Chapter

Existing Environment

1.1 *STUDY AREA*

Sakhalin Island is situated along the East Coast of the Russian Far East, north of Japan, between 46 and 54 degrees northern latitude and 140 and 146 degrees eastern longitude. The island is elongate in shape being approximately 950 km long from north to south and 160 km wide east to west at its widest point.

The island is separated from the Russian mainland to the west by the shallow Tatar Strait which is generally 100 km wide but narrows to 10 km in the north of the Island. To the south the island is separated from the Japanese island of Hokkaido by the La Perouse Straight, which is 60 km wide at its narrowest point. To the east and north the island is bordered by the Sea of Okhotsk.

The study area is shown in *Figure 1.1*.

There are three main elements to the Sakhalin Pipeline Transportation System (PTS):

- an approximately 808 km twin pipeline to convey gas and oil respectively:
- a Gas Disposition Terminal (GDT) to supply gas to the existing gas pipeline system; and
- Booster Station # 2 (BS#2) to boost the pressure in both oil and gas pipelines.

1.1.1 *Pipeline*

The pipeline route itself is shown in *Figure 1.2*.

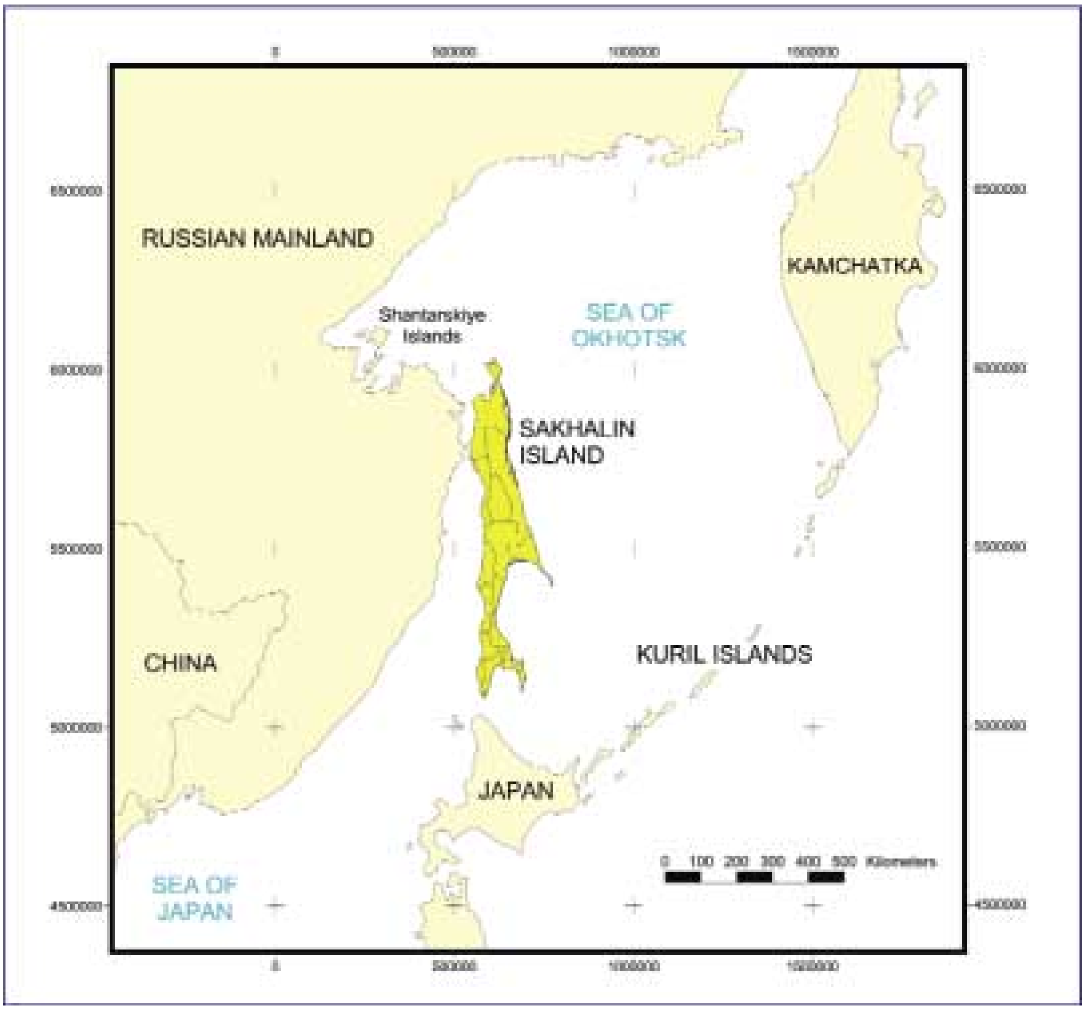
For survey and logistical purposes, the pipeline route was divided into segments, as shown in *Figure 1.3*. Wherever possible, these segment numbers have been used to describe the main baseline components. Nevertheless, for some baseline components, data had been divided according to varying geographical categories, eg by Sakhalin Region administrative district, climatic zones or by the pipeline KP itself. The overlap and relationship between the various categories used to describe the existing environment encountered along the pipeline route is summarised in.

As can be seen in *Figure 1.3* the division of the route segments referenced to KPs (from north to south) is as follows:

- Segment 1: KP 0.784 - KP 126.57 Nogliki and Okha districts;
- Segment 8: KP 126.57 - KP 159.84 Nogliki district;
- Segment 6: KP 0.26 - KP 29 Nogliki district;
- Segment 9: KP 29 - KP 49 Nogliki District;
- Segment 2: KP 5.28 - KP 131.75 Tymovsk district;
- Segment 3: KP 131.75 - KP 301.93 Smirnykh district;
- Segment 4: KP301.93 - KP 427.73 Makarov district;
- Segment 5: KP 427.73 - KP 574.78 Dolinsk, Yuzhno Sakhalinsk and Aniva Districts; and
- Segment 7: KP 574.78 - KP 598.68 for the gas pipeline and KP 574.78 - KP599.54 for the oil pipeline, Korsakov district.

These segment and KP numbers have been inherited from work undertaken during project development, and as such the numbering does not follow a sequential system. Nevertheless using *Figure 1.3* as a key map, geographical locations can be derived along the pipeline route.

Figure 1.1 *Study Area*



Note: BS#1 is located at the OPF site and is discussed in *Volume 3* of this EIA.

A complete list of baseline information, studies, and reports is provided in *Appendix A of Volume 1*.

Figure 1.2a Onshore Pipeline Route

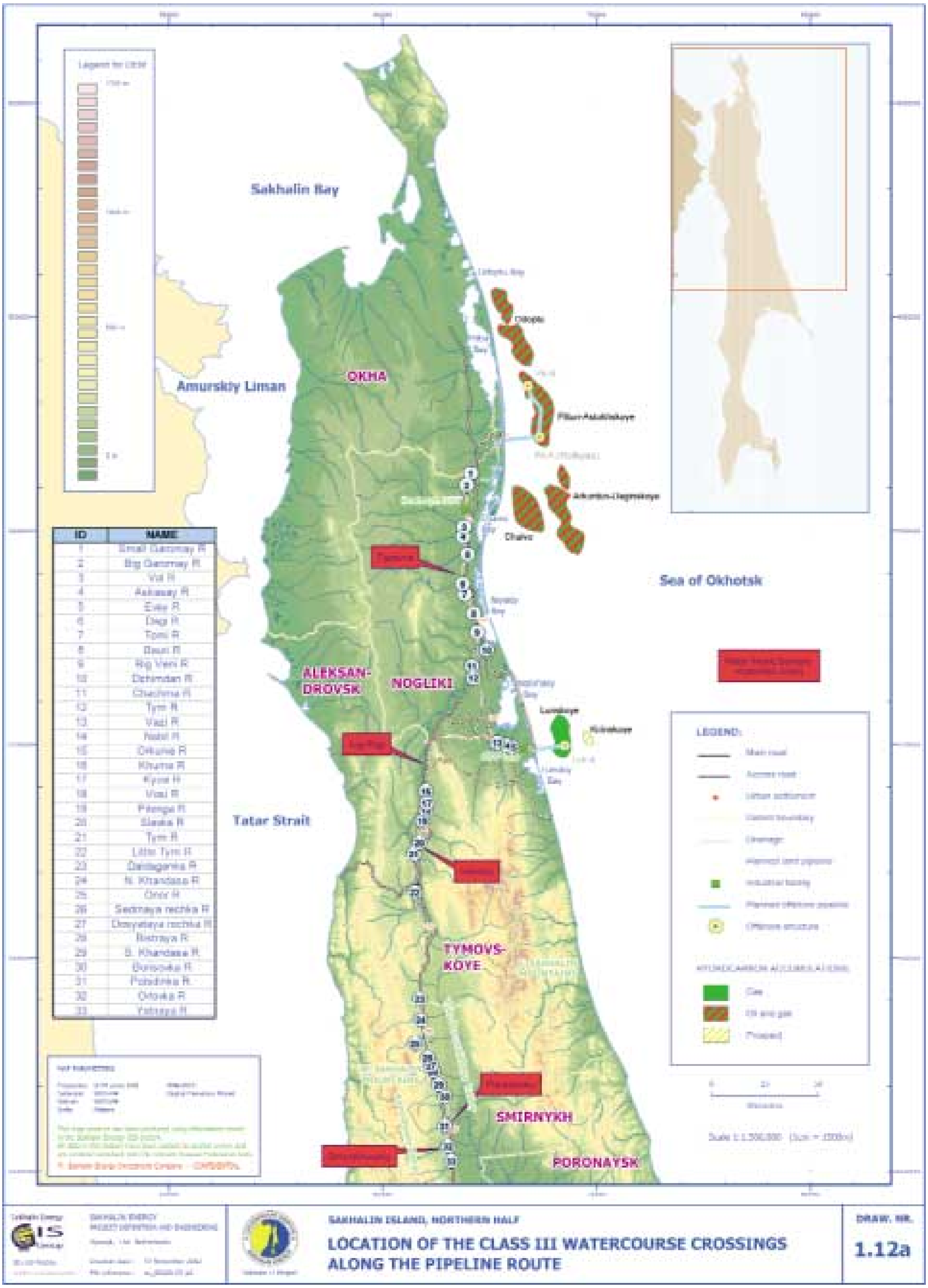


Figure 1.2b Onshore Pipeline Route

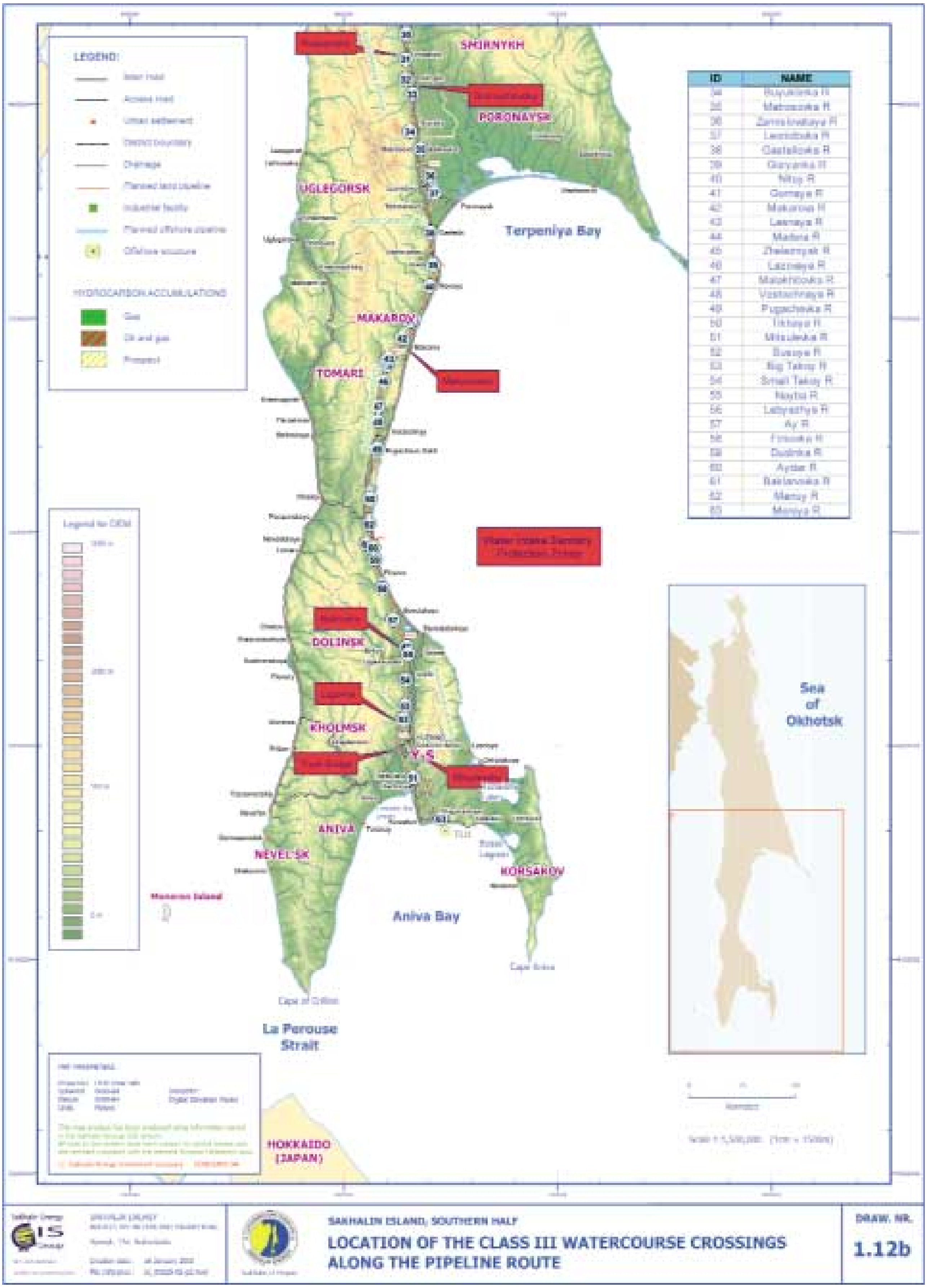
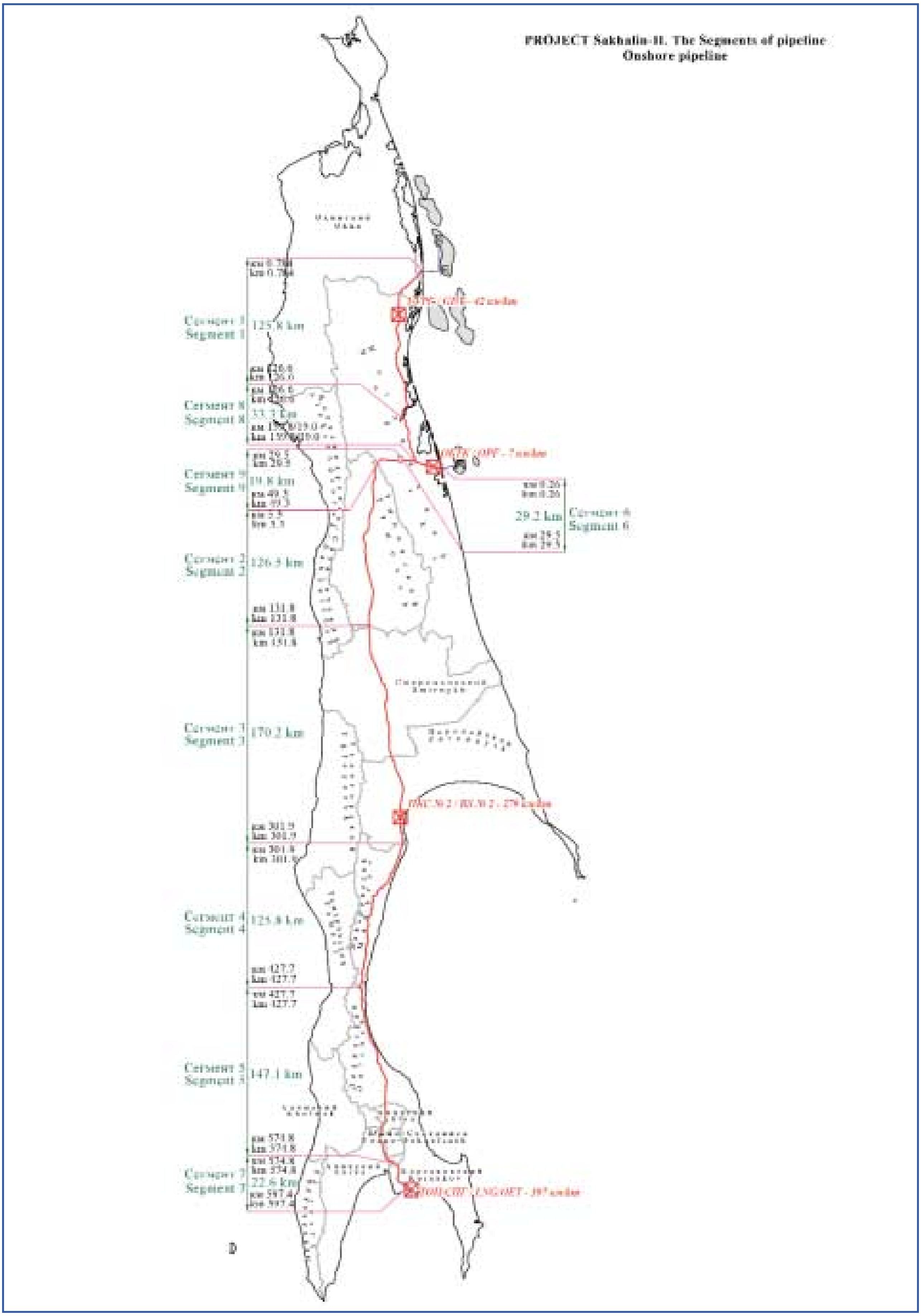


Figure 1.3 Pipeline Segments Map



1.1.2 *Gas Disposition Terminal*

The GDT is located in the Nogliki district close to the location where the SEIC pipelines will cross the 'Okha-Komsomolsk' gas pipeline. The closest settlement to the GDT is Val, located to the south west of the site (TEO-C Volume 3, Book 8.4, Appendix E). The general location is shown in *Figure 1.2* and *Figure 1.4* in more detail (TEO-C, Volume 3, Book 2, Part 4). The main co-ordinates of the GDT site are detailed in chapter 2.

1.1.3 *BS#2*

The BS#2 is located approximately 2 km to the north of the settlement of Gastello, near the south-east boundaries of the Poronaysk district and 3 km inland from the Bay of Terpeniya on the coast of the Sea of Okhotsk (TEO-C Volume 3, Book 8.3.1, Appendix E). The general location is shown in *Figure 1.2*, with a detailed location shown in *Figure 1.5* (TEO-C, Volume 3, Book 2, Part 3), co-ordinates are given in *Chapter 2*. Note: BS#1 is located at the OPF site and is discussed in *Volume 3* of this EIA.

1.2 *SOURCES OF INFORMATION*

Information for the description of the existing environment is based on a range of baseline surveys. A full list of environmental baseline surveys executed by SEIC is provided in *Appendix A*. The Environmental Impact Assessment Version 3 (July 2002) and TEO-C including the Environmental Protection Books were of particular importance in compilation of this chapter.

Table 1.1 Pipeline Baseline Summary

Baseline segment	Boundaries	Length (km)	KP	Geographical Area	Pipeline	Construction Spread
1	Piltun landfall to Imchin River	124.8	0.784-126.57 (GDT at 41.1KP)	North Sakhalin plain	Oil 508mm (20") Gas 508mm (20")	1
8	Imchin River to Section 6	33.3	126.57-159.64	North Sakhalin plain	Oil 508mm (20") Gas 508mm (20")	1: to OPF 2: downstream of OPF
6	Lunskoye landfall to Ershik River/ Sredny brook junction	28.4	1-29.46 (OPF at KP7)	Nabil Ridge/ Eastern coastal plain	Oil 508mm (20") (to OPF) Gas 508mm (20") to OPF) Oil 610 (24") (from OPF) Gas (1219 (48") (from OPF) Multiphase 2 * 762 (30") (from Lun to OPF) MEG 114.3 (4.5") from OPF to Lun	2
9	Ershik River/ Sredny brook junction to Vervil River	19.8	29.46-49.3	Nabil Ridge	Oil 610 (24") Gas (1219 (48")	2
2	Vervil River to Daldaganka River	126.5	5.28-131.75	Tym - Poronaysk Lowlands (upper reaches)	Oil 610 (24") Gas (1219 (48")	2: to KP124 3: downstream of KP124
3	Daldanka River (Tymovsk Smirnykh Boundary) to Chulymka River (Poronaisk Makarov boundary)	170.2	131.75-301.93 (BS#2 at KP279)	Tym - Poronaysk Lowlands (lower reaches)	Oil 610 (24") Gas (1219 (48")	3: to KP264 4: downstream of KPKP264
4	Chulymka River (Poronaisk/ Makarov to Makarov/ Dolinsk district boundary	125.8	301.93-427.73	Makarov coastline	Oil 610 (24") Gas (1219 (48")	4: to KP 424 5: downstream of KP424
5	Makarov/ Dolinsk boundary to Ossinovka River	147.1	427.73-574.78	Dolinsk region/ Susanaisk Lowland	Oil 610 (24") Gas (1219 (48")	5
7	Ossinovka River to LNG plant	24.x?	574.78-599.54	Korsakov Plateau	Oil 610 (24") Gas (1219 (48")	5

Settlements passed/ nearby	# Class III River Crossings by pipeline	Vegetation	Admin District	Climate	# IUP bridges over rivers	# IUP culverts over rivers
Boatasyn, Val, Dagi, Nogliki	12	Secondary forests on former natural forest sites and long standing secondary	Okha/	Northern	0	0
Katangli	0	secondary forests dominating with some meadow, bog and established open coniferous forest	Nogliki	Northern	0	0
	4		Nogliki	Northern	0	0
Nysh			Nogliki	Northern	0	0
Slava, Tymovskoye, Palevo	23	Original dark coniferous forest dominating in the north, secondary communities and long standing forest in the central section and orignal light coniferous and open woodland prevailing in the south with increasing cultivated land	Tymovsk	Mid	20	6
Onor, Pobedino, Smirnykh, Koshevoy			Smirnyk	Mid	4	0
Matrosovo, Poronaisk, Gastello, Gastello, Vakhurshev, Makarov, Tossi, Pugachevo	11	Secondary forests on former natural forest sites and long standing secondary secondary forests dominating with original dark coniferous forest	Poronaysk/ Makarov	Mid	3	0
Firsovo, Zagorskiy, Sokol, Yuzhno Sakhalinsk	13	Dark coniferous forests dominating in the north with increasing cultivated land and dominating in the south	Dollinsk, Aniva, Kholmsk, Yuzhno-Sakhalinsk	South	3	0
Korsakov		Dark coniferous forests dominating	Korsakov	South	0	2

