0.008
	System	7.3	109.5	0.00018	0.020	0.980	0.020
III.B	**Offshore Pipeline**	5.5	82.5	0.00018	0.015	0.985	0.015
	Onshore Pipeline	3.1	46.5	0.00018	0.008	0.992	0.008
	System	8.6	129	0.00018	0.023	0.977	0.023
IV, V, VI, VII	**Offshore Pipeline**	6.1	91.5	0.00018	0.016	0.984	0.016
	Onshore Pipeline	1.5	22.5	0.00018	0.004	0.996	0.004
	System	7.6	114	0.00018	0.021	0.980	0.020

Table III.C-3h CONCAWE Spill Rates ≥1,000 Barrels for Pipelines Based on Volume

Source	Oil Reserve Volume Billion Barrels	Spills per Billion Barrels	Mean Number of Spills	Probability of No Spills	Probability of One or More Spills
Pipeline	0.12	0.87	0.10	0.90	0.10

Table III.C-3i S.L. Ross Spill Rates ≥1,000 Barrels for Offshore Pipelines and Gravel Island Based on Mile/Year and Well/Year

Alternative		Miles of Pipeline	Mile/ Years	Spills Per Mile/Year	Mean Number of Spills	Probability of No Spills	Probability of One or More Spills
I	**Offshore Pipeline**	6.10	91.50	0.00025	0.02	0.977	0.023
	Onshore Pipeline	1.50	22.50	0.00025	0.01	0.994	0.006
	System	7.60	114.00	0.00025	0.03	0.972	0.028
II	**No Action**	0	0	0.00018	See	Table	III.C-3k
III.A	**Offshore Pipeline**	4.20	63.00	0.00025	0.02	0.984	0.016
	Onshore Pipeline	3.10	46.50	0.00025	0.01	0.988	0.012
	System	7.30	109.50	0.00025	0.03	0.973	0.027
III.B	**Offshore Pipeline**	5.50	82.50	0.00025	0.02	0.980	0.020
	Onshore Pipeline	3.10	46.50	0.00025	0.01	0.988	0.012
	System	8.60	129.00	0.00025	0.03	0.968	0.032
IV, V, VI, VII	**Offshore Pipeline**	6.10	91.50	0.00025	0.02	0.977	0.023
	Onshore Pipeline	1.50	22.50	0.00025	0.01	0.994	0.006
	System	7.60	114.00	0.00025	0.03	0.972	0.028
		Wells	Well Year	Spills per Well-Year			
	Gravel Island	14.00	210.00	0.000036	0.008	0.992	0.008

Table III.C-3j U.S. DOT Spill Rates ≥1,000 Barrels for Pipelines Based on Mile/Year

Alternative		Miles of Pipeline	Mile/Years	Spills Per Mile/Year	Mean Number of Spills	Probability of No Spills	Probability of One or More Spills
I	**Offshore Pipeline**	6.1	91.5	0.00023	0.021	0.979	0.021
	Onshore Pipeline	1.5	22.5	0.00023	0.005	0.995	0.005
	System	7.6	114	0.00023	0.026	0.974	0.026
II	**No Action**	0	0	0.00023	See	Table	III.C-3k
III.A	**Offshore Pipeline**	4.2	63	0.00023	0.015	0.986	0.014
	Onshore Pipeline	3.1	46.5	0.00023	0.011	0.989	0.011
	System	7.3	109.5	0.00023	0.025	0.975	0.025
III.B	**Offshore Pipeline**	5.5	82.5	0.00023	0.019	0.981	0.019
	Onshore Pipeline	3.1	46.5	0.00023	0.011	0.989	0.011
	System	8.6	129	0.00023	0.030	0.971	0.029
IV, V, VI, VII	**Offshore Pipeline**	6.1	91.5	0.00023	0.021	0.979	0.021
	Onshore Pipeline	1.5	22.5	0.00023	0.005	0.995	0.005
	System	7.6	114	0.00023	0.026	0.974	0.026

Table III.C-3k Estimated Chance of No Spills Occurring for Alternative I from Historical Data

Alternatives	Infrastructure	Source	MMS OCS	Alaska North Slope (ANS)	MMS /ANS & Trans-Alaska Pipeline	MMS/ANS and CONCAWE	S.L. Ross OCS	MMS/ANS and USDOT
Alternative I	Gravel Island	Spills/Bbbl	94	94-96	94-96	94-96		94-96
Liberty Island		Well Years	na	na	na		99.2	
and Liberty.	Onshore and	Spills/Bbbl	85	99	99	90		
Pipeline Route	Offshore Pipeline	Spills/Mile/Year	na	na	99.2	98	97.1	97.4
Alternative II No Action	Gravel Island	Spills/Bbbl Well Years	No chance of spills occurring due to Liberty. The chance of a spill occurring is not zero. The chance of an oil spill occurring is moved to a new location where production occurs.					
	Onshore and Offshore Pipeline	Spills/Bbbl Spills/Mile/Year						
Alternative III.A	Gravel Island	Spills/Bbbl	94	94-96	94-96	94-96		94-96
Southern Island		Well Years	na	na	na		99.2	
and Eastern	Onshore and	Spills/Bbbl	85	99	99	90		
Pipeline Route	Offshore Pipeline	Spills/Mile/Year			99.2	98	97.3	97.5
Alternative III.B	Gravel Island	Spills/Bbbl	94	94-96	94-96	94-96		94-96
Use Tern Island		Well Years	na	na	na		99.2	
and Tern Island	Onshore and	Spills/Bbbl	85	99	99	90		
Pipeline Route	Offshore Pipeline	Spills/Mile/Year			99.1	97.7	96.8	97.1
Alternatives IV.A, IV.B. &IV.C	Gravel Island	Spills/Bbbl	94	94-96	94-96	94-96		94-96
Pipe in Pipe		Well Years	na	na	na		99.2	
Pipe in HPDE Flexible Pipe	Onshore and Offshore Pipeline	Spills/Bbbl Spills/Mile/Year	There is no historical spill data on these types of pipelines. See Table II.C-5 for the probability of a spill larger than 1,000 barrels based on modeled failure rates.					

Source for all tables: USDOI, MMS, Alaska OCS Region

Table III.C-4 Large and Small Spill Sizes We Assume for Analysis in this EIS by Alternative

	ASSUMED SPILL SIZE IN BARRELS									
	LARGE								SMALL	
	CRUDE OIL							DIESEL OIL	CRUDE OR DIESEL	REFINED OIL
	GRAVEL ISLAND[1]	OFFSHORE PIPELINE					ONSHORE PIPELINE	GRAVEL ISLAND (Diesel Tank)	OPERATION SPILLS OFFSHORE AND ONSHORE	OPERATION SPILLS OFFSHORE AND ONSHORE
		Leak-Detection and Location System		Pressure-Point Analysis And Mass-Balance Line-Pack Compensation						
		Leak	Rupture	Summer Leak	Winter Leak	Rupture				
Alternative I BPXA Proposal	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative II, No Action	Spills occur elsewhere from oil reserves produced at another location									
Alternative III, Use Alternative Island Locations and Pipeline Routes	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative IV, Use Different Pipeline Designs										
Assumption 1, Neither Outer nor Inner Pipe Leaks										
Alternative IV.A Use Pipe-in-Pipe System	925	0			0		720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative IV.B Use Pipe-in-HDPE System	925	0			0		720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative IV.C Use Flexible Pipe System	925	0			0		720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative I Single Wall (for comparison)	925	0			0		720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Assumption 2, Both Outer and Inner Pipes Leak										
Alternative IV.A Use Steel Pipe-in-Pipe System	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative IV.B Use Pipe-in-HDPE System	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative IV.C Use Flexible Pipe System	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative I Single Wall (for comparison)	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and < 25 bbl	53 of 0.7 bbl
Assumption 3, Only the Inner Pipe Leaks										
Alternative IV.A Use Pipe-in-Pipe System	925	0			0		720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative IV.B Use Pipe-in-HDPE System	925	0			0		720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative IV.C Use Flexible Pipe System	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative I Single Wall (for comparison)	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Assumption 4, Only the Outer Pipe Leaks										
Alternative IV.A Use Pipe-in-Pipe System	925	0			0		720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative IV.B Use Pipe-in-HDPE System	925	0			0		720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative IV.C Use Flexible Pipe System	925	Na	Na	Na	Na	Na	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative I Single Wall (for comparison)	925	Na	Na	Na	Na	Na	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative V, Use Steel Sheetpile	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative VI, Use Duck Island Mine	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl
Alternative VII, Use a 15-Foot Trench Depth	925	125	1,580	715	2,956	1,580	720–1,142	1,283	17<1 bbl, 6 ≥1 and <25 bbl	53 of 0.7 bbl

Source: USDOI, MMS Alaska OCS Region

[1] The revised Oil Discharge Prevention and Contingency Plan prohibits the drilling of new wells or sidetracks from existing wells into major liquid-hydrocarbon zones at its drill sites during the defined period of broken ice and open water (BPXA, 2001; Section 2.1.7). This period begins on June 13 of each year and ends with the presence of 18 inches of continuous ice cover for one-half mile in all directions from the Liberty island. This drilling moratorium eliminates the environmental effects associated with a well blowout during drilling operations in the Beaufort Sea during broken-ice or open-water conditions.

Table III.C-5 Concentration of Dispersed Oil Remaining in the Water Column After 1, 3, 10, and 30 Days From Possible Pipeline and Facility Crude-Oil Spills

Area and Assumed Dispersal Depth	Dispersed[1] Oil Concentration in Parts per Million After				Area and Assumed Dispersal Depth	Dispersed Oil Concentration in Parts per Million After			
	1 Day	3 Days	10 Days	30 Days		1 Day	3 Days	10 Days	30 Days
PIPELINE SPILLS INTO OPEN WATER									
125 Barrels									
Foggy Island Bay					*Beaufort Sea*				
5 feet (1.5 meters)	0.510	–	–	–	33 feet (10 meters)	–	0.038	0.019	–
10 feet (3.0 meters)	–	0.124	–	–	49 feet (15 meters)	–	–	0.013	0.007
20 feet (6.1 meters)	–	–	0.030	0.015					
715 Barrels[2]									
Foggy Island Bay					*Beaufort Sea*				
5 feet (1.5 meters)	0.510	–	–	–	33 feet (10 meters)	–	0.038–0.089	0.019–0.044	–
10 feet (3.0 meters)	–	0.124–0.294	–	–	49 feet (15 meters)	–	–	0.013–0.031	0.015
20 feet (6.1 meters)	–	–	0.030–0.070	0.035					
1,580 Barrels									
Foggy Island Bay					*Beaufort Sea*				
5 feet (1.5 meters)	0.194	–	–	–	33 feet (10 meters)	–	0.019	0.015	–
10 feet (3.0 meters)	–	0.063	–	–	49 feet (15 meters)	–	–	0.010	0.008
20 feet (6.1 meters)	–	–	0.024	0.017					
PIPELINE SPILLS IN BROKEN ICE/MELTOUT CONDITIONS									
125 Barrels									
Foggy Island Bay					*Beaufort Sea*				
5 feet (1.5 meters)	0	–	–	–	33 feet (10 meters)	–	–	0.001	–
10 feet (3.0 meters)	–	0.004	–	–	49 feet (15 meters)	–	–	–	0.001
20 feet (6.1 meters)	–	–	0.002	0.001					
715 Barrels[2]									
Foggy Island Bay					*Beaufort Sea*				
5 feet (1.5 meters)	0	–	–	–	33 feet (10 meters)	–	–	0.001	–
10 feet (3.0 meters)	–	0.004–0.009	–	–	49 feet (15 meters)	–	–	–	0.001
20 feet (6.1 meters)	–	–	0.002	0.002					
2,956 Barrels									
Foggy Island Bay					*Beaufort Sea*				
5 feet (1.5 meters)	0.0	–	–	–	33 feet (10 meters)	–	–	0.001	–
10 feet (3.0 meters)	–	0.0	–	–	49 feet (15 meters)	–	–	–	0.001
20 feet (6.1 meters)	–	–	0.002	0.002					
FACILITY SPILL INTO OPEN WATER									
925 Barrels									
Foggy Island Bay					*Beaufort Sea*				
5 feet (1.5 meters)	0.153	–	–	–	33 feet (10 meters)	–	0.018	0.029	–
10 feet (3.0 meters)	–	0.060	–	–	49 feet (15 meters)	–	–	0.020	0.008
20 feet (6.1 meters)	–	–	0.046	0.018					
FACILITY SPILL UNDER BROKEN ICE/MELTOUT CONDITIONS									
925 Barrels									
Foggy Island Bay					*Beaufort Sea*				
5 feet (1.5 meters)	0.0	–	–	–	33 feet (10 meters)	–	–	0.002	–
10 feet (3.0 meters)	–	0.008	–	–	49 feet (15 meters)	–	–	–	0.0
20 feet (6.1 meters)	–	–	0.003	0.002					

Source: USDOI, MMS, Alaska OCS Region

[1] The analysis assumes uniform distribution of the dispersed hydrocarbons throughout the part of the water column defined by the discontinuous areas shown in Appendix A, Table A-6g and the water depths shown in this table.

[2] The 715-barrel oil spill is assumed to take place during a 7-day period, and the daily spill rates are the same. The concentration of dispersed oil in the water after the first day would be about the same as the concentration estimated for the 125-barrel spill, which is the result of a small leak over a 24-hour period. The concentration of dispersed oil in the water after 3 and 10 days is assumed to range between the concentration for the 125-barrel spill and the concentration for a 715-barrel spill in which the entire 715 barrels leaked into the water in less than 1 day. After 30 days, the concentration of dispersed oil from the 715-barrel spill is assumed to be uniformly distributed in the water.

Table III.C-6 Concentration of Dispersed Oil Remaining in the Water Column After 1 to 30 Days From a Possible Diesel-Oil Spill

Spill/Assumed Dispersal Depth	Dispersed[1] Oil Concentration in Parts per Million After			
	1 Day	3 Days	*7 Days* / 10 Days	30 Days
Facility Spill Into Open Water				
1,283 Barrels				
5 feet (1.5 meters)	43.557	–	–	–
10 feet (3.0 meters)	–	5.603	–	–
20 feet (6.1 meters)	–	–	*1.219*	–
Facility Spill Under Broken Ice/Meltout Conditions				
1,283 Barrels				
5 feet (1.5 meters)	1.728	–	–	–
10 feet (3.0 meters)	–	0.519	–	–
20 feet (6.1 meters)	–	–	0.153	0.091

[1] The analysis assumes uniform distribution of the dispersed hydrocarbons throughout the part of the water column defined by the discontinuous areas shown in Appendix A, Table A-6g and the water depths shown in this table.

Table III.C-7 Distances from Liberty Island to Channels Between the Barrier Islands

Channel	Distance from Liberty Island (nautical miles)	Travel Time Between Liberty Island and the Channel Assuming a 0.3-Knot Surface Current	
		Hours	Days
West of Cross Island	16	53	2.2
Between Cross and Narwhal Islands	9.5	32	1.3
Newport Entrance (between Karluk and Stockton Islands)	7	23	1
East of Stockton Island	17	56	2.3

Source for both tables: USDOI, MMS, Alaska OCS Region

Table III.C-8 Nearshore Waves: Heights and Periods

	Wind Velocity (miles per hour)								
	20			30			40		
	Fetch (miles)								
	5	10	15	5	10	15	5	10	15
Water Depth (feet)	**Wave Height (feet)**								
5	0.9	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.6
10	1.2	1.5	1.7	1.6	2.0	2.1	2.0	2.4	2.5
	Period (seconds)								
5	2.0	2.4	2.5	2.4	2.6	2.8	2.6	2.9	3.1
10	2.2	2.6	2.8	2.5	3.0	3.2	2.8	3.3	3.5

Source**:** U.S. Army Corps of Engineers (1984b:Figs. 3-27 and 3-28).

Table III.C-9 Annual Maximum Sustained Winds: Oliktok Point and Barter Island

	Return period (years)			
	2	5	25	100
	Wind Speed (knots)			
Oliktok Point	39.1	46.9	59.2	76.8
Barter Island	52.1	61.7	76.8	97.9

Source: Brower et al. (1988).

Table III.C-10 Rates of Infilling of Seafloor Scours and Gouges in the Vicinity of Liberty

Study	In-Filling Rate (ft/year) Yearly Average	Comments
Egg Island	4 - 7	Reimnitz and Kempema (1982, 1983)* Island sheltered from currents.
Sagavanirktok Delta	5 - 8	Reimnitz and Kempema (1982, 1983)* Exposed areas. From currents.
Depth of deposit immediately after an event	1.6	Reimnitz and Kempema (1982, 1983)* From suspended particle immediately after event. Initial in-filling will depend on the soil type, and could be nearly negligible for cohesive soil or flat-sided craters.
Endicott Strudel	0.3 - 1	Adjacent to the causeway; attributed to the settlement of suspended particles.
Duck Island/Sagavanirktok Delta	5	Harding Lawson (1981)* and McClelland (1982)*.
Liberty Pipeline Route	8.1 (maximum)	Coastal Frontiers Corporation (1999)*.
Off Resolution Island in the Sagavanirktok Delta	1.8	Coastal Frontiers Corporation (1999)*.
Northstar Test Trench	2 - 4	Coastal Frontiers Corporation (1999)*.
Liberty area (before 1997 survey)	0.2 - 0.7	Based on an analysis of winds ≥20 knots.

Source: *as cited in Blanchet et al. (2000)

Table III.D-1 Air-Quality Impact-Analysis Summary—Liberty Project (PSD Class II Increment Analysis)

Pollutant	Averaging Period	Maximum Concentration[1] (µg/m³)	PSD Class II Increment Level (µg/m³)	% of Class II Increment
NO_2	annual	24.0[2,3]	25	96.0
SO_2	3-hour	183.0[4]	512	35.7
	24-hour	88.2[4]	91	96.9
	annual	5.1[3]	20	25.5
PM_{10}	24-hour	22.0[4]	30	73.3
	annual	1.8[4]	17	10.6

Source: BPXA (1998e:Table 3-2).
[1] All maximum concentrations occur within 200 meters of facility boundary. [2] NO_2 concentration includes contribution of 1.9 micrograms per cubic meter from other PSD sources. [3] Maximum concentrations occur during the pre-2001 sealift operations (initial drilling phase). [4] Maximum concentrations occur during long-term operations (production phase).

Table III.D-2 National Ambient-Air-Quality Standard Analysis

Pollutant	Averaging Period	Maximum Conc.[1]	Background Concentration[2]	Total Conc.	NAAQS*	% of NAAQS
Initial Drilling/Commissioning Period						
NO_2	Annual	22.1	7.8	29.9	100	29.9
SO_2	3-hour	168.7	6.8	175.5	1,300	13.5
	24-hour	81.4	4.8	86.2	365	23.6
	annual	5.1	0.1	5.2	80	6.5
PM_{10}	24-hour	21.4	7.0	28.4	150	18.9
	annual	1.3	0.1	1.4	50	2.8
CO	1-hour	804.0	--	804.0	40,000	2.0
	8-hour	245.6	--	245.6	10,000	2.5
Long-Term Operations						
NO_2	Annual	19.2	7.8	27.0	100	27.0
SO_2	3-hour	183.0	6.8	189.8	1,300	14.6
	24-hour	88.2	4.8	93.0	365	25.5
	annual	2.7	0.1	2.8	80	3.5
PM_{10}	24-hour	22.0	7.0	29.0	150	19.3
	annual	1.8	0.1	1.9	50	3.8
CO	1-hour	804.0	--	804.0	40,000	2.0
	8-hour	270.4	--	270.4	10,000	2.7

Source: BPXA (1998e:Table 3-3).
[1] All maximum concentrations occur within 200 meters of facility boundary.
[2] Background concentrations include global background and contributions from existing emission sources.
*National Ambient Air Quality Standards

Table III.D-3 Estimated Alaska Employment from Liberty Project Design and Construction

Material/Service	Average Number of Personnel (Monthly)	Start of Project	Estimated Duration (months)	Primary Contractor	Location of Workforce	Estimated Direct Labor Hours	Estimated Wages (total $)
Engineering	17	0	41	VEI	Anchorage	140,000	$10,000,000
Anchorage Fabrication	119	0 + 14 mos.	22	APC	Anchorage	653,000	$35,900,000
Island Construction	65	0 + 22 mos.	14	AIC	North Slope	265,000	$14,600,000
Pipeline Construction	49	0 + 28 mos.	7	HCC	North Slope	98,000	$5,400,000
Facilities Installation	98	0 + 36 mos.	5	VCI	North Slope	143,000	$7,800,000
Drilling	55	0 + 38 mos.	15	BPXA	North Slope	240,000	$10,857,000
Anchorage Support Staff	29	0	41	BPXA	Anchorage	203,000	$15,200,000
TOTAL						**1,742,000**	**$99,757,000**

Source: Table courtesy of BPXA. VEI = Veco Engineering, Inc.; APC = Alaska Petroleum Contractors; AIC = Alaska Interstate Construction; HCC = Houston Contracting; VCI = Veco Construction, Inc.

Table III.D-4 Estimated Alaska Employment from Liberty Project Operations

Material/ServiceS	Average Number of Personnel (Monthly)	Start of Project*	Estimated Duration (months)	Primary Contractor	Location of Workforce	Annual Direct Labor Hours	Annual Estimated Wages ($)
Operations Personnel	20	0 + 37 mos.	ongoing	BPXA/contractor tbd	North Slope	60,000	$1,800,000
Support Personnel	5	0 + 37 mos.	ongoing	tbd	North Slope	10,000	$200,000
Anchorage Staff	25	0 + 34 mos.	ongoing	BPXA/contractor tbd	Anchorage	50,000	$2,000,000
Annual Maintenance	50	0 + 47 mos.	2 weeks per year	tbd	North Slope	8,400	$168,000
TOTAL						**128,400**	**$4,168,000**

Source: Table courtesy of BPXA. *0 = 0 in Table III.D-3. tbd = to be determined.

Table III.D-5 Estimated Production and Federal, State and North Slope Borough Revenue from the Liberty Project by Year. In millions of dollars, except estimated production (thousand barrels per day).

	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL	PERCENT
Estimated Production (thousand barrels per day)	**4.1**	**58.5**	**58.5**	**46.7**	**39.0**	**30.0**	**22.0**	**15.0**	**10.6**	**9.0**	**7.6**	**6.9**	**6.2**	**5.6**	**5.2**	**3.8**		
Projected Gross Revenue*	18	256	256	205	171	131	96	66	46	39	33	30	27	25	23	17	1440	
Annual Revenue Net of Royalty	16	224	224	179	149	115	84	57	41	34	29	26	24	21	20	15	1260	
Capital Expense	6	85	85	68	57	44	32	22	15	13	11	10	9	8	8	6	480	
Operating Expenses	3	43	43	34	28	22	16	11	8	7	6	5	5	4	4	3	240	
Total Expenses	9	128	128	102	85	66	48	33	23	20	17	15	14	12	11	8	720	**65**
Taxable Income	7	96	96	77	64	49	36	25	17	15	12	11	10	9	9	6	540	
Federal Royalty	2	23	23	19	16	12	9	6	4	4	3	3	2	2	2	2	130	
Federal Income Tax	2	33	33	27	22	17	12	8	6	5	4	4	3	3	3	2	182	
Total Federal Revenue	4	56	56	46	38	29	21	14	10	9	7	7	5	5	5	4	312	**28**
State Share of Federal Royalty	1	9	9	7	6	4	3	2	2	1	1	1	1	1	1	1	49	
State Income Tax	0	2	2	2	1.5	1	0.5	0.5	0.5	0.5	0	0	0	0	0	0	11	
State Spill and Conservation Tax	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	4	
Total State Revenue	1	13	13	11	9	7	5	3	2	2	2	2	1	1	1	1	63	**6**
Ad Valorem Tax	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	5	
	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	5	**0.5**

Source: Table courtesy of BPXA (BPXA, 1998a:5-10).
* Nominal (as spent) dollars.
The assumptions used for this Table are as follows:

- North Slope wellhead: $12 per barrel
- Transportation tariffs: $4.00
- Oil price (wellhead plus transportation tariffs): $16.00 per barrel
- Reserves: 120 million barrels
- Royalty rate: 12.5%
- State share of royalty: 27%
- Federal income tax rate: 35%
- State income tax rate: 4%
- State spill and conservation tax: $0.034 per barrel
- Ad valorem tax rate: 2%

Projections of capital expense, operating expenses, Federal tax, and royalty and ad valorem tax in this table are different than those in Appendix D-1. The MMS recognizes these differences. The MMS prepared Appendix D-1 as an independent analysis to determine technically and economically feasible development options.

Table III.D-6 Kadleroshilik River Mine Site Land Areal Coverage by Land Cover Type (Class)

Class	Land Cover Description	Wetland	Phase 1 Mine Cell		Phase 2 Mine Cell		Reserve Area		Total Mine Site	
			Acres	Percent of Area	Acres	Percent of Area	Acres	Percent of Area	Acres	Percent of Area
Ia	Water	No	0.15	0.8%	0.01	0.1%	0.06	0.3%	0.21	0.4%
IIIa	Wet Sedge Tundra	Yes	0.15	0.8%	0.00	0.0%	0.00	0.0%	0.15	0.3%
Va	Moist Sedge, Dwarf Shrub Tundra	Yes	0.02	0.1%	1.02	8.2%	0.22	1.0%	1.26	2.4%
Vc	Dry Dwarf Shrub, Crustose Lichen	Yes	7.26	38.1%	4.83	38.8%	3.23	15.1%	15.32	29.0%
IXb	Dry Barren/Dwarf Shrub, Forb Grass Complex	Yes	2.00	10.5%	3.41	27.4%	3.85	18.0%	9.26	17.5%
IXc	Dry Barren/Forb Complex	Yes	1.44	7.6%	2.11	17.0%	9.47	44.2%	13.02	24.6%
IXf	Dry Barren/Dwarf Shrub, Grass Complex	Yes	1.90	10.0%	0.16	1.3%	0.00	0.0%	2.06	3.9%
Xa	River Gravel	No	6.12	32.2%	0.89	7.1%	4.59	21.4%	11.6	21.9%
	Total Land Cover Area		19.03	100.0%	12.43	100.0%	21.42	100.0%	52.87	100.0%
	Total Wetland Area		12.77	67.1%	11.53	92.7%	16.77	78.3%	41.06	77.6%

Source: Noel and McKendrick (2000).
Total Wetland Area is defined by the U.S. Army Corp of Engineers as Land Cover Types (Class) III.a, Va,Vc, IXb, IXc, and IXf.

Table IV.A-1 List of Alternatives and their Location in the EIS

	Alternative Number and Name	EIS Section That Provides: Description of Alternative	EIS Section That Provides: Environmental Effects of Alternative
I	**Liberty Development and Production Plan – (The BPXA Proposal)**	II.A	III
II	**No Action – (Alternative II)**	II.B	IV.B
	Alternative Drilling Locations and Pipeline Route	II.C.1.a	IV.C.1
I	Use Liberty Island Location and Pipeline Route (Liberty DPP)	II.C.1.d	IV.C.1.c
III.A	Use Southern Island Location and Eastern Pipeline Route	II.C.1.b	IV.C.1.d
III.B	Use Tern Island Location and Pipeline Route	II.C.1.c	IV.C.1.e
	Alternative Pipeline Designs	II.C.2	IV.C.2
I	Use Single-Wall Pipe System (Liberty DPP)	II.C.2.e	IV.C.2.h
IV.A	Use Pipe-in-Pipe System	II.C.2.b	IV.C.2.i
IV.B	Use Pipe-in-HDPE System	II.C.2.c	IV.C.2.j
IV.C	Use Flexible Pipe System	II.C.2.d	IV.C.2.k
	Alternative Upper Island Slope Protection Systems	II.C.3	IV.C.3
I	Use Gravel Bags (Liberty DPP)	II.C.3.c	IV.C.3.a
V	Use Steel Sheet Pile	II.C.3.b	IV.C.3.b
	Alternative Gravel Mine Sites	II.C.4	IV.C.4
I	Use Kadleroshilik River Mine Site (Liberty DPP)	II.C.4.c	IV.C.4.a
VI	Use Duck Island Gravel Mine	II.C.4.b	IV.C.4.b
	Alternative Pipeline Burial Depths	II.C.5	IV.C.5
I	Use a 7-Foot Burial Depth	II.C.5.d	IV.C.5.a
VII	Use a 15-Foot Pipeline Trench Depth	II.C.5.c	IV.C.5.b
	Combination Alternatives	II.D	IV.D
A	Combination Alternative A	II.D.2.a	IV.D.5
B	Combination Alternative B	II.D.2.b	IV.D.6
C	Combination Alternative C	II.D.2.c	IV.D.7
I	Liberty DPP	II.D.2.d	IV.D.4

Source: USDOI, MMS, Alaska OCS Region (2000)

Table IV.A-2 Location in the EIS of the General Effects Analyses that are the Same for All Alternatives

Resource	EIS Section that Discusses the Effects Of …					
	Large Oil Spill	Disturbances	Discharges	Small Oil Spills	Seawater Intake	Abandonment
Threatened and Endangered Bowhead Whales	III.C.2.a.(1)(b)1)	III.C.3.a.(1)(b)1)	III.D.1.a.(1)	III.D.3.a.(1)		III.D.6.a.(1)
Threatened and Endangered Eiders	III.C.2.a.(2)(b)1)	III.C.3.a.(2)(b)1)	III.D.1.a.(2)	III.D.3.a.(2)		III.D.6.a.(2)
Seals, Walruses, Beluga Whales, and Polar Bears	III.C.2.b.(2)(a)	III.C.3.b.(2)(a)	III.D.1.b	III.D.3.b		III.D.6.b
Marine and Coastal Birds	III.C.2.c.(2)(a)	III.C.3.c.(2)(a)	III.D.1.c	III.D.3.c		III.D.6.c
Terrestrial Mammals	III.C.2.d.(2)(a)	III.C.3.d.(2)(a)	III.D.1.d	III.D.3.d		III.D.6.d
Lower Trophic-Level Organisms	III.C.2.e.(2)(a)	III.C.3.e.(2)(a)	III.D.1.e	III.D.3.e		III.D.6.e
Fishes	III.C.2.f.(1)(b)1)	III.C.3.f.(1)(b)1)	III.D.1.f.(1)	III.D.3.f.(1)	III.D.4.a.	III.D.6.f.(1)
Essential Fish Habitat	III.C.2.f.(2)	III.C.3.f.(2)	III.D.1.f.(2)	III.D.3.f.(2)	III.D.4.b.	III.D.6.f.(2)
Vegetation-Wetland Habitats	III.C.2.g.(2)(a)	III.C.3.g.(2)(a)	III.D.1.g	III.D.3.g		III.D.6.g
Subsistence-Harvest Patterns	III.C.2.h.(2)	III.C.3.h.(2)(a)	III.D.1.h.	III.D.3.h.		III.D.6.h.
Sociocultural Systems	III.C.2.i.(2)	III.C.3.i.(2)(a)	III.D.1.I	III.D.3.I		III.D.6.I
Archaeology Resources	III.C.2.j.(2)	III.C.3.j.(2)	III.D.1.j	III.D.3.j		III.D.6.j
Economy	III.C.2.k.	III.C.3.k.	III.D.1.k	III.D.3.k		III.D.6.k
Water Quality	III.C.2.l.(2)(a)	III.C.3.l.(2)(a)	III.D.1.l	III.D.3.l.(2)(a)		III.D.6.l.(2)(a)
Air Quality	III.C.2.m.(2)	III.C.3.m.(2)	III.D.1.m	III.D.3.m		III.D.6.m

Source: USDOI, MMS, Alaska OCS Region (2000)

Table IV.A-3

Summary Comparisons of Impacts Among Alternatives for the Liberty Development Project Environmental Impact Statement

Bowhead Whales
Spectacled and Steller's Eiders
Seals, Walruses, Beluga Whales and Polar Bears
Marine and Coastal Birds
Terrestrial Mammals
Lower-Trophic Level Organisms
Fishes
Essential Fish Habitat
Vegetation-Wetlands
Subsistence-Harvest Patterns
Sociocultural Systems
Archaeological Resources
Economy
Water Quality
Air Quality
Environmental Justice

Note to the Reader: Please keep the following information in mind as you read the summaries in this table.

This EIS will use the comparative term "the same as" to indicate an impact essentially is identical or as similar as can be determined to that noted for another alternative. Within the EIS analysis, we use the phrase "the same as" to indicate to the reader that two impacts are considered to be equal. We do not intend this in the pure or mathematical sense. We are not saying two impacts are exactly the same or identical. Rather, we use the phrase to indicate that two impacts are so close that finding a difference between them is beyond our analytical ability to measure or analyze.

The effects associated with potential oil spills are based on the assumptions that a spill occurs and no spill response activities were conducted that could reduce the amount of oil in the environment or prevent oil from reaching critical areas.

The summaries presented in this table are based on the comprehensive analysis in Sections III.C and D and Section IV.C.

Bowhead Whales

Alternative I – Proposed Action

Effects of Oil Spills:
The effects of an oil spill on bowhead whales are unknown, but some conclusions can be drawn from studies that have looked at the effects of oil spills on other cetaceans. If a spill occurred and contacted bowhead habitat during the fall and spring migrations a large portion of the population could be exposed to the oil. It is likely some of these whales would be contacted and experience temporary, nonlethal effects, including one or more of the following symptoms:

- oiling of their skin, causing irritation
- inhaling hydrocarbon vapors
- ingesting oil-contaminated prey
- fouling of their baleen
- losing their food source
- moving temporarily from some feeding areas

Prolonged exposure to freshly spilled oil could kill some whales, but we expect that number to be very small with such a low chance of contact. Studies on the physiologic and toxic effects of oil on whales have concluded there was no evidence that oil contamination had been responsible for the death of a cetacean. Nevertheless, the effects of oil exposure to the bowhead whale population are uncertain, speculative, and controversial. The effects would depend on how many whales contacted oil, the duration of contact, and the age/degree of weathering of the spilled oil.

The chance of an oil spill greater than or equal to 500 barrels from the offshore production island and the buried pipeline occurring and entering the offshore waters is estimated to be on the order of 1% over the life of the field. Oil from a large spill could contact areas outside the barrier islands where bowhead whales may be present. The area northwest of project area (habitat where bowhead whales may occur during their fall migration) generally has the highest percent chance of contact by an oil spill from Liberty Island and the offshore portion of the pipeline. During open water the chance of crude oil contacting various parts of this area from (1) an island spill ranges from 8-15% over a 30-day to 8-16% over a 360-day period and (2) from a pipeline spill ranges from 7-13% over a 30-day period to 7-14% over a 360-day period. During winter the chance of crude oil contacting various parts of this area from (1) an island spill ranges from 2-3% over a 30-day to 5-15% over a 360-day period and (2) from a pipeline spill ranges from 1-3% over a 30-day period to 4-13% over a 360-day period. The chance that an oil spill would contact the spring lead system over a 360-day period during the summer or winter is estimated to be less than 0.5%.

The chance of a large diesel spill from Liberty Island contacting various parts of the area northwest of the Liberty project area (1) during open water ranges from 1-6% over a 30-day and (2) during the winter ranges from less than 0.5-3% over a 30-day period. The chance that an diesel spill would contact the spring lead system over a 3-day period is estimated to be less than 0.5%.

The potential for bowhead whales to be affected by spilled oil from the Liberty Project is relatively small, based on the estimated size of a spill and the relatively low chance (16% or less) of spilled oil reaching the main bowhead fall migration route outside the barrier islands.

Effects of Disturbances:
Noise sources associated with the Liberty Project that may affect bowhead whales are drilling and other noise associated with production operations, vessel traffic, aircraft traffic, construction, and oil-spill cleanup. Underwater industrial noise from these sources, including drilling noise measured from artificial gravel islands, has not been audible in the water more than a few kilometers away. Because the main bowhead whale's migration corridor is 10 kilometers or more seaward of the barrier islands, drilling and production noise from Liberty Island is not likely to reach many migrating whales. Noise also is unlikely to affect the few whales that may be in lagoon entrances or inside the barrier islands due to the rapid attenuation of industrial sounds in a shallow-water environment. Subsistence whalers have stated that noise from some drilling activities displaces whales farther offshore away from their traditional hunting areas.

Marine-vessel traffic outside the barrier islands probably would include only seagoing barges transporting modules and other equipment and supplies from Southcentral Alaska to the Liberty location, most likely between mid-August and mid- to late September in Year 2 and Year 3. Barge traffic continuing into September could disturb some bowheads. Whales are likely to avoid being within 1-4 kilometers of barges, although a few whales may react only when the vessel is less than 1 kilometer away. Fleeing behavior usually stops within minutes after a vessel has passed, but it may last longer. Vessels and aircraft inside the barrier islands should not affect bowhead whales.

Because island and pipeline construction would occur during the winter and be well inside the barrier islands, it is not likely to affect bowhead whales. Reshaping of the island and placement of slope-protection material should be completed by mid-August, before the bowhead whales start their migration. Whales should not be affected by these activities, even during the migration, because the island is well shoreward of the barrier islands, and whales infrequently go there. Bowhead whales are not likely to be affected by sediment or turbidity from placing fill for island construction, island reshaping before placing slope-protection material, or pipeline trenching or backfilling.

Alternative III

Alternative III.A
Southern I./Eastern Pipeline

Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I.

Alternative III.B
Tern I. and Pipeline

Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I.

Bowhead Whales			
Alternative IV	**Alternative V** **Use Sheetpile**	**Alternative VI** **Use Duck I Mine Gravel Site**	**Alternative VII** **Use a 15-Foot Trench Depth**
Alternative IV.A **Pipe-in-Pipe** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I **Alternative IV.B** **Pipe-in-HDPE** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.C** **Flexible Pipe** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I

<table>
<tr><th colspan="2">Spectacled and Steller's Eiders</th></tr>
<tr><th>Alternative I – Proposed Action</th><th>Alternative III</th></tr>
<tr><td rowspan="4">Effects of Oil Spills:
Mortality resulting from the Liberty Project would add to natural mortality and could interfere with recovery from any declines of the Arctic Coastal Plain (North Slope of Alaska) spectacled eider population. Also, it would be considered an incidental take under the Endangered Species Act. An oil spill from Liberty Island or associated marine pipeline would have the highest probability of contacting areas of Foggy Island Bay and the eastern Sagavanirktok River Delta where spectacled eiders may be staging in open water off river deltas in spring following migration or throughout this area prior to fall migration. For contact to occur, spill occurrence would have to coincide with area and timing of eider presence and oil cleanup partially unsuccessful. Oil could contact these eiders from early June through September. Mortality from a spill that moves well offshore would be difficult to estimate.

Aerial surveys conducted by the Fish and Wildlife Service located spectacled eiders only in outer or offshore of Harrison Bay. This suggests that relatively few eiders are likely to be present in the main Liberty Project area to the east where the probability of oil-spill contact is relatively high; thus, few appear likely to be contacted by a spill. A model developed by the Fish and Wildlife Service estimates that low oil-spill mortality could be experienced by that portion of the coastal plain population occupying marine waters between the Kogru River (west) to Brownlow Point (east). Recovery from even small losses is not likely to occur quickly due to the species' low reproductive rate, especially in this eastern portion of its range where eider numbers are relatively low. Long-term Fish and Wildlife Service survey data indicating a non-significant downward trend in the coastal plain spectacled eider population suggests that any substantial spill-related mortality in this eastern segment of the population could represent a significant loss, at least until the species recovers from its threatened status.

Small oil spills are expected to cause few deaths among nesting, broodrearing, or staging eiders. Potentially one or two spectacled eiders and their productivity could be lost as a result of an onshore spill. Reduction of prey populations from an oil or diesel fuel spill could have a negative effect on foraging success of eiders in the local area, especially in spring when there is limited open water. However, sufficient alternate foraging habitat is expected to be available during and following the breeding season, although the amount of high-quality habitat in the Beaufort Sea area remains unknown, as do details of eider foraging habits. Also unknown is whether eiders would move to such areas when disturbed by an oil spill or activities associated with spill response.

Steller's eiders are not expected to occur in the Liberty Project area.

Effects of Disturbances:
Helicopter flights to Liberty Island during pack-ice breakup may disturb some spectacled eiders feeding in open water off the Sagavanirktok River Delta or smaller river deltas. If they relocate to other areas, competition for food available during this period following migration may result in decreased survival or breeding success for some individuals. Likewise, summer flights to the island may displace some eiders from preferred marine foraging areas or juveniles from coastal habitats occupied after they fledge. The extra energy and time used in responding to such disturbance and finding alternate habitat may result in decreased survival of some juvenile eiders. Using boats instead of helicopters to supply Liberty Island during the open-water season would minimize airborne disturbance but would increase the possible disturbance from boats. Due to expected low density of spectacled eiders in the Liberty area, it is likely that few would collide with structures on Liberty island.

Onshore, frequent flights over nesting or broodrearing eiders may cause them to relocate in less favorable habitat; eiders that abandon a nest probably will not renest. Females temporarily displaced from a nest by occasional onshore pipeline-inspection flights may expose eggs to predation. Either situation may result in fewer young produced. Most onshore activities in the Liberty area are likely to affect at most only a few individuals, and careful selection of aircraft routes could eliminate most disturbance of nesting eiders. Displacement of eiders from the vicinity of disturbing activities would eliminate them from only a small proportion of available similar habitat, although the amount of high-quality habitat in the Beaufort Sea area remains unknown, as are details of eider foraging habits. This likely would be a minor effect. Development of the Liberty Prospect is expected to result in only a small amount of habitat loss involving displacement of few eiders to alternate sites. Spill-cleanup activities may disturb nesting, broodrearing, or staging eiders or juveniles occupying coastal habitats, resulting in decreased survival. Spectacled eider mortality from collisions with Liberty Island structures is estimated to be 2 or fewer per year. Collisions with the onshore pipeline are considered unlikely.

The small losses and displacements likely to result from the above activities may cause population effects that would be difficult to separate from natural variation in population numbers. However, any decline in productivity or survival resulting from the Liberty Project would be additive to natural mortality and could interfere with the recovery from any decline the coastal plain spectacled eider population may experience. Disturbance of spectacled eiders by Liberty Project activities could result in a take under the Endangered Species Act.

Steller's eiders are not expected to be found in the Liberty Project area.</td>
<td>Alternative III.A
Southern I./Eastern Pipeline</td></tr>
<tr><td>Effects of Oil Spills:
The probability of oil-spill contact and potential effects in most environmental resource areas or land segments from Alternative I and Alternative III.A island sites and offshore pipeline spill points are essentially the same, including the probability of contact in the western Simpson Lagoon area, where spectacled eider use is documented. There is a difference in probability of contact in the southern Foggy Island Bay area due to island location, which suggests that there is a somewhat greater potential for oil-spill contact with eiders from this Alternative than from Alternative I. However, we conclude that effects, though different, would not be significantly different, because the difference between this Alternative and Alternative I in probability of oil contacting any spectacled eiders that may occur in southern Foggy Island Bay is not substantial, and the extent of eider use of this area is uncertain.

Effects of Disturbances:
Disturbance effects from Alternative III.A and Alternative I are expected to be the same except those resulting from aerial inspection of the onshore portion of the pipeline. Such traffic potentially would disturb more eiders along the greater onshore length of the Alternative III.A pipeline than along the Alternative I pipeline. This is not viewed as a significant difference.</td></tr>
<tr><td>Alternative III.B
Tern I. and Pipeline</td></tr>
<tr><td>Effects of Oil Spills:
The chance of a spill from the Alternative III.B Tern Island location and offshore portion of the pipeline route contacting environmental resource areas or land segments is only slightly lower than from the Alternative I Liberty Island location. Alternative III.B could result in lower adverse effects to eiders, although there is little evidence they occur frequently in this area, because of a somewhat lower probability for contacts from pipeline leaks.

Effects of Disturbances:
Disturbance under Alternative III.B is expected to be the same as for Alternative I, with no significant adverse population effects likely to occur.</td></tr>
</table>

Spectacled and Steller's Eiders			
Alternative IV	**Alternative V**	**Alternative VI**	**Alternative VII**
Alternative IV.A **Pipe-in-Pipe**	**Use Sheetpile**	**Use Duck I Mine Gravel Site**	**Use a 15-Foot Trench Depth**
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I **Alternative IV.B** **Pipe-in-HDPE** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.C** **Flexible Pipe** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I	**Effects of Oil Spills:** Effects of an oil spill on spectacled eiders under Alternative VI is expected to be essentially the same as for Alternative I. **Effects of Disturbances:** The potential for occurrence of resting, foraging, or nesting eiders is likely to be lower at the Duck Island quarry site than at the proposed Kadleroshilik site due to the undisturbed character and vegetative cover of the latter. Although this represents a substantial difference in habitat availability between the two sites, spectacled eiders are not actually expected to be nesting at either site, so no significant difference in effects of habitat disturbance on the spectacled eider is expected between this Alternative and Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I

Seals, Walruses, Beluga Whales and Polar Bears

Alternative I – Proposed Action	Alternative III
Effects of Oil Spills: Seals, polar bears, possibly a few individual beluga whales, and walruses most likely would contact oil from a large spill in the Foggy Island Bay and Mikkelsen Bay areas. An estimated 60-150 ringed seals (out of a resident population of 40,000) and fewer than 50 bearded seals (based on their sparse distribution in the project area) out of a population of several thousand) could be affected by the large spill. An estimated 5-30 bears could be lost if the spill contacted Cross Island where many polar bears may congregate if bowheads whales are harvested in the area. The loss of a large number of bears represents a severe event. The more likely loss from Liberty development would be no more than three to six bears. The seal and polar bear populations are expected to recover individuals killed by the spill within 1 year, and there would be no effect on the population. A small number of beluga whales and maybe a few walruses could be exposed to the spill and may be affected from the exposure. For a spill of 5,912 barrels (twice the spill size the MMS model estimated) oil could contact 0-25 polar bears in open-water conditions and 0-61 polar bears in autumn mixed-ice conditions. The oil-spill trajectories contacted small numbers of bears far more often than they contacted large numbers of bears. In October, 75% of the trajectories oiled 12 or fewer bears while in September, 75% of the trajectories oiled 7 or fewer polar bears. The median number of polar bears that could be affected by a 5,912-barrel spill in October was 4.2. Barring environmental degradation after such a loss, survival of young born in the year of the spill should prevent net changes in population size. These results are comparable to the estimate of 5-30 bears. A spill from Liberty is likely to affect 12 or fewer polar bears. The polar bear population is expected to recover this likely loss within 1 year. Secondary effects could come from oil contaminating food sources. A spill might affect the abundance of some prey species in local, coastal areas of Foggy Island Bay, where epibenthic food such as amphipods (small shrimp) concentrate; however, a spill should not greatly decrease abundant food, such as arctic cod. Local changes in the abundance of some food sources would not affect the seal populations or, in turn, affect the polar bear population in the Beaufort Sea. **Effects of Disturbances:** Construction activity would displace some ringed seals within perhaps 1 kilometer of the island and along the pipeline route in Foggy Island Bay. Seals and polar bears would be exposed to noise and disturbance from pipeline dredging and burial activities in Foggy Island Bay. This disturbance of seals and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season. Low flying helicopters and vessel traffic moving to and from the Liberty Project area briefly could disturb a few polar bears and possibly a few walruses, and beluga whales. These disturbances would not affect overall seal, walrus, beluga whale, or bear abundance and distribution in Foggy Island Bay. Walruses and beluga whales would not be affected by Liberty construction activities because these species do not occur in the project area during the winter season when the island and pipeline would be constructed. Noise sources that may affect beluga whales are drilling and other noise associated with production operations, vessel and aircraft traffic, construction, and oil-spill cleanup. Underwater industrial noise, including drilling noise measured from artificial gravel islands, has not been audible in the water more than a few kilometers away. Because the beluga whale’s migration corridor is far offshore of the barrier islands, drilling and production noise from Liberty Island is not likely to reach many migrating beluga whales. Noise also is unlikely to affect the few whales that may be in lagoon entrances or inside the barrier islands due to the rapid attenuation of industrial sounds in a shallow-water environment. Because island and pipeline construction would occur during the winter and be well inside the barrier islands, it is not likely to affect beluga whales. Food smells coming from the camp on the island may attract a few bears to the production island. This attraction could require deliberate hazing of these polar bears, but this effect would not be significant to bear abundance or distribution. Low-flying helicopters or boats would cause some ringed and bearded seals to dive into the water, and a few females may be temporarily separated from their pups. This displacement is expected to be brief (a few minutes to less than 1 hour)... Low flying helicopters and vessel traffic moving to and from the Liberty Project area briefly could disturb a few polar bears and possibly a few walruses, and beluga whales. These disturbances would not affect overall seal, walrus, beluga whale, or bear abundance and distribution in Foggy Island Bay. These disturbances would not affect overall seal, walrus, beluga whale, or bear abundance and distribution in Foggy Island Bay Vehicle traffic on ice roads from the Endicott causeway directly to the production island and along the coast to Foggy Island Bay/Kadleroshilik River could disturb and displace a few denning polar bears and a small number of denning ringed seals. The number of bears and seals, walruses, and beluga whales potentially displaced is expected to be low and would not affect their populations.	**Alternative III.A** **Southern I./Eastern Pipeline** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative III.B** **Tern I. and Pipeline** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.

Seals, Walruses, Beluga Whales and Polar Bears			
Alternative IV	**Alternative V**	**Alternative VI**	**Alternative VII**
Alternative IV.A **Pipe-in-Pipe**	**Use Sheetpile**	**Use Duck I Mine Gravel Site**	**Use a 15-Foot Trench Depth**
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.B** **Pipe-in-HDPE** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.C** **Flexible Pipe** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Effects of a large oil spill on seals, walruses, beluga whales, and polar bears under Alternative VI are expected to be the same as under Alternative I Section. **Effects of Disturbances:** Using the Duck Island gravel mine rather than the Kadleroshilik River mine site would avoid potential noise and disturbance of denning polar bears in the Kadleroshilik River area during winter. Using this gravel mine site probably would involve an increase in ice-road traffic to and from the Sagavanirktok River to Liberty Island, which could present a potential increase in disturbance of polar bears and seals in this area. The potential effect on polar bears from mining and other development activities could be reduced along the coast of the Kadleroshilik River. Because mining operations are expected to occur during winter when walruses and beluga whales are not present in the project area, they are not likely to be affected.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Burying the offshore pipeline deeper would double the amount of benthic habitat altered by pipeline installation. This alternative would increase the amount of time that seals and polar bears would be exposed to noise and disturbance from pipeline dredging and burial activities in Foggy Island Bay. The disturbance of seals, and polar bears would be local, within about 1 mile along the pipeline route, and would persist for one season. Low flying helicopters and vessel traffic moving to and from the Liberty Project area briefly could disturb a few polar bears and possibly a few walruses, and beluga whales. These disturbances would not affect overall seal, walrus, beluga whale, or bear abundance and distribution in Foggy Island Bay. Walruses and beluga whales would not be affected by Liberty Island construction activities because these species do not occur in the project area during the winter season when the island would be constructed and when the pipeline would be laid.

Marine and Coastal Birds

Alternative I – Proposed Action

Effects of Oil Spills:

A large oil spill in the Liberty Project area would have the highest probability of contacting Foggy Island Bay habitats and the eastern Sagavanirktok River Delta, where waterfowl and other aquatic birds may be staging following spring migration or throughout this area prior to fall migration. A Fish and Wildlife Service population model, using survey data limited to July and August, estimates mortality of **long-tailed ducks** from a 5,912-barrel spill (twice the spill size an MMS oil-spill model estimates) that contacts lagoons in the Harrison Bay to Brownlow Point area, where part of this species' population concentrates during the molt period, was estimated to be 1,443-2,062 individuals in 1999 and 2000 at average bird densities. (This is equivalent to about 1-2% of the average population present on the coastal plain although the specific-source breeding populations of these individuals is unknown, and 6-7% of the population in the survey area estimated in mid to late summer.) at average bird densities. According to estimates by the population model, total mortality in this central Beaufort Sea area potentially could range from a small fraction to many times this number (i.e., 0.01%-35%), depending on the severity of oil contact in a specific area and the number of birds present. This number could increase substantially if a spill occurred during a migration period, when hundreds or occasionally thousands of waterbirds are moving along the Beaufort Sea coast daily. Mortality at the higher end of this range would be considered a significant adverse effect on population numbers and productivity. Should **long-tailed ducks** be contacted by a spill outside the barrier islands, mortality is likely to be considerably lower than this number due to the lower bird density.

Oil could contact flocks of **king** and **common eiders** offshore from May (spring migrants in leads) to October or early November, although mortality from a spill that moves offshore would be difficult to estimate. **King** and **common eider** populations have declined 50% or more in the past 20 years, and substantial oil-spill mortality could represent a significant loss and intensify this trend. Potentially three-quarters of the North Slope/Canadian population could pass the Liberty area during migration. How many of these individuals actually would enter areas with a substantial probability of oil spill contact is not known, because migrants do not necessarily pass through the nearshore zone where Liberty island would be located.

Species that are declining in numbers, such as **king** and **common eiders** and the **red-throated loon**, or have limited capacity for population growth, such as **loons** and **seaducks** in general, are expected to recover slowly from oil-spill mortality. In particular, because of historic or current declines and/or vulnerability during specific periods for **king** and **common eiders** and **long-tailed ducks,** and the estimated mortalities from an assumed oil spill, an offshore spill could result in significant impacts to these species. Such effects could occur if a large flock of spring-migrant **king eiders** were to contact oil in an offshore lead, or if **common eider** flocks were contacted in spring runoff waters, or if any of these species were to contact a nearshore spill during fall east to west migration when a progression of flocks of these species will pass the Liberty area. As noted above, the Fish and Wildlife Service model output may represent minimal estimates of mortality for certain periods when birds are more numerous, such as during migration periods.

A spill that enters open water off river deltas in spring could contact migrant **loons, swans**, **long-tailed ducks, eiders**, and **glaucous gulls**. Some of the several hundred broodrearing, molting, or staging **brant** and **snow geese** could contact oil in coastal habitats. Also, several thousand **shorebirds** could encounter oil in shoreline habitats, and the rapid turnover of migrants during the migration period suggests that many more could be exposed. Also, substantial numbers of premigratory **red phalaropes** foraging in lagoons could be contacted by a spill. Effects are expected to be similar to those outlined above.

An onshore pipeline spill in summer probably would affect only a few nests, even considering all species. If the oil spread to streams or lakes, **long-tailed ducks**, **brant**, and **greater white-fronted geese** that gather on large lakes to molt could be adversely affected in larger numbers. Losses of oiled birds in this case could range up to a few hundred individuals, a minor effect for species whose populations are relatively abundant and stable or increasing (for example, **northern pintail**, **geese**, **glaucous gull**, most **shorebirds**, **songbirds**).

For most species, the relatively small losses likely to result from a spill may be difficult to separate from the natural variation in population numbers, but their populations are not expected to require lengthy recovery periods. However, this assumption should not diminish efforts by industry and agencies to identify measures that could mitigate potential long-term effects on particular species that, for the most part, remain speculative. Much of the information needed to determine the recovery rate of most bird populations from incidents causing mortality is superficially known at best. Thus, until such information is available it will be difficult to accurately assess the long-term effect (i.e., rate of recovery) of oil-spill mortality on such populations.

Reduction of prey populations from an oil spill may reduce foraging success of **shorebirds** and **sea ducks** that depend on this local energy source for molt or migration. Substantial areas of at least superficially similar foraging habitat apparently are available onshore and offshore following the breeding period, although the amount of high quality foraging habitat in the Beaufort Sea area for particular species remains unknown, as are details of foraging habits for most species.

Effects of Disturbances (Continued):

Helicopter flights to Liberty Island during breakup of the pack ice may disturb early-arriving species including loons and king or common eiders feeding in open water off the Sagavanirktok River Delta or smaller river deltas. If they relocate to other areas, competition for food available during this period following migration may result in decreased survival or breeding success. During the summer, flights to the island may displace some long-tailed ducks and eiders from preferred marine foraging areas and snow goose and brant family groups from coastal broodrearing areas. These flights are not likely to directly cause bird mortality, but extra energy and time used in response to disturbance and to find alternate areas may result in decreased fitness and, potentially, survival to breeding age in some individuals. Substantial areas of at least superficially similar foraging habitat apparently are available onshore and offshore following the breeding period, although the amount of high-quality foraging habitat in the Beaufort Sea area for particular species remains unknown, as are details of foraging habits for most species. Using vessels instead of helicopters would minimize airborne disturbance while increasing surface disturbance. The latter generally would result in negligible effects to bird populations. Most birds flying near the island are expected to see and avoid it when visibility is good, and thus, bird mortality from collisions with the island under these conditions are expected to be low. The largest single day total of recent (late September/early October 2001) bird fatalities at the currently operational Northstar island occurred during a foggy period (but darkness also would obscure the facility).

Frequent flights over nesting or broodrearing waterfowl and shorebirds on the mainland or barrier islands may cause birds to relocate in less-favorable habitat. Birds that abandon a nest may not renest, or may be delayed to a less-favorable period. Adults temporarily displaced from nests by occasional onshore pipeline-inspection flights may expose eggs or nestlings to predation. Any of these situations may result in fewer young produced.

Marine and Coastal Birds

Alternative I – Proposed Action

Effects of Disturbances (Concluded):
Most onshore activities in the Liberty area are likely to disturb relatively few birds. Construction and vehicle traffic in winter may displace a few ptarmigan from near the activity. Spill-cleanup activities may displace some nesting, broodrearing, juvenile, or staging waterfowl and shorebirds from preferred habitats, resulting in lower survival. Development of the Liberty Prospect is expected to result in a small amount of habitat loss involving displacement of a few birds to alternate sites. This is likely to be a minor effect, unless it results in decreased survival either by itself or in combination with other factors. Withdrawal of freshwater from lakes during winter for construction of ice roads and pads is expected to have negligible effects on tundra-nesting bird populations. Mortality from collisions with onshore structures is expected to be negligible. The discovery of a possible buff-breasted sandpiper mating lek at the proposed Liberty gravel mine site during a recent survey suggests that the island could represent an important resource during the mating period for this uncommon species, and thus the consequences of its removal could represent more than a minor effect.

The small losses and displacements likely to result from the above activities are expected to cause minor changes in numbers that may be difficult to separate from natural variation in population numbers for any species. Such changes are not expected to require lengthy recovery periods. However, this assumption should not diminish efforts by industry and agencies to identify measures that could mitigate potential long-term effects on particular species that, for the most part remain speculative. Any mortality resulting from development of the Liberty Prospect would be additive to natural mortality, requiring some time for recovery from such losses, and may interfere with the recovery of Arctic Coastal Plain populations should declines in these species (for example, king and common eiders) continue.

Alternative III

Alternative III.A – Southern I./Eastern Pipeline

Effects of Oil Spills:
Although the chance of a spill from the Alternative III.B Tern Island location and offshore portion of the pipeline route contacting environmental resource areas or land segments is only slightly lower than from the Alternative I Liberty Island location, Alternative III.B could result in slightly lower adverse effects on waterbirds because of a somewhat lower probability for contacts from pipeline leaks.

Effects of Disturbances:
Disturbance effects from Alternative III.A and Alternative I are expected to be the same except those resulting from aerial inspection of the onshore portion of the pipeline. Such traffic potentially would disturb approximately twice as many nesting or broodrearing loons, waterfowl or shorebirds along the greater onshore length of the Alternative III.A pipeline than along the Alternative I pipeline. Because of the population size and status of species most likely to be involved, this is not viewed as a significant difference.

Alternative III.B – Tern I. and Pipeline

Effects of Oil Spills:
Although the chance of a spill from the Alternative IIIB Tern Island location and offshore portion of the pipeline route contacting Environmental Resource Areas or Land Segments is essentially the same as from the Alternative I Liberty Island location, Alternative IIIB would result in lower adverse effects on waterbirds because of a somewhat lower probability for contacts from a nearshore pipeline leak.

Effects of Disturbances:
Disturbance of waterbirds under Alternative IIIB is expected to be the same as for Alternative I, with no significant adverse population effects likely to occur

Alternative IV

Alternative IV.A – Pipe-in-Pipe

Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I

Alternative IV.B – Pipe-in-HDPE

Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative

Alternative IV.C – Flexible Pipe

Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I

Alternative V
Use Sheetpile

Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I

Alternative VI
Use Duck I Gravel Mine Site

Effects of Oil Spills:
Effects of an oil spill on marine and coastal birds under Alternative VI is expected to be essentially the same as for Alternative I.

Effects of Disturbances:
The potential for occurrence of resting, foraging, or nesting birds, and probably ptarmigan in winter, is likely to be considerably lower at the Duck Island quarry site than at the proposed Kadleroshilik site due to the undisturbed character and vegetative cover of the latter. Most importantly, disruption or burial of existing habitat at the Kadleroshilik site would eliminate an apparent buff-breasted sandpiper mating lek observed in the 2001 breeding season. This shorebird and its mating areas are uncommon, so if this is a traditional lek site it represents a valuable resource for the species in this area. Any action that would have a negative impact on this species' reproductive success could represent a more than a minor threat to its local coastal plain population. Loss of nest sites of three other shorebird species and rock ptarmigan would represent a minor adverse effect of gravel mine development at this site. Thus a lower effect on marine and coastal bird species typically occupying such habitats is expected if this Alternative is chosen in place of Alternative I.

Alternative VII
Use a 15-Foot Trench Depth

Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I

<table>
<tr><th colspan="3">Terrestrial Mammals</th></tr>
<tr><th rowspan="2">Alternative I – Proposed Action</th><th colspan="2">Alternative III</th></tr>
<tr><th>Alternative III.A
Southern I./Eastern Pipeline</th><th>Alternative III.B
Tern I. and Pipeline</th></tr>
<tr>
<td>Effects of Oil Spills:
A large offshore spill is most likely to contact some coastal areas from Prudhoe Bay, the Sagavanirktok River Delta east to Mikkelsen Bay. Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou (out of an estimated resident population of the Central Arctic Herd of 27,000 individuals) and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. A large onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

Secondary effects could come from disturbance associated with spill-cleanup activities and temporary local displacement of some caribou, muskoxen, grizzly bears, and foxes. These activities, however, would not affect the terrestrial mammals’ movements or overall use of habitat.

Effects of Disturbances:
Helicopter and ice-road traffic, encounters with people, and mining and construction operations could disturb individual or small groups of these mammals for a few minutes to a few days or no more than about 6 months within about 1 mile of these activities. These disturbances would not affect populations. This traffic could briefly disturb some caribou, muskoxen, and grizzly bears, when the aircraft pass overhead or nearby, but would not affect terrestrial mammal populations.

Traffic for constructing the ice roads, production island, pipeline, and gravel pads and to haul gravel and supplies could disturb some caribou and muskoxen along the ice roads during the 2 years of development and during other winters, when further work on the project is needed. This traffic would occur during December though early May, with more ice-road construction and traffic occurring during the 2 years of development. Some continued ice-road activity would occur during the 15-20 years of production to support project operations. These disturbances would have short-term effects on individual animals and would not affect populations.

Encounters between grizzly bears and oil workers or with facilities could lead to the removal of problem bears. However, the amount of onshore activity associated with Liberty (1.4 miles of onshore pipeline with no onshore camp facilities) is not likely to result in the loss of any bears. Arctic fox numbers could increase in the project area because of the possible availability of food and shelter on the production island. However, the amount of onshore activity associated with Liberty (1.4 miles of onshore pipeline with no onshore camp facilities) would not result in a significant increase in fox abundance. BPXA’s wildlife interaction plan and treatment of galley wastes should help to reduce the availability of food to foxes.</td>
<td>Effects of Oil Spills:
Under this alternative, caribou, muskoxen, grizzly bears, and arctic foxes may be more likely to encounter an oil spill from the southern production island, should it occur, because the island would be located closer to shore. A large crude oil or diesel fuel is most likely to contact some coastal areas from the Sagavanirktok River Delta east to Mikkelsen Bay. Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. A large onshore pipeline spill could occur and oil less than 5 acres of vegetation along the pipeline landfall to the Badami tie-in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

Effects of Disturbances:
Effects of disturbances on terrestrial mammals under Alternative III.A are expected to be the same as for Alternative I.</td>
<td>Effects of Oil Spills:
Under this alternative, caribou, muskoxen, grizzly bears, and arctic foxes are as likely to encounter an oil spill from the Tern production island, should it occur, as they are from the Liberty Island location, because the island is located about the same distance from shore. The effect of potential oil spills, is likely to be about the same as described under the Alternative I. A large crude oil or diesel fuel is most likely to contact some coastal areas from the Sagavanirktok River Delta east to Mikkelsen Bay. Caribou may use some of these areas for relief from insects. The main potential effect on terrestrial mammals that contact spilled oil could be the loss of fewer than 100 caribou and a few muskoxen, grizzly bears, and arctic foxes. These losses are expected to be replaced by normal reproduction within about 1 year. A large onshore pipeline spill could occur and oil fewer than 5 acres of vegetation along the pipeline landfall to the Badami tie in. Such a spill is not expected to directly affect caribou or other terrestrial mammals and would cause very minor ecological harm.

