



ENVIRONMENTAL ATLAS GIPSDALEN, SVALBARD

Vol. I

Sensitivity of The Gipsdalen Environment

Prepared for Northern Resources Ltd.
by the Norwegian Polar Research Institute
Editors: Bente Brekke and Rasmus Hansson



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PREFACE

This Environmental Atlas is the first product of the an Environmental Impact Assessment for a proposed coal mining project in Gipsdalen, Svalbard. The project is carried out by the Norwegian Polar Research Institute on behalf of Northern Resources Ltd. The atlas consists of:

- Volume I (this volume): "Sensitivity of the Gipsdalen Environment", including a preliminary impact assessment of the proposed coal mining project, and (in separate cover) a vegetation map (two sheets), a conservation value map for vegetation, and a quaternary geology and geomorphology map. As this volume contains confidential information its distribution is restricted until further notice.
- Volume II: "Reports on the Flora, Vegetation, Fauna and Quaternary Geology of Gipsdalen, and the Marine Ecology of Gipsvika"; full reports from the work carried out in 1989, also including the above mentioned maps. The fauna report is in Norwegian, with an exhaustive English summary.

The fauna report presented in these volumes is not complete. A winter/spring Svalbard reindeer *Rangifer tarandus platyrhynchus* survey, a Ringed seal *Phoca hispida*/marine mammal survey, and a literature study of the reactions of Ringed seals and other marine mammals to dis-

turbance, are being carried out during the spring of 1990, and will be reported during the summer of 1990. A study of Pink-footed geese *Anser brachyrhynchus* including their reaction to disturbance, and additional seabird counts are planned to be carried out during the summer of 1990 and reported early in the autumn of 1990. Based on the complete series of environmental studies and the plans for coal mining in Gipsdalen, an Environmental Impact Assessment of coal mining in Gipsdalen is planned to be prepared during the autumn of 1990.

The vegetation and quaternary geology maps were produced at a higher quality than strictly needed for this project. The production was thus partly funded by the Norwegian Polar Research Institute and the Department of Physical Geography, University of Oslo, respectively. The project is otherwise funded by Northern Resources Ltd.

We thank those who have made contributions to reports and maps (see author list). We also acknowledge the contributions of Fridtjof Mehlum (scientifically responsible), Ian Gjertz, Halvar Ludvigsen, and the Governor of Svalbard.

Bente Brekke

Rasmus Hansson

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SUMMARY AND CONCLUSIONS

Conservation values in Gipsdalen

For place names, see Fig. 1.

- A well developed system of raised beach forms between Dalkallen and the river, is suggested worthy of conservation (Figs. 2 and 3).
- Two areas of large tundra polygon patterns, between Dalkallen and the river, are suggested worthy of conservation (Figs. 2 and 3).
- A field of well-formed De Geer moraines, between Boltonbreen and Methuenbreen, is suggested worthy of conservation (Figs. 2 and 3).
- Three of the rarest vascular plants on Svalbard; *Carex amblyrhyncha* (buttstarr), *Juncus castaneus* (kastanjesiv) and *Kobresia simpliciuscula* (myrtust) occur in a few areas of thermophilic marshes mainly in lower Gipsdalen (Figs. 2 and 7 (enclosed)).
- Several areas on Gipshukodden, along the shores of Gipsvika and on the valley floor between Aitkenfjellet and Usherfjellet have vegetation of high or very high conservation value (Figs. 2 and 7 (enclosed)). In these areas no construction work and no driving on unfrozen ground should occur.
- *Braya purpurascens* (purpurkarse) is totally protected by the Norwegian Government to comply with the requirements for ratification of the Bern Convention. This species occurs in very large populations throughout Gipsdalen, but must not be disturbed without an exemption from the protection given by the Government (Fig. 5, enclosed).
- The Gåsøyane Bird Sanctuary is included in the List of Wetlands of International Importance (the Ramsar Convention). The normal provisions for national parks and bird sanctuaries apply also to this area, but they are also subject to international attention.

Conflicts

For location of unavoidable conflicts, see Figs. 2 and 4.

The following summary covers all expectedly unavoidable conflicts, irrespectable of the conservation value of the environmental resources involved.

The lowest possible level of conflict between nature conservation interests and the proposed coal mining project in Gipsdalen seems to be achieved by locating

- the harbour facilities to northwest Gipsvika,

- the conveyor and road along the western slope of Gipsdalen, and
- the mine entrance to the southern base of Norströmfjellet.

The alternative harbour location at the Gipshukodden headland, and alternative road locations e.g. in the bottom of the valley, would imply a much higher level of conflict.

Unavoidable conflicts/impacts seem to be:

- Pink-footed and Barnacle geese *Anser brachyrhynchus* and *Branta leucopsis* and Red-throated diver *Gavia stellata* (small populations) will disappear from the valley.
- The most important wader locality in the area will be destroyed.
- The Gåsøyane Bird Sanctuary (a Ramsar area) will be negatively affected through loss of goose foraging, moulting and rearing areas in Gipsdalen.
- Areas with vegetation of high and intermediate conservation value will be intersected by the conveyor and the road.
- Areas with *Braya purpurascens* (purpurkarse), will be affected (Fig. 5, enclosed).
- Areas with surface material that is vulnerable to wear will be intersected by the conveyor and road.

Conflicts that may be reduced or avoided are:

- The level of disturbance from transport (chiefly hovercraft), ship, power station, activity in the harbour, the mine entrance areas and leisure time activity by the crew, is each important for the cumulative impact on the wildlife and should be treated as a whole. Species like Svalbard reindeer *Rangifer tarandus platyrhynchus*, Ringed plover *Charadrius hiaticula* and Purple sandpiper *Calidris maritima* are for example relatively tolerant to disturbance (or may habituate to it), up to a certain level.
- The "fence effect" of installations (conveyor, road, harbour area) for reindeer may be reduced by reducing sound and movement in the areas, and by avoiding creation of physical obstacles.
- The degree of impact on areas with vegetation of conservation value.
- The degree of impact on areas of vulnerable surface material, may both be reduced significantly through relatively simple, practical measures.

Recommendations

In addition to the instructions given in the Environmental Regulations for Svalbard, the following measures would contribute to reducing the environmental impact of the proposed activity:

- Avoidance (or prohibition) of all activities related to the mining west of the proposed harbour site and east of the Gipsdalen river.
- Low-noise technology should be used when possible.