Figure 1.4 GDT Site Plot Plan

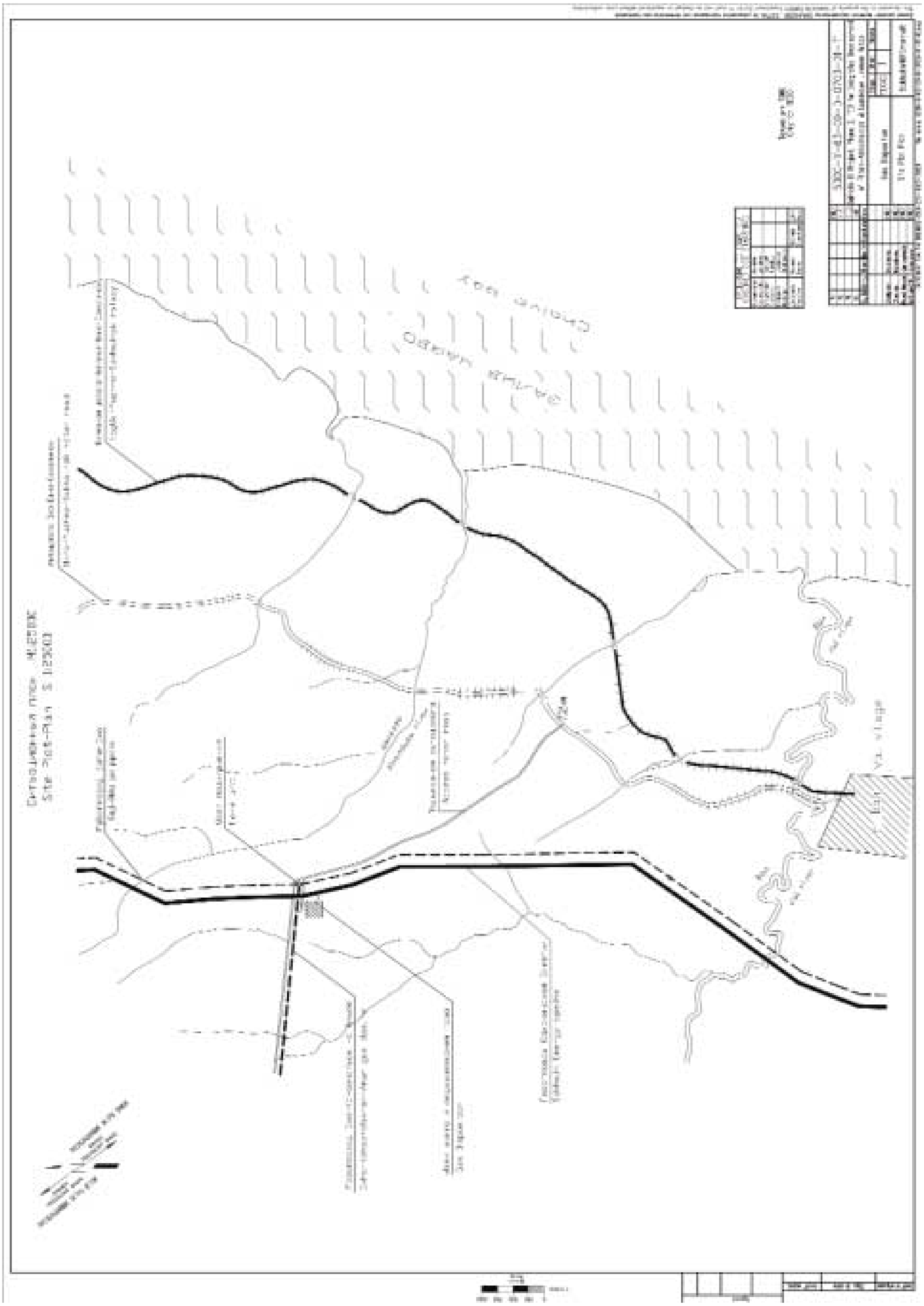
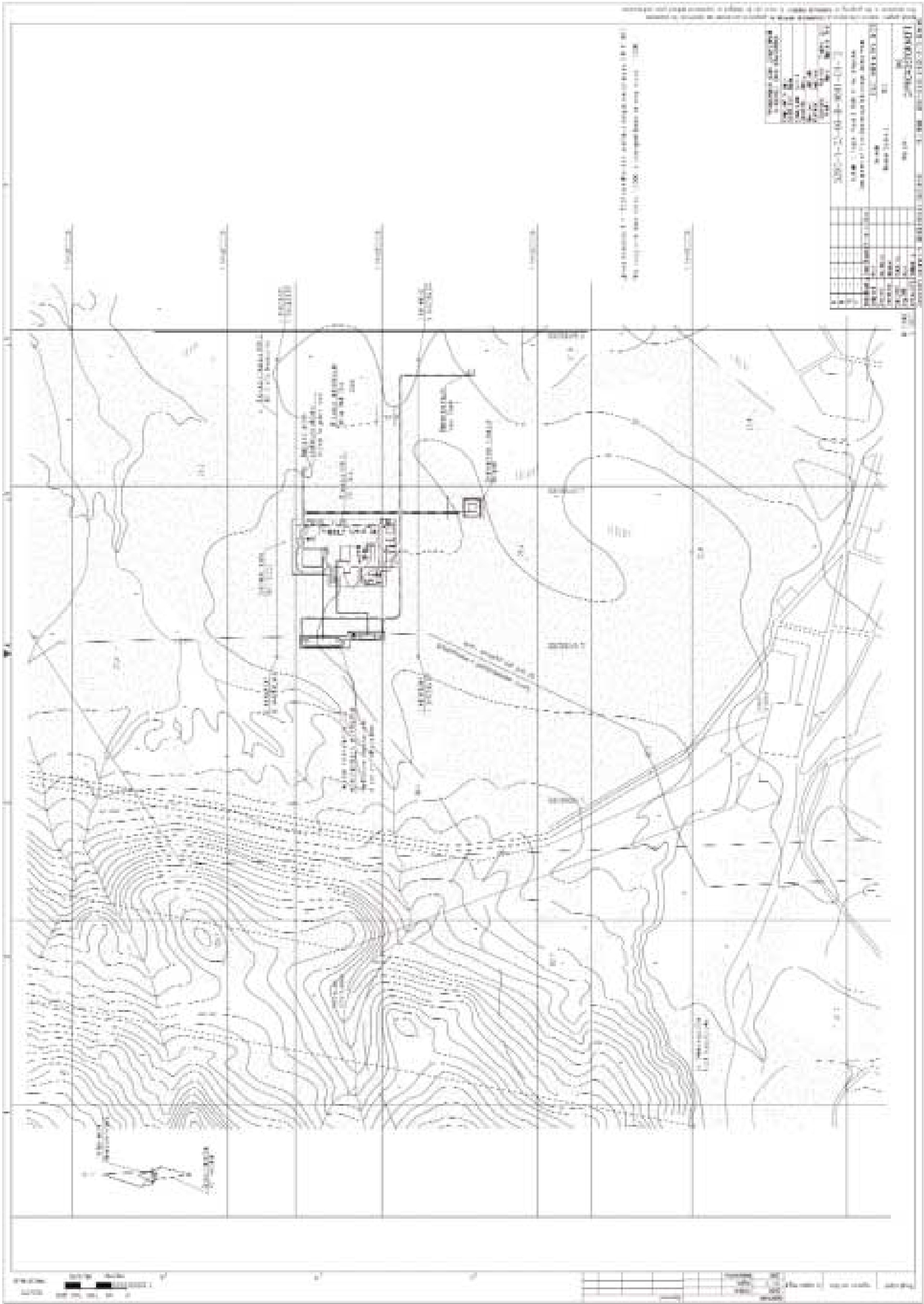


Figure 1.5 BS#2 Site Location



1.3 PHYSICAL ENVIRONMENT

1.3.1 Landscape, Topography and Visual Amenity

Pipeline

Sakhalin Island is mountainous, its tectonic formation is a result of being along the junction of the Eurasian and North American tectonic plates. The highest peak, found in the Eastern-Sakhalin Mountains is 1609 m. The mountains are of a low and medium altitude, aligned in a north-south direction parallel to the plate boundaries. The Tym-Poronaiskaya Valley separates the Western-Sakhalin Mountains from the Eastern-Sakhalin Mountains. The Susanaisky and Tonino-Anivsky Ranges are situated in the south of the island. Plains and lowlands occupy approximately 25% of the island, the largest being the Northern Sakhalin Plain. The Susunaiskaya and Muravyevskaya lowlands are situated in the south. Plains and lowlands are often swampy or have numerous meandering rivers (SrVKF, 1994). The topography traversed by the pipeline varies greatly as can be seen in *Table 1.2*.

The island has a high density system of rivers and lakes, with numerous streams. The main valleys have extensive braiding and floodplains. Rivers in the mountain regions have high powers of erosion, creating dynamic landscapes. The majority of lakes are coastal lagoons.

Forested landscapes of various types prevail, with both primary and secondary coniferous forests being present, as well as broadleaved forests (ash, elm, birch, aspen, alder, willow, poplar). Logging and forestry activities have damaged large areas of primary forest, as have forest fires. Burnt out areas are particularly widespread in the north. In the southern part of the island coniferous forests are dominated by Sakhalin fir. Intermountain depressions and wetland areas are vegetated with larch forests. The majority of forests in the south are secondary, with areas of grass and herb meadow, and heathlands. In the absence of fires, forests regenerate within about 30 years. North of Dolinsk, spruce is the dominant species, with alder and birch in recently cleared areas, superseded by larch. Limited areas of virgin forest remain in the Lunsky region, near the coast.

Wetland areas come in various types, occupying the wettest and coldest areas of river valleys and the edges of lagoons along the coast. Mar is an open boggy marsh woodland which is particularly common in the north.

Agricultural land comprises pasture and hay fields, with 30% being ploughed for potatoes, vegetables and fodder crops. These are centred on the central and southern parts of the island.

Natural grasslands are found mainly on maritime terraces and in larger river floodplains, forming sedge, grass or herb meadows. Secondary grasslands are more common. Some mountain areas in the south are covered with dense bamboo, which often grows in previously burned areas.

The coastline comprises three main types:

- *steep coastlines with low mountains* sloping into the sea in the central part of the island;
- *flat coastlines with numerous lakes and shallow bays*, found on the *Sakhalin Shelf* to the north; and
- *coastlines of undulating topography*, river mouths and beaches.

The shallow bays on the north east coastline of the Sakhalin Shelf include those at Piltun, Chaivo, Lunskoye, Nabilsky and Nivsky. They typically have shallow seas, with narrow inlets to the sea, numerous river and stream mouths and adjacent wetlands. Approximately 20% of the coastline is accumulating and is stable and 40% is eroding, due partly to sea-level rise. The lagoon straights are the most dynamic areas of coastline, with the most active erosion occurring at Chaivo-Dagi and Staro-Nabilsky.

Figure 1.6 *Typical Sakhalin Mountains*

Figure 1.7 *Typical Sakhalin Plains*

Figure 1.8 *Typical Sakhalin Swampy Areas*

GDT

The GDT site is relatively flat, the highest elevation mark of the land surface within the site is 38.9 m, the lowest mark is 31.7 m in the site's southwest corner.

BS#2

The BS#2 site is also relatively flat and has local relief varying from 25 m to 35 m.

1.3.2 Soils

Sakhalin Island is located within the Far Eastern Taiga-Forest Bioclimatic Region. In general, soils tend to be boggy, fragile and podzolised. In the south of Sakhalin, mountain forest brown, soddy, meadow, boggy alluvial and peaty soils are dominant. In the middle of the island (the Poronaisk, Smirnykh and Tymovsk Areas) alluvial soils and mountain forest acid podzolised soils are dominant along the pipeline route. Deep, humus soddy soils may form in old logging sites and areas cleared by burning. Northern slopes, unwooded areas as well as some forests areas are characterised by humic-illuvial and peaty podzols. In the north of the Tymovsk Area, in the Nogliki and Okha areas, the flat sand-clay marine plains are characterised by the prevalence of podzols under automorphic conditions and peaty, meadow, boggy alluvial and other soils under semi and hydromorphic conditions.

Soil has been mapped at a scale of 1:25 000 for the entire pipeline route, these maps form part of TEO-C, Volume 3, Book 8.2.1, Section 7. A summary soil map is included as *Figure 1.9*.

The topography of much of the proposed pipeline route comprises sequences of river valleys (occasionally flood plains) and interfluve terrains, with specific soils associated with each. The dominant soils, along with other geological and hydrogeological descriptions of the pipeline route, are summarised in *Table 1.2*.

Figure 1.9a Soils Along the Pipeline Route

Table 1.2 Soil, Geological and Hydrological Features Along the Pipeline Route

Pipeline Section	Geographical Area	Geology			Hydrological Body
		Chronological Era	Stratigraphical Suites	Predominant Rock Types	
Segment 1	North Sakhalin Plain	Pliocene	Nutov	Sands, sandstone, gravels, subordinate clays	North Sakhalin Artesian Basin
		Miocene	Uyni, Dagi, Okobykai	Shales, siltstones, sandstones	
Segment 2	Tym - Poronaysk Lowlands	Pliocene	Nutov	Sands, sandstone, gravels	The Poronaysk Artesian Basin
		Miocene	Okobykai	Shales, siltstones, sandstones	
Segment 3	Tym - Poronaysk Lowlands	Pliocene	Nutov	Sands, sandstone, gravels	The Poronaysk Artesian Basin
		Miocene	Okobykai	Shales, siltstones, sandstones	
Segment 4	Makarov coastline	Miocene	Gastellovka, Kholmsk, Chekov, Verkhneduysk, Sertunay, Muruyamskaya	Sands, sandstones, conglomerates, tuffs, thin coal seams in the Verkhneduysk Suite.	The Western Sakhalin Hydrogeological Body
		Cretaceous	Bykovskaya, Krasnoyarskaya	Shales, siltstones, conglomerates and tuffs.	

Geological Folding and Faulting		Major Seismic Faults Crossed by Pipelines # of crossings (KPs)	Dominant Soil Types		Gromorpho-logical Process
Deformation	**Faulting**		**A/B Horizon**	**C/D Horizon of Significant Risk**	
North Sakhalin Anticline	North Sakhalin fault zone	2 (19.28, 19.69)	Peaty podzolic soils, swampy podzolic soils, samdy podzolic soils	Alluvial sediments, peat, weathered argillaceous strata	None
Central Sakhalin Syncline	Central Sakhalin fault zone	0	Brown forest and brown forest gley soils, sod podzolic soils, alluvial boggy soils	Alluvial sediments, silts, peat	None
Central Sakhalin Syncline	Central Sakhalin fault zone	8 (154.0, 169.9, 192.3, 196.7, 199.5, 200.8, 207.4, 282.4)	Alluvial boggy soils, brown forest gley soils, peaty gley soils, alluvial soils, swampy podzolic soils	Alluvial sediments, prolluvial sediments	Landslides and snowflows
Eastern limb of the Western Sakhalin Anticline	Central Sakhalin fault zone	5 (326.1, 330.6, 334.8, 335.0, 367.9)	Brown forest gley soils, eroded brown forest soils, brown podzolic soils, swampy podzolic soils, alluvial boggy soils.	Alluvial sediments, prolluvial sediments, weathered argillaceous strata.	Landslides, mudslides, snowflows

Table 1.2 Soil, Geological and Hydrological Features Along the Pipeline Route (Continued)

Pipeline Section	**Geographical Area**	**Geology**			**Hydrological Body**
		Chronological Era	**Stratigraphical Suites**	**Predominant Rock Types**	
Segment 5	Dolinsk region/ Susunaisk Lowland	Miocene	Gastellovka, Kholmsk, Chekov, Verkhneduysk, Sertunay, Muruyamskaya	Sands, sandstones, conglomerates, tuffs, thin coal seams in the Verkhneduysk Suite.	The Susunaisk Artesian Basin
Segment 6	East Sakhalin Coastal Plain	Pliocene	Nutov	Sands, sandstones, gravels, subordinate clays	North Sakhalin Artesian Basin
		Miocene	Uyni, Dagi, Okobykai	Shales, siltstones, sandstones	
	Nabil Ridge	Jurassic - Cretaceous	Nabil Series	Slates, sandstones, limestone, greywacke, arkose, basalt	
Segment 7	Korsakov Plateau	Tertiary	Krasnopolskaya	Sandstone, tuffs	The Susunaisk Artesian Basin/ Tunachinsky Artesian Basin
Segment 8	North Sakhalin Plain	Pliocene	Nutov	Sands, sandstones, gravels, subordinate clays	North Sakhalin Artesian Basin
		Miocene	Uyni, Dagi, Okobykai	Shales, siltstones, sandstones	
Segment 9	Nabil Ridge	Jurassic - Cretaceous	Nabil Series	Slates, sandstones, limestone, greywacke, arkose, basalt	North Sakhalin Artesian Basin

Geological Folding and Faulting		Major Seismic Faults Crossed by Pipelines # of crossings (KPs)	Dominant Soil Types		Gromorphological Process
Deformation	**Faulting**		**A/B Horizon**	**C/D Horizon of Significant Risk)**	
Aniva-Susanaisk Megadepression	Central Sakhali fault zone	8 (520.6, 539.4, 542.8, 550.0, 550.7, 551.8, 552.0, 552.3)	Alluvial sod soils, alluvial boggy soils, brown podzolic soils, meadow gley soils, brown forest soils	Alluvial sediments, marine sediments, weathered argillaceous strata	Snowflows
Eastern Sakhalin Anticline	North Sakhalin fault zone	0	Swampy podzolic soils, peaty soils, brown forest	Marine sediments, alluvial soils, gley soils	None sediments
Susanaisk-Aniva Anticline	Mereisky Fault Zone	0	Brown taiga, brown forest soils, meadow gley soils	Colluvial deposits, alluvial sediments	None
North Sakhalin Anticline	North Sakhalin fault zone	1 (142.65)	Peaty podzolic soils, swampy podzolic soils, sandy podzolic soils	Alluvial sediments	None
Eastern Sakhalin Anticline	North Sakhalin fault zone/Central Sakhalin fault zone	0	Alluvial boggy soils, brown forest gley soils	Alluvial sediments, colluvial deposits	Snowflows

Figure 1.9b Soils Along the Pipeline Route

Preliminary mapping identifies the following soils in terms of their vulnerability (*Table 1.3* to *Table 1.11*).

Table 1.3 *Potentially Vulnerable Soils in the Okha Area*

Km	Soil Type
24-5	Peaty podzolic, peat boggy soils

Table 1.4 *Potentially Vulnerable Soils in the Nogliki Area*

Km	Soil Type
7-3	Peaty podzolic gley soils
3-0	Peat soils
Route branch: sheets 11, 8, 9	
157-145	Peaty podzolic, gley, peat soils
145-132	Peat, alluvial boggy soils
125-119, 102-100, 94-46	Peat soils
119-112, 111-102, 100-92, 94-46, 5-0	Peaty podzolic soils
45-21	Podzolic, peaty podzolic gleyish soils
21-0	Peat, peat podzolic, alluvial boggy soils

Table 1.5 *Potentially Vulnerable Soils in the Tymovsk Area*

Km	Soil Type
132-123 and 116-112	Peat, boggy alluvial soils
123-116	Brown forest gley soils
112-74	Soddy podzolic soils, including gleyish and cultivated ones
74-7	Peaty, peat podzolic, alluvial meadow and boggy soils

Table 1.6 *Potentially Vulnerable Soils in the Smirnykh Area*

Km	Soil Type
233-220	Brown forest gleyish soils, including cultivated ones
220-213, 168-156 and 155-153	Brown forest gley soils
213-168	Brown forest gley, alluvial boggy and meadow soddy soils
156-155 and 153-132	Peat, boggy alluvial soils

Table 1.7 Potentially Vulnerable Soils in the Poronaisk Area

Km	Soil Type
302-243	Alluvial boggy, peaty gley soils, including cultivated ones
243-233	Brown forest gleyish soils, including cultivated ones

Table 1.8 Potentially Vulnerable Soils in the Makarov Area

Km	Soil Type
428-424 and 420-407	Brown forest gley soils
424-420	Peaty gley, alluvial soddy soils
407-402	Meadow soddy, alluvial soils
402-3345	Brown forest gley, meadow soddy alluvial soils
345-341	Brown forest eroded soils
341-302	Alluvial soddy gley, peaty gley, boggy soils

Table 1.9 Potentially Vulnerable Soils in the Dolinsk Area

Km	Soil Type
522-517	Brown forest gleyish soils
517-513	Meadow boggy alluvial soils
513-509	Soddy gley soils
509-502	Peat podzolic gley soils
502-484	Brown forest gley soils
484-479, 450-446 and 438-435	Meadow soddy gley soils
479-469	Brown podzolic soddy gleyish soils
469-467	Peaty podzolic soils
467-450 and 446-438	Brown podzolic, soddy gleyish, eroded soils
435-428	Brown forest gley soils

Table 1.10 Potentially Vulnerable Soils in the Aniva Area

Km	Soil Type
572-564	Brown forest, brown taiga, meadow gleyish, alluvial soddy gley soils
564-554 and 551-523	Same, cultivated
554-551	Brown forest gleyish soils

Table 1.11 Potentially Vulnerable Soils in the Korsakovo Area

Km	Soil Type
597-598	Peaty soils
598 - 594	Brown taiga soils (raw humus brown soils)
594-592	Brown forest gley soils
592-572	Brown forest, brown taiga, meadow gleyish, alluvial soddy gley soils

On raised land the reported thickness of the surface soil layers (A and B horizons), which is typically formed of brown forest soils, mountain taiga etc, is only 0.4 to 0.7 m. Being thin, these soils are easily eroded during extreme climatic events by surface water run-off, and particularly where they are disturbed by construction activities. In the lowland areas where high water tables or standing water persists, soil thicknesses of up to 5.0 m are reported in areas of peat formation, and up to 5.6 m in areas of swampy soil formation. *Table 1.12* details the topsoil depths for the different soils found along the pipeline corridor. With regard to construction activities, these are similarly fragile terrains.

Table 1.12 Thickness of the Topsoil Along the Pipeline Right of Way

No.	Soil	Thickness, cm
1.	Alluvial soddy-gley	25 - 35
2.	Alluvial soddy	25 - 40
3.	Alluvial boggy	50 - 90
4.	Meadow-soddy	15 - 25
5.	Meadow-soddy alluvial	20 - 30
6.	Meadow-soddy gley	25 - 50
7.	Meadow-boggy alluvial	50 - 300
8.	Meadow gley	20 - 30
9.	Soddy-gley	25 - 40
10.	Soddy podsolic	10 - 20
11.	Brown podsolic	15 - 25
12.	Brown taiga	20 - 30
13.	Brown forest	15 - 25
14.	Brown forest gley	15 - 23
15.	Brown forest gley-like	20 - 27
16.	Podsolic	5 - 15
17.	Peaty-gley	30 - 50
18.	Peaty-podsolic	20 - 40
19.	Peaty-podsolic gley-like	20 - 30
20.	Peaty	50 - 250
21.	Peat-podsolic gley	50 - 70
22.	Peat	120 - 600
23.	Bog	50 - 200

1.3.3 *Geology*

Introduction

The majority of the proposed pipeline route crosses land where the near-surface geology consists of sedimentary drift deposits of the Quaternary era, ie recent. The solid geology that forms the bedrock beneath most of the recent drift deposits comprises sedimentary strata of the Tertiary era. Along sections of the route in the Nabil/Nysh areas, older volcanic basalt rocks of Jurassic and Cetaceous age directly underlie the recent deposits.