Effects of Disturbances:
The general effects of disturbance on terrestrial mammals for this alternative are expected to be the same as analyzed for Alternative I.</td>
</tr>
</table>

Terrestrial Mammals			
Alternative IV	**Alternative V**	**Alternative VI**	**Alternative VII**
Alternative IV.A **Pipe-in-Pipe**	**Use Sheetpile**	**Use Duck I Gravel Mine Site**	**Use a 15-Foot Trench Depth**
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Effects of a large oil spill on terrestrial mammals under Alternative VI are expected to be the same as under Alternative I. **Effects of Disturbances:** Using the Duck Island Gravel Mine site rather than the Kadleroshilik River mine site would avoid potential noise and disturbance to muskoxen from ice-road traffic and mining activities in the Kadleroshilik River area during winter.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.
Alternative IV.B **Pipe-in-HDPE**			
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.			
Alternative IV.C **Flexible Pipe**			
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I			

<table>
<tr><th colspan="3">Lower Trophic-Level Organisms</th></tr>
<tr><th rowspan="2">Alternative I – Proposed Action</th><th colspan="2">Alternative III</th></tr>
<tr><th>Alternative III.A
Southern I./Eastern Pipeline</th><th>Alternative III.B
Tern I. and Pipeline</th></tr>
<tr>
<td>Effects of Oil Spills:
A large, offshore oil spill probably would have short-term effects on plankton and long-term effects on the fouled coastlines. Up to one-third of the Stefannson Sound coastline would be affected by a large spill in open water. While the ice-gouged coastline is inhabited by mobile, seasonal invertebrate species that probably would recover within a year, fractions of the oil probably would persist in the sediments for about 5 years in most areas, and probably would persist up to 10 years in areas where water circulation is reduced. Liberty crude is highly viscous and particularly resistant to natural dispersion; therefore, very little probably would be dispersed down in the water column and affect benthic communities such as the Boulder Patch kelp habitat. However, diesel oil, which would be used on the island for startup and emergency fuel, could be dispersed down to the seafloor. If 1,283 barrels of diesel were spilled from a fuel-delivery barge at the island during the open-water season, the concentration is estimated to be toxic within an area of about 18 square kilometers (7 square miles). Such toxicity probably would stunt the seasonal growth of kelp plants and reduce the population size of associated invertebrates for several years. Oil-spill responses in general would have both minor beneficial and adverse effects on these organisms. The risk of a diesel-fuel spill at Liberty would be reduced by the provision in Section 2.1.5 of the spill-response plan for surrounding fuel barges with oil-spill containment boom during fuel transfer operations.

Effects of Disturbances:
Alternative I would disturb lower trophic-level organisms in three primary ways: (1) island construction for Alternative 1 would bury up to 23 acres of typical benthic organisms; (2) pipeline trenching would disturb additional benthos, burying up to 14 acres with very low (1%) coverage of kelp and marginal kelp substrate; and (3) sediment plumes from pipeline and island construction probably would reduce Boulder Patch kelp production by 2-4% per year. The buried 14 acres is estimated to equal less than 0.1% of the Boulder Patch kelp habitat. The 1% coverage of the kelp and marginal substrate in the pipeline corridor means that the lost kelp biomass and production probably would be less than 0.0001% of the Boulder Patch total. However, the effect (burial of kelp substrate) probably would last forever.

Sediment plumes from pipeline trenching and island construction probably would drift over other parts of the Boulder Patch, reducing light penetration and kelp production. The production probably would be reduced slightly due to winter construction of the island, but the reduction is estimated to be within levels of natural variation. Pipeline-installation activities during kelp-growth Year 2 probably would reduce annual production by about 4%. In Year 3, the kelp production probably would be reduced by 2% during the summer growth season due to sediment dispersal from stockpile Zone 1. Therefore, the overall effect would extend over three consecutive kelp-growth years, and about one-third of the effect would be due to the proposed stockpile.

Kelp and other organisms that grow on hard substrates would colonize the island’s concrete slope from 6-feet deep to the seafloor. This 3-acre portion of the concrete slope probably would become a kelp habitat within a decade. Upon abandonment, the concrete mats probably would become buried naturally or would be removed, cutting back on the new kelp habitat. BPXA also could mitigate some trenching effects, if excess quarry boulders were placed on the backfill in the outer portion of the trench. Boulder Patch studies showed that bare rocks were colonized by kelp within a decade, and quarry boulders probably would help to reduce the longevity of trenching effects from “permanent” to approximately “decade long.”

Kelp growth within about 14 acres or 0.1% of the Boulder Patch probably would be decreased annually by thickened ice roads during the life of the project. BPXA could mitigate the effect by extending the proposed route about 5% around the southern part of the Boulder Patch.</td>
<td>Effects of Oil Spills:
Diesel-fuel spills: There might be specific differences in the effects of diesel-fuel spills because of the longer distance between the alternative island site and the Boulder Patch kelp habitat. In the unlikely event of a diesel spill, the longer distance would reduce slightly the risk of diesel effects to the kelp community.

Effects of Disturbances:
There would be specific differences in disturbance effects. The disturbance effects under this alternative would be lower than for Alternative I for two reasons: (1) There is no kelp in the eastern pipeline route; therefore, trenching would not eliminate kelp habitat, causing only minor, short-term effects only to the silty/sandy sediments. This conclusion would be the same regardless of the pipeline burial depth in the alternative pipeline route; however, fewer survey data are available for the alternative route, so we are less certain about these conclusions than for Alternative I. (2) The shorter pipeline length and the shallower water depth for the island would reduce the footprint of the project and the amount of turbidity caused by construction activity. A smaller sediment plume still probably would drift northwest over the Boulder Patch, reducing light levels and kelp production by an estimated 5% during construction. However, in relation to the large range of natural variability, the disturbance effects on lower trophic-level organisms barely would be detectable.</td>
<td>Effects of Oil Spills:
Diesel-fuel spills: There might be specific differences in the effects of diesel-fuel spills. The longer distance between the island and the Boulder Patch would allow greater dispersion of any spilled diesel fuel, reducing the toxicity to the kelp community.

Effects of Disturbances:

There also would be specific differences in disturbance effects. The disturbance effects would be lower than for Alternative I but similar to the effects of the plan with a Southern Island and Eastern Pipeline Route (Alternative III.A). The differences in island footprints and pipeline lengths means that the Tern Island alternative would affect about 35 fewer acres of typical benthos than Alternative I.</td>
</tr>
</table>

Lower Trophic-Level Organisms				
Alternative IV			**Alternative V** **Use Sheetpile**	**Alternative VII** **Use a 15-Foot Trench**
Alternative IV.A **Pipe-in-Pipe**	**Alternative IV.B** **Pipe-in-HDPE**	**Alternative IV.C** **Flexible Pipe**		
Effects of Oil Spills: The general oil-spill risk to these organisms would be about the same for Alternative 1 and pipe-in-pipe because the main risk in both cases would come from spills of diesel rather than Liberty crude **Effects of Disturbances:** There would be specific differences in the disturbance effects. The pipe-in-pipe design would require shallower burial depth, causing fewer effects than Alternative I in two important ways: (1) shallower burial in the Alternative I pipeline route permanently would eliminate 2 acres or fewer of very diffuse kelp, boulder, and suitable substrate than would the Alternative I burial depth; and (2) the amount of turbidity generated by shallower burial would be only two-thirds of that for Alternative I, probably causing less reduction in annual kelp production during the construction phase. There is no kelp or solid substrate in the eastern or Tern pipeline corridors, so shallower burial there would not save any kelp habitat; however, the reduced suspended sediments probably would cause less reduction in annual kelp production during the construction phase.	**Effects of Oil Spills:** The general oil-spill risk to these organisms would be about the same for Alternative 1 and pipe-in-HDPE because the main risk in both cases would come from spills of diesel rather than Liberty crude. **Effects of Disturbances:** There would be specific differences in the disturbance effects. The pipe-in-HDPE pipeline would require shallower burial depth, causing fewer effects than Alternative I in two important ways. (1) Shallower burial in the Alternative I pipeline route permanently would eliminate 2 fewer acres of very diffuse kelp, boulder, and suitable substrate than would the Alternative I burial depth. (2) The amount of turbidity generated by shallower burial would be only two-thirds of that for Alternative I, probably causing less reduction in annual kelp production during the construction phase. There is no kelp or solid substrate in the eastern or Tern pipeline corridors, and shallower burial there would not save any kelp habitat; however, the reduced suspended sediments probably would cause less reduction in annual kelp production during the construction phase.	**Effects of Oil Spills:** The general oil-spill risk to these organisms would be about the same for Alternative 1 and flexible pipe because the main risk in both cases would come from spills of diesel rather than Liberty crude. **Effects of Disturbances:** There would be specific differences in the disturbance effects. The flexible pipe would require less burial depth, causing fewer effects than Alternative I in two important ways: (1) shallower burial in the Alternative I pipeline route would permanently eliminate 2 fewer acres of very diffuse kelp, boulder and suitable substrate than would the Alternative I pipeline design; and (2) the amount of turbidity generated by shallower burial would be only two-thirds of that for Alternative I, probably causing less reduction in annual kelp production during the construction phase. These effects of shallower burial would be the same for the alternate island design (steel sheetpile). There is no kelp or solid substrate in the eastern or Tern pipeline corridors, and shallower burial there would not save any kelp habitat; however, the reduced suspended sediments probably would cause less reduction in annual kelp production during the construction phase.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative VI** **Use Duck I. Gravel Mine** **Effects of Oil Spills:** The general oil-spill risk to these organisms would be the same for the project with the Duck Island mine and for the Alternative 1mine site. **Effects of Disturbances:** There would be specific differences in the disturbance effects because gravel from the Duck Island mine might be hauled along an ice road over the Boulder Patch.	**Effects of Oil Spills:** The general oil-spill risk to these organisms would be about the same with deeper pipeline burial and with the Alternative 1 pipeline-burial depth because the main risk in both cases would come from spills of diesel fuel rather than Liberty crude. **Effects of Disturbances:** There would be specific differences in the disturbance effects. The disturbance effects of deeper pipeline burial would be greater than the effects of Alternative I in two important ways: (1) deeper burial in the Alternative I pipeline route would permanently eliminate 3 additional acres of very diffuse kelp, boulder, and suitable substrate; and (2) the amount of turbidity generated by deeper burial would be about two times greater than for Alternative I, possibly causing additional reduction in annual kelp production during the construction phase. These effects of deeper burial would be the same for the alternate island design (steel sheetpile). There is no kelp or solid substrate in the eastern or Tern pipeline corridors, so deeper burial there would not eliminate additional kelp habitat, however, the additional suspended sediments possibly would cause additional reduction in annual kelp production during the construction phase.

<table>
<tr><th colspan="2">Fishes</th></tr>
<tr><th>Alternative I – Proposed Action</th><th>Alternative III</th></tr>
<tr><td rowspan="4">Effects of Oil Spills:
The likely effects on arctic fishes (including incidental anadromous species) from a large oil or diesel fuel spill assumed to occur at Liberty Island or from the buried pipeline and enter offshore waters would depend primarily on the season and location of the spill, the lifestage of the fishes (adult, juvenile, larval, or egg), and the duration of the oil contact. Because of their very low numbers in the spill area, no measurable effects are expected on fishes in winter. Effects would be more likely to occur from an offshore oil spill moving into nearshore waters during summer, where fishes concentrate to feed and migrate. The probability of an offshore oil spill contacting nearshore waters in summer ranges from less than 1-26%. If an offshore spill did occur and contact the nearshore area, some marine and migratory fish may be harmed or killed. However, it would not be expected to have a measurable effect on fish populations and recovery would be expected within 5 years. In general, the effects of fuel spills on fish are expected to be less than those of crude-oil spills.

If a pipeline oil spill occurred onshore and contacted a small waterbody supporting fish (for example, ninespine stickleback, arctic grayling, and Dolly Varden char) and had restricted water exchange, it would be expected to kill or harm most of the fish within the affected area. Recovery would be expected in 5-7 years. However, because of the small amount of oil or diesel fuel likely to enter freshwater habitat, the low diversity and abundance of fish in most of the onshore area, and the unlikelihood of spills blocking fish migrations or occurring in overwintering areas or small waterbodies (containing many fish or fish eggs), an onshore spill of this kind is not expected to have a measurable effect on fish populations on the Arctic Coastal Plain.

Effects of Disturbances:

Noise and discharges from dredging, gravel mining, island construction, island reshaping, and pipeline trenching associated with Liberty are expected to have no measurable effect on fish populations (including incidental anadromous species). While a few fish could be harmed or killed, most in the immediate area would avoid these activities and would be otherwise unaffected. Effects on most overwintering fish are expected to be short term and sublethal, with no measurable effect on overwintering fish populations. Placement of the concrete mat would create additional food resources for fishes and, thereby, would have a beneficial effect on nearshore fish populations in the Beaufort Sea.</td><td>Alternative III.A
Southern I./Eastern Pipeline</td></tr>
<tr><td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I.</td></tr>
<tr><td>Alternative III.B
Tern I. and Pipeline</td></tr>
<tr><td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I.</td></tr>
</table>

Fishes			
Alternative IV	**Alternative V** **Use Sheetpile**	**Alternative VI** **Use Duck I Gravel Mine Site**	**Alternative VII** **Use a 15-Foot Trench Depth**
Alternative IV.A **Pipe-in-Pipe** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.B** **Pipe-in-HDPE** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.C** **Flexible Pipe** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Oil-spill related effects would remain unchanged from that of Alternative I. **Effects of Disturbances:** Alternative VI is expected to have similar effects on fishes as Alternative I. While the Duck Island mine site would eliminate any possibility of disturbing fish due to dredging, gravel mining, island construction, island reshaping, and pipeline trenching, it also would eliminate the possibility of creating overwintering habitat on the Kadleroshilik River, as discussed for Alternative I. Otherwise, Alternative VI is not expected to result in measurable differences in effects on fishes.	**Effects of Oil Spills:** Oil-spill effects would remain unchanged from those of Alternative I. **Effects of Disturbances:** Alternative VII would be expected to have a slightly greater effect on fishes than Alternative I, due to more trenching and disturbance. Overall, this would not be expected to result in measurable differences in effects on fishes over that of Alternative I.

<table>
<tr><th colspan="2">Essential Fish Habitat</th></tr>
<tr><th>Alternative I – Proposed Action</th><th>Alternative III</th></tr>
<tr><td rowspan="4">Effects of Oil Spills:
In the event of a large, offshore oil spill, the most likely potential threat to individual salmon would occur if spilled oil came in contact with spawning areas or migratory pathways. However, salmon are not believed to spawn in the intertidal areas or the mouths of streams or rivers of the Beaufort Sea. Therefore, contact between spilled oil and spawning areas is very unlikely. If spilled oil concentrated along the coastline at the mouths of streams or rivers, the potential movements of a small number of salmon could be disrupted during migrations. Zooplankton and fish form most of the potential diet for salmon in the Beaufort Sea. Zooplankton populations could be subjected to short-term, localized, negative effects from oil spilled as a result of Liberty development. Nearshore coastal lagoons support seasonal concentrations of zooplankton, which are potential prey for juvenile and adult salmon during summer. If contacted by surface oil, these zooplankton likely would be killed or otherwise affected. Crude or diesel oil spilled between May and September could cause the death of limited numbers of fish of a variety of species that are potential prey for salmon in the Beaufort Sea. Mortality rates would be expected to be low, with the most likely effects on fish being sublethal, including changes in growth, feeding, fecundity, and temporary displacement. Although measurable effects on prey populations would not be expected, any mortality of fish potentially would have an adverse effect on essential fish habitat.

The extent to which marine plants are a component of salmon essential fish habitat, by providing habitat for potential prey, is discussed in the section on lower-trophic-level organisms. Juvenile lifestages of salmon inhabit fresh or estuarine waters and generally feed on insects. Oil spilled in wetland habitat could kill vegetation and associated insect species and, thus, have an adverse effect on essential fish habitat lasting from less than 10 years to several decades. Because of the predominance of shorefast ice in the Liberty area, there is no resident marine flora in waters less than 6 feet deep. Therefore, no effects are expected on marine plants in those waters. Crude oil that reached benthic marine plants, such as macroalgae inhabiting the Boulder Patch, likely would be weathered and dispersed due to wave action and, thus, have little toxicity. Therefore, little effect would be expected on the exposure of marine life associated with benthic vegetation. On the other hand, spilled diesel fuel would mix deeper into the water column and drift slowly in the same direction as the modeled sediment plume from island construction. Although spilled diesel would be unlikely to kill plants in the Boulder Patch, seasonal growth could be slowed. Moreover, animal life associated with the Boulder Patch plant community likely would be reduced.

Salmon and their prey require relatively clean water in which to live and perform their basic life functions. Essential fish habitat would be adversely affected to the extent that water quality would be degraded. As discussed extensively in Section III.C.2.l, water quality would be significantly degraded over a fairly large area for a period of from days to months, if a large spill of crude or diesel oil occurred. The relative effect of an oil spill on water quality during times of open water would be relatively long lived and widespread, as compared to times of broken or complete ice cover. The effects of a diesel spill generally would be more acute and widespread than the effects of a crude oil spill under similar environmental conditions.

Effects of Disturbances:
None of the lifestages of salmon have been documented to use or inhabit the areas expected to be disturbed directly by Liberty construction and operations. Nonetheless, the waters surrounding the development have been included in the area designated Essential Fish Habitat for Alaskan salmon. Thus, Essential Fish Habitat would be adversely affected by disturbances to potential prey, to prey habitat, to potential substrate, and to marine and fresh waters. As a result of disturbances caused by Liberty Island construction and operation, fish and zooplankton might experience short-term, localized but unmeasurable effects. This would include potential adverse effects from noise during construction and operations and from increased turbidity and sedimentation as a result of dredging, gravel mining, island construction, and pipeline trenching. Marine plants could be subjected to short-term, localized, negative effects due to mechanical removals of individuals and from sedimentation resulting from pipeline trenching and island construction. Pipeline construction is expected to bury up to 14 acres of kelp and solid substrate, and sediment plumes are expected to reduce kelp production by 6% during 1 year. The effect of disturbance on water quality is discussed in Section III.C.3.l. Water quality would be affected primarily by increased turbidity that would result from construction of the gravel island and pipeline, abandonment of Liberty Island, and reclamation of the gravel mine. Turbidity and salinity of seawater discharged from the Liberty Island production facility are expected to be slightly higher than water in surrounding Foggy Island Bay. All of these disturbances are expected to be fairly localized and short term.</td>
<td>Alternative III.A
Southern I./Eastern Pipeline</td></tr>
<tr><td>The potential adverse effects of this alternative on essential fish habitat could be reduced slightly, because the size of the island footprint and amount of offshore trenching would be reduced. Otherwise, the effects from possible oil spills or from other activities would be similar to the Proposal.</td></tr>
<tr><td>Alternative III.B
Tern I. and Pipeline</td></tr>
<tr><td>The potential adverse effects of this alternative on essential fish habitat could be slightly reduced primarily because of expected smaller effects on fish and algae at the Boulder Patch. The longer distance between Tern Island and the Boulder Patch would reduce the risk of diesel fuel spills to the kelp and associate fish communities. The disturbance effects would be slightly lower for the alternative, because pipeline trenching would not eliminate kelp. Less material would be used to construct Tern Island than would be used for Liberty, and the total amount of particulate matter suspended would be less. The turbidity plume would be expected to have a shorter duration than the plume associated with Liberty.</td></tr>
</table>

Essential Fish Habitat			
Alternative IV	**Alternative V**	**Alternative VI**	**Alternative VII**
Alternative IV.A **Pipe-in-Pipe**	**Use Sheetpile**	**Use Duck I Gravel Mine Site**	**Use a 15-Foot Trench Depth**
The effects of Alternative IV.A are expected to be essentially the same on potential salmon prey and associated vegetation for all Alternatives. Water quality is expected to be improve, because the total amount of suspended-particulate matter would be less than under the Alternative I. **Alternative IV.B** **Pipe-in-HDPE** The effects of Alternative IV.B are expected to be essentially the same on potential salmon prey and associated vegetation as Alternative I. Water quality is expected to be improved slightly, because the total amount of suspended-particulate matter would be slightly less than under the Alternative I. **Alternative IV.C** **Flexible Pipe** The effects of Alternative IV.C are expected to be essentially the same on potential salmon prey and associated vegetation for all alternatives. Water quality is expected to be improved, because the total amount of suspended-particulate matter would be less than under the Alternative I.	The effects of Alternative V are expected to be the same as Alternative I.	The potential net effect of this alternative on essential fish habitat is expected to be similar to Alternative I. However, using the Duck Island mine site as a source for gravel would eliminate any possibility of disturbance of fish or algae from increased turbidity and sedimentation downstream of the mine site. It also would eliminate the potential countervailing effect of creating overwintering habitat on the Kadleroshilik River for fish that potentially would serve as prey for salmon.	The potential adverse effects of this alternative on essential fish habitat could be slightly increased compared to Alternative I. The risk of oil spills to essential fish habitat would be unchanged. However, deeper burial in the proposed pipeline route would permanently eliminate about 3 more acres of diffuse kelp and solid substrate. Moreover, the amount of suspended sediments from deeper burial would be about two times greater than for Alternative I, possibly causing additional reduction in annual kelp production during the construction phase.

Vegetation-Wetland Habitats		
Alternative I – Proposed Action	**Alternative III**	
	Alternative III.A Southern I./Eastern Pipeline	**Alternative III.B Tern I. and Pipeline**
Effects of Oil Spills: The main potential effects of a large offshore spill on vegetation and wetlands include oil-fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer (if the oil contaminated both plant surface and subsurface structures during the summer period of maximum thaw). A second main effect is the disturbance of wetlands from cleanup activities. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades. However, the local persistence of oil in coastal wetlands is not expected to have significant effects on the distribution and abundance of plant species (vegetation-wetlands) in the region. A large onshore spill would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie in, causing some ecological harm. Oiled vegetation should recover within a few years but may take more than 10 years to fully recover. **Effects of Disturbances:** Disturbances mainly come from constructing gravel pads and ice roads and installing the onshore pipeline and tie in with the Badami pipeline. Gravel pads, pipeline trench, and the 1.5-mile-long onshore pipeline would destroy only 0.8 acre of vegetation and affect a few acres of nearby vegetation and have only local effects on the tundra ecosystem. Ice roads would have local effects (compression of tundra under the ice roads and the tearing and breaking of some plants in drier habitats) on vegetation, with recovery expected within a few years. The construction and installation of the onshore pipeline and gravel pad on State land will be required to have a Section 404/10 permit and approval by the Corps of Engineers. The permit and approval process is expected to minimize adverse effects on wetlands.	**Effects of Oil Spills:** Under this alternative, coastal vegetation and wetlands in the Foggy Island Bay area probably are more likely to be oiled by an assumed production-island spill with the island located closer to shore (4.1 miles [6.6 kilometers] compared to 6.1 miles [9.8 kilometers] under Alternative I). The main potential effects of a large offshore spill on vegetation and wetlands include oil fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer. A second main effect is the disturbance of wetlands from cleanup activities. Complete recovery of heavily oiled coastal wetlands from these disturbances and oil could take several decades. However, the local persistence of oil in coastal wetlands is not expected to have significant effects on the distribution and abundance of plant species (vegetation-wetlands) in the region. **Effects of Disturbances:** Effects of disturbances on vegetation-wetlands under Alternative IIIA are expected to be the same as for Alternative I. Moving the production-island a little closer to shore is not expected to increase the amount vegetation-wetlands altered under Alternative I.	**Effects of Oil Spills:** Under this alternative, coastal vegetation and wetlands in the Foggy Island Bay area probably are as likely to be oiled by an assumed production-island spill at the Tern Island location as at the proposed Liberty location because both locations are about equal distance to shore. The main potential effects of a large offshore spill on vegetation and wetlands include oil fouling, smothering, asphyxiation, and poisoning of plants and associated insects and other small animals. In this case, complete recovery of moderately oiled wetlands of the Sagavanirktok River east to Mikkelsen Bay would take perhaps 10 years or longer. However, the local persistence of oil in coastal wetlands is not expected to have significant effects on the distribution and abundance of plant species (vegetation-wetlands) in the region. A large onshore spill would oil no more than 5 acres of vegetation along the pipeline landfall to the Badami tie in would cause very minor ecological harm. Oiled vegetation should recover within a few years but may take more than 10 years to fully recover. **Effects of Disturbances:** The effects of disturbance on vegetation and wetlands for this alternative are expected to be the same as analyzed for Alternative I.

Vegetation-Wetland Habitats			
Alternative IV	**Alternative V**	**Alternative VI**	**Alternative VII**
Alternative IV.A **Pipe-in-Pipe**	**Use Sheetpile**	**Use Duck I Gravel Mine Site**	**Use a 15-Foot Trench Depth**
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** The effects of a large spill on vegetation-wetlands for this alternative are expected to be the same as analyzed for Alternative I. **Effects of Disturbances:** Using Duck Island-Sagavanirktok River gravel mines rather than the Kadleroshilik River mine site would avoid disturbance of the sparsely vegetated gravel bar on the Kadleroshilik River. Consequently, the disturbance effect on vegetation and wetlands from mining activities would be avoided. Disturbance of vegetation and wetlands from the Liberty Project would still occur at the pipeline land-fall site and along the on shore pipeline route. Effects would be local and have very little effect on overall the vegetation and wetlands habitats.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.
Alternative IV.B **Pipe-in-HDPE**			
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.			
Alternative IV.C **Flexible Pipe**			
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.			

<table>
<tr><th colspan="2">Subsistence-Harvest Patterns</th></tr>
<tr><th>Alternative I – Proposed Action</th><th>Alternative III</th></tr>
<tr><td rowspan="4">Effects of Oil Spills:
The chance of an oil spill greater than or equal to 500 barrels occurring from the offshore production island and the buried pipeline and entering the offshore waters is estimated to be low. Based on the assumption that a spill has occurred, the chance of an oil spill during summer from either Liberty Island or the pipeline contacting important traditional bowhead whale and seal harvest areas of Cross and McClure islands over a 360-day period would be 16% or less. A spill also could affect other subsistence resources and harvest areas used by the communities of Nuiqsut and Kaktovik. For crude oil or diesel fuel spills, conditional probabilities have been used to determine the likelihood of oil contact with subsistence-resources areas.

Overall, oil spills could affect subsistence resources periodically in the communities of Nuiqsut and Kaktovik. In the unlikely event of a large oil spill, many harvest areas and some subsistence resources could be unavailable for use. Some resource populations could suffer losses and, as a result of tainting, bowhead whales could be rendered unavailable for use. Tainting concerns in communities nearest the spill event could seriously curtail traditional practices for harvesting, sharing, and processing bowheads and threaten a pivotal underpinning of Inupiat culture. There also is concern that the International Whaling Commission, which sets the quota for the Inupiat subsistence harvest of bowhead whales, would reduce the harvest quota following a major oil spill or as a precaution as the migration corridor becomes increasingly developed to ensure that overall population mortality did not increase. Such a move would have a profound cultural and nutritional impact on Inupiat whaling communities. Whaling communities distant from and unaffected by potential spill effects are likely to share bowhead whale products with impacted villages. Harvesting, sharing, and processing of other subsistence resources should continue but would be hampered to the degree these resources were contaminated. In the case of extreme contamination, harvests could cease until such time as resources were perceived to be safe by local subsistence hunters. Overall, effects are not expected from routine activities and operations.

Tainting concerns also would apply to polar bears and seals and beluga whales, walruses, fish, and birds. Additionally, a large oil spill could cause potential short-term but serious adverse effects to long-tailed ducks and king and common eider populations. A potential loss of one or two polar bears could reduce their availability locally to subsistence users, although they are seldom hunted by Nuiqsut hunters except opportunistically while in pursuit of more preferred subsistence resources.

All areas directly oiled, areas to some extent surrounding them, and areas used for staging and transportation corridors for spill response would not be used by subsistence hunters for some time following a spill. Oil contamination of beaches would have a profound impact on whaling because even if bowhead whales were not contaminated, Inupiat subsistence whalers would not be able to bring them ashore and butcher them on a contaminated shoreline. The duration of avoidance by subsistence users would vary depending on the volume of the spill, the persistence of oil in the environment, the degree of impact on resources, the time necessary for recovery, and the confidence in assurances that resources were safe to eat. Such oil-spill effects would be considered significant.

Effects of Disturbances:
For the communities of Nuiqsut and Kaktovik, disturbances periodically could affect subsistence resources, but no resource or harvest area would become unavailable and no resource population would experience an overall decrease. Disturbance and noise could affect subsistence species that include bowhead whales, seals, polar bears, caribou, fish, and birds. Oil-spill cleanup would increase these effects. Disturbances could displace subsistence species, alter or reduce subsistence-hunter access to these species and, therefore, alter or extend the normal subsistence hunt. However, potential disruptions to subsistence resources should not displace traditional practices for harvesting, sharing, and processing those resources. Beluga whales rarely appear in the Liberty Project area. We do not expect them to be affected by noise or other project activities, nor do we expect changes in Kaktovik’s subsistence harvest of beluga whales.</td><td>Alternative III.A
Southern I./Eastern Pipeline</td></tr>
<tr><td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I.</td></tr>
<tr><td>Alternative III.B
Tern I. and Pipeline</td></tr>
<tr><td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I.</td></tr>
</table>

Subsistence-Harvest Patterns			
Alternative IV	**Alternative V**	**Alternative VI**	**Alternative VII**
Alternative IV.A **Pipe-in-Pipe**	**Use Sheetpile**	**Use Duck I Gravel Mine Site**	**Use a 15-Foot Trench Depth**
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.
Alternative IV.B **Pipe-in-HDPE**			
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.			
Alternative IV.C **Flexible Pipe**			
Effects of Oil Spills: Same as Alternative I. **Effects of Disturbances:** Same as Alternative I			

Sociocultural Systems	
Alternative I – Proposed Action	**Alternative III**
Effects of Oil Spills: Effects on the sociocultural systems of communities of Nuiqsut and Kaktovik could come from disturbance, from small changes in population and employment, and periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup. In the unlikely event that a large oil spill occurred and contaminated essential whaling areas, major effects could occur when impacts from contamination of the shoreline, tainting concerns, cleanup disturbance, and disruption of subsistence practices are factored together. Such impacts would be considered significant. **Effects of Disturbances:** Effects on the sociocultural systems of communities near the Liberty Project area could occur as a result of disturbance from industrial activities; changes in population and employment; and effects on subsistence-harvest patterns. These effects could affect the social organization, cultural values, and social health of the communities. Together, effects periodically may disrupt but not displace ongoing social systems, community activities, and traditional practices for harvesting, sharing, and processing subsistence resources.	**Alternative III.A** **Southern I./Eastern Pipeline** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative III.B** **Tern I. and Pipeline** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.

Sociocultural Systems			
Alternative IV	**Alternative V** **Use Sheetpile**	**Alternative VI** **Use Duck I Gravel Mine Site**	**Alternative VII** **Use a 15-Foot Trench Depth**
Alternative IV.A **Pipe-in-Pipe** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.B** **Pipe-in-HDPE** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.C** **Flexible Pipe** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Using steel sheetpile in island construction would relieve ongoing concerns of local subsistence hunters about gravel bags from past gravel island developments contaminating the environment and creating navigation hazards for whaling boats. Using steel sheetpile would serve to reduce overall stress in the local Inupiat population, particularly Nuiqsut, over the development of Liberty Island in the Beaufort Sea offshore environment. This reduction in stress of local Inupiat could be considered a slight reduction in effect to sociocultural systems and also could be construed as taking into account local knowledge and concern for the offshore environment and its resources. General oil-spill effects on sociocultural systems would be the same as for Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.

<table>
<tr><th colspan="2">Archaeological Resources</th></tr>
<tr><th>Alternative I – Proposed Action</th><th>Alternative III</th></tr>
<tr><td rowspan="4">Effects of Oil Spills:
The physical contact of spilled crude oil with archaeological sites does not seem to cause a significant impact. Archaeological sites can be physically disturbed, altered or destroyed by general cleanup operations. Mitigating these effects can be provided by conducting archaeological surveys were prior to initiating cleanup operations and known sites avoided. If avoidance is not possible, site mapping, scientifically recording and collecting artifacts, and onsite monitoring by an archaeologist during cleanup activities could be instituted. Also an education program aimed at cleanup workers could be instituted on how to recognize an archaeological site, what to do if a site is found and remind them of the penalties for vandalizing a site. Surveillance can instituted at those sites deemed to be particularly vulnerable to vandalism. The significance of an archaeological site is more important than the numbers of sites disturbed.

Effects of Disturbances:
Any bottom- or surface-disturbing activity, such as pipeline construction, island installation, anchoring of vessels, or oil-spill-cleanup activities could damage previously unidentified archaeological sites. Physical disturbance of sites could cause destruction of artifacts, disturbance or complete loss of site context, and result in the loss of data. Archaeological sites are a nonrenewable resource and could not be replaced.

Archaeological surveys are required both onshore and offshore in areas where there is the potential for archaeological resources to occur. Therefore, potential impacts to archaeological resources from physical disturbance would be mitigated. If a previously unknown archaeological site is discovered during construction, MMS and the State Historic Preservation Officer will be immediately contacted.</td>
<td>Alternative III.A
Southern I./Eastern Pipeline</td></tr>
<tr><td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I.</td></tr>
<tr><td>Alternative III.B
Tern I. and Pipeline</td></tr>
<tr><td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances:
Same as Alternative I.</td></tr>
</table>

Archaeological Resources			
Alternative IV	**Alternative V**	**Alternative VI**	**Alternative VII**
Alternative IV.A	**Use Sheetpile**	**Use Duck I Gravel Mine Site**	**Use a 15-Foot Trench Depth**
Pipe-in-Pipe **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.B** **Pipe-in-HDPE** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I. **Alternative IV.C** **Flexible Pipe** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.

<table>
<tr><th colspan="2">Economy</th></tr>
<tr><th>Alternative I – Proposed Action</th><th>Alternative III</th></tr>
<tr><td rowspan="4">Economic Effects of the Proposed Action:
MMS, using BPXA projections and MMS models, estimates that the Liberty Project will generate approximately the following economic benefits:
• $100 million in wages and 870 full-time equivalent construction jobs for 1 year in Alaska during 14-18 months of construction
• $4.2 million in wages and 50 jobs annually for operations for 16 years in Alaska.
• 1,248 indirect full-time equivalent jobs during the 14-18 months of construction.
• 78 indirect full-time equivalent jobs each year for 16 years of operations.
• $480 million capital expenditure, $240 million operating expenditures.
• $344 million total Federal revenue.
• $63 million total State revenue $5 million ad valorem tax to the North Slope Borough.
• $114 million net present value of receipts to Federal and State governments.

Effects of Oil Spills:
Employment generated to clean up possible large oil spills of 715-2,956-barrel oil spills is estimated to be 30-125 cleanup workers for 6 months in the first year, declining to zero by the third year following the spill.

Effects of Disturbances:
We do not expect disturbances to affect the cash economy. If there were any effects from disturbances to the economy, they would be general effects that could result from developing the Liberty Proposal and would apply to all alternatives in this EIS, except for the No Action Alternative.</td><td>Alternative III.A
Southern I./Eastern Pipeline</td></tr>
<tr><td>Economic Effects of Alternative III.A:
Alternative III.A could generate fewer jobs, fewer wages, and less revenue to the Government than the Proposal. This alternative could result in a decrease of approximately $1.7 million in wages for 12 months, 9 direct jobs in Alaska for 12 months, 14 indirect jobs in Alaska for 12 months, and $10 million in net present value to the company. The decrease is based primarily on the reduction in costs resulting from the shorter pipeline, which is greater than the additional costs of directional drilling. The net present value to the Government is estimated to be $107, or $7 million less than the Proposal.</td></tr>
<tr><td>Alternative III.B
Tern I. and Pipeline</td></tr>
<tr><td>Economic Effects of Alternative III.B:
Alternative III.B could generate fewer jobs, fewer wages, and less revenue to the Government than for the Proposal. This alternative could result in a decrease of approximately $1.7 million in wages for 12 months, 9 direct jobs in Alaska for 12 months. 14 indirect jobs in Alaska for 12 months, and $10 million in net present value to the company . The decrease is based primarily on the reduction in costs resulting from using less gravel for the construction of the island, which is greater than the additional cost of directional drilling. . The net present value to the government is estimated to be $107, or $7 million less than the Proposal.</td></tr>
</table>

<table>
<tr><th colspan="5">Economy</th></tr>
<tr><th colspan="3">Alternative IV</th><th>Alternative V
Use Sheetpile</th><th rowspan="2">Alternative VII
Use a 15-Foot Trench</th></tr>
<tr><th>Alternative IV.A
Pipe-in-Pipe</th><th>Alternative IV.B
Pipe-in-HDPE</th><th>Alternative IV.C
Flexible Pipe</th><td>Economic Effects of Alternative VII:
Same as Alternative I.</td></tr>
<tr>
<td rowspan="3">Economic Effects of Alternative IV.A:
Alternative IV.A could generate more jobs, more wages, and greater capital expenditure than Alternative I. This alternative could result in an increase of $4 million in wages for 7 months, 34 direct jobs in pipeline construction in Alaska for 7 months, 50 indirect jobs in Alaska for 7 months, and $20 million in capital expenditures. The increased cost of this alternative is based primarily on additional labor, welding, and material cost.</td>
<td rowspan="3">Economic Effects of Alternative IV.B:
Alternative IV.B (pipe-in-HDPE) could generate more jobs, greater wages, and greater capital expenditures than the Proposal. This alternative could result in an increase of $2.4 million in wages for 7 months, 22 direct jobs in pipeline construction in Alaska for 7 months, 33 indirect jobs in Alaska for 7 months, and $12.6 million in capital expenditures. The increased cost of this alternative is based primarily on additional labor and material costs.</td>
<td rowspan="3">Economic Effects of Alternative IV.C:
Alternative IV.C could generate more jobs, greater wages, and greater capital expenditures than for the Proposal. This alternative could result in increases of $0.9 million in wages for 7 months, 8 direct jobs in pipeline construction in Alaska for 7 months, 12 indirect jobs in Alaska for 7 months; and $5.1 million in capital expenditures. The increased cost of this alternative is based primarily on increased material cost. Due to the increased cost of the pipeline, the pipeline tariff would be higher. Higher pipeline tariffs mean higher allowable transportation costs and reduced royalty revenue to the Government from the project and reduced Section 8(g) payments to the State.</td>
<th>Alternative VI
Use Duck I. Gravel Mine</th>
<td rowspan="3">Economic Effects of Alternative VII:
Alternative VII could generate more jobs and greater wages than for the Proposal. Assuming labor costs for construction of the deeper pipeline would increase by as much as two times over those of the Proposal, this alternative could result in increases of $10.8 million in wages; 100 direct jobs in pipeline construction for 7 months in Alaska; and 150 indirect jobs in Alaska. This twofold factor is about in proportion to the volume of additional material to be handled in this alternative as compared to the Proposal. Higher pipeline construction costs could result in higher pipeline tariffs. Higher pipeline tariffs could reduce royalty revenue to the Federal Government from the project and likewise reduce Section 8(g) payments to the State.</td>
</tr>
<tr><td>Economic Effects of Alternative VI:
Alternative VI could generate more jobs, greater wages, and greater costs than Alternative I. This alternative could result in an increase of approximately $4.4 million in wages for 14 months; 20 direct jobs in Alaska for 14 months; 30 indirect jobs in Alaska for 14 months; approximately $15 million in cost for gravel island construction; and additional costs associated with gravel mining and hauling for pipeline construction. The increased costs are based on three factors. Dewatering the Duck Island site would cost about $2.4 million. The distance from the Duck Island mine to the island is about 17.3 miles or about 2.7 times farther from the Kadleroshilik mine, causing increased costs of hauling. The Duck Island haul route could include preparation of a longer floating ice segment than the route to the island in Alternative 1.</td></tr>
<tr></tr>
</table>

Water Quality		
Alternative I – Proposed Action	**Alternative III**	
	Alternative III.A Southern I./Eastern Pipeline	**Alternative III.B Tern I. and Pipeline**
Effects of Oil Spills: During open water, hydrocarbons dispersed in the water column from a large (greater than or equal to 500 barrels) crude oil spill could exceed the 0.015-parts per million chronic criterion for 10-30 days in an area that ranges from 30-45 square kilometers (11.6-17.4 square miles) to 51-186 square kilometers (19.7-71.8 square miles). Hydrocarbons in the water could exceed the 1.5-parts per million acute (toxic) criterion during the first day in the immediate vicinity of the spill. A large crude oil spill in broken sea ice or when the sea ice melts could exceed the chronic criterion for several days in an area of about 7.6 square kilometers (2.9 square miles). Hydrocarbons from a 1,283-barrel diesel oil spill during open water could exceed the acute (toxic) criterion for about 7 days in an area of about 18 square kilometers (7 square miles). During broken sea ice or melting ice conditions, a 1,283-barrel diesel spill could exceed the acute (toxic) criterion for about 1 day in an area of about 1 square kilometer (0.4 square mile) and the chronic criterion for more than 30 days in an area of about 103 square kilometers (39.8 square miles). The effects from a spill occurring under the ice would be similar to those described for broken ice or melting conditions; the oil would be trapped and essentially remain unchanged until breakup occurred and the ice began to melt. A large crude or refined oil spill (greater than or equal to 500 barrels) would significantly affect water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring and oil entering the offshore waters is estimated to be about 1% over the life of the field. Also, regional (more than 1,000 square kilometers [386 square miles]), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely. **Effects of Disturbances:** The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality ; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and are expected to occur during the winter and end within a few days after construction stops. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Available data from site-specific chemical studies indicate construction activities are not expected to introduce or add any chemical pollutants. **Effects of Discharges on Water Quality:** Treated seawater would be the primary discharge from the Liberty Island production facility. The discharged waters would be a few degrees warmer and contain higher concentrations of suspended sediments and dissolved salts when compared to the water in Foggy Island Bay. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality. The water also would contain some chemicals that have been added to prevent biofouling, scaling, and corrosion. Mixing in the receiving waters of the bay is estimated to dilute the effluent waters by a 50:1 ratio within about 6 meters (20 feet) of the island. Additional mixing would continue, as waters are carried away from the island by the currents.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances and Discharges:** The greatest effect on water quality from construction of the gravel island and pipeline would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Construction of the Southern Island requires less gravel and time than Liberty Island, and construction of the eastern pipeline requires less excavating and backfilling than the Liberty pipeline. The amount of suspended sediments in the water column is estimated to be 14% less during Southern Island construction and 32% less during eastern pipeline construction compared to the amounts suspended by Liberty Island and pipeline construction, respectively. Suspended sediments from Southern Island and eastern pipeline construction are estimated to be in the water column 3-5 and 15 days less, respectively, compared to Liberty Island (45-60 days) and pipeline (49 days). Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Available data from site-specific chemical studies indicate construction activities are not expected to introduce or add any chemical pollutants. The effects of discharges are expected to be the same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances and Discharges:** The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Tern Island construction requires less gravel and time than Liberty Island, and the Tern pipeline construction requires less excavating and backfilling than the Liberty pipeline. The amount of suspended sediments in the water column is estimated to be 25% less during Tern Island construction and 10% less during Tern pipeline construction compared to the amounts suspended by Liberty Island and pipeline construction, respectively. Suspended sediments from Tern Island and pipeline construction are estimated to be in the water column 15 and 5 days less, respectively, compared to Liberty Island (45-60 days) and pipeline (49 days). Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Available data from site-specific chemical studies indicate construction activities are not expected to introduce or add any chemical pollutants. The effects of discharges are expected to be the same as Alternative I.

<table>
<tr><th colspan="5">Water Quality</th></tr>
<tr><th colspan="3">Alternative IV</th><th>Alternative V
Use Sheetpile</th><th>Alternative VII
Use a 15-Foot Trench</th></tr>
<tr><th>Alternative IV.A
Pipe-in-Pipe</th><th>Alternative IV.B
Pipe-in-HDPE</th><th>Alternative IV.C
Flexible Pipe</th><td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges:
Same as Alternative I.</td><td rowspan="3">Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges:
The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. Pipeline trenching and backfilling would take longer and/or use more equipment than estimated for the Liberty Pipeline buried at a minimum depth of 7 feet. The overall effects of turbidity are expected to be about 98% greater for the 15-foot trench compared to the 10-foot trench. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Available data from site-specific chemical studies indicate construction activities are not expected to introduce or add any chemical pollutants.

The effects of discharges are expected to be the same as Alternative I.</td></tr>
<tr><td rowspan="2">Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges:
The greatest effect on water quality from construction of the gravel island and pipeline would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. The duration of turbidity from the pipe-in-pipe pipeline trenching is expected to be 11 days shorter compared to the Liberty pipeline (49 days). The overall effects of turbidity are expected to be about 23% less for the pipe-in-pipe pipeline construction compared to the Liberty pipeline construction. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface prior to pipeline construction. Available data from site-specific chemical studies indicate construction activities are not expected to introduce or add any chemical pollutants.

The effects of discharges are expected to be the same as Alternative I.</td><td rowspan="2">Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges:
The greatest effect on water quality from gravel island and pipeline construction would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. The duration of turbidity from pipe-in-HDPE pipeline trenching is expected to be 4 days shorter compared to Liberty Pipeline (49 days). The overall effects of turbidity are expected to be about 7% less for the pipe-in-pipe pipeline construction compared to the Liberty pipeline construction. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Available data from site-specific chemical studies indicate construction activities are not expected to introduce or add any chemical pollutants.

The effects of discharges are expected to be the same as Alternative I.</td><td rowspan="2">Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges:
The greatest effect on water quality from construction of the gravel island and pipeline would be additional turbidity caused by increases in suspended particles in the water column. Increases in turbidity generally are expected to be considerably less than the 7,500 parts per million suspended solids used in the analysis as an acute (toxic) criterion for water quality; exceptions may occur within the immediate vicinity of the construction activity. Turbidity increases from construction activities generally are temporary and expected to occur during the winter and end within a few days after construction stops. The duration of turbidity from trenching of the flexible pipeline is expected to be about 15 days shorter compared to the Liberty pipeline (49 days). The overall effects of turbidity are expected to be about 31% less for the pipe-in-pipe pipeline construction compared to the Liberty pipeline construction. Material excavated from the pipeline trench but not used for backfill most likely would be left in an area where active erosion of sediment particles could occur during breakup and open water. This material would be similar in composition to seafloor sediments in the trenching and disposal areas, and its contribution to the future turbidity from waves and currents is expected to be about the same as the sediments existing at the seafloor surface before pipeline construction. Construction activities are not expected to introduce or add any chemical pollutants.

The effects of discharges are expected to be the same as Alternative I.</td><th>Alternative VI
Use Duck I. Gravel Mine</th></tr>
<tr><td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges:
Same as Alternative I.

If the Duck Island gravel mine is used as a source of gravel for Liberty Island 600 million gallons of water would have to be pumped from the site before mining could be done. Presently, gravel pit dewatering is authorized in accordance with the Environmental Protection Agency's General National Pollution Discharge Elimination System Permit AKG-31-0000 covering Alaska's North Slope Borough; the permit authorizes the removal of up to 1.5 million gallons per day. If the removal rate were increased, to decrease dewatering time, the permit or Best Management Practices Plan may have to be modified. Water from the mine site is used to construct ice roads. Increasing the mine dewatering rate from 1.5 to 5 million gallons per day most likely would have little, if any, measurable effect on the quality of the receiving waters.</td></tr>
</table>

Air Quality

Alternative I – Proposed Action	Alternative III
Effects of Oil Spills: Oil spills from the offshore gravel island and the buried pipeline could cause a small, local increase in the concentrations of gaseous hydrocarbons (volatile organic compounds) due to evaporation from the spill. The concentrations of volatile organic compounds would be very low and normally be limited to only 1 or 2 square kilometers (0.4-0.8 square mile). During open-water conditions, spreading of the spilled oil and action by winds, waves, and currents would disperse the volatile organic compounds so that they would be at extremely low levels (although over a relatively larger area). During broken-ice or melting-ice conditions, because of limited dispersion of the oil, there would be some increase in volatile organic compounds for several hours, possibly up to 1 day. The effects from a spill occurring under the ice would be similar to but less than those described for broken-ice or melting-ice conditions; the oil would be trapped and essentially remain unchanged until the ice began to melt and breakup occurred. Some of the volatile organic compounds, however, would be released from the oil and dispersed, even under the ice. In any of these situations, moderate or greater winds would further reduce the concentrations of volatile organic compounds in the air. Concentrations of criteria pollutants would remain well below Federal air-quality standards. The overall effects on air quality would be minimal. **Effects of Disturbances:** No effects from disturbances to air quality are expected. Impacts to air quality would result from discharges (air emissions). **Effects of Discharges (Air Emissions) on Air Quality:** The Liberty Proposal would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Ambient Air Quality Standards. Therefore, the effects would be low. The air-quality analysis is based on the specific emission controls and emission limitations that BPXA would apply to meet the appropriate Environmental Protection Agency regulations. This will include the requirement to use dry, low nitrogen oxide technology for the turbines to reduce emissions further. These controls become part of the proposed project and are written into the permit and, thus, are binding. The use of best available control technology and compliance with the Environmental Protection Agency emission standards is the primary factor in reducing emissions of criteria pollutants (such as nitrogen oxides and sulfur dioxide). BPXA also plans voluntary reduction of greenhouse gases (notably carbon dioxide); this also would result in a slight additional reduction in emissions of other pollutants. These voluntary measures, however, will not be part of the permit and, therefore, are not enforceable. BPXA's Development and Production Plan (BPXA, 2000a), especially Sections 12.3 (p.104) and 6.2.1 (pp. 45-47) have some additional information; their *Part 55 Permit Application for the BP Exploration (Alaska) Inc. Liberty Development Project,* includes a thorough discussion of control measures.	**Alternative III.A** **Southern I./Eastern Pipeline** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances and Discharges (Air Emissions):** Same as Alternative I. **Alternative III.B** **Tern I. and Pipeline** **Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances and Discharges (Air Emissions):** Same as Alternative I.

<table>
<tr><th colspan="4">Air Quality</th></tr>
<tr><th>Alternative IV</th><th>Alternative V</th><th>Alternative VI</th><th>Alternative VII</th></tr>
<tr><th>Alternative IV.A
Pipe-in-Pipe</th><th>Use Sheetpile</th><th>Use Duck I Gravel Mine Site</th><th>Use a 15-Foot Trench Depth</th></tr>
<tr>
<td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges (Air Emissions):
Same as Alternative I.

Alternative IV.B
Pipe-in-HDPE
Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges (Air Emissions):
Same as Alternative I.

Alternative IV.C
Flexible Pipe
Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges (Air Emissions):
Same as Alternative I.</td>
<td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges (Air Emissions):
Same as Alternative I.</td>
<td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges (Air Emissions):
The general effects of this alternative gravel mine site on air quality are expected to be the same as analyzed for Alternative I. The most noticeable effects on air quality are caused by emissions from equipment. The Liberty Proposal would cause a small, local increase in the concentrations of criteria pollutants. Concentrations would be within the Prevention of Significant Deterioration Class II limits and National Ambient Air Quality Standards. Therefore, the effects would be low.

If the Duck Island gravel mine is used as a source of gravel for Liberty Island, the gravel would need to be hauled about 17.4 miles (28 kilometers), or about 2.7 times farther from the Liberty Island construction sites than the proposed Kadleroshilik mine.</td>
<td>Effects of Oil Spills:
Same as Alternative I.

Effects of Disturbances and Discharges (Air Emissions):
Same as Alternative I.</td>
</tr>
</table>

Environmental Justice	
Alternative I – Proposed Action	**Alternative III**
Effects of Oil Spills and Disturbances: Alaska Inupiat Natives, a recognized minority, are the predominant residents of the North Slope Borough, the area potentially most affected by Liberty development. Effects on Inupiat Natives could occur because of their reliance on subsistence foods, and Liberty development may affect subsistence resources and harvest practices. Potential effects would be experienced by the Inupiat community of Nuiqsut, and possibly Kaktovik, within the North Slope Borough. In the unlikely event that a large oil spill occurred and contaminated essential whaling areas, major effects could occur when impacts from contamination of the shoreline, tainting concerns, cleanup disturbance, and disruption of subsistence practices are factored together. However, effects are not expected from routine activities and operations. When we consider the little effect from routine activities and the low likelihood of a large spill event (the chance of one or more large spills [greater than or equal to 500 barrels] occurring and entering offshore waters is low, on the order of 1% over the life of the field), disproportionately high adverse effects would not be expected on Alaskan Natives from Liberty development under the Proposal. Any potential effects on subsistence resources and subsistence harvests are expected to be mitigated substantially, though not eliminated. Mitigation in place for the Liberty Project was developed through discussions with local, Borough, and agency representatives. Also, Inupiat traditional knowledge had a large part in mitigation and monitoring development, including the timing of project activities. Existing conflict avoidance agreements between the oil industry and Inupiat whalers are important mechanisms for overcoming conflicts. BPXA has committed to dialogue with Native whalers and, if and when the project is approved, existing mitigation requires BPXA to conduct all development and production operations in a manner that prevents unreasonable conflicts between these operations and subsistence activities, particularly the bowhead whale hunt. Stipulation 5 also provides a mechanism to address unresolved conflicts between industry and subsistence activities. Historically, conflicts have been avoided by a negotiated Conflict Avoidance Agreement with the Alaska Eskimo Whaling Commission that coordinates industry activities with subsistence whaling.	**Alternative III.A** **Southern I./Eastern Pipeline** **Effects of Oil Spills and Disturbances:** Same as Alternative I. **Alternative III.B** **Tern I. and Pipeline** **Effects of Oil Spills and Disturbances:** Same as Alternative I.

Environmental Justice			
Alternative IV	**Alternative V**	**Alternative VI**	**Alternative VII**
Alternative IV.A Pipe-in-Pipe	**Use Sheetpile**	**Use Duck I Mine Gravel Site**	**Use a 15-Foot Trench Depth**
Effects of Oil Spills and Disturbances: Same as Alternative I. **Alternative IV.B Pipe-in-HDPE** **Effects of Oil Spills and Disturbances:** Same as Alternative I. **Alternative IV.C Flexible Pipe** **Effects of Oil Spills and Disturbances:** Same as Alternative I.	**Effects of Oil Spills:** Same as Alternative I. **Effects of Disturbances:** Same as Alternative I.	**Effects of Oil Spills and Disturbances:** Same as Alternative I.	**Effects of Oil Spills and Disturbances:** Same as Alternative I.

Table IV.C-1 Potential Reduction in Boulder Patch Kelp Production due to Suspended-Sediment Plumes from Liberty Construction

	Alternative		
	I Proposal	III.A Southern Island	III.B Tern Island
Winter Island Construction	0.13%	0.00%	0.00%
Winter Pipeline Construction	4.10%	1.40%	3.90%
Zone 1 or Zone 3 Disposal	2.10%	3.70%	3.70%
Total	6.33%	5.10%	7.60%

Notes: The reductions were estimated with the same process that was used by Ban et. al., (1999), in the report entitled *Liberty Development: Construction Effects on Boulder Patch Kelp Production*. The estimates for the proposal are listed also in Table 3-1 of the report. The estimates for the Southern and Tern alternatives were calculated with the same procedure. The estimates are for percent reductions in kelp production over the entire Boulder Patch during 1 year.

Table IV.C-2 A Comparison of Construction Time by Pipeline Design and Construction Activity

Construction Activity	Construction Time (days)			
	Single-Wall Pipe Alt I	Pipe-in-Pipe Alt IV.A	Pipe-in-HDPE Alt IV.B	Flexible Pipe Alt IV.C
Mobilize Equipment, Material, and Workforce	3	3	3	3
Construct Ice Roads	47	56	47	47
Slot Ice for Trench	11	14	11	11
Trenching	49	38	45	34
Preparing Pipeline Makeup Site	37	47	47	37
Welding Pipe Strings	17	48	34	—
Transporting Pipe String	8	10	10	8
Welding Tie In	10	33	22	9
Installing Offshore Pipeline	35	29	37	30
Backfilling Trench	36	30	44	38
Hydrostatic Testing	5	5	5	5
Demobilizing Equipment	2	2	2	2

Source: INTEC (2000)

Table IV.D-1 Key Project Element Summary for the Combination Alternatives

	Combination Alternative A	Combination Alternative B	Combination Alternative C	BPXA Proposal (Liberty DPP)
GRAVEL ISLAND				
a. Location	Liberty Island	Southern Island	Tern Island	Liberty Island
b. Upper Slope Protection	Steel Sheetpile	Gravel Bags	Gravel Bags	Gravel Bags
c. Lower Slope Protection – Cement Mats	22,500	16,000	23,500	17,000
d. Amount of Gravel	855,000 cu yd	684,800 cu yd	659,000 cu yd	797,600 cu yd
e. Maximum Footprint Dimension	905' * 1240'	800' * 1110'	925' * 1,260'	835' * 1170'
f. Maximum Footprint Size	25,8 acres	21.9 acres	26.8 acres	22.4 acres
g. Working Surface	345' * 680'	345' * 680'	345' * 680'	345' * 680'
h. Water Depth at Island	22 feet	18 feet	23 feet	22 feet
PIPELINE				
a. Pipe Design	1 Steel pipe in a steel Pipe	1Steel pipe in HDPE	1 Steel pipe in a steel Pipe	1 Steel pipe
b. Route	Liberty Route	Eastern Route	Tern Route	Liberty Route
c. Engineering Calculation of Probability of a Spill Larger than 1,000 bbl during project life	0.234%	1.38%	0.234%	1.38%
d. Average Trench Depth/Range in (Feet)	10.5 / (8 -12)	10 / (7.5 - 11.5)	15 feet	10.5 / (8 -12)
e. Quantity of Trench Dredge/Excavation Material	724,000 cu yd	466,190 cu yd	1,298,095 cu yd	724,000 cu yd
f. Quantity of Trench Backfill Material	724,000 cu yd	466,190 cu yd	1,298,100 cu yd	724,000 cu yd
g. Minimum Burial Depth	7 feet	6 feet	11 feet	7 feet
h. Trench Width	61’ X 132’	59’ X 126’	120’-152’	61’ X 132’
i. Surface Area Disturbed by Trench	59 acres	49 acres	91 acres	59 acres
j. Offshore Length	6.1 miles	4.2 miles	5.5 miles	6.1 miles
k. Onshore Length	1.5 miles	3.1 miles	3.1 miles	1.5 miles
GRAVEL MINE SITE				
a. Location	Duck Island	Kadleroshilik River	Duck Island	Kadleroshilik River
b. Number of Haul Days	90-120 or use more equipment	40-57	60-90 or use more equipment	45-60
c. Distance from Island	20 miles	5 miles	21 miles	6 miles

Source: USDOI, MMS, Alaska OCS Region (2000)

Table IV.D-2 Comparison of Selected Features of the Combination Alternatives

Selected Alternative Attributes	Combination A Liberty Island Route Pipe in Pipe Steel sheetpile Duck Island Gravel 7-Foot burial Depth	Combination B South Island/Eastern Route Pipe in HDPE Gravel Bags Kadleroshilik River Gravel 6-Foot burial depth	Combination C Tern Island/Tern Route Pipe in Pipe Steel Sheetpile Duck Is Gravel 11-Foot Burial Depth	BPXA Proposal Liberty Island Route Singled walled pipe Gravel Bags Kadleroshilik River Mine 7-Foot burial depth
Distance from bowhead migration	**nearest**	**farthest**	**second farthest**	**nearst**
Likelihood of disturbance of bowhead whales and subsistence hunting	**low**	**lowest**	**lower**	**low**
Gravel requirement	**855,000 cu yd** (most)	**684,800 cu yd** (thirdmost)	**659,000 cu yd** (least)	**797,600 cu yd** (secondmost)
Gravel haul distance	**20 miles** (secondmost)	**5 miles** (least)	**21 miles** (most)	**6 miles** (thirdmost)
Use of existing offshore gravel	**None**	**none**	**most**	**none**
Mine wetland habitat destroyed	**Least**	**most**	**least**	**most**
Impacts from gravel bags	**None**	**low**	**none**	**low**
Newly buried ocean bottom (island)	**25.8 acres** (most)	**21.9 acres** (thirdmost)	(least)	**22.4 acres** (secondmost)
Temporarily disturbed habitat from pipeline trench	**59 acres** (secondmost)	**49 acres** (least)	**91 acres** (most)	**59 acres** (secondmost)
Length of offshore pipeline deeper than 8-foot water depth	**Least**	**least**	**most**	**least**
Average depth of pipeline trench	**10.5 ft**	**10 ft**	**15 ft**	**10.5 ft**
Distance from Boulder Patch	**1 mile** (nearst)	**2.5 miles** (farthest)	**1.5 miles** (second farthest)	**1 mile** (nearest)
Likelihood of impacts to the Boulder Patch	**Low**	**lowest**	**Lower**	**low**
Length offshore pipeline	**6.1 miles** (most)	**4.2 miles** (least)	**5.5 miles** (secondmost)	**6.1 miles** (most)
Length onshore pipeline	**1.5 miles** (least)	**3.1 miles** (most)	**3.1 miles** (most)	**1.5 miles** (least)
Secondary pipeline spill containment	**Yes**	**yes**	**Yes**	**no**
Likelihood of pipeline leak offshore	**Lower**	**lowest**	**Lowest**	**low**
Likelihood of pipeline leak onshore	**Lower**	**low**	**Low**	**lower**
Directional drilling	**Least**	**most**	**Most**	**least**
Risk to maximum recovery of oil	**Least**	**most**	**Most**	**least**
Costs over the BPXA Proposal	**$51.5 million** (thirdmost)	**$24.5 million** (secondmost)	**$59 million** (most)	same
Economic return to BPXA	**Second highest**	**third highest**	**Least**	**highest**
Economic benefits to Federal and State government	**Second highest**	**third highest**	**Least**	**highest**

Source: USDOI, MMS, Alaska OCS Region (2000)

Table IV.D-3 Additional Costs For Component And Combination Alternatives

Task	BPXA Proposal	III.A Southern Island [1]	III.B Tern Island [1]	IV.A Pipe-in-Pipe [2]	IV.B Pipe-in-HDPE [2]	IV.C Flexible Pipe [2]	V Steel Sheetpile	VI Duck Island Gravel Mine	VII Bury Deeper	
	Cost of Component Alternative ($ Millions)									
a. Directional Drilling	76			76	76	76	76	76	76	
b. Pipeline	20			40	34	28	20	20	20	
c. Pipeline Trenching	7			9	8	5	7	7	21	
d. Pipeline Ice Road	4			6	4	4	4	4	6.5	
e. Gravel Transportation	13			13	13	13	13	28	13	
g. Slope Protection/ Island Foundation	29			29	29	29	35	29	29	
h. Mine Site Dewatering	0			0	0	0	0	2.5	0	
i. Mine Site Rehabilitation	0			0	0	0	0	0	0	
j. Other [3]	215			215	215	215	215	215	215	
Total Cost	**364**			**388**	**379**	**370**	**370**	**381.5**	**380.5**	
Total Additional Cost Over BPXA Proposal	**0**	**9.5** [1]	**10** [1]	**24**	**15**	**6**	**6**	**17.5**	**16.5**	
	Additional Cost of Combination Alternative ($ Millions) [4]									*Total Additional Cost Over BPXA Proposal*
A				28 [5]			6	17.5		**51.5** [5]
B		9.5 [1]			15					**24.5** [1]
C			10 [1]	9 [6]			6	17.5	16.5	**59.0** [1,6]
Liberty DPP										**0**

Source: BPXA (2000a), INTEC (2000), Appendix D-1

1 Columns III.A and III.B, and the corresponding totals, reflect the Net Present Value difference for all the costs associated with Island Location and Pipeline Route as calculated by MMS in Table D.1-3, Appendix D-1, Economic Analysis of Alternatives for Net Present Value of Additional Directional Drilling Costs.