- Compulsory corridors and low-impact procedures for transport and for activity in the harbour and mine entrance areas.
- Areas and time periods should be protected from hiking, skidoo driving, etc.
- A "lowest possible degree of conflict" route for conveyor and road may be identified during a field survey with representatives from NRL, the Governor of Svalbard and experts on vegetation and quaternary geology.
- Special care should be taken to avoid altering drainage patterns, etc.

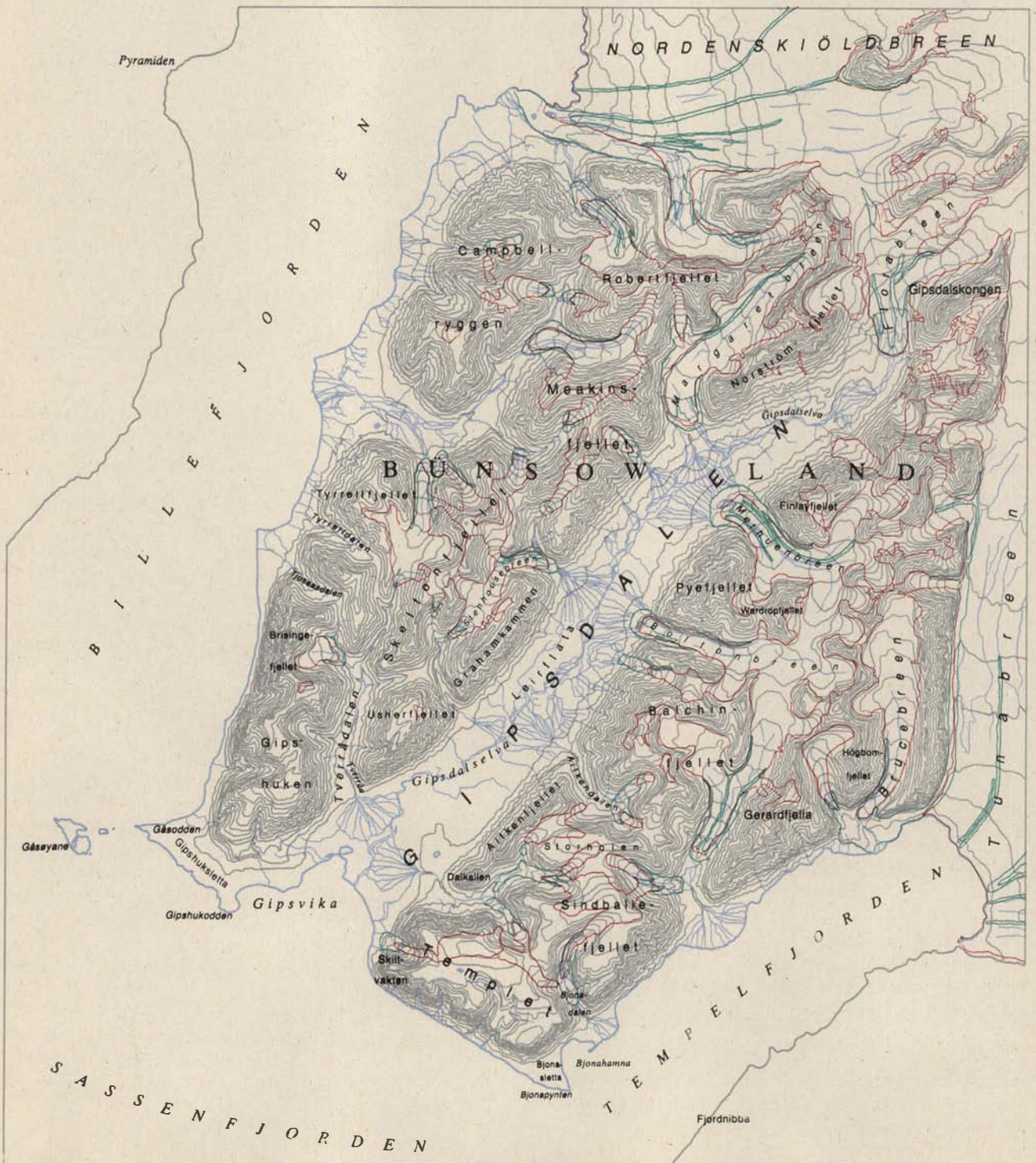


Figure 1 Bünsow Land with Gipsdalen, Central Spitsbergen, Svalbard.