For the purposes of this text the recent 'drift' geology is described in terms of 'deposits', and the 'solid' geology (bedrock) is described in terms of suites of 'strata', both of which exist along each segment of proposed pipeline. In the context of Sakhalin Island, each deposit or suite of strata typically has a limited variability in terms of composition, but can be up to thousands of metres thick.

Stratigraphy

The recent deposits of Quaternary age largely comprise alluvial and marine clays, silts, sands, and gravels in variable proportions and layering structures. These deposits are typically associated with terrestrial erosions and flooding events or episodes of marine transgression. The thickness of these deposits typically ranges from 15 to 20 m, but can be thousands of metres thick in coastal depressions such as the Tym-Poronaysk lowland through which the route passes. Other locally extensive recent deposits that may directly underlay the route in lowland areas include lacustrine silts and clays that can be up to tens of metres thick.

The solid geology that forms the bedrock along the route is summarised in *Table 1.2*. The thickness of these rocks, which are generally of marine/deltaic origin, typically total hundreds of metres.

Structure and Tectonics Activity

The folding and faulting that is exhibited by the solid geology along the route is summarised in *Table 1.2*.

Sakhalin is generally considered to be located within a compressive tectonic regime, however the majority of the fault zones that bisect the route are described as zones of 'stretching', ie subject to an extensional regime. This description is in line with the general orientation of the fault zones in that they are parallel with horst and graben blocks, which is also indicative of an extensional regime. The proposed route of the pipeline generally follows the lowland areas of the island, which are associated with the fault bounded graben depressions, and as such along much of its length the route is inherently associated with the presence of historical or potentially currently active faults.

The following faults, which originated within the solid geology, and also cut through the recent deposits thus indicating they may remain active, are specifically reported to exist along the route: The Aprelovsky Complex, the Pokrovsky Overthrust, the Tym-Poronaysk Fault, the Makarov Fault, the Zmeinogorsky Fault, the Piltun Fault, and the Verkhne - Piltun Fault. The route can be separated into three sections where the following ranges of movement at faults are typically measured:

- Nysh to Lunskoye/Piltun - Horizontal, 88 mm yr^{-1}; vertical, 17 mm yr^{-1} (since the Neftegorsk Earthquake, 1995);

- Nysh to Pobedino - Limited movement generally orientated vertically at a rate of up to 4 mm yr^{-1}; and
- Pobedino to Prigodnoye - Horizontal, 67 mm yr^{-1}; vertical, 15 mm yr^{-1}.

Recently along the route lateral fault movement has been approximately measured up to 70 mm yr^{-1} and vertical movement up to 15 mm yr^{-1}. Over the longer term historical records show that there is no single dominant direction of movement.

Sakhalin can be separated into four regions of modern (neo) tectonic activity, of which the route passes through the following three, which are all described as extensional regimes:

- North Sakhalin: which is generally exhibiting tectonic tilting resulting in regional subsidence of up to -5.0 mm yr^{-1} along the eastern coast.
- Middle Sakhalin: which is generally stable to the north of Poronaysk where regional movements of between -1.7 to +2.0 mm yr^{-1} have been recorded, and is subsiding to the south of Poronaysk where vertical movement of up to -4.0 mm yr^{-1} is occurring.
- Yuzhno - Sakalinsk: which is generally exhibiting tilting resulting in regional subsidence of up to -7.2 mm yr^{-1} in the Susunaisk Lowland.

Since the Neftegorsk earthquake in 1995 the seismicity rating of much of the route has been raised from the occurrence of one magnitude 6 to 7 event every one thousand years to one magnitude 8 to 9 event every one thousand years.

There are 24 locations where the pipeline crosses seismic faults, as shown in *Table 1.2*. These are also shown in *Figure 1.10* along with the seismic zones of Sakhalin Island.

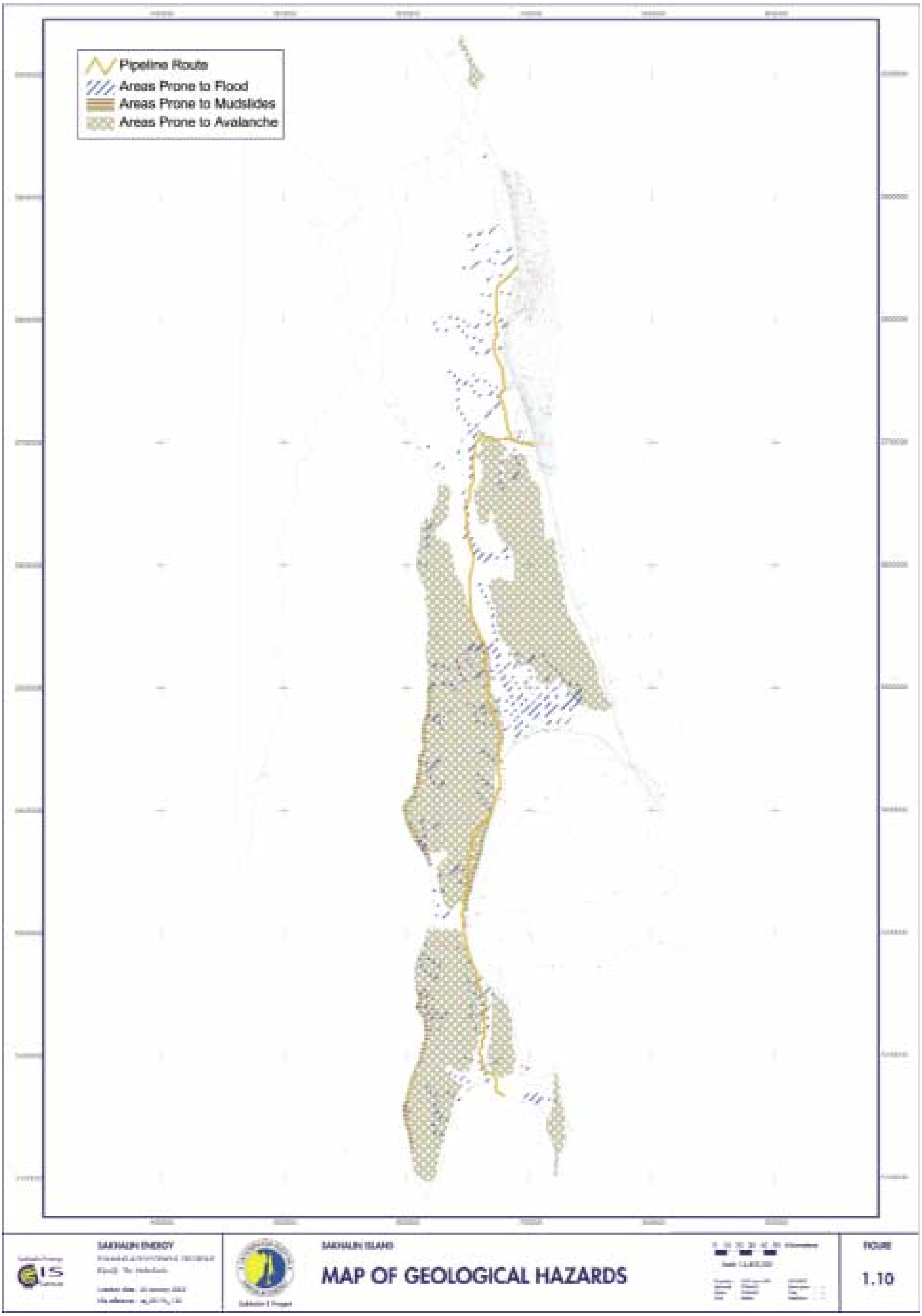
Significant Geomorphological Processes

The main geomorphological processes that should be considered from a geohazard perspective are as follows.

- *Landslide:* these may be initiated by seismic activity, presence of steep slopes, increased loading, undermining or reduced slope stability due to climatic effects. All of these contributing factors may occur due to natural or anthropogenic causes.
- *Mudflows, mudslides and snowflows:* these are initiated by liquefaction of the loose surficial deposits with large mudflows and snowflows potentially travelling long distances very rapidly. They all have the potential to damage buried services as well as surface features.
- *Liquefaction:* this locally important phenomenon is typically activated by seismic activity and may manifest itself in both saturated and dry unlithified soils.
- *Erosion:* due to alluvial flooding is a significant contributing factor to landslides and mudflows. Coastal erosion of up to 20 m per year has been reported along parts of the east coast.

A map of the main geological hazards on Sakhalin Island is provided in *Figure 1.10*.

Figure 1.10 Map of Geological Hazards



1.3.4 *Surface and Ground Water*

Surface Water

The island has a relatively high-density drainage river system with large numbers of short length and small rivers and streams. The main river valleys have extensive braiding and floodplains. The major features of annual flow regimes are long cycles of winter freezing and spring thawing with significant input of groundwater flows.

The majority of Sakhalin rivers and larger streams host salmon spawning grounds in their upper reaches. The majority of urban water supply systems use river intakes. The main river systems and lakes of Sakhalin are illustrated in *Figure 1.11*.

The rivers traversed by the route of the pipeline exhibit significant diversity of physical and geographical conditions, topography, geology and geomorphologic characteristics. Due to these conditions on Sakhalin Island the potential silting of watercourses in the course of construction operations can be significantly influenced by the activation of plane and linear erosion processes at the slopes of the valleys and sloping riverbanks. These processes can be especially important for the submountain regions with higher erosion potential (semi-mountain inflows of Tym and Poronai rivers and also the rivers of the eastern slopes of West-Sakhalin mountains).

Sakhalin Island has many lakes. Major lakes belong to the lagoon lake type, common for seacoasts. In northern Sakhalin, lakes are shallow with low, bogged coasts. Along the north-eastern coast of the island there is a chain of lakes most of which are former lagoons, now separated from the sea by sand dunes.

SEIC has developed a River Crossing Position Paper incorporating watercourse classification information (used in Definition Engineering Document: Rivers Classification and Crossing Design) and corresponding engineering and environmental considerations with respect to construction methodologies (Gamble, 2002). The information presented below is taken from this document.

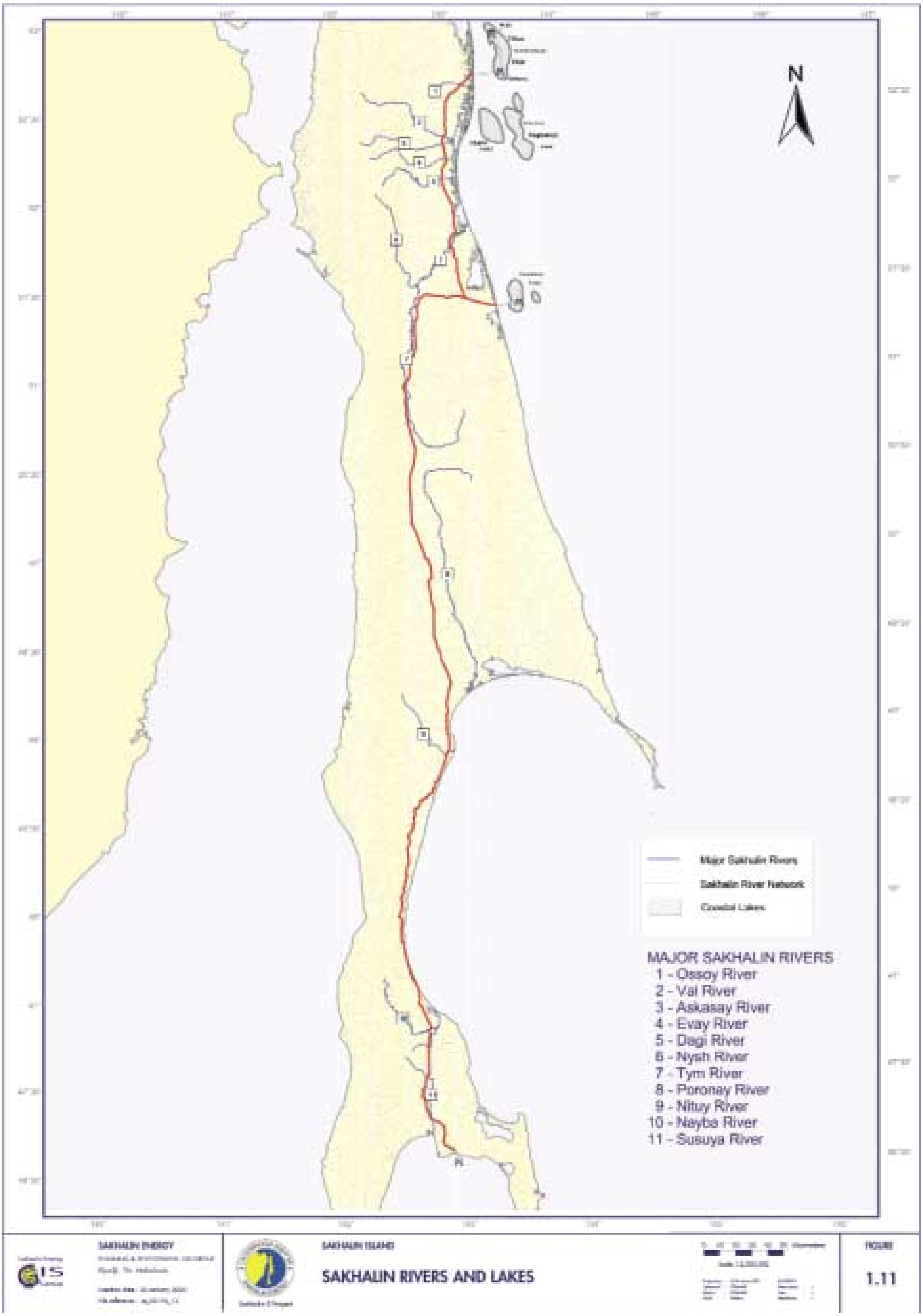
Between 1997 and 2001, topographical and geotechnical surveys of the onshore pipeline corridor (approximately 808 km) documented some 1167 surface watercourses. The final chosen route crosses some 1103 of the initially identified watercourses.

A classification of the watercourses to be crossed by the Sakhalin II pipelines for salmon spawning sensitivity is based upon a compilation of available information and existing regulatory requirements for the environmental protection for fish resources. Data sources utilised during the classification included Government Fishery Agencies, Fishery Institutes, University and SEIC environmental surveys and testing data. Additional data has been collected and the watercourse classifications were provided to SakhRYBVOD for review. SakhRYBVOD is the Sakhalin Oblast Fish Inspection Committee.

Watercourses were classified following discussions with SakhRYBVOD, as noted below:

- Group I - watercourses with no salmon spawning, and insignificant importance for fishery;
- Group II - watercourses with insignificant salmon spawning, and minor importance for fishery; and
- Group III - watercourses with significant salmon spawning and major importance for fishery.

Figure 1.11 Sakhalin Rivers and Lakes



Group I watercourses still include dry or intermittent streams, brooks, ponds, irrigation canals, springs and sources, small rivers with short lengths, widths and depths being tributaries to larger rivers. Group II watercourses include rivers where spawning areas are present, but where no data on the location or extent of the spawning area exist or where the spawning areas are smaller than 10 000 m^2. Group III water courses includes rivers with spawning areas greater than 10 000 m^2.

As a result, the watercourses were categorised in three major and six minor sub-groups as detailed in *Table 1.13*.

Table 1.13 Number and Type of Watercourses Crossed by the Sakhalin II Pipelines

Category	Class/type of watercourse	Number
I	Streams of no importance to fishery (no spawning)	161
I	Brooks	486
I	Lakes	8
I	Canals	251
I	Spring and seeps	3
I	Small stream with periodic / insignificant spawning	86
I	Total watercourse in Group I	995
II	Watercourses with minor importance for fishery - insignificant salmon spawning (Group II)	45
III	Watercourses of major importance for fishery - significant salmon spawning (Group III)	63
II + III	Total watercourses in Group II and III	108
I +II + III	Grand Total	1103

Furthermore, the watercourses crossed by the Sakhalin II pipelines were evaluated using physical and hydrological characteristics such as width, depth, water flow, soil-bedrock conditions etc. These characteristics were determined by a mixture of desktop and fieldwork evaluations, using data gathered during baseline surveys - both engineering (topographical and geotechnical) surveys and environmental (hydrology) surveys.

The initial Group classifications described above then allowed further sub-classification according to width (four sub-classes) and depth (three sub-classes). Additionally, rivers with up to 0.5 m depth were also sub-classified according to the density of bottom sediments (firm or loose ground). The sub-classifications were made by SEIC design contractor Starstroi/Ecmos (Russian engineering and construction company) and provided for review to SakhRYBVOD.

The classification and sub-classification process described above gives 48 different categories of watercourses to be crossed and these were then evaluated for potential environmental impact caused by proposed construction methods of river crossing. These initial categories allowed engineering designs for the construction methods to proceed with due consideration of the environmental impact to the fauna and flora, and particularly to the salmon resources. *Table 1.14* shows these categories.

Table 1.14 Watercourse Categories Based on Group Classification and Stream Width, Depth and Sediments

Width	**≤0.5m firm**	**≤0.5m loose ground**	**Depth 0.5-1.5m ground**	**>1.5m 0.5-1.5m**	**Total**
≤10m					
Group I	823	17	76	57	973
Group II	27	3	9	0	39
Group III	18	2	11	1	32
Total	868	22	96	58	1044
10-15m					
Group I	3	0	1	5	9
Group II	3	0	1	0	4
Group III	3	2	5	2	12
Total	9	2	7	7	25
15-30m					
Group I	0	0	1	6	7
Group II	0	1	0	1	2
Group III	0	3	3	5	11
Total	0	4	4	12	20
>30m					
Group I	1	0	1	4	6
Group II	0	0	0	0	0
Group III	0	0	5	3	8
Total	1	0	6	7	14
Group I	827	17	79	72	995
Group II	30	4	10	1	45
Group III	21	7	24	11	63
Total	878	28	113	84	1103

It can be seen that out of the 1103 watercourses to be crossed, 76% (840) are less than 10 m wide and less than 0.5 m deep at the point to be crossed.

Details of the 63 Group III watercourses deemed to be more sensitive to crossing impacts are shown in *Table 1.15*. The locations of these watercourse crossings are shown in *Figure 1.12*.

Figure 1.12a Location of the 63 Class III Watercourse Crossings Along the Pipeline

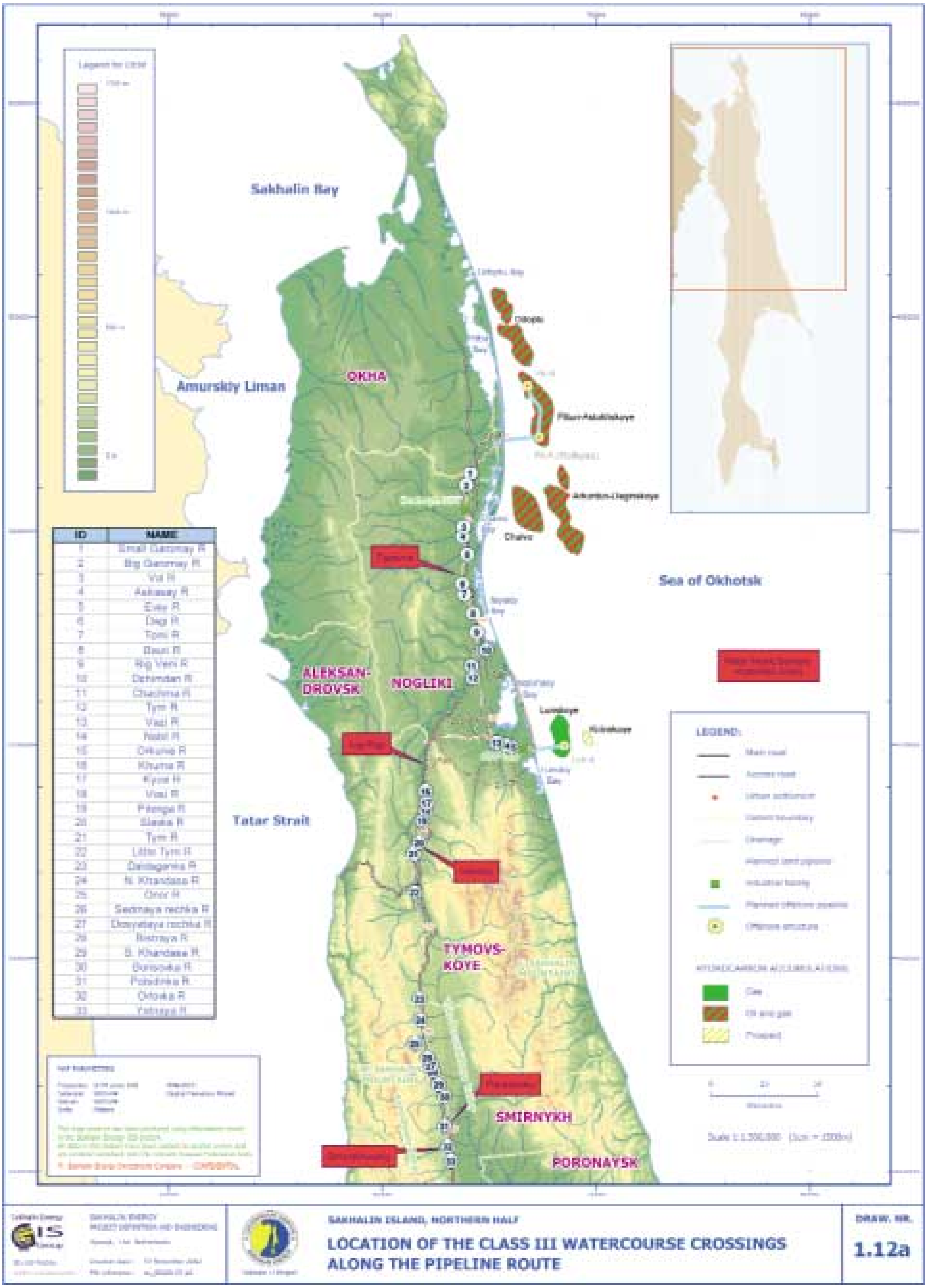


Figure 1.12b Location of the 63 Class III Watercourse Crossings Along the Pipeline