2 Columns IV.A, IV.B, and IV.C are from the Pipeline System Alternatives as prepared by INTEC (2000).

3 Other costs include expenditures for Facility Construction, Infrastructure, BPXA Management Overhead, Permitting and Studies, Operating Capital, and Contingency, as provided by BPXA, which do not vary between alternatives.

4 Additional cost over the cost of the BPXA Proposal.

5 This number is adjusted to includes costs ($4 million) associated with the 7-foot burial depth for the Pipe-in-Pipe Design for single season construction as per Table A4-1, INTEC (2000).

6 The $24 million cost for pipe-in-pipe has been adjusted to $9 million for this combination alternative, because the deeper trench depth already includes $16.5 million for additional trenching and ice road maintenance. Therefore, this combination alternative would cost about $59 million.

Table V.B-1a Alaska North Slope Oil and Gas Discoveries as of November 30, 2001

	Name	Location of Field or Pool	Production Oil, Gas	Location of Production Facility	Discovery	Production Began	Category	Ranking Criteria
	PAST DEVELOPMENT AND PRODUCTION							
1	South Barrow	Onshore	Gas	Onshore	1949	1950	Field	
2	Prudhoe Bay	Onshore	Oil	Onshore	1967	1977	Field	
3	Lisburne	Onshore	Oil	Onshore	1967	1981	Field	
4	Kuparuk	Onshore	Oil	Onshore	1969	1981	Field	
5	East Barrow	Onshore	Gas	Onshore	1974	1981	Field	
6	Milne Point	Onshore	Oil	Onshore	1969	1985	Field	
7	Endicott	Offshore	Oil	Offshore	1978	1986	Field	
8	Sag Delta	Offshore	Oil	Onshore	1976	1989	Field	
9	Sag Delta North	Offshore	Oil	Offshore	1982	1989	Satellite[1]	
10	Schrader Bluff	Onshore	Oil	Onshore	1969	1991	Satellite[2]	**When**
11	Walakpa	Onshore	Gas	Onshore	1980	1992	Field	**Production**
12	Pt McIntyre	Offshore	Oil	Onshore	1988	1993	Field	**Began**
13	N. Prudhoe Bay	Onshore	Oil	Onshore	1970	1993	Field	
14	Niakuk	Offshore	Oil	Onshore	1985	1994	Field	
15	Sag River	Onshore	Oil	Onshore	1969	1994	Satellite[3]	
16	West Beach	Onshore	Oil	Onshore	1976	1994	Field	
17	Cascade	Onshore	Oil	Onshore	1993	1996	Field	
18	West Sak	Onshore	Oil	Onshore	1969	1997	Satellite[2]	
19	Badami	Offshore	Oil	Onshore	1990	1998	Field	
20	Eider	Offshore	Oil	Offshore	1998	1998	Satellite[1]	
21	Tarn	Onshore	Oil	Onshore	1991	1998	Field	
22	Tabasco	Onshore	Oil	Onshore	1992	1998	Satellite[2]	
23	Midnight Sun	Onshore	Oil	Onshore	1998	1999	Satellite[4]	
24	Alpine	Onshore	Oil	Onshore	1994	2000	Field	
25	Northstar	Offshore	Oil	Offshore	1984	2001	Field	
26	Aurora	Onshore	Oil	Onshore	1999	2001	Satellite[4]	
27	NW Eileen/Borealis	Onshore	Oil	Onshore	1999	2001	Field	
28	Polaris	Onshore	Oil	Onshore	1999	2001	Satellite[4]	
	PRESENT DEVELOPMENT							
29	Meltwater	Onshore	Oil	Onshore	2000	(2002)	Pool	
30	Nanuk/Nanuq	Onshore	Oil	Onshore	1996	(2003)	Pool	**When**
31	Palm	Onshore	Oil	Onshore	2001	(2003)	Pool	**Production**
32	Liberty	Offshore	Oil	Offshore	1983	(2003)	Pool	**Is Expected**
33	Fiord	Onshore	Oil	Onshore	1992	(2003)	Pool	
	REASONABLY FORESEEABLE FUTURE DEVELOPMENT AND PRODUCTION							
34	Spark/Rendezvous	Onshore	Gas & Oil	Onshore	2000		Prospect	
35	Kalubik	Offshore	Oil	Onshore	1992		Prospect	
36	Pete's Wicked	Onshore	Oil	Onshore	1997		Prospect	
37	Sikulik	Onshore	Gas	Onshore	1988		Pool	
38	Thetis Island	Offshore	Oil	Offshore	1993		Prospect	**When We Estimate**
39	Gwydyr Bay	Offshore	Oil	Onshore	1969		Pool	**Chance and**
40	Point Thomson	Onshore	Gas & Oil	Onshore	1977		Pools	**Timing of**
41	Mikkelson	Onshore	Oil	Onshore	1978		Prospect	**Development**
42	Sourdough	Onshore	Oil	Onshore	1994		Pool	**(highest/first to**
43	Yukon Gold	Onshore	Oil	Onshore	1994		Prospect	**lowest/last)**
44	Flaxman Island	Offshore	Oil	Offshore	1975		Prospect	
45	Sandpiper	Offshore	Gas & Oil	Offshore	1986		Pool	
46	Stinson	Offshore	Oil	Offshore	1990		Prospect	
47	Hammerhead	Offshore	Oil	Offshore	1985		Pool	
48	Kuvlum	Offshore	Oil	Offshore	1987		Prospect	
	SPECULATIVE FUTURE DEVELOPMENT							
49	Hemi Springs	Onshore	Oil	Onshore	1984		Prospect	
50	Ugnu	Onshore	Oil	Onshore	1984		Pool	
51	Umiat	Onshore	Oil	Onshore	1946		Pool	
52	Fish Creek	Onshore	Oil	Onshore	1949		Prospect	
53	Simpson	Onshore	Oil	Onshore	1950		Pool	
54	East Kurupa	Onshore	Gas	Onshore	1976		Show	**Insufficient**
55	Meade	Onshore	Gas	Onshore	1950		Show	**Information to**
56	Wolf Creek	Onshore	Gas	Onshore	1951		Show	**Estimate Chance**
57	Gubik	Onshore	Gas	Onshore	1951		Pool	**of Development**
58	Square Lake	Onshore	Gas	Onshore	1952		Show	
59	E. Umiat	Onshore	Gas	Onshore	1964		Prospect	
60	Kavik	Onshore	Gas	Onshore	1969		Show	
61	Kemik	Onshore	Gas	Onshore	1972		Show	

Notes: Field information is taken from State of Alaska, Dept. of Natural Resources (2000a). **Footnotes** for Satellites identify the associated production unit: [1]Duck Island Unit; [2]Kuparuk River Unit; [3]Milne Point Unit; [4]Prudhoe Bay Unit. **Parentheses** indicate when production startup is expected.
Definitions: Field—infrastructure (pads/wells/facilities) installed to produce one or more pools. Satellite—a pool developed from an existing pad. Pool—petroleum accumulation with defined limits. Prospect—a discovery tested by several wells. Show—a one-well discovery with poorly defined limits and production capacity.

Table V.B-1b Trans-Alaska Pipeline System and Future Natural Gas Projects

Name	Estimated Pipeline Length (miles)	Project Description and Route
Active Project		
Trans-Alaska Pipeline (TAPS)	800	TAPS is the key transportation link for all North Slope oil fields. It has been in operation since 1977 and to-date has carried nearly 13 billion barrels of oil. Approximately 16.3 square miles are contained in the pipeline corridor that runs between Prudhoe Bay and Valdez. The Dalton Highway (or Haul Road) was constructed parallel to the pipeline between Prudhoe Bay and Fairbanks. The pipeline design capacity is 2 million barrels per day, and it reached near peak capacity in 1988. Presently, TAPS is running at about 1.0 million barrels per day. The lower operational limit is generally thought to be between 200,000 and 400,000 barrels per day. If oil production from northern Alaska cannot be sustained above this minimum rate, the TAPS system will become nonoperational and all oil production is likely to be shut in.
Future Natural Gas Projects		
Trans-Alaska Gas System (TAGS)	800	The TAGS plan consists of a gas-conditioning plant on the North Slope; an 800 mile, 42 inch, pipeline; a liquefied natural gas (LNG) plant and marine terminal at Valdez; and a fleet of new LNG carriers. LNG would be transported to Japan and other Pacific Rim countries. The Yukon Pacific Corporation has obtained permits for construction of TAGS and export of Alaska North Slope gas to Asia. The LNG facility and marine terminal in Valdez has received the Final EIS prepared by the Federal Energy Regulatory Commission. Yukon Pacific believes the large scale of the project (2.05 billion cubic feet per day to yield 14 million metric tons of LNG annually) will make this project competitive with other new LNG projects. The project is currently stalled by the lack of commitments from the North Slope gas producers, delivery contracts to Asian buyers, and high construction costs.
Alaska Natural Gas Transportation System (ANGTS)[1]	2,102	The ANGTS plan is a pipeline system connecting Alaska North Slope gas production through Canada to the lower 48. The new pipeline would run parallel to TAPS from the North Slope to interior Alaska and then cross the Yukon Territory to connect to existing pipelines in Alberta. The primary market would be consumers in the U.S. Numerous permits, rights-of-way, and approvals have been obtained for the proposed pipeline route through Alaska and Canada. Downward revisions to construction costs and the recent increase in gas prices into the $3-$4-million-cubic-foot range make this project more appealing today. Currently, several variations to routes are being considered for the overland gas pipeline system.
Arctic Resources, Northern Gas Pipeline Project	326 offshore 874 onshore	The ARC project involves a 52 inch, high pressure gas pipeline running offshore from Prudhoe Bay in Alaska to the Mackenzie delta in the Northwest Territory and then south through the Mackenzie River Valley to the existing gas pipeline network in northern Alberta. The 326 mile offshore portion would be trenched in 30-60 feet of water. The 874 mile onshore portion would also be buried. It is expected to deliver 2.5 billion cubic feet per day to markets primarily in the U.S. The project would involve a consortium of gas producers, pipeline companies, and native corporations in both Alaska and Canada. Commitments of gas producers and gas buyers have not yet been obtained nor have right-of-way permits been issued.
Natural Gas to Liquids Conversion[2]	Will use existing TAPS Pipeline	Atlantic Richfield Co. (ARCO) and Syntroleum Corp constructed a pilot-scale, natural gas to liquids (GTL) conversion facility in Puget Sound, Washington. More recently, BP-Amoco has begun design work on a GTL pilot project on the Kenai Peninsula in Alaska. As a result of the BP-Amoco-ARCO merger, BP-Amoco now holds an equal interest in the gas reserves in the Prudhoe Bay field. All of the major North Slope gas owners (BP-Amoco, Exxon-Mobil, and Phillips-Alaska) are studying the feasibility of various gas commercialization projects. GTL is an attractive option because it will use the existing TAPS pipeline (extending its life and lowering future tariffs) and produce clean-burning fuels to meet more stringent Environmental Protection Agency emission standards for vehicles. At the present time, the overall cost of a full-scale gas to liquids project is comparable to a similar sized LNG project.. As an emerging technology, new cost-reduction breakthroughs are expected for gas to liquids processing, improving the economic potential for future gas to liquids projects .

[1] Thomas et al. (1996). [2] Alaska Report (1997).

Table V.B-1c Future Lease Sales

Sale	Proposed Sale Date(s)	Area/Description	Resources or Hydrocarbon Potential
FEDERAL OCS			
5-Year Program – 186, 195, 202	2003, 2005, 2007	As much as 9.9 million acres from the Canadian border on the east to Barrow on the west in the Beaufort Sea (Federal Register, 2001c).	1.02-1.71 Bbbl Oil (Estimated)
Northeast NPR-A	June 2002	As much as 3 million acres of the Northeast NPR-A Planning Area (USDOI, BLM, 2001).	0.50-2.2 Bbbl Oil (Estimated)
Northwest NPR A	To Be Determined	As much as 9.98 million acres of the Northwest NPR-A Planning Area (Federal Register, 2001d).	To Be Determined
STATE OF ALASKA			
North Slope Areawide	Oct 2002, Oct 2003, Oct 2004, , Oct 2005	As much as 5,100,000 acres of State-owned lands between the Canning and Colville Rivers and north of the Umiat Base Line (about 69 20' N).	*Moderate to High*
Beaufort Sea Areawide	Oct 2002, Oct 2003, Oct 2004, Oct 2005	Unleased State-owned tide and submerged lands between the Canadian border and Point Barrow and some coastal uplands acreage located along the Beaufort Sea between the Staines and Colville rivers. The gross proposed sale area is in excess of 2,000,000 acres. The State of Alaska was scheduled to hold its first areawide sale in the Beaufort Sea on October 13, 1999. This sale was delayed pending the outcome of the BP Amoco and ARCO merger and related uncertainties in future lease holdings.	*Moderate to High*
North Slope Foothills Areawide	May 2002	State-owned lands lying between the NPR-A and the Arctic National Wildlife Refuge south of the Umiat Baseline and north of the Gates of the Arctic National Park and Preserve. The gross proposed sale area is in excess of 7,000,000 acres.	*Moderate*

Source: USDOI, MMS, Alaska OCS Region

Table V.B-2 Past Development: 2000 Production and Reserve Data

Unit or *Area*	Field	Type (Oil or Gas)	Discovery	Production[1] Began	Production[1] Gas (BCF)	Production[1] 2000 Oil (MMbbl)[1]	Production to	Reserves[2] Oil (MMbbl)[1]	Reserves[2] Gas (BCF)
Duck Island	Endicott	O	1973	1987	–	11.622	Endicott	189[3]	–
	Sag Delta North[2]	O	1989	1989	–	–[3]	Endicott	-	–
	Sag Delta[2]	O	1976	1989	–	–[3]	Endicott	-	–
	Eider	O	1998	1998	–	0.148	Endicott	5	–
	Ivishak	O			–	0.248	Endicott	–	
Prudhoe Bay	Prudhoe Bay	O	1967	1977	–	187.056	Prudhoe	2,678	–
	P Bay Satellites	O	–	–	–	–	Prudhoe	311	–
	Lisburne	O	1968	1981	–	3.202	Lisburne	37	–
	Niakuk	O	1985	1994	–	7.336	Lisburne	56	–
	West Beach	O	1976	1994	–	0.401	Lisburne	6	–
	N. Prudhoe Bay	O	1970	1993	–	–	Lisburne	1	–
	Pt McIntyre	O	1988	1993	–	23.737	Lisburne	227	
	Midnight Sun	O	1998	1999	–	1.441	Prudhoe		
	Aurora	O	1999	2001	-	-	Prudhoe	40	
	NW Eileen/Borealis	O	1999	2001			Prudhoe	80	–
	Polaris	O	1999	2001			Prudhoe	40	-
Kuparuk River	Kuparuk River	O	1969	1981	–	74.133	Kuparuk	960	–
	Tabasco	O	1992	1998	–	1.911	Kuparuk	27	–
	Tarn	O	1992	1998	–	8.767	Kuparuk	63	–
	West Sak	O	1969	1998	–	1.520	Kuparuk	101	–
Milne Point	Milne Point	O	1969	1985	–	16.572	Milne Pt.	292	–
	Cascade[4]	O	1993	1996	–	–	Milne Pt.	-[4]	–
	Schrader Bluff	O	1969	1991	–	2.498	Milne Pt.	105	–
	Sag River	O	1968	1994	–	–	Milne Pt.	7	–
Badami	Badami	O&G	1990	1998	–	0.930	TAPS	8	–
Colville River	Alpine	O	1994	2000	–	2.231	Kuparuk	427	–
Northstar	Northstar	O	1984	2001	-	-	Prudhoe	158	-
***NPR-A*[1]**	East Barrow	G	1974	1981	0.090	–	Barrow	–	5
	South Barrow	G	1949	1950	0.037	–	Barrow	–	4
	Walakpa	G	1980	1993	1.352	–	Barrow	–	25
All Units or Areas Total								**5,818**	**34**

[1] Production information is from State of Alaska, AOGCC (2001), [2] Reserves were estimated by subtracting 2000 production from State of Alaska AOGCC (2001) from the Reserve Data in State of Alaska, DNR (2000). Reserve estimates for Aurora and Polaris are from Drilling Wire Alaska 2001 a and b respectively. [3]Endicott include Endicott, Sag Delta and Sag Delta North. [4] Cascade is included in Milne Point.

Table V.B-3 Past Development: Infrastructure and Facilities

UNIT OR *AREA* Field	Gravel Roads, Pads, & Airstrips (acres)	Pipelines: Gathering, Common Carrier, Unspecified (miles) G	C	U	Gravel Num.	Mines Acres	Wells[5]	Pads	Reserve Num.	Pits Acres	Facilities: Prod. Centers	Camps Base & Const.	Plants: Power Topping Gas Seawater	Docks & Cause-ways	Airports & Airstrips	Roads (miles)	River Cross-ings
DUCK ISLAND																	
Endicott	392[2]	3	26		1[2]	179[2]	129	2[1]	0[2]	0[2]	0	0[1]	3[1]	2[1]	0[1]	15[1]	1[1]
PRUDHOE BAY																	
Prudhoe Bay	4,590[2]			145	6[2]	726[2]	1,764	38	106[2]	560[2]	6[1]	4[1]	4[1]	2[1]	2[1]	200[1]	3[1]
Lisburne	213[2]	50	–	–	0[2]	0[2]	80	5[1]	10[2]	16[2]	1[1]	1[1]	1[1]	0[1]	0[1]	18[1]	–
Niakuk	22[2]	5		–	0[2]	0[2]	19		0[2]	0[2]	–	–	–	–	–	–	–
West Beach	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
N. Prudhoe Bay	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Pt. McIntyre	33[2]	12	–	–	0[2]	0[2]	84	–	0[2]	0[2]	–	–	–	–	–	–	–
Aurora	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0
KUPARUK RIV.																	
Kuparuk River	1,435[2]	97	37		5[2]	564[2]	996	34[1]	126[2]	161[2]	3[1]	2[1]	4[1]	1[1]	1[1]	94[1]	5
West Sak	–	–	–	–	0	0	17		0	0	0	0	0	0	0		0
MILNE POINT																	
Milne Point	205[2]	30	10		1[2]	43[2]	182	4[1]	20[2]	19[2]	1[1]	0[1]	2[1]	0[1]	0[1]	19[1]	1[1]
Cascade	31[2]	–	–	–	0[2]	0[2]	–	–	0[2]	0[2]	–	–	–	–	–	–	–
Schrader Bluff	–	–	–	–	–	–	52	–	–	–	–	–	–	–	–	–	–
Sag River	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–
BADAMI	85[2]		26	35	1[2]	89[2]	10	2	0[2]	0[2]	1	1	0	1	1	4.5	5
ALPINE	97			34	0	0	150	2	0	0	1	2	–	0	1	3	5
West of Kuparuk																	
Tarn[3]	72.8			10	0-1[4]		16	2	0	0	0	0	0	0	0	10	2
NORTHSTAR	18	26	26	0	0	0	23	1	0	0	1	1	0	0	0	0	0
Totals	**7,126**	**197**	**99**	**224**	**14-15**	**1,601**	**3,537**	**89**	**262**	**756**	**13**	**110**	**14**	**6**	**5**	**364**	**22**
NPR-A																	
East Barrow							4										
South Barrow							19										
Walakpa							9										

[1] Eg&G Idaho, Inc. (1991). [2] BPXA (1996). [3] U.S. Army Corps of Engineers, Public Notice of Application for Permit Reference Number 4-970705. [4] The gravel would come from Mine Site F and should be sufficient. However, a future aliquot to the north has already been permitted for expansion necessary, this aliquot may need to be opened to support the project. [5] Alaska Oil and Gas Conservation Commission 1998 Annual Report.

Table V.B-4 Present Development: Estimated Reserve Data

Unit or Area	Field	Type (Oil, Gas)	Discovery	Status	Oil Reserves (MMbbl)
Kuparuk	Meltwater	Oil	2000	Present Development	50
Colville River	Fiord	Oil	1992	Present Development	50
Colville River	Nanuk/Nanuq	Oil	1996	Present Devvlopment	50
Kuparuk	Palm	Oil	2001	Present Development	35
Liberty	Liberty	Oil	1993	Present Development	120
Total for All Units or Areas					305

Table V.B-5 Present Development: Proposed Infrastructure and Facilities

Unit or Area/Field	Gravel Roads, Pads, & Airstrips (acres)	Pipelines (miles)	Gravel Mines		Wells	Pads	Reserve Pits		Facilities					Roads (miles)	River Cross-ings
			Num.	Acres			Num.	Acres	Prod. Centers	Camps Base & Const.	Plants: Power Topping Gas Seawater	Docks & Cause-ways	Airports And Airstrips		
Kuparuk/Meltwater	78	10	1	-	26	1	0	0	0	0	0	0	1	10	0
Colville River/Fiord	40	7	1	45	40	1	0	0	0	0	0	0	1	0	0
Colville River/ Nanuk/Nanuq	40	4	0	0	40	1	0	0	0	0	0	0	0	3.8	0
Kuparuk/Palm		5	0	0	18	1	0	0	0	0	0	0	0	–	0
Prudhoe/NW Eileen/Borealis		5	0	0	60	1	0	0	0	0	0	0	0	–	0
Prudhoe/Polaris						1	0	0	0	0	0	0	0	–	0
Liberty/Liberty [a]	22.4	6.1	1	31	23	1	0	0	1	1	1	0	0	0	0

[a]BPXA (2000a).

Note: Fiord (Petroleum News Bulletin, 2001a), Meltwater (Petroleum New Bulletin, 2000) , Nanuq (Petroleum News Bulletin, 2001b) Palm wells estimated using a 2Mmbbl recovery typical of Kuparuk reservoir satellites.

Table V.B-6a Reasonably Foreseeable Future Development: Estimated Resources for Purposes of Analysis

Area/Group	Pool	Type (Oil, Gas)	Discovery	Facility Location	Oil Resource (MMbbl)
NPR-A	Spark/Rendezvous	G&O	2000	Onshore	To Be Determined
Western Group	Kalubik	O	1992	Offshore	
	Thetis Island	O	1993	Offshore	250
Central Group (Northstar)	Gwyder Bay	O	1969	Offshore	
	Pete's Wicked	O	1997	Onshore	
	Sandpiper	G&O	1986	Offshore	200
Eastern Group (Badami)	Mikkelson	O	1978	Onshore	
	Sourdough	O	1994	Onshore	
	Yukon Gold		1994	Onshore	
	Pt. Thompson	G&O	1977	Onshore	
	Flaxman Island	O	1975	Offshore	
	Stinson	O	1990	Offshore	
	Hammerhead	O	1985	Offshore	
	Kuvlum	O	1987	Offshore	1,000
Total					1,450

Source: USDOI, MMS, Alaska OCS Region

Resource estimates are assumed for purposes of cumulative-effects analysis only. Accurate oil volumes for individual fields generally are unavailable, as these discoveries have not been adequately delineated or studied for their development potential. Most of these discoveries are noncommercial at the present time and will require new technology or higher oil prices to be economic. It is possible that many of these pools will remain undeveloped. Future development likely would occur in conjunction with the infrastructure for the fields shown in parentheses.

Resource estimates for Hemi Springs and Ugnu are not included in the above table, but they are included in the 2.0 billion barrels expected to be produced from satellites, pools, and enhanced recovery in existing fields. Gas resources are not listed because commercial production from the North Slope will require a new gas transportation system to reach outside markets.

The oil volume including the Point Thompson pool is largely condensate recovered with associated gas production wells. We assume that produced gas will be used for field operations (fuel) or be reinjected into reservoirs in nearby oil fields to optimize oil production. Reinjected gas could be recovered at some later date, when a transportation system for North Slope gas is constructed.

Table V.B-6b Reasonably Foreseeable Future Development: Estimated New Infrastructure for Purposes of Analysis

Area/Group	Pads	Footprint (Acres)	Wells	Production Facilities	Base Camps	Docks	Airstrips	Roads	Pipeline (Miles)
NPR-A									
Western	4	120	131	1	1	1	0	0	38
Central	3	60	87	0	0	0	0	0	22
Eastern	9	300	320	5	3	2	3	12	125
Southern	1	25	20	0	0	0	0	12	12

Source: USDOI, MMS, Alaska OCS Region

Development Assumptions: (1) Industry will minimize permanent (gravel) roads by using ice roads; (2) new pipelines from satellite fields will tie into pipelines from main fields (Alpine, Northstar, Badami, Kuparuk River); (3) number of pads and wells are estimated from resource volumes; (4) production pad footprints are estimated from pad number, connecting roads, landfall/docks, and airstrips. Hemi Springs and Ugnu are considered to be examples of satellites and enhanced oil recovery, respectively, and will be developed using existing infrastructure of the Prudhoe Bay and Kuparuk River fields.

Table V.B-7a Oil and Gas Production 1969 to December 2000 on the North Slope of Alaska

Production To Date	Oil (billions of barrels)	Gas (billions of cubic feet)	Reference
Onshore	12.889	38.76[1,2]	
Offshore	0.417	0	State of Alaska, AOGCC (2001)
Total	**13.306**	**38.76**[2]	

Source: USDOI, MMS, Alaska OCS Region

Table V.B-7b Summary of Reserve and Resource Estimates We Use for Analytical Purposes in the Cumulative Analysis

Production Activity	Oil (billions of barrels)	Contribution of Liberty by Volume of Oil (%)	Reference Table
Low End of the Range (Past and Present)	6	2.0	Table V.B-7c
Middle Portion (Past, Present, and Reasonably Foreseeable)	11	1.1	Table V.B-7c
High End (Past, Present, Reasonably Foreseeable, and Speculative)	14	0.8	Table V.B-7c

Source: USDOI, MMS, Alaska OCS Region
For purposes of analysis, oil volumes are rounded to the nearest billion barrels.

Table V.B-7c Detailed Reserve and Resource Estimates We Use for Analytical Purposes in the Cumulative Analysis

Activity	Oil (billions of barrels)	Gas (billions of cubic feet)	Reference Table
Past and Present Production (total)	6.127	34[1]	Table V.B-2
onshore–past (Prudhoe Bay, Kuparuk River, Milne Point, Badami, Colville River & NPRA)	5.470	34[1]	Table V.B-4
offshore–past (Duck Island Unit and Northstar)	0.352		
onshore–present (Fiord, Meltwater, Nanuk and Palm)	0.185		
offshore-present (Liberty)	0.120		
Reasonably Foreseeable Future Production (total)	5.13	–[2]	Table V.B-6a
Discovered Onshore	0.500		
Discovered Offshore	0.950		
Undiscovered Onshore	2.300[4]		
Undiscovered Offshore	1.38[5a]		
Speculative Production (total)	3.22	32,800[3]	See Notes Below
Onshore	2.300[4]		
Offshore	0.92[5b]		
Total	**14.477**	**32,834**	Tables V.B.1a to 7b

Source: USDOI, MMS, Alaska OCS Region.
Notes: Production and Reserve Data as of December 2000.
[1]Gas production to date is from Barrow gas fields supplied for local use to the village of Barrow. [2]Currently, all gas production from existing oilfields is consumed by facilities or reinjected for reservoir pressure maintenance. No gas production is transported and marketed outside of the North Slope. [3]Future production of natural gas assumes that a transportation system eventually will be constructed to move North Slope gas resources to outside markets. All proposed systems are uneconomic under current conditions. [4]Includes 2.0 billion barrels in unnamed satellite fields and from enhanced oil recovery from existing oil fields. Also, 0.300 billion barrels estimated for NPR-A multiple sales under the Preferred Alternative (RDC, 1997). [5a] Includes 60% of the mid-point undiscovered resources between the base case ($18.00) and high case ($30.00) of MMS's 2000 Assessment of Beaufort Sea. [5b]Includes the remaining portion (40%) of the mid-point undiscovered offshore resources recoverable between $18.00 and $30.00 per barrel.

Table V.B-7d Estimates for Speculative Oil and Gas Resources

Area	Oil (billions of barrels)	Gas (trillions of cubic feet)	Study/Source
Beaufort Shelf	1.8–3.2		MMS (2000)–*1*
Northern Alaska	0.6–3.3	—	USGS (1995)–*2*
Beaufort-MacKenzie River Delta	1.0	9.0	NEB (1998)–*3*
Northeast NPR-A	0.5–2.2	—	MMS/BLM (1997)–*4*
Arctic National Wildlife Refuge	2.4–6.3	—	USGS (1998)–*5*
North Slope-State lands	4.0	32.8	Industry–*6*; MMS–*7*
Chukchi Shelf	1.0–6.1	—	MMS (2000)–*1*

Sources: *1*, MMS Update Assessment for 2002-2007 OCS Program. *2*, USGS Circular 1145. *3*, National Energy Board, Canada, Probabilistic Estimates of Hydrocarbon Volumes in the MacKenzie Delta and Beaufort Sea Discoveries. *4*, USDOI, BLM and MMS, 1998. *6*, Informal industry estimates of oil recoverable from enhanced recovery technology and from new small satellite fields near existing North Slope infrastructure. *7*, Discovered but undeveloped gas reserves, mainly associated with existing oil fields (Sherwood and Craig, 2000).

Notes: The resource estimates for the Beaufort Shelf (USDOI, MMS, Alaska OCS Region, 2000) and Northern Alaska (U.S. Geological Survey, 1995) are mean undiscovered volumes that are economically recoverable at oil prices between $18 and $30 per barrel. Economic resources represent a small fraction of the total recoverable petroleum endowment, much of which is in pools too small or too remote to be economic under modeling assumptions. It is impossible to accurately predict the timing of commercial discoveries or future production volumes for speculative resources. Resource estimates often change with new information or modeling assumptions. For example, a new Geological Survey assessment (1998) reports that more economic oil may occur in the small coastal plain of the Arctic National Wildlife Refuge than previously estimated (U.S. Geological Survey, 1995) for all of Northern Alaska. The economic analysis in Section III.D.5 including Table III.D-5 uses $16 per barrel price for the proposal. The estimates shown above use $18 to $30 as reference prices. Assuming different price ranges is reasonable given the volatility of oil prices. A more optimistic assumption, that is a higher price, is reasonable for the cumulative case.

For the Liberty Proposal, exploration/appraisal is completed and the field is ready for development. For the cumulative case, regional exploration in Arctic Alaska is not complete and development may be delayed long into the undetermined future. The hope for giant oil fields will continue to draw leasing and exploration activities in the future. However, it is unreasonable to speculate on the timing and infrastructure needed to produce resources that have not been discovered. More than 30 trillion cubic feet of gas has been discovered on the North Slope and remains undeveloped due to the lack of a regional transportation infrastructure and market. This huge proven resource base will undoubtedly be produced before major exploration efforts are focused on undiscovered gas resources in other onshore areas or the Beaufort Sea off Alaska.

Table V.B-8 Seasonal Transportation Access for Projects off the Road System

Project	Construction Period			Operation/Production Period		
	Summer	Breakup	Winter	Summer	Breakup	Winter
LIBERTY [1]						
Aircraft [2]	10-20 round trips daily[3]	10-20 round trips daily	10-20 round trips daily	3 round trips weekly [4]	1 round trip daily	3 round trips weekly [4]
Surface	None	None	400 round trips daily[5]	None	None	100 round trips per season[6]
Marine	150 local round trips + sealift	None	None	4-5 round trips per season[7]	None	None
ALPINE[8]						
Aircraft [9]	4-7 round trips monthly	N/A	3-6 round trips monthly	4 round trips monthly or as needed	N/A	4 round trips monthly or as needed
Surface	Frequent	N/A	Frequent	Daily	N/A	Daily
Marine	N/A	N/A	N/A	N/A	N/A	N/A
NORTHSTAR[10]						
Aircraft [11]	See footnote [11]	N/A	2,480 round trips	See footnote [11]	N/A	7 round trips per month
Surface	See footnote [12]	N/A	35,013 [12] round trips	See footnote [12]	N/A	190 round trips Yearly
Marine	132 round trips	N/A	None	5-6 round trips Yearly	N/A	None
BADAMI [13]						
Aircraft	See footnote [13]	See footnote [13]	See footnote [13]	36 round trips weekly during drilling[14]	40 round trips weekly during drilling[14]	2 round trips weekly during drilling [14]
Surface	See footnote [13]	See footnote [13]	See footnote [13]	1 round trip yearly[15]	N/A	30 round trips daily during drilling [16]
Marine	See footnote [13]	See footnote [13]	See footnote [13]	10[17]	N/A	N/A

[1]Liberty construction phase December 1999 through the 4th quarter of 2001; production phase 4th quarter of 2001 until around 2015. [2]All Liberty-related aircraft traffic is calculated as helicopter trips. [3]A maximum figure for summer movement. Transport movements to be shared with work boats. [4]Does not include one helicopter flight per week to inspect the pipeline corridor. [5]Indicates a "worst case" situation. [6]100 round trips per season post drilling, 400 round trips per season during drilling. [7]4-5 round trips per month during drilling; 4-5 round trips per season post-drilling. [8]For the Alpine Project, summer is defined as April 20 to November 30; the rest of the year is winter. Alpine construction and development drilling phase may last from present to approximately 2005, with the field life estimated at another 15 to 20 years. [9]Aircraft operations calculated for the Alpine project, by Arco contractors, were made on the basis of an amalgamation of three aircraft type: Hercules cargo planes, Twin Otter's and Boeing 737's. [10]The Northstar project should be completed (island construction and development drilling) within 4 years of initiation. The life of the field is projected at 15 to 20 years. The transportation requirements indicated here are the construction of the Northstar island in a single season. [11]Data presented in the Northstar Final EIS (US Army Corps of Engineers, 1999) for helicopter transport is not separated out by season. [12]Data presented in the Northstar Final EIS for surface transport is not separated out by season. However, of the presented figure of 35,013 surface transport round trips, 2,775 round trips are composed of bus trips and would be primarily involved with the movement of personnel to construction sites. The balance of the surface transport trips are truck traffic. [13]The Badami project has proceeded beyond the construction phase and is now in developmental drilling. [14]For all three periods, 6 aircraft operations will occur weekly after drilling. [15]Planned pipeline inspection via rolligon; emergency use of rolligons not estimated. [16]After drilling, 3 yearly round trips planned for pipeline inspection via rolligons; emergency use not estimated. [17]An additional 10 round trips are planned in summer of 1998 to support drilling operations.

Table V.B-8a Sea-Ice Road Water-Volume Requirements

Road Length (Miles)	SEA ICE ROAD WATER VOLUMES (Gallons) Road Width (feet) 100	200	300	400
0.5	888,624	1,777,248	2,665,872	3,554,496
1.0	1,777,248	3,884,496	5,331,744	7,108,992
1.5	2,665,872	5,331,744	7,997,616	10,663,488
2.0	3,554,496	7,108,992	10,663,488	14,217,984
2.5	4,443,120	8,886,240	13,329,360	17,772,480
3.0	5,331,744	10,663,488	15,995,232	21,326,976
3.5	6,220,368	12,440,736	18,661,104	24,881,472
4.0	7,108,992	14,217,984	21,326,976	28,435,968
4.5	7,997,616	15,995,232	23,992,848	31,990,464
5.0	8,886,240	17,772,480	26,658,720	35,544,960
5.5	9,774,664	19,549,728	29,324,592	39,099,456
6.0	10,663,488	21,326,976	31,990,464	42,653,952
6.5	11,552,112	23,104,224	34,656,336	46,208,448
7.0	12,440,736	24,881,472	37,322,208	49,762,944
7.5	13,329,360	26,658,720	39,988,080	53,317,440
8.0	14,217,984	28,435,968	42,653,952	56,871,936
8.5	15,106,608	30,213,216	45,319,824	60,426,432
9.0	15,995,232	31,990,464	47,985,696	63,980,928
9.5	16,883,856	33,767,712	50,651,568	67,535,424
10.0	17,772,480	34,544,960	53,417,440	71,089,920

Assumptions:
– 6-inch freshwater cap on top of brine ice.
– Water volumes are calculated for construction only.
– No additional water included for ice-road maintenance.
– No contingency for rough ice surfaces.
Source: Alaska Interstate Construction, LLC.

Table V.B-8b Tundra-Ice Road Water-Volume Requirements

Road Length (Miles)	TUNDRA ICE ROAD WATER VOLUMES (Gallons) — Road Width (feet) 30	50	100	200
0.5	213,270	355,450	710,899	1,421,798
1.0	426,540	710,899	1,421,798	2,843,597
1.5	639,809	1,066,349	2,132,698	4,265,395
2.0	853,079	1,421,798	2,843,597	5,687,194
2.5	1,066,349	1,777,248	3,554,496	7,108,992
3.0	1,279,619	2,132,698	4,265,395	8,530,790
3.5	1,492,888	2,488,147	4,976,294	9,952,589
4.0	1,706,158	2,843,597	5,687,194	11,374,387
4.5	1,919,428	3,199,046	6,398,093	12,796,186
5.0	2,132,698	3,554,496	7,108,992	14,217,984
5.5	2,345,967	3,909,946	7,819,891	15,639,782
6.0	2,559,237	4,265,395	8,530,790	17,061,581
6.5	2,772,507	4,620,845	9,241,690	18,483,379
7.0	2,985,777	4,976,294	9,952,589	19,905,178
7.5	3,199,046	5,331,744	10,663,488	21,326,976
8.0	3,412,316	5,687,194	11,374,387	22,748,774
8.5	3,625,586	6,042,643	12,085,286	24,170,573
9.0	3,838,856	6,398,093	12,796,186	25,592,371
9.5	4,052,125	6,753,542	13,507,085	27,014,170
10.0	4,265,395	7,108,992	14,217,984	28,435,968

Assumptions:
– 6-inch total road thickness.
– 2/3 of thickness is freshwater.
– 1/3 of thickness is snow.
– Typical tundra topography.
– 20% contingency for topographic feature correction, (i.e., stream ramps, etc.).
– Water volumes are calculated for construction only.
– No additional water included for ice-road maintenance.
Source: Alaska Interstate Construction, LLC

Table V.B-8c Some Characteristics of North Slope Oil Fields

Oil Field[1] (Year Production Began)	Unit Area (hectares)[2]	Number of Production Facility Pads	Mine Sites and Gravel Placement: Area Disturbed (hectares)	Mine Sites and Gravel Placement: Percent of Unit Disturbed (%)
Prudhoe Bay (1977)	99,103.2	50	2,592.5	2.62
Kuparuk River (1981)	104,514.2	49	1,033.8	0.99
Milne Point (1985)	22,002.8	11	182.0	0.83
Lisburne (1986)	32,359.5	8	100.7	0.31
Endicott (1987)	7,099.1	2	207.1	2.92
Point McIntyre (1993)	4,384.1	2	12.7	0.29
Niakuk (1994)	2,623.7	1	9.8	0.37
Badami (1998)	15,139.6	1	74.4	0.49
Alpine (2000[3])	32,576.5	2	56.5	0.17
Northstar (2001[3])	12,491.8	1	1.8	0.01
Liberty (2003[3])	2,152.9	1	2.2	0.10
Pt Thomson/Sourdough	33,896.8	4	112.0	0.33
TAPS and Dalton Highway (North Slope)	NA	NA	4,412.9	NA

Source: Gilders and Cronin (2000).
[1]Oil field refers to both units and participating areas.
[2]Unit areas cannot be totaled because of overlap that exists among the units and participating areas.
[3]Table V.B-1a.

Table V.B-9 Summary of Cumulative Effects

Resources	Summary of Effects
a. Endangered Species: **Bowhead Whale** **Eiders** **Other Species**	Bowhead whales temporarily may avoid noise-producing activities, and contact with spilled oil could cause temporary, nonlethal effects, and a few could die from prolonged exposure to freshly spilled oil. The Liberty Project's contribution to cumulative effects is expected to be limited to temporary avoidance behavior by a few bowhead whales in response to vessel traffic. If an unlikely large oil spill (greater than or equal to 500 barrels) occurred significant adverse effect would occur to spectacled eiders. Disturbance may cause short-term energy loss when displaced from preferred habitat and a large oil spill could result in significant losses in offshore and nearshore areas. Liberty would be additive to effects from all projects in this cumulative analysis, but only in the case of a large offshore oil spill would Liberty be expected to increase adverse cumulative effects to potentially significant population levels. Oil transportation from Liberty to ports along the U.S. west coast likely would contribute little to cumulative effects on species along transportation routes.
b. Seals, Walruses, Beluga Whales and Polar Bears	Ongoing activities that may effect seals, walruses, beluga whales and polar bears include disturbance, habitat alteration, and spilled oil. Overall effects (mainly from oil) should last no more than one generation for seals (about 5-6 years), walruses, beluga whales and polar bears (about 7-10 years). Liberty should only briefly and locally disturb or displace a few seals, walruses, beluga whales and polar bears. A few polar bears could be temporarily attracted to the production island with no significant effects on the population's distribution and abundance.
c. Marine and Coastal Birds	If an unlikely large oil spill occurred, significant adverse effects would occur to long-tailed ducks, common eiders, and king eiders. Losses could be substantial from a large oil spill contacting offshore staging areas, in lagoons or along beaches during the brief period of exposure. Disturbance from support activities could cause displacement to less favorable foraging areas. Effects of Liberty would be additive to effects observed or anticipated for cumulative projects and, in the case of a large oil spill, could measurably increase adverse effects at the population level in several species.
d. Terrestrial Mammals	About half the Central Arctic Caribou Herd uses coastal habitat adjacent to the Liberty area during summer. Oil development in the Prudhoe Bay area is likely to continue to displace some caribou during the calving season within about 4 kilometers of roads with vehicle traffic. Liberty is expected to contribute less than 1% of the local short-term disturbance of caribou. Liberty should only briefly and locally disturb or displace a few muskoxen and grizzly bears.
e. Lower Trophic Organisms	Effects of additional drilling discharges, construction-related activities and oil spills are not expected to substantially affect organisms near Liberty island or elsewhere. Liberty is not expected to make a measurable contribution to the cumulative effects on these organisms.
f. Fishes	Small numbers of fish in the immediate area of an offshore or onshore oil spill may be killed or harmed, but this would not have a measurable effect on fish populations. Marine and migratory fishes are widely distributed in the Beaufort Sea and are not likely to be affected by the Liberty Project. Oil is not expected to contact overwintering areas during winter. Hence, the Liberty Project is not expected to contribute measurably to the overall cumulative effect on fishes.

Table V.B-9 Summary of Cumulative Effects (continued)

Resources	Summary of Effects
g. Vegetation-Wetland Habitats	Construction causes more than 99% of the effects, with spills having a very minor role. Rehabilitation of gravel pads can result in the growth of grasses-sedges within 2 years after abandonment of the pads. Natural growth of plant cover would be very slow. Liberty would contribute less than 1% of the cumulative disturbance effects on 9,000 acres now affected by oil development.
h. Subsistence-Harvest Patterns	In the past, drilling and seismic activity near the bowhead whale migration route has made subsistence whaling more difficult, and if a large oil spill occurred, subsistence harvests in Nuiqsut and Kaktovik could be affected with one or more important subsistence resources becoming unavailable or undesirable for use for 1-2 years, a significant adverse effect. Liberty is expected to have periodic effects on subsistence resources, but no harvest areas would become unavailable for use and no resource population would experience an overall decrease.
i. Sociocultural Systems	Past and present development of oil and gas and other projects have had negative effects on North Slope communities by producing conflicts to traditional lifestyles and straining social and health service providers. At the same time, tax revenues from past oil and gas development have also produced positive effects that include increased funding for infrastructure, higher incomes (that can be used to purchase better tools for subsistence), better health care, and improved educational facilities. Liberty development could produce periodic disturbance effects to communities near the Liberty Project but would not displace any sociocultural systems, community activities, or traditional practices.
j. Archaeological Resources	Liberty's contribution to cumulative effects and the cumulative effects overall are expected to be minimal for archaeological resources, because any surface-disturbing activities that could damage archaeological sites would be mitigated by current State and Federal procedures.
k. Economy	This cumulative analysis projects employment increases as follows: 2,400 direct oil industry jobs at peak, declining to 1,300; about 3,400 indirect jobs at peak, declining to 2,000; about 150 jobs for North Slope Borough residents at peak, declining to 50; about 5-125 jobs for 6 months for cleanup of an oil spill in the Beaufort Sea; and about 10,000 jobs and 25% price inflation for 6 months for cleanup of a tanker oil spill in the Gulf of Alaska. This cumulative analysis projects annual revenues as follows: $125 million Federal, $77 million State, and $28 million for the State and North Slope Borough. Liberty's contribution to the cumulative effects above is between 3% and 36%.
l. Water Quality	A large crude or refined oil spill (greater than or equal to 500 barrels) would have a significant effect on water quality by increasing the concentration of hydrocarbons in the water column to levels that greatly exceed background concentrations; however, the chance of a large spill occurring is low. Also, regional (more than 1,000 square kilometers – 386 square miles), long-term (more than 1 year) degradation of water quality to levels above State and Federal criteria because of hydrocarbon contamination is very unlikely. Resuspended sediments from construction activities are not expected to exceed acute water-quality criteria and permitted discharges will be designed to ensure rapid mixing and dilution of the discharge. The effects from the Liberty Project from construction activities are expected to be short term, lasting as long as the individual activity, and have the greatest impact in the immediate vicinity of the activity.
m. Air Quality	Projects in the past and present now have caused essentially no deterioration in air quality or contribute measurably to global climate change. Air emissions from the Liberty Project essentially would have no effects on air quality.
n. Environmental Justice	Alaska Inupiat Natives are a recognized minority and are potentially the most affected by Liberty Development. Effects could occur to the communities of Nuiqsut and possibly Kaktovik. Effects are not expected from routine activities, but could occur from a large oil spill, although not from the Liberty Project. Oil-spill contamination of the essential whaling area and subsistence foods are the main concerns. Any potential effects to subsistence resources and subsistence harvests are expected to be mitigated substantially, though not eliminated.

Table VI.A-1 Breeding Season Nest and Bird Densities for Selected Species in the Kadleroshilik River Area in 1994

Species	Breeding Season (Nests) [2]	Breeding Season [3]	Brood-Rearing Season [3]	Post-Breeding Season [3]	9-13 June [4]	11-18 July [4]	17-23 August [4]
Red-Throated Loon	0.0	0.5	0.4	0.2	0.3	1.0	0.0
King Eider	0.7	1.8	0.3	1.0	0.7	1.7	1.7
Long-Tailed Ducks	1.3	8.1	1.2	---	10.7	5.0	0.0
Lesser Golden-Plover	1.7	3.8	4.1	3.8	7.3	2.0	3.7
Semi-Palmated Sandpiper	9.0	19.9	6.7	0.2	27.3	8.0	0.0
Pectoral Sandpiper	12.0	28.3	20.0	41.0	42.0	23.3	29.0
Dunlin	4.0	9.2	5.9	5.8	10.0	9.0	7.0
Stilt Sandpiper	1.3	4.7	1.1	0.0	5.7	4.0	0.0
Red-Necked Phalarope	3.3	14.0	4.8	1.2	19.0	8.3	1.0
Red Phalarope	7.7	12.5	3.6	0.7	19.7	4.0	0.7
Lapland Longspur	25.0	65.3	35.6	52.7	82.0	34.0	50.3

[1] Source: Troy Ecological Research Assocs. (1995b)

[2] Density, nests per square kilometer

[3] Average density, birds per square kilometer

[4] Density, birds per square kilometer

Table VI.B-1 Resources Used in Barrow, Kaktovik, and Nuiqsut

Species	Inupiaq Name	Scientific Name	Location B[1]	Location K[2]	Location N[3]
Marine Mammals					
Bearded seal	*Ugruk*	Erignathus barbatus	√	√	√
Ringed seal	*Natchiq*	Phoca hispida	√	√	√
Spotted seal	*Qasigiaq*	Phoca largha	√	√	√
Ribbon seal	*Qaigulik*	Phoca fasciata	√		
Beluga whale	*Quilalugaq*	Delphinapterus leucas	√	√	
Bowhead whale	*Agviq*	Balaena mysticetus	√	√	√
Polar bear	*Nanuq*	Ursus maritimus	√	√	√
Walrus	*Aiviq*	Odobenus rosmarus	√	√	
Terrestrial Mammals					
Caribou	*Tuttu*	Rangifer tarandus	√	√	√
Moose	*Tuttuvak*	Alces alces	√	√	√
Brown bear	*Aklaq*	Ursus arctos	√	√	√
Dall sheep	*Imnaiq*	Ovis dalli	√	√	√
Musk ox	*Uminmaq*	Ovibus moschatus		√	√
Arctic fox (Blue)	*Tigiganniaq*	Alopex lagopus	√	√	√
Red fox [4]	*Kayuqtuq*	Vulpes fulva	√	√	√
Porcupine	*Qinagluk*	Erethizon dorsatum	√		
Ground squirrel	*Siksrik*	Spermophilus parryii	√	√	√
Wolverine	*Qavvik*	Gulo gulo	√	√	√
Weasel	*Itigiaq*	Mustela erminea		√	√
Wolf	*Amaguk*	Canis lupus	√	√	√
Marmot	*Siksrikpak*	Marmota broweri		√	√
Fish					
Salmon (ns)			√	√	√
Chum	*Iqalugruaq*	Oncorhynchus keta	√		√
Pink (humpback)	*Amaqtuuq*	Oncorhynchus gorbuscha	√	√	√
Silver (coho)	*Iqalugruaq*	Oncorhynchus kisutch		[5]	
King (chinook)		O. tshawytscha			
Sockeye (red)		Oncorhynchus nerka			
Whitefish (ns)	*Aanaakliq*	Coregonus sp.	√	√	
Round w.f.	*Aanaakliq*	Prosopium cylindraceum	√		
Broad w.f.	*Aanaakliq*	Coregonus nasus	√	√	√
Humpback w.f.	*Pikuktuuq*	Coregonus clupeaformis	√		√
Least cisco	*Iqalusaaq*	Coregonus sardinella	√	√	√
Bering,Arctic cisco	*Qaaktaq*	Coregonus autumnalis	√	√	√
Other f.w. fish					
Arctic grayling	*Sulukpaugaq*	Thymallus arcticus	√	√	√
Arctic char	*Iqalukpik*	Salvelinus alpinus	√	√	√
Burbot (Ling cod)	*Tittaaliq*	Lota lota	√	√	√
Lake trout	*Iqaluaqpak*	Salvelinus narnaycush	√	√	√
Northern pike	*Siulik*	Esox lucius	√		

Species	Inupiaq Name	Scientific Name	Location B[1]	Location K[2]	Location N[3]
Fish (continued)					
Other coast. fish					
Capelin	*Pagmaksraq*	Mallotus villosus	√		
Rainbow smelt	*Ilhuagniq*	Osmerus mordax	√		√
Arctic cod	*Iqalugaq*	Boreogadus saida	√	√	√
Tomcod	*Uugaq*	Eleginus gracilis	√	√	
Flounder (ns)	*Nataagnaq*	Liopsetta glacialis		√	
Birds					
Snowy owl	*Ukpik*	Nyctea scandiaca			√
Red-throated loon	*Qaqsraupiagruk*	Gavia stellata	√		
Tundra swan	*Qugruk*	Cygnus columbianus		√	√
Eider					
Common eider	*Amauligruaq*	Somateria mollissima	√	√	√
King eider	*Qinalik*	Somateria spectabilis	√	√	√
Spectacled eider	*Tuutalluk*	Somateria fischeri	√		
Steller's eider	*Igniqauqtuq*	Polysticta stelleri	√		
Other ducks (ns)	*Qaugak*		√	√	
Pintail	*Kurugaq*	Anas acuta		√	
Long-tailed ducks	*Aaqhaaliq*	Clangula hyemalis	√	√	
Surf scoter	*Aviluktuq*	Melanitta perspicillata	√		
Goose					
Brant	*Niglingaq*	Branta bernicla n.	√	√	√
White-fronted g.	*Niglivialuk*	Anser albifrons	√	√	√
Snow goose	*Kanuq*	Chen caerulescens	√	√	√
Canada goose	*Iqsragutilik*	Branta canadensis	√	√	√
Ptarmigan (ns)	*Aqargiq*	Lagopus sp.	√	√	√
Willow ptarmigan	*Nasaullik*	Lagopus lagopus	√		
Other resources					
Berries (ns)			√	√	√
Blueberry	*Asiaq*	Vaccinium uliginosum	√		
Cranberry	*Kimminnaq*	Vaccinium vitis-idaea	√		
Salmonberry	*Aqpik*	Rubus spectabilis	√		
Bird eggs (ns)	*Mannik*		√	√	
Gull eggs				√	
Geese eggs				√	
Eider eggs			√	√	
Greens/roots (ns)			√	√	√
Wild rhubarb	*Qunulliq*	Oxyric digyna	√		
Wild chives	*Quagaq*	Allium schoenoprasum	√		
Clams	*Imaniq*		√		
Wood				√	√
Fresh water	*Imiq*		√		
Fresh water ice	*Sikutaq*		√		
Sea ice	*Siku*		√		

Sources: Stephen R. Braund and Assocs. and University of Alaska, Anchorage, Institute of Social and Economic Research (1993); Pedersen (1995a,b); Stephen R. Braund and Assocs. (1996).
Footnotes: [1] B, Barrow, resources used 1987–1990. [2]K, Kaktovik, resources used 1992–1993. [3]N, Nuiqsut, resources used 1993. [4]Red fox (Cross, Silver) [5]Harvest of silver, king, and sockeye salmon is rare.
Note: An unchecked box may mean a resource was not used or, especially in the case of "Other Resources," the resource might have been used but use was reported as "berries" rather than "blueberries," for example.
Abbreviations: ns, nonspecified; w.f., whitefish; f.w., freshwater; coast., coastal.

Table VI.B-2 Proportion of Inupiat Household Food Obtained from Subsistence Activities, 1977, 1988, and 1993 (proportion is measured in percent)

	All Communities of the North Slope Borough		
Proportion	**1977**	**1988**	**1993**
None	13	20	18
Less Than Half	42	31	25
Half	15	14	15
More Than Half	30	35	42

Source: Harcharek (1995).

Table VI.B-3 Participation in Successful Harvests of Selected Resources (percentage of households per resource)

	Barrow[1]	Nuiqsut[2]	Kaktovik[3]
Total	87 %	90 %	89 %
Marine mammals	76	37	40
Terrestrial mammals	77	76	68
Fish	60	81	81
Birds	65	76	64
Marine mammals			
Bowhead whale	75 %	5 %	6 %
Walrus	29	0	2
Bearded seals	46	7	28
Ringed seals	19	31	26
Spotted seals	1	2	4
Polar bear	7	2	4
Terrestrial mammals			
Caribou	77 %	74 %	55 %
Moose	7	10	6
Brown bear	0	8	0
Dall sheep	3	0	28
Wolverine	1	16	13
Arctic Fox	5	13	15
Red Fox	*	23	11
Fish			
Whitefish (all species)	54 %	74 %	70 %
Grayling	21	65	15
Arctic Char	5	31	79
Salmon (all species)	16	36	9
Burbot	10	57	0
Birds			
Geese	40 %	73 %	47 %
Eiders	52	36	38
Ptarmigan	26	45	57

All numbers are percentages.
Sources: Stephen R. Braund and Assocs. and University of Alaska, Anchorage, Institute of Social and Economic Research (1993); Pedersen (1995a,b); Stephen R. Braund and Assocs. (1996).
Notes: Dates resources used: [1]1987–1990. [2]1993. [3]1992–1993.
*Represents less than 0.1%.

Table VI.B-4 Percent of Total Subsistence Resources Consumed and Total/Per Capita Harvests

	Barrow (%)		Nuiqsut (%)		Kaktovik (%)	
Resource	**1962-82[1]**	**1989**	**1993**	**1994-95**	**1962-82**	**1992**
Bowhead Whale	21.3	38.7	28.7	0	27.5	63.2
Caribou	58.2	22.2	30.6	58	16.2	11.1
Walrus	4.6	8.9	0	—	3.2	— *
Bearded Seal	2.9	2.1	0.3	—	7.4	2.4
Hair Seals	4.3	1.6	2.7	2 [2]	4.1	1.0
Beluga Whales	0.5	0.	0	—	6.2	0.
Polar Bears	0.3	2.2	0.	—	2.8	0.7
Moose	0.3	2.2	1.6	5	3.5	1.1
Dall Sheep	0	0.1	0	—	3.8	2.5
Muskox	—	—	0	—	—	
Small Land Mammals	0.1	— *	— [3]	— [3]	0.4	— *
Birds[4]	0.9	3.3	1.5	5	0.4	1.9
Fishes	6.6	7.8	33.7	30	21.7	13.4
Vegetation	—	0.1	1.4	— *	—	0.1
Total Harvest (lb)	**928,205**	**872,092**	**160,035**	**267,818**	**32,408**	**170,939**
Per Capita Harvest (lb)	**540**	**289.16**	**399.19**	**741.75**	**219**	**885.60**

Source: Stoker, 1983, as cited by ACI/Braund (1984); Stephen R. Braund & Assocs. (1989); State of Alaska, Dept. of Fish and Game (1995a).
Notes: [1] Averaged for the period.
[2] Represents all marine mammals harvested in 1994-95: 1 polar bear and 35 ringed seals.
[3] Not harvested for food. [4] Birds and eggs. [5] Not calculated in report. *Represents less than 0.1 percent.

Table VI.B-5 Nuiqsut 1993 Subsistence-Harvest Summary for Marine Mammals, Terrestrial Mammals, Fish, and Birds

	Total Number Harvested	Edible Pounds Harvested: Total	Household Harvest Mean	Per capita
Marine Mammals				
Total Marine Mammals	113	85,216	936.44	236.01
Bowhead Whale	3	76,906	845.12	213.00
Polar Bear	1 *	0	0.00	0.00
Bearded Seal	6	1,033	11.35	2.86
Ringed Seal	98	7,277	79.96	20.15
Spotted Seal	4 *	0	0.00	0.00
Terrestrial Mammals				
Large Land Mammals	691	87,306	959.40	241.80
Brown Bear	10 *	734	8.06	2.03
Caribou	672	82,169	902.95	227.57
Moose	9	4,403	48.38	12.19
Muskox	0	0	0.00	0.00
Dall Sheep	0	0	0.00	0.00
Small Land Mammals/Furbearers	599 §	84	0.92	0.23
Arctic Fox	203	0	0.00	0.00
Red Fox	63	0	0.00	0.00
Marmot	0	0	0.00	0.00
Mink	0	0	0.00	0.00
Parka Squirrel	336	84	0.92	0.23
Weasel	10	0	0.00	0.00
Wolf	31	0	0.00	0.00
Wolverine	19	0	0.00	0.00
Fishes				
Total Fish	71,897	90,490	994.39	250.62
Total Salmon	272	1,009	11.08	2.79
Total Nonsalmon	71,626	89,481	983.30	247.83
Smelt	304	42	0.46	0.12
Cod	62	7	0.07	0.02
Burbot	1,416	5,949	65.37	16.48
Char	618	1,748	19.20	4.84
Grayling	4,515	4,063	44.65	11.25
Total Whitefish	64,711	77,671	853.53	215.12
Cisco	51,791	34,943	383.98	96.78
Arctic Cisco	45,237	31,666	347.97	87.70
Least Cisco	6,553	3,277	36.00	9.08
Birds				
Total Birds and Eggs	3,558	4,325	47.53	11.98
Migratory Birds	2,238	3,540	38.90	9.80
Ducks	772	1,152	12.66	3.19
Eider	662	1,059	11.63	2.93
Geese	1,459	2,314	25.43	6.41
Brant	296	356	3.91	0.99
Canada Geese	691	830	9.11	2.30
White Fronted	455	1,092	12.00	3.02
Swan	7	73	0.80	0.20
Ptarmigan	973	681	7.48	1.89

Number of households in the sample = 62; number of households in the community = 91.
Source: State of Alaska, Dept. of Fish and Game, Community Profile Database (1995b).
Footnotes: *Not eaten. §Some not eaten.

Table VI.B-6 Subsistence Harvest by Month for Nuiqsut, July 1, 1994, to June 30, 1995

	1994						1995						Total	Est.Total
Item	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**71 HH's**	**83 HH's**
Arctic Char	0	8	0	0	0	0	0	0	0	0	0	0	8	8
Arctic Cisco[1]	0	0	37	5,737	2,400	1,050	262	0	0	0	0	0	9,486	9,842
Broad Whitefish	1,535	25	75	855	500	0	0	0	0	0	0	130	3,120	3,237
Burbot	0	0	0	9	76	3	0	0	0	0	0	0	88	91
Fish Unidentified	0	0	0	0	0	0	0	0	0	0	0	75	75	78
Grayling	0	24	225	110	84	0	0	0	0	0	0	2	445	462
Humpback Salmon	10	0	0	0	0	0	0	0	0	0	0	0	10	10
Humpback Whitefish[1]	0	0	0	150	25	0	0	0	0	0	0	0	175	182
Least Cisco	0	0	0	0	0	750	0	0	0	0	0	0	750	778
Northern Pike	0	0	0	0	0	0	0	0	0	0	0	18	18	19
Whitefish Unidentified	0	0	0	50	425	0	0	0	0	0	0	0	475	493
Caribou	63	32	6	80	13	4	9	5	13	7	2	15	249	258
Moose	1	1	1	1	0	0	1	0	0	0	0	0	5	5
Wolf	0	0	0	0	1	1	3	0	12	1	0	0	18	19
Wolverine	0	0	0	0	1	1	2	1	1	2	0	0	8	8
Arctic Fox	0	0	0	0	0	1	1	1	3	0	0	0	6	6
Fox Unidentified	0	0	0	0	4	0	0	0	0	0	0	0	4	4
Red Fox	0	0	0	0	0	1	1	1	1	1	0	0	5	5
Polar Bear	0	0	0	0	1	0	0	0	0	0	0	0	1	1
Tundra Swan	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Geese Unidentified	0	0	0	0	0	0	0	0	0	0	409	48	457	474
Eider Unidentified	0	0	0	0	0	0	0	0	0	0	50	40	90	93
Ptarmigan	0	0	0	0	0	0	0	0	0	33	23	0	56	58
Sandhill Crane	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Ringed Seal	2	10	0	0	0	0	0	0	0	6	0	5	23	24
Salmonberries (gal)	0	9	0	0	0	0	0	0	0	0	0	0	9	9
Cranberries (gal)	0	0.5		0	0	0	0	0	0	0	0	0	0.5	1
Blueberries (gal)	0	2.5		0	0	0	0	0	0	0	0	0	2.5	3
Blackberries (gal)	0	0.5		0	0	0	0	0	0	0	0	0	0.5	1

Source: Brower and Opie (1997); Brower and Hepa (1998).
Notes: HH=Households. [1]The harvest of arctic cisco and humpback whitefish is under represented: one household provided evidence of a significant but unquantifiable harvest by saying that "sled loads" were harvested "every couple of days during October and November."

Table VI.B-7 North Slope Borough Employment by Industry 1990-1998

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total Industries	9,185	9,208	8,400	8,823	9,570	9,114	9,149	9,102	9,404
Mining	5,126	5,018	4,411	4,213	4,617	4,436	4,431	4,158	4,753
Construction	373	484	387	361	623	415	344	354	371
Manufacturing	0	0	0	0	0	2	3	7	8
Trans.,Comm., & Util.	362	364	241	238	378	403	428	440	435
Wholesale Trade	0	0	0	0	0	0	0	0	0
Retail Trade	252	205	213	487	522	481	524	540	567
Finance, Ins., R.E.	183	177	167	166	166	145	143	175	177
Services	976	1,031	1,008	1,308	949	804	890	1,046	1,035
Government	1,901	1,929	1,964	2,040	2,315	2,428	2,385	2,293	2,068
Federal	107	98	78	57	70	78	43	38	28
State	32	64	60	59	58	58	57	52	56
Local	1,762	1,767	1,827	1,925	2,187	2,293	2,286	2,204	1,983
Miscellaneous	0	0	5	0	0	0	1	1	1
Total Less Mining	4,059	4,190	3,989	4,610	4,953	4,678	4,718	4,854	4,651

Source: Alaska Department of Labor and Workforce Development, Research and Analysis Section.

Table VI.B-8 Employment Estimates (in Thousands)

	1995	1996	1997	1998	1999
Anchorage – Matsu Region	131	132	135	141	144
Kenai Peninsula Borough	16	16	16	17	17
Fairbanks North Star Borough	31	31	32	33	33
Total	178	179	183	191	194

Source: Alaska Department of Labor and Workforce Development, Research and Analysis Section.