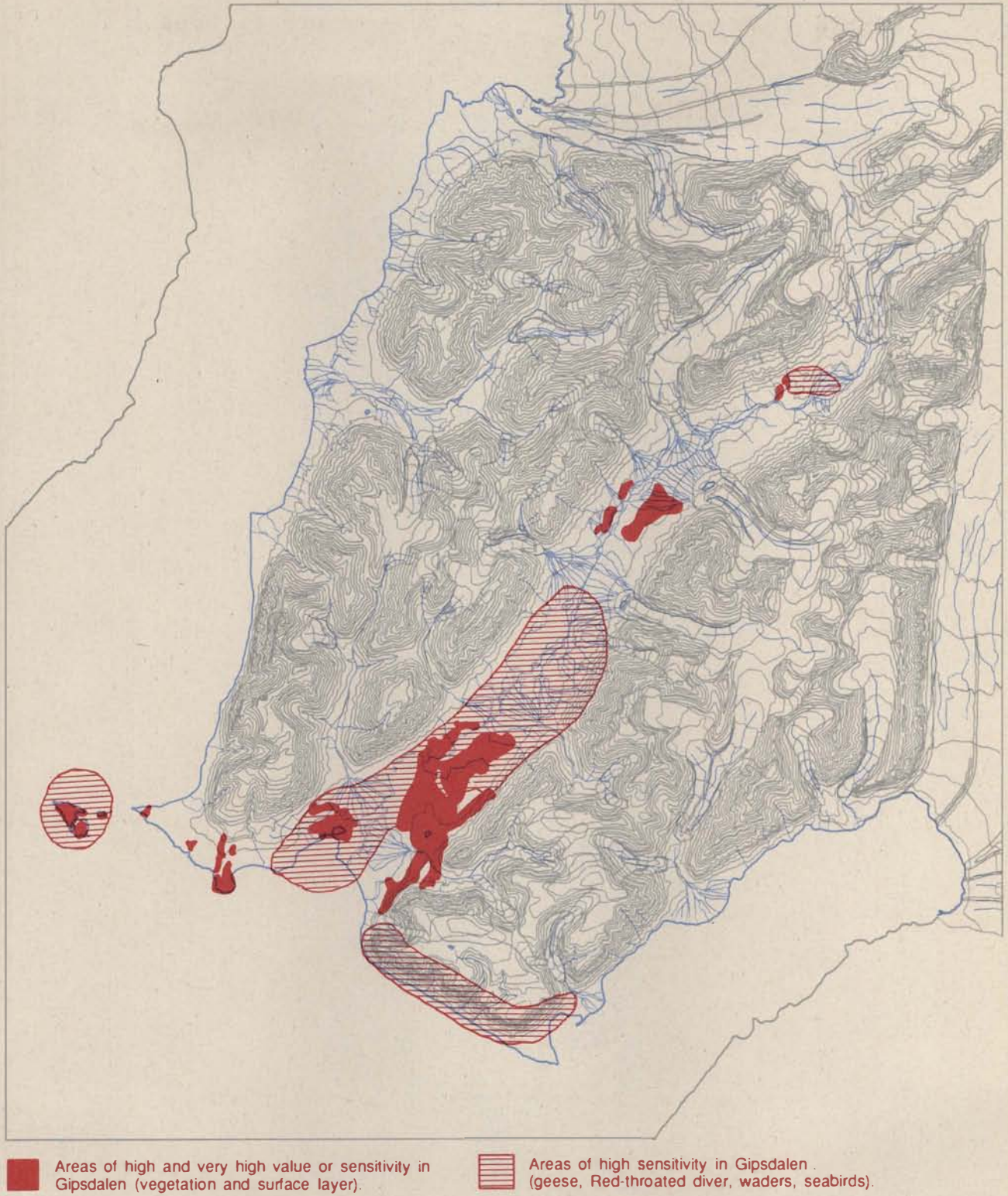


Figure 2 Valuable and sensitive areas in Gipsdalen.

1 : 100,000

GIPSDALEN, Svalbard Evaluation of Vulnerability



- GROUP 1 Areas that are invulnerable to wear
- GROUP 2 Areas that are slightly or moderately vulnerable to wear
- GROUP 3 Areas that are vulnerable to wear
- GROUP 4 Areas that are greatly vulnerable to wear and subsequent erosion
- GROUP 5 Areas worth conservation

Figure 3 Conservation value and vulnerability to wear of areas in Gipsdalen.

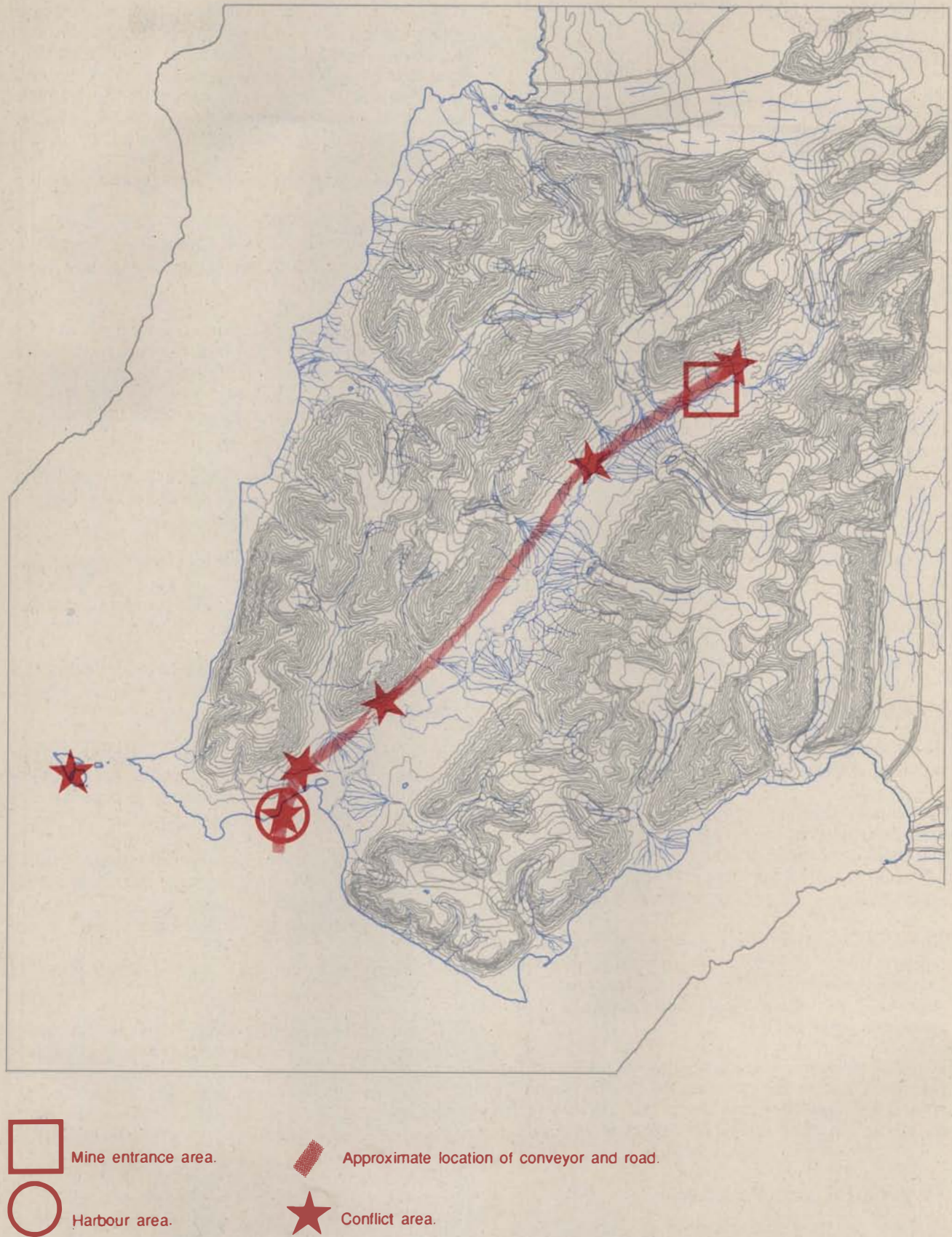


Figure 4 Main conflict areas related to the proposed coal-mining project.

INTRODUCTION

Background

In the summer of 1989, the Norwegian Polar Research Institute was employed by Northern Resources Ltd. (NRL) to produce the environmental data and impact assessments needed in connection with NRL's planned coal mining project in Gipsdalen.