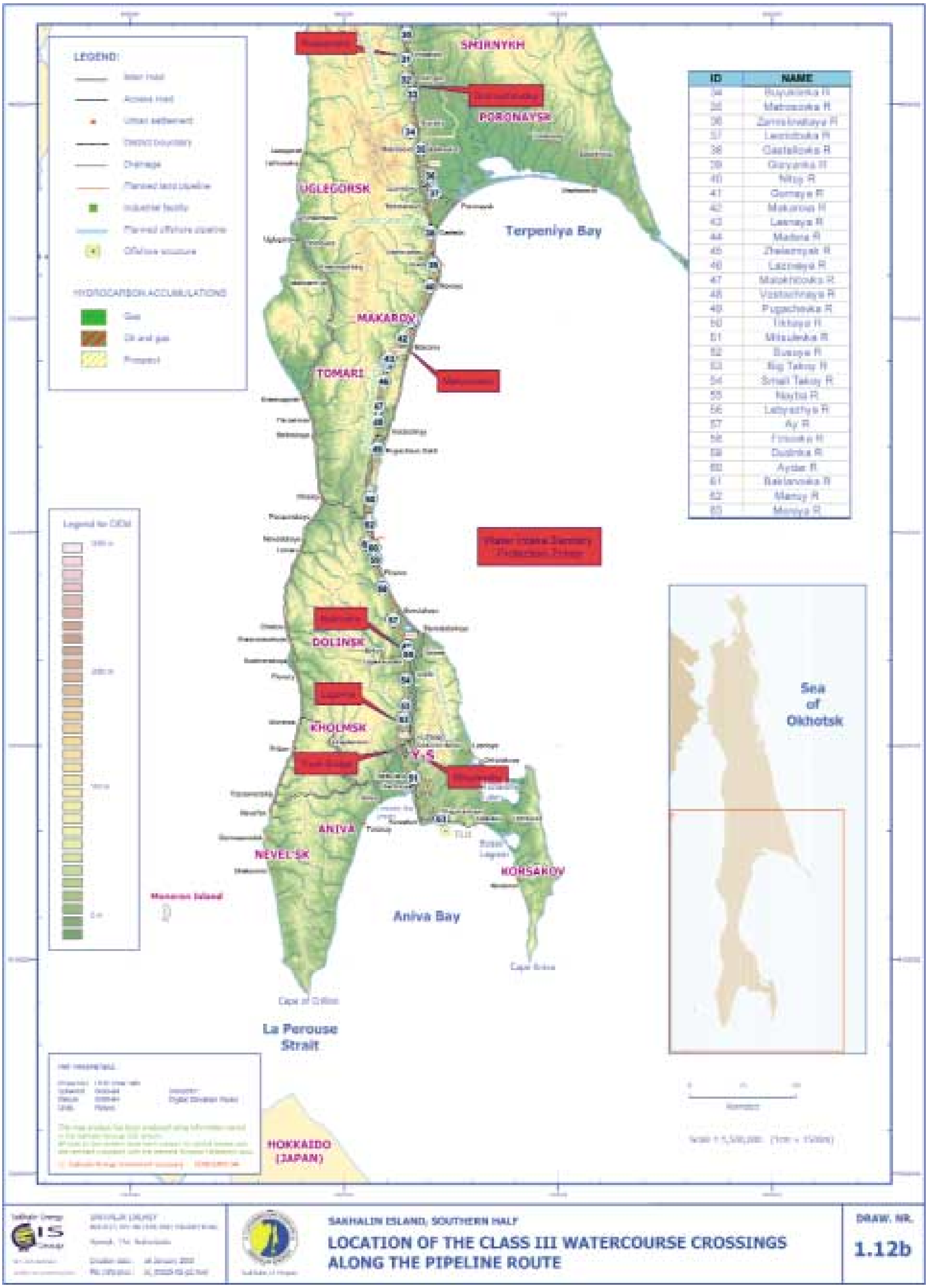


Figure 1.13 Typical Sakhalin Rivers

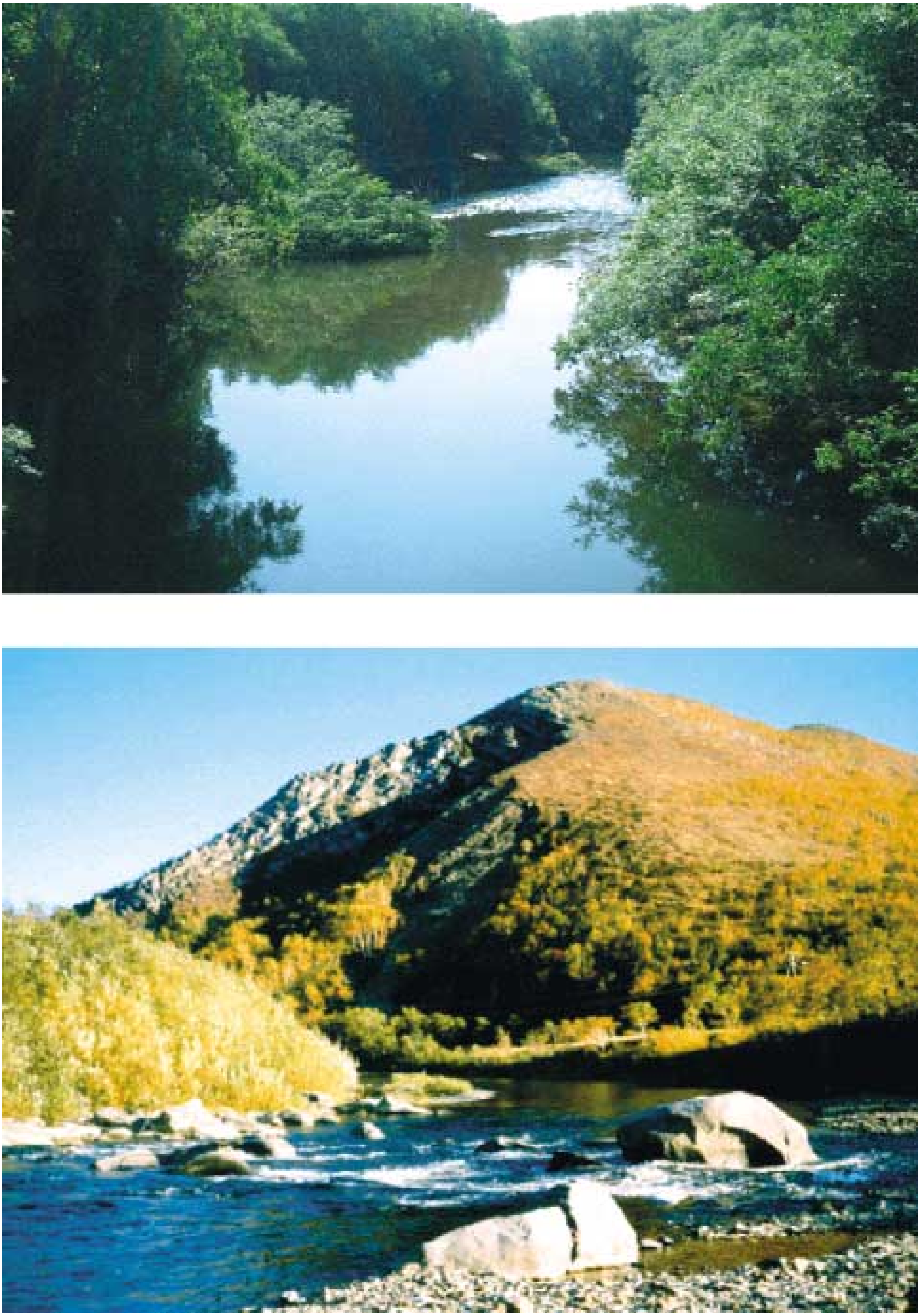


Table 1.15 Details for Group III Watercourses

Seg.	ROW km	Watercourse Name	Outfall	River length, km	Depth, m at the crossing location	Width, m at the crossing location	Water protect zone width, m	Total thou. m^2
Section from PA field up to settl.Nysh								
1	23.4	R.Mal.Garomay	Chaivo Bay	40	1	6	100	24
1	29	R.Bol. Garomay	Chaivo Bay	42	1.9	10	100	33.6
1	49.5	R.Val	Chaivo Bay	112	2.6	33	300	313.5
1	54.5	R.Askasay	Chaivo Bay	95	1.5	13	200	100.6
1	63	R. Evay	Chaivo Bay	117	2.9	12	300	84.5
1	78	R.Dagi	Nyisk Bay	116	1.2	15	300	323
1	83	R.Tomi (2 crossings)	Dagi Bay	30	1.1	8	100	24
1	93	R.Bauri	Nyisk Bay	15.6	1	4	100	12.9
1	101	R.Bol. Veni	Nyisk Bay	40	2.7	21	100	20.2
1	111	R. Dgimdan	Nyisk Bay	68	1.4	40	200	53.5
1	121	R.Chachma	R.Tym	100	3.3	22	100	40.9
1	124	R.Tym	Nyisk Bay	330	3.3	175	400	1828
Section from Lunskoye field up to settl. Nysh								
6	11.2	R.Orkunie	Nabilsky Bay	33	0.4	12	100	20
6	14	R.Nabil	Nabilsky Bay	85	1.5	37	200	372
6	18	R.Vazi	Nabilsky Bay	40	1.5	53	100	19.5
9	44.6-44.9	R.Pilenga	R.Tym	63	0.3	8-18	200	196.6

Spawning areas Including Upstream m within 500m, m²	Down-stream within 500m, m²	Location of the pipeline river crossings	Spawning area quality	Section of river crossing by ROW	Period of salmon max. migration	Period of young salmon maximum migration	Recommended construction period (approx.)	Trenching method	Pipe laying method
N/A	N/A	Upper, middle		Lower stream	01.08-25.09	10.05-05.07	October-March	III	B
500	400*	Upper, middle	medium	Middle stream	01.08-25.09	10.05-05.07	October-March	III	B
No	No*	Upper, middle	medium	Lower stream	01.08-25.09	10.05-05.07	October-March	VI, VII, VIII	C,D
No	No*	Upper, middle	medium	Upper stream	01.08-25.09	10.05-05.07	October-March and July	III	B
No	No*	Upper	medium	Lower stream	01.08-25.09	10.05-05.07	October-March	IV	B
200	150	Upper, middle	medium	Upper stream	01.08-25.09	10.05-05.07	October-March	III	B
N/A	N/A	Upper	good	Lower stream	01.08-25.09	10.05-05.07	October-March	III	B
N/A	N/A	Upper, middle	good	Middle stream	01.08-25.09	10.05-05.07	October-March	III	B
N/A	N/A	Upper, middle	good	Lower stream	01.08-25.09	10.05-05.07	October-March	IV	B,C
N/A	N/A	Upper	good	Lower stream	01.08-25.09	10.05-05.07	October-March	IV	B,C
N/A	N/A	Upper, middle		Lower stream	01.08-25.09	10.05-05.07	October-March		
No	No		good	Lower stream	05.07-25.09	10.05-05.07	October-March; HDD - the whole year round	VIII	D
N/A	N/A	Upper		Middle stream	25.07-25.09	10.05-05.07	October-March	I	A
No	No*	Note 1	medium	Lower stream	25.07-25.09	10.05-05.07	October-March	VI, VII, VIII	C,D
N/A	N/A	Upper, middle		Lower stream	25.07-25.09	10.05-05.07	October-March	VI\VII\VIII	C,D
No	600		good	Lower stream	25.07-25.09	10.05-05.07	October-March	I	A

Table 1.15 Details for Group III Watercourses Continued

Seg.	ROW km	Watercourse Name	Outfall	River length, km	Depth, m at the crossing location	Width, m at the crossing location	Water protect zone width, m	Total thou. m²
Section from settl. Nysh up to settl. Prigorodnoye								
2	31.2	R. Khuma	R. Tym		0.7	6	100	37.5
2	35.8	R.Kuvi	R.Tym	20.2	0.2	5,5	100	29
2	39.1	R. Vosie	R. Tym	30	1.5	8	100	68.7
2	55.1	R.Slavka	R.Tym	33.6	0.3	8	100	54.2
2	61	R.Tym (second crossing)	Nyisk Bay		0.9	45	400	1828
2	79	R.Mal.Tym	R.Tym	66	1	14.5	200	232.4
2	130	R. Daldaganka	R.Poronay	31	0.9	4.5	100	21
3	142	R.Sev. Khandasa	R.Poronay	54	0.5	6	100	70
3	153	R.Onor	R.Poronay	72	0.8	15	200	220
3	160	Sedmaya rechka	Desyataya rechka		0.3	4	100	27.5
3	164	Desyataya rechka	R.Poronay		0.3	10	100	30
3	167	R.Bystraya	R.Poronay	28	0.3	5.7	100	30
3	174	Yu. Khandasa	R.Poronay	50	0.8	9	100	85
3	181	R.Borisovka	R.Poronay	33	0.2	4	100	27
3	196	R.Pobedinka	R.Poronay	40	0.3	8	100	108
3	205	R.Orlovka	R.Poronay	83	0.9	18	200	319
3	213	R.Elnaya	R.Poronay	39	0.5	8	100	140
3	230	R.Biuklinka	R.Poronay	63	0.3	12	200	153
3	239	R.Matrosovka	R.Poronay	57	0.2	9	100	233

Spawning areas Including Upstream m within 500m, m²	Spawning areas Including Down-stream within 500m, m²	Location of the pipeline river crossings	Spawning area quality	Section of river crossing by ROW	Period of salmon max. migration	Period of young salmon maximum migration	Recommended construction period (approx.)	Trenching method	Pipe laying method
No	No*	Middle, down.	good	Lower stream	10.07-10.10	10.05-05.07	October-March	III	B
N/A	N/A	Upper, middle, down	good	Lower stream	30.07-10.10	10.05-05.07	October-March	I	A
No	No*	Middle, down.		Lower stream	10.07-10.10	10.05-05.07	October-March	III	B
1000	600*	Middle, down.	good	Lower stream	10.07-10.10	10.05-05.07	October-March	I	A
No	No*	Upper	good	Upper stream	10.07-10.10	10.05-05.07	October-March	VIII	D
No	No*		good	Lower stream	10.07-10.10	10.05-05.07	October-March	III	B
No	No*		medium	Middle stream	30.07-05.10	06.05-01.07	October- March and July	III	B
No	No *	Middle, Upper		Middle stream	30.07-05.10	06.05-01.07	October-March	I	A
No	No *		bad	Middle stream	30.07-05.10	06.05-01.07	October- March and July	III	B
No	No *		good	Upper stream	30.07-05.10	06.05-01.07	October- March and July	I	A
No	No *		medium	Middle stream	30.07-05.10	06.05-01.07	October- March and July	I	A
No	No *		good	Middle stream	30.07-05.10	06.05-01.07	October- March and July	I	A
No	No *		good	Middle stream	30.07-05.10	06.05-01.07	October-March	III	B
N/A	N/A	Upper	good	Middle stream	30.07-04.10	06.05-02.07	October-March	I	A
N/A	N/A	Upper, middle, down		Middle stream	30.07-04.10	06.05-02.07	October-March	I	A
700	800		medium	Lower stream	30.07-05.10	06.05-01.07	October-March	IV	B,C
N/A	N/A	Upper, middle, down	good	Lower stream	30.07-04.10	06.05-02.07	October-March	I	A
N/A	N/A	Upper, middle, Fish rearing station		Middle stream	30.07-04.10	06.05-02.07	October-March	VIII	D
N/A	N/A	Upper, middle		Upper stream	30.07-04.10	06.05-02.07	October- March and July	I	A

Table 1.15 *Details for Group III Watercourses Continued*

Seg.	ROW km	Watercourse Name	Outfall	River length, km	Depth, m at the crossing location	Width, m at the crossing location	Water protect zone width, m	Total thou. m^2
Section from settl. Nysh up to settl. Prigorodnoye								
3	253	R.Zamyslovataya	R.Poronay	40	0.4	6	100	34
3	259	R.Leonidovka	Terpeniya Bay	80	0.4	17	200	118
3	281	R. Gastellovka	Terpeniya Bay	32	0.5	19	100	58.5
3	297	R.Goryanka	Terpeniya Bay	30	1.6	13	100	67
4	307	R.Nituy	Terpeniya Bay	86	0.1	15	200	535
4	324	R. Gornaya	Terpeniya Bay	33	0.5	5.5	100	253.3
4	341	R.Makarova	Terpeniya Bay	93	0.6	30.5	200	299
4	349-350.3	R.Lesnaya	Terpeniya Bay	32	0.2	25	100	103
4	353	R.Madera	R. Lesnaya	19	0.6	9	100	47
4	356	R.Zheleznyak	R. Lesnaya	12	0.2	5.5	100	25
4	371	R.Lazovaya	Terpeniya Bay	36	0.5	4	100	220.3
4	379	R.Malkhitovka	R.Lazovaya	15	0.4	14.5	100	23
4	386	R.Vostochnaya	Sea	13	0.2	2	100	15
4	400	R.Pugachevka	Terpeniya Bay	44	2	26.5	100	190
4	422	R.Tikhaya	Sea	17	0.2	8	100	26.8
5	437	R.Manuy	Terpeniya Bay	36	3.3	24.5	100	58
5	450	R.Baklanovka	Sea	12	0.7	9.4	100	28.1
5	451	R.Aidar	Sea	11	0.2	5.6	100	20.5
5	455	R.Dudinka	Sea	15	0.3	14.1	100	29.4

Spawning areas Including: Upstream m within 500m, m²	Down-stream within 500m, m²	Location of the pipeline river crossings	Spawning area quality	Section of river crossing by ROW	Period of salmon max. migration	Period of young salmon maximum migration	Recommended construction period (approx.)	Trenching method	Pipe laying method
No	150*		good	Upper stream	30.07-05.10	06.05-01.07	October-March	I	A
500	500		medium	Middle stream	30.07-05.10	06.05-01.07	October-March	I/IV	A
No	No*		bad	Lower stream	25.07-10.09	06.05-01.07	October-March;	I/IV	A
No	No*		bad	Lower stream	25.07-10.09	06.05-01.07	October-March;	IV	B
150	350		medium	Lower stream	25.07-10.09	06.05-01.07	October-March	I	A
50	150		good	Lower stream	25.07-10.09	06.05-01.07	October-March	I/II,III	A
60	80*		bad	Lower stream	25.07-10.09	06.05-01.07	October-March;	IV	B,C
1500	1500*		medium	Middle stream	25.07-10.09	06.05-01.07	October-March;	I/IV	A
N/A	N/A	Upper, middle, down		Lower stream	25.07-04.10	06.05-02.07	October-March;	III	B
N/A	N/A	Upper, middle, down		Lower stream	25.07-04.10	06.05-02.07	October-March;	I	A
400	400*		medium	Middle stream	25.07-10.09	06.05-01.07	October-March;	I	A
800	700*		good	Lower stream	25.07-10.09	06.05-01.07	October-March;	I/II,III	A
500	500*		medium	Middle stream	25.07-10.09	06.05-01.07	October-March;	I	A
No	No*		bad	Lower stream	25.07-10.09	06.05-01.07	October-March	IV	B,C
N/A	N/A	Upper, middle, down		Lower stream	05.07-04.10	06.05-02.07	October-March	I	A
No	No*		medium	Lower stream	05.07-10.09	03.05-05.07	October-March	IV	B,C
N/A	N/A	Upper, middle, down		Lower stream	05.07-10.09	03.05-25.06	October-March	III	B
N/A	N/A	Upper, middle, down		Lower stream	05.07-10.09	03.05-25.06	October-March	I	A
N/A	N/A	Upper, middle, down		Lower stream	05.07-10.09	03.05-25.06	October-April	III	A

Table 1.15 Details for Group III Watercourses Continued

Seg.	ROW km	Watercourse Name	Outfall	River length, km	Depth, m at the crossing location	Width, m at the crossing location	Water protect zone width, m	Total thou. m²
Section from settl. Nysh up to settl. Prigorodnoye								
5	469	R.Firsovka	Terpeniya Bay	26	0.5	24.2	100	168
5	488	R.Ai	Sea	29	0.9	14.8	100	60
5	503	R. Lebyazhya	Lake Lebyazhye	33	0.18	1.9	100	27.5
5	506	R.Naiba	Terpeniya Bay	119	2.3	53.5	300	1030
5	519	M.Takoy	B. Takoy	28	1.1	10	100	20.4
5	531	R.B. Takoy	R. Naiba	58	0.2	9	200	305
5	538	R.Susuya	Aniva Gulf	86	0.32	16.4	200	55.8
5	570	R.Mitsulevka	R. Susuya	22	0.75	4.9	100	14.62
7	597	R.Mereya	Aniva Gulf	14	2	16	100	17.6

TOTAL RIVERS OF group III - 63

* Expert estimate - no spawning areas on the examined watercourses in 500-metres zone

Note 1: 265 thou.m^2-main river bed from 12 km from outfall up to head; 107 thou.m^2-inflows.

Note 2: 8 large inflows, spawning area in inflows -520 thou.m^2, incl. 315 thou m^2-in R. Takoy and 20,4 thou.m^2-in R. Mal. Takoy.

Note 3: Upper, middle, 11 inflows of 1 rank, spawning in inflows of 1 and 2 ranks

Spawning areas Including		Location of the pipeline river crossings	Spawning area quality	Section of river crossing by ROW	Period of salmon max. migration	Period of young salmon maximum migration	Recommended construction period (approx.)	Trenching method	Pipe laying method
Upstream m within 500m, m²	Down-stream within 500m, m²								
300	300*		good	Lower stream	05.07-10.09	03.05-05.07	October-March	VIII	D
N/A	N/A	Upper, middle		Lower stream	05.07-10.09	03.05-25.06	October-April	III	A
100	100*		medium	Middle stream	05.07-10.09	03.05-05.07	October-March;	I	A
100	150	Note 2	medium	Lower stream	05.07-10.09	03.05-05.07	October-March;	VI, VII, VIII	C,D
1200	1200*		Medium		05.07-10.09	03.05-05.07	October-March;	III	B
800	800*		Medium	Upper stream	05.07-10.09	03.05-05.07	October-March;	I/II,III	A
N/A	N/A	Note 3		Upper stream	05.06-05.10	03.05-25.06	October-March	IV	A
N/A	N/A	Upper, middle		Middle stream	15.05-05.10	03.05-25.06	October-March	III	B
No	No*		good	Lower stream	20.06-15.09	03.05-05.07	October-March	IV	B,C

Some typical rivers likely to be found on the proposed route are shown in *Figure 1.13*.

The Khanguza river is the largest watercourse adjacent to the area of the GDT although there are numerous smaller springs in the area. Most watercourses nearby are typically slow flowing, with wide floodplains and intermittent swampy areas. Many small watercourses are in the hills adjacent to the GDT site and flow into Chaivo Bay (TEO-C, Volume 3, Book 8.4, Appendix E).

The BS#2 site is located on the western border of the Poronai Valley and is confined to the area between two rivers: Gastellovka (1.7 to 2.3 km south of the site) and Chernushka (approximately the same distance to the north). 2 km eastwards from the site, is the Sea of Okhotsk coast (The Bay of Patience) (TEO-C, Volume 3, Book 8.3.1, Section 5).

The BS#2 construction camp is similarly located on the western boundary of the Poronaiskaya valley, the closest watercourse is the Chernushka River, approximately 100 m from the BS#2 site (TEO-C, Volume 3, Book 8.3.2, Section 5).

Ground Water

Despite the vast area that is crossed by the proposed route, reports suggest that the nature of the recent geological deposits and solid strata, which directly underlie the route and constitute important aquifers, are generally limited to various types of sedimentary lithologies (See *Chapter 1.3.3*). In order to avoid the repetition of discussion regarding the hydrogeological conditions that prevail along each individual segment of the route for the purposes of this report the discussion of the baseline hydrogeological environment can be limited to regional and generic features.

Regional Aquifers

The proposed route of the pipeline crosses five distinct hydrogeological areas, which are set out in *Table 1.2*.