Table VI.C-1 Quaternary Marine Transgressions

Transgression	Shoreline	Age	Correlation	
			North America	**Europe**
Krusensternian	Within 2 m of present	Approx 5,000 years	Late Wisconsin Retreat/Late Flandrian	Late Würm and Recent
Woronzofian	2-5 m below present	25,000 to 48,000 years	Middle Wisconsin interstade	Middle Würm interstade
Pelukian	7-10 m above present	Ca. 100,000 years	Sangamon Interglacial	Broerup Interstade (?) and Riss Würm Interglaciation
Wainwrightian	20-25 m above present	158,000-540,000 years	Pre-Illinoian interglacial	Mindel-Riss Interglaciation
Fishcreekian	25-35 m above present	1,500,000-2,480,000 years	Late Pliocene-Early Pleistocene	
Bigbendian	35-60 m above present	>2,400,000 years	Late Pliocene	Early Pleistocene
Colvillian	40-60 m above	<3,500,000 years	Late Pliocene	

Source: After Hopkins (1967) and Dinter, Cater, and Brigham-Grette (1990).

Table VI.C-2 Late Pleistocene Regressive Events

Age	Shoreline	Correlation
13,000 yrs before present	approximately 50 m below present	Beginning of Krusensterian Transgression
18,000 yrs before present	approximately 90 m below present	Beginning of Flandrian Transgression

Source: From Hopkins (1967).

Table VI.C-3a Trace Metal Concentrations in Beaufort Sea Sediments and Waters

Area		Arsenic (As)	Chromium (Cr)	Mercury (Hg)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)	Barium (Ba)	Copper (Cu)	Nickel (Ni)	Vanadium (V)
Sediments (ppm)											
Nearshore, Lagoons, and Bays[1]	Range	—[2]	17–19	0.02–0.09[3]	3.9–20	19–116	0.04–0.31	185–745	4.9–37	334	33–153
Nearshore, Lagoons, and Bays[19]	Mean	—	96	—	11	109	0.16	651	23	—	115
	Std Dev	—	±23	—	±4	±13	±0.06	±117	±4	—	±30
	Range	—	67–219	—	3.9–23.2	77–134	0.06–0.29	309–1,112	14.3–38.1	—	80–229
Shelf[5]	Range	16–23[6]	85[4]	0.03–0.16[7]	3[8]	98	0.2[7]	—	57	47	140[4]
Slope and Abyssal[8]	Range	55[6] 2[9]	99[9]	0.07–0.17[7]	—	82	—	—	59	56	19
Northstar[20]		7.1	16.6	—	—	—	—	63	—	—	—
Average Liberty		5.5	18.5	—	10.1	—	—	67.5	—	—	—
Pipeline Routes[12]		5.5	12.2	0.035	5.36	—	—	44.8	—	—	—
Foggy Island Bay[19]	Mean	—	87	—	9.11	110	0.14	620	23	—	160
	Std Dev	—	±9.70	—	±2.91	±12	±0.03	±47	±2.20	—	±20
Suspended Sediments (ppm of dry weight)[13]	Range	—	21–140	—	—	8–232	—	—	5–83	10–100	2–307
Average World Coastal Ocean[8]	Range	—	10–100	0.01–0.07[10]	2–20	5–200	0.2–3.0	60–1,500[11]	5–40	16–47[11]	130[9]
Effects Range[21] (ppm)											
Effects Range — Low*		33.0	80.0	0.15	35.0	120	5.0	—	70.0	30.0	—
Effects Range — Median*		85.0	145.0	1.3	110.0	270	9.0	—	390.0	50.0	—
Water (ppb)											
Total[13]	Range	—	0.1–2.1	0.005–0.57[7]	—	0.4–3.7[14]	—	—	0.4–2.1	—	—
Dissolved[8]	Range	—	0.02–0.3	0.008–0.032[15]	0.02–1.7	0.2–3.4	0.02–0.11	—	0.3–1.8	—	—
Typical Worldwide Marine Total[16]	Range	1.35–2.5[17]	0.3	0.001[18]	0.01	1	0.04	—	0.3	0.3	—

Source: USDOI, MMS (1996a).

Notes: *The Effects Range-Low (ERL) is defined as the concentration of a substance in the sediment that results in an adverse biological effect in about 10% of the test organisms, and the Effects Range-Median (ERM) is defined as the concentration of a substance that affects 50% of the test organisms.

[1] Boehm et al. (1987).
[2] No data.
[3] Northern Technical Services (1981), Weiss et al. (1974).
[4] Naidu, 1982, cited in USDOI, MMS (1996a).
[5] Naidu (1974).
[6] Robertson and Abel (1979).
[7] Weiss et al. (1974).
[8] Thomas (1988).
[9] Naidu et al. (1980).
[10] Nelson et al. (1975) (for central Bering Shelf and Chukchi Sea).
[11] Chester (1965).
[12] Upper row—Montgomery Watson (1997). Lower row–Montgomery Watson (1998).
[13] OCSEAP data, NODC/NOAA data bank.
[14] Burrell et al. (1970).
[15] Guttman, Weiss and Burrell (1978) (for Chukchi and Beaufort Seas).
[16] Bernhard and Andreae (1984).
[17] Burton and Statham (1982) in Langston (1990).
[18] Gill and Fitzgerald 1(985).
[19] Boehm et al.(1990).
[20] Montgomery Watson (1996).
[21] Long and Morgan (1990).

Table VI.C-3b Trace Metal Concentrations in Beaufort Sea Sediments and Waters – ANIMIDA (Chromium, Mercury, Lead, Zinc, Cadmium, Barium, Copper, Nickel, Vanadium)

ANIMIDA Stations		Chromium (Cr)	Mercury (Hg)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)	Barium (Ba)	Copper (Cu)	Nickel (Ni)	Vanadium (V)
Sediments (μg/g)										
All	Mean	52.1	0.04	9.9	63.5	0.21	407	17.0	22.2	84.8
	Std. Dev	±25.3	±0.04	±5.4	±35.5	±0.14	±160	±11.2	±11.5	±43.4
	Range	12.7 - 104.3	0.003 - 0.20	3.2 - 22.3	14.8 - 131	0.05 - 0.79	155 - 753	4.0 - 46.9	6.0 - 48.4	26.9 - 173
Liberty	Mean	54.2	0.03	10.0	63.8	0..18	418	16.2	22.2	83.8
	Std. Dev	±19.0	±0.02	±3.6	±24.9	±0.10	±124	±7.9	±8.0	±28.0
	Range	27.8 - 86.5	0.010 - 0.074	6.4 - 18.2	34.0 - 108	0.07 - 0.37	289 - 674	7.4 - 30.9	12.4 - 39.3	51 - 133
Northstar	Mean	53.6	0.04	9.7	63.9	0.22	448	17.3	22.5	88.9
	Std. Dev	±29.9	±0.03	±6.4	±41.8	±0.11	±169	±12.5	±12.6	±55.1
	Range	12.7 - 104.3	0.008 - 0.09	32 - 20.3	13.7 - 131	0.07- 0.43	164 - 712	12.5 - 37.6	7.1 - 43.0	28.1 - 173
BSMP Stations	Mean	49.0	0.04	9.8	63.0	0.24	360	17.4	22.0	82.1
	Std. Dev	±26.9	±0.05	±6.1	±39.2	±0.19	±177	±12.9	±13.5	±45.0
	Range	15.1 - 91.1	0.003 - 0.20	3.2 - 22.3	14.8 - 124	0.05 - 0.79	155 - 753	4.0 - 46.9	6.0 - 48.4	26.9 - 153
Suspended Sediments - August 1999 (μg/g)		**Chromium (Cr)**	**Mercury (Hg)**	**Lead (Pb)**	**Zinc (Zn)**	**Cadmium (Cd)**	**Barium (Ba)**	**Copper (Cu)**	**Nickel (Ni)**	**Vanadium (V)**
All	Mean	92.2	-	21.3	135	0.64	708	39.1	-	-
	Std. Dev	±9.1	-	±5.2	±14	±0.29	±41	±7.4	-	-
	Range	70.3 - 107		13.3 - 46.6	106 - 162	0.27 - 1.43	660 - 798	31.3 - 66.2		
Liberty	Mean	97.4	-	21.5	143	0.67	738	37.6	-	-
	Std. Dev	±5.0	-	±2.3	±14	±0.23	±28	±2.9	-	-
	Range	98.3 - 107		20.7 - 24	137	0.55 - 0.57	412 - 798	33.8 - 39		
Northstar	Mean	92.6	-	21.9	137	0.72	700	41.3	-	-
	Std. Dev	±8.4	-	±6.6	±11	±0.33	±43	±9.3	-	-
	Range	70.8 - 107		13.3 - 46.6	117 - 162	0.32 - 1.46	660 - 739	31.3 - 66.2		
BSMP Stations	Mean	87.2	-	19.7	123	0.44	700	35.8	-	-
	Std. Dev	±11.2	-	±3.5	±10	±0.11	±35	±2.6	-	-
	Range	70.3 - 97.1		13.5 - 25.3	106 - 134	0.27 - 0.64	648 - 750	31.9 - 40.1		
Colville River	-	70.1	-	-	-	0.67	868	33.8	12.6	115
Sagavanirktok River	-	90.7	-	-	-	1.12	753	43.1	17.3	186

Table VI.C-3b Trace Metal Concentrations in Beaufort Sea Sediments and Waters -- ANIMIDA (Chromium, Mercury, Lead, Zinc, Cadmium, Barium, Copper, Nickel, Vanadium) *(Continued)*

ANIMIDA Stations		Chromium (Cr)	Mercury (Hg)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)	Barium (Ba)	Copper (Cu)	Nickel (Ni)	Vanadium (V)
Suspended Sediments - April 2001 Under Ice (μg/g)										
Background Stations[1]	Range	113 - 583	-	31.2 - 471	100 - 3,310	1.29 - 6.42	646 - 2,960	83.4 - 458	-	-
Background Northstar Station[3]	Range	113 - 121	-	31.2 - 40.6	128 - 662	1.31 - 3.96	712 - 1,090	87.1 - 121	-	
Northstar Trench Stations[2]	Range	113 - 278	-	25.4 - 224	146 - 1,690	0.48 - 2.31	612 - 928	77.2 - 154	-	
		Chromium (Cr)	**Mercury (Hg)**	**Lead (Pb)**	**Zinc (Zn)**	**Cadmium (Cd)**	**Barium (Ba)**	**Copper (Cu)**	**Nickel (Ni)**	**Vanadium (V)**
Effects Range[21] (ppm)										
Effects Range — Low*		80.0	0.15	35.0	120	5.0	—	70.0	30.0	—
Effects Range — Median*		145.0	1.3	110.0	270	9.0	—	390.0	50.0	—
Water (ppb)										
Average Continental Crust (Wedepohl, 1995)										
		126	0,04	14.8	65	0.52	584	25	56	98

Source: Boehm et al. (2001)

Notes: *The Effects Range-Low (ERL) is defined as the concentration of a substance in the sediment that results in an adverse biological effect in about 10% of the test organisms, and the Effects Range-Median (ERM) is defined as the concentration of a substance that affects 50% of the test organisms.

1. Background are located in Foggy Island Bay in the vicinity of the Proposed Liberty Island, north of Prudhoe Bay, and in the vicinity of Northstar Island at distances greater than 0.5 kilometers.
2. Background Northstar station location about 1 kilometer north of the pipeline.
3. Stations where water samples were collected during backfilling operations. The stations were located 200 and 300 meters from the trench.

Table VI.C-3c Trace Metal Concentrations in Beaufort Sea Sediments and Waters – ANIMIDA (Aluminum, Antimony, Arsenic, Berylium, Cobalt, Iron, Manganese, Silver, Titanium)

ANIMIDA Stations		Aluminum (Al)	Antimony (Sb)	Arsenic (As)	Berylium (Be)	Cobalt (Co)	Iron (Fe)	Manganese (Mn)	Silver (Ag)	Titanium (Ti)
Sediments (μg/g)		%					%			
All	Mean	3.61	0.49	1.15	1.23	7.6	2.03	269	0.11	0.38
	Std. Dev	±1.71	±0.24	±0.52	±0.60	±4.6	±0.93	±133	±0.07	±0.19
	Range	1.13 - 7.26	0.15 - 1.14	0.1 - 2.73	0.4 - 2.30	2.2 - 18.3	0.72 - 3.89	62.4 - 606	0.03 - 0.44	0.12 - 0.92
Liberty	Mean	3.76	0.52	1.11	1.13	6.9	1.98	245	0.10	0.41
	Std. Dev	±1.27	±0.18	±0.33	±0.38	±2.0	±0.67	±70	±0.03	±0.14
	Range	2.36 - 6.32	0.33 - 1.01	0.68 - 1.73	1.50 - 2.00	4.50 - 11.4	0.72 - 3.47	170 - 397	0.03 - 0.16	0.29 - 0.81
Northstar	Mean	3.68	0.44	1.19	1.25	7.1	2.07	272	0.12	0.37
	Std. Dev	±2.10	±0.23	±0.58	±0.61	±3.6	±1.14	±167	±0.07	±0.21
	Range	1.13 - 7.26	0.22 - 0.84	0.42 - 2.27	0.60 - 2.30	2.70 - 13.1	0.74 - 3.89	62.4 - 606	0.04 - 0.13	0.15 - 0.75
BSMP Stations	Mean	3.41	0.50	1.17	1.24	7.6	2.06	287	0.11	0.36
	Std. Dev	±1.74	±0.30	±0.62	±0.60	±4.6	±0.96	±144	±0.09	±0.22
	Range	1.33 - 6.43	0.15 -1.14	0.10 - 2.73	0.40 - 2.30	2.20 - 18.3	0.72- 3.47	89.8 - 545	0.06 - 0.44	0.12 - 0.92
Suspended Sediments - August 1999 (μg/g)										
All	Mean	7.48	-	-	-	-	2.03	-	-	-
	Std. Dev	±0.44	-	-	-	-	±0.03	-	-	-
	Range	6.44 - 8.28					3.54 - 4.37			
Liberty	Mean	7.85	-	-	-	-	3.92	-	-	-
	Std. Dev	±0.29	-	-	-	-	±0.21	-	-	-
	Range	7.45 - 7.76					3.87 - 3.9			
Northstar	Mean	7.42	-	-	-	-	3.98	-	-	-
	Std. Dev	±0.44	-	-	-	-	±0.23	-	-	-
	Range	6.44 - 8.28					3.54 - 4.37			
BSMP Stations	Mean	7.28	-	-	-	-	3.81	-	-	-
	Std. Dev	±0.38	-	-	-	-	±0.22	-	-	-
	Range	6.77 - 7.85					3.56 - 4.13			
Colville River	-	6.92	-	-	-	-	3.8	-	-	-
Sagavanirktok River	-	8.02	-	-	-	-	4.34	-	-	-

Table VI.C-3c Trace Metal Concentrations in Beaufort Sea Sediments and Waters – ANIMIDA (Aluminum, Antimony, Arsenic, Berylium, Cobalt, Iron, Manganese, Silver, Titanium) *(Continued)*

ANIMIDA Stations		Aluminum (Al)	Antimony (Sb)	Arsenic (As)	Berylium (Be)	Cobalt (Co)	Iron (Fe)	Manganese (Mn)	Silver (Ag)	Titanium (Ti)
Suspended Sediments - April 2001 Under Ice (μg/g)										
Background Stations[1]	Range	2.86 - 5.99	-	-	-	-	2.9 - 6.48	-	-	
Background Northstar Station[3]	Range	4.49 - 5.12	-	-	-	-	4.0 - 5.03	-	-	
Northstar Trench Stations[2]	Range	3.84 - 7.35	-	-	-	-	3.8 - 4.49	-	-	
Effects Range[21] (ppm)										
Effects Range — Low*	-	-	2.0	33.0	-	-	-	-	1.0	-
Effects Range — Median*	-	-	25.0	85.0	-	-	-	-	2.2	-
Water (ppb)										
Average Continental Crust (Wedepohl, 1995)										
		7.96	0.30		2.4	24	4.32		0.07	0.52

Source: Boehm et al. (2001)

Table VI.C-3d PAH and TPHC Concentrations in Beaufort Sea Sediments, River Sediments and Peat -- ANIMIDA

ANIMIDA Stations		PAH	Total PHC	
Sediments		**(µg/Kg)**	(mg/Kg)	
All	Mean			
	Std. Dev			
	Range			
Liberty	Mean	380	7.1	
	Std. Dev	±180	±4.8	
	Range	130 - 860	2.6 - 8.6	
Northstar	Mean	330	4.9	
	Std. Dev	±320	±4.7	
	Range	6.8 - 960	0.21 - 9.8	
BSMP Stations	Mean			
	Std. Dev			
	Range	21 - 2,700	0.40 -50	
River Sediments and Peat				
Colville River		2,200 & 2,600	31 & 36	
Kuparuk River		100	11	
Sagavanirktok River		320	5.8	
Colville Peat		1,900	32	
Kuparuk Peat		110	21	

Source: Boehm et al, 2001

Table VI.C-3e Trace Metal Concentrations in Foggy Island Bay Surface and Subsurface Sediments

	Chromium (Cr)	Mercury (Hg)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)	Barium (Ba)	Copper (Cu)	Nickel (Ni)
Sediments (mg/Kg)								
All Samples	5.84 -33.1	0.01 - 0.09	2.33 - 50.3	20.1 - 110.0	0.05 - 1.12	28.6 - 171.0	2.91 - 41.2	6.48 - 47.1
Surface Samples	8.51 -13.0	0.01 - 0.05	6.03 - 9.29	34.9 - 57.8	0.11 - 0.34	29.5 - 58.5	6.29 - 15.1	12.4 - 20.7
Core Samples Proposed Liberty Pipeline (Alternative I) Transect,	7.9 - 23.3	0.01 - 0.09	2.33 - 50.3	27.6 - 99.8	0.11 - 1.12	31.4 - 108.0	5.04 - 41.2	9.41 - 35.3
Core Samples Proposed Southern Island Pipeline (Alternative III.A) Transect,	5.84 - 33.1	0.01 - 0.08	3.22 - 17.6	20.1 - 110.0	0.05 - 0.59	26.6 - 171.0	2.91 - 30.9	6.48 -47.1
Core Samples Proposed Tern Pipeline (Alternative III.B) Transect,	12.6 - 23.7	0.03 - 0.07	7.51 - 13.5	42.4 - 107.0	0.20 - 0.67	36.7 - 81.1	9.96 - 26.6	16.8 - 36.2
Screening Level[1] (mg/Kg)								
	—	0.41	450	410	5.1	—	390	140
Effects Range[2] (ppm)								
Effects Range — Low*	80.0	0.15	35.0	120	5.0	—	70.0	30.0
Effects Range — Median*	145.0	1.3	110.0	270	9.0	—	390.0	50.0

	Antimony (Sb)	Arsenic (As)	Iron (Fe)	Manganese (Mn)	Silver (Ag)	Calcium (ca)
Sediments (mg/Kg)						
All Samples	0.04 - 0.35	2.4 - 15.2	6,620 - 36,000	52.7 - 738	0.02 - 0.297	2,160 - 86,600
Surface Samples	0.1 - 0.17	4.6 - 8.0	11,300 - 16,500	142 - 256	0.033 - 0.105	25,100 - 73,200
Core Samples Proposed Liberty Pipeline (Alternative I) Transect,	0.08 - 0.35	3.4 - 15.2	8,640 - 34,000	105 - 385	0.035 - 0.297	13,800 - 85,500
Core Samples Proposed Southern Island Pipeline (Alternative III.A) Transect,	0.04 - 0.23	2.4 - 12.1	6,620 - 36,000	52.7 - 520	0.02 - 0.17	2,160 - 86,600
Core Samples Proposed Tern Pipeline (Alternative III.B) Transect,	0.06 - 0.15	4.3 - 11.3	13,100 - 26,900	117 - 738	0.06 - 0.21	18,800 - 80,900
Screening Level[1] (mg/Kg)						
	150	57	—	—	6.1	—
Effects Range[2] (ppm)						
Effects Range — Low*	2.0	33.0	—	—	1.0	—
Effects Range — Median*	25.0	85.0	—	—	2.0	—

Source: URS Corporation, 2001. **Footnotes:** **1.** Screening levels identify chemical concentrations at or below which there is no reason to believe that dredged material would result in unacceptable adverse effects due to toxicity measured by sediment bioassays (Dredged Material Evaluation Framework, Lower Columbia River Management Area used (Lower Columbia River Management Area, 1998)). **2.** Long and Morgan, 1990

Table VI.C-3f Trace Metal Concentrations in Beaufort Sea Sediments - 1997

	Chromium (Cr)	Methyl Mercury (MeHg)	Total Mercury (THG)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)	Barium (Ba)	Copper (Cu)	Nickel (Ni)
Sediments (mg/Kg)	(μg/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)	(ng/g)
Range	39 - 92	0.001 - 0.267	6.1 - 30.9	9 - 41	58 - 147	0.056 - 0.881	280 - 927	10 - 42	18 - 52
Mean	63	0.057	17.2	15	96	0.264	569	27	34
Effects Range[1] (ppm)									
Effects Range — Low	80.0			35.0	120	5.0	—	70.0	30.0
Effects Range — Median	145.0			110.0	270	9.0	—	390.0	50.0

	Vanadium (V)	Arsenic (As)	Iron (Fe)	Manganese (Mn)
Sediments (mg/Kg)	(ng/g)	(ng/g)	%	(ng/g)
Range	72 - 179	9 - 45	1.98 - 6.05	294 - 1796
Mean	117	16	3.36	540
Effects Range[1] (ppm)				
Effects Range — Low		33.0	-	-
Effects Range — Median		85.0	-	-

Source: Naidu et al., 2001
1. Long and Morgan, 1990

Table VI.C-4 Ambient-Air-Quality Standards Relevant to the Liberty Project (measured in µg/m³; an asterisk [*] indicates that no standards have been established)

Pollutant[1]	Annual	24 hr	8 hr	3 hr	1 hr	30 min
	Averaging Time Criteria					
Total Suspended Particulates [2]	60 [3]	150	*	*	*	*
Class II [4]	19 [3]	37	*	*	*	*
Carbon Monoxide	*	*	10,000	*	40,000	*
Ozone [5]	*	*	*	*	235 [6]	*
Nitrogen Dioxide	100 [7]	*	*	*	*	*
Class II [4]	25 [7]	*	*	*	*	*
Inhalable Particulate Matter (PM10) [8]	50 [9]	150 [10]	*	*	*	*
Class II [4]	17	30	*	*	*	*
Lead	1.5[11]	*	*	*	*	*
Sulfur Dioxide	80 [7]	365	*	1,300	*	*
Class II [4]	20 [7]	91	*	512	*	*
Reduced Sulfur Compounds [2]	*	*	*	*	*	50

Source: State of Alaska, Dept. of Environmental Conservation (1982), 80, 18, AAC, 50.010, 18 AAC 50.020; 40 CFR 52.21 (43 FR 26388); 40 CFR 50.6 (52 FR 24663); 40 CFR 51.166 (53 FR 40671).

Footnotes: [1]All-year averaging times not to be exceeded more than once each year, except that annual means may not be exceeded. [2]State of Alaska air-quality standard (not national standard). [3]Annual geometric mean. [4]Class II standards refer to the PSD Program. The standards are the maximum increments in pollutants allowable above previously established baseline concentrations. [5]The State ozone standard compares with national standards for photochemical oxidants, which are measured as ozone. [6]The 1-hour standard for ozone is based on a statistical, rather than a deterministic, allowance for an "expected exceedance during a year." [7]Annual arithmetic mean. [8]PM10 is the particulate matter less than 10 micrometers in aerodynamic diameter. [9]Attained when the expected annual arithmetic mean concentration, as determined in accordance with 40 CFR 50 subpart K, is equal to or less than 50 µg/m³. [10]Attained when the expected number of days per calendar year with a 24-hour average concentration above 150 µg/m³, as determined in accordance with 40 CFR 50, subpart K, is equal to or less than 1. [11]Maximum arithmetic mean averaged over a calendar quarter.

Table VI.C-5 Measured Air-Pollutant Concentrations at Prudhoe Bay, Alaska 1986-1996 (measured in µg/m³; absence of data is indicated by asterisks [**])

Pollutant[1]	A[2]	B[3]	C[4]	D[5]	National Standards[6]	Class II Increments[7]
	Monitor Sites					
Ozone						
Annual Max. 1 hr	115.8	180.3	115.6	100.0	235	**
Nitrogen Dioxide						
Annual	26.3	11.9	16.0	4.9	100	25
Inhalable Particulate Matter (PM10)						
Annual	**	**	10.5	**	50	17
Annual Max. 24 hr	29.3	**	25.0 [8]	**	150	30
Sulfur Dioxide						
Annual	2.6	**	5.2	2.6	80	20
Annual Max. 24 hr	10.5	**	26.2[8]	13.1	365	91
Annual Max. 3 hr	13.1	**	44.5	55.0	1,300	512
Carbon Monoxide						
Annual Max. 8 hr	**	**	1,400	**	10,000	**
Annual Max. 1 hr	**	**	2,500 [8]	**	40,000	**

Sources: ERT Company (1987), Environmental Science and Engineering, Inc. (1987), and ENSR, 1996, as cited in U.S. Army Corps of Engineers (1999).

Footnotes: [1]Lead was not monitored. [2]Site CCP (Central Compressor Plant), Prudhoe Bay monitoring program, selected for maximum pollutant concentrations. All data are for years 1992-1996. [3]Site Pad A (Drill Pad A), Prudhoe Bay monitoring program, site of previous monitoring, selected to be more representative of the general area or neighborhood. All data are for years 1992-1996. [4]Site CPF-1 (Central Processing Facility), Kuparuk monitoring program, selected for maximum pollutant concentrations. Ozone, nitrogen dioxide, and sulfur dioxide are for years 1990-1992; PM_{10} and carbon monoxide data are for 1986-1987. [5]Site DS-1F, Kuparuk monitoring program site selected to be representative of the general area or neighborhood. All data are for years 1990-1992. [6]Applicable National Ambient Air Quality Standards. Please refer to Table VI.C-4 for more specific definitions of air-quality standards. [7]Class II PSD Standard Increments. [8]Second highest observed value (in accordance with approved procedures for determining ambient-air quality).

Table VI.C-6 Climatic Conditions Onshore Adjacent to the Liberty Project

	Arctic Coast
Distance to the ocean (km)	<20
Elevation (m)	<50
Air Temperature (°C)	
Mean diurnal amplitude	4 to 8
Range (extreme low-high)	–50 to + 26
Mean annual	–12.4 ± 0.4
Annual amplitude	17.5 ± 1.2
Degree-Day (°C-day)	
Freeze	4930 ± 150
Thaw	420 ± 120
Precipitation (mm)[1]	
Snow	113
Rain	85
Annual total	198
Seasonal Snow Cover	
Average starting date	27 Sep.
Range	4 Sep. to 14 Oct.
Average duration (days)	259
Range (extreme)	212 to 288
Average maximum thickness (cm)	32
Range (extreme)	10 to 83
Thaw Season	
Average starting time	6 Jun.
Range (extreme)	26 May to 19 Jun.
Average length (days)	106
Range (extreme)	77 to 153

Source: Zhang, Osterkamp, and Stamnes (1996).
[1] From Natural Resources Conservation Service (1994).

Table VI.C-7 Wind Speed and Air Temperature at Tern Island from February to May 1987

Month	Average Wind Speed		Median Wind Speed		Average Air Temperature		Median Air Temperature	
	kts	m/s	kts	m/s	°F	°C	°F	°C
February	9.0	4.6	7.5	3.9	-21.6	-29.8	-21.5	-29.7
March	9.4	4.8	6.0	3.1	-17.6	-27.6	-14.0	-25.6
April	9.1	4.7	9.0	4.6	-4.5	-20.3	-6.0	-21.1
May	12.4	6.4	12.0	6.2	17.0	-8.3	13.0	-10.6

Source: USDOI, MMS (1998). Calculated from meteorological data collected at Tern Island in 1987.

Table VI.C-8a Current Speeds in Foggy Island Bay

	Current (cm/s)			
Month	**Maximum**	**Mean**	**Location**	**Source**
November	9.6	1.4		Matthews (1981)
December	9.3	1.3		Matthews (1981)
January		0.7		Matthews (1981)
February		<2		Montgomery Watson (1997, 1998)
	Range	*Range*		
July–September	20–68	4–16	70 17.60 N 147 43.00 W	Hachmeister et al. (1987); Short et al. (1990, 1991); Morehead et al. (1992a;b); and Morehead, Dewey, and Horgan (1993).

Table VI.C-8b Annual Current Speeds in Stefanson Sound

Mooring		**Current (cm/s)**			
Identifier	**Time**	**Maximum**	**Mean**	**Location**	**Source**
Argo	9/19/99-9/1/00	99	3.2	70^{0} 27.177 148^{0} 12.722	Weingartner and Okkonen (2001)
Dinkum	9/19/99-9/1/00	114	1.8	70^{0} 23.352 147^{0} 53.656	Weingartner and Okkonen (2001)
McClure	9/19/99-9/1/00	82	1.6	70^{0} 20.204 147^{0} 32.701	Weingartner and Okkonen (2001)

Table VI.C-9 River Discharge

River	**Approximate Length (miles)**	**Discharge (cf/s)**	**Drainage (sq miles)**	**Drains From**
Shaviovik	100	800	1,700	Arctic Foothills
Kadleroshilik	75	325	650	Arctic Coastal Plain
Sagavanirktok	260	2,770	4231	Arctic Foothils
Sagavanirktok (East Channel)		83		Arctic Foothills

Table IX-1 Discharge Conditions for a Well Blowout to Open Water

	Volume of Oil (Barrels)				
Discharge Category	**Day 1**	**Day 2**	**Day 3**	**Day 15**	**15 Day Totals**
Well's Discharge Volume	15,000	15,000	15,000	15,000	225,000
Evaporation (20%)	-3,000	-3,000	-3,000	-3,000	-45,000
Fall out to Gravel Island	6000	6,000	6,000	6,000	90,000
Oil Remaining on Gravel Island	-3,400	0 [1]	0 [1]	0 [1]	-3,400
Oil Draining to the Sea from Gravel Island	0	6000	6,000	6,000	86,600
Oil Falling to the Sea	6,000	6,000	6,000	6,000	90,000
Total Oil to the Sea	8,600	12,000	12,000	12,000	176,600

Source: S.L. Ross Environmental Research Ltd., D.F. Dickins and Associates, and Vaudrey and Associates (1998) and BPXA (2000b).
Notes: Assumes Alaska North Slope crude; constant wind speed of 20 knots; winds change from WSW to ENE; current speed of 0.6 knots; wave height of 1-5 feet; and air temperature of 45 °F.
[1] After hour 14, the gravel island is saturated with oil. All oil falling on the gravel island drains to the sea.

Table IX-2 Discharge Conditions for a Well Blowout to Broken Ice

	Volume of Oil (Barrels)				
Discharge Category	**Day 1**	**Day 2**	**Day 3**	**Day 15**	**15 Day Totals**
Well's Discharge Volume	15,000	15,000	15,000	15,000	225,000
Evaporation (20%)	-3,000	-3,000	-3,000	-3,000	-45,000
Fall out to Gravel Island	6000	6,000	6,000	6,000	90,000
Oil Remaining on Gravel Island	-3,400	0 [1]	0 [1]	0 [1]	-3,4000
Oil Draining to the Sea from Gravel Island	4800	6,000	6,000	6,000	86,600
Oil Falling to the Open Water	3,000	3,000	3,000	3,000	45,000
Oil Falling to Ice Floes	3,000	3,000	3,000	3,000	45,000
Total Oil to the Environment	8,600	12,000	12,000	12,000	176,600
Oil Thickness on Floe	0.0004 to 0.9 mm				

Source: S.L. Ross Environmental Research Ltd., D.F. Dickins and Associates, and Vaudrey and Associates (1998) and BPXA (2000b).
Notes: Assumes Alaska North Slope crude; wind speed averages 19 knots; air temperature 8–18 °F; 5/10ths icefloes; ice is 0.6-0.8 feet thick and covered by 2-4 inches of snow; floes are hundreds of thousands of feet in size; 50% of the oil spray lands on the ice, 50% lands on the water.
[1] After 14 hours, the gravel island is saturated with oil. All oil falling on the gravel island drains to the sea.

Table IX-3a General Mass Balance of Oil from a 180,000-Barrel Winter Meltout Spill

Day[1]	Oil Remaining (bbl)	Evaporated (bbl)	Dispersed (bbl)	Sedimented (bbl)	Onshore (bbl)
0	156,000	22,000 [2]	—	—	—
3	111,000	24,000	13,000	1,100	29,000
10	96,000	27,000	19,000	1,600	34,000
30	87,000	28,000	25,000	2,100	36,000
60	63,000	32,000	40,000	3,400	39,000

Source: USDOI, MMS, Alaska OCS Region (1998); based on ocean-ice weathering model of Kirstein and Redding (1987).
Notes: Based on a 177,900-barrel spill size with values rounded to the nearest 1,000 and 100. Assumes oil pools on ice to 2 millimeters at 32 °F for 0-10 days, depending on when it was spilled, and melts out into 50% broken ice at 32 °F, with 11-knot winds.
Footnotes: [1]Days after meltout of winter spilled oil (97% of total spillage) or summer spillage (3% of total spillage). [2]Evaporation on day 0 attributable to evaporation during oil pooling on the ice surface prior to oil release to the water (= meltout).

Table IX-3b Areas of Discontinuous and Thick Slicks from a 180,000-Barrel Winter Meltout Spill

	Discontinuous Slick Area (km^2)[1]	Area of Thick Slick (km^2)[2]
Initial Spill Area	—	125
Area During Oil Pooling on Ice Surface	—	12
Days after Spill Reaches Water Surface[1]		—
3	160	5
10	770	8
30	3,200	16
60	7,900	22

Source: USDOI, MMS, Alaska OCS Region (1998).
Footnotes: [1]Calculated from Ford (1985) and Kirstein and Redding (1987). [2] Based on ocean-ice weathering model of Kirstein and Redding (1987).

Table IX-4 Length of Coastline a 180,000-Barrel Spill May Contact Without any Oil-Spill Response

	Amount of coastline contacted in miles and kilometers[1]	
Days	**Winter Ice Conditions**	**Summer Open Water**
3	48 (77.23)	65 (104.5)
10	48 (77.23)	130 (209.17)
30	48 (77.23)	200 (321.8)
60	48 (77.23)	220 (353.98)
90	48 (77.23)	—
180	55 (88.50)	—

Source: USDOI, MMS, Alaska OCS Region (1998).
[1]Calculated from oil-spill-risk analysis conditional probabilities. We add the length of land segments with chance of contact >0.5% to estimate the amount of coastline contacted. This calculation assumes no oil spill response and includes land segments that have a very small chances of contact.

Table IX-5a General Mass Balance of Oil from a Spill of 180,000 Barrels in Open Water

Day[1]	Oil Remaining in Slick (bbl)	Evaporated (bbl)	Dispersed (bbl)	Sedimented (bbl)	Onshore (bbl)
0	180,000	0	—	—	—
3	122,000	20,000	11,000	1,000	22,000
10	93,000	26,000	29,000	2,600	26,000
30	60,000	31,000	49,000	4,100	36,000
60	39,000	34,000	58,000	5,100	39,000

Source: USDOI, MMS, Alaska OCS Region (1998);
based on ocean-ice weathering model of Kirstein and Redding (1987).
Notes: Based on a 177,900-barrel spill size with values rounded to the nearest 1,000 and 100.
Assumes Alaska North Slope crude, constant wind speed of 20 knots, and air temperature of 45 °F.
Footnotes: [1] We assume day 0 is 15 days after the start of the spill, when all the oil is in the water.

Table IX-5b Areas of Discontinuous and Thick Oil Slicks from a Spill of 180,000 Barrels in Open Water

Days After Spill Reaches Water Surface	Discontinuous Slick Area (km^2)[1]	Area of Thick Slick (km^2)[2]
3	290	7
10	1,370	12
30	5,700	19
60	14,000	24

Source: USDOI, MMS, Alaska OCS Region (1995).
[1] Calculated from Ford (1985) and Kirstein and Redding (1987).
[2] Based on ocean-ice weathering model of Kirstein and Redding (1987).

Table IX-6 Summary of the Conditional Probabilities (expressed as percent chance) That an Oil Spill Starting During Summer or Winter at the Liberty Gravel Island (L1) will Contact a Certain Environmental Resource Area Within 1, 3, 10, 30, or 360 Days

Environmental Resource Area	Summer Spill From Liberty Gravel Island Time in Days					Winter Spill from Liberty Gravel Island Time in Days				
	1	3	10	30	360	1	3	10	30	360
All Land Segments	27	54	74	87	94	1	4	8	13	98
Spring Lead 1	n	n	n	n	n	n	n	n	n	n
Spring Lead 2	n	n	n	n	n	n	n	n	n	n
Spring Lead 3	n	n	n	n	n	n	n	n	n	n
Spring Lead 4	n	n	n	n	n	n	n	n	n	n
Spring Lead 5	n	n	n	n	n	n	n	n	n	n
Ice/Sea Segment 6	n	n	n	n	1	n	n	n	n	1
Ice/Sea Segment 7	n	n	1	3	3	n	n	n	n	1
Ice/Sea Segment 8	n	n	1	1	2	n	n	n	1	1
Ice/Sea Segment 9	n	n	3	3	4	n	n	1	1	4
Ice/Sea Segment 10	n	1	3	4	5	n	n	1	2	5
Ice/Sea Segment 11	n	1	5	8	8	n	n	1	1	5
Ice/Sea Segment 12	n	n	1	3	3	n	n	n	n	1
Ice/Sea Segment 13	n	n	1	3	3	n	n	n	n	n
ERA 14	n	n	n	n	n	n	n	n	n	n
ERA 15	n	n	n	n	n	n	n	n	n	1
ERA 16	n	n	n	n	1	n	n	n	n	2
ERA 17	n	n	1	1	1	n	n	n	n	4
ERA 18	n	n	n	1	2	n	n	n	n	4
ERA 19	n	n	n	2	2	n	n	n	n	2
ERA 20	n	n	2	4	4	n	n	n	n	4
ERA 21	n	n	2	6	7	n	n	n	n	7
Simpson Lagoon	n	2	5	8	10	n	n	n	n	14
Gwyder Bay	n	2	5	6	6	n	n	n	n	2
ERA 24	n	1	4	7	8	n	n	n	1	8
Prudhoe Bay	1	4	6	6	7	n	n	1	1	5
ERA 26	3	10	12	13	14	n	n	1	1	8
ERA 27	9	15	17	18	18	n	1	1	2	12
ERA 28	2	7	11	11	12	n	1	1	3	20
ERA 29	n	3	7	10	11	n	n	1	1	11
ERA 30	n	6	11	13	14	n	1	1	2	11
ERA 31	n	4	7	9	9	n	n	1	1	11
Boulder Patch 1	10	18	21	21	21	1	1	3	4	25
Boulder Patch 2	52	59	60	60	61	5	6	7	11	59
ERA 34	10	15	16	17	17	1	1	1	2	9
ERA 35	29	33	34	34	34	4	5	6	10	46
ERA 36	12	14	16	17	17	1	2	2	3	16
ERA 37	6	12	13	14	15	1	2	3	4	23
ERA 38	4	10	12	12	13	n	1	2	3	15
ERA 39	1	6	13	15	16	n	1	2	3	15
ERA 40	n	4	10	13	14	n	n	1	2	16
ERA 41	n	1	6	9	9	n	n	1	1	7
Canning River	n	n	2	3	3	n	n	n	n	4
ERA43	n	n	3	7	7	n	n	n	1	4
Simpson Cove	n	n	1	2	2	n	n	n	n	2
ERA45	n	n	3	5	5	n	n	n	n	2
Arey Lagoon, Hula Hula River	n	n	1	1	2	n	n	n	n	1
Whaling Area/Kaktovik	n	n	1	3	3	n	n	n	n	1
Thetis Island	n	n	1	2	2	n	n	n	n	5
Spy Island	n	n	1	2	3	n	n	n	n	5
Leavitt and Pingok Islands	n	n	3	4	4	n	n	n	n	8
Bertoncini, Bodfish, and Cottle	n	2	6	8	10	n	n	n	1	15
Long Island	n	3	8	9	9	n	n	n	1	8
Egg and Stump Islands	n	6	9	10	10	n	n	1	2	12
West Dock	1	7	9	10	10	n	n	1	2	11
Reindeer and Argo Islands	n	4	7	8	8	n	n	1	1	10
Cross and No Name Islands	n	2	6	7	8	n	n	1	1	11
Endicott Causeway	14	19	21	22	22	1	1	2	3	15
Narwhal, Jeanette and Karluk	6	11	13	15	15	1	2	3	4	21
Tigvariak Island	10	14	16	17	17	1	2	2	3	13
Pole and Belvedere Islands	1	6	8	10	10	n	1	2	3	16
Challenge, Alaska, Dutchess a	1	2	5	6	7	n	n	1	2	13
Flaxman Island	n	1	3	4	5	n	n	n	1	7

Land Segment	Summer Spill From Liberty Gravel Island Time in Days					Winter Spill from Liberty Gravel Island Time in Days				
	1	3	10	30	360	1	3	10	30	360
16	n	n	n	n	1	n	n	n	n	3
17	n	n	n	n	n	n	n	n	n	2
18	n	n	n	n	n	n	n	n	n	1
19	n	n	n	1	2	n	n	n	n	1
20	n	n	n	1	1	n	n	n	n	1
21	n	1	2	3	4	n	n	n	n	7
22	n	1	4	5	6	n	n	n	n	4
23	n	4	6	7	7	n	n	1	2	11
24	n	1	2	3	3	n	n	n	n	1
25	4	9	12	12	13	1	1	1	2	7
26	17	22	25	26	26	1	2	3	5	27
27	5	9	10	11	11	n	1	1	2	13
28	1	4	6	7	7	n	n	1	1	7
29	n	1	3	3	4	n	n	n	n	5
30	n	1	1	2	2	n	n	n	n	3
31	n	n	n	1	1	n	n	n	n	1
32	n	n	1	2	2	n	n	n	n	2
33	n	n	1	2	2	n	n	n	n	1
34	n	n	n	1	2	n	n	n	n	n

Source: Johnson, Marshall and Lear (2000). n = less than 0.5%.
Note: For Environmental Resource Areas See Maps A-2 and A-3, Land Segments See Map A-1 and Liberty Gravel Island See Map A-6

Table IX-7 Hypothetical 200,000-Barrel Tanker-Spill-Size Examples

	200,000-barrel spill[1]					
Time After Spill in Days	**1**	**3**	**10**	**30**	**45**	**60**
Oil Remaining (%)	79	70	53	37	33	31
Oil Dispersed (%)	2	7	19	32	35	37
Oil Evaporated (%)	16	21	26	29	30	30
Thickness (mm)	5.1	2.9	1.4	0.7	0.5	0.4
Area of Thick Slick (km^2)[2]	4.7	7.3	12	17	19	21
Discontinuous Area (km^2)[3]	88.0	365.2	1,737.5	7,210.9	12,192.6	17,698.7

Source: USDOI, MMS, Alaska OCS Region (1995). **Notes:** Calculated with the SAI oil-weathering model of Kirstein, Payne, and Redding (1983). **Footnotes:** [1]Summer 11.7-knot-windspeed, 9.9-°C, 1.0-meter-wave height. Average Weather Marine Area C (Brower et al., 1988). [2]This is the area of oiled surface. [3]Calculated from Equation 6 of Table 2 in Ford (1985): The discontinuous area of a continuing spill or the area swept by an instantaneous spill of a given volume.

Table IX-8 Mass Balance of Oil Through Time of a Hypothetical 200,000-Barrel Oil Spill Along Tanker Segment T6

Days	**1**	**3**	**10**	**30**	**45**	**60**
Oil Evaporated[1]	30,000 [2]	40,000	48,000	56,000	58,000	58,000
Oil Disbursed[1,3]	4,000	9,000	31,000	55,000	57,000	60,000
Oil Sedimented[1,3]	0	5,000	9,000	11,000	13,000	16,000
Oil Onshore[1,3]	0	17,000	30,000	40,000	45,000	55,000
Oil Remaining[1,3]	162,000	125,000	78,000	36,000	23,000	7,000

Source: MMS, Alaska OCS Region (1995). **Footnotes:** [1]Calculated with the SAI oil-weathering model of Kirstein, Payne, and Redding (1983). The examples are for a Cook Inlet crude type in Summer 9.9-°C sea-surface temperature and 11.7-knot winds. [2]Barrels. [3]Modified to fit fate calculations of Gundlach et al. (1983) and Wolfe et al. (1993).

Table IX-9 200,000-Barrel Spill Dispersed-Oil Characteristics

Time after Spill in Days[1]	**Oil Dispersed[1] (%)**	**Discontinuous Area[1] (km^2)**	**Assumed Dispersion Depth (m)**	**Dispersed-Oil Concentration (µg/l)**
1	2	88.0	1	6,477
3	7	365.2	2	2,731
10	19	1,737.5	7.5	416
30	32	7,210.9	15	84
45	35	12,192.6	17.5	47
60	37	17,698.7	20	30

Source: USDOI, MMS, Alaska OCS Region (1995). [1]Table IX-7.

FIGURES

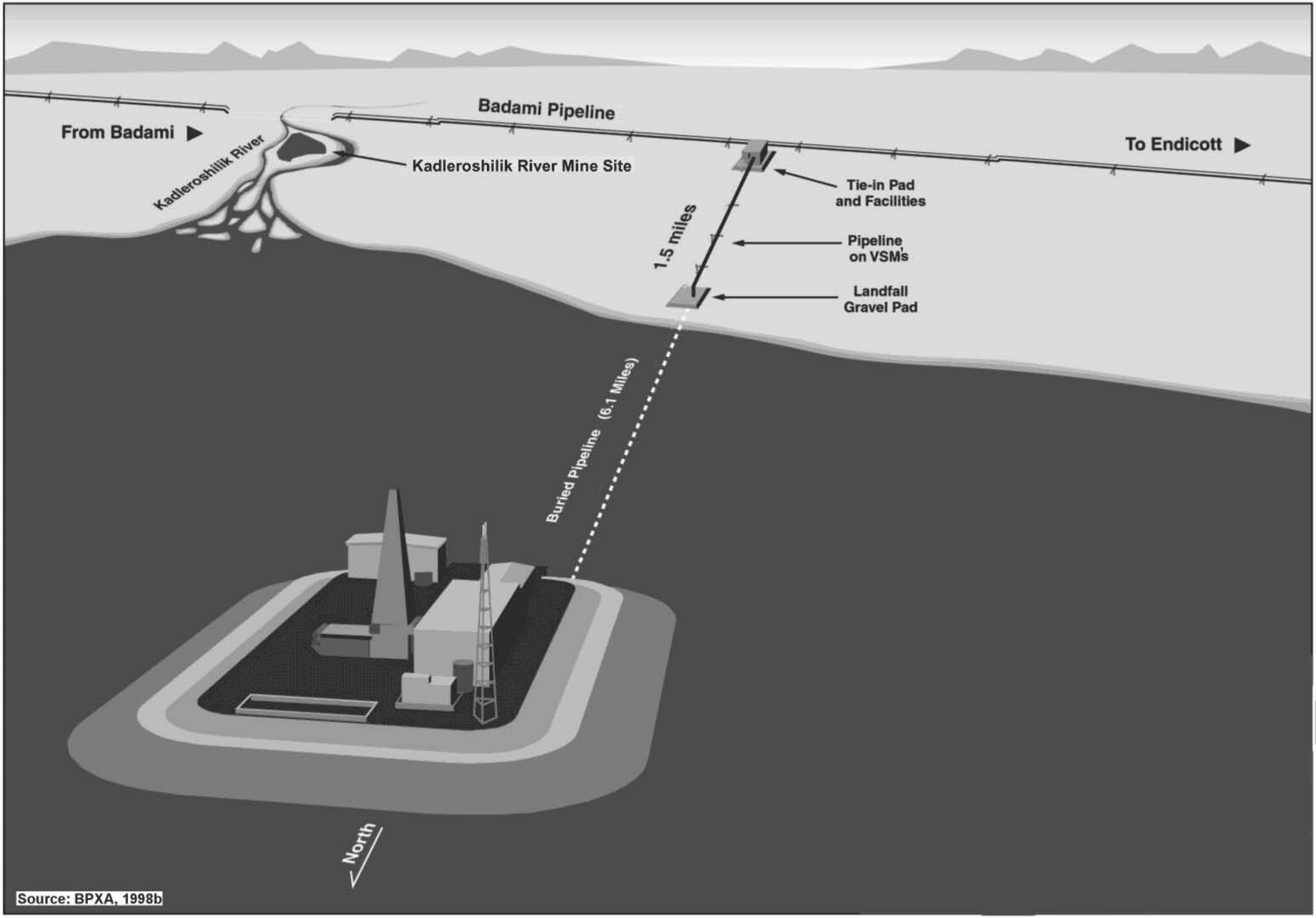
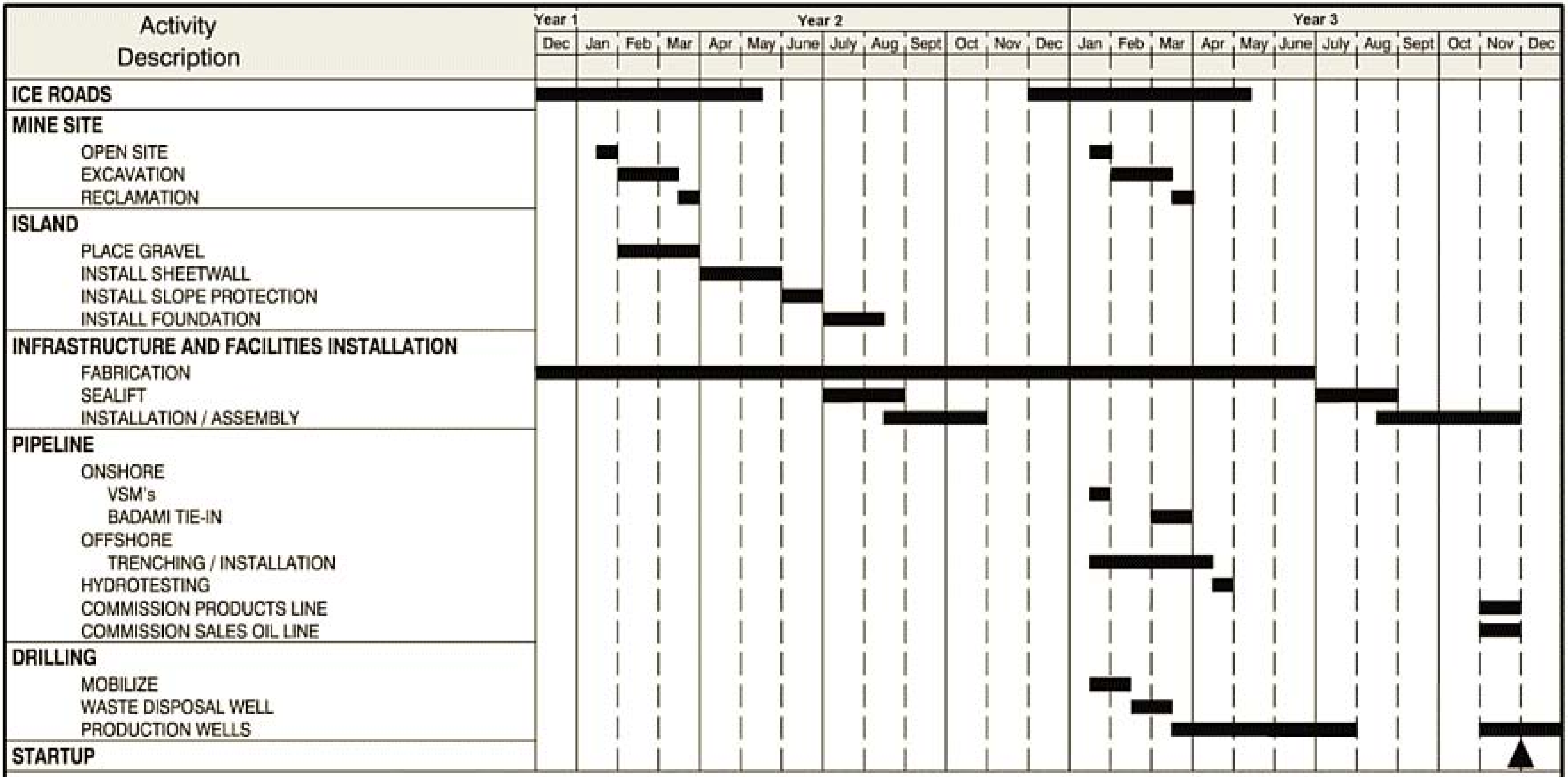
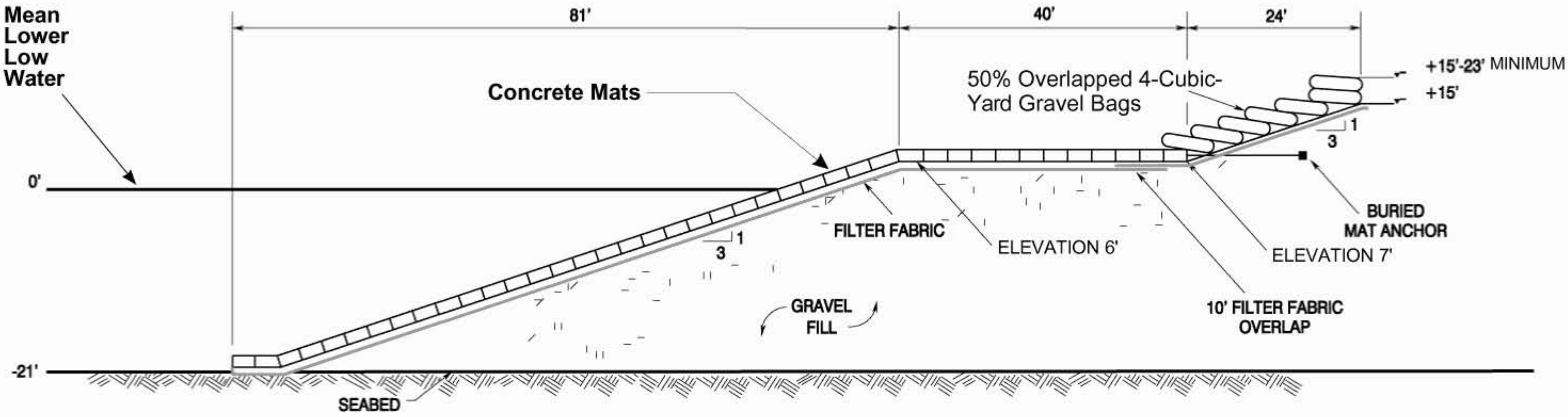


Figure II.A-1 Liberty Development Project: Conceptual 3-D Rendering of the Proposed Liberty Island and Pipeline



Source: BPXA, 2000

Figure II.A-2 Liberty Construction Schedule- Year 1 to Year 3



Source: BPAX, 1998a

ALL DIMENSIONS ARE APPROXIMATE

Figure II.A-3 Liberty Development Project: Island Slope Protection, Cross-Section and Details

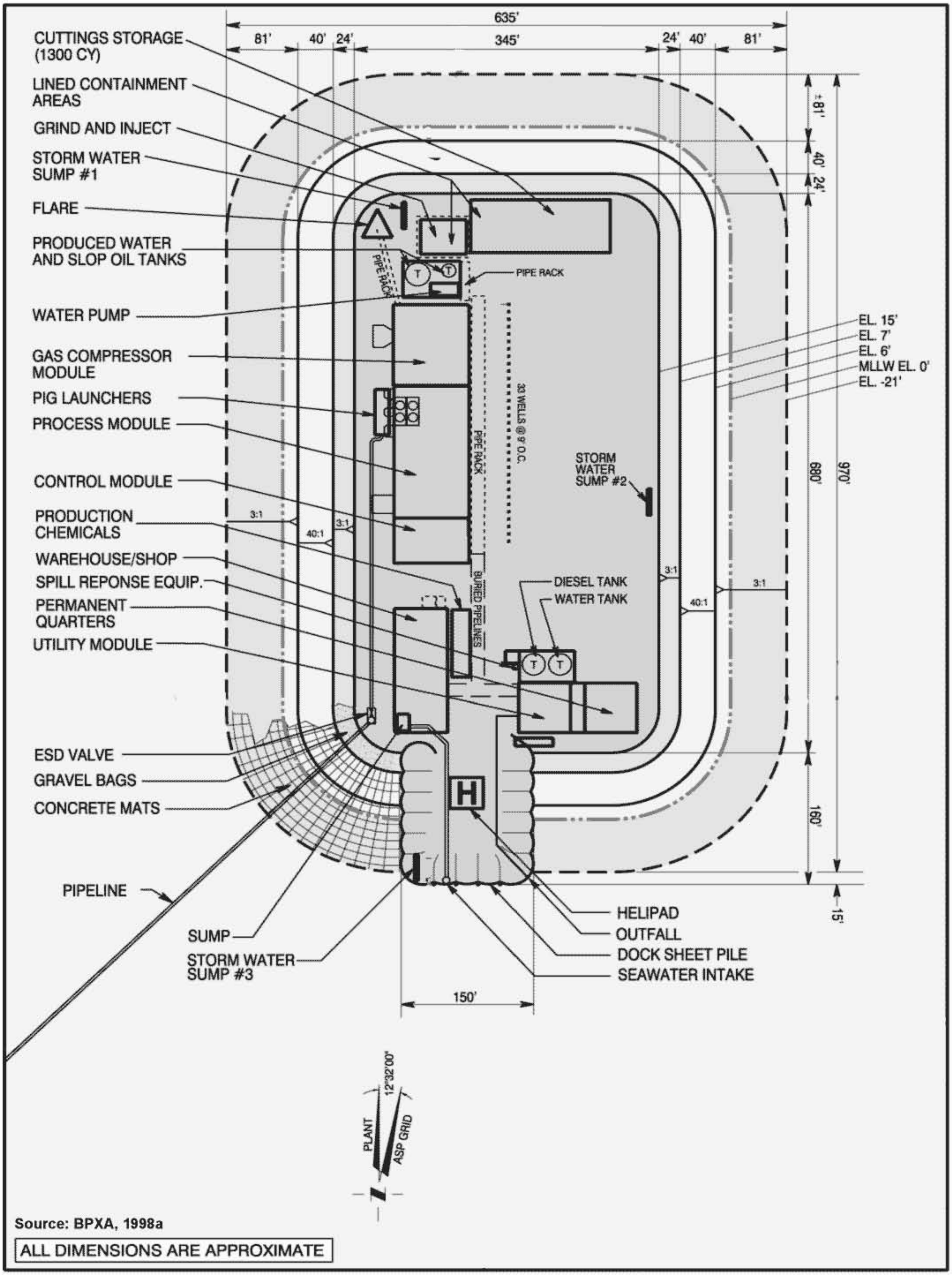
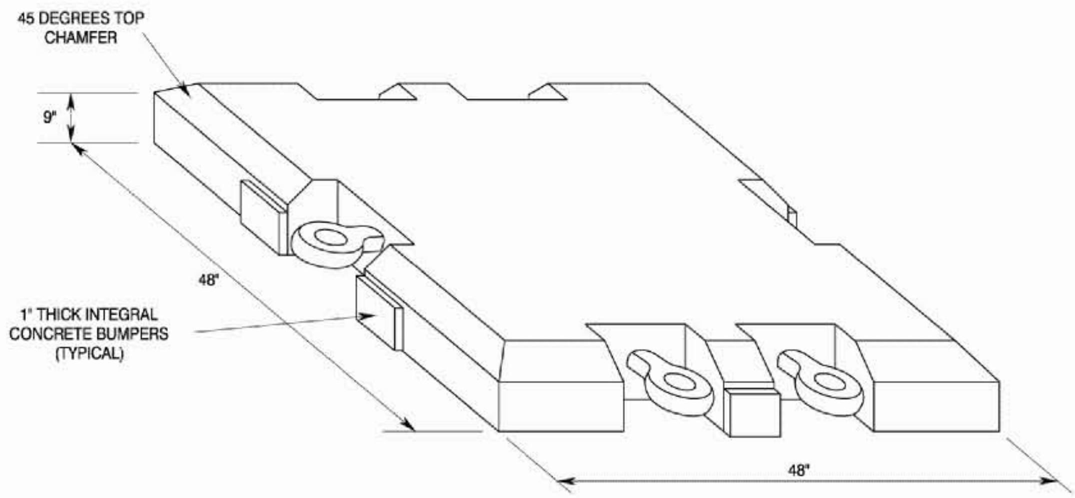
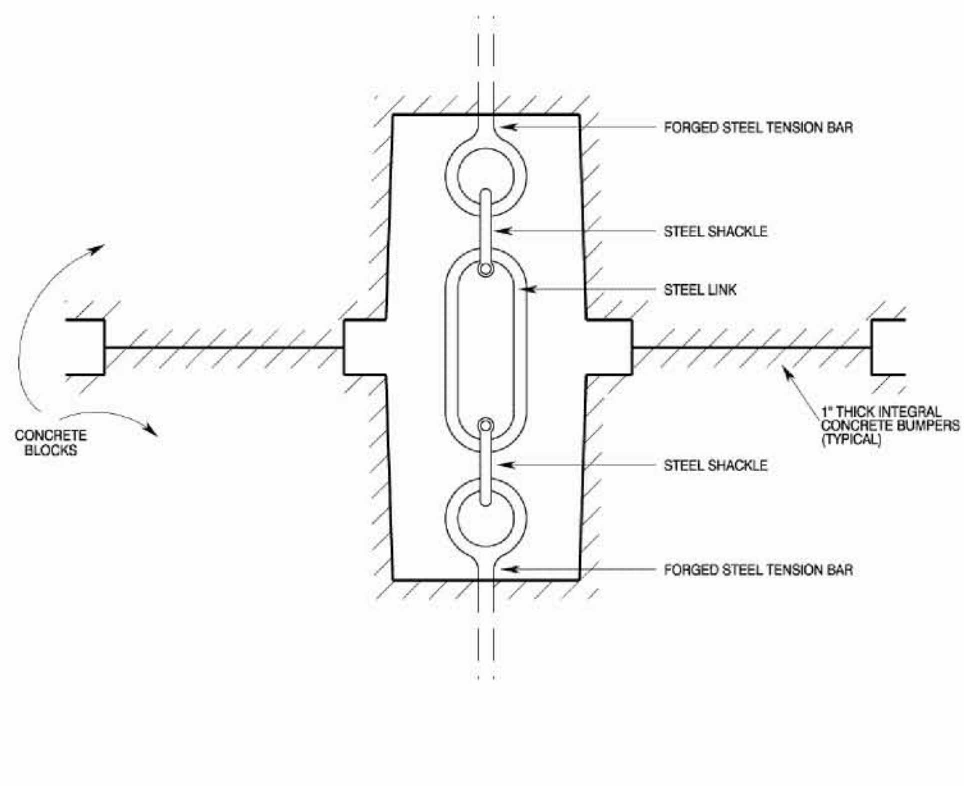


Figure II.A-4 Liberty Development Project: Island Layout



Source: BPXA, 1998a

Figure II.A-5 Liberty Development Project: Island Slope Protection, Concrete Block



Source: BPXA, 1998a

Figure II.A-6 Liberty Development Project: Island Slope Protection, Concrete Mat Linkage Detail

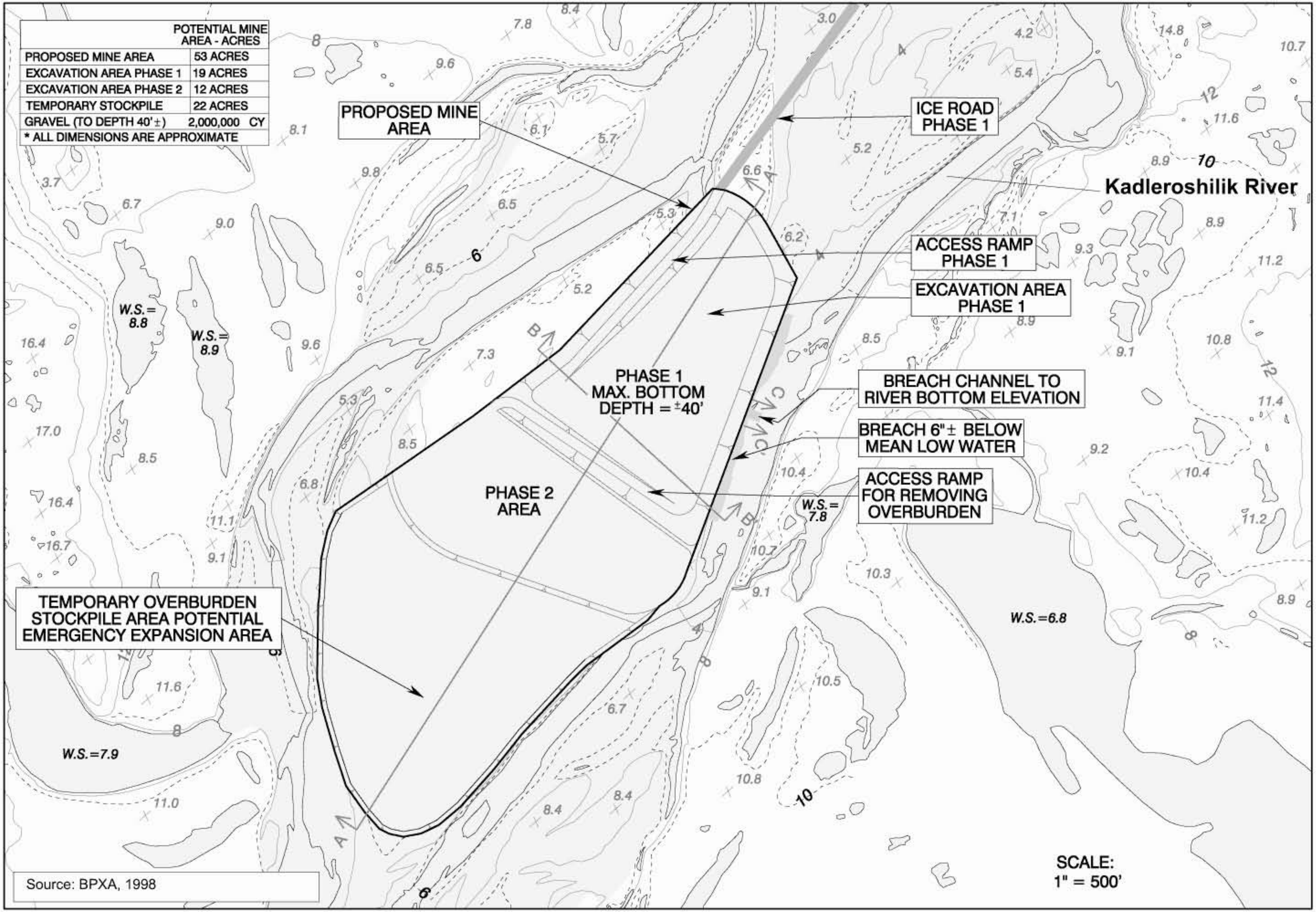
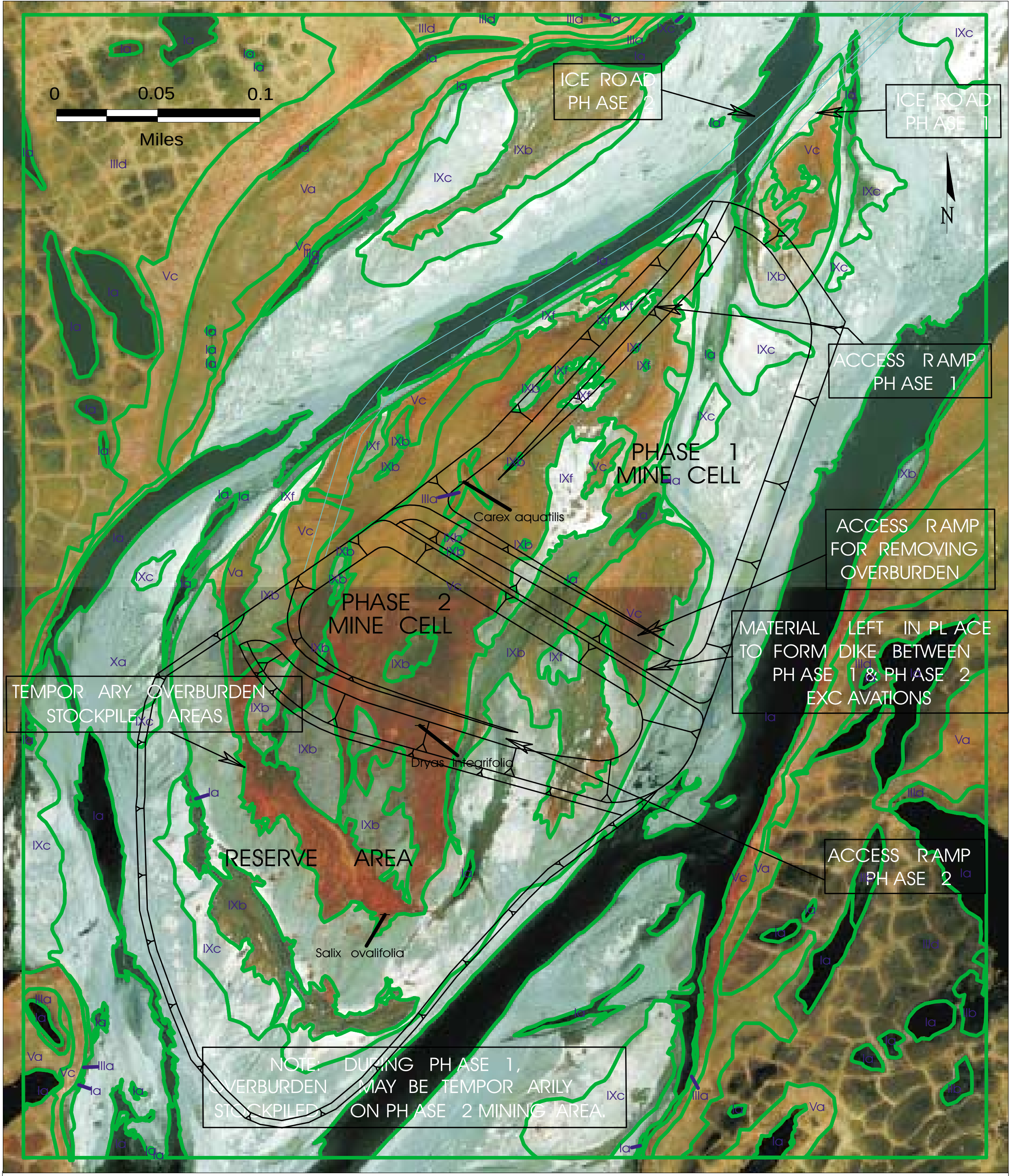


Figure II.A-7a Proposed Kadleroshilik River Mine Site - Phase I - Plan View



Area (acres)	Class	Land Cover Description
23.97	Ia	Water
0.65	IIb	Aquatic Graminoid Tundra
0.82	IIIa	Wet Sedge Tundra
26.08	IIId	Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex
14.17	Va	Moist Sedge, Dwarf Shrub Tundra
27.97	Vc	Dry Dwarf Shrub, Crustose Lichen Tundra
13.16	IXb	Dry Barren/Dwarf Shrub, Forb Grass Complex
20.45	IXc	Dry Barren/Forb Complex
2.92	IXf	Dry Barren/Dwarf Shrub, Grass Complex
49.35	Xa	River Gravels

Ground Data Site
Vegetation Community
Vegetation Polygon
IXc — Vegetation Polygon Label

Map Projection: US State Plane, AK Zone 3
Datum: NAD 27
View Scale: 1:3,000
Map Scale: 1:6,000
Photo Date: 2 July 1994
Photo Scale: 1:6,000
Photo Resolution: 0.5 ft/pixel (by AeroMap U.S.)
Prepared by: LGL Alaska Research Associates, Inc.