Environmental regulations concerning industrial activities in Svalbard

This product is designed to meet the demands laid down in the Regulations Concerning Conservation of the Natural Environment on Svalbard.

Coal mining is among the activities or enterprises subject to the obligation to report to the Governor of Svalbard when intended to be initiated (§6).

According to §8, this report shall be sent to the Governor of Svalbard at the latest one year before the activity or enterprise is intended to start.

The Ministry of the Environment may, however, accept a shorter time limit in the individual case.

In accordance with this, the Ministry and the Governor have accepted that subsequent parts of the Environmental Atlas Gipsdalen will be reported during the summer and autumn of 1990.

The report shall, in addition to inform about the intended activity, contain information on the effects of the activity from the point of view of pollution as well as other effects on the landscape and the natural environment (§8).

However, pollution issues are primarily the responsibility of the Norwegian State Pollution Control Authority (SFT). Thus, this report does generally not treat pollution aspects of the proposed project.

The Ministry may, according to §9, demand further information on environmental effects and instruct the operator to carry out further environmental studies after the report is received.

The MUPS programme

The Ministry of the Environment has decided that the Norwegian Polar Research Institute shall coordinate environmental studies requested from commercial companies planning industrial or other activities on Svalbard. To assume this task the Institute has established the programme "Environmental Studies in Svalbard" (MUPS). As a MUPS subproject the Institute has developed

and coordinated the compilation of an "Assessment System for the Environment and Industrial Activities in Svalbard" (Hansson et al. 1990). The assessment system is an attempt at systematic examination of the entire range of the problem connected with "the impact of industrial activities on the natural environment in Svalbard".

The objectives of the assessment system are:

- To provide the environmental authorities with an overview of the major questions concerning the environment raised by industrial and other activities.
- To provide the environmental authorities with a tool for planning and implementing the necessary research and monitoring, and for systematically applying the results in the administration and design of continued research and monitoring.
- To limit imposed research and monitoring to approaches and tasks that may lead to concrete and serviceable results.

Specifically the assessment system is meant to

- indicate the potential environmental impacts of greatest significance,
- be based on scenarios and plans for industrial development and the best available understanding of ecological processes,
- be able to respond to and assimilate alterations in scenarios for industrial development and new knowledge concerning ecological conditions in the specific area, and
- represent the views of a broad range of specialists with the experience required from industrial activities, research and environmental management in Svalbard.

The framework of the assessment system is simple:

- The system selects a limited number of environmental resources or features (e.g. geological formations, species, plant societies, or human interests) called "Valued Ecosystem Components" (VECs). The concern of the assessment system is restricted to these preferred VECs.
- The system contains a series of "Impact Hypotheses" (IHs), statements about expected effects on VECs of specified human encroachments. For each IH, the system recommends countermeasures, surveys, monitoring and research to be carried out if the actual encroachment is being proposed or implemented.

The development of the Environmental Atlas Gipsdalen is based on the MUPS assessment

system. The plans initially presented by NRL were evaluated using the system. We found that the proposed construction and mining activities are likely to affect the following VECs:

- Svalbard reindeer
- Arctic fox
- Ringed seal
- Eiders and geese
- Seabirds
- Svalbard ptarmigan
- Marine biological resources
- Vegetation and soil
- Littoral zone
- Outdoor recreation
- Protected areas

Although Arctic fox *Alopex lagopus* and Svalbard ptarmigan *Lagopus mutus hyperboreus* are undoubtedly present within the affected area, we considered it unlikely that they would be negatively affected by the planned activities to any significant degree. Thus, no studies or surveys concerning these VECs were proposed as part of the project.

The importance of the Gipsdalen area for outdoor recreation is limited compared to other areas in the inner parts of Isfjorden, and no study concerning this VEC was proposed. However, it is imagineable that an operating mine with a total staff of 330 may affect outdoor recreation in the area, and studies or monitoring of such an effect might be demanded by the Governor at a later stage.

No studies concerning the status of Gåsøyane as a bird sanctuary (see VEC Protected areas) were carried out in 1989, but the eider and goose nesting populations on the isles are of major concern to the project.

Objective of the Environmental Impact Assessment for Gipsdalen

The ultimate objective of the complete Environmental Impact Assessment Gipsdalen is to provide

- 1) detailed information on the occurrence and location of environmental resources in the area potentially affected by coal mining activities,
- 2) detailed information on the sensitivity of these natural resources to relevant types of human impacts, and
- 3) an assesment of the environmental impacts of the proposed activities.

The project is intended to provide environmental information that will

- enable the operator to adjust plans and activities in order to minimize environmental impacts at an early stage in the process,
- enable the Ministry of the Environment to evaluate the need for, and, if necessary, issue instructions concerning changes in the reported plans and activities as well as special measures to prevent environmental damage.

1) and 2) are presented in this report Environmental Atlas Gipsdalen, Svalbard volumes I and II, and in the supplementary reports from the 1990 winter and spring surveys of Svalbard reindeer *Rangifer tarandus platyrhynchus* and Ringed seals *Phoca hispida*, and the 1990 summer surveys of geese, eiders and seabirds.

3), see below.

Sub-projects in the Environmental Impact Assessment for Gipsdalen

Summer 1989:

- A general zoological survey in Gipsdalen (see VECs Svalbard reindeer, Eiders and geese, Seabirds, as well as other animal life).
- A general marine ecological survey of Gipsvika and adjacent areas (see VECs Marine biological resources and Littoral zone).
- A general botanical/vegetational survey in Gipsdalen (see VEC Vegetation and soil).
- A general survey of quarternary geology and geomorphology in Gipsdalen (see VEC Vegetation and soil).

Winter/spring 1990:

- A survey of Svalbard reindeer, including possible calving in Gipsdalen and Bünsow Land (see VEC Svalbard reindeer).
- A survey of Ringed seals (stationary winter population, pupping) as well as other marine mammals in Gipsvika and adjacent waters (see VEC Ringed seal).
- A literature study on effects of disturbance of marine mammals (see VEC Ringed seal).

Summer 1990:

- A study on Pink-footed geese area utilization and reactions to disturbance in the Gipsdalen area (see VEC Eiders and geese).
- Additional surveys to supplement incomplete data from the summer 1989 surveys.

Autumn 1990 (see 3), page 9):

- A comprehensive Environmental Impact Assessment of the Gipsdalen coal mining project, based on the complete data from the surveys and studies conducted, and on more detailed plans for the coal mining project than currently available.