Within all these features groundwater exists in two forms:

- The uppermost layer of groundwater exists as pore water throughout the recent sedimentary deposits (clays, sands and gravels). These deposits occur at the surface along the majority of the route and are generally highly permeable (with the exception of some clays). In areas of varied topographical relief, ie Segments 2, 3, 4, 5, 7 and 9, shallow groundwater will thus have a very short residency time and will rapidly contribute to surface water flows.
- Deeper aquifers exist as fissure water within faults and fractures that cut through the largely argillaceous (shale and siltstones) and arenaceous (sandstones) solid strata of Tertiary, Cretaceous and Jurassic age (see *Chapter 1.3.3*). These deeper aquifers can be in hydrologic continuity with the surface aquifers or locally confined by low permeability strata. The composition of groundwater within the bedrock changes depending on the lithology and on the presence of geothermal processes or hydrocarbon reserves.

Along the proposed route of the pipeline the thickness of the recent sedimentary deposits varies greatly from tens of metres upon the flanks and ridges of valleys to thousands of metres in the lowland areas. The groundwater that is included in the thicker deposits, ie the Poroniask Artesian Basin, is locally abstracted for both residential and industrial uses.

The thickness of the bedrock aquifer may also be up to thousands of metres. Locally this groundwater is also abstracted for industrial and residential uses.

Water Intake Points

A search of the area 10 km either side of the pipeline route encompasses 226 groundwater intakes, 25 surface water intakes, as well as four sites with work currently underway to explore for perspective ground water intakes. For each water intake, a Sanitary Protection Zone (SPZ) is established to protect the integrity of that water source. The SPZ size depends on factors such as direction and gradient of natural ground water flow, the thickness and lithologic composition of water saturated rock, the status of protection of water-bearing horizons from surface contaminant penetration, depth of their occurrence and the flow rates of production wells. The mean radius of these SPZ is approximately 1.5-2.5 km. Of all the identified water intakes, the pipeline route crosses only ten of the water intake SPZs, these are detailed in *Table 1.16* and shown in *Figure 1.12*. With the exception of one intake (at Makarovsky), the pipeline route passes downstream of the surface water intakes along the pipeline route impact zone, which means that potential contaminating spills cannot adversely impact the water intakes themselves. The intake at Makarovsky is located 3 km downstream of the pipeline route.

Table 1.16 *Water Intake Point SPZs Crossed by the Pipeline*

#	Name	Type of water intake	Location of intake point	Length of crossing (m)
1	Tapauna	Ground	0.3-0.8 km east of KP 75-77	1125
2	Argi-Pagi	Ground	0.6 km west of KP 19-20	300
3	Slaviskiy	Ground	0.8-0.9 km west of KP 57-58	500
4	Pobedinskiy	Ground	1.2-1.7 km north east of KP 196	120
5	Smirnykhovskiy	Ground	0.7-0.9 km north west of KP 206	900
6	Makarovskiy	Surface	3km from pipeline	3000
7	Nabinskiy	Ground	0.5 km east of KP 506	2250
8	Lugovoe	Ground	2.5 km south east of KP 545	3500
9	Truck Bridge	Ground	1.65 km west of KP 560	500
10	Mitsulevskiy	Ground	1.2-1.5 km south of KP 568-569	2300

1.3.5 Climate and Meteorology

Introduction

The climatic conditions of Sakhalin can be divided into three regions (northern, central and southern). Therefore the climatic conditions along the pipeline route are split as follows:

- Northern: Sections 1, 8, 6, and 9 of the onshore pipeline route (as described in *Chapter 1.1* and shown in *Figure 1.3* and the GDT.
- Central: Sections 2, 3, and 4 of the onshore pipeline route, including BS#2.
- Southern: Sections 5 and 7 of the onshore pipeline route.

The range of climatic conditions (as described below) is caused by the combined effect of the significant length of the island in the north-south direction, the mountainous topography, and the various thermal regimes of the seas and currents. The seasonal change of the areas of low and high pressure over the continent and sea drive these climatic conditions, leading to the influx of dry air from the continent during the winter months (December to February), and of humid air from the surface of the sea during the summer months (June to August). Climate data from the Russian Meteorological Agency SakhUGMS can be found in TEO-C, Volume 3, Book 8.2.1, Exhibit 6.1.

The following sections describe the divisions of climatic conditions throughout the year.

Northern Region

The northern climatic region extends to the northeast coast of the north Sakhalinsk lowland and includes the districts of Okha and Nogliki. The average annual temperature in this region is -10°C.

This area is characterised by cold winters that last approximately six months of the year (see *Figure 1.14*), with the coldest month being January experiencing temperatures of between -38.6°C to -48°C in some areas (approximately 200 days of temperatures below zero). These lasting frosty conditions and patchy shallow snow cover cause deep frost penetration of the soil, and the formation of isolated permafrost areas. Intensive winds from the north and west of between 4.2 - 7.1 ms^{-1} in this region facilitate the formation of sand dunes and lagoons on the low-lying coasts. The predominant wind conditions in the area are shown in *Figure 1.15*.

Figure 1.14 *Average Monthly Air Temperature (Okha and Nogliki)*

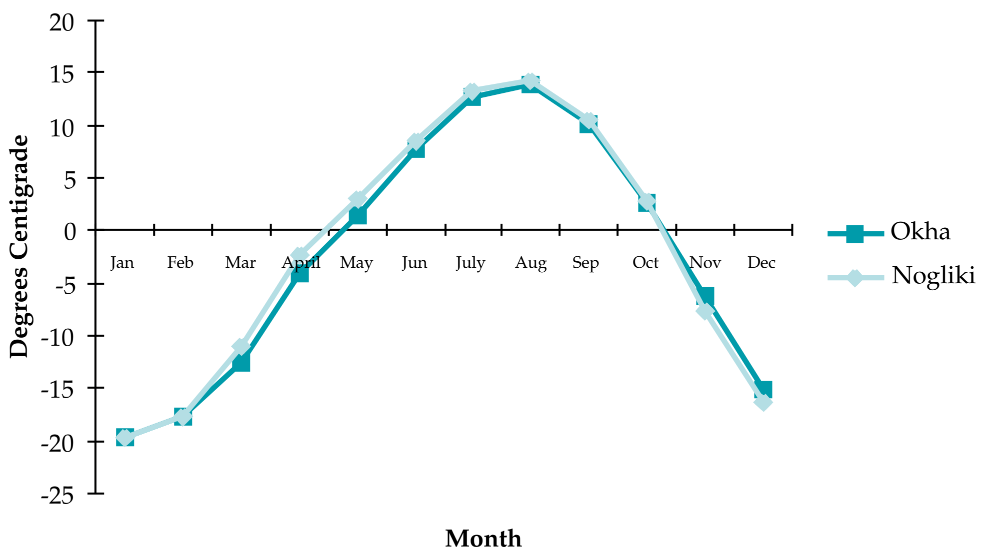
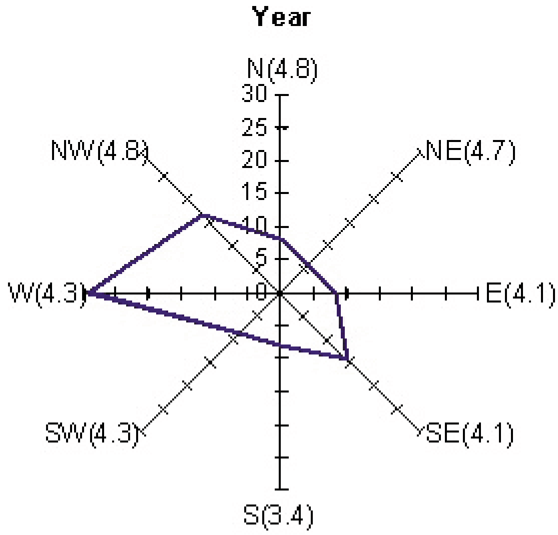


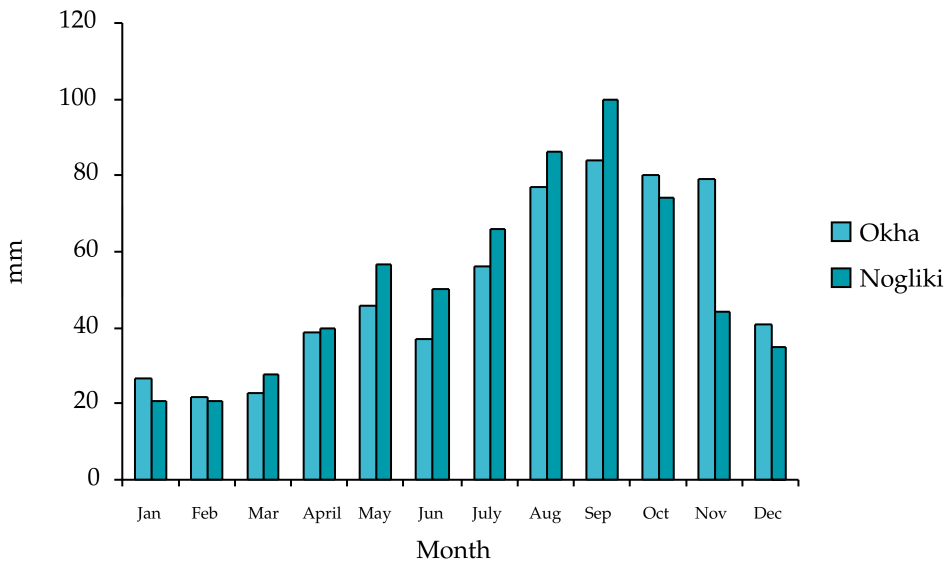
Figure 1.15 *Windrose for Northern Sakhalin*



Precipitation levels are low during the winter months, with a maximum average daily precipitation of 7 - 13 mm in February (see *Figure 1.16*)

Spring in the northern region is cold and windy with the occasional light frost. Temperatures begin to rise above zero in early May (see *Figure 1.14*). The summer months are cool and cloudy, with frequent fogs. The average temperature ranges from 8.9°C (on the coast) in July to 11.5°C (inland) in August. Temperatures can reach a maximum of 18.5°C in the area of the proposed pipeline. Precipitation at this time of year increases to a maximum monthly average of 98 - 104 mm in August (see *Figure 1.16*).

Figure 1.16 *Average Monthly Precipitation (Okha and Nogliki)*



The northern region experiences high relative humidity (84 - 93% during the summer and 70 - 80% during the winter). During the summer months these conditions combined with the cold temperatures can restrict evaporation in the soil, and only a small amount of precipitation can cause soil swamping.

Central Region

The central climatic region can be subdivided into the following areas.

- *Northern part of the Tym-Poronaysk Valley, including the Tymovsk district (central):* Distinct climatic features in this area are determined by the presence of the mountain ranges. The valley has a typical continental climate characterised by a cold winter and a relatively warm and dry summer. Temperatures in the winter months reach an average minimum of -15.5°C in January. During the summer months the temperature reaches an average maximum of 16.4°C in August. Although the summer is short with approximately 130 days of temperatures above zero, it is warmer than in the coastal areas.
- *Upper part of the Tym-Poronaysk Valley, Smirnykhovsk District (west):* This area is characterised by warm winters and cold and cloudy summers. This district has a particularly high altitude and average monthly temperatures in the winter reach between -17.2°C and -19.4°C. During daylight hours thaws can occur when temperatures in January can reach 1 - 2°C. Average monthly temperatures start to reach above zero in early May and average monthly temperatures during the summer reach between 12.4 - 15.3°C.
- *East slopes of the Kamyshov ridge, including the Poronaysk and Makarov districts (east):* The climate in this region is influenced particularly by the sea as the valley widens to the south towards Terpeniya Bay, where the Booster Station is located. The winters are mild and the summers are cool and wet. During the spring the cold sea currents carry cold water and ice from the Okhotsk sea, decreasing the air temperatures and causing light frosts in June, July and August. Intense precipitation in this area cause landslides and avalanches from the slopes. Terpeniya Bay is covered in ice and so temperatures in this district are low with the average winter temperature ranging from 12.8°C to -16.6°C. August is the hottest month with an average maximum temperature of 19.1°C.

Figure 1.17 shows the average monthly air temperatures for Tymoskoye, Onor, and Makarov in the central region of Sakhalin Island (TEO-C, Volume 3, Book 8.2.1, Section 6).

The central region receives an annual average precipitation of 792 mm y^{-1}, and is often referred to as a monsoon climate (*Figure 1.18*). 520 mm y^{-1} of this falls as rain (most of which falls from August to October), 150 mm y^{-1} as snow, and 122 mm y^{-1} of which is combined. Snow cover is on average 58 cm thick, reaching a maximum of 96 cm. Levels of relative humidity are similar to those of the northern region with highs of 84 - 85% during the summer months, decreasing to 70 - 73% during the winter months.

Figure 1.17 Average Monthly Air Temperature (Tymoskoye, Onor and Makarov)

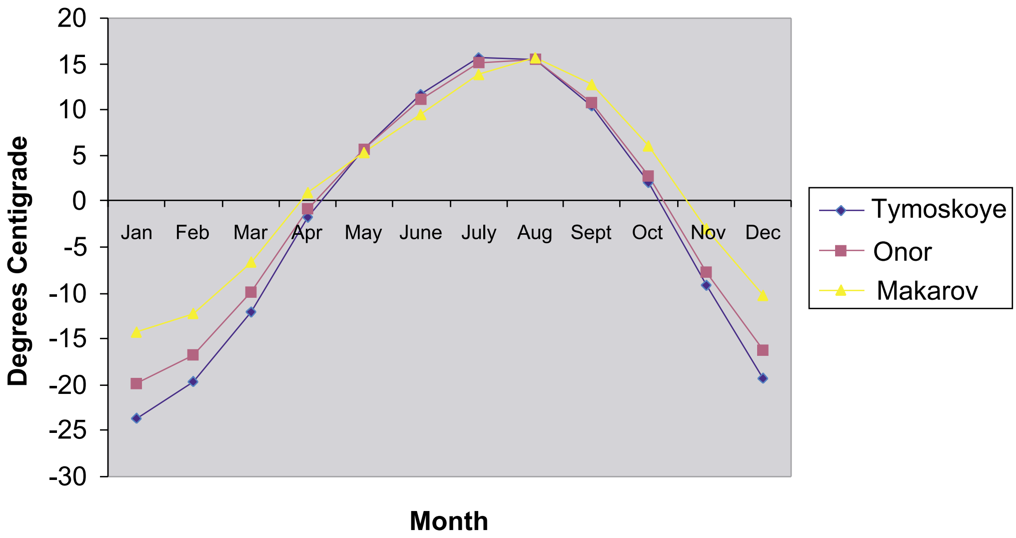
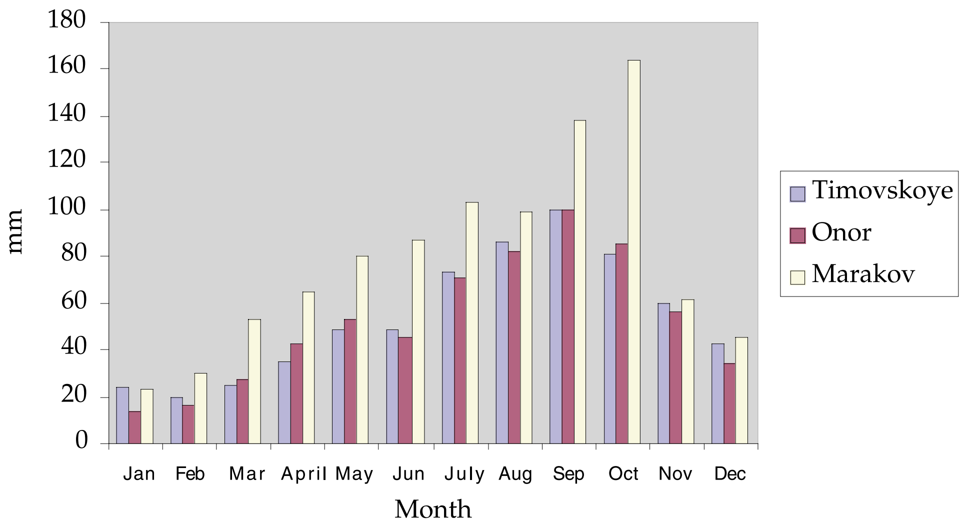


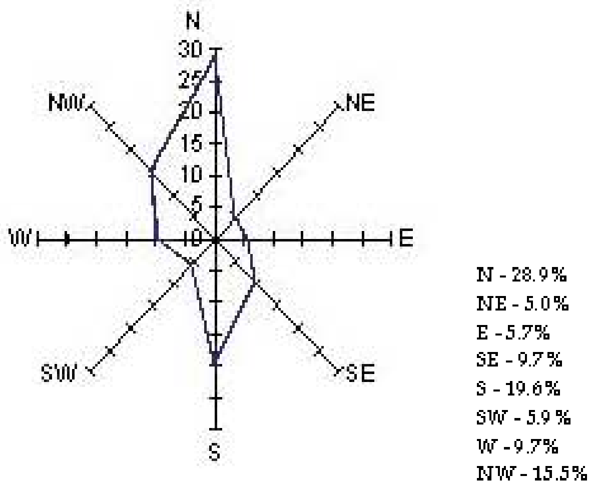
Figure 1.18 Average Monthly Precipitation (Tymoskoye, Onor and Makarov)



Fogs mainly occur from April to September in the central region, and there are two main processes by which they form. Warm air masses collect over the cold sea currents to the west, and the fog is dispersed by the mountain range as it moves across the island. Radiation fog is created at night in the inland valleys by the movement of cold air down the valley sides to slide underneath the warmer air on the valley floor.

Westerly winds are predominant during the winter (3.9 ms^{-1}) and southeasterly winds during the summer (3.2 ms^{-1}). Wind directions are dictated by the monsoon circulation, and the orientation of the river valleys. *Figure 1.19* is a windrose for Terpeniya Bay (considered representative of the Central Region) that contains the values of average wind speed with reference to compass points (TEO-C, Volume 3, Book 8.3.1, Appendix E).

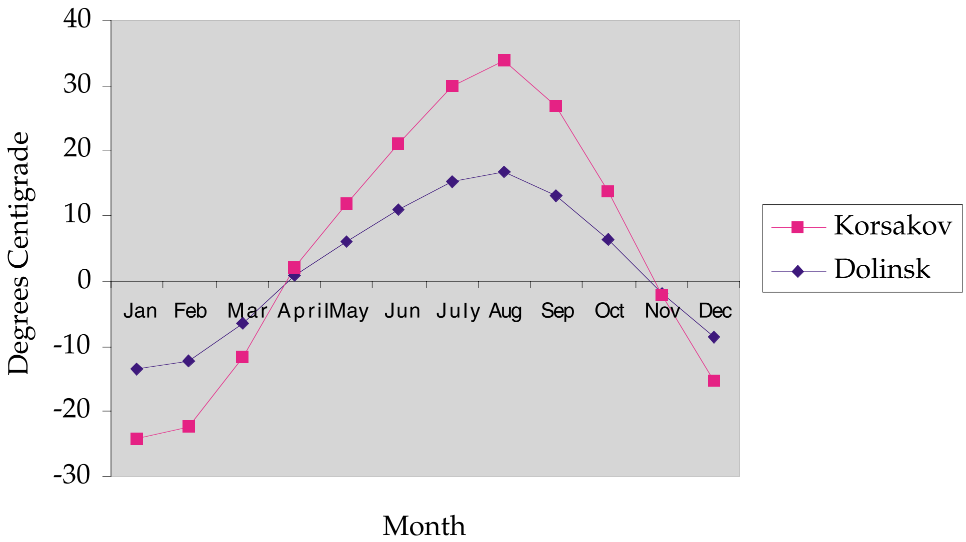
Figure 1.19 Windrose for Terpeniya Bay 2001



Southern Region

The southern climatic region includes the Dolinsk, Aniva and Korsakov districts. This region is characterised by a more moderate climate due to the latitude and the warm Tsushima sea currents. The average annual temperature is cold ranging from 1.8°C in Ogonki to 2.5°C in Dolinsk. The coldest month is January when temperatures have an average minimum of -40°C. August is the hottest month with temperatures of an average maximum of 35°C (*Figure 1.20*).

Figure 1.20 Average Monthly Air Temperature (Korsakov and Dolinsk)



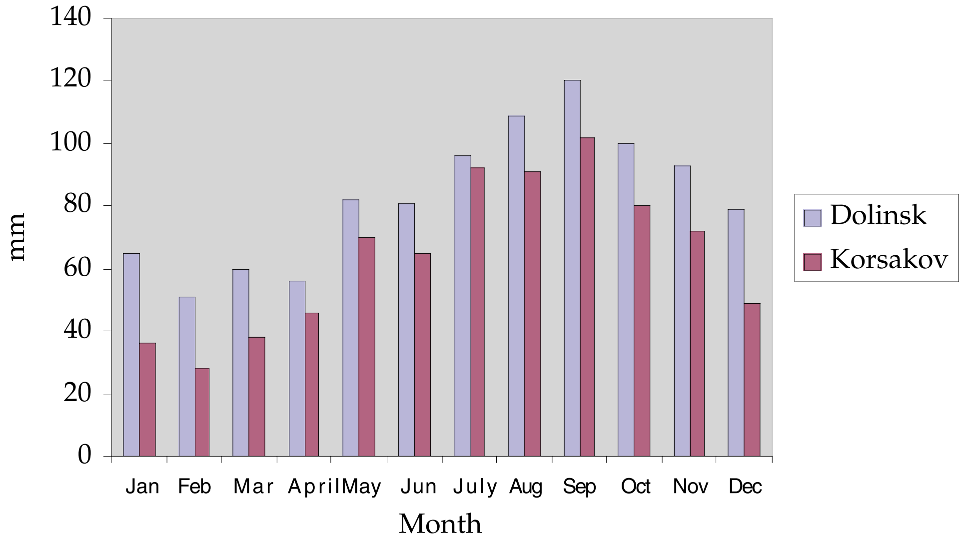
The annual average precipitation is 800 mm, falling mostly from September to October (see *Figure 1.18*). A high relative humidity is sustained throughout the year in the southern region with highs of 84 - 87% in August, and lows of 73 - 78% in April (TEO-C, Volume 3, Book 8.2.1, Section 6).

The southern region, like the northern and central region experiences fog from April to September (approximately 60 days per year). Occasional winter radiation fogs occur in Yuzhno-Sakhalinsk.

Winds are mainly from the west and are persistent and moderate. Average speeds from December to January are 2-4 m s^{-1} whereas during the summer months the prevailing wind is lighter and from the south.

Specific information about the climatic conditions at the LNG/OET site can be found in *Volume V*.

Figure 1.21 *Average Monthly Precipitation (Korsakov and Dolinsk)*



Hazardous Meteorological Conditions

Hazardous weather conditions significantly affect both the land and the seas of Sakhalin Island. Conditions such as prolonged periods of frozen ground, icy conditions, snowstorms and thunderstorms. Icy conditions can impact on land and sea operations from November to May, in some cases these can occur in June, September and October.