Figure II.A-07b Proposed Liberty Mine Footprint and Vegetation Types, Kadleroshilik River, Alaska’s North Slope

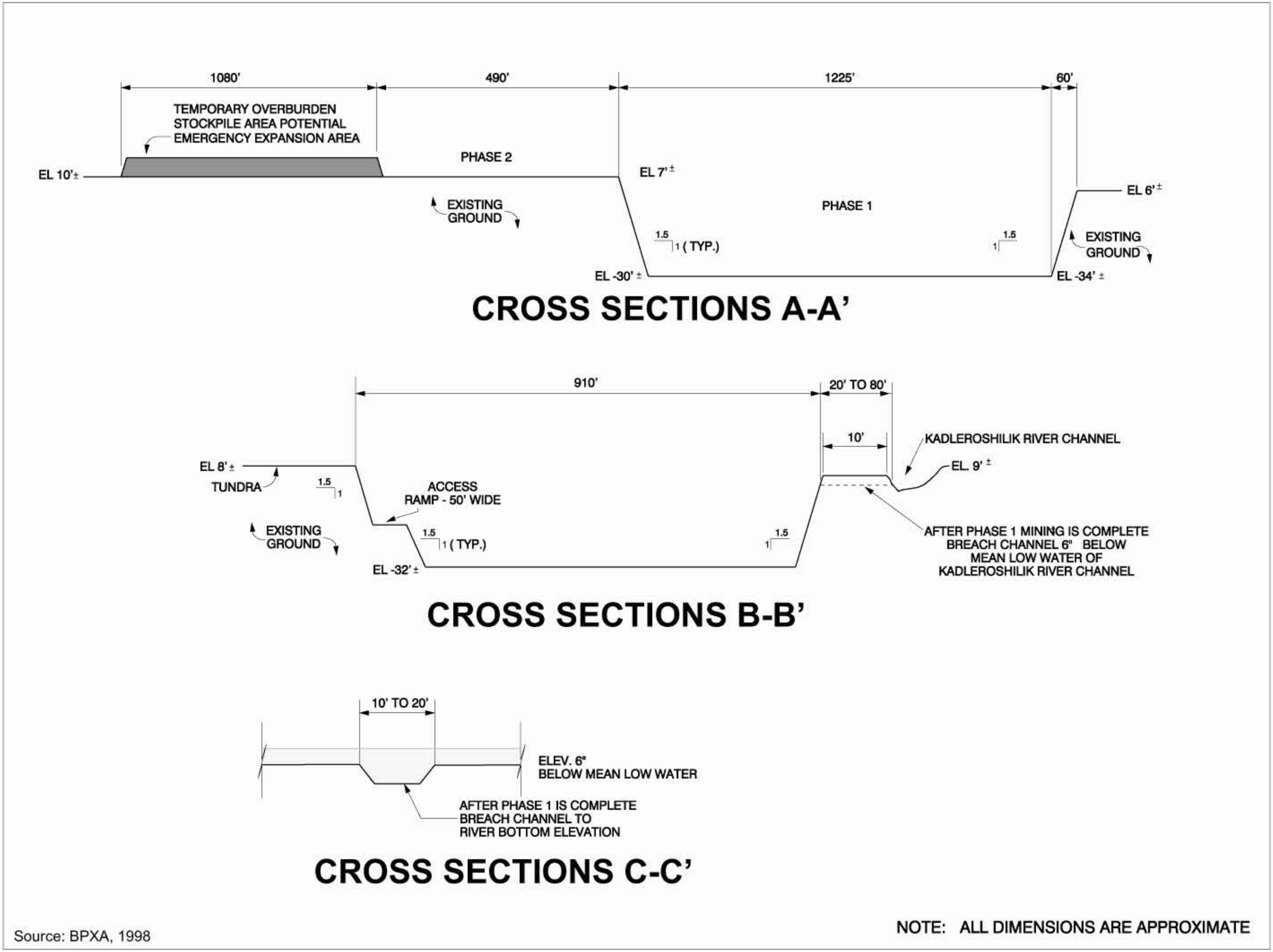


Figure II.A-8 Proposed Kadleroshilik River Mine Site - Phase I - Cross Sections

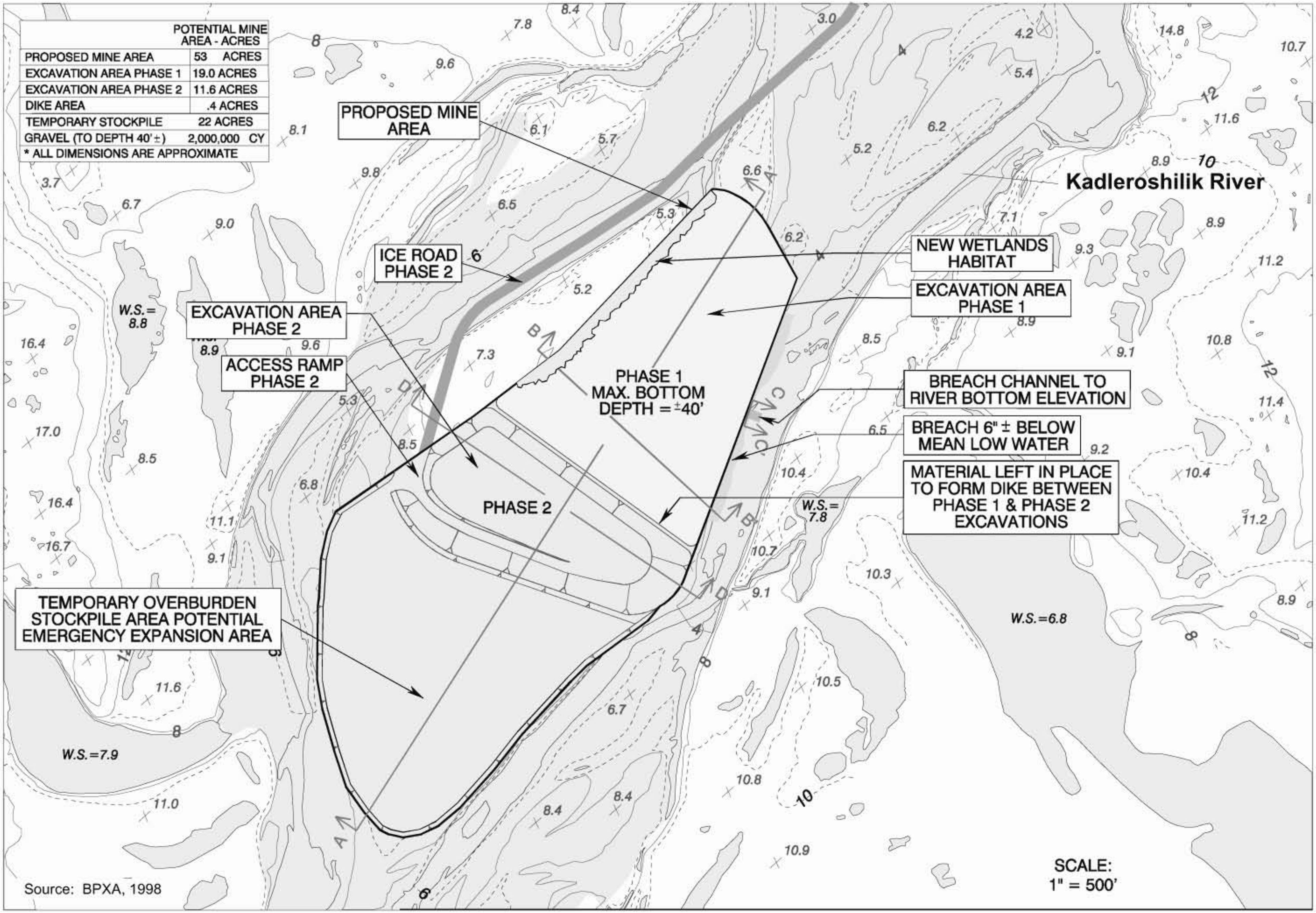


Figure II.A-9 Proposed Kadleroshilik River Mine Site - Phase II - Plan View

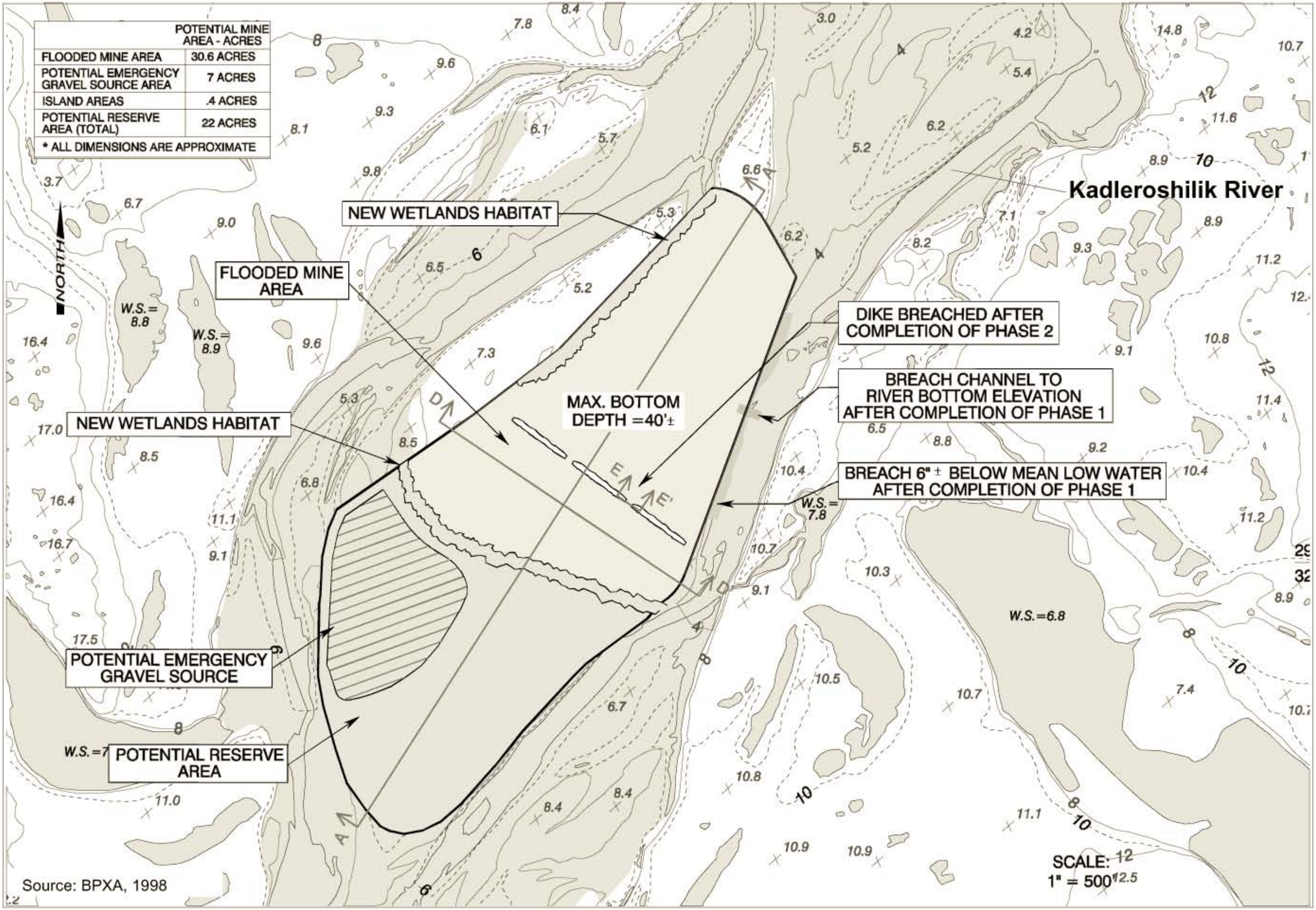


Figure II.A-10 Proposed Kadleroshilik River Mine Site - Rehabilitation Plan - Plan View

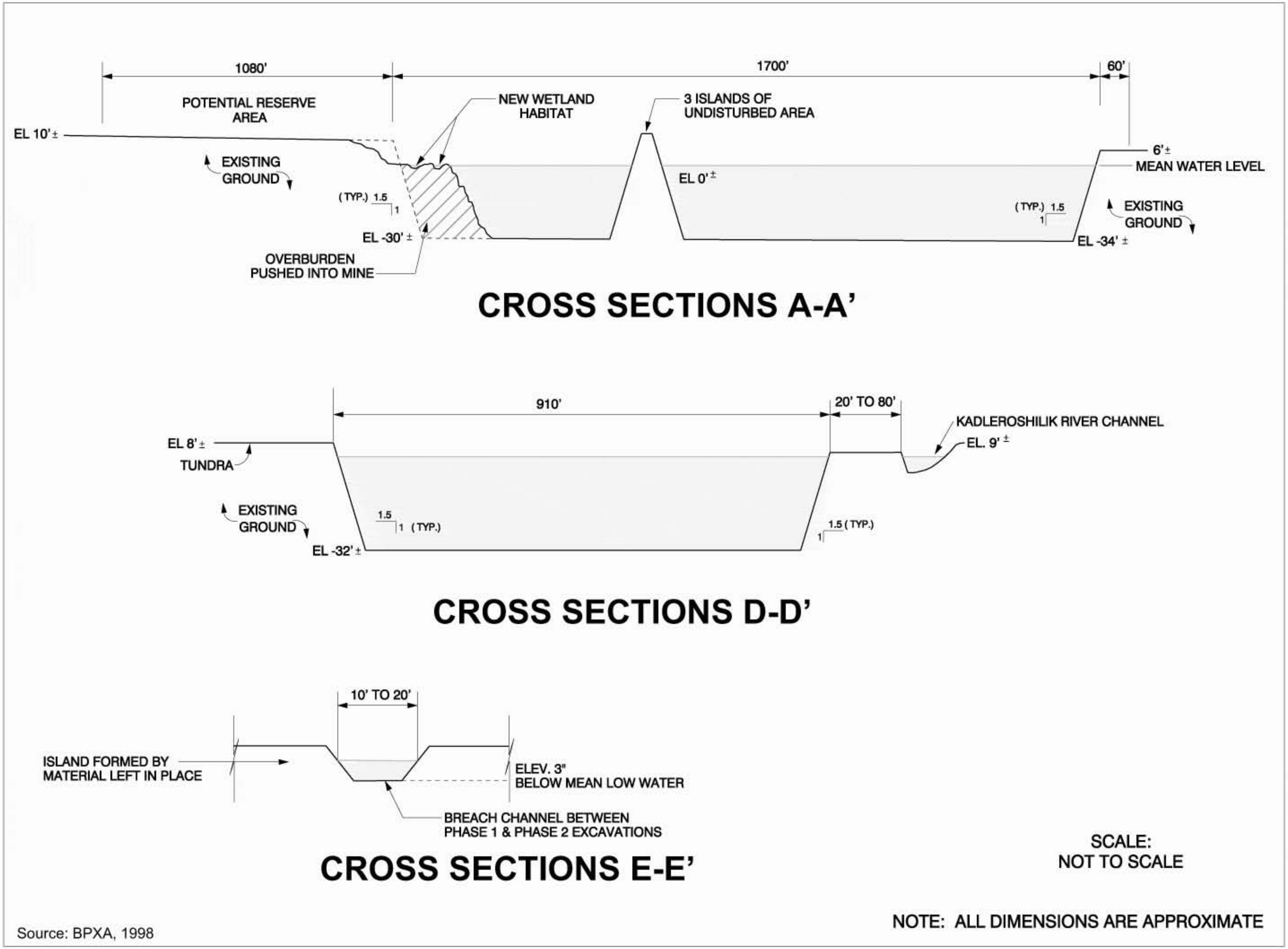
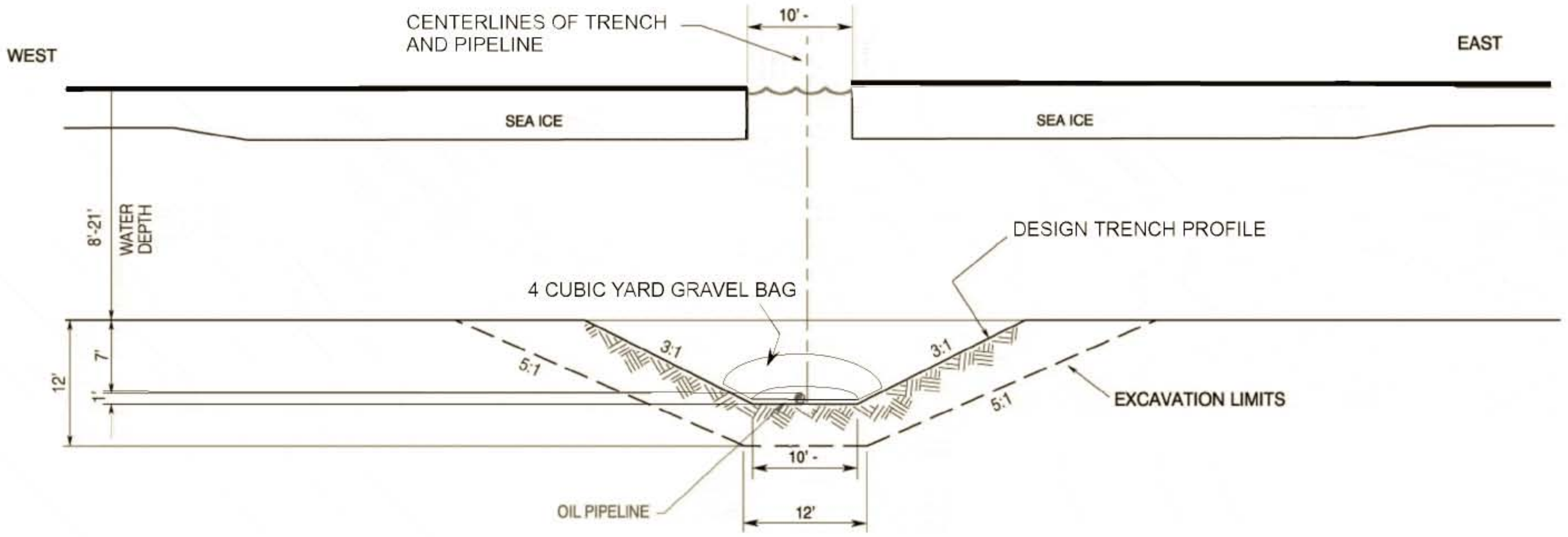


Figure II.A-11 Proposed Kadleroshilik River Mine Site - Rehabilitation Plan - Cross Sections



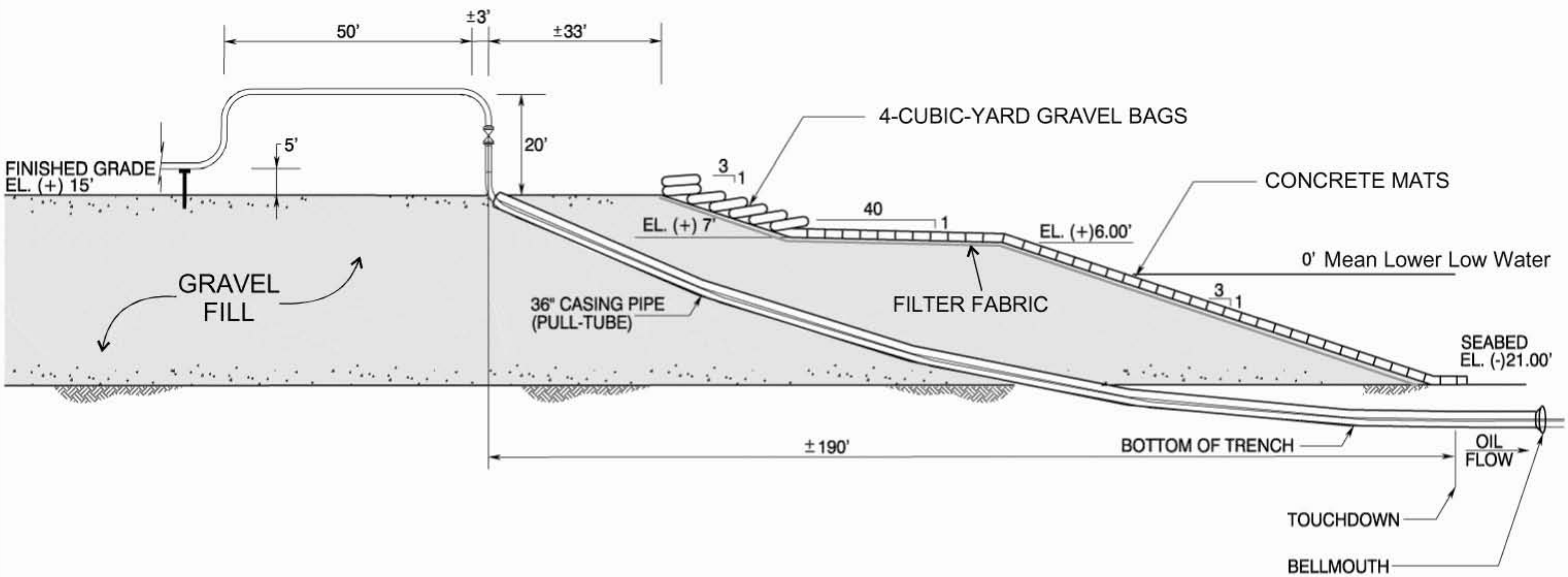
NOTES:

1. PIPELINE DEPTH OF COVER IS 7 FEET MINIMUM.
2. TRENCH SIDE SLOPES ARE VARIABLE, DEPENDING ON SOIL CONDITIONS.
3. TRENCH WILL BE BACK FILLED WITH A COMBINATION OF EXCAVATED MATERIAL, SELECT BACK FILL (GRAVEL) AND GRAVEL BAGS.

ALL DIMENSIONS ARE APPROXIMATE

Source: BPXA, 1998a

Figure II.A-12 Liberty Development Project: Pipeline Trench Section, Intermediate/Deep (8 to 21 feet) Water Depths



Source: BPXA, 1998b

ALL DIMENSIONS ARE APPROXIMATE

Figure II.A-13 Liberty Development Project: Pipeline Island Approach, Cross-Section

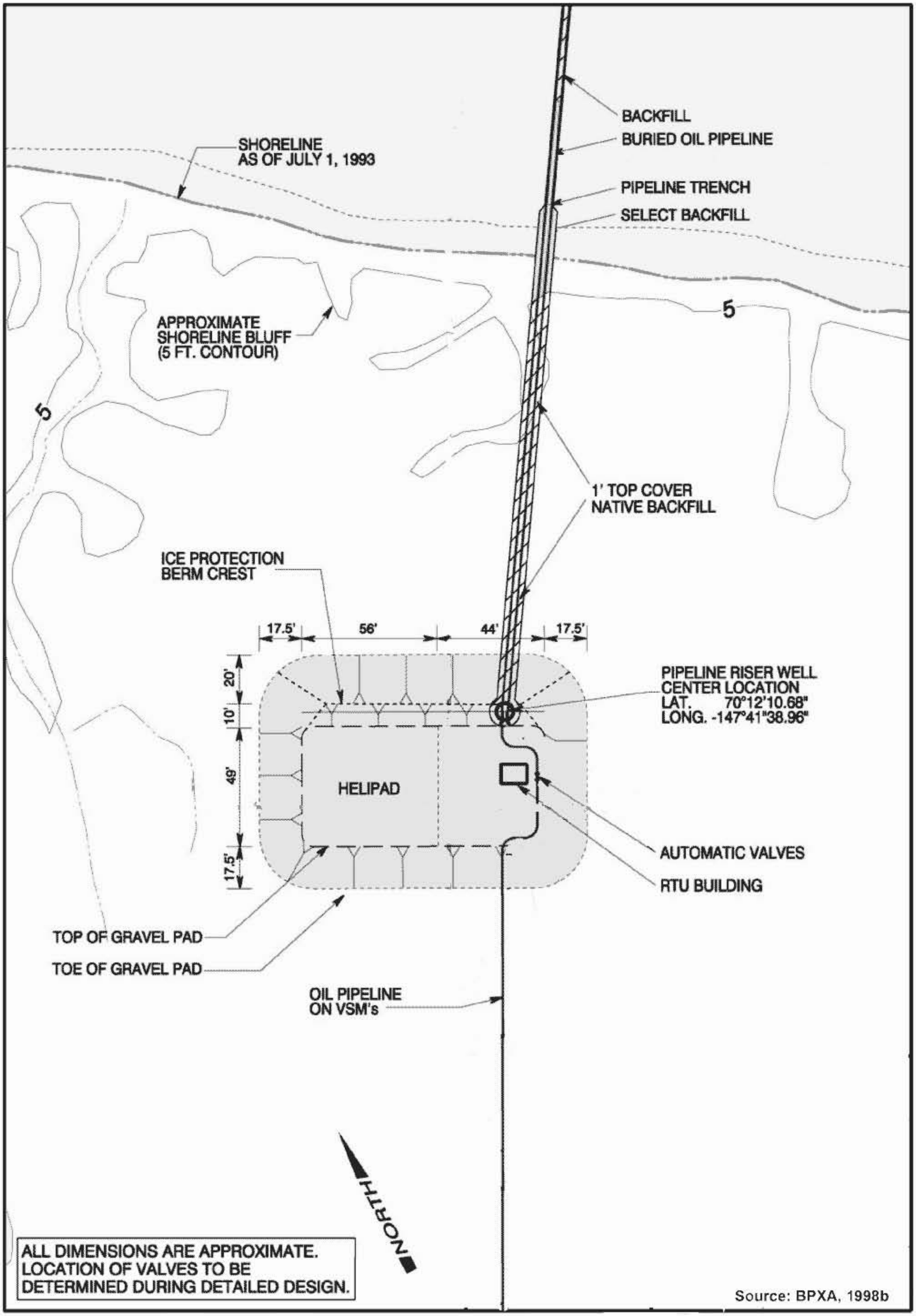


Figure II.A-14 Liberty Development Project: Shore Cross Pad

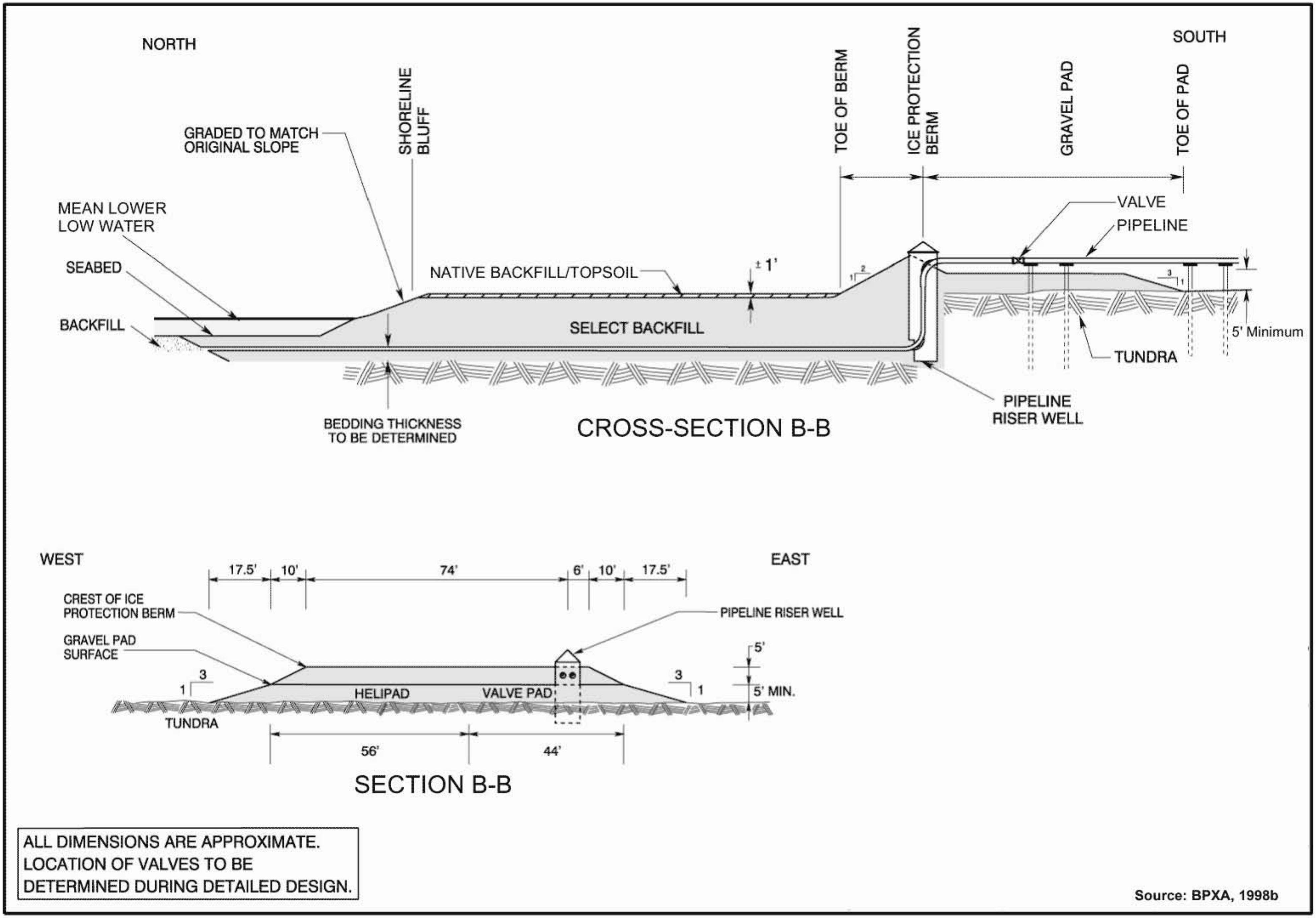


Figure II.A-15 Liberty Development Project: Pipeline Landfall Valve Pad, Cross-Sections

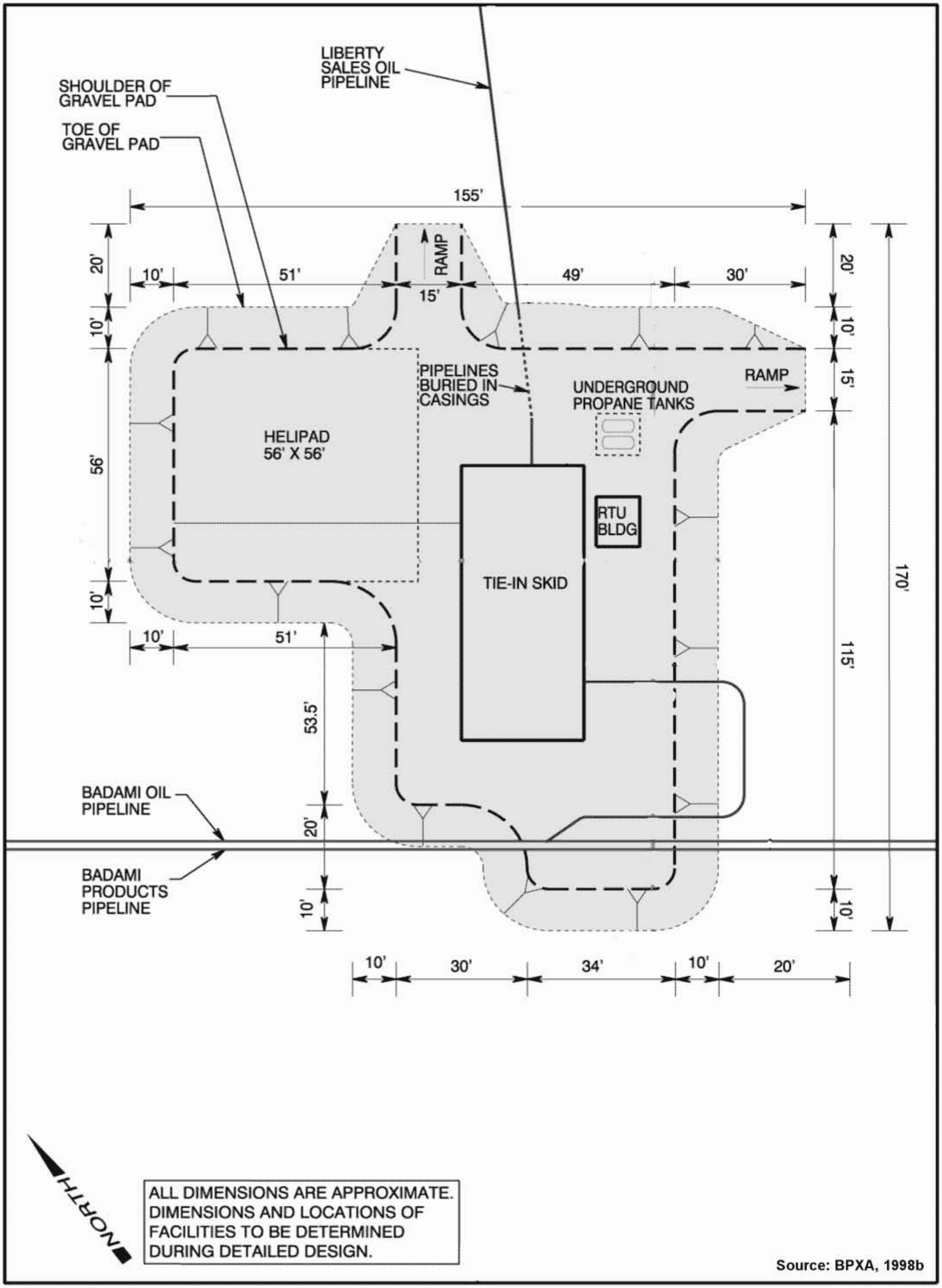


Figure II.A-16 Liberty Devolopment Project: Pad at Badami Pipeline Tie-In, Plan View

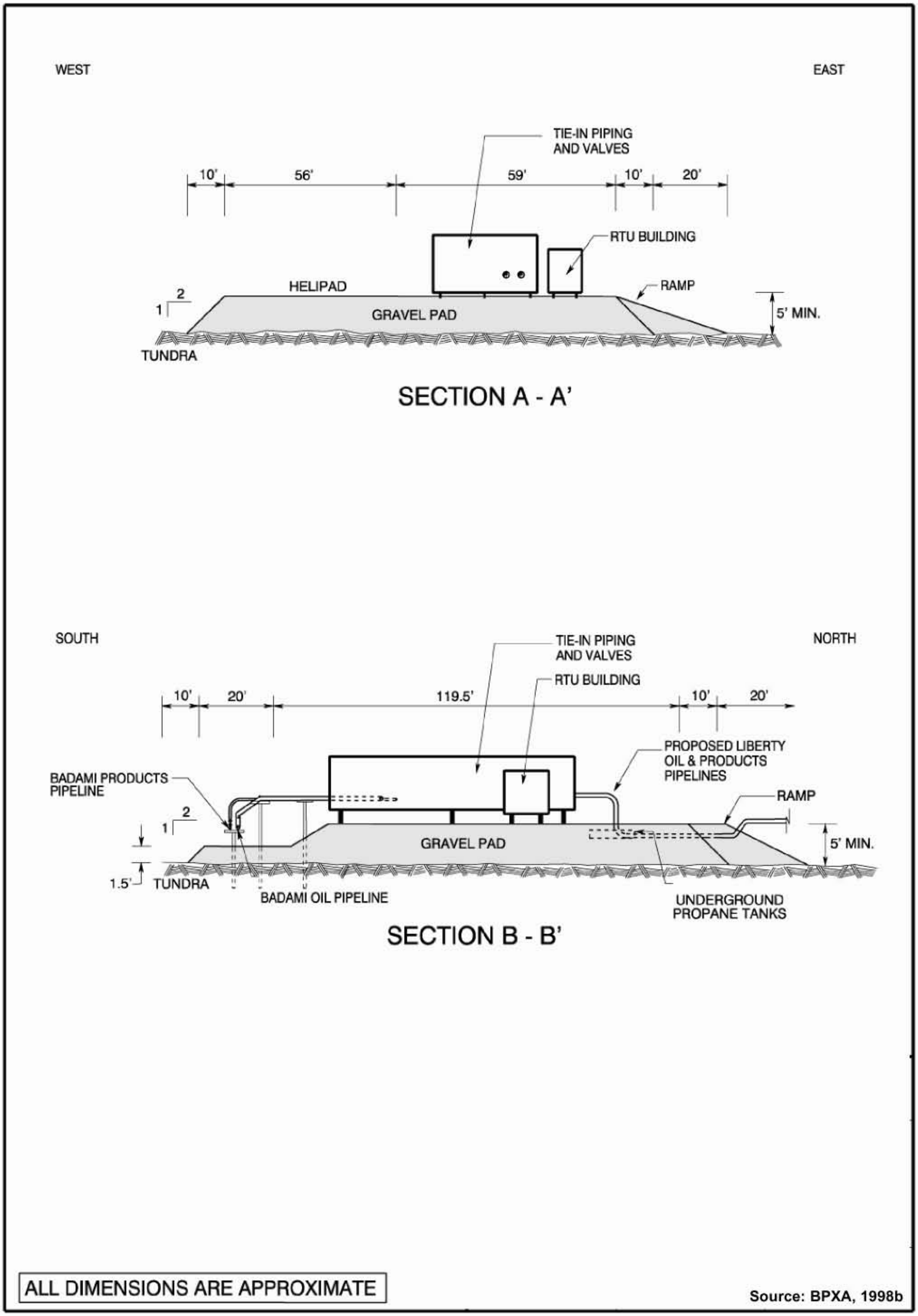


Figure II.A-17 Liberty Development Project: Tie-In Pad - Cross Sections

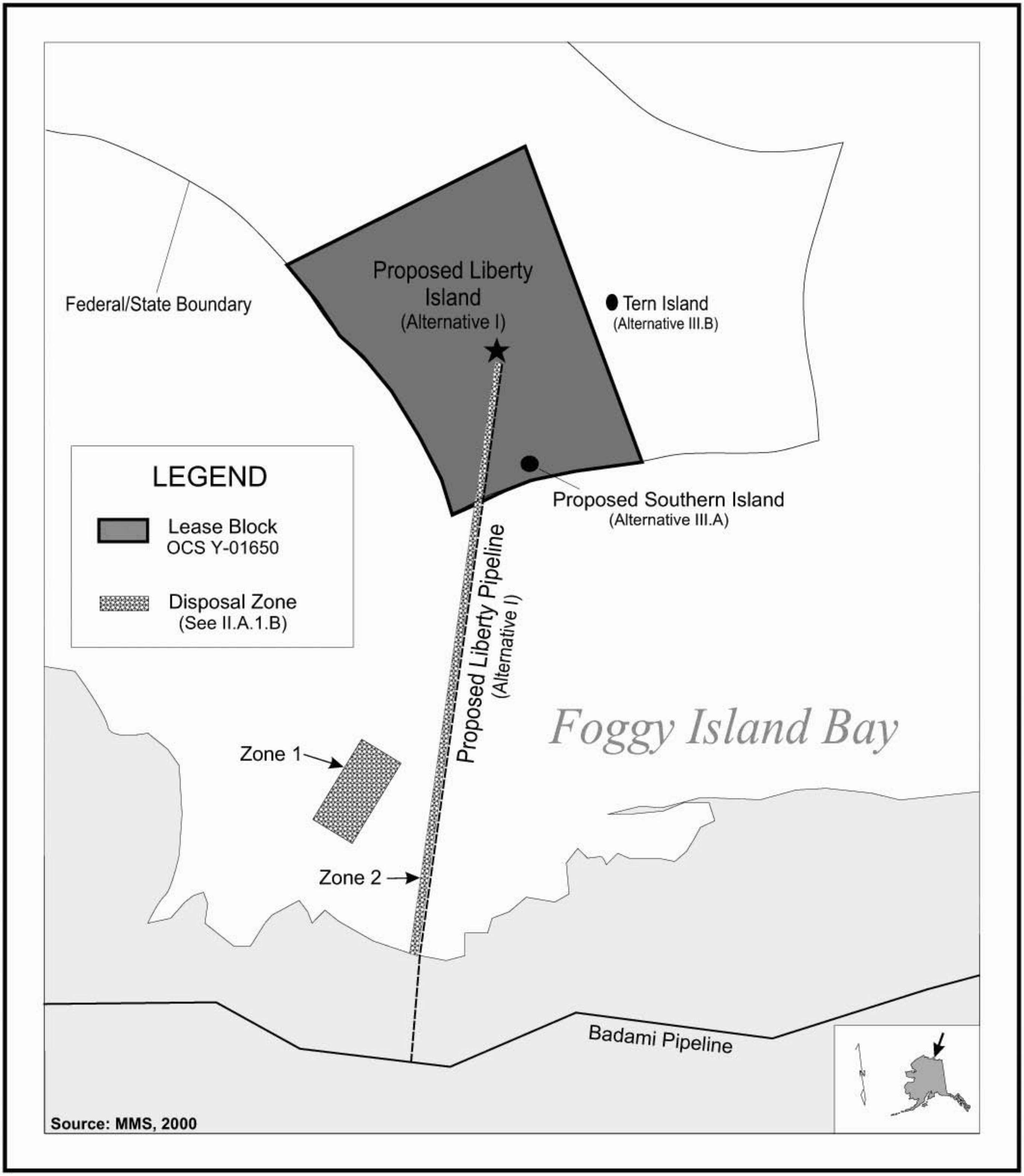
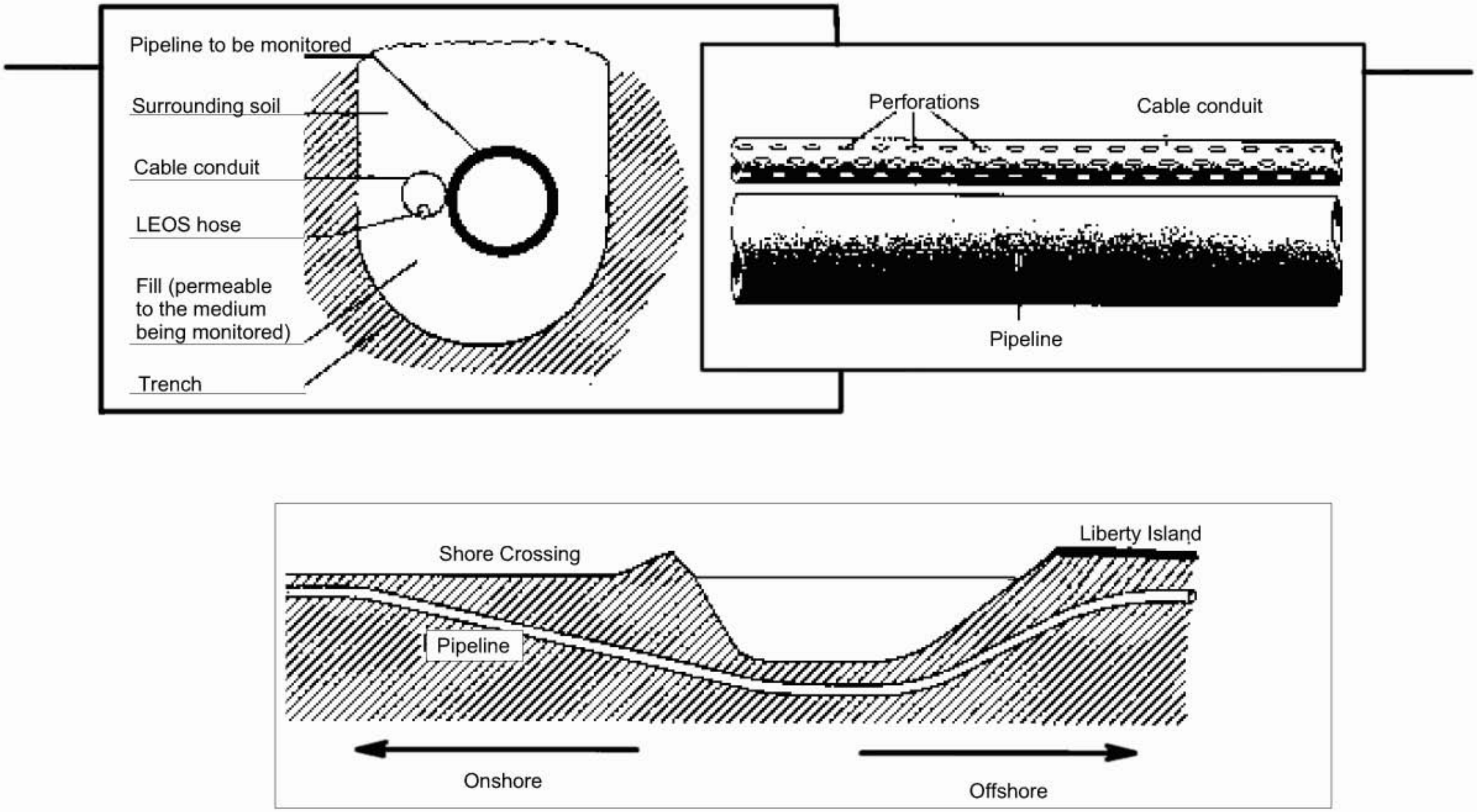


Figure II.A-18 Liberty Development Project: Alternative I Proposed Liberty Island and Pipeline and Dredged Material Disposal Zones



Source: Seimens, 2000

Figure II.A-19 Offshore Pipeline with LEOS Installed (Leak Detection and Location System)

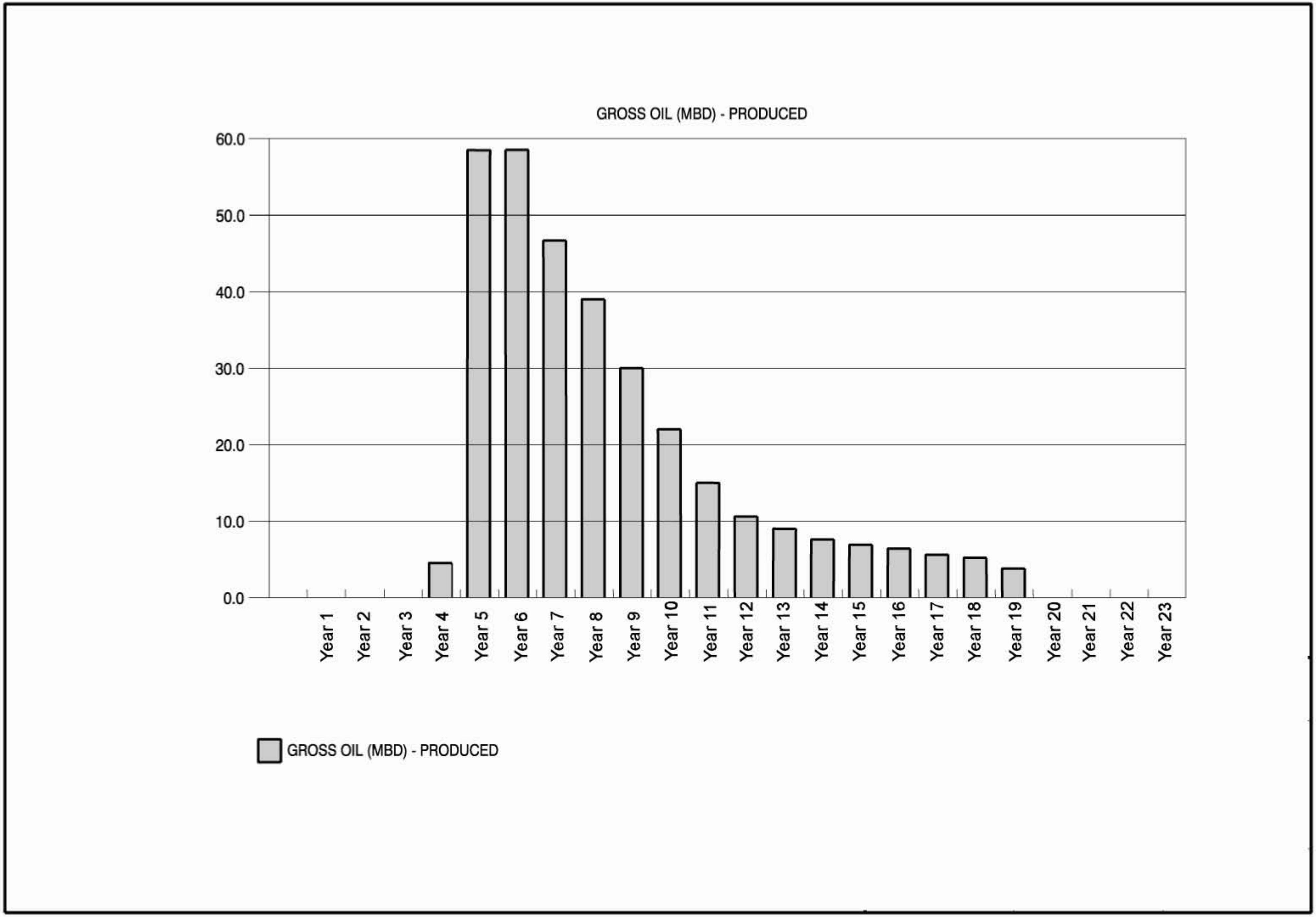


Figure II.A-20 Liberty Development Project: Projected Oil Production Schedule Years 4 through 19

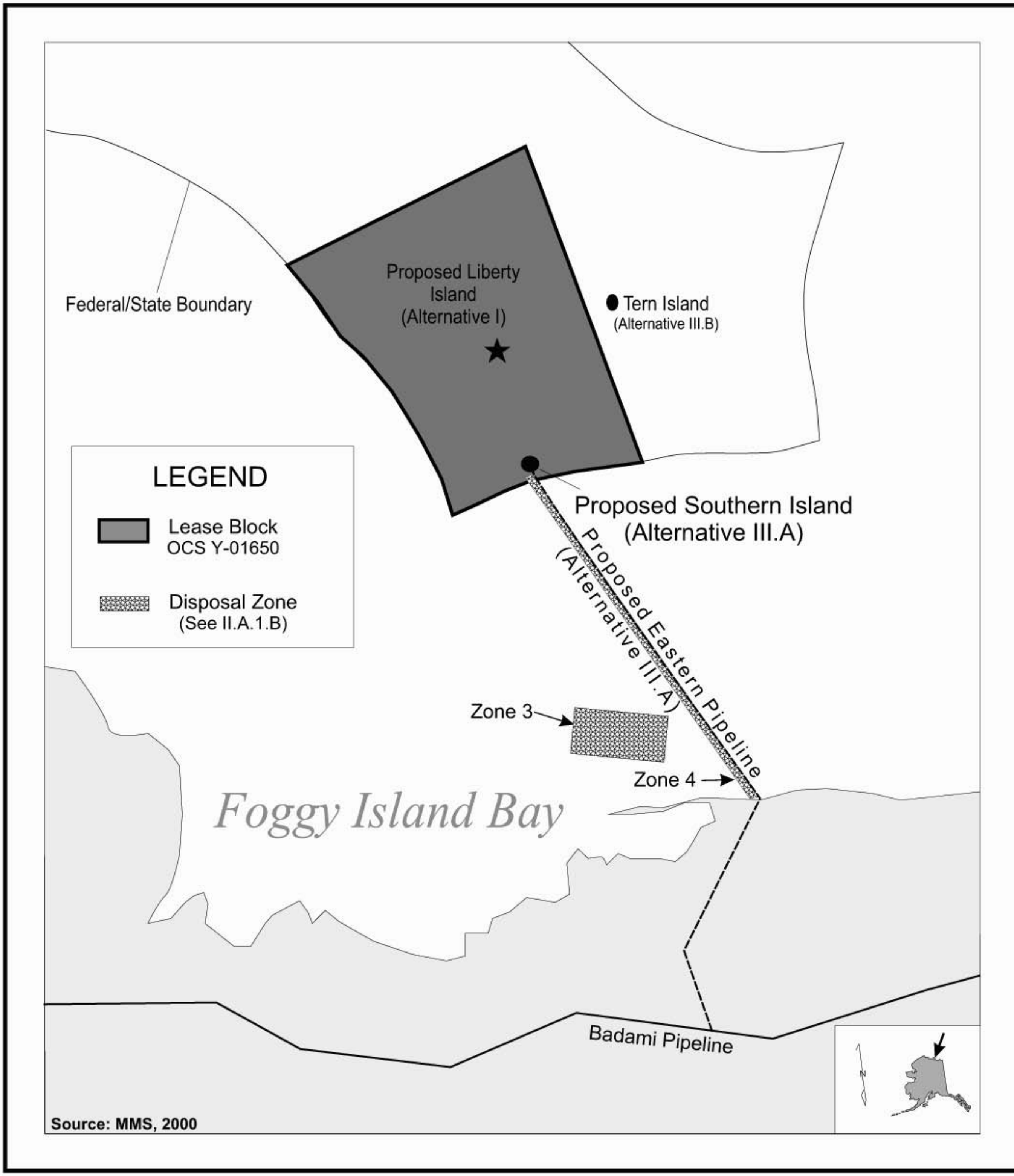


Figure II.C-1 Liberty Development Project: Alternative III.A Proposed Southern Island, Proposed Eastern Pipeline and Dredged Material Disposal Zones

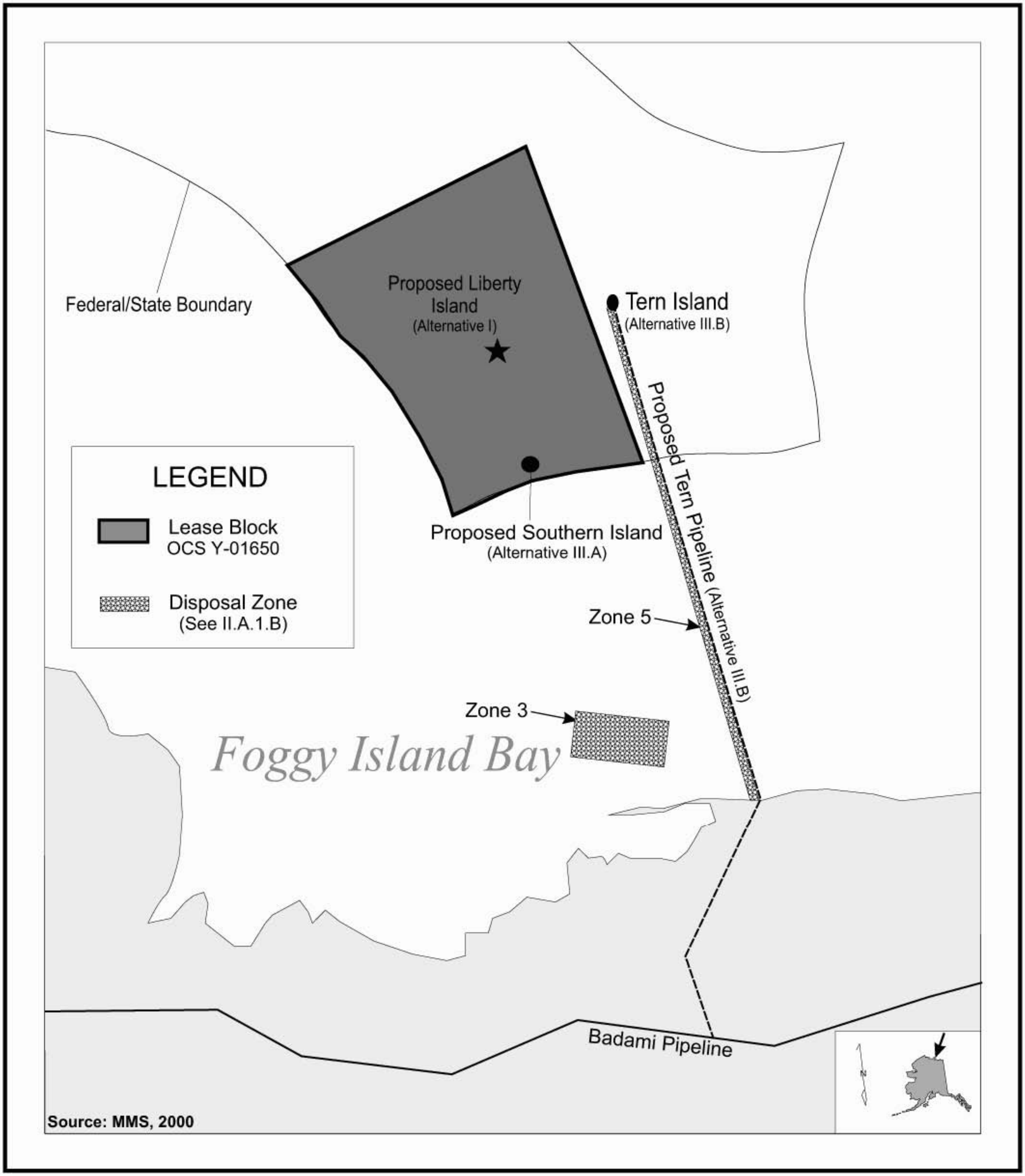


Figure II.C-2 Liberty Development Project: Alternative III.B Tern Island and Proposed Tern Pipeline and Dredged Material Disposal Zones