Evaluation of sensitivity and environmental impact

The data presented in this report permit statements on the sensitivity of most environmental resources in Gipsdalen and the Gipsvika area. They also permit a preliminary environmental impact assessment and some recommendations.

However, as data on important species and seasons are not yet compiled, this report does not present a comprehensive impact assessment. Nor does it attempt to utilize quantified ranking systems for the sensitivity of the potentially affected resources in the area (see e.g. Dickins et al. 1987).

The evaluations and rankings of sensitivity in this report are based on the scientific judgement and experience of the involved scientists and managers.

However, a MUPS sub-project designated to evaluate the scientific soundness and practical applicability of existing methods for quantified sensitivity ranking has been initiated. The project will use data from the Environmental Atlas Gipsdalen, Svalbard. The results of the project will be taken into consideration during the preparation of the Gipsdalen Environmental Impact Assessment.

Additionally, a project investigating the practical usefulness of Geographic Information Systems (GIS) in environmental impact assessments will use Environmental Atlas Gipsdalen as a case study.

Study area

The study area covers the valley Gipsdalen, the coast of Bünsow Land from Bjonadalen in the east (including Tempelfjellet) to Gipshukodden and Gåsøyane in the west and the bay Gipsvika with surrounding areas.

CURRENT PLANS FOR COAL MINING IN GIPSDALEN

Northern Resources Ltd. was approved as operator of the Gipsdalen concession by the Bergmesteren for Svalbard in June 1988. Northern Resources has since appointed Eboroil Canada

Inc. as managing contractor for the project.

Gipsdalen coal has been classified as low-sulphur, high-volatile bituminous coal, suitable for domestic and industrial use in various European countries. Sales of up to 400,000 tonnes per year are expected to the large lump UK household market. Total expected production is 1.4 million tonnes of washed coal. Additionally, research is underway into on-site uses of coal fines. It is anticipated that the mine will enter into production in 1992.

The proposed mine is to be located at the head of Gipsdalen, with the mine mouth and stores sited on the basement outcropping at the base of Norströmfjellet. Coal will be transported to Gipsvika by an 18 km enclosed conveyor system, to be installed on the western side of the valley. A road will be constructed alongside the conveyor belt.

A 20,000 tonne stockpile will be located close to the washery. A secondary conveyor system will be used to connect the washery, the sales stockpile and the loading facilities.

Accommodation, power station, stores and workshops will be pre-fabricated prior to installation. They will be mounted on barges in Gipsvika, close to the washery and harbour.

Port facilities will be constructed using the spills from developing the in-mine haulage roads. Therefore the first construction activity will be the installation of the conveyor, followed by haulage road development. The harbour is proposed to be located in Gipsvika just south of Gipshuken and extending southwards with the dock located near the 20 m fathom line.

Initially, the sales stockpile will be located at the Permian section on the western shore of Gipsvika and will be extended using the spill from the mine. The final capacity of the stockpile is expected to be 250,000 tonnes.

Maximum production level is expected to be 3 million tonnes of rock and coal per annum, of which 1.4 million tonnes will be washed, saleable coal, 350,000 tonnes will be fines, and the remainder will be rock.

The washery will require 100-110 tonnes of water per hour. It is currently proposed to use water-makers on the barges, but tests will also be run on possible fresh-water supplies from the valley.

Electricity will be provided by a 10,000 kW diesel (possibly coal fines) power station. The power requirements are currently estimated to 8,400 kW.

The accommodation barge will be outfitted for 375 persons. When in full production, the mine will require a total staff of 330 per day. Employees

will be brought to Svalbard (Longyearbyen) for 3 weeks of work, followed by 10 days leave abroad.

Hovercrafts will be used to transport personnel to and from Longyearbyen, and equipment from Gipsvika to the mine site. The proposed hovercraft type is expected to produce a sound level not above 73 dB at 150 m. An amphibious, belt-driven craft is also considered for personnel and equipment transport in difficult ice-conditions and on sensitive ground. A super ice class combination carrier will provide year-round shipping service to the mine.

Longyearbyen is planned to serve as a base for logistical support.

TYPES OF IMPACT

The construction phase

The construction phase will include:

- Approximately one year of transportation of equipment (large amounts) in addition to crew between Gipsvika and the mine entrance at the head of Gipsdalen.
- Installation of the conveyor system from Gipsvika to the mine entrance and the system for spill discharge into Gipsvika.
- Construction of haulage roads in the mine at the base of Norströmfjellet.
- Construction of the port facilities in Gipsvika north.
- Installation of barge-mounted accommodation and workshop units (possibly preceded by temporary facilities on the shore?) and washery barges, etc. in the port area.
- Construction of a road alongside the conveyor belt.

Transport

Transport (during both the construction and the production phase) will be carried out by means of:

- A large ice-going vessel carrying equipment, stores, etc., and taking out coal, calling at Gipsvika through Isfjorden.
- Hovercraft carrying crew between Gipsvika and Longyearbyen and crew and equipment between Gipsvika and the mine entrance.
- Amphibious, belt-driven craft ("Arktos"). May be used to carry equipment from ship to shore, and to carry equipment and crew

between Gipsvika and the mine entrance before the harbour and the road is constructed.

- Trucks. Will be used to a limited degree when the road has been constructed, according to NRL representatives.
- Helicopters. Will hardly be used, according to NRL representatives.

Areas that will be physically affected

A harbour location right south of Gipshuken has been proposed. The total area covered by stockpiles, loading facilities, stores, hovercraft and other vehicle facilities etc. is unknown. Estimate: < 1 km². The harbour must probably extend 1.5 - 2.0 km southwards into the bay to reach sufficiently deep water.

The width of the area strip affected by the conveyor and the road will depend on the distance between them, and the extent of cuttings needed. With an estimated mean strip width of 50 m, 18 km of conveyor and road cover a total area of 0.9 km².

Outside the mine entrance an area of unknown size will be needed for the hopper, vehicles, stores, and possibly ventilation system and other buildings. Area size unknown. Estimate: < 1 km².

In addition to physically covering areas, installations may "lock up" other areas (although not necessarily being physically impossible to pass) by keeping animals from passing.

The production phase

The production phase will include the same activities and the same equipment as the construction phase, but with different levels of activity:

- Less frequent transportation of heavy equipment through the valley, more frequent transportation of crew between Longyearbyen and Gipsvika and in the valley, more activity in the harbour area.
- No need for transportation in the valley on ground outside the road.