1.3.6 Air Quality

In general, there has been a trend of decreasing emissions to the air over the last several years, as detailed in *Table 1.17*. This is primarily due to the closure of enterprises using old and inefficient technologies such as the Poronaisk Pulp and Paper Mill (PPM), the Makarov PPM, the Dolinsk PPM, the Makarov and Tikhmenevskii coal mines, and the Shirovskii Open Coal Pit as well as the modernisation of equipment in other enterprises. The main individual air emitters in Sakhalin are the two Sakhalin State Regional Power Plants, the Korsakov Municipal Association of Boiler and Heat Utilities, DOAO Okhinsk Heat and Power Plant, and the Okhaneftegaz and Katanglineftegaz oil and gas producing administrations, the Trunk Oil Pipeline Administration in Nogliki and Okha, and automotive vehicles. Automotive vehicles were recorded to be responsible for 46% of emissions to the atmosphere in 2000 (Yefanov, 2001).

Percentage of air emissions per administrative district can be seen in *Table 1.18*. As would be expected, the districts with the most people and industry (Yuzhno-Sakhalinsk, Uglegorsk and Poronaisk) record the greatest proportion of emissions. Monitoring studies of pollutant emissions in cities and inhabited locations along the proposed pipeline route conducted by the Sakhalingidromet Administration were carried out at four points: the city of Poronaisk, the township of Novo-Aleksandrovsk, the city of Yuzhno-Sakhalinsk, and the city of Korsakov. Specific results are shown in *Table 1.19* and briefly discussed below:

- Poronaisk: The average annual concentrations of sulphur dioxide, carbon monoxide, and hydrogen sulphide remained at the same level throughout the 1992-2000 period. Because of the closing of the Poronaisk Pulp and Paper Mill, the pollution of the city's air by dust, nitrogen dioxide, and soot has decreased, and does not exceed the MPC for most parameters, with the exception of soot. There has also been a significant decrease in the hydrogen sulphide content of the air.
- Novo-Aleksandrovsk: In the period 1992-2000 the average annual concentrations of carbon monoxide, hydrogen sulphide, and nitrogen dioxide remain at approximately the same level. In recent years, because of the closure of a number of industrial enterprises there has been a trend toward a decrease in air pollution by dust, sulphur dioxide and soot.
- Yuzhno-Sakhalinsk: For more than 10 years the city has been among the Russian cities with the highest air pollution. Fairly high concentrations of nitrogen dioxide (6.6 MPC), soot (31.6 MPC), and benz(a)pyrene (6.8 MPC) are constantly recorded here. This is especially typical of the cold period of the year, when the highest frequency of meteorological conditions that are unfavourable for the dispersal of impurities is seen. The average annual concentrations of sulphur dioxide, carbon monoxide, nitrogen dioxide, and hydrogen sulphide in the last 10 years have remained at approximately the same level. Some decrease has been seen in suspended matter and nitric oxide in the air. However, the soot content in the atmosphere continues to increase.
- Korsakov: Soot is the main impurity contaminating the air of this city. Over the last 10 years, air pollution has remained at the same levels for carbon monoxide, nitrogen dioxide, and soot. Levels of suspended matter have increased in recent years, while sulphur dioxide concentrations show a trend toward decreasing values.

Despite the fact that significant air pollution is seen at a number of distinct places in Sakhalin, as a whole the air quality along the pipeline route itself is considered to be good.

*Table 1.17 Amount of Pollutant Emissions into the Air in Sakhalin Oblast, 1993-2000**

Emissions of noxious substances (thousand metric tons/yr)								
Item	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Total emissions for the Oblast								
Total:	**194.541**	**207.357**	**214.227**	**201.827**	**192.331**	**166.802**	**169.599**	**161.412**
Including:								
Solid	43.575	42.859	45.365	38.372	37.659	32.394	35.636	34.599
Gaseous and liquid	150.966	164.498	168.862	163.455	154.672	134.408	133.963	126.813
Of which:								
Sulphur dioxide	19.205	18.140	30.903	28.982	28.775	27.485	26.962	26.559
Carbon monoxide	98.664	111.997	106.625	103.974	97.081	81.152	80.093	77.309
Nitrogen oxides	23.607	24.246	23.247	22.685	21.467	20.065	20.404	17.771
Hydrocarbons	9.034	9.607	7.754	7.567	7.050	5.473	6.331	4.940
Volatile Organic Substances	0.663	0.183	0.146	0.100	0.118	0.106	0.121	0.167
Others	0.292	0.325	0.187	0.147	0.181	0.127	0.052	0.067
Emissions from fixed sources								
Total:	**120.332**	**132.648**	**122.608**	**112.957**	**104.795**	**78.041**	**88.827**	**87.102**
Including:								
Solid	43.575	42.859	45.331	38.339	37.627	32.362	35.607	34.567
Gaseous and liquid	76.757	89.789	77.276	74.618	67.168	45.679	53.220	52.535
Of which:								
Sulphur dioxide	19.205	18.140	17.760	16.494	16.475	15.013	15.613	16.118
Carbon monoxide	37.794	51.127	42.711	41.718	35.759	18.971	23.508	25.253
Nitrogen oxides	14.285	14.924	13.459	13.191	12.115	10.582	11.775	9.834
Hydrocarbons	4.517	5.09	3.014	2.968	2.520	0.880	2.151	1.096
Volatile Organic Substances	0.663	0.183	0.146	0.100	0.118	0.106	0.121	0.167
Others	0.292	0.325	0.187	0.147	0.181	0.127	0.052	0.067

* The percentage of raions affected by gas-pipeline construction in pollutant emissions for Sakhalin Oblast is 80%.

Table 1.18 Percentage of Air Emissions per Administrative District

Administrative raions of Oblast	**Total emission (thous mt yr^{-1})**	**Kholmsk**	**Dolinsk**	**Korsakovsk**	**Makarovsk**	**Uglegorsk**	**Yuzhno-Sakhalinsk**	**Okha**	**Al-Sakhalinskii**	**Tomari**	**Poronaisk**	**All others**
Total:	87.102	3.95	5.49	6.56	1.79	11.84	22.8	6.70	2.85	0.20	22.17	15.66
Including:												
Solid	34.567	3.68	7.00	6.31	1.47	18.20	21.20	0.16	4.70	0.23	29.51	7.56
Gaseous, liquid	52.535	4.14	4.50	6.72	1.99	7.66	23.85	11.00	1.63	0.18	17.34	20.99

Table 1.19 Air Quality Levels in Poronaisk, Novo-Alekandrovsk, Yuzhno-Sakhalinsk and Korsakov

	MPC (mg/m^3)		Poronaisk	Novo-Aleksandrovsk	Yuzhno-Sakhalinsk*	Korsakov*
Sulphur Dioxide	0.54	Average Annual	< MPC	< MPC	< MPC	< MPC
		Max one-time conc.	<MPC	<MPC	<MPC	<MPC
Nitrogen Dioxide	0.085	Average Annual	1.8 MPC (>1MPC 24.5%)	2.6 MPC (>1MPC 59.8%)	2.6 MPC (>1MPC 58.5%)	1.2 MPC (>1MPC 19.7%)
		Max one-time conc.	2.2 MPC	8.5 MPC	6.6 MPC	4.8MPC
Suspended matter	0.5	Average Annual	< MPC	< MPC	2MPC	4.4MPC
		Max of av. daily conc.	2.7 MPC	6 MPC (>1 MPC 35.6%)	10.7 MPC (>1MPC 74.0%)	72MPC** (>10MPC 64 times)
Carbon Monoxide	5	Average Annual	< MPC	< MPC	1.2 MPC (>1MPC 19.4%)	< MPC
		Max one-time conc.	1.8 MPC	2.8 MPC	5.4MPC	2MPC
Specific impurities	8 μg/m^3	Average Annual	4.3 μg/m^3	2 μg/m^3	1.7 μg/m^3	5.0 μg/m^3
		Max one-time conc.	1 MPC	< MPC	< MPC	3.2 MPC
Soot	0.15	Average Annual	1.7 MPC	2.7 MPC (>1MPC 37.2%)	2.7 MPC (>1MPC 40.2%) (>10MPC 12 times)	2.8MPC (>1MPC 44.5%)
		Max one-time conc.	2.5 MPC	10.8 MPC	31.5 MPC	6.7MPC

Where there are results from more that one monitoring station, the worst recordings are presented.

- **highest one time concentration.

1.3.7 *Noise*

Measured background noise levels are not available for the entire pipeline route. However, as the pipeline route has been selected to avoid as many industrial and populated centres as possible it follows that background noise levels are low. This is consistent with over 99% of the route lying within lands classified as forestry fund, state reserve, agricultural, Specially Protected Territory and water fund land. Typically noise levels will vary depending upon the distance to nearby roads, railways, settlements or other industrial establishments.

Noise receptors (settlements) close to the pipeline route are shown in *Figure 1.22* and noted in *Table 1.20*. Distances are from the centre of settlement, so it is possible that the outskirts of the settlement are closer than indicated on the map or in the *Table 1.20*.

Figure 1.22a Noise Receptors (settlements) Close to the Pipeline Route

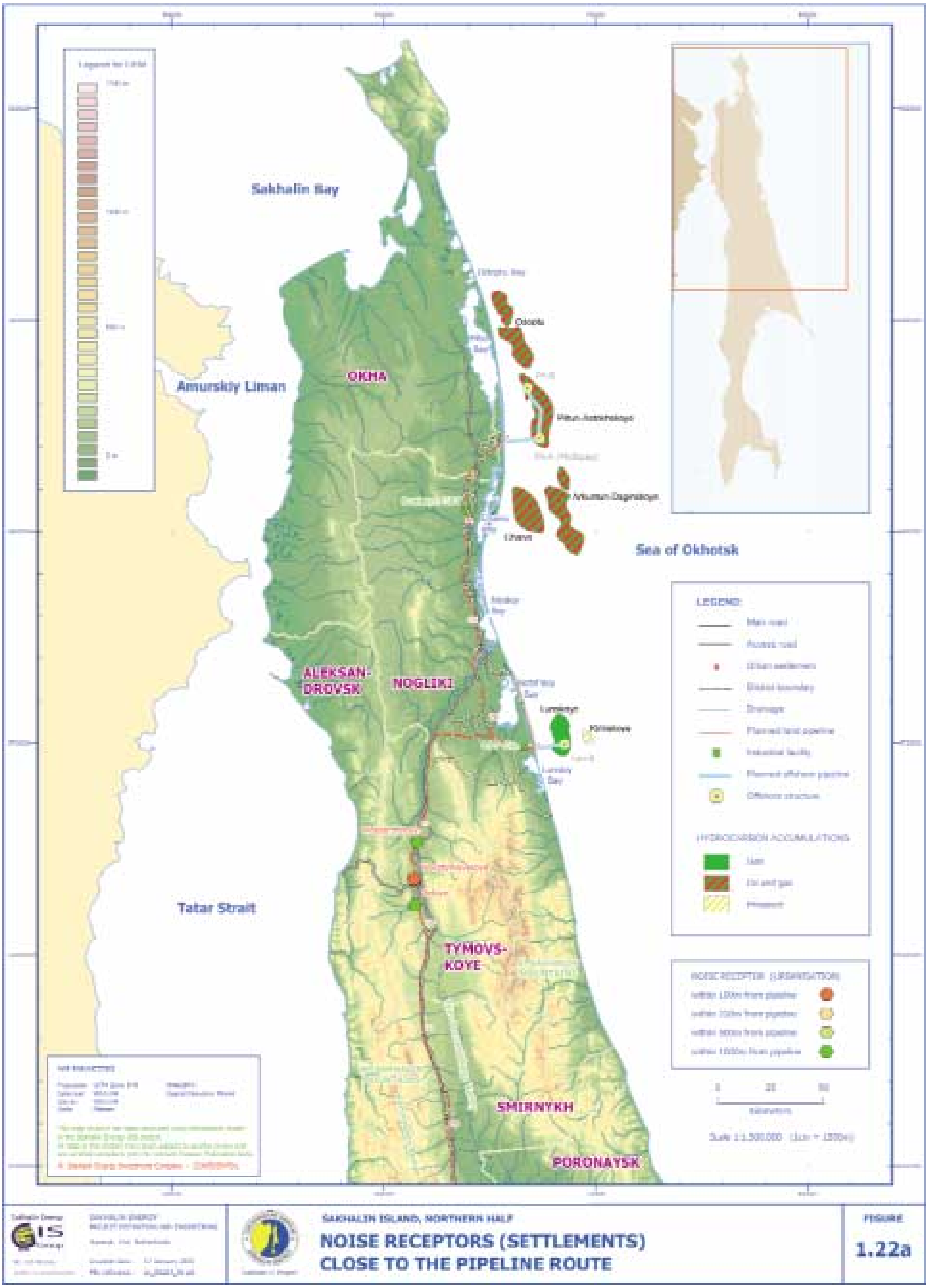


Figure 1.22b Noise Receptors (settlements) Close to the Pipeline Route

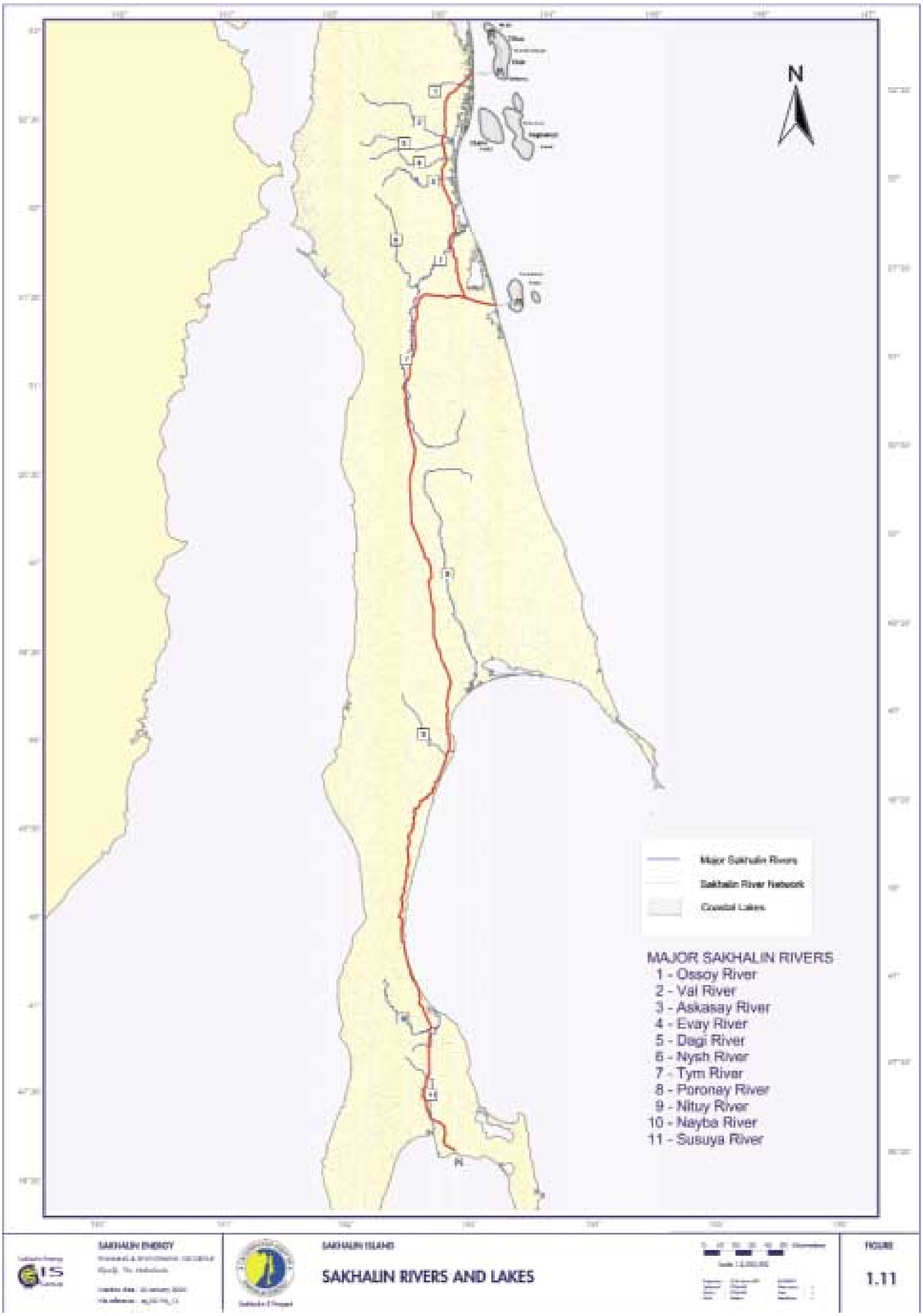


Table 1.20 Distance from Pipeline Route to the Centre of Settlements Along Pipeline Route

0 - 100m	100 - 250m	250 - 500m	500 - 1000m
Novotymovskoye		Tikhaya Dudino Firsovo Kurskaya-Sakhalinsk	Molodezhnoye Beloye Pugachevo Novotroitskoye

1.4 BIOLOGICAL ENVIRONMENT

1.4.1 Ecosystems

Historical Background

Floristic research on Sakhalin was initiated by F.W.Schmidt in the 1860s and 1870s. During the first half of the 20th Century Japanese workers studied the southern half of the island, while Russian scientists worked on northern Sakhalin. Since the entire island was transferred to Russian jurisdiction, more concentrated studies on vegetation have been carried out, but the plant cover of Sakhalin remains among the least studied in the Russian Far East. Full details of these studies are provided in FESU (2000).

Physical Environment

The major vegetation zones on Sakhalin are doubtless controlled primarily by the climate as elsewhere in northern latitudes. Some plantation trees and introduced species tend to fail in the severe conditions, leading to vegetational change in some habitats modified by man (FESU 2000). Details of Sakhalin climate are provided in *Chapter 1.3.5*.

As well as climate soils and hydrological conditions are of over-riding importance in determining the distribution patterns of natural and semi-natural vegetation types on Sakhalin. The principal vegetation types range from dwarf-shrub communities on the driest soils, through forests in mesic 'plakor' habitats, and boggy woodlands on impeded and low-lying substrates, to bogs and marshes in the wettest places (FESU, 2000). Information on soils and hydrology are provided in *Chapters 1.3.2* and *1.3.4*.

Human influences on the vegetation are also a major factor. Much of the forest is secondary (especially in the southern part of the island) following fires and logging in the early part of the 20th Century (FESU, 2000). There are substantial forestry plantations, and some areas of agricultural land, mainly in large river valleys (FESU, 2000). Ongoing human effects are listed and discussed in TEO-C Volume 3, Book 8.2.1, Section 8, and include land drainage, forest clearance for arable land and homesteads, forest fires, impacts from recreational activities, geological prospecting and grazing.

Vegetation Zones

The northern part of the pipeline route is located in the South Okhotsk dark-coniferous-sylvatic geobotanical region. The southern part is close to the boundary between this region and the East Asian mixed coniferous-broad-leaved geobotanical region, but Tolmachev (1955) considered that southwestern Sakhalin vegetation could not be assigned to this, even though there are many temperate species typical of the East Asian region.

The vegetation of the pipeline route crosses three vegetational sub-zones recognised by Tolmachev as follows.

- *Dark coniferous forest sub-zone with dominant fir.* On Plakor soils in the southern part of Sakhalin there are dark coniferous forests with *Abies sachalinensis* and *Picea ajanensis*, mostly secondary in origin. They are peculiar in having species of Eastern Asian sub-oceanic distribution, eg *Sasa* spp., *Vaccinium praestans*. In basins between mountains *Larix* spp. dominate with some *Picea ajanensis* and *Abies sachalinensis*.
- *True moss dark coniferous forests with dominant spruce.* From the Dolinsk area northwards to latitude 51.3N Picea ajanensis rises to dominance. East Asian species disappear, and species of the Manchurian distribution type reach their northern limits, eg *Juglans ailanthifolia, Quercus mongolica, Ulmus japonica*. Successional broad-leaved woodlands occur on river terraces, comprising *Salix rorida* and *Chosenia arbutifolia* in the early stages, then *Populus maximowiczii* woodland, and finally woodland of *Fraxinus mandshurica, Juglans ailanthifolia* and *Ulmus japonica*.
- *Larch forest sub-zone*. Above latitude 51.3N *Picea ajanensis* decreases and *Larix* species rise to dominance on sandy soils. Along significant associates are *Pinus pumila* and lichens (*Cladonia* spp.) are abundant in open woodland on dry soils. Small bogs may be skirted with forests of *Alnus hirsuta*.

Leaving aside rural vegetation and other anthropogenic types, several natural vegetation types occur azonally throughout these sub-zones. These include aquatic, wetland and coastal types. Descriptions are given in FESU (2000, 2002a).

Based on the information available it is only possible to summarise the general characteristics of these regional vegetation zones, it is not possible to make assumptions about the relative sensitivities of the different zones. However these are widespread zones of vegetation and therefore are unlikely to be vulnerable to localised impacts. The subsequent sections of this chapter will provide more information on the more localised vegetation baseline conditions that may be exposed to impacts from the pipeline and associated works.

1.4.2 Vegetation and Flora

Methods

There is no accepted classification for the entire vegetation of Sakhalin (FESU, 2000), and surveys were initially carried out to provide a vegetation classification for the pipeline route using a phytosociological approach. Existing data from a variety of sources were supplemented with data from field surveys. These were carried out in a 200 m strip along the pipeline route (100 m either side) between 07.07.00 and 03.09.00 and 3 September 2000 (optimal for botanical fieldwork) using the standard methods of Mueller-Dombois & Ellenberg (1974). Species-cover was recorded on the Domin-Krajina scale in 20 m by 20 m sample plots in homogeneous examples of vegetation types. Similar samples were objectively grouped using TWINSPAN analysis (Hill 1979), and then sorted by conventional methods of phytosociological tabulation.

Vegetation samples (over 600 including data from previous studies) were then assigned to phytosociological units at three hierarchical levels - alliances, associations and sub-associations. These were named by reference to a diagnostic combination of species (they were not given formal phytosociological names).

Further surveys were carried out between 09.08.01 to 30.09.01 taking in a 4 km corridor (2 km either side of the route). During both surveys the precise locations of rare or protected plant species were noted.

Broader geobotanical units (than those of the phytosociological association) were derived from GIS-analysis of satellite imagery covering the 4 km corridor centred on the pipeline route. Details of the procedure are given in FESU (2002a). These units were used as the basis for mapping the vegetation along the length of the 4 km route corridor. Locations of notable plant species were also mapped.

The Principal Vegetation Types

The phytosociological classification of vegetation types (dividing to sub-association level) is presented in FESU (2000). An overview is presented in *Table 1.21*. Full descriptions, photographs, and phytosociological tables of diagnostic species are presented in FESU (2000) with additional data in appendices.