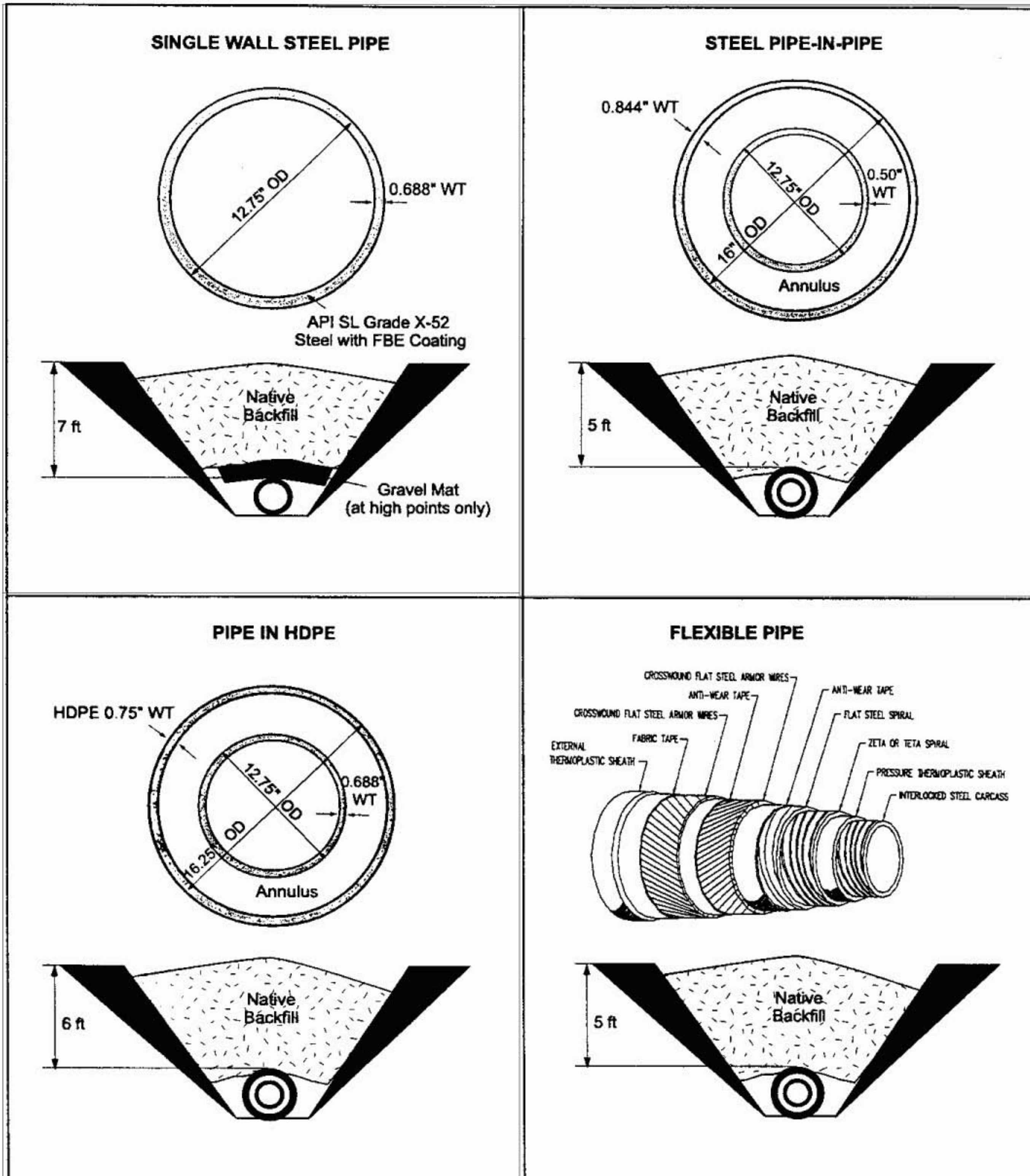
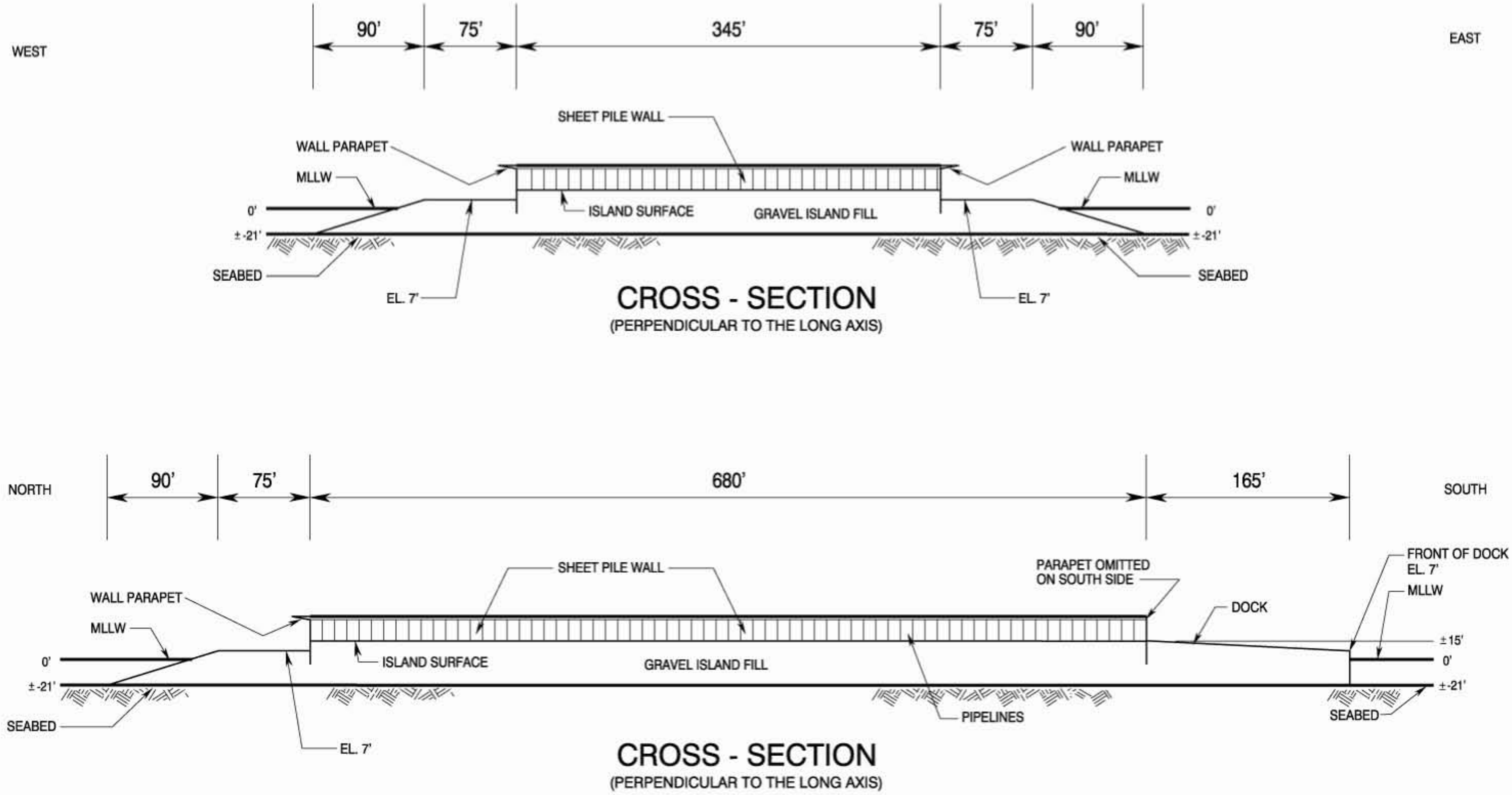


Figure II.C-3 Liberty Pipeline Design Comparison - Cross Sections



MLLW = Mean Lower Low Water

Source: BPXA, 1998b

ALL DIMENSIONS ARE APPROXIMATE

Figure II.C-4 Liberty Development Project: Sheet Pile Island (Alternative IV), Cross Sections

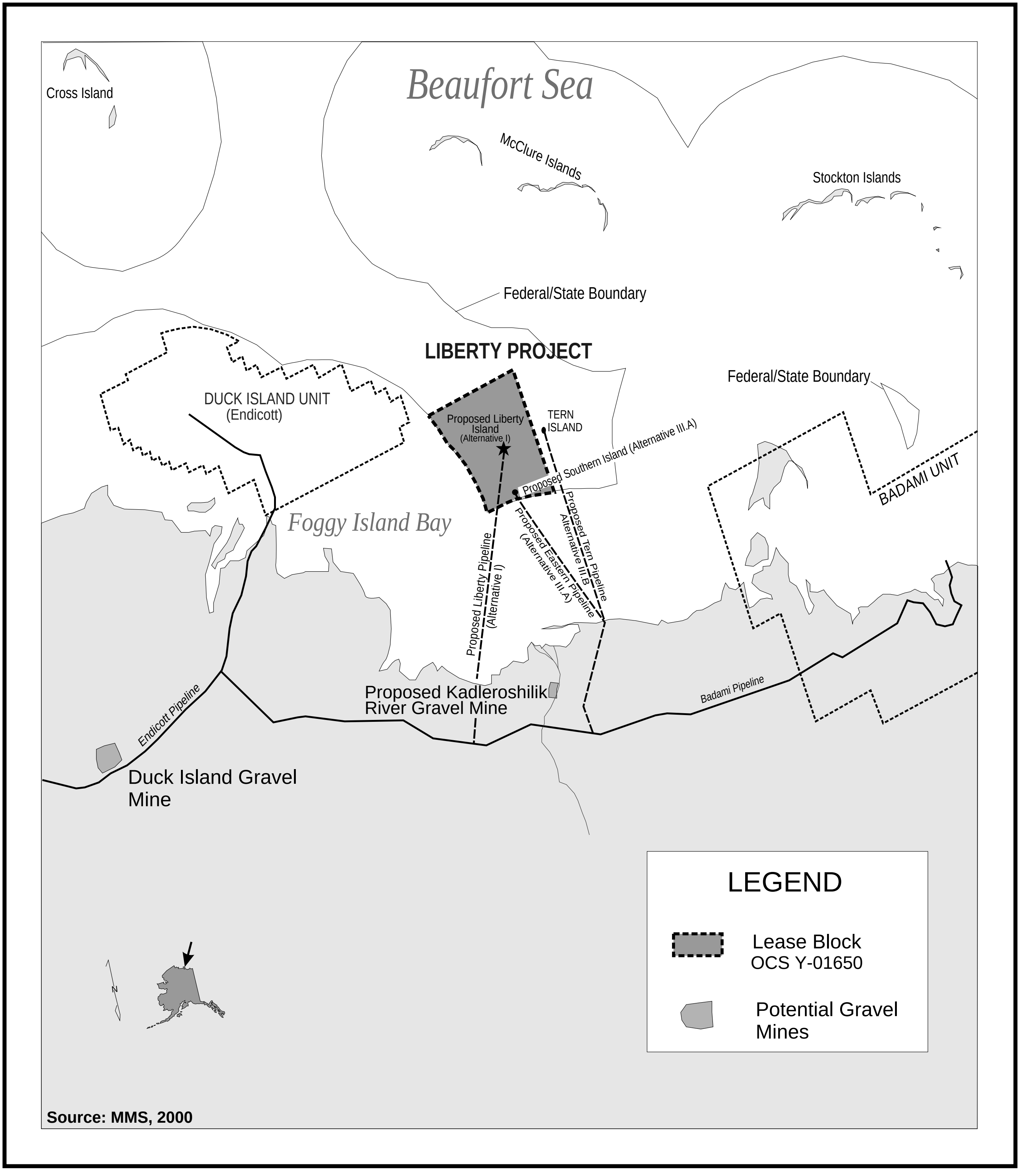


Figure II.C-5 Potential Gravel Mine Sites

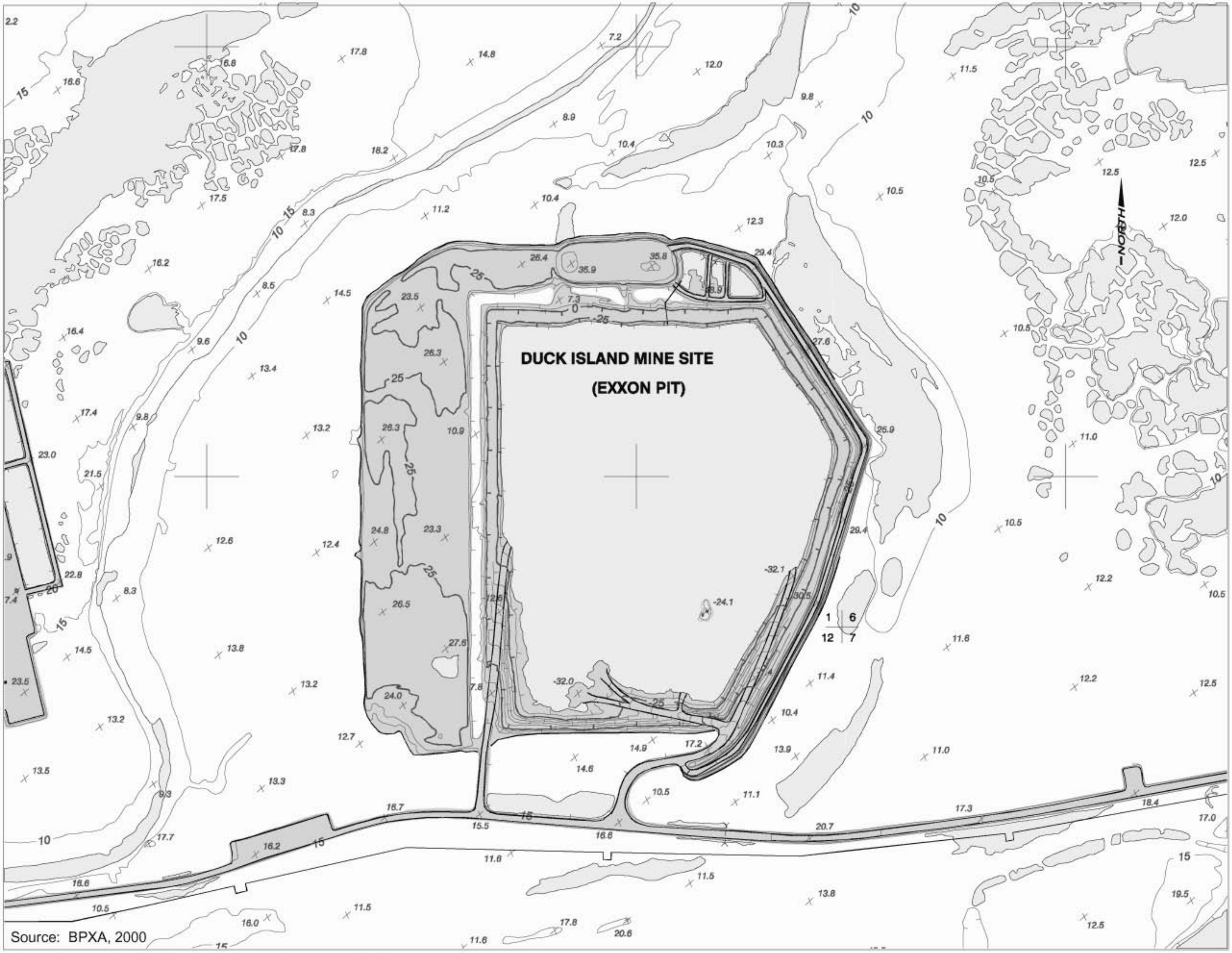


Figure II.C-6 Duck Island Mine Site - Existing Facility - Plan View

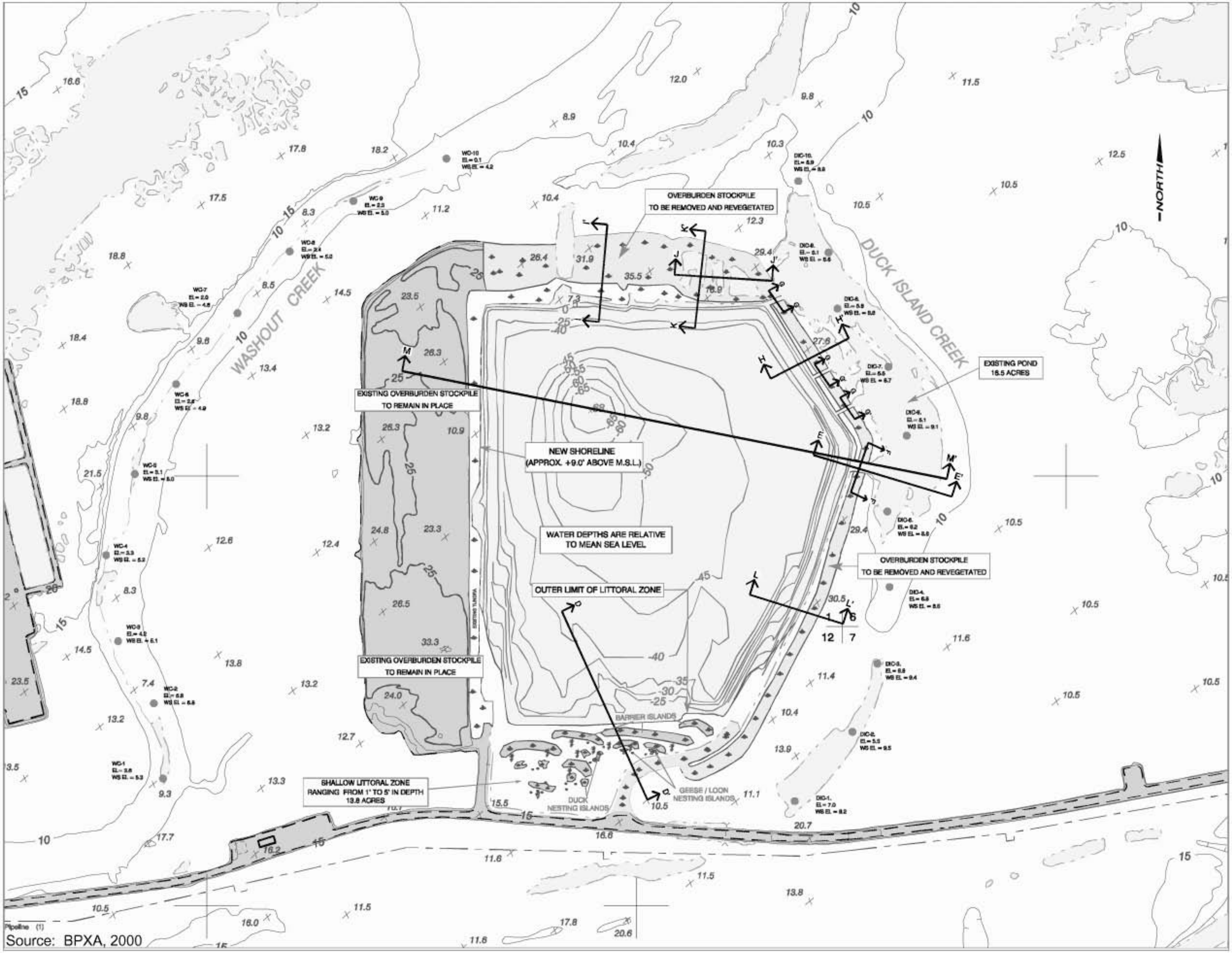


Figure II.C-7 Duck Island Mine Site - Proposed Restoration - Plan View

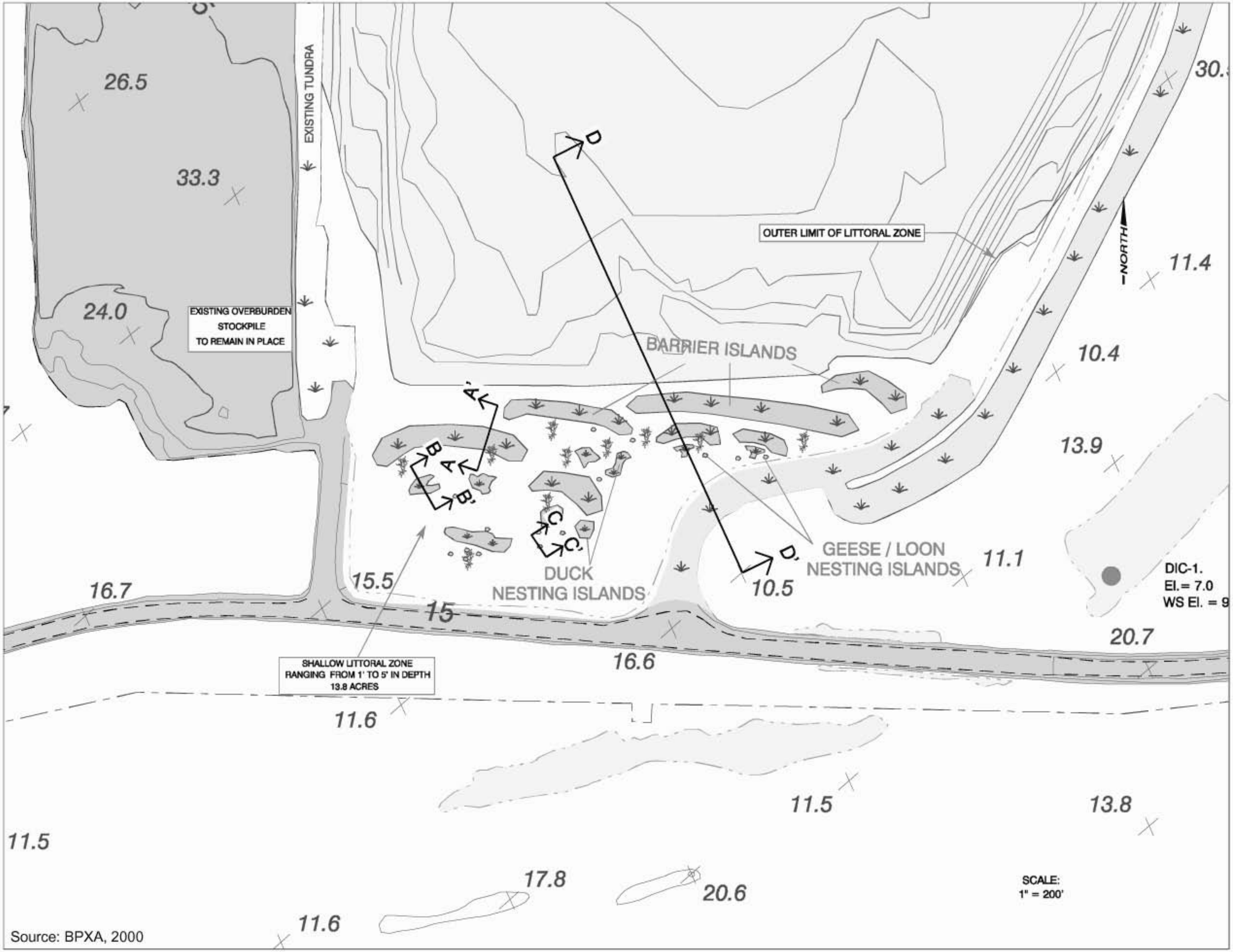
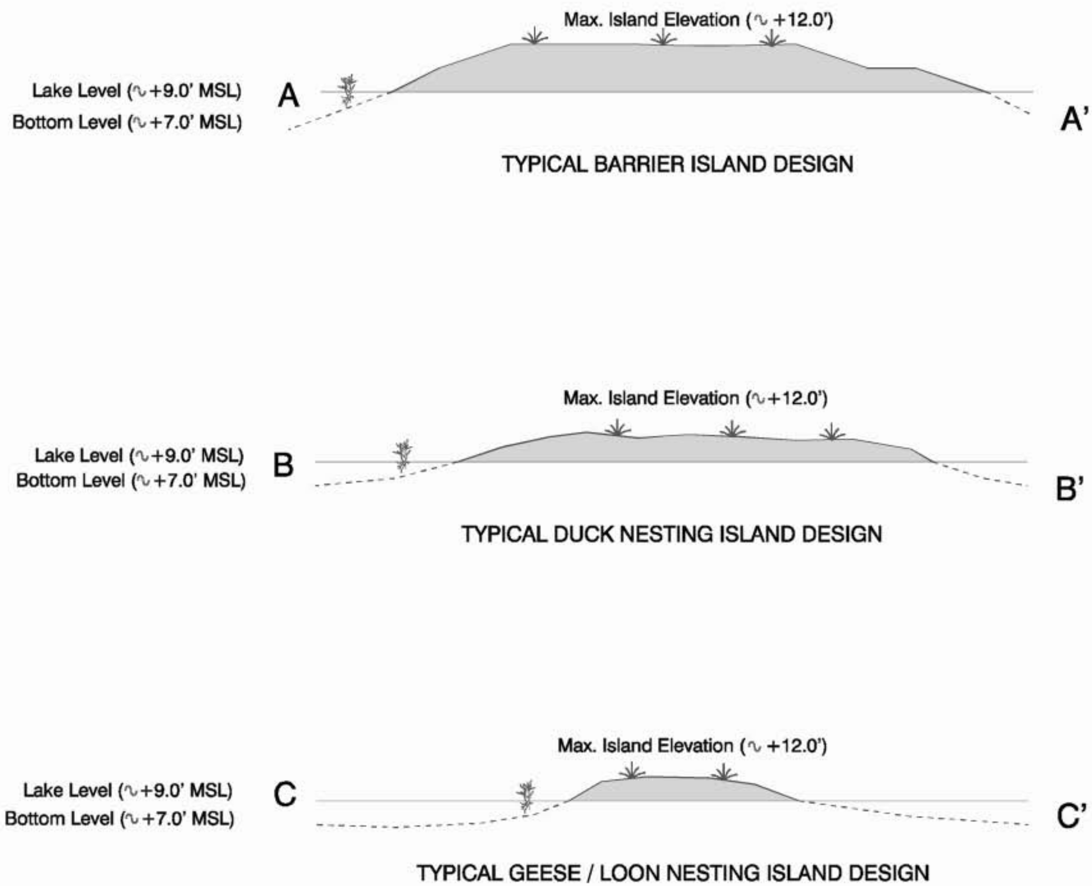


Figure II.C-8 Duck Island Mine Site - Proposed Restoration Littoral Zone - Plan View



Source: BPXA, 2000

Figure II.C-9 Duck Island Mine Site - Proposed Restoration - Typical Cross-Sections

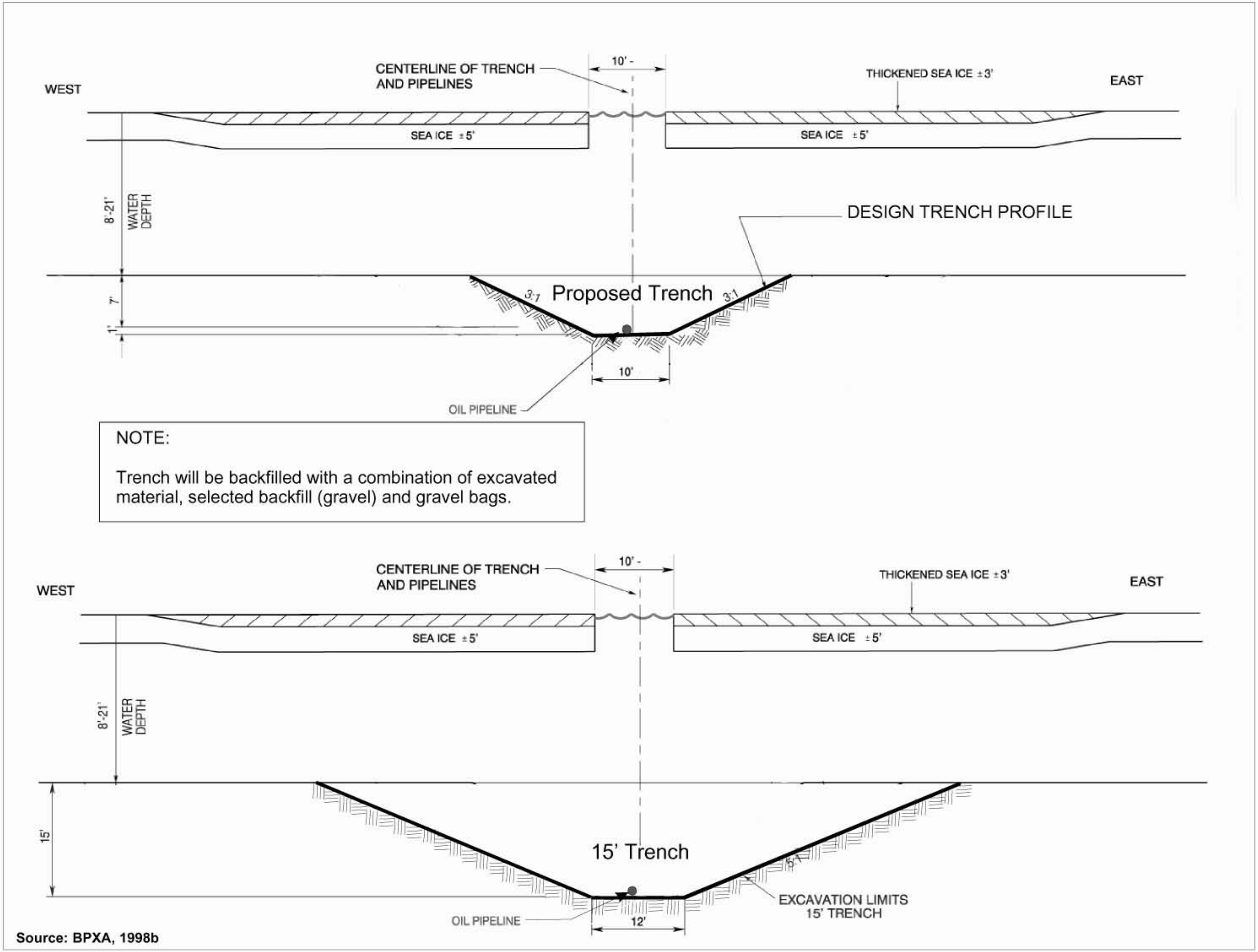


Figure II.C-10 Liberty Development Project: Comparison of Proposed Trench (Alternative I) and 15-Foot Deep Trench (Alternative VII)

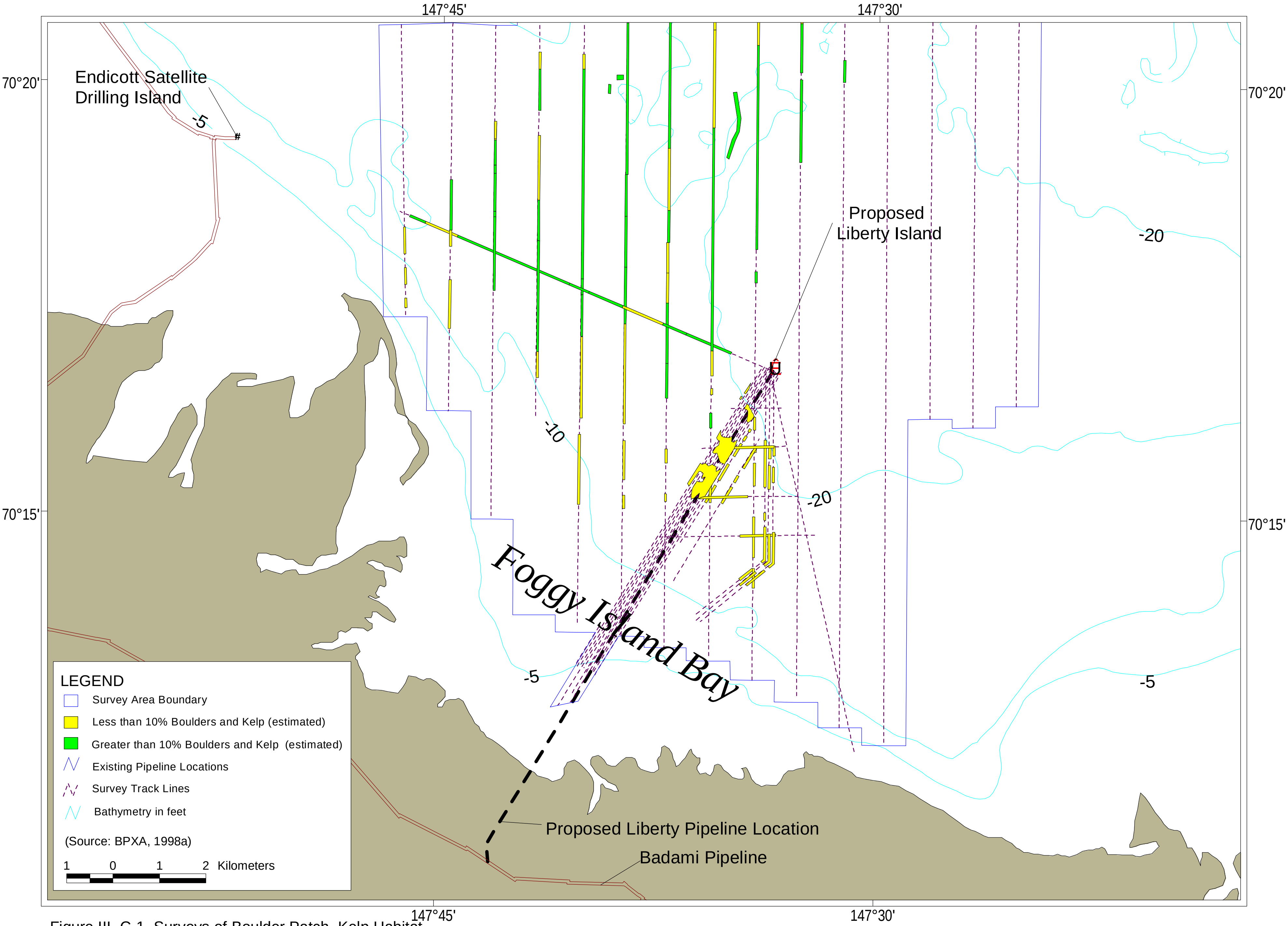


Figure III. C-1 Surveys of Boulder Patch Kelp Habitat

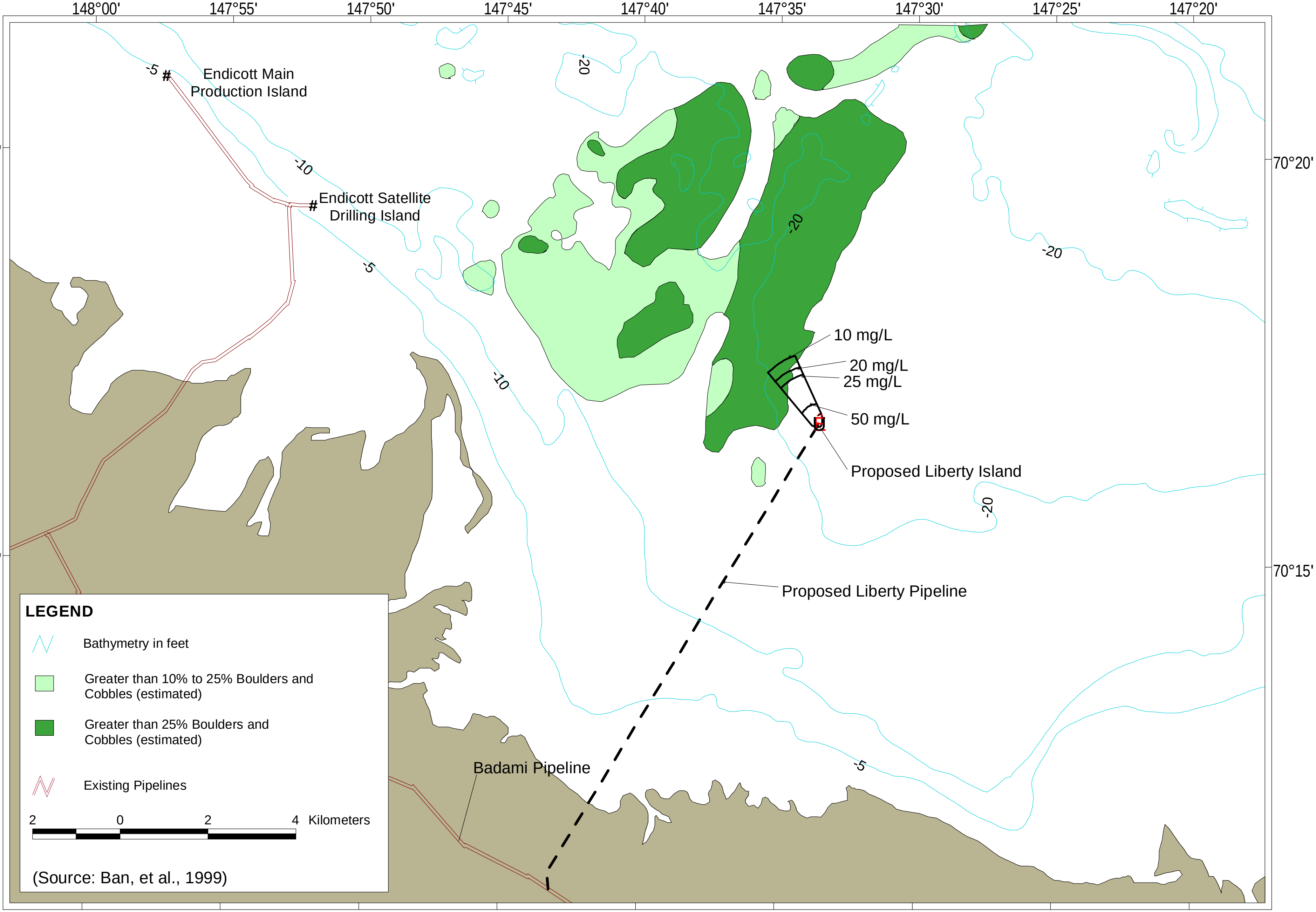


Figure III.C-2 Maximum Area of Boulder Patch Kelp Habitat that would be Exposed to Suspended Solids from Liberty Island Construction, Winter Conditions, Concentrations in Milligrams per Liter (mg/L).

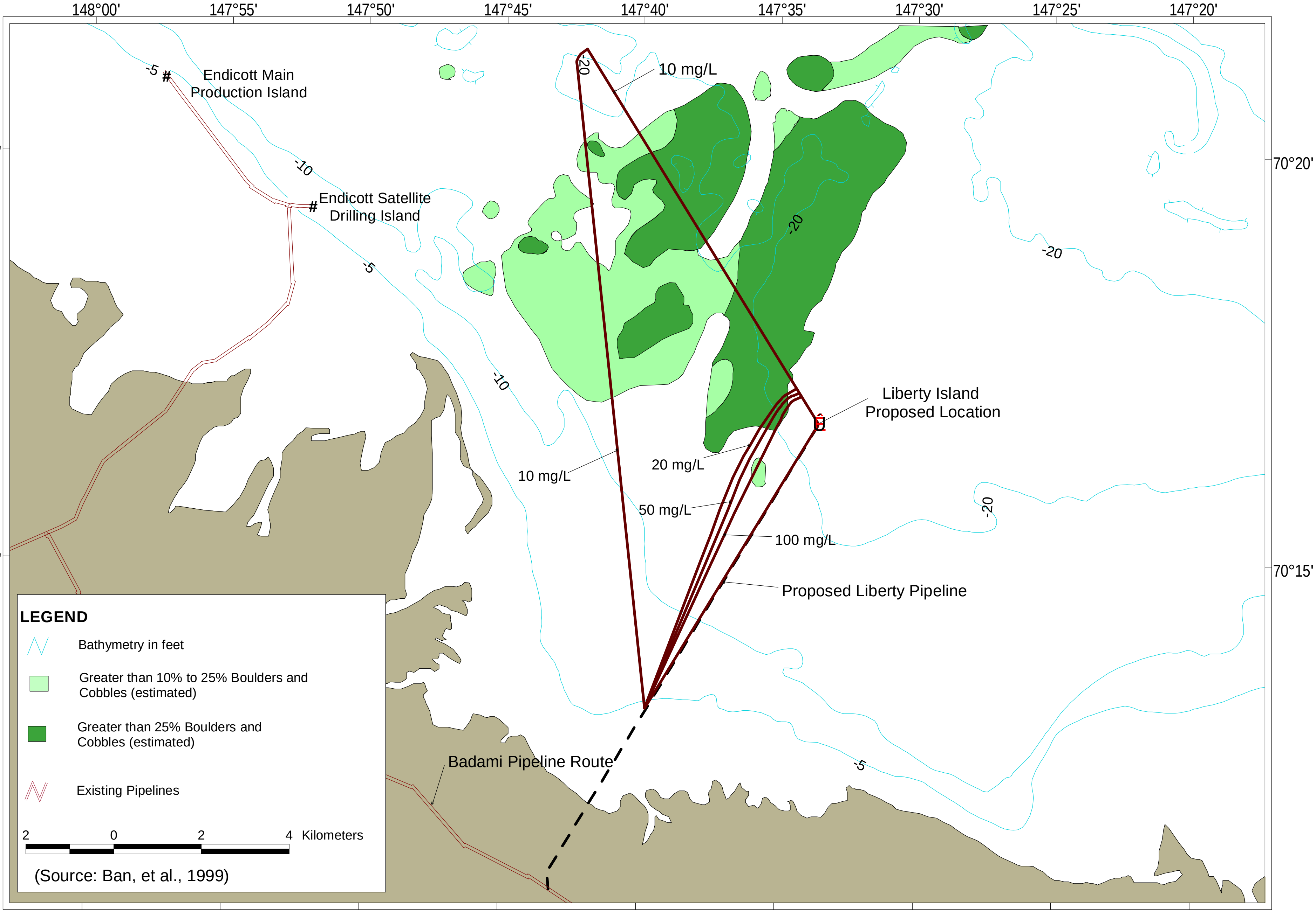


Figure III.C-3 Maximum Area of Boulder Patch Kelp Habitat Exposure to Suspended Solids from Liberty Pipeline Construction, Winter Conditions, Concentrations in Miligrams/per Liter (mg/L).

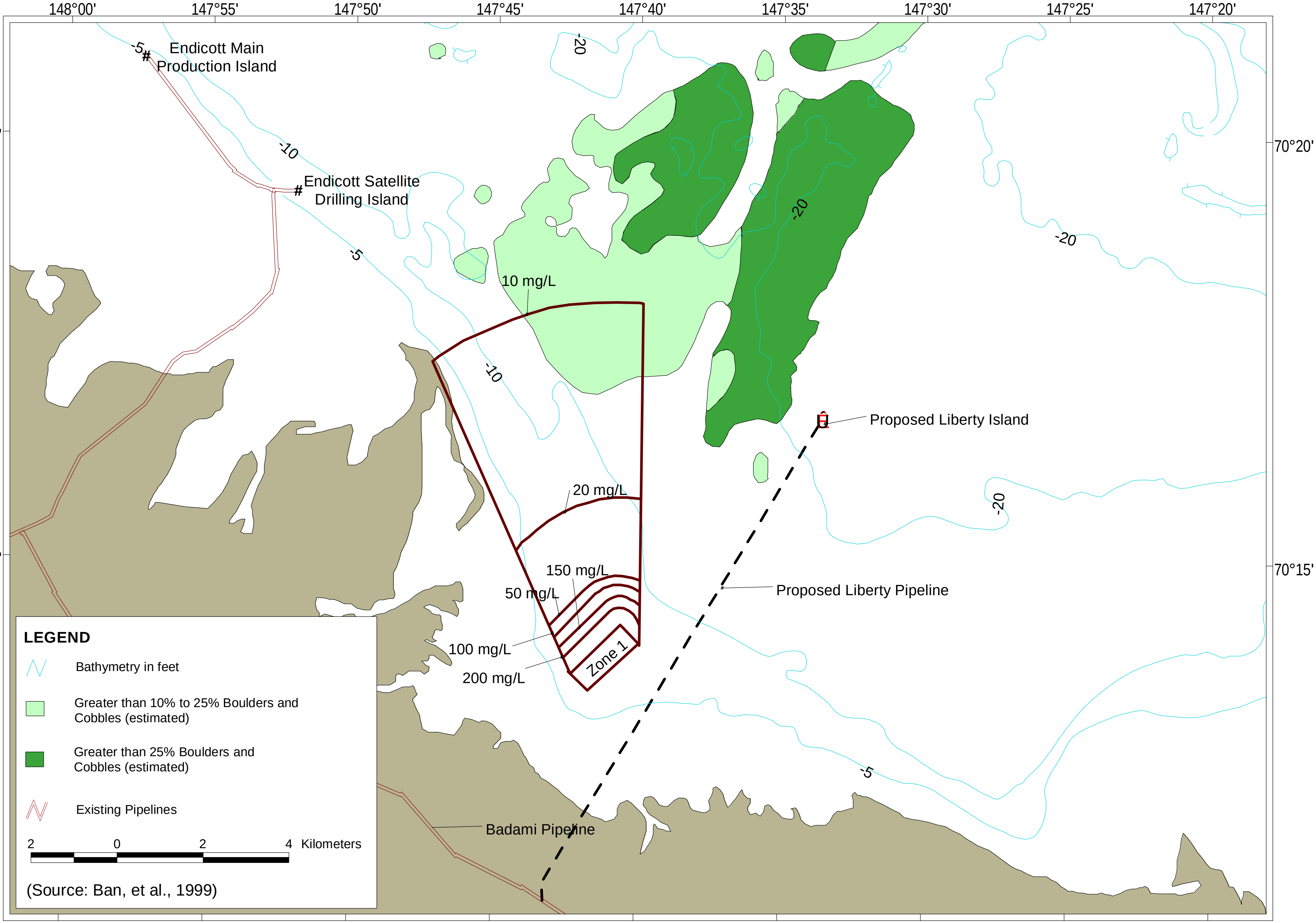
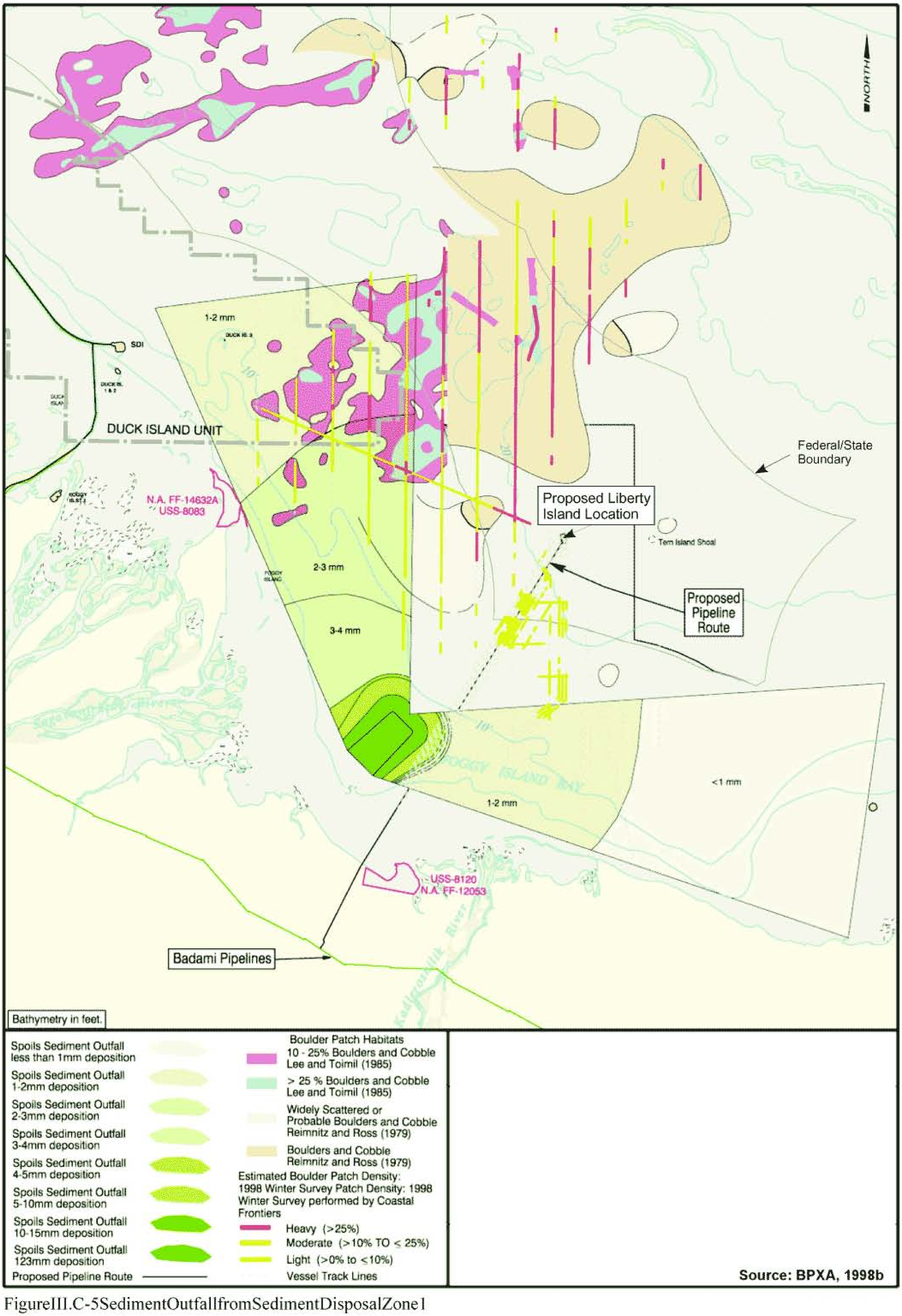
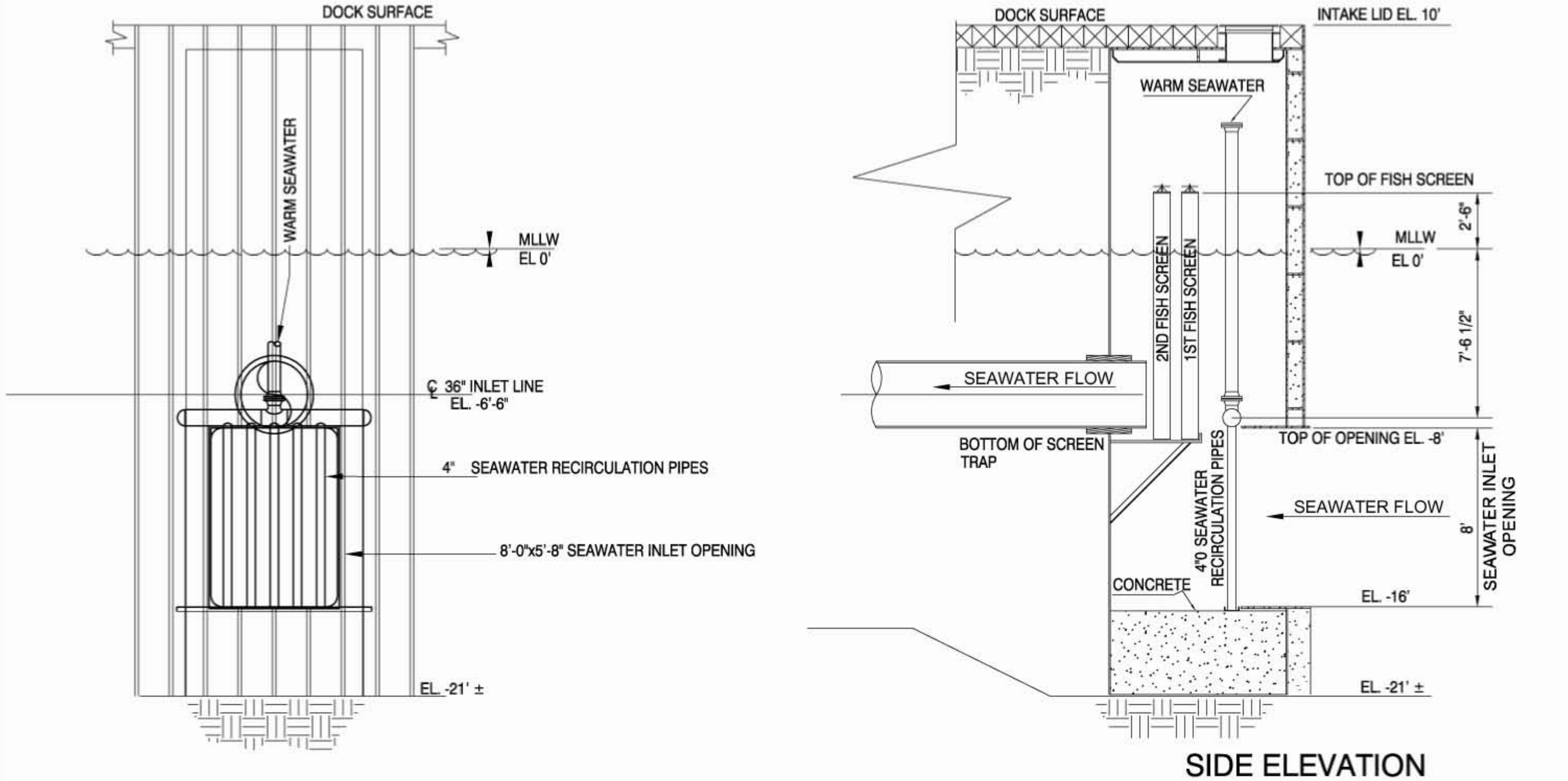


Figure III.C-4 Maximum Area of Boulder Patch Kelp Habitat Exposure to Suspended Solids from Alternative I Dredged Material Disposal Zone 1, Breakup Conditions, Concentrations in Miligrams per Liter (mg/L).



FigureIII.C-5SedimentOutfallfromSedimentDisposalZone1



MLLW = Mean Lower Low Water

Source: BPXA, 1998b

ALL DIMENSIONS ARE APPROXIMATE

Figure III.D-1 Liberty Development Project: Seawater Intake Detail

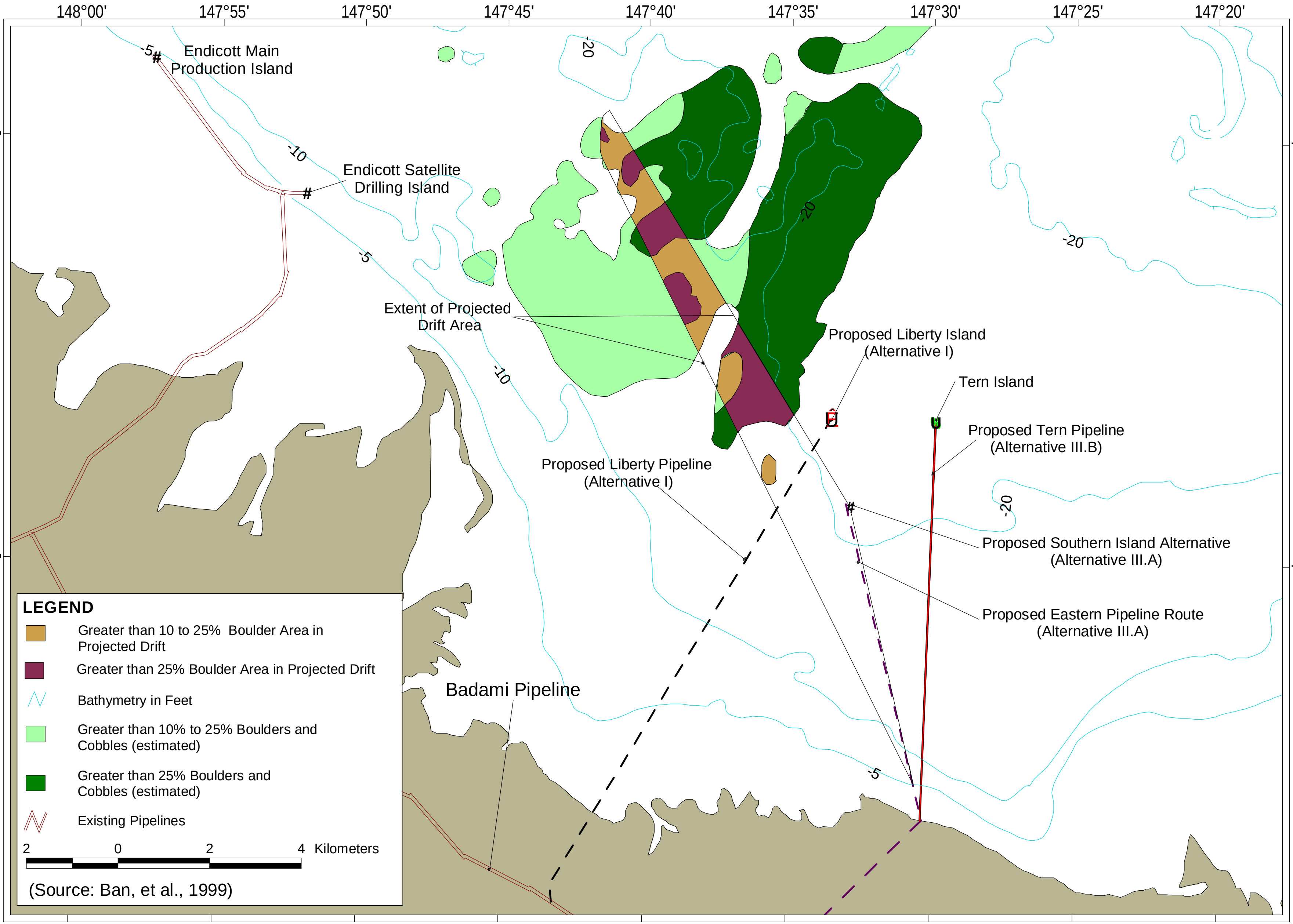


Figure IV.C-1 Maximum Area of Boulder Patch Kelp Habitat Exposure to Suspended Solids from the Proposed Eastern Pipeline Trench Excavation.

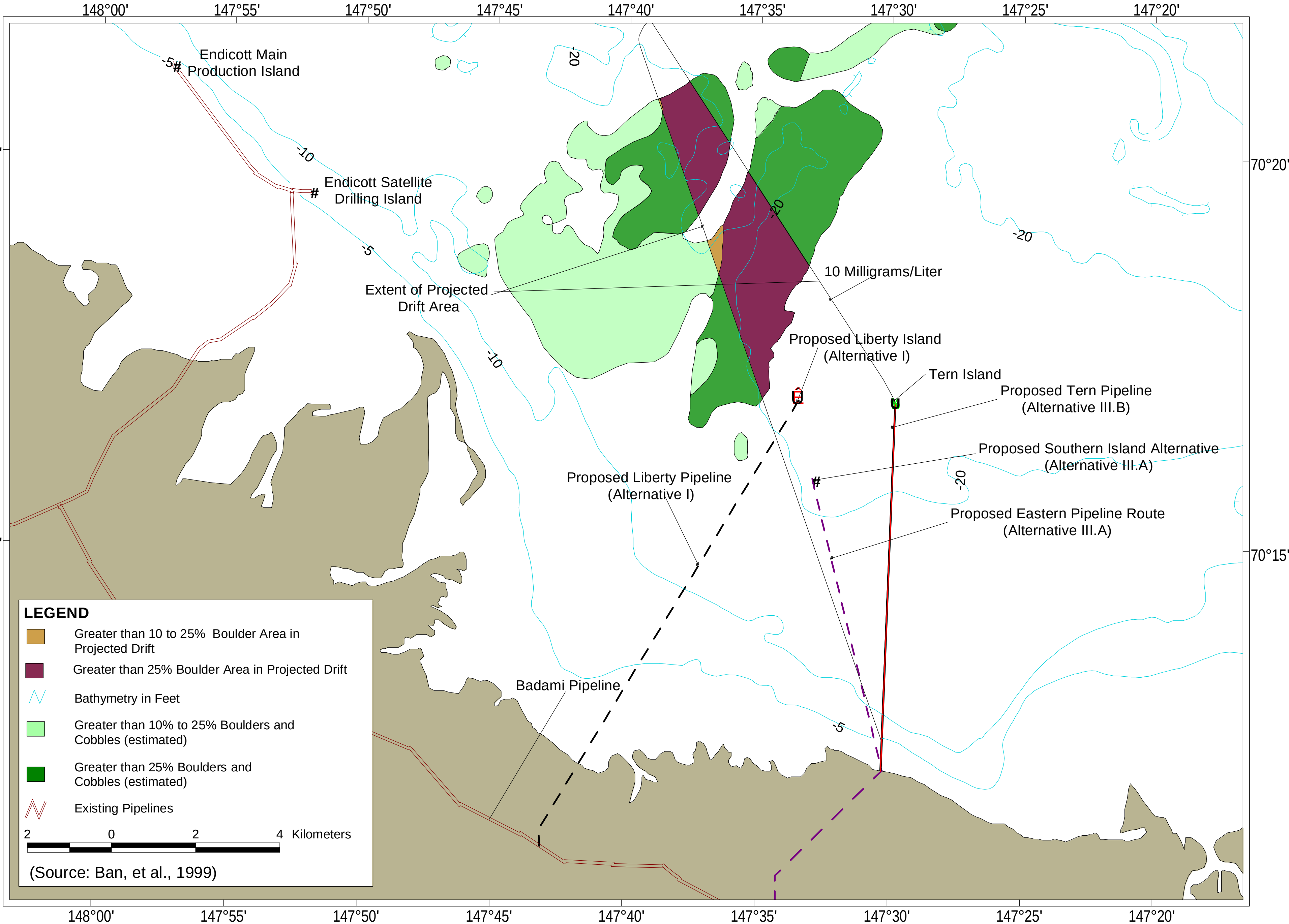


Figure IV.C-2 Maximum Area of Boulder Patch Kelp Habitat Exposure to Suspended Solids from the Proposed Tern Pipeline Trench Excavation.

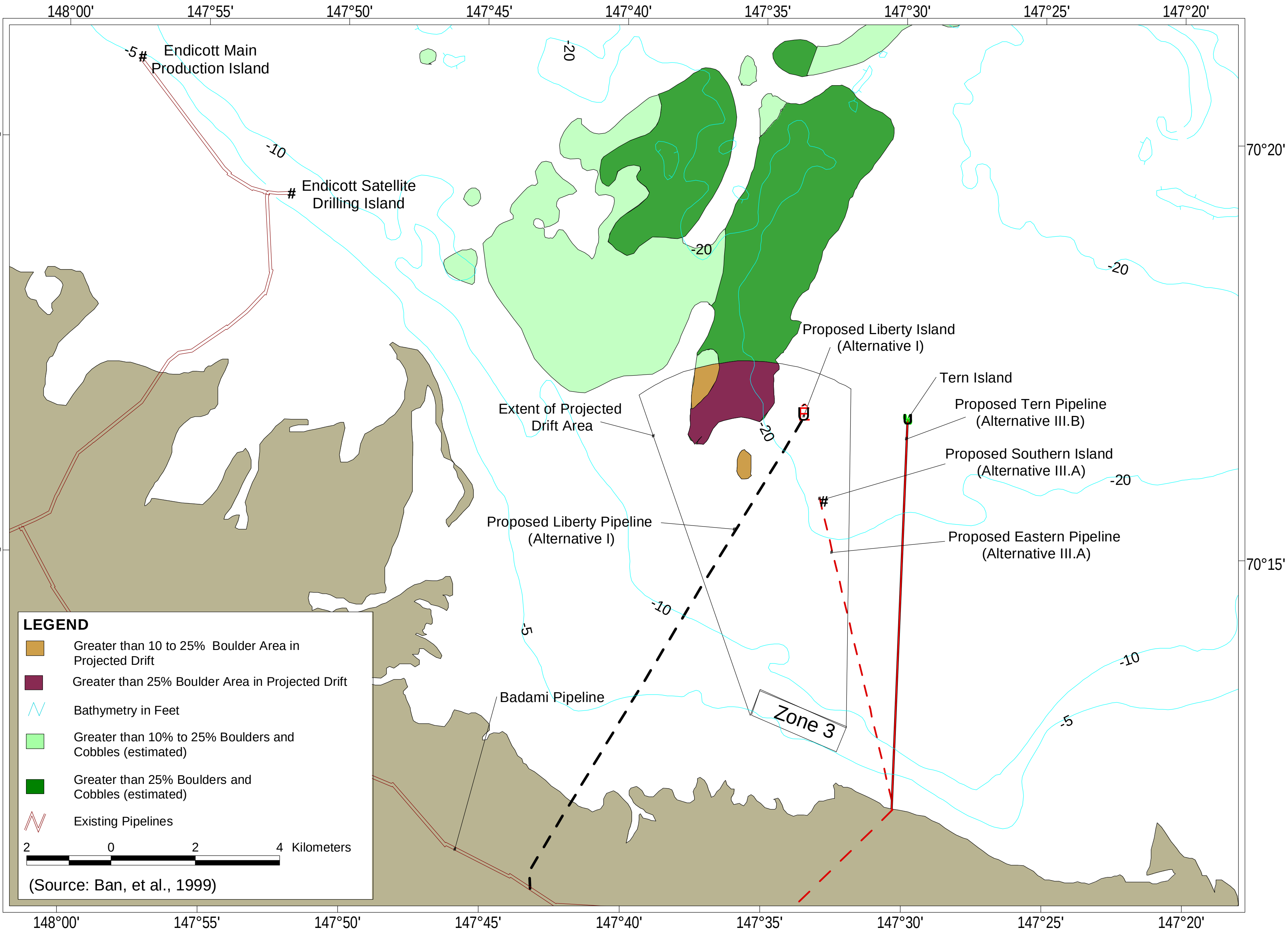


Figure IV.C-3 Maximum Area of Boulder Patch Kelp Habitat Exposure to Suspended Solids from the Disposal of Excavated Trench Materials in Zone 3 .