Sound impact

Sound impact is expected to be the most pronounced impact besides the physical encroachments:

- Ship propellers and engines will produce sound that may be transmitted over relatively large distances under water. Reflections from ice-

cover may further enhance sound transmission. The dB level of this type of sound, and thus the area it may affect, remains unknown and must be measured *in situ*.

- The hovercraft being developed for the project is expected to produce not more than 73 dB at 150 m distance. For comparison: a skidoo may produce a similar sound level at 5 m distance. The intensity of acoustical waves in air decreases inversely proportional to the square of the distance from the source ($1/r^2$ for a spherical propagating wave). For each doubled distance the sound is thus dampened 6 dB. Ideally this would indicate that the sound level from this hovercraft at 1200 m and 2400 m will be 55 dB and 49 dB, respectively. In the 2 - 3 km wide Gipsdalen, then, no location would experience less than ca. 50 dB if the hovercraft passed along the middle of the valley. However, as high frequencies are far more dampened than low, and topography and reflecting layers in the atmosphere may enhance or impede sound propagation significantly, the practical situation may be quite different. *In situ* sound tests of a prototype are thus needed to establish the actual sound impact from the hovercraft.
- The harbour area will produce an unknown, but probably significant sound level, particularly near or in the infrasound area. The sources will be all heavy machinery, the power station (particularly if equipped with diesel engines), the ship when in harbour, the conveyor system, and the loading facilities. The low frequency sound from the harbour may cover a large area.

Emissions/pollution

Pollution is not covered by this study. However, possible sources are:

- Discharge water from the washery, 100-110 m³/hour (composition unknown).
- Discharge water from accommodation unit?
- Leakage of liquids from stores and ship (fuels, hydraulic oils, etc.).
- Exhaust/emissions from power station (diesel or coal fines/water fuelled).
- Dust from coal stockpiles.

Visual impact

Installations, buildings, etc. and moving vehicles may

- influence the behavior of animals, and

- influence the recreational experience of humans.

ENVIRONMENTAL VALUES IN GIPSDALEN

Quaternary geology and geomorphology

Gipsdalen is a typical, dry central Spitsbergen valley. Except for the raised beach forms and De Geer moraines mentioned below, Gipsdalen does not contain forms of particular interest from a geomorphological point of view. A scale 1:40,000 map of the quaternary geology and geomorphology of Gipsdalen is presented (Fig. 6, enclosed).

Classification of vulnerability

Based on this map and a classification system for vulnerability to wear, the sensitivity of areas in Gipsdalen is identified (Fig. 3).

The areas are classified as:

Group 1 *Invulnerable to wear:* surface continuously changing, usually very coarse gravel or exposed bedrock/ice. Traces of wear disappears quickly.

Group 2 *Slightly or moderately vulnerable to wear:* coarse gravel/sediment and little water/ice in upper layers, little vegetation cover. Traces of wear are shallow, no subsequent erosion.

Group 3 *Vulnerable to wear:* fine-grained sediment and relatively high water/ice content in upper layers, continuous vegetation, flat. Traces of wear are prominent and may be extended through subsequent erosion.

Group 4 *Greatly vulnerable to wear and subsequent erosion:* Similar characteristics as Group 3, and additionally: sloping ground, very high water/ice content in flat areas, running water in sloping. Traces of wear are very prominent, and damage will normally increase significantly because of melting, mass movement, and erosion by running water.

Group 5 *Worthy of conservation:* e.g. unique land forms, rare plant communities, occurrences of fossils, etc. of particular scientific, pedagogical or historical value, important for tourism/recreational experience, etc. Not necessarily vulnerable to wear.

Valuable and vulnerable areas

Close to the mouth of the valley, between Dalkallen and the river, there are well-developed systems of raised beach forms (Vol. II: Figs. 4, 13 and front cover in the report on Quaternary Geology and Geomorphology). These are of

scientific interest and worthy of conservation (Group 5).

Patterns of large tundra polygons also occur in these areas. Two of the most representative areas are classified in Group 5.

The field of De Geer moraines between Boltonbreen and Methuenbreen is among the most interesting in Svalbard, where such moraines are uncommon. The moraines are classified to Group 5. They are also vulnerable to impact.

Between Aitkenfjellet and Usherfjellet, mainly on the eastern side of the river, most of the flat vegetated areas with fine-grained marine or gelifluction material are vulnerable to wear (Group 3-4). Along both sides of the valley from Gipsvika to Rinkbreen, patches of Group 3 and some Group 4 areas occur. Slope, water and/or vegetation cover make these areas vulnerable.

The raised beach areas are slightly or moderately vulnerable to wear. The areas not classified as Group 5 belong to Group 2.

Steep slopes and talus cones are considered invulnerable or moderately vulnerable to wear (Group 1 or 2). This goes for most of the higher parts of the valley slopes. Parts of the fossilized and vegetated alluvial fans are somewhat more vulnerable (Group 2).

Current alluvial plains (e.g. Leirflata) and active alluvial fans (in front of the side valleys), are considered invulnerable (Group 1).

The existing vehicle track running through Gipsdalen mainly follows dry areas. The wear is distinct, but not expanding, except in some moist areas where new tracks are being made alongside the old ones and melting and fluvial erosion are extending the damage (Vol. II: Figs. 22, 23, 24 in the report on Quaternary Geology and Geomorphology show examples of vulnerability Group 2, 3 and 4 from the track).

Flora and vegetation

The vegetation pattern of Gipsdalen (Vol. II: Fig. 6 in the report on Vegetation and Flora, and enclosed vegetation maps) differs from that of all other investigated areas in the inner fjords by being a virtual limestone semidesert (or arctic steppe), with low productivity due to lack of nutrients (except Ca, Mg), drought, and selective effects of the abundant calcium carbonate. The open vegetation types, resulting from the specialized ecological conditions, are widely distributed in Gipsdalen.

The Gipsdalen area contains botanical values at several levels. Three vascular plants are very rare on a European *Carex amblyrhyncha* (buttstarr) or Svalbard scale *Juncus castaneus* (kast-

anjesiv), and *Kobresia simpliciuscula* (myrtust). Several others are rare on a Svalbard (regional) scale. Many occurrences are marginal in a phytogeographical or ecological context. This is due to the location of the area in an inner fjord zone with warmer climate than anywhere else in the world at this latitude.