Table 1.21 *Phytosocialogical Units*

Class	Order	Alliance/Associations (Sub-associations)
Picea-Rhodococcum	*Picea-Abies*	*Abies sachalinensis-Sasa sachalinensis-Sasa kurilensis* - 1 association 11110 *Abies sachalinensis-Sasa sachalinensis* *Picea ajanensis-Abies sachalinensis-Hylocomium splendens* - 3 associations, 2 sub-associations 11210 *Picea ajanensis-Abies sachalinensis-Leptorumohra amurensis* (11211 ~typical, 11212 ~*Hylocomium splendens*); 11220 *Picea ajanensis-Abies sachalinensis-Hylocomium splendens*; 11230 *Picea ajanensis-Abies sachalinensis-Linnaea borealis* *Picea ajanensis-Abies sachalinensis-Ledum palustre* - 2 associations, 2 sub-associations 11310 *Picea ajanensis-Abies sachalinensis-Sphagnum* spp. (11311 ~*Rubus chamaemorus*, 11312 ~*Carex schmidtii*); 11320 *Picea ajanensis-Abies sachalinensis-Solidago pacifica*
Larix dahurica	*Larix-Ledum*	*Larix-Picea-Rhodococcum* - 3 associations, 4 sub-associations 21110 *Larix-Anaphalis margaritacea*; 21120 *Larix-Abies-Coptis trifolia* (21121 ~*Ledum palustre*, 21122 *Carex globularis*); 21130 *Larix-Picea-Maianthemum dilatatum* (21131 ~typical, 21132 ~*Vaccinium uliginosum*); 21 *Larix-Chamaedaphne calyculata* - 3 associations 21210 *Larix-Vaccinium uliginosum*; 21220 *Larix-Myrica tomentosa*; 21240 *Larix-Ledum hypoleucum* *Larix-Cladonia* spp. - 1 association 21310 *Larix-Pinus pumila-Cladonia stellaris* 30000 *Pinus pumila* - class barely represented in north only
Alnus glutinosa	*Alnus japonica-Alnus hirsute*	*Alnus hirsuta* - 2 associations, 4 sub-associations 41110 *Alnus hirsuta-Senecio cannabifolius* (41111 ~*Filipendula kamtschatica*, 41112 ~*Rosa acicularis*); 41120 *Alnus hirsuta-Lysichiton camtschatcense* (41121 ~*Cacalia kamtschatica*, 41122 ~*Sphagnum* spp.)

Table 1.21 Phytosocialogical Units Continued

Class	Order	Alliance/Associations (Sub-associations)
Quercus mongolica		51000 *Ulmus-Fraxinus* - fragmentary examples in *Picea*-dominated forest in 2 river valleys
Salix schwerinii	*Populus suaveolens*	61100 *Populus suaveolens* - common but associations not distinguished 61200 *Chosenia arbutifolia* - common but associations not distinguished
Calamagrostis langsdorffii	*Calamagrostis langsdorffii*	*Calamagrostis langsdorffii* - 3 associations, 5 sub-associations 71110 *Calamagrostis langsdorffii-Senecio cannabifolius* (71111 *~Filipendula kamtschatica*, 71112 *~Carex sordida*); 71120 *Calamagrostis langsdorffii-Iris setosa* (71121 *~Angelica genuiflexa*, 71122 *~Ranunculus acris*, 71123 *~Fragaria iinumae*); 71130 *Calamagrostis langsdorffii-Naumburgia thyrsiflora* 71200 *Carex schmidtii* - common but associations not distinguished
Sphagnum-Oxycoccus	*Sphagnum magellanicum*	*Sphagnum magellanicum* - 2 associations 81110 *Osmundastrum asiaticum* (81111 *~Artemisia opulenta*, 81112 *~Equisetum sylvaticum*); 81120 *Sphagnum* spp.-*Rubus chamaemorus* (81121 *~Myrica tomentosa*, 81122 *Carex schmidtii*)
Elytrigia repens	*Elytrigia repens*	*Phalaroides arundinacea* - 2 associations, 3 sub-associations 91110 *Phleum pratense-Trifolium repens* (91111 *~Agrostis stolonifera*, 91112 *~Dactylis glomerata*, 91113 *~Ranunculus acris*); 91120 *Alopecurus pratensis-Ranunculus acris*
Chamerion angustifolium		10100 *Chamerion angustifolium* - common but associations not distinguished

The occurrence of these vegetation types is also summarised in FESU (2000) on the basis of route segments 1 to 9 (see *Chapter 2.1.2*). A summary of the different vegetation types (by code) found in each segment of the pipeline is given in *Table 1.22*.

Table 1.22 The Major Vegetation Types in Sections of the Route

Segment	Vegetation types
1	11230, 21131, 21132, 21210, 21220, 21310, 81121
2	11220, 11230, 21131, 21132, 21240, 91112, 91120
3	11220, 11320, 21110, 21122, 21131, 21240, 21210, 21220, 41112, 41122, 71112, 81111, 81112
4	11211, 11230, 41112, 81111, 81112
5	11110, 11211, 11230, 21110, 21122, 21131, 21240, 21220, 41121, 71121, 71130, 81111, 81121, 81122, 91111, 91112, 91120
6	11230, 21122, 21131, 21132, 21210, 21220, 81121
7	11211, 11220, 11230, 11311, 11312, 11320, 21110, 21121, 21122, 41121, 71111, 71112, 71121, 71130, 71123, 71122, 81112, 81122, 91113

For segment definitions see *Section 2.1.2*. For vegetation type codes see *Table 1.21*.

The main geobotanical units are described in detail in FESU (2002a), though some additional units are included in mapping presented as an appendix to TEO-C Volume 3, Book 2.1, Section 8. They are summarised here in *Table 1.23*. (Further detail on forestry is provided in *Section 1.4.1 Landuse*).

Table 1.23 *Geobotanical Units*

Code in FESU (2002a)/code in TEO-C Volume 3, Book 2.1, Section 8, unit description, district occurrence

a) Natural dark coniferous forests
1/1 Mesophytic fir and spruce (*Abies sachalinensis, Picea ajanensis*), fir, and spruce forests with true mosses (*Pleurozium schreberi, Hylocomium splendens, Dicranum scoparium, Rhytidiadelphus triquetrus, Ptilium crista-castrenis*), dwarf shrubs (*Rhodococcum vitis-idaea, Linnaea borealis, Vaccinium praestans*) and short herbage (*Maianthemum bifolium, Chamaepericlymenum canadense*) on slopes and drained plots of river terraces. O,N,T,(S), P, M, D,K.

2/2 Hygrophytic fir and spruce (*Abies sachalinensis, Picea ajanensis*), fir, and spruce forests with larch (*Larix gmelinii), Picea glehnii, Ledum palustre*, dwarf shrubs (*Rubus chamaemorus, Chamaedaphne calyculata*), sedges (*Carex schmidtii, C. disperma*) and peat mosses (*Sphagnum girgensohnii, S. squarrosum, S. magellanicum*) in wet habitats on waterlogged river terraces. (K).

b) Natural and established open coniferous forests of slopes and river valleys
3/6 Mesophytic and hygromesophytic larch forests with dwarf shrubs (*Rhodococcum vitis-idaea*), dwarf shrubs and reed-grass (*Calamagrostis langsdorffii*), and dwarf shrubs and short herbs (*Chamaepericlymenum canadense, Maianthemum bifolium, Maianthemum dilatatum*) with undergrowth of *Sorbus sambucifoila, Rosa acicularis, Sorbaria sorbifolia* and *Spiraea betulifolia* on slopes and drained plots of river terraces. (O), N, T, S, P, (M), (D), (K).

4/10 Larch open woodlands (*Larix gmelinii*) with Japanese Stone-pine (*Pinus pumila*), lichens (*Cladonia stellaris, C. mitis, C. rangeriferina*) and dwarf shrubs (*Rhodococcum vitis-idaea, Arctostaphylos uva-ursi, Empetrum sibiricum*) on well-drained dry slopes and river terraces with sandy soils. O, N.

10/12 Japanese Stone-pine (*Pinus pumila*) thickets with true mosses, lichens (*Cladonia stellaris, C. mitis, C. rangeriferina*) and dwarf shrubs (*Empetrum sibiricum, Arctous japonica*) on sandy shore dunes. (O, N- Piltun and Lunsky shore-crossings).

18/19 Waterlogged open larch forests (*Larix gmelinii*) with reed grasses, sedges (*Calamagrostis langsdorffii, Carex schmidtii*), cotton-grass (*Eriophorum russeolum*), peat mosses (*Sphagnum girgensohnii, S. squarrosum, S. teres, S. fallax, S. fimbriatum, S. capillifolium*), hygrophilous shrubs (*Ledum palustre, Oxycoccus palustris*) on low weakly drained waterlogged river terraces. (N - Lunskiy shore-crossing)

18/also 19 Waterlogged larch (*Larix gmelinii*) open woodlands (‘mires’) with ledum and dwarf shrubs (*Ledum palustre, Chamaedaphne calyculata, Vaccinium uliginosum*) on plots of flood lands and on flat weakly drained plots. N, (T), S, (P), D

c) Successional deciduous forests of flood-plains and river valleys
6/23 Mesophytic and hygromesophytic willow (*Salix udensis,* and *Chosenia arbutifolia*,) and alder (*Alnus hirsuta, Duschekia fruticosa*) and poplar (*Populus suaveolens, P. maximowiczii*) forests on lowered drained plots of river flood lands. T, S, P, M, (A)

7 Alder forests of Alnus hirsuta with elements of Sakhalin tall herbage (*Filipendula camtschatica, Cacalia hastata, C. kamtshatica, Senecio cannabifolius*) on weakly drained plots of river flood lands. No distribution information in FESU (2002a)

5/24 Mesophytic willow (*Salix rorida, Toisusu cardiophylla*), broad-leaved (*Ulmus japonica, Fraxinus mandshurica*) and poplar (*Populus suaveolens, P. maximowiczii*) forests with undergrowth of *Rubus sachalinensis, Rosa acicularis, Sambucus racemosa, Spiraea* spp. on high drained plots of river flood lands. T, P, M

Table 1.23 Geobotanical Units Continued

Code in FESU (2002a)/code in TEO-C Volume 3, Book 2.1, Section 8, unit description, district occurrence

d) Secondary forests on former natural-forest sites
8/27 White birch (*Betula platyphylla*) and aspen (*Populus tremula*) forests with *Salix caprea* and admixture *Alnus hirsuta* and with undergrowth of *Sorbaria sorbifolia, Rosa acicularis, Spiraea beauverdiana* and other shrubs with herb cover of *Filipendula camtschatica, Senecio cannabifolius, Calamagrostis langsdorffii* on weakly drained and waterlogged plots of river terraces. T, (S), (P), M, D, A, K

9/29 Meadowed birch (*Betula platyphylla*) open woodlands with admixture of *Sorbus commixta* and *Osmundastrum asiaticum, Cimicifuga simplex, Chamaenerion angustifolium* in the herb layer. P,M

11/30 Shrub thickets of *Rubus sachalinensis, Rosa acicularis, R. amblyotis* with *Calamagrostis langsdorffii, Chamaenerion angustifolium, Artemisia opulenta* in the herb layer on drained dry slopes and river terraces. M,P

25/31 Fireweed thickets (*Chamerion angustifolium*) in burnt out larch forests (*Larix gmelinii*) with reed-grass (*Calamagrostis langsdorffii*), varied and short herbs (*Coptis trifolia, Maianthemum dilatatum, Carex globularis, Equisetum sylvaticum*) on dry slopes and drained river and marine terraces. T

23/34a Burnt out areas in larch forests (*Larix gmelinii*) with Japanese stone pine (*Pinus pumila*) overgrowing with dwarf shrubs (*Arctostaphylos uva-ursi, Rhodoccocum vitis-idaea*) on well-drained dry slopes and river terraces with sandy soils. O, N

24/34c Burnt out areas in larch forests (*Larix gmelinii*) with ledum (*Ledum palustr*e) and *Myrica tomentosa, Betula middendorffii, Chamaedaphne calyculata* on plots of flood lands and on flat weakly drained plots. T

26/26 Cuttings in spruce and fir (*Picea ajanensis, Abies sachalinensis*) forests, growing over with *Osmundastrum asiaticum, Calamagrostis langsdorffii, Ledum palustre, Chamaepericlymenum canadense* on wealky drained river and marine terraces. (N)

e) Meadows
14/35 Xeromesophytic reed-grass and herb (*Calamagrostis langsdorffii*) and herb meadows (*Antennaria dioicia, Anaphalis margaritacea*) on well-drained plots of river and marine terraces and on slopes on former burnt out areas and cuttings in coniferous forests including plantations. M, (P)

13/36 Reed-grass and herb (*Calamagrostis langsdorffii*) and herb (*Artemisia opulenta, Anaphalis margaritacea, Aruncus dioicus*) meadows on well-drained plots of river and marine terraces and on slopes. T, S, (P), (M), D, A (K)

15/37 Combination of hygromesophytic reed-grass (*Calamagrostis langsdorffii*) meadows with elements of tall herbage (*Senecio cannabifolius, Filipendula camtschatica*) on moderately drained plots of river and marine terraces. (T), (S), (P), (M), D, A, (K)

12/38 Hygrophytic sedge (*Carex dispalata, Carex limosa*) and reed-grass (*Calamagrostis angustifolia, Calamagrostis langsdorffii*) meadows on weakly drained plots of river and marine terraces. (T), (S), (P), D, A

16/39 Sagebrush, sedge, and wild rye (*Leymus mollis, Carex macrocephala, Artemisia stelleriana, Artemisia arctica*) meadows on open seashore plots. (O, N - Piltun and Lunskiy shore-crossings)

17/40 *Sasa* thickets (*Sasa kurilensis, S. senanensis*) with rare B*etula platyphylla, Acer ukurunduense, Sorbus commixta* on well-drained slopes. (M), (D), (A)

f) Bogs
21/41 Oligotrophic peat moss bogs (*Sphagnum palustre, S. magellanicum, S. riparium*) with bog dwarf shrubs (*Oxycoccus palustris, Andromeda polifolia, Rubus chamaemorus*). O, T, S

22/42 Combination of peat moss (*Sphagnum russowii, S. capillifolium, S. girgensohnii, S. fuscum*), shrub (*Myrica tomentosa, Betula middendorffii, Chamaedaphne calyculata*), and herb (*Carex globularis, Rubus chamaemorus, Menyanthes trifoliata*) bogs on very weakly drained cold river and marine terraces. O,N,T

20/43 Combination of hygrophytic meadows and herb bogs (*Carex schmidtii, Carex limosa, Osmundastrum asiaticum*) on very weakly drained river terraces. O, N, (T)

Table 1.23 *Geobotanical Units Continued*

Code in FESU (2002a)/code in TEO-C Volume 3, Book 2.1, Section 8, unit description, district occurrence

g) Plantations and agricultural land
27/46a Pine plantations (*Pinus sylvestris*). M, D, A, K

28/46b Plantations of fir (*Abies sachalinensis*) and spruce (*Picea ajanensis*). M, D, (A), K

29/46c Larch plantations (*Larix gmelinii*). D, (K)

32/49 Agricultural lands, kitchen gardens. T, (S), P, (M), A

District abbreviations: O - Okhinskiy, N - Noglikskiy, T - Tymovskiy, S - Smirnykhovskiy, P - Poronayskiy, M - Makarovskiy, D - Dolinskiy, A - Anivskiy, K - Korsakovskiy. Where codes are placed in parentheses FESU (2002a) indicates limited occurrence in the district.

The categories of geobotanical units have been mapped for the pipeline route and are shown in *Figure 1.23*. The table below presents the percentage of the pipeline length that crosses each of the seven principle habitats.

Table 1.24 *Percentage of Pipeline Routes Crossing Different Habitats*

Habitat	% of route length
Natural dark coniferous forests	16.0
Natural and established open coniferous forests of slopes and river valleys	30.4
Successional deciduous forests of flood-plains and river valleys	8.1
Secondary forests on former natural-forest sites	30.1
Meadows	0.9
Bogs	4.5
Plantations and agricultural land	9.9

Vegetation types in 47 construction sites (settlements, storage sites etc) were surveyed between 01.08.01 and 30.09.01 (starting from the north to avoid the onset of winter). Detailed vegetation descriptions (based on geobotanical units) and mapping are given for every site in FESU (2002b). Unique vegetation units were described at each site, so that the vegetational variation within each site is distinguished efficiently (units appropriate for vegetation description over the whole pipeline route might not discriminate among types that are obviously different within a small site). Typically each site account deals with a site not exceeding 1 km square (usually much less), giving descriptive accounts of between two and eight vegetation types, mapping of the types, and tables giving cover values for the species recorded in each type.

Approximately 70% of the pipeline ROW is located in Forestry Fund Land. The location of the different forestry reserves traversed by the pipeline route is shown in *Figure 1.24*. Typical examples of vegetation types are shown in *Figure 1.25* to *Figure 1.30*.