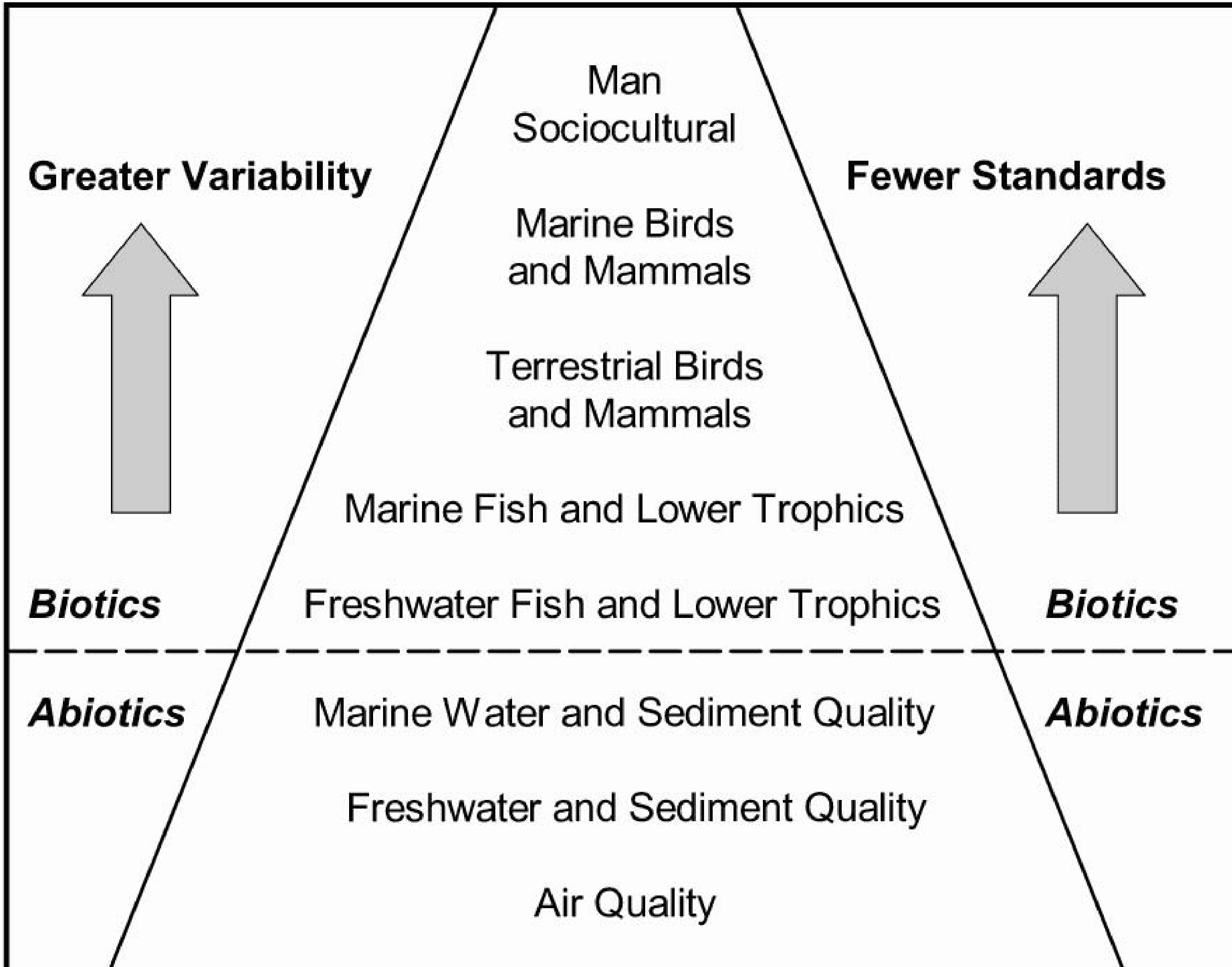


Figure V-1 Relationship Among Resources, Standards, and Degree of Variability

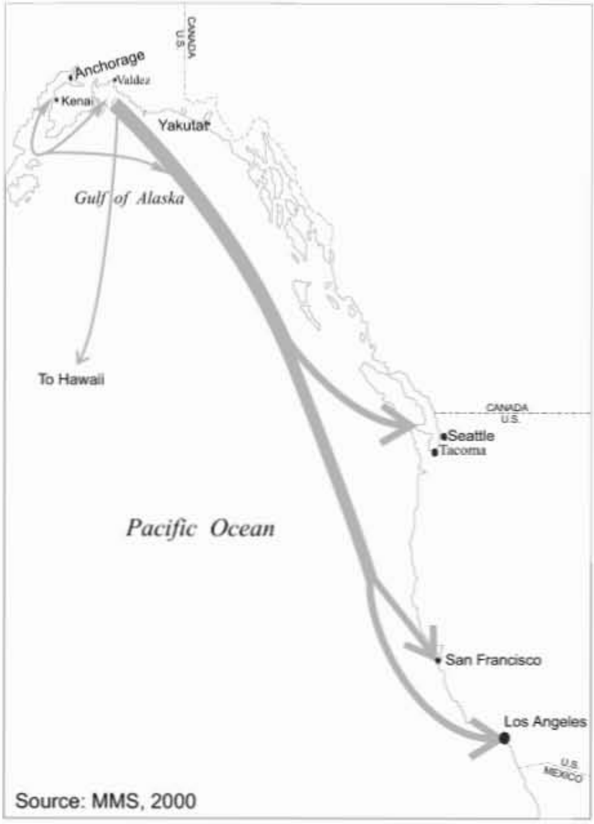


Figure V-2 General Tanker Routes and Ports of Entry

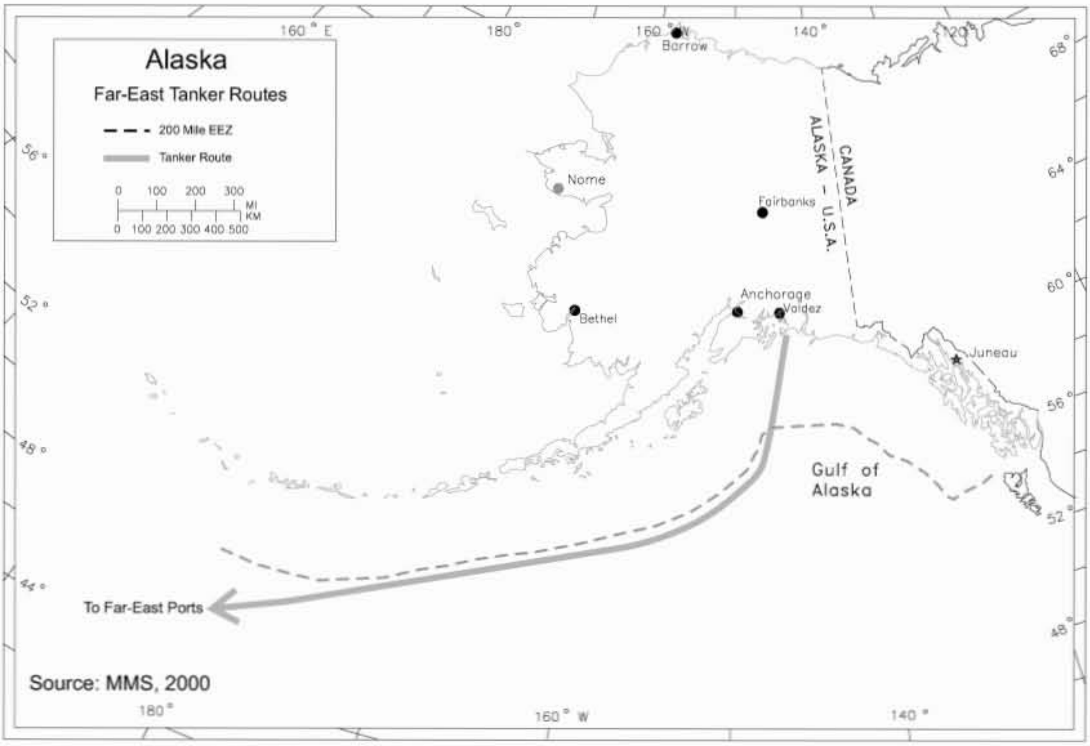


Figure V-3 Potential Valdez to Far East Tanker Route

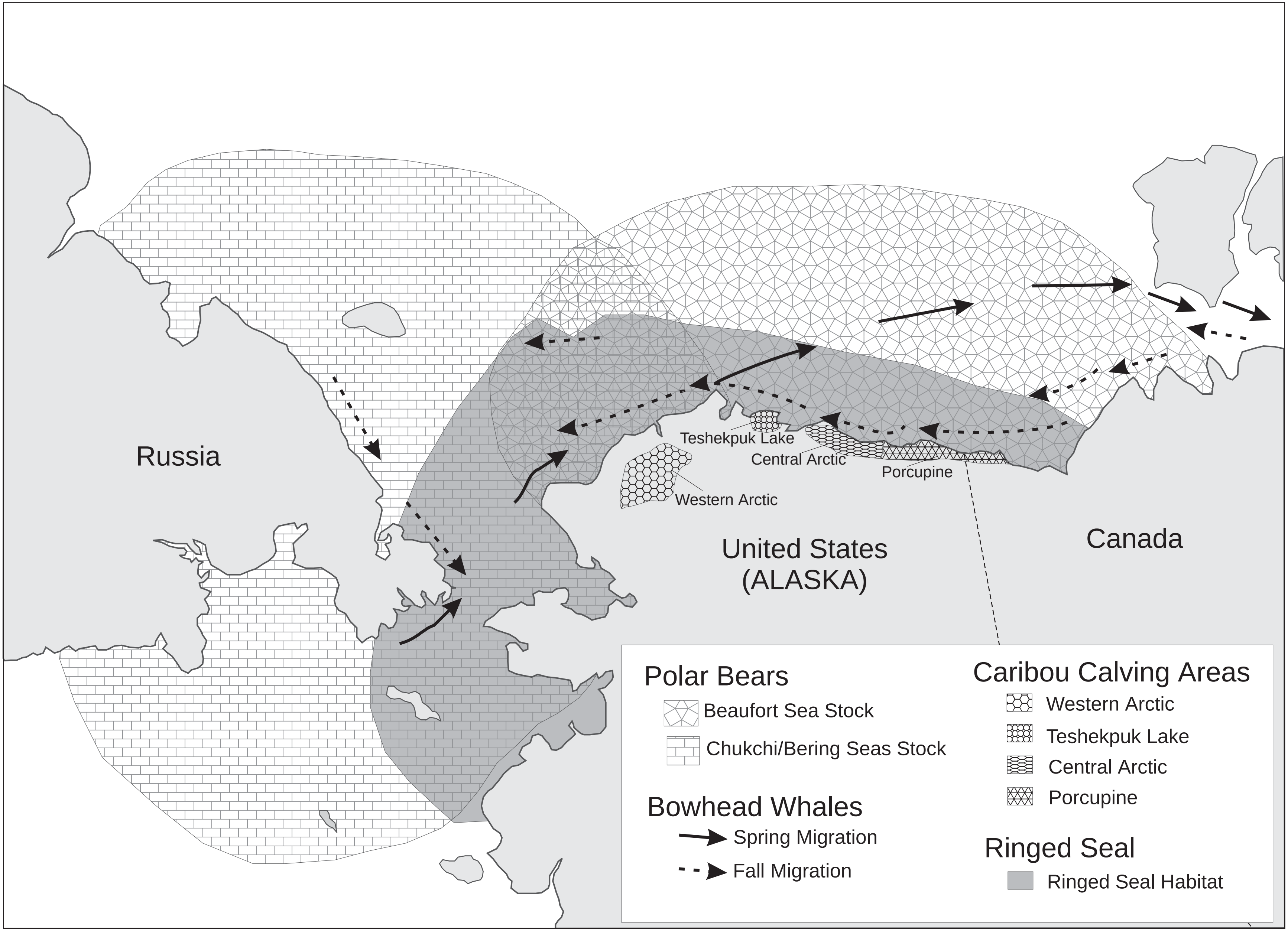


Figure V-4 Polar Bear Stocks, Ringed Seal Habitat, Bowhead Whale Migration Routes, and Caribou Calving Areas.

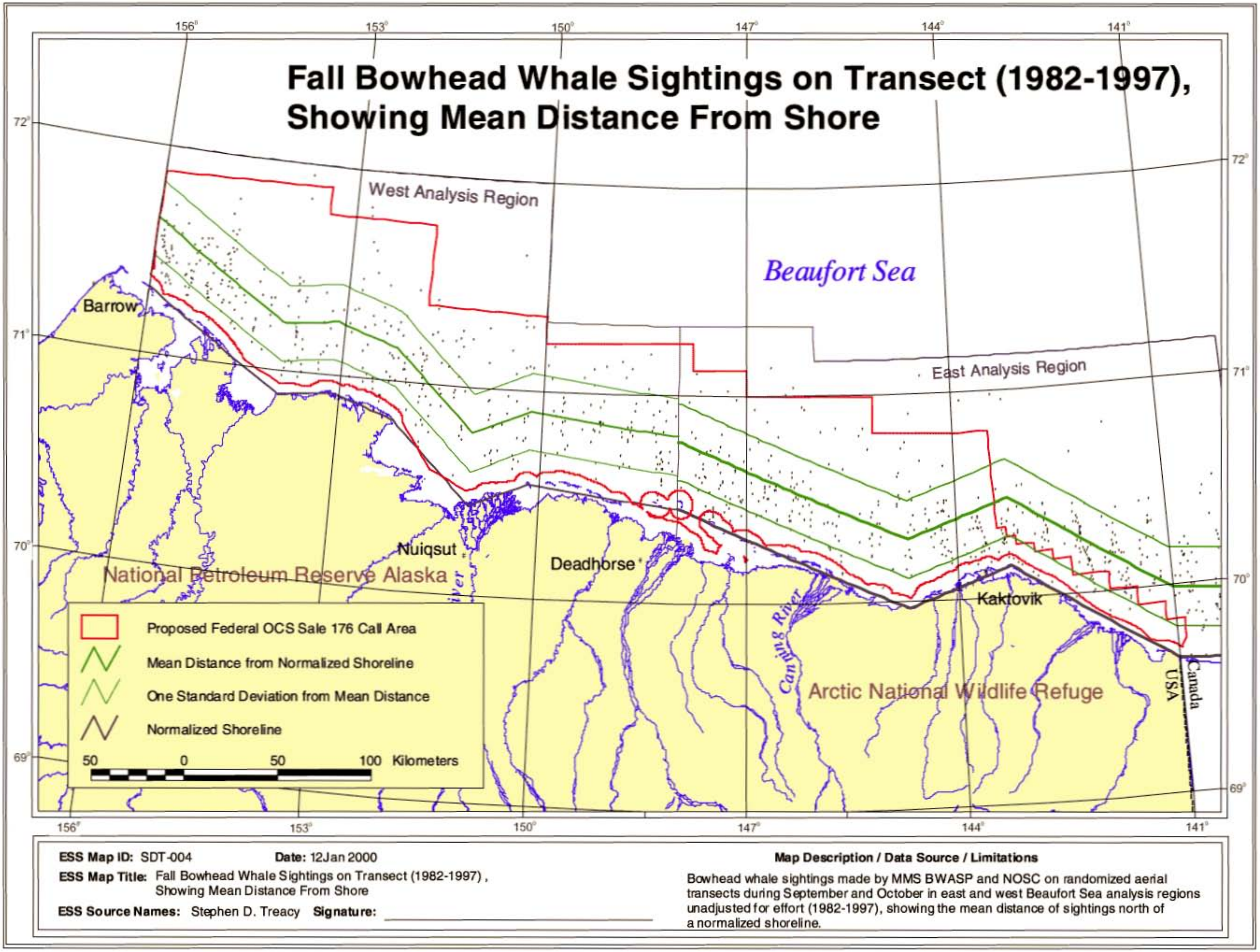


Figure VI.A-1 Fall Bowhead Whale Sightings on Transect (1982-1997), Showing Mean Distance From Shore

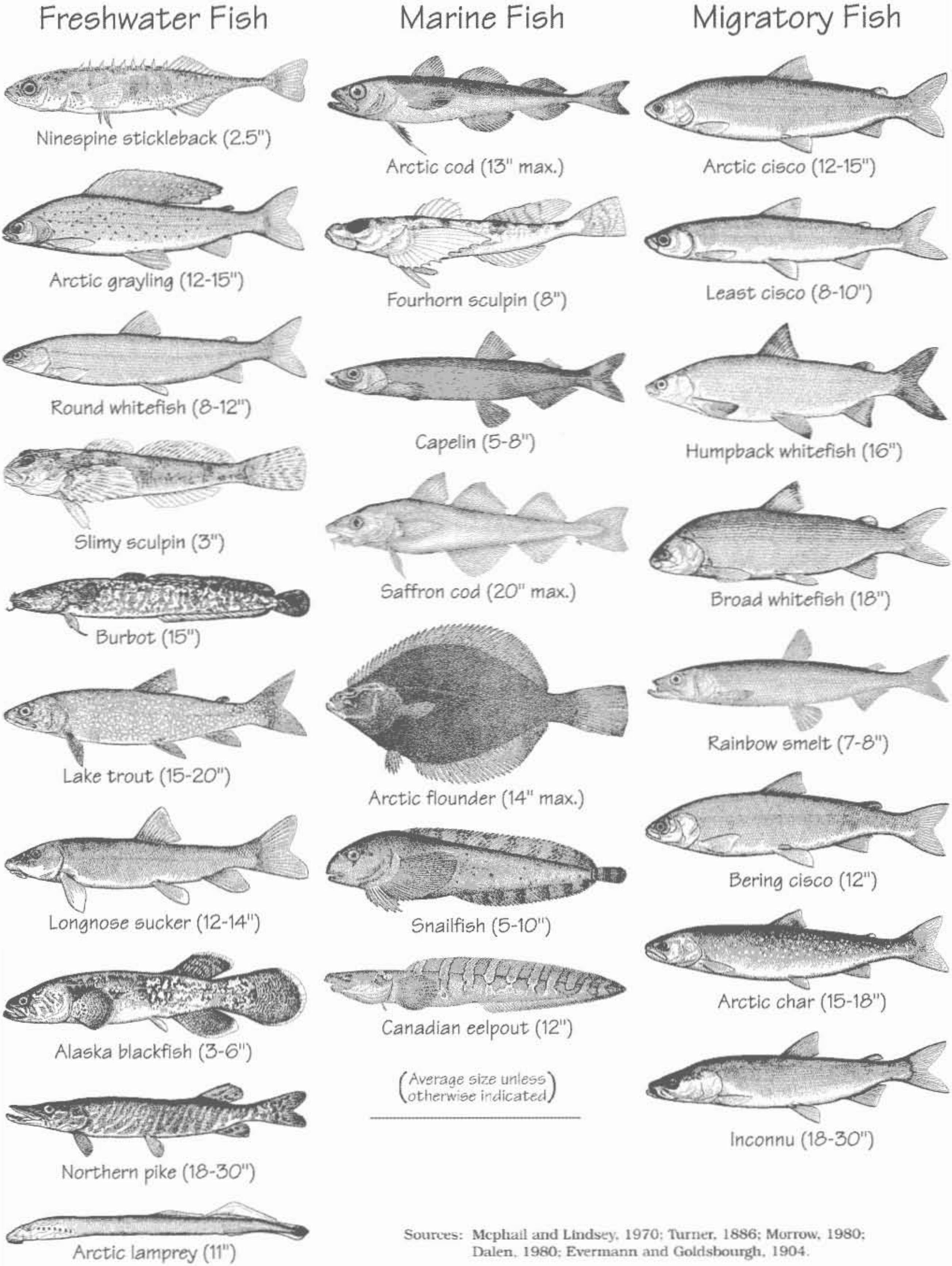


Figure VI.A-2 Fish of the Arctic Environment

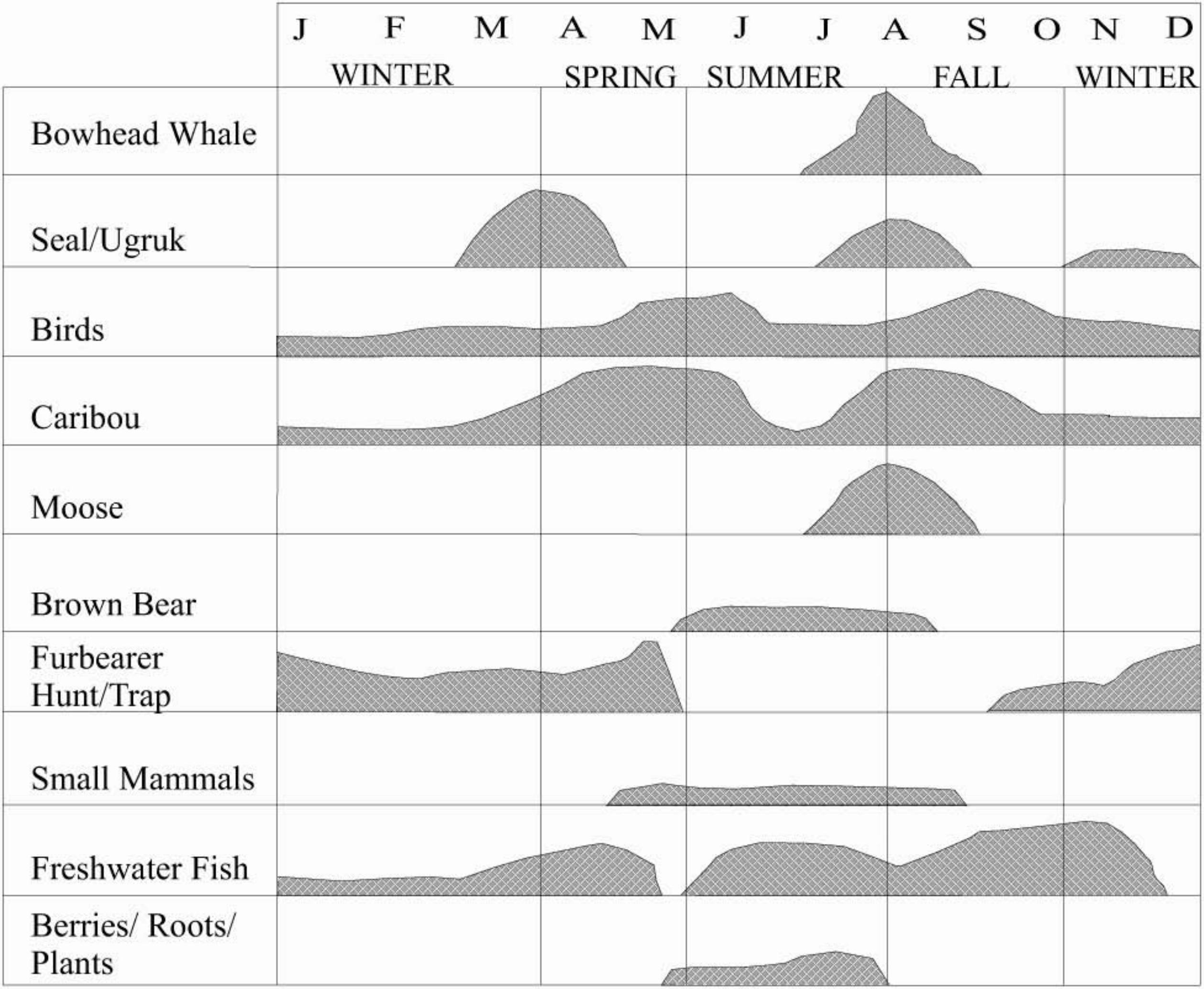


Figure VI.B-1 Nuiqsut Annual Subsistence Cycle. Patterns indicate desired periods for pursuit of each species based upon the relationship of abundance, hunter access, seasonal needs, and desirability. Peaks represent optimal periods of pursuit of subsistence resources. (Data for invertebrates, sheep, and ocean fish are unavailable.)
Source: North Slope Borough Contract Staff, 1979; Impact Assistance, Inc., 1990.

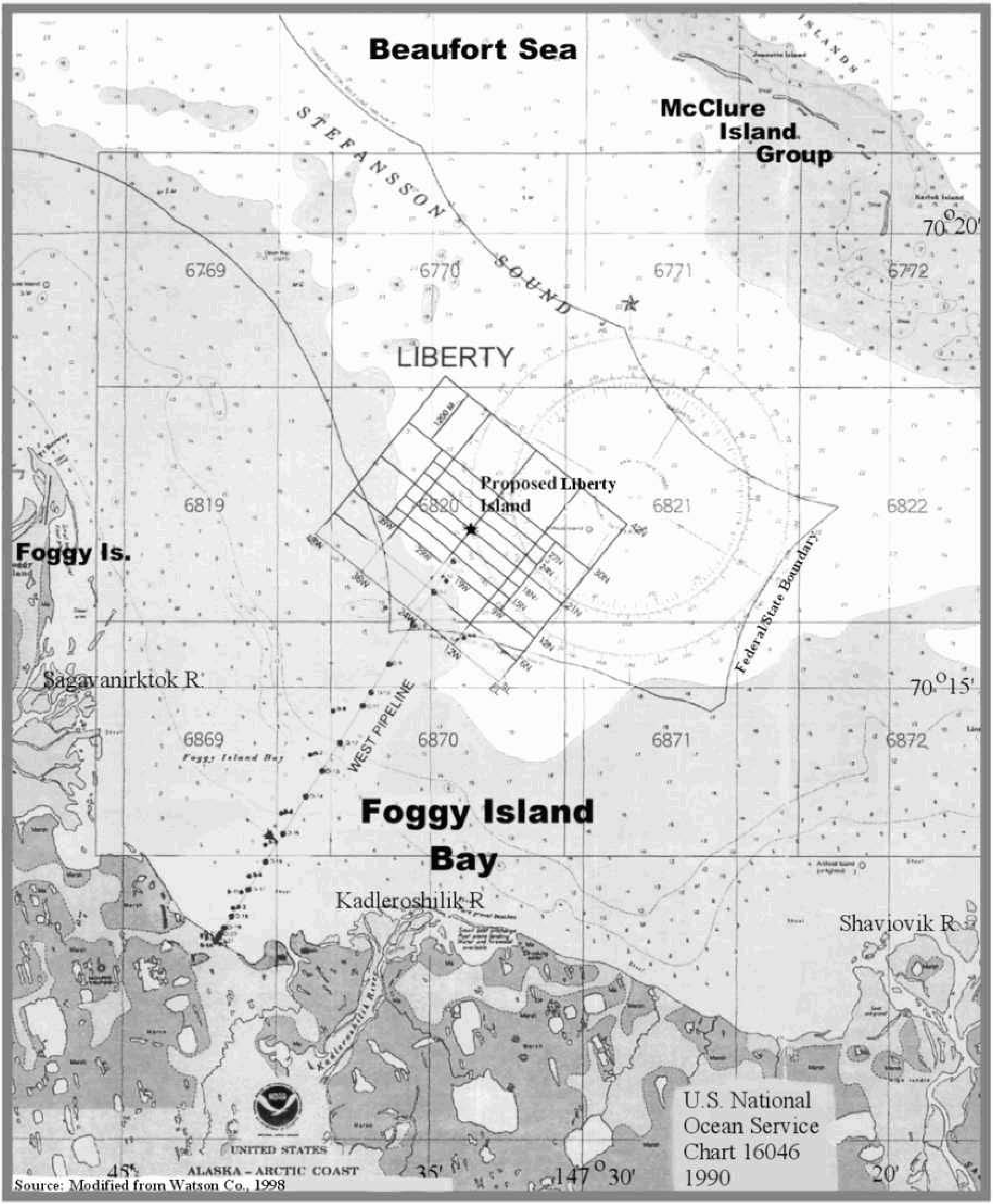


Figure VI.C-1 Index map showing the proposed Liberty Island site, high resolution seismic survey grid, western pipeline route survey line, and core hole locations.

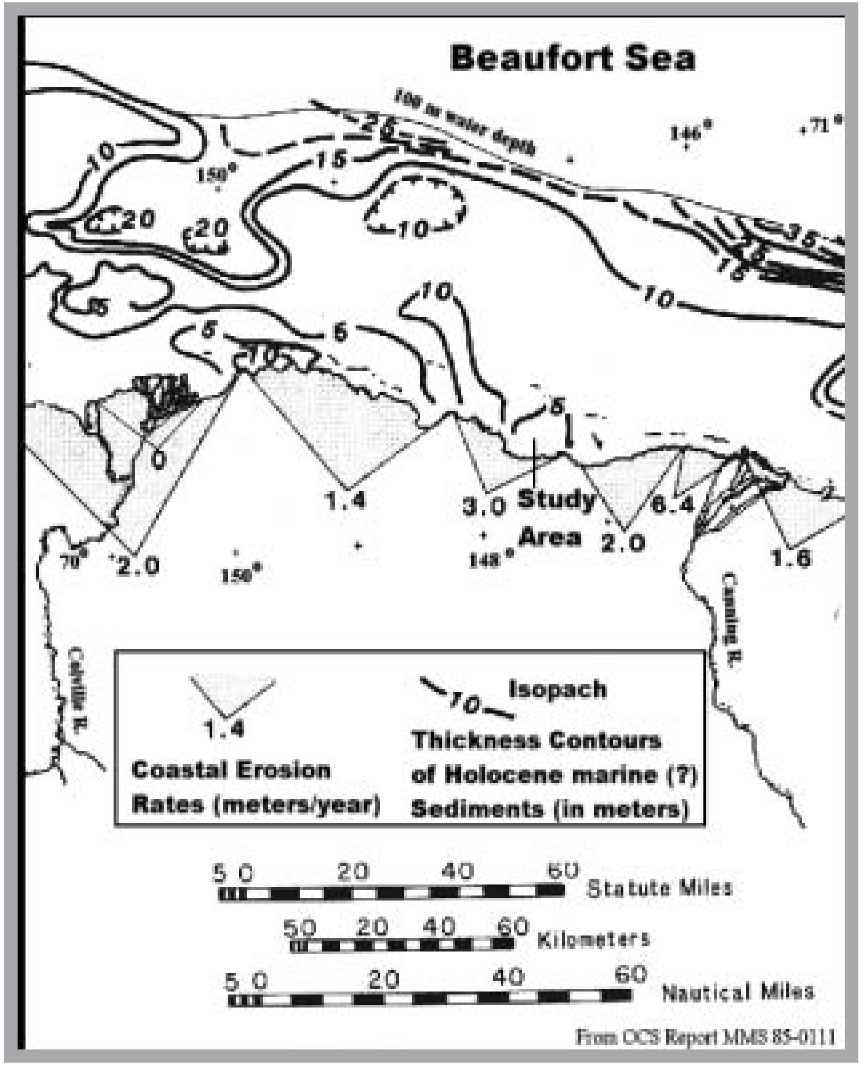


Figure VI.C-2 Isopach map showing thickness of the shallow Holocene, seismically transparent, unit that is interpreted as being composed of marine sediments (modified from Dinter, 1982). Erosion rates for shoreline segments are shown in meters per year and were measured in 20- and 30-year intervals (after Hopkins and Hartz, 1978). This figure is reproduced from the Beaufort Sea Geologic Report (OCS Report MMS 85-0111).

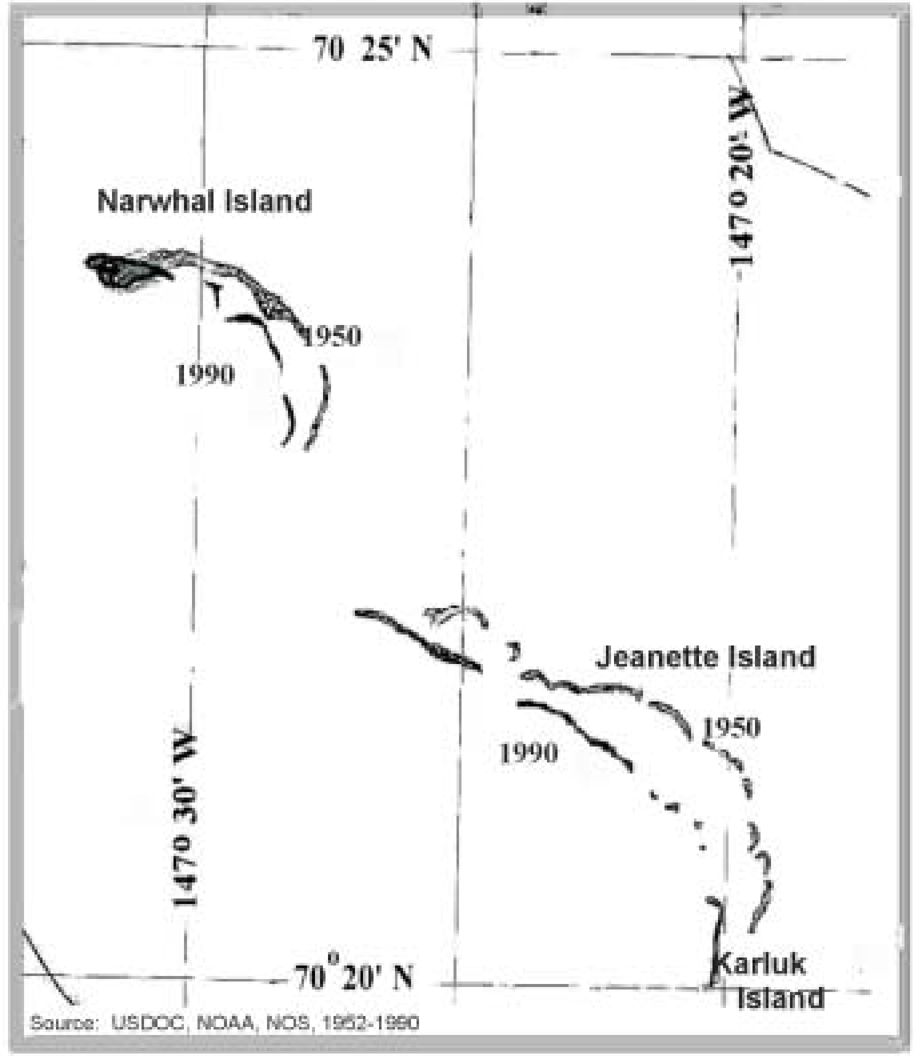


Figure VI.C-3 McClure Island Group. Comparison of island locations from approximately 1950 to approximately 1990 showing net migration to the southwest.

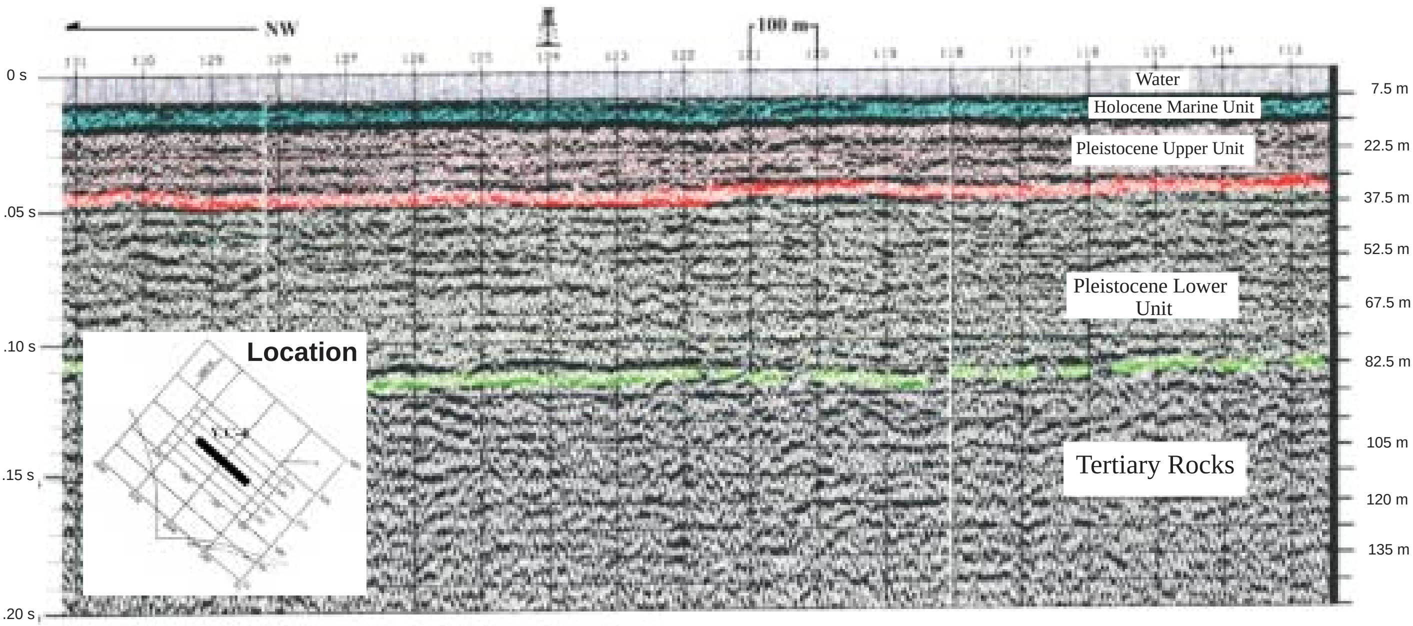


Figure VI.C-4 Minisparker profile record passing through the island site, showing Pleistocene and Holocene stratigraphic units overlying strata of Tertiary age. The uppermost unit, interpreted as Holocene marine sediments, is mapped on a regional scale in Figure VI.C-2. The seismic stratigraphic horizon between the Pleistocene upper and lower units is correlative to "Seismic Horizon 3" of Dinter et. al (1990) shown in Figure V.C-5. Minisparker record from Watson Company Liberty Site Survey.

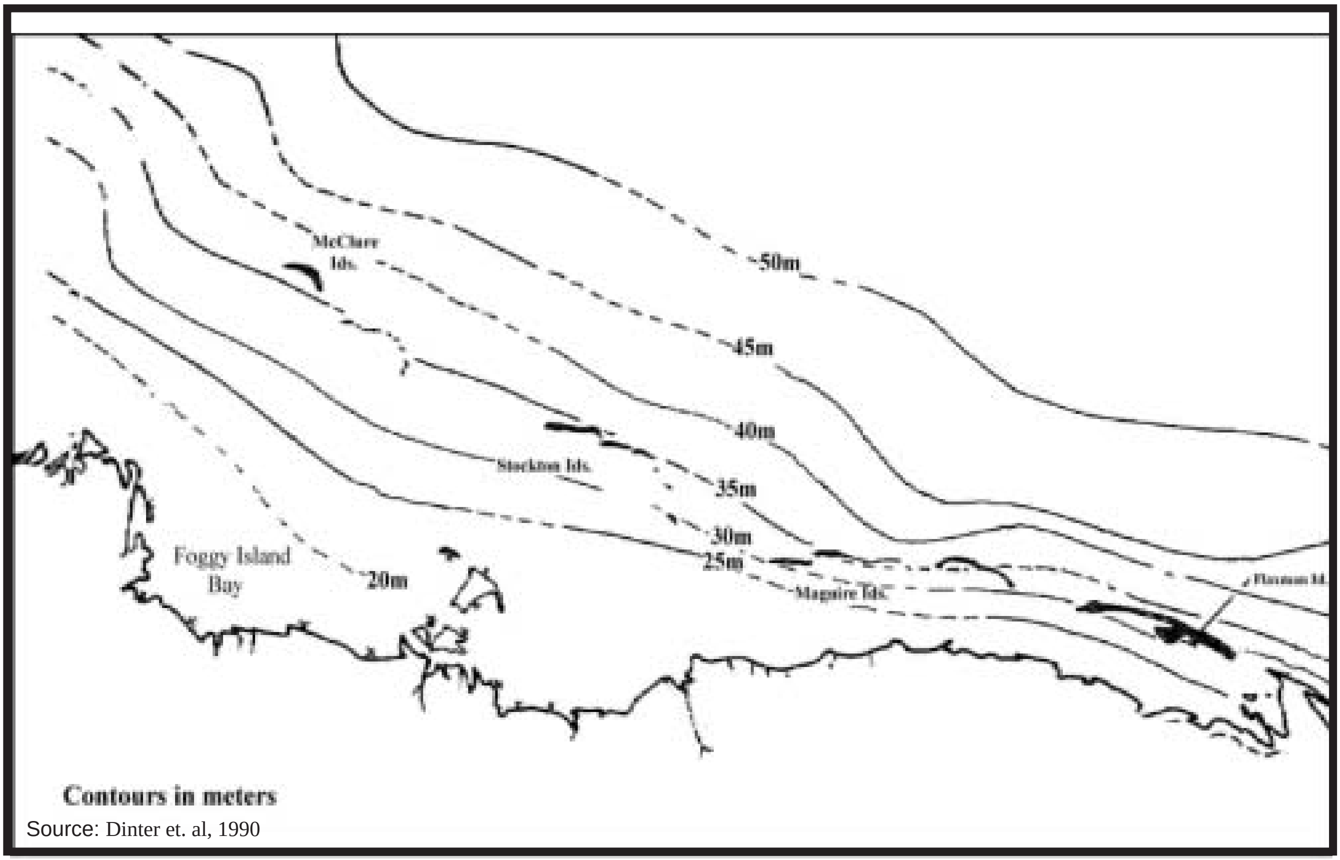


Figure VI.C-5 Generalized contour map on the surface of "Seismic Horizon 3", which separates upper and lower Pleistocene sedimentary units

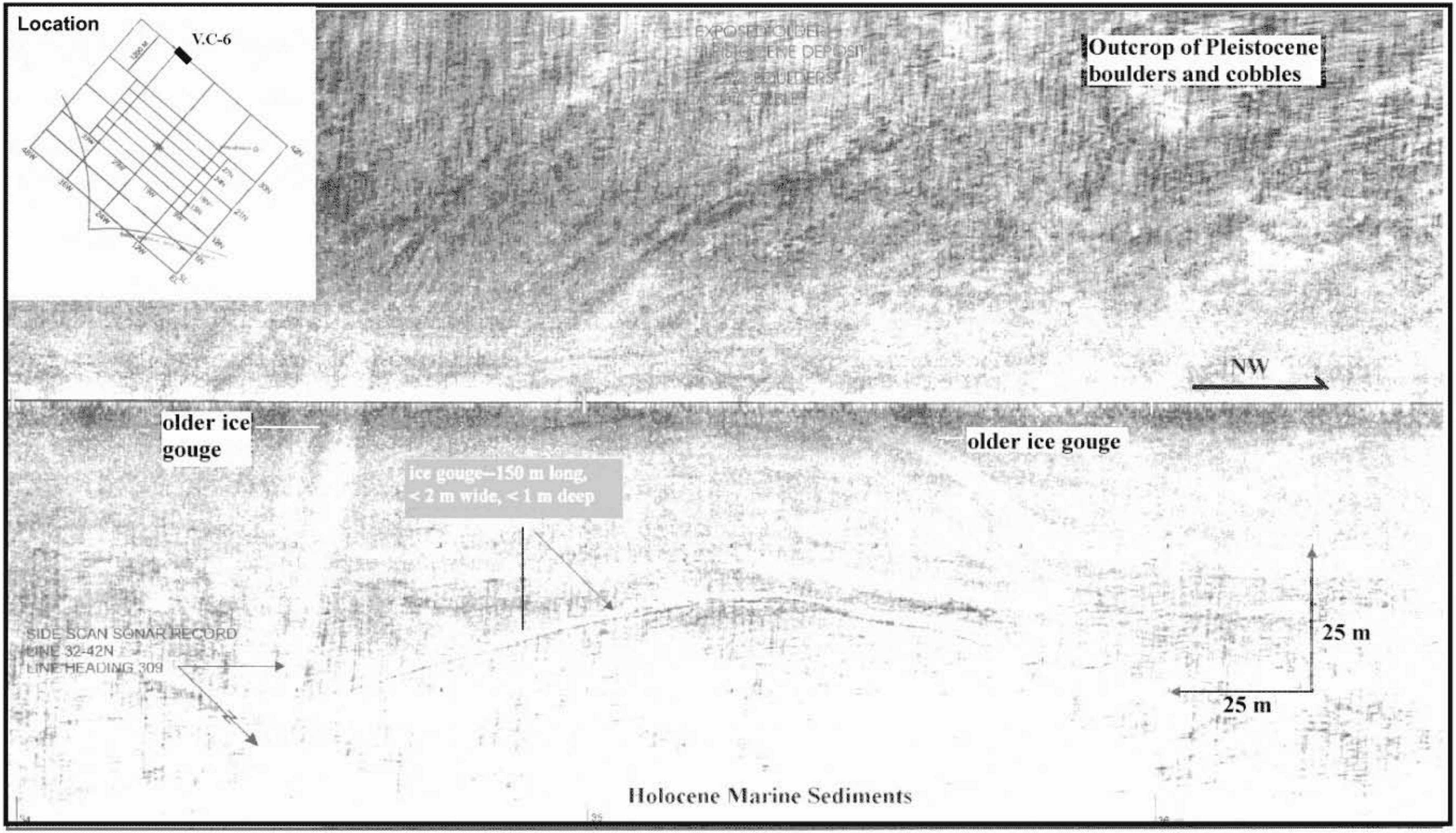


Figure VI.C-6 Side-scan sonar record showing area of boulder and cobbles and adjacent Holocene marine sediments. Older and wide relict ice gouges and young narrow ice gouges can be seen in the sediments. Side-scan sonar record from Watson Company Liberty Site survey.

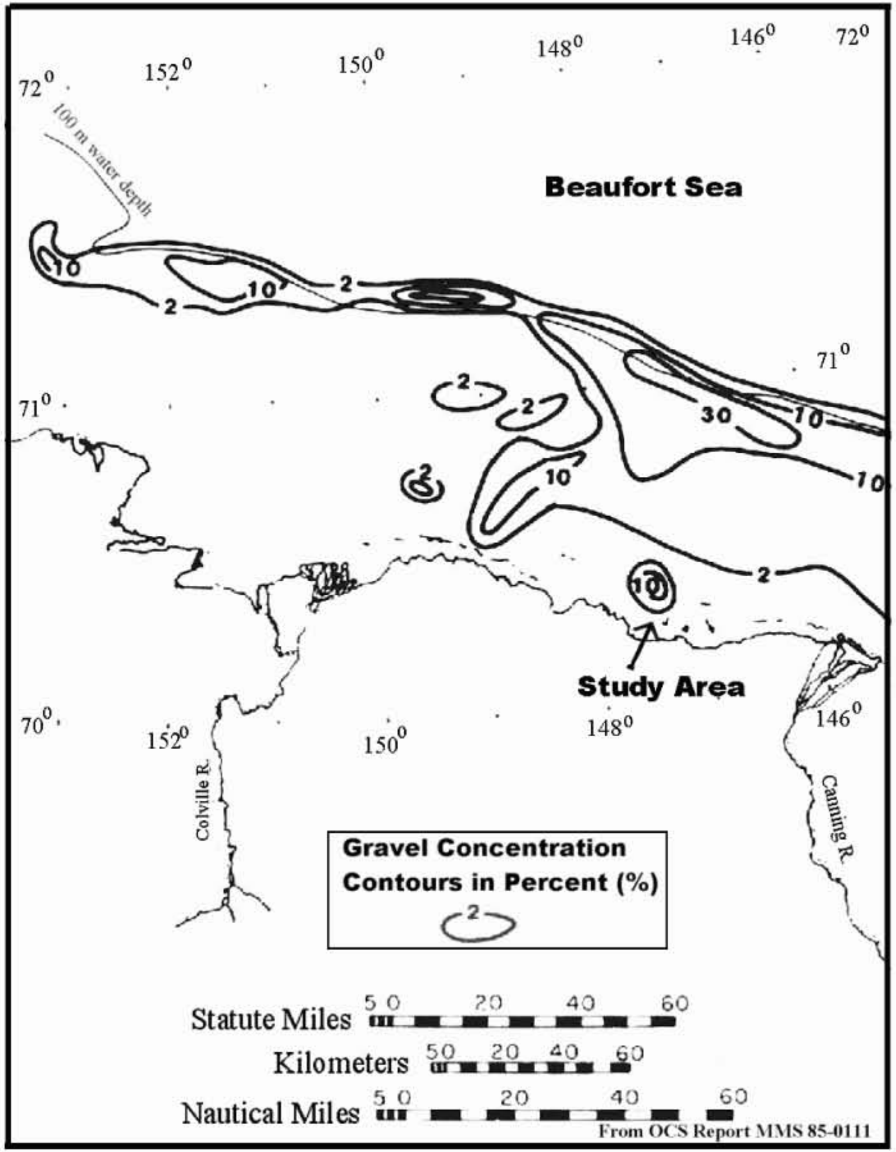


Figure VI.C-7 Regional Distribution of Gravel (>2mm) in the Central Beaufort Sea

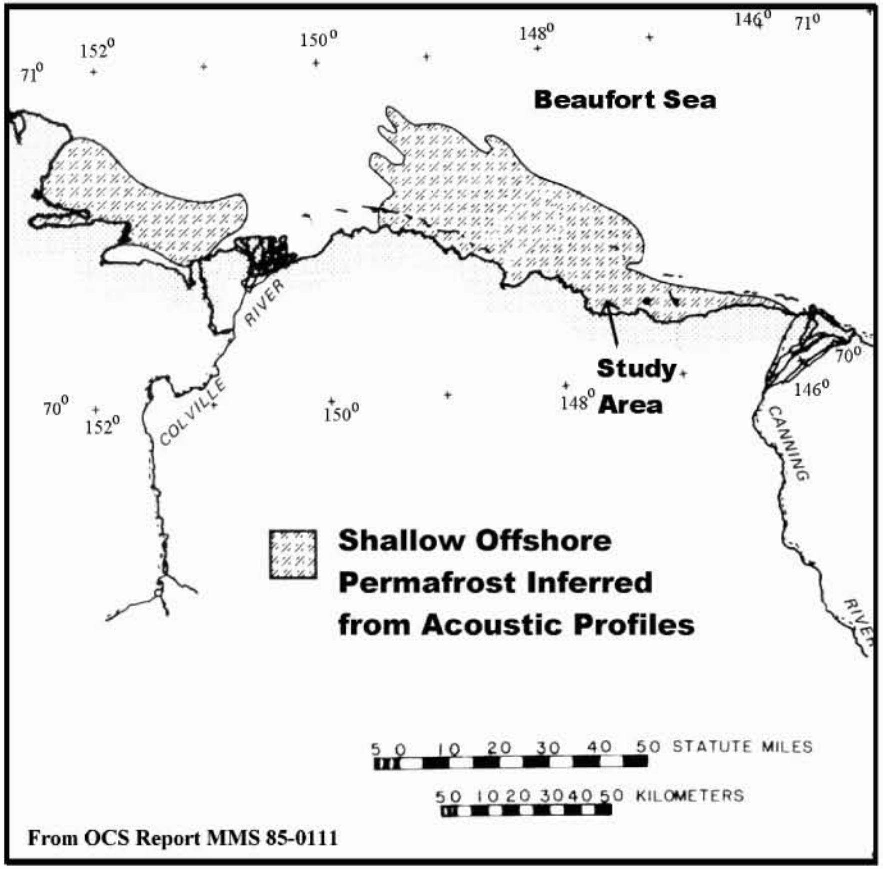


Figure VI.C-8 Regional Inferred Shallow Permafrost

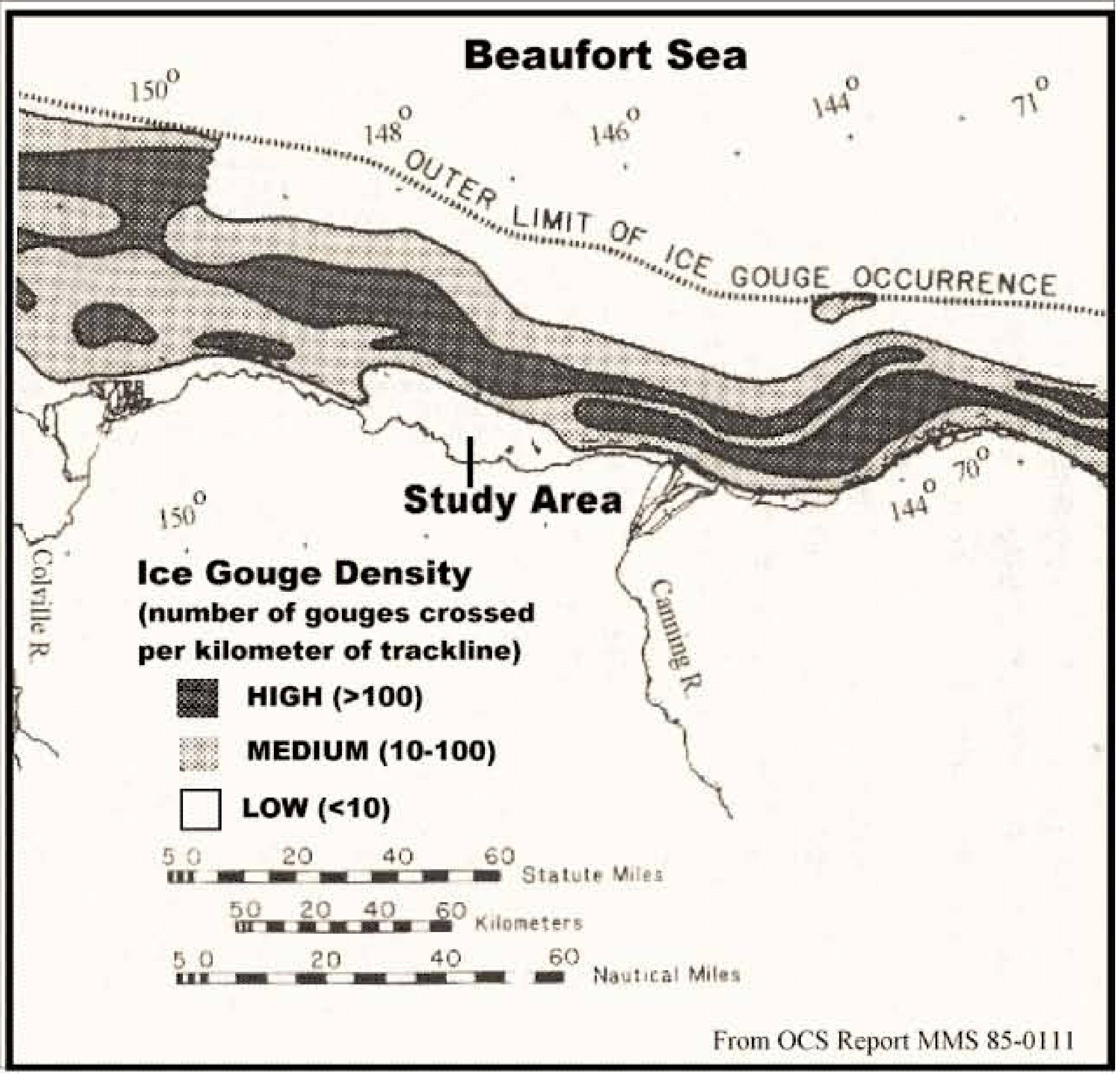
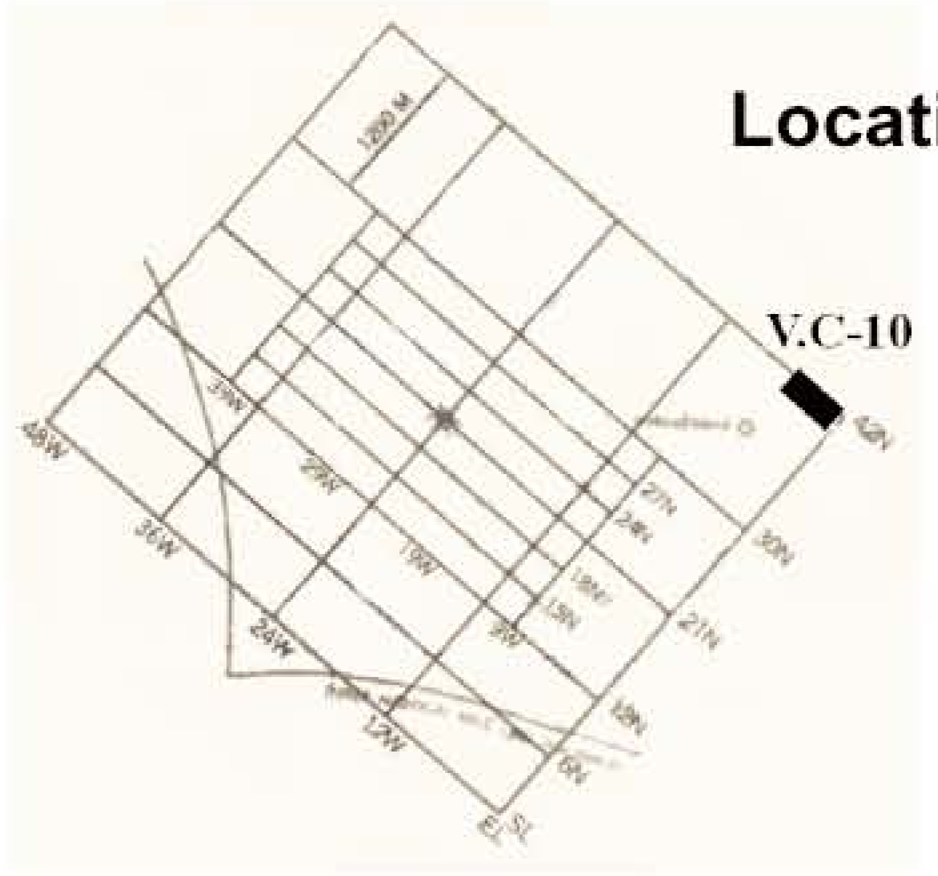


Figure VI.C-9 General distribution of ice gouge density based on the number of ice gouge crossings on acoustic data during USGS marine survey (Barnes, 1981). Modified figure from the Beaufort Sea Geologic Report (OCS Report MMS 85-01 11)



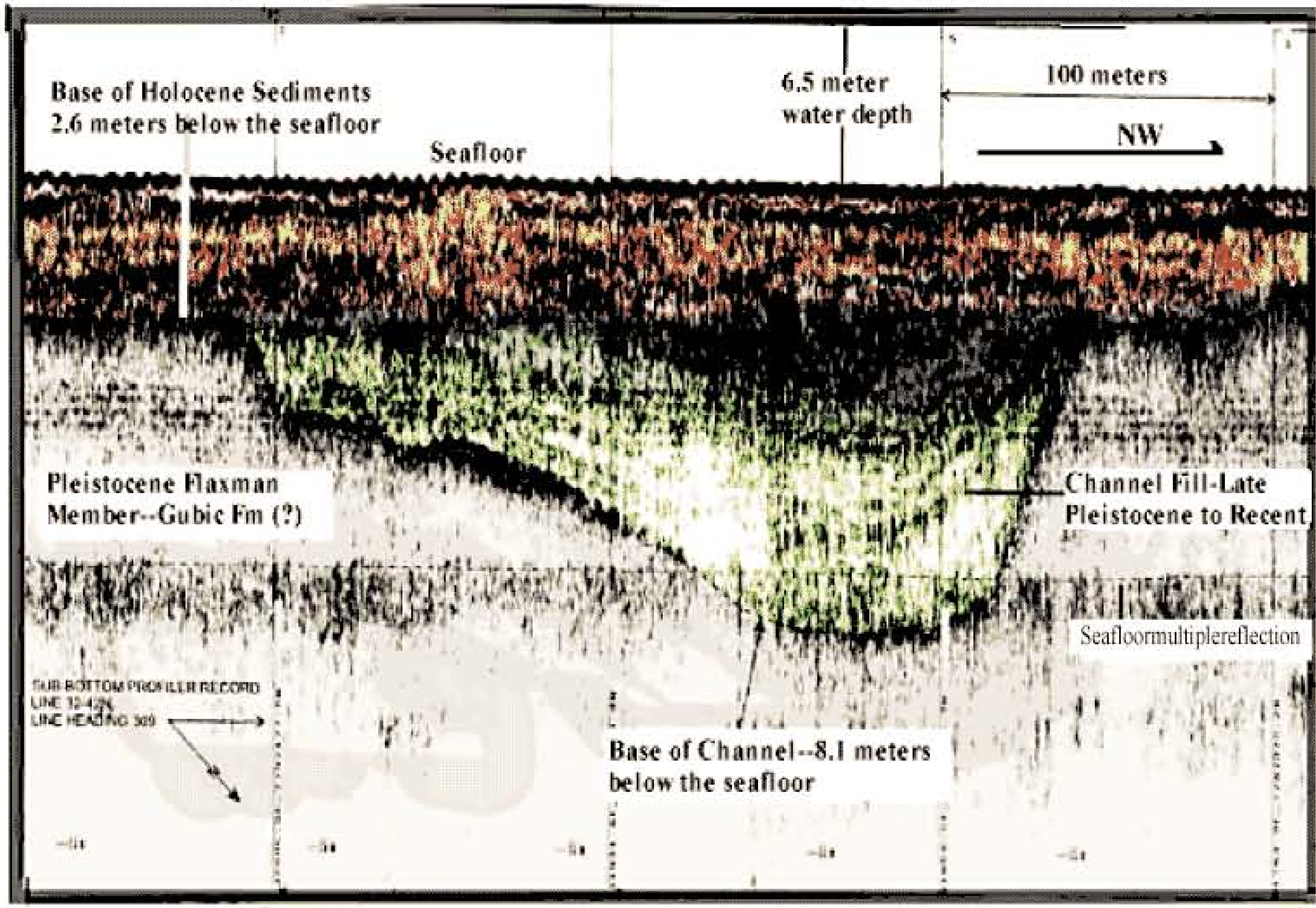


Figure VI.C-10 "Chirp" high-resolution seismic profile records showing a submerged buried Pleistocene or Holocene channel. At a lower sea level, the channel cut into Pleistocene sedients approximately 5.5 meters. After sea level rose, it was drowned and subsequently covered by 2.6 meters of Holocene marine sediments. Record from Watson Company Liberty Site survey.

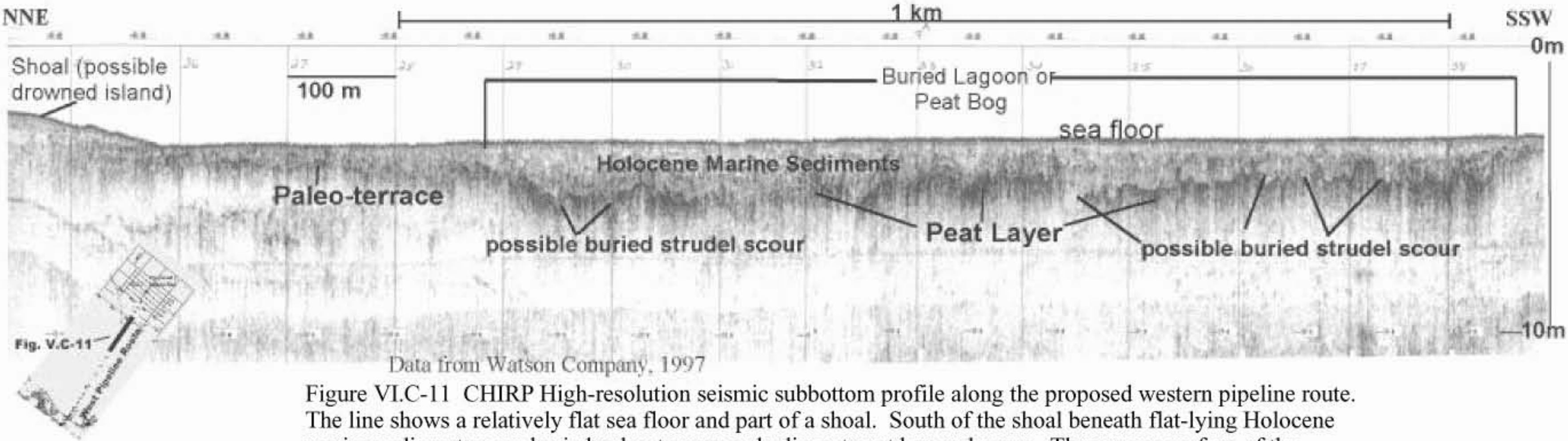


Figure VI.C-11 CHIRP High-resolution seismic subbottom profile along the proposed western pipeline route. The line shows a relatively flat sea floor and part of a shoal. South of the shoal beneath flat-lying Holocene marine sediments are a buried paleo-terrace and adjacent peat bog or lagoon. The uneven surface of the peat layer may be due to repeated downward excavation by strudel scouring. Water depths range from about 19 feet (5.8 meters) at the center of the record to 15 feet (4.5 meters) over the shoal. Vertical exaggeration is approximately 2.5 to 1.