One of the very few plant species totally protected in Norway - *Braya purpurascens* (purpurkarse) - occurs in very large populations throughout Gipsdalen. No construction activity can be undertaken without disturbing or destroying parts of the populations. This species is one of those protected by the Norwegian Government to comply with the requirements for ratification of the Bern Convention of 1983. An exemption from the protection must be given by the Norwegian Government before any construction activity is undertaken.

Valuable and vulnerable areas

The nationally and regionally rare and vulnerable species are confined to a few vegetation types of restricted distribution in the area:

- a) Sloping, drained marshes of a thermophilic type.
- b) Open, calcareous, gravelly or silty ridges.
- c) Silty river margins.
- d) Bird-cliffs.

Sites of the types a)-c) may be influenced by the planned activities. Their location is indicated in Vol. II: Fig. 5 in the report on Flora and Vegetation, see also front page).

Fauna

In this section on fauna, some preliminary results from the winter and spring reindeer and Ringed seal surveys are included. These are not included in the report on Fauna in Vol. II.

The principal conservation interests among birds and mammals at Svalbard concern

- rare or endangered species, e.g. Pink-footed and Barnacle geese, and
- endemics; Svalbard ptarmigan and Svalbard reindeer,
- some high-arctic species, e.g. King eider *Somateria spectabilis*, Sanderling *Calidris alba* and Ivory gull *Pagophila eburnea*,
- internationally important populations of seabirds, in particular Fulmar *Fulmarus glacialis* and alcids, and
- marine mammals.

We recorded a total of 22 bird species in the study area. All except four were found breeding: Barnacle goose, Long-tailed duck *Clangula hyemalis*, Ivory gull and Black guillemot *Cepphus grylle*. At least Black guillemot probably breeds in the area as well, while Ivory gull is unlikely to do so. Barnacle goose breeds at Gåsøyane, and could possibly breed at Bünsow Land proper.

The Gåsøyane Bird Sanctuary is included in the List of Wetlands of International Importance (the Ramsar Convention of 1971). Although this does not imply other conservation rules than those applying to other bird sanctuaries in Svalbard, the environmental authorities must be expected to be reluctant in accepting negative impacts on Ramsar areas.

No population or occurrence of particular interest were found for any bird species in Gipsdalen. Sanderling and Turnstone *Arenaria interpres* are scarce and locally distributed at Svalbard. Both species breed in Gipsdalen, but a population was found for Turnstone only. However, uncertainty exists regarding this species' vulnerability, and its status in the archipelago is probably underrated. Gipsvika and Gipsdalen are also utilized by moulting Pink-footed and Barnacle geese, but the numbers recorded in 1989 constitute only 1-2 % of the Svalbard populations. Most other species occurred in small numbers.

The total seabird population at Templet was censused to be in excess of 10,000 pairs, the dominant species being Fulmar, Kittiwake *Rissa tridactyla* and Brünnich's guillemot *Uria lomvia*. The populations of Little auk *Alle alle* and Puffin *Fratercula arctica* remain unknown. This puts Templet in the lower range of a previous rough estimate (10,000 - 100,000 pairs), but nonetheless makes it one of the seabird colonies in the Isfjorden area with the highest number of species and individuals.

Generally no significant aspect of mammal distribution was found during the summer survey. A small number of reindeer was recorded, as well as some Bearded seals *Erignathus barbatus* and White whales *Delphinapterus leucas*. Ringed seals and Polar bears *Ursus maritimus* were encountered in neighbouring areas.

No zoological qualities of particular interest were found in the planned mining area, and the upper reaches of Gipsdalen are in general very poor in animal life. Though Pink-footed geese occur here as well, the importance of these areas is small compared to Gipsdalen downstream from Leirflata.

Preliminary results from Ringed seal and Svalbard reindeer surveys indicate:

- The Ringed seal population in Gipsvika is low, but in Tempelfjorden north of Bjonapynten the density of territorial adults is the highest

recorded in Svalbard. The whole area must thus be regarded as important to Ringed seals.

- Bünsow Land appears to have a small, stationary population of reindeer (approximately 40 animals), mainly staying in the lower parts of Gipsdalen and under the bird-cliffs in Templet, as winter grazing areas in upper Gipsdalen are poor. Bünsow Land may well come to play a vital role in the continued spontaneous expansion of Svalbard reindeer in the Isfjorden area.

Polar bears are not common in the area, but individuals may occur at any time, particularly in the winter. The number of bears observed annually in inner Isfjorden appears to be increasing.

Marine ecology

Gipsvika is a subarctic bay under indirect influence of the West Spitsbergen Current. It has a rich and diversified fauna compared to other Svalbard fjords. Low density, few dominants and a great number of rare species in the benthos show an untypical pattern for an Arctic ecosystem. The fresh and cold water runoff with suspensions is not as stressing here as in other fjord pools. Cooled brackish and muddy waters of fjord pools usually reduce both the pelagic and benthic life.

It is difficult to establish the role of Gipsvika for the neighbouring areas since we do not know much about the marine ecology of Isfjorden. However, we can state that Gipsvika serves as a nursery ground for numerous Bivalves, and some areas within the bay are of importance as feeding grounds for seabirds and seals. The key areas of the Gipsvika ecosystem are:

- 1) The deep water channel supporting the bay with highly saline transformed Atlantic waters carrying plankton from the Spitsbergen shelf.
- 2) The outflow channel along Tempelfjellet, where the majority of fresh-water runoff goes.

The marine ecological survey was conducted at 30 sampling stations situated in Gipsvika, the largest bay of Sassenfjorden, in August 1989. The bay covers 3.2 km², and its water volume amounts to 6x10⁷m³. Its coasts are of low, gravel and stony beaches with small spots of rocks and two river mouths. Surrounding mountains and the opening towards Isfjorden cause the prevailing wind directions SW and NW.

The bottom of the bay is covered by stones on eastern, shallow parts, while deeper down mud and silt occur.

The hydrology of Gipsvika is governed by local waters of Sassenfjorden. No direct inflow from

the open sea was found during our study. In the centre of the bay local upwelling and temporal eddies occur, which might be responsible for zooplankton aggregations.

Benthic fauna consisted of over 160 species grouped in three main communities. Macrobenthos density was low; only one species was found in more than 1000 ind/m². The occurrence frequency was also low for all species. Only three species were found in more than 50 % of collected samples. The Shannon-Wiener diversity coefficients were exceptionally high ranging from 2 to 8. Phytobenthos occurrence was restricted to the shallower and sheltered part of the bay, 14 common and widely distributed taxa were noticed.