Figure 1.23a Categories of Geobotanical Units Along the Pipeline Route

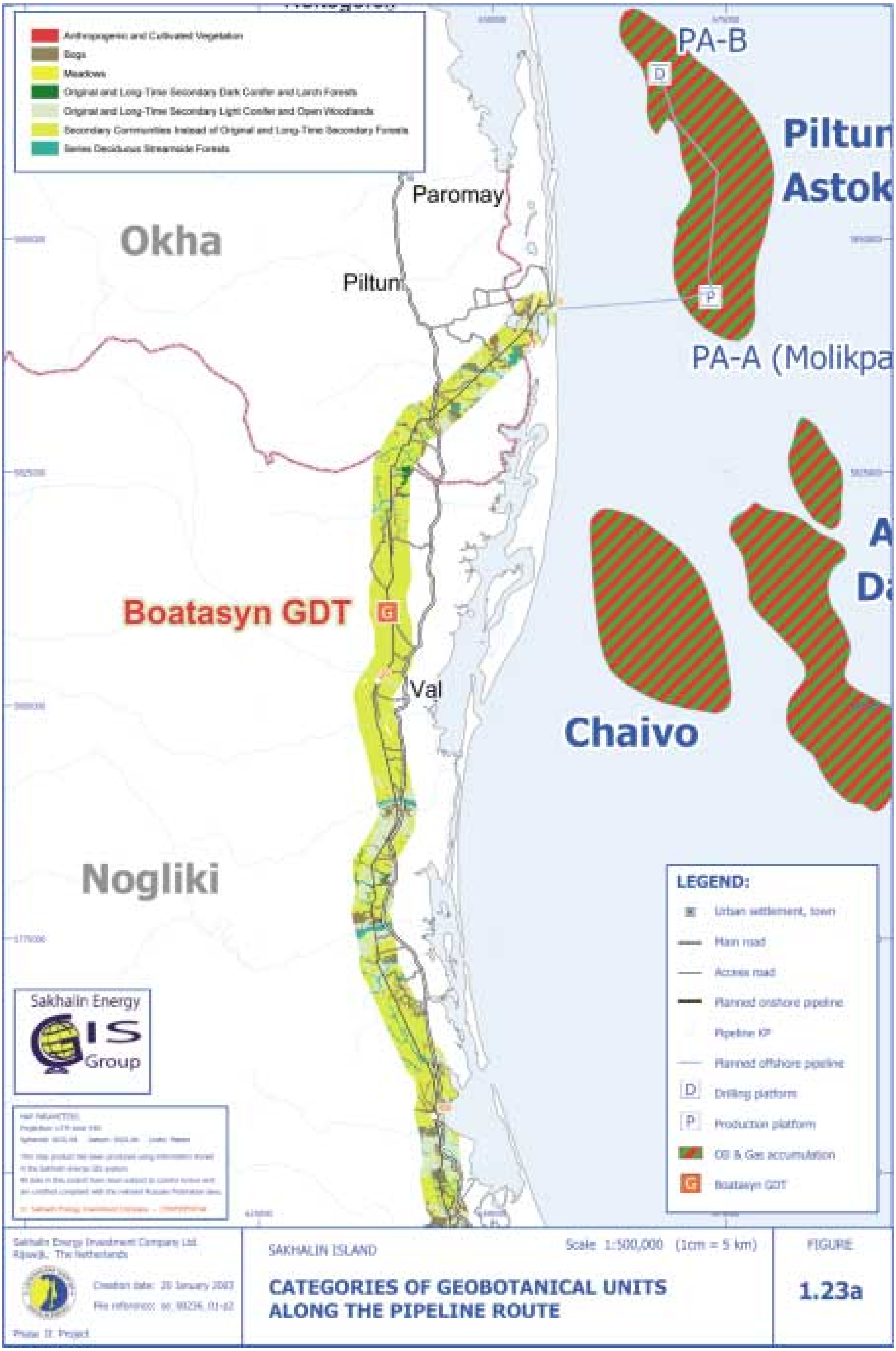


Figure 1.23b Categories of Geobotanical Units Along the Pipeline Route

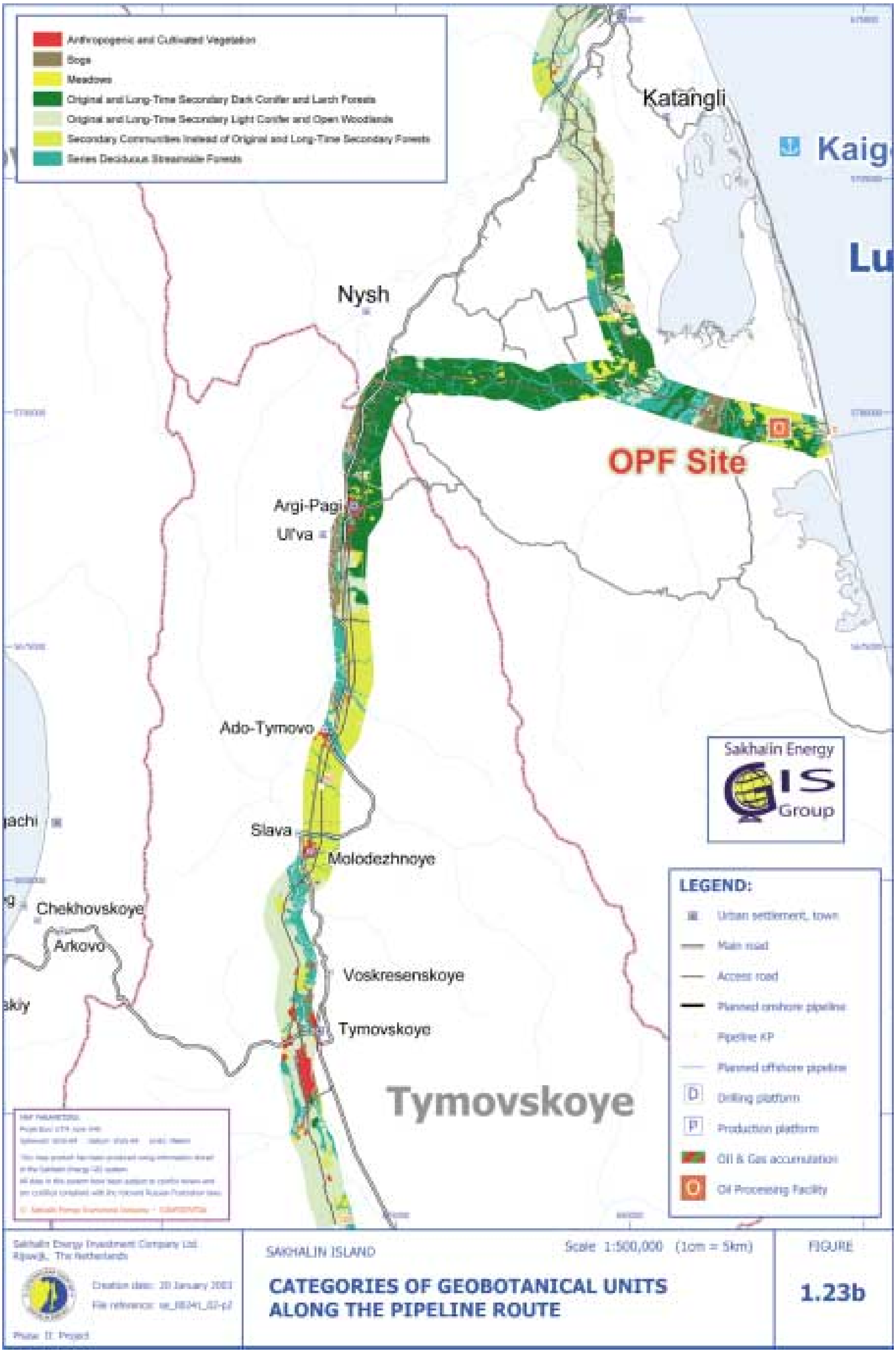


Figure 1.23c Categories of Geobotanical Units Along the Pipeline Route

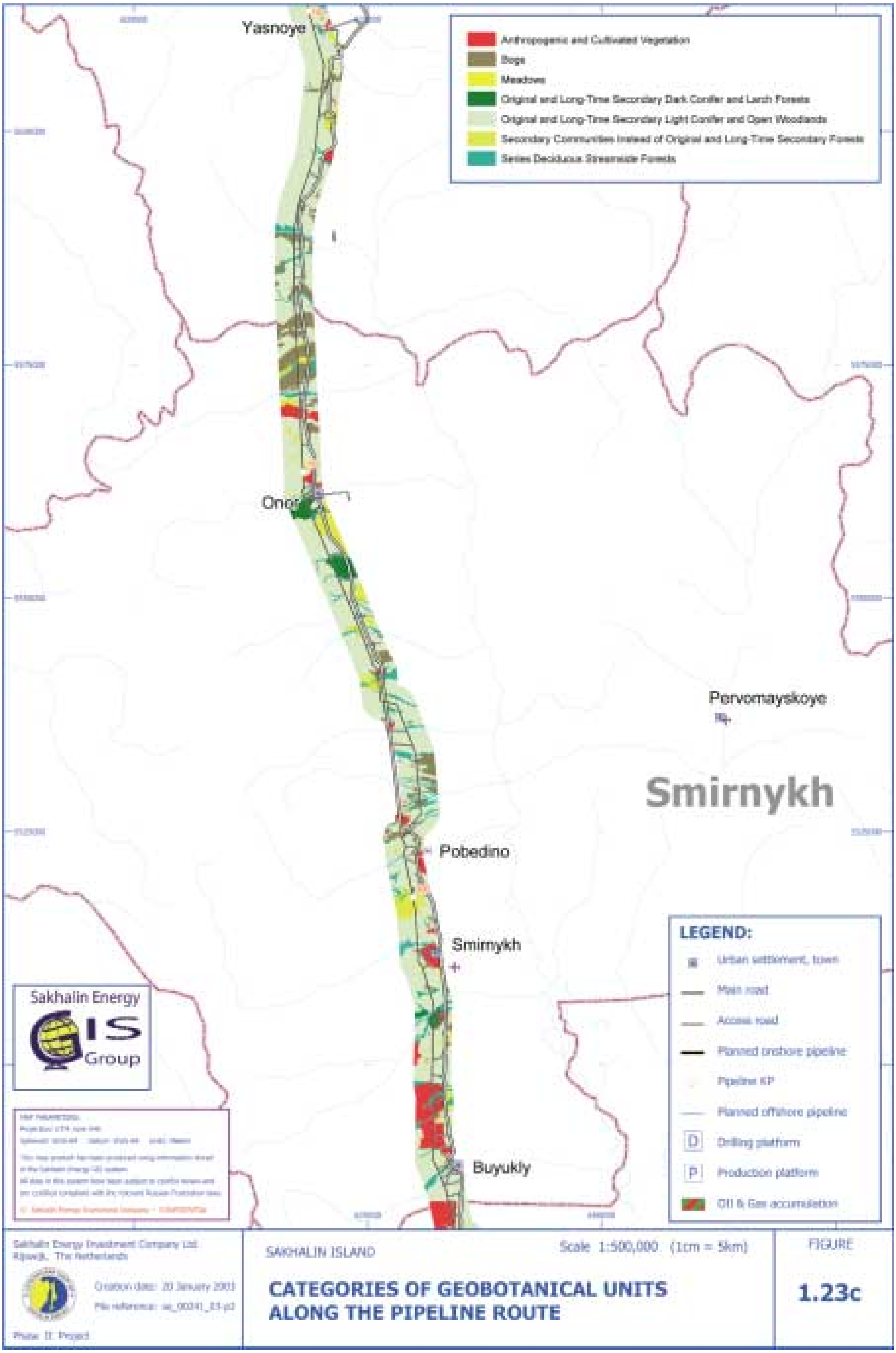


Figure 1.23d Categories of Geobotanical Units Along the Pipeline Route

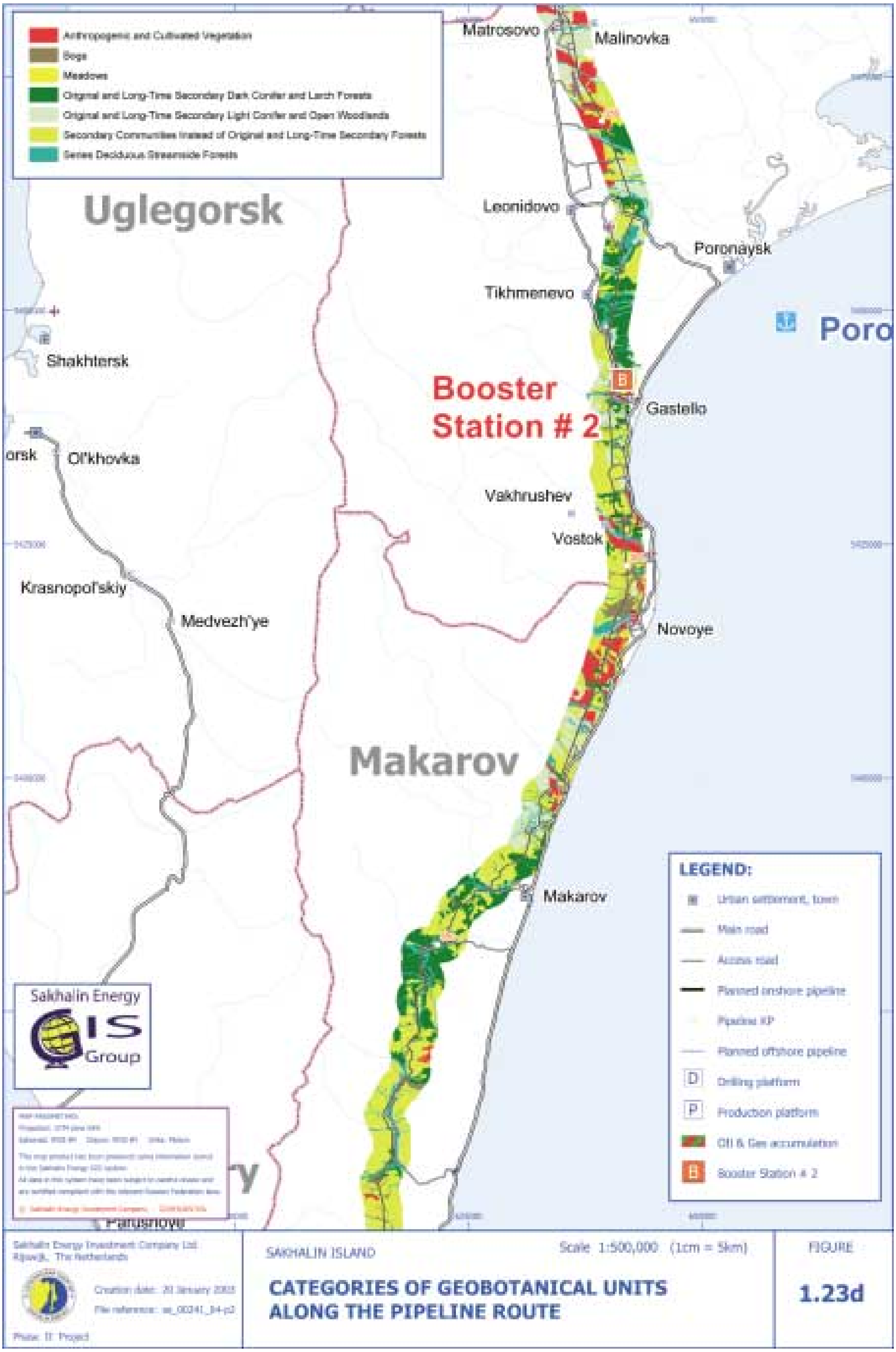


Figure 1.23e Categories of Geobotanical Units Along the Pipeline Route

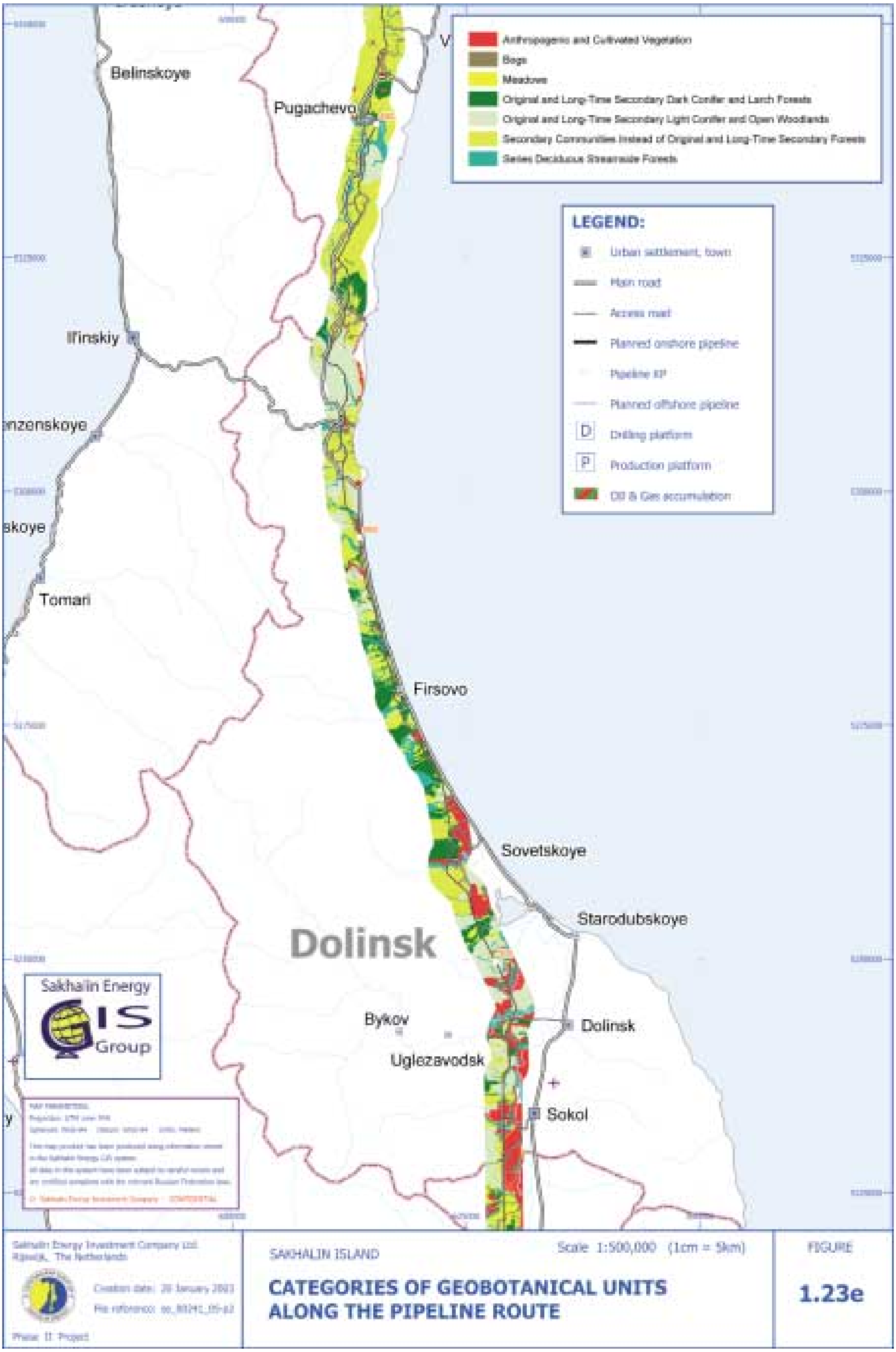


Figure 1.23f Categories of Geobotanical Units Along the Pipeline Route

Figure 1.24a Forestries Along the Pipeline Route

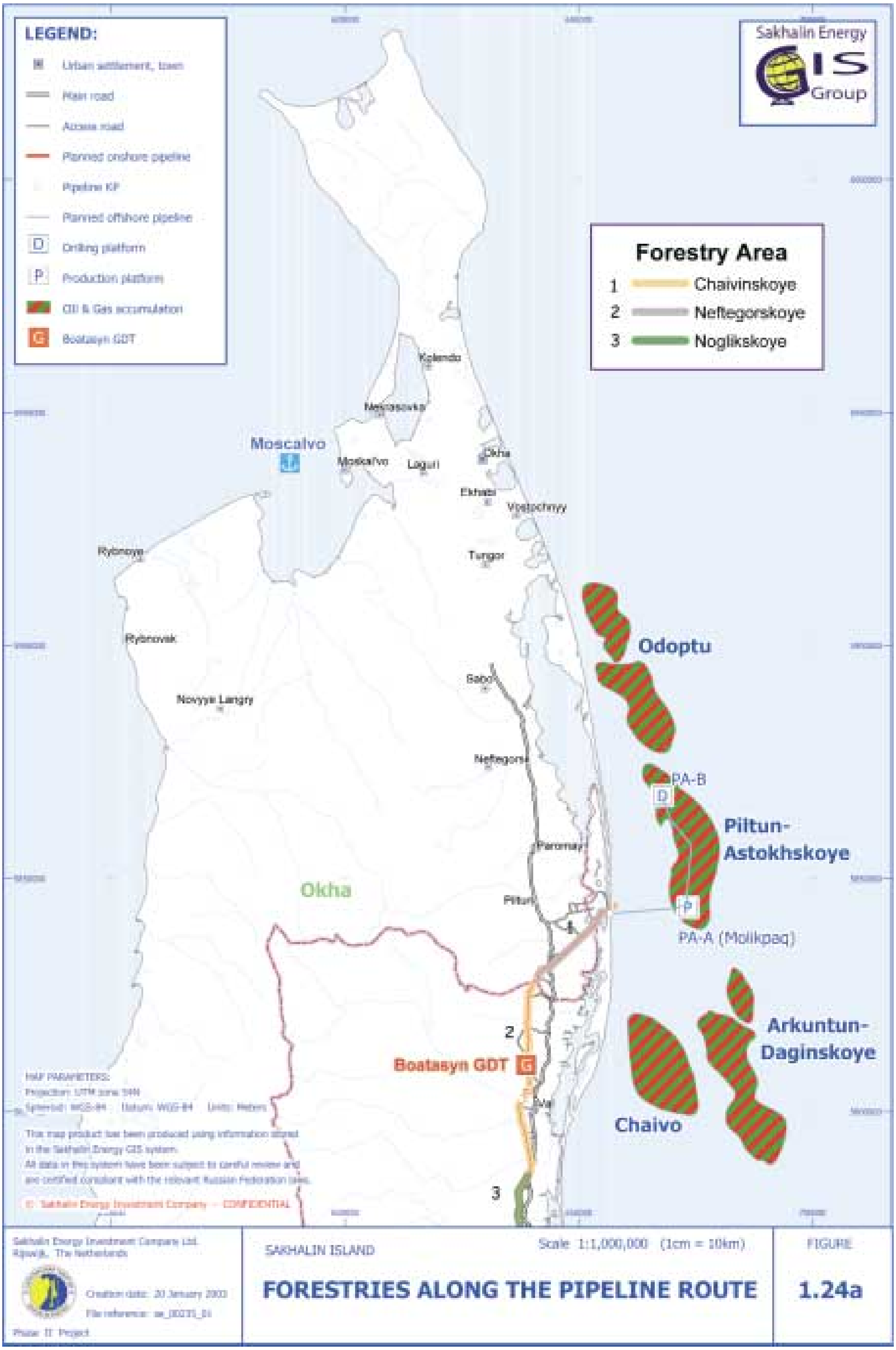


Figure 1.24b Forestries Along the Pipeline Route

Figure 1.24c Forestries Along the Pipeline Route

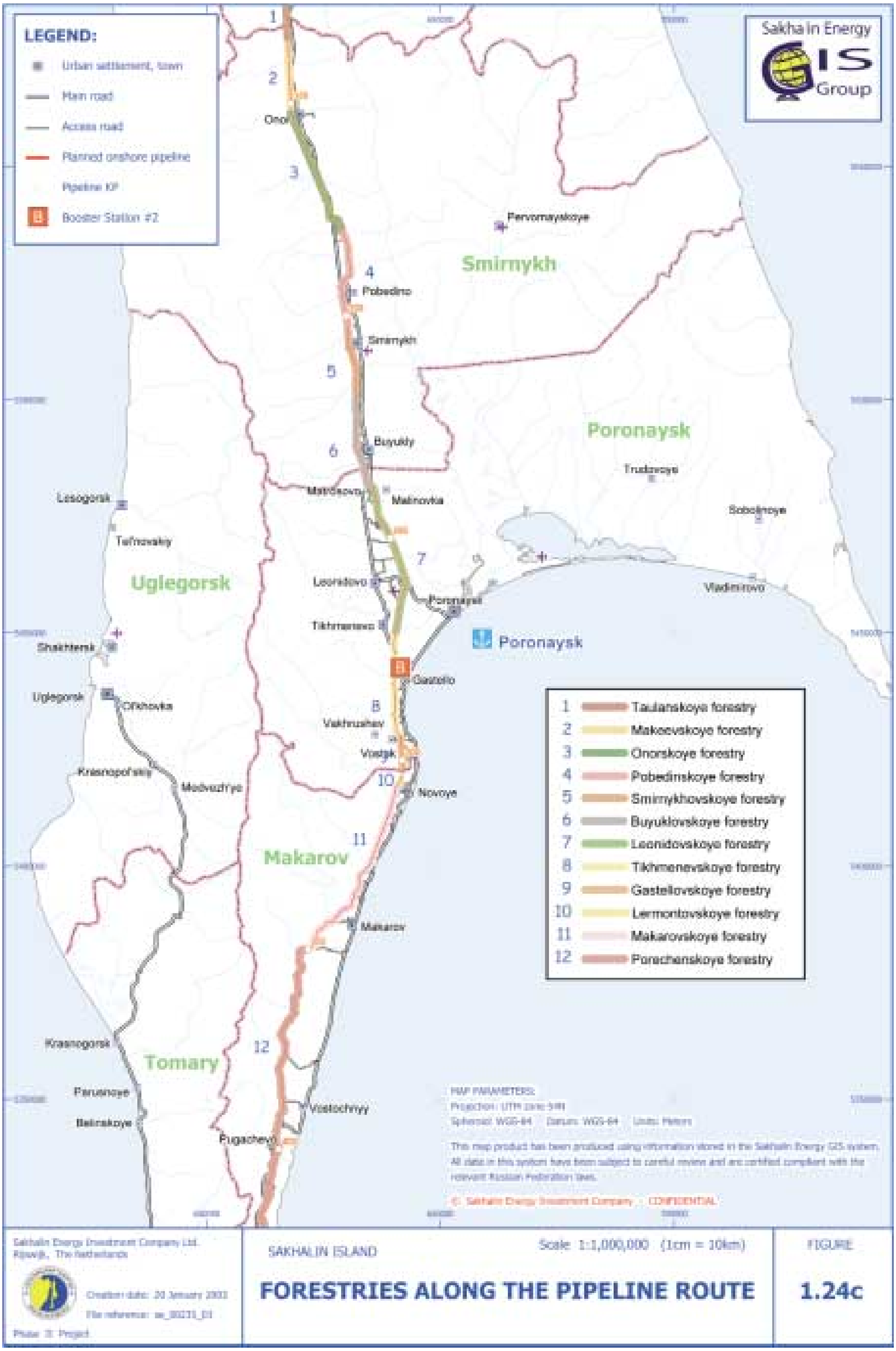


Figure 1.24d Forestries Along the Pipeline Route

Figure 1.25 Dark Coniferous Forest

Figure 1.26 Dwarf Pine Thickets with Fructose Lichens

Figure 1.27 Tree Plantations

Figure 1.28 Secondary Grassland

Figure 1.29 Bog with Larch

Figure 1.30 Wetlands

Plant Species

Surveys in a 200 m strip along the pipeline route (100 m either side) in 2000 recorded the following:

- 567 vascular plant species in 319 genera and 98 families;
- 119 bryophytes in 55 genera and 31 families (102 mosses, 17 liverworts);
- 192 lichens in 52 genera and 28 families; and
- 235 species of fungi in 103 genera and 46 families.

Full species lists are given in FESU (2002a). The surveys would not have detected early-flowering geophytes (mostly bulbs) and spring therophytes.

Further surveys in 2001 further expanded these lists as they included areas extending up to 2 km either side of the pipeline route. Fully annotated species lists are given in FESU (2002a), including details of synonomy, habitat preferences (in relation to the pipeline route), relative abundance, life-form class, and economic uses. Revised summary figures are as follows:

- 709 vascular plant species in 397 genera and 102 families; and
- bryophytes, lichens and fungi as FESU (2000).

FESU (2000, 2002a) give analyses of the extent to which taxonomic groups are represented among the species (floristic analysis), and the numbers of species referable to major vegetation types (phytocenosial analysis), which may be summarised as follows:

- sylvatic (ie forest) element - 196 species, mostly woody or perennial herbs;
- meadow element - 126 species, mostly herbs;
- meadow and sylvatic generalists - 55 species;
- bog element - 106 species;
- water element - 5 species;
- riparian element - 38 species;
- aquatic element - 35 species;
- coastal species - 29 halophytic species; and
- epilythic element (growing on rock) - 12 species.

A total of 137 species are independently classed as adventive species.

Protected and rare species are discussed in FESU (2000, 2002a). Information on those present in the vicinity of the pipeline route is collated in Appendix 8-8-4 of Volume 3, Book 3.2.1, Section 8. Of these species recorded in 2000 and 2001 surveys on the pipeline corridor, grid references for all occurrences are also given in this appendix (51 sites for 14 species).

According to FESU (2002a) the protected species that were recorded are in fact widespread on Sakhalin - several species are rare in the Far East region of Russia but abundant on Sakhalin. However, FESU (2002a) did consider the population of *Picea glehnii* in the southern part of the route as being especially important. A summary is given in *Table 1.25* and *Table 1.26*.