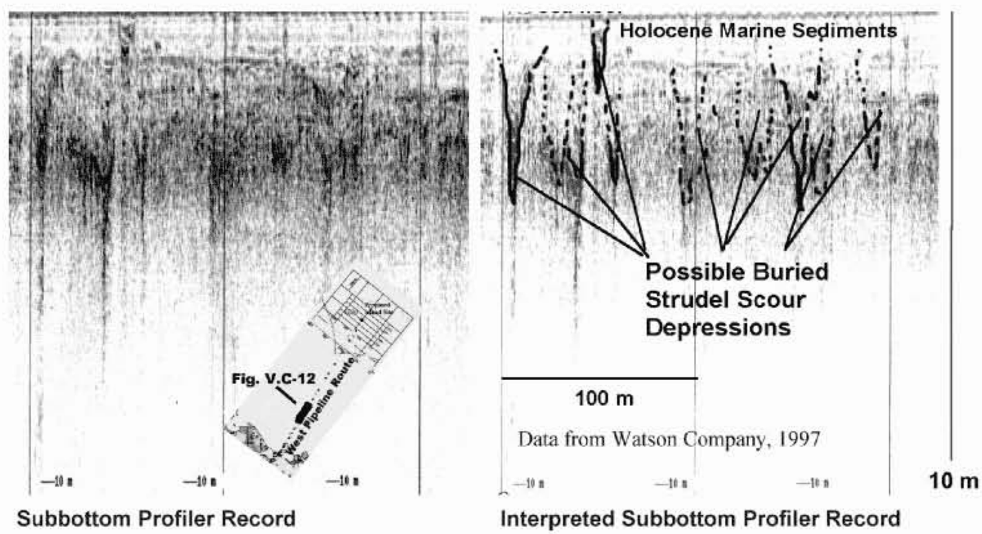
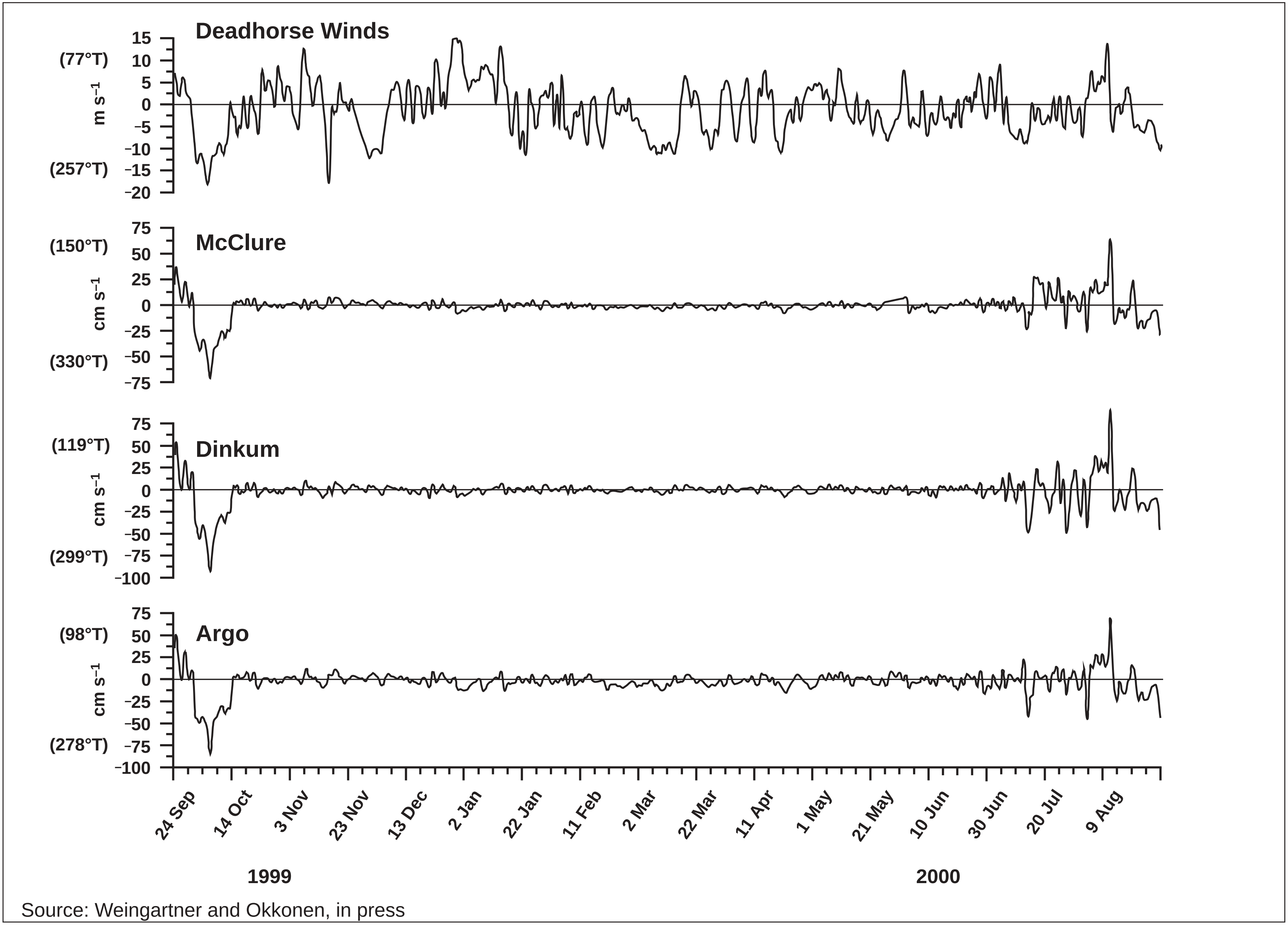


Figure VI.C-12 Comparison of an uninterpreted and an interpreted CHIRP high-resolution subbottom profile record along the southern end of the proposed western pipeline route. The interpretation at right outlines anomalies that may be filled-in strudel scour depressions. Water depth is 7.5 feet (2.3 meters). Vertical exaggeration is approximately 2.5 to 1.



Source: Weingartner and Okkonen, in press

Figure VI.C-13 Winds and currents projected along their principal axis of variance. The direction of the positive and negative values at each location is indicated along the ordinate. The currents were low-pass filtered to suppress diurnal and semi-diurnal tidal fluctuations. The winds were smoothed with a 25-hour running mean.

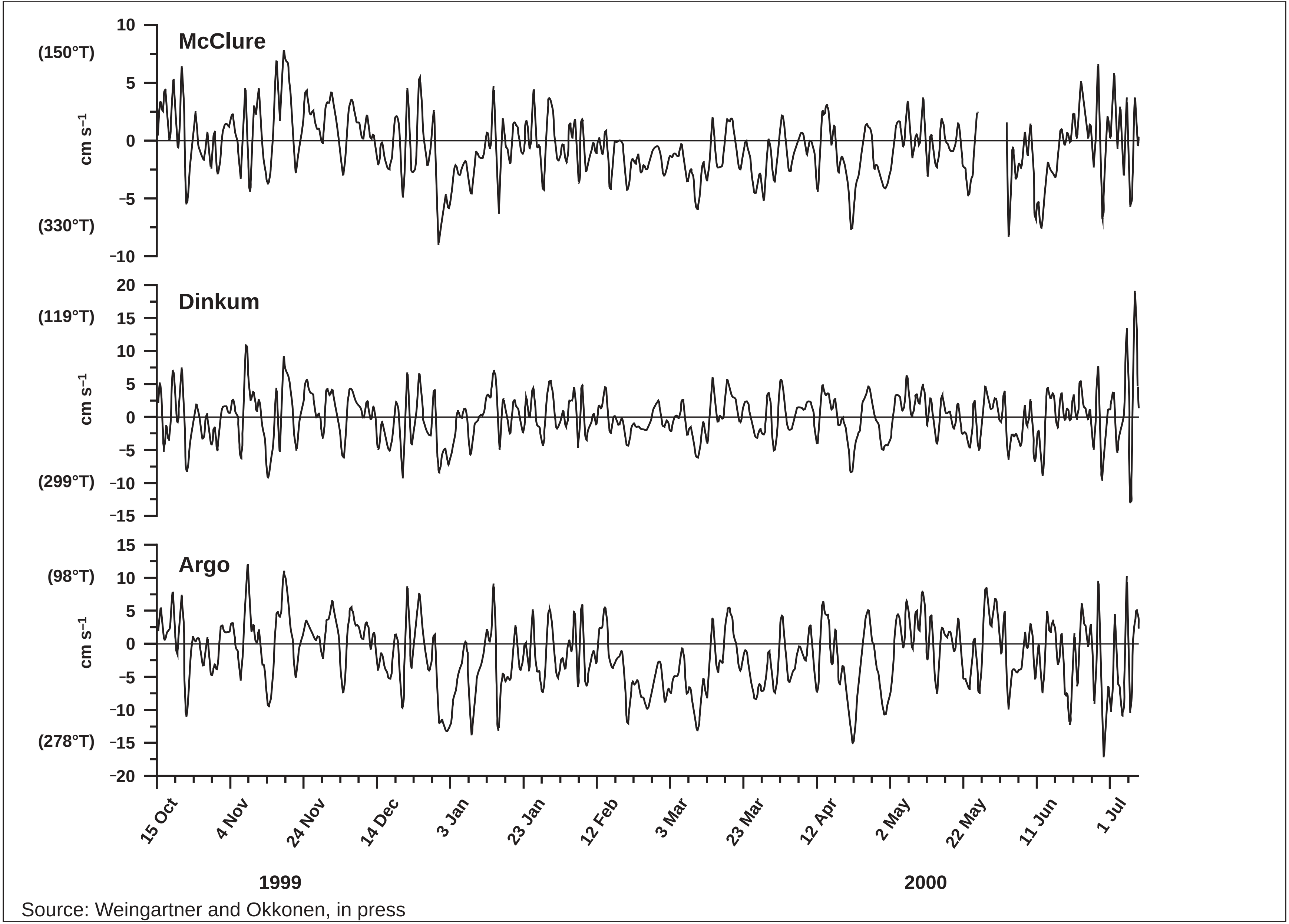


Figure VI.C-14 Time series of the (unfiltered) current from 1.5m above the acoustic doppler current profiler projected onto the principal axis of variance during the landfast ice period.

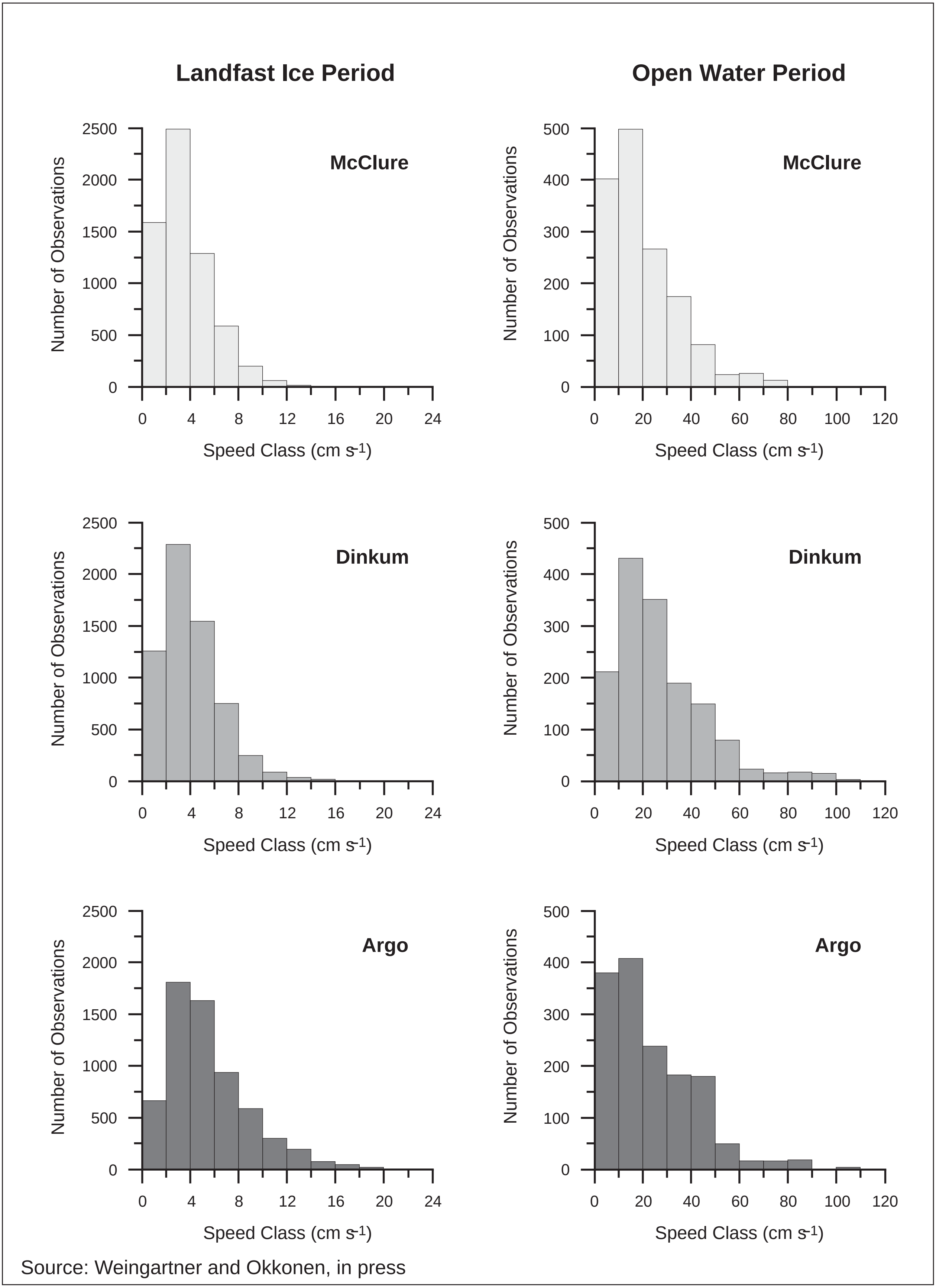
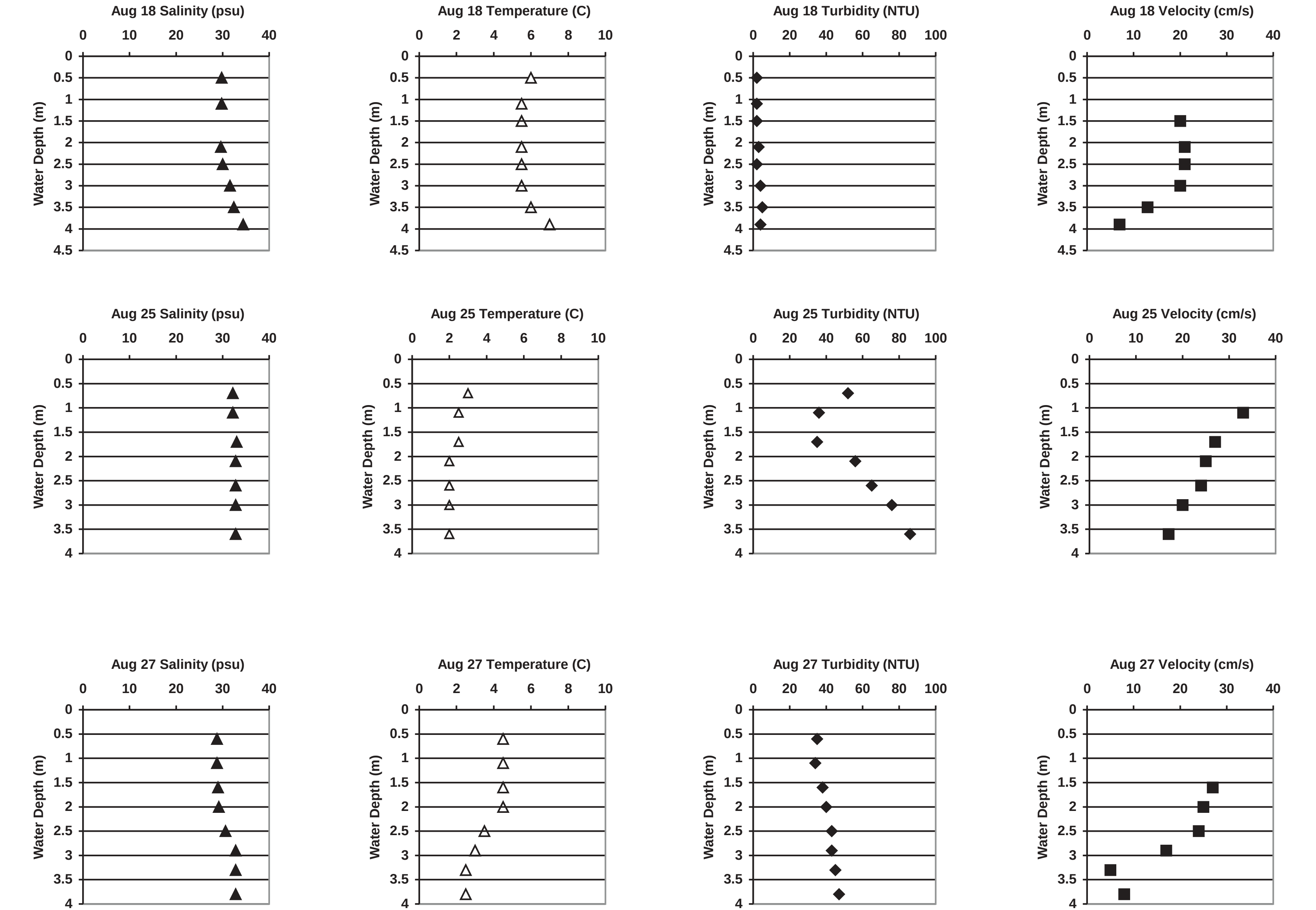
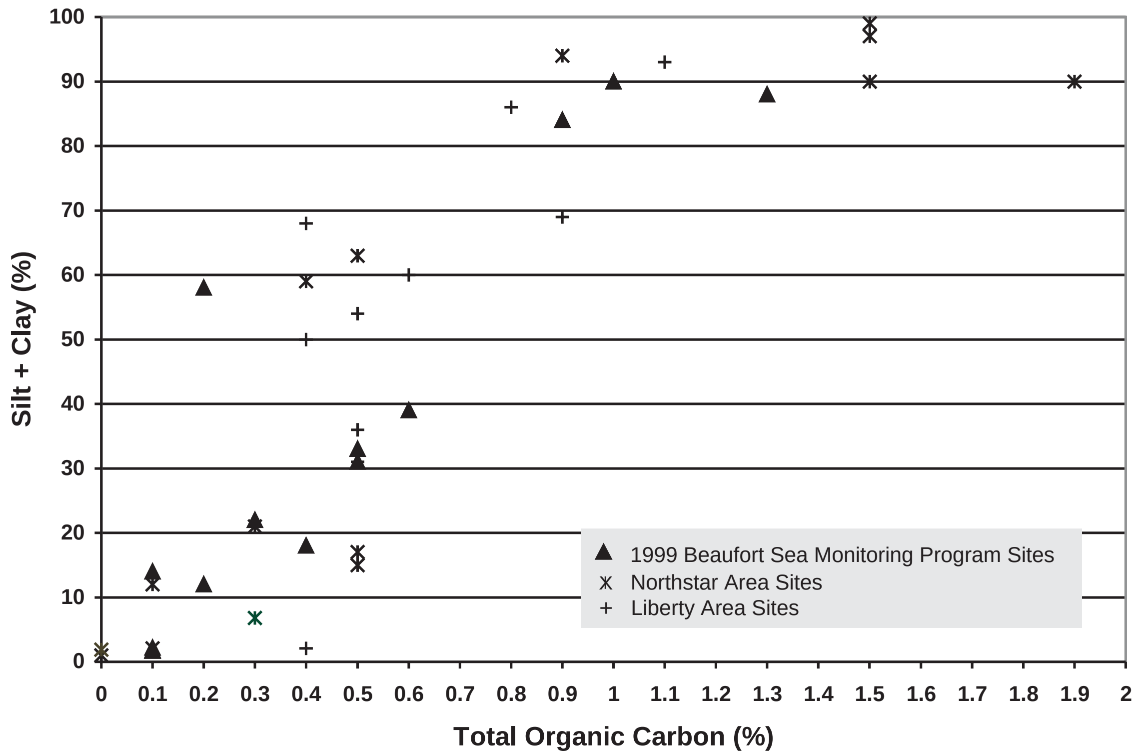


Figure VI.C-15 Histograms of current speed during the landfast ice and open water period.



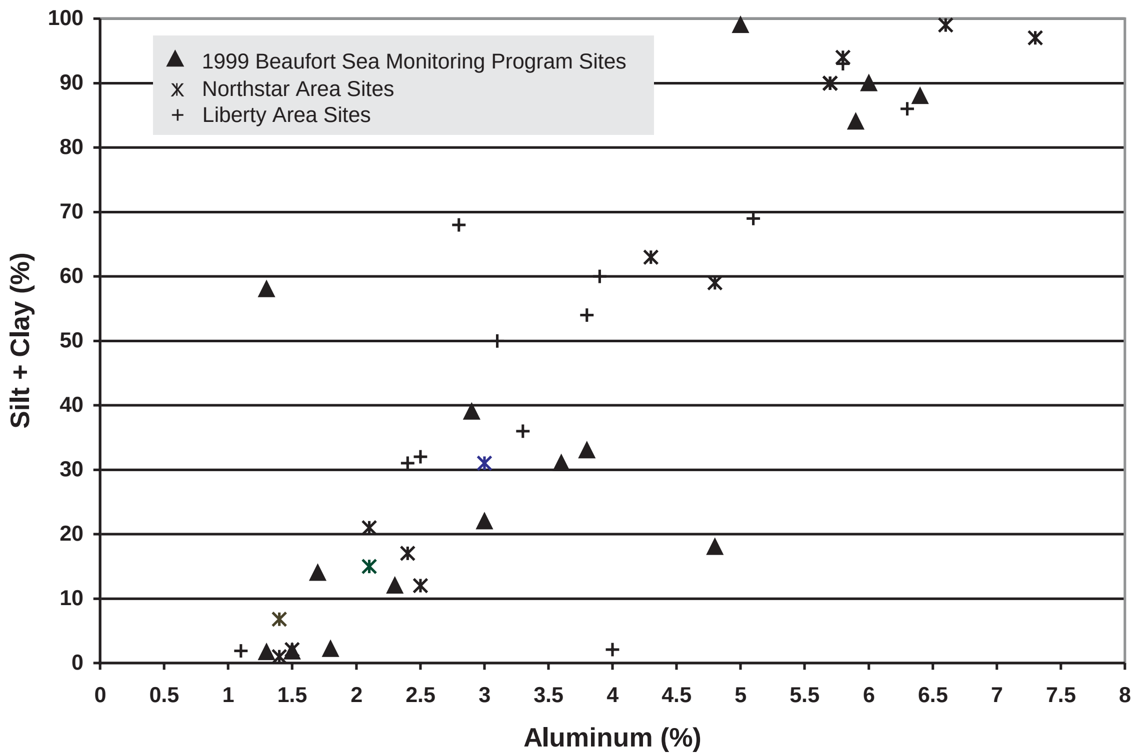
Source: Boehm et al., 2001

Figure VI.C-16 Vertical Profiles for Salinity, Temperature, Turbidity (*In Situ*), and Current Velocity at a Site (N13) Southwest of Northstar Island during 1999 before and after Storm Conditions



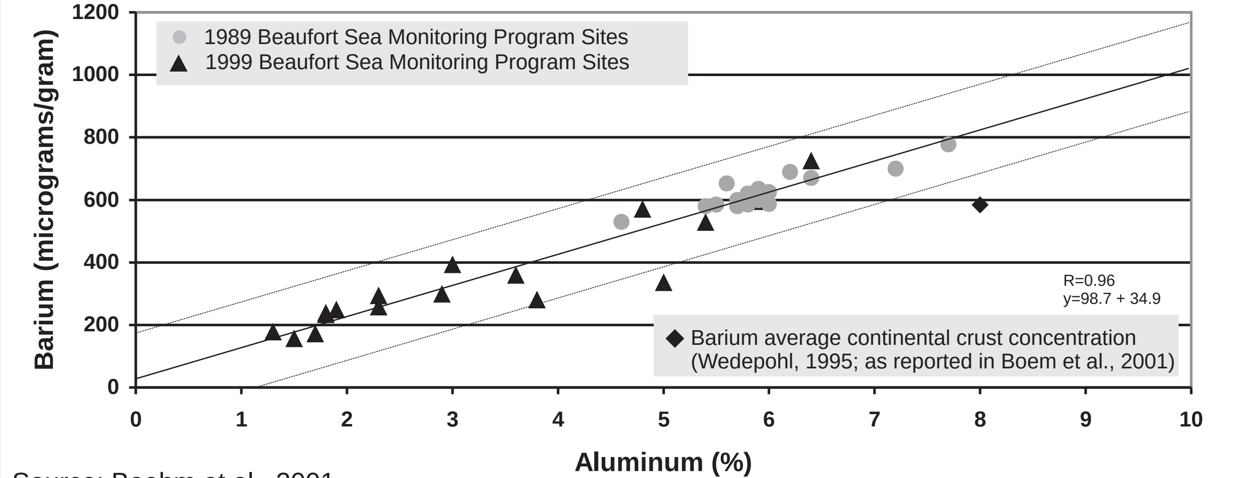
Source: Boehm et al., 2001

Figure VI.C-17 Total Organic Carbon versus Silt + Clay for Surficial Sediments from 1999 Beaufort Sea Monitoring Program, Northstar Area and Liberty Area Sites.



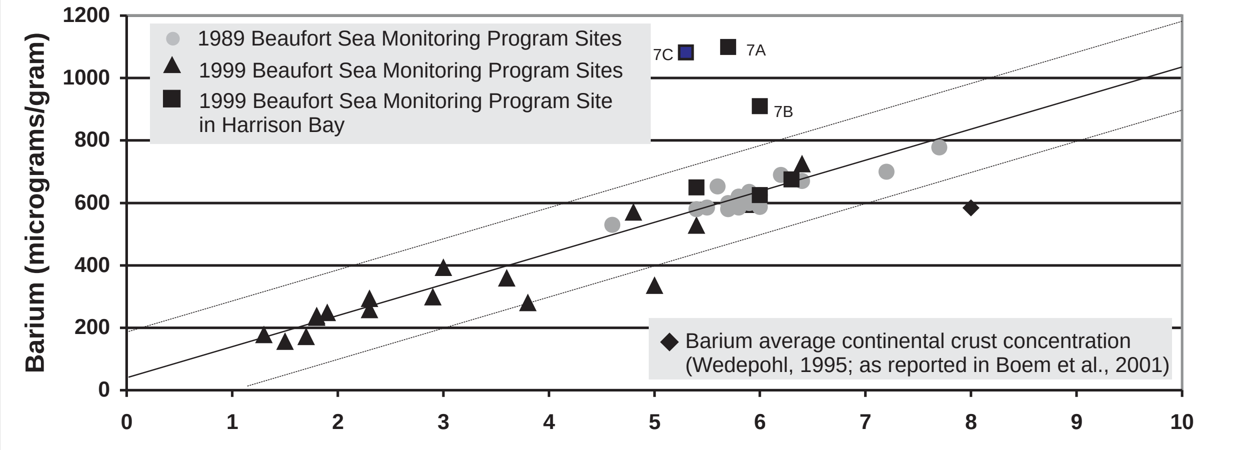
Source: Boehm et al., 2001

Figure VI.C-18 Concentration of Aluminum versus Silt + Clay for Surficial Sediments from 1999 Beaufort Sea Monitoring Program, Northstar Area and Liberty Area Sites.



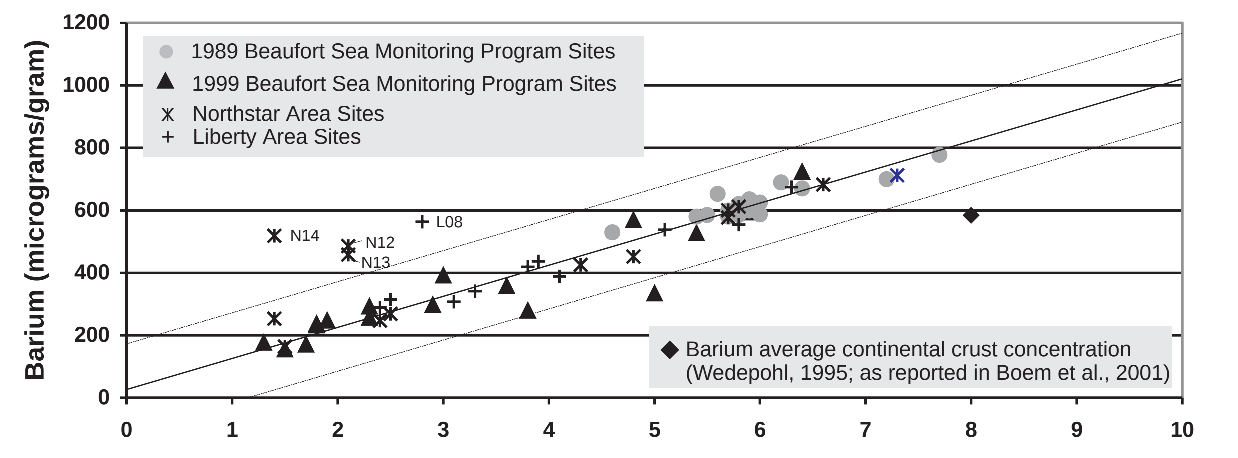
Source: Boehm et al., 2001

Figure VI.C-19a Concentrations of Aluminum versus Barium in Surficial Sediments from 1989 and 1999 Beaufort Sea Monitoring Program Sites



Source: Boehm et al., 2001

Figure VI.C-19b Concentrations of Aluminum versus Barium in Surficial Sediments from 1989 and 1999 Beaufort Sea Monitoring Program Sites and 1989 BSMP Harrison Bay Sites



Source: Boehm et al., 2001

Figure VI.C-19c Concentrations of Aluminum versus Barium in Surficial Sediments from 1989 and 1999 Beaufort Sea Monitoring Program Sites and Northstar Area and Liberty Area Sites

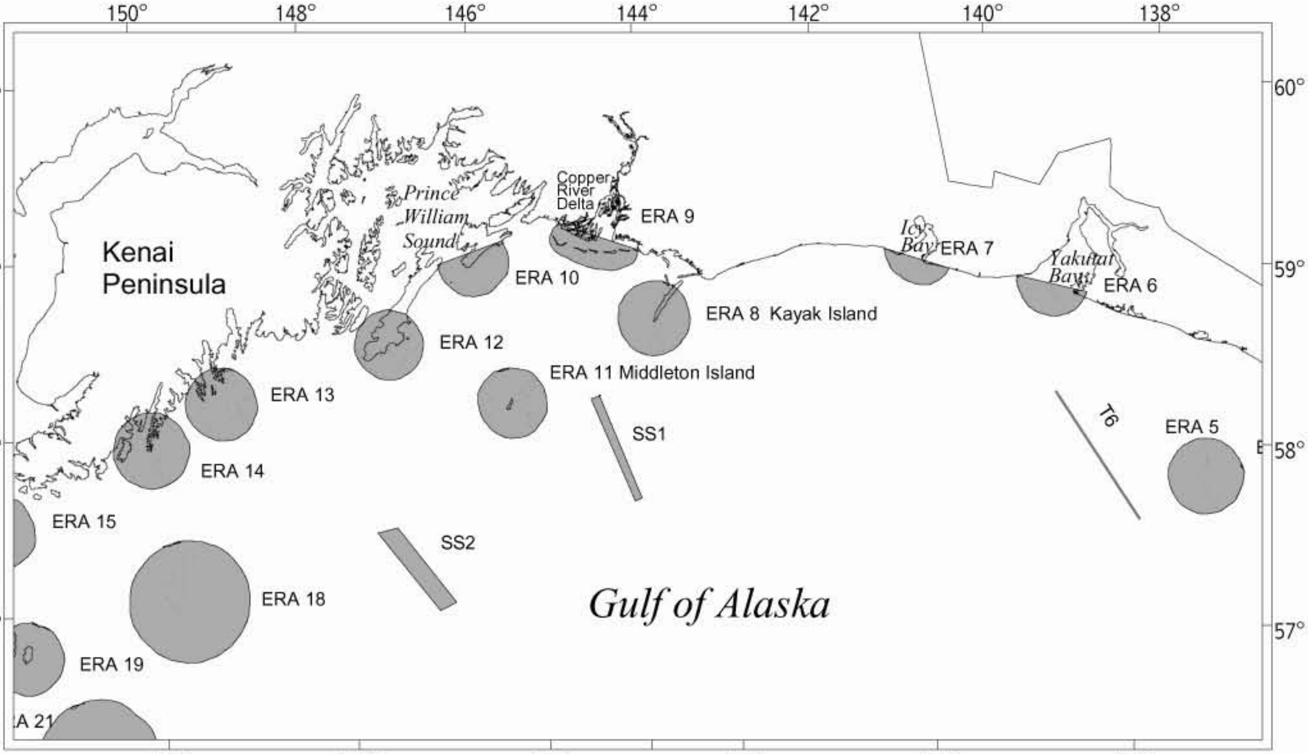


Figure IX-1a. Environmental Resource Areas, Sea Segments and Tanker Segment T6 Used in the Analysis of a Tanker Spill in the Gulf of Alaska

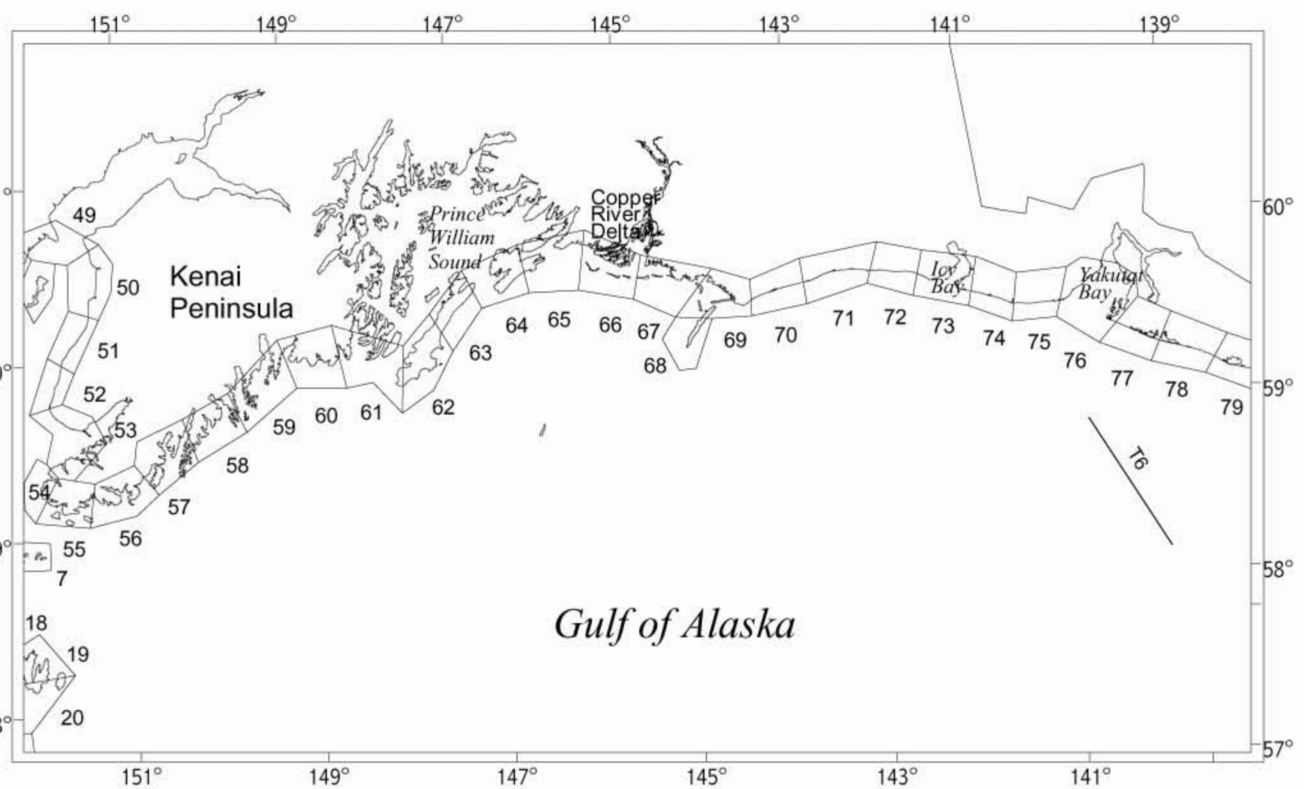


Figure IX-1b. Land Segments and Tanker Segment T6 Used in the Analysis of a Tanker Spill in the Gulf of Alaska

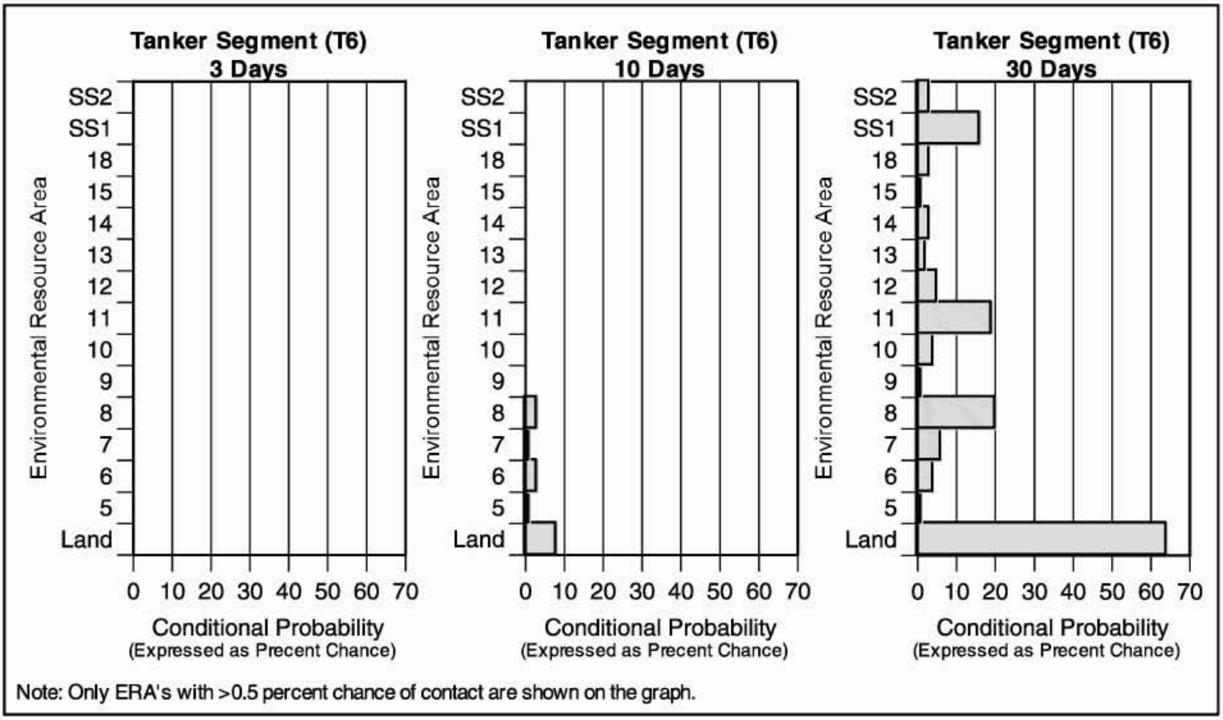


Figure IX-2a. Estimated Conditional Probabilities (expressed as percent chance) Than an Oil Spill Greater Than or Equal to 1,000 Barrels Starting at Tanker Segment T6 in the Summer Season Will Contact Certain Environmental Resource Areas (ERA), Sea Segments (SS) and Land within 3, 10 or 30 Days

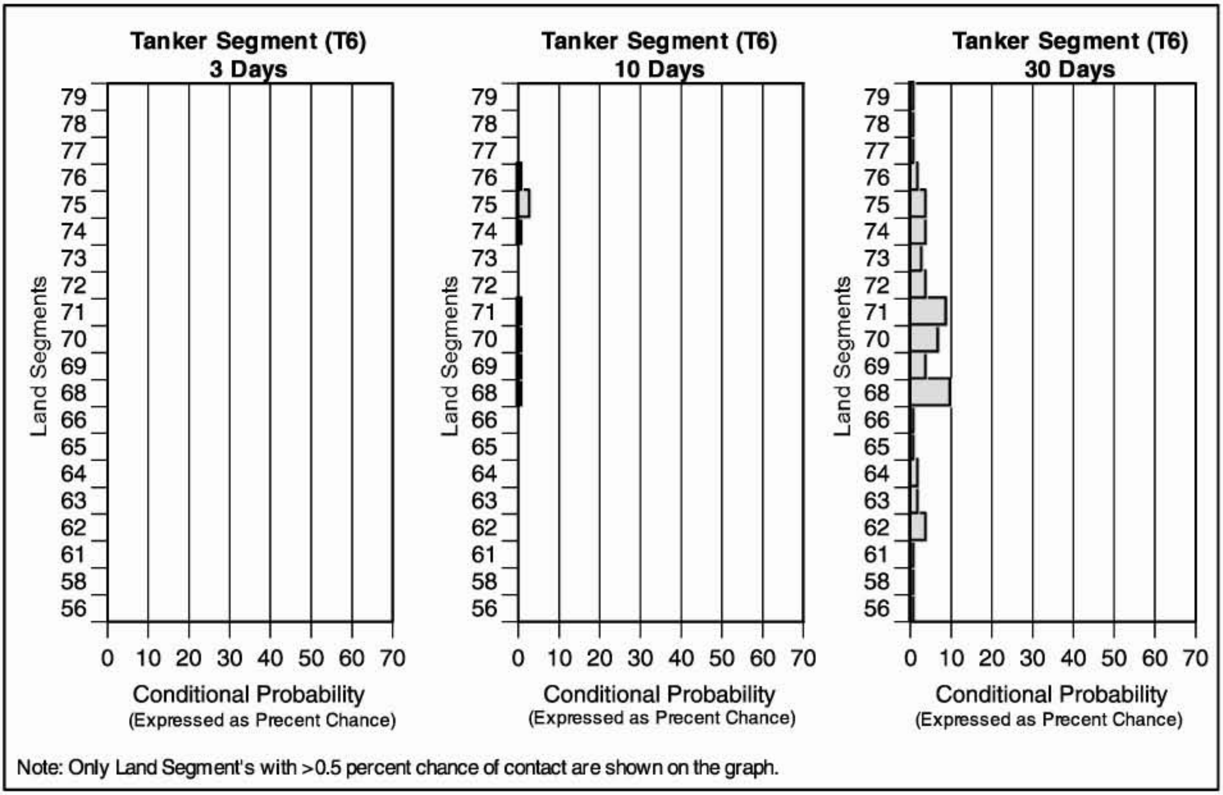


Figure IX-2b. Estimated Conditional Probabilities (expressed as percent chance) Than an Oil Spill Greater Than or Equal to 1,000 Barrels Starting at Tanker Segment T6 in the Summer Season Will Contact Certain Land Segments within 3, 10 or 30 Days

MAPS

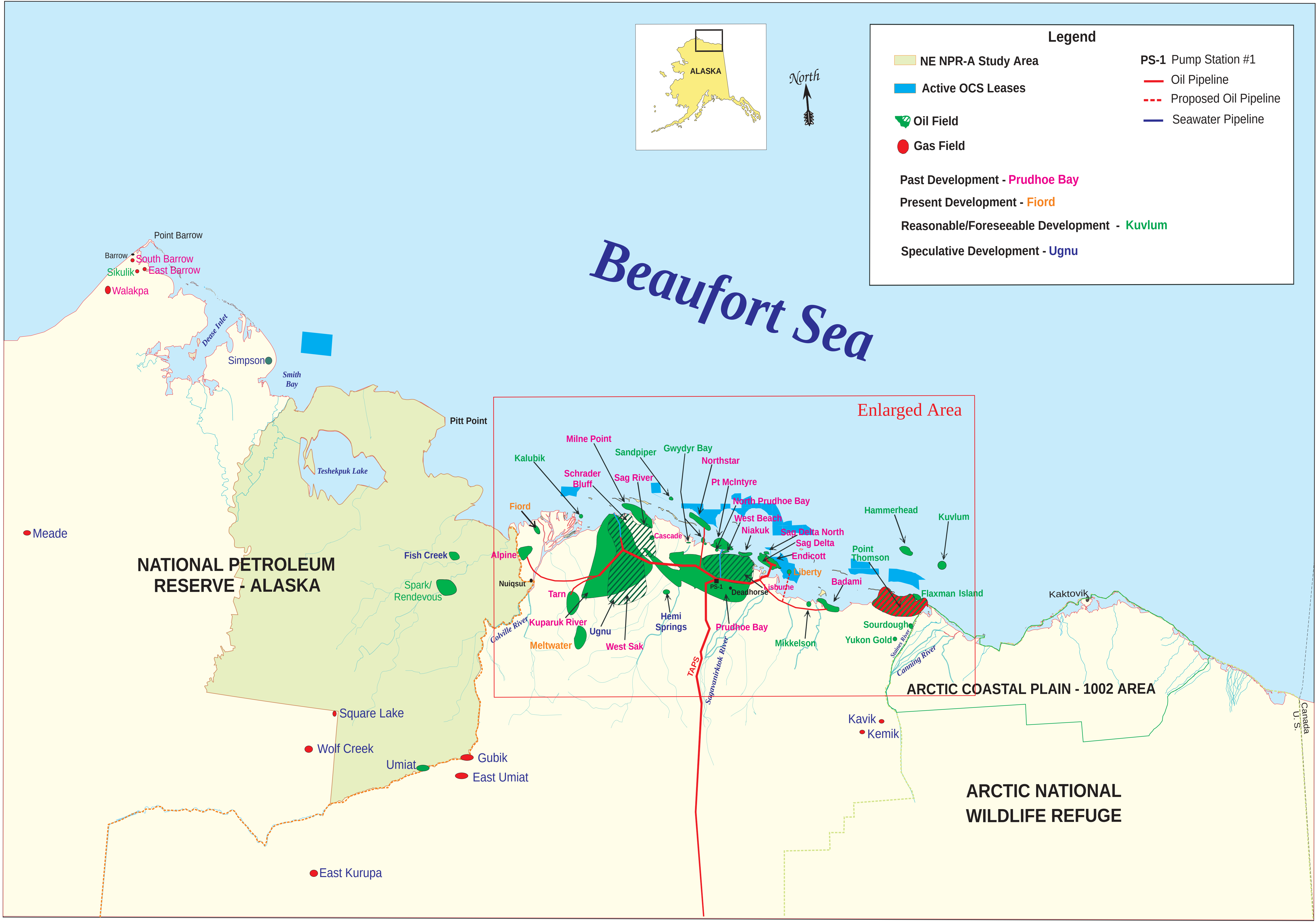
Map 1 Liberty Project Area.

Sources: BPXA 1998a; Ban et al, 1999.

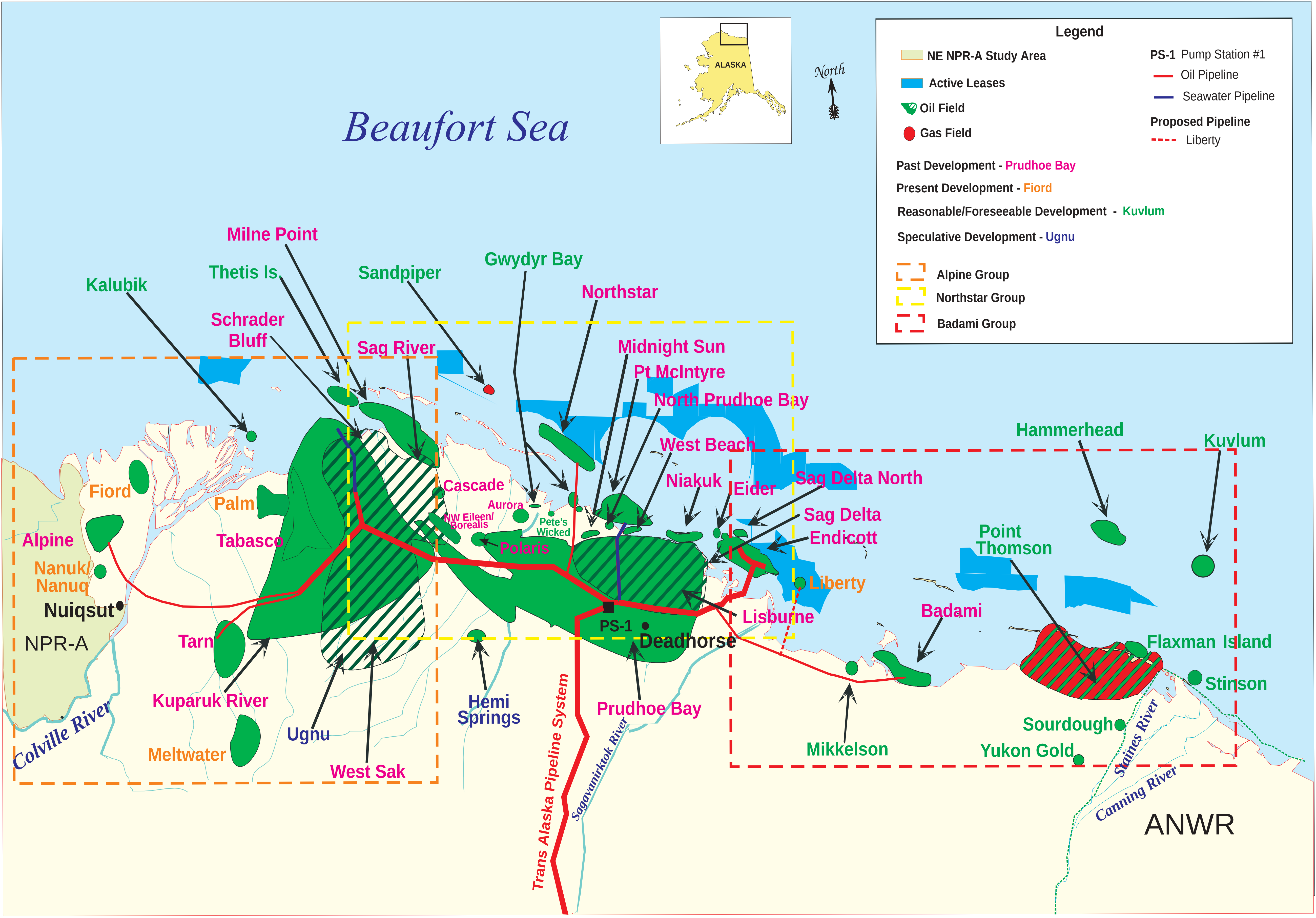
Map 2A Seals and Polar Bears, Gravel Island, Gravel and Ice Roads, and Pipelines.
Sources: USDOI, MMS (Sales 170 FEIS); BP Exploration, 1995; LGL Woodward-Clyde Consultants, and applied Sociocultural Research 1998; Treacy 1987-98.

Map 2B Terrestrial Mammals, Gravel Islands, Gravel and Ice Roads, and Pipelines.

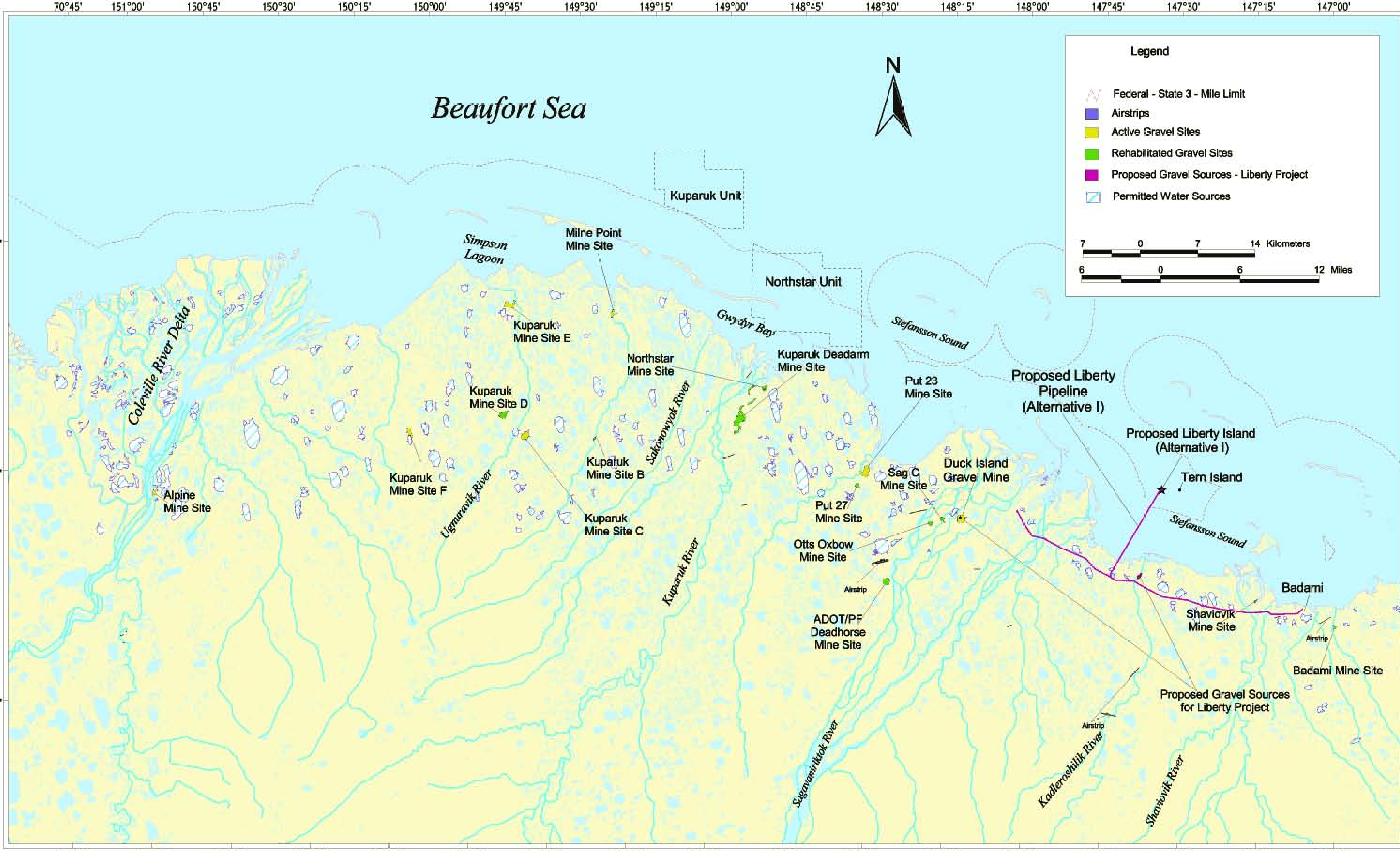
Sources: USDOI, MMS 1998 (Sale 170 FEIS); BP Exploration, 1995; LGL, Woodward-Clyde Consultants, and Applied Sociocultural Research 1998.



Map 3a Location of Oil and Gas Discoveries on the North Slope of Alaska and Federal Leases on the Outer Continental Shelf



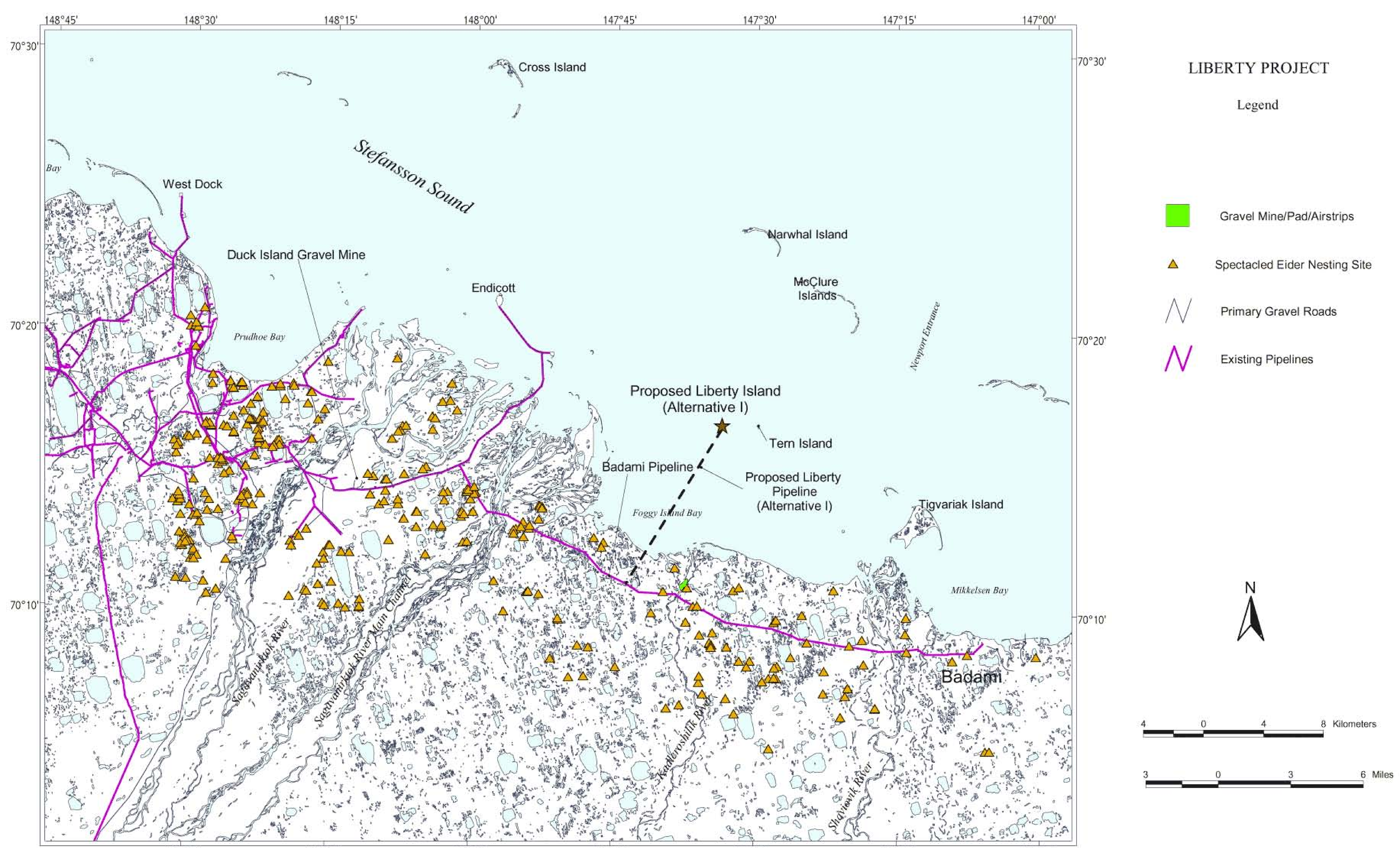
Map 3b Enlarged Area of Major Oil and Gas Activity on the North Slope of Alaska



Map 3c Permitted Gravel and Water Sources
Source: BPXA 1999

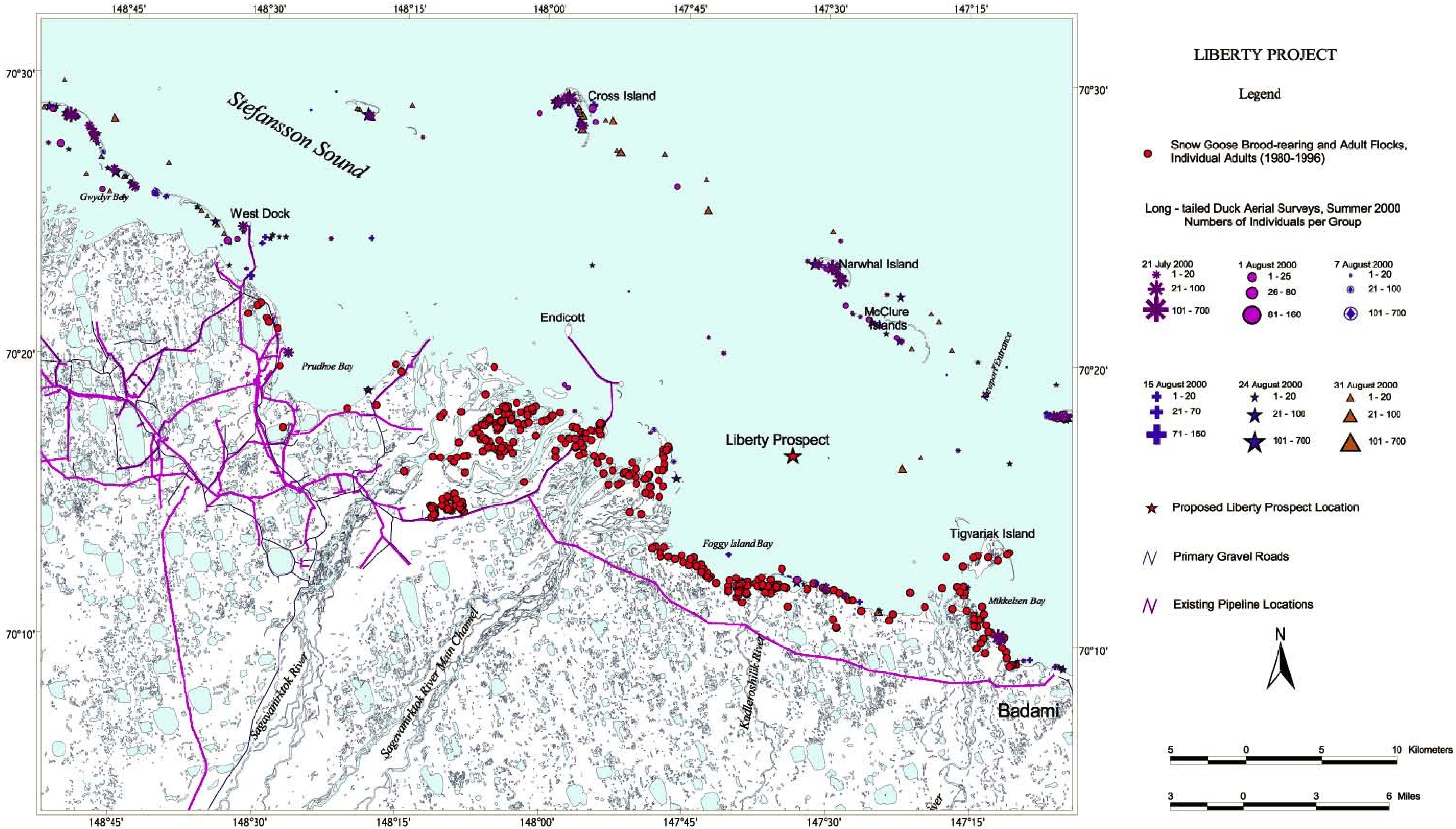
Map 4 Nuiqsut's Bowhead Whale Strikes (1937 - 1996)

Sources: Adapted from Dept. of Wildlife Management, North Slope Borough, 1993 Map.



Map 5 Spectacled Eider Sightings

Sources: BPXA 1995; Troy Ecological Research Associates 1993c, 1995a, 1996a, 1996b, 1997; Warnock and Troy, 1992.



Map 6 Snow Goose Sightings and Distribution of Molting Long-tailed Ducks (Snowgoose sightings in the extreme western area not shown)

Sources: BPXA 1995; Johnson 1995; Noel and Johnson, 1996; Johnson 1998 (unpublished data); Johnson and Gazey, 1992; Johnson and Noel 1996; Johnson and Richardson, 1981; USFWS 2001 (unpublished data).

Map 7 Tundra Swan and Brant Sightings, and Common Eider Nesting Areas

Sources: Johnson 1994a, b; Johnson and Herter 1989; Johnson and Noel 1996; LGL unpublished data; Noel and Johnson, 1996; Stickney et al., 1994.

Map 8 Distribution and Abundance of Waterfowl Observed on Aerial Surveys 31 August - 2 September 1999

Source: USDOI, FWS, Personal Communication 1999.

Map 9 Historical Subsistence Land Use for Nuiqsut (Described 1973-1986)

Source: Pedersen, In Prep.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.

20 Years of Service to America

MMS

Minerals Management Service

1982-2002