The meiofauna from the tidal zone of Gipsvika was similar to that of other Svalbard localities with regard to its abundance and taxonomical composition. Zooplankton communities were typical for inner fjord pools, dominated by small copepods. Unusually high concentrations of *Bivalvia* larvae were found in the centre of the bay. The amount of phytoplankton was high despite late summer sampling. It was dominated by minor flagellates resembling the post bloom assemble.

ENVIRONMENTAL SENSITIVITY

Quaternary geology and geomorphology

- Between Aitkenfjellet and Usherfjellet, mainly on the eastern side of the river, most of the flat, vegetated areas with fine-grained marine material are vulnerable to wear, and in some patches greatly vulnerable to wear and subsequent erosion.
- The field of De Geer moraines between Boltonbreen and Methuenbreen are vulnerable to wear.
- Along both sides of the valley from Gipsvika to Rinkbreen, areas that are vulnerable or greatly vulnerable to wear occur (Fig. 3).

During possible implementation of the proposed plans for coal mining, the following factors affecting terrain wear should be taken into consideration:

- **Vegetation Cover:** Removal of the vegetation cover will alter the thermal balance in the active layer and may cause erosion.
- **Surficial Material:** Fine-grained material has an ice/water content often > 50%. It is unstable and subjected to mass movement and erosion.
- **Topography:** Exposure is significant to snow accumulation and thus length of snow-free

season and amount of meltwater. Gradient is significant to mass movement and erosion and thus terrain wear.

- **Permafrost:** The depth of the active layer influences drainage and the stability of the sediment. Insulative capacity of the vegetation cover, type of material, length of snow-free season and water balance influence the permafrost.
- **Water Access:** Accumulation of water on the ground may cause increased permafrost melting. Tracks on slopes act as water channels and may cause erosion.

Flora and Vegetation

- The plant species most sensitive to impacts occur mostly in the lower parts of the valley, confined to sloping, drained thermophilic marshes; open, calcareous, gravelly or silty ridges and silty river margins (Vol. II: Fig. 5 in the report on Flora and Vegetation).

The main dangers to the botanical values arising from the proposed coal mining activities are:

- Erosion on ridge tops, in the slopes and in the marsh areas along the conveyor system and planned new transport road.
- Changed drainage in marshes (both impeded and enhanced) due to construction and ditching.
- Increase in influx of nutrient from sewage or diffuse seepage from working sites. Such impacts would be very detrimental to the extremely nutrient-poor ecosystems of Gipsdalen. Sewage from the mining site would influence the entire fluvial system of the valley, and threaten several elements of botanical value.
- Impacts on sites of special botanical values.

Fauna

Sensitive species in the Gipsdalen area are mainly Red-throated diver, Pink-footed and Barnacle geese, Eider *Somateria mollissima*, Turnstone, Kittiwake and Brünnich's guillemot. The two goose species in particular are very sensitive to human disturbances.

1) Pink-footed and Barnacle geese are

- sensitive to disturbance when breeding (May; Gåsøyane, lower/mid Gipsdalen including Leirflata and lower side valleys on eastern side of Gipsdalen),

- extremely sensitive to disturbance when moulting (June; Gåsøyane, north Gipsvika, lower/mid Gipsdalen including Leirflata), and
 - sensitive to disturbance after moulting, during and after rearing (July-October; Gåsøyane?, north Gipsvika, lower/mid Gipsdalen including Leirflata (Fig. 2 and 5).
- 2) Red-throated diver is sensitive to disturbance by traffic (particularly hiking) on the breeding grounds (late June - late July; lower/mid Gipsdalen including Leirflata).
 - 3) Turnstone is sensitive to disturbance by traffic (particularly hiking) on the breeding grounds (June - July; north Gipsvika).
 - 4) Kittiwake and Brünnich's guillemot are sensitive to disturbance from aircraft (or similar sound).
 - 5) All ducks, geese, gulls and alcids are very sensitive to oil fouling.
 - 6) Svalbard reindeer sensitivity will be evaluated in the next phase of the programme. A preliminary evaluation indicates that reindeer are sensitive to disturbance in March - May (negative energy balance and pregnant/calving females).
 - 7) Ringed seal sensitivity will be evaluated in the next phase of the programme. Currently, no information indicates that Ringed seals are particularly sensitive to impacts.

Sensitive areas are mainly:

- The beach ridge area in the northwest part of Gipsvika, where harbour facilities are planned. This is the single most important wader locality within the study area, and is also of importance to Barnacle geese.
- Gipsdalselva and the whole valley bottom up to and inclusive of the clay deposits at Leirflata. This area is important as moulting and rearing ground for geese, particularly Pink-footed geese. Red-throated diver, King eider and Arctic skua also breed in the area. The area is also important pasture for Svalbard reindeer during summer and possibly parts of the winter.
- The lower parts of the side valleys on the eastern side of Gipsdalen (breeding Pink-footed geese).
- Templet (breeding seabirds).
- Gåsøyane Bird Sanctuary (Ramsar area) with breeding geese, Eider and Arctic tern. Disturbance of geese in Gipsdalen may also affect Gåsøyane.

- Gipsvika. This area is very sensitive to oil spills or leaks. Seabirds, ducks and geese are very sensitive to oil fouling and may easily be affected here, but also in the rest of Isfjorden.

Marine ecology

- The sensitivity of the benthos fauna to changed currents and back eddies created by the harbour, and to oil and other pollution is unknown.

EXPECTED CONFLICTS

The main conflict areas related to the proposed project are shown in Fig. 4.

Expected and potentially significant conflicts between nature conservation interests and the proposed coal mining project in Gipsdalen are listed below, labelled I, II or III, indicating classification in one of the following categories:

Class I: Conflicts that can not be avoided if the coal mining project is to be carried out.

Class II: Conflicts that can be reduced through alternative solutions or countermeasures.

Class III: Conflicts that can be minimized or avoided through alternative solutions or countermeasures.

The harbour area

The harbour area, including stockpiles and installations on land (assumed location alternative in north-west Gipsvika, right south of Gipshuken):

(I) Will exclude Pink-footed and Barnacle geese breeding on Gåsøyane and in other areas from currently important foraging areas. The distances between most breeding areas in Gipsdalen/Gåsøyane and planned installations are sufficient for the geese to continue breeding, according to studies from Greenland, but they will probably not accept this level of disturbance after hatching. It is not known whether or not suitable moulting and rearing grounds are available in nearby areas. The consequences will most probably be serious, unless other foraging areas are available (e.g. along Billefjorden).

(II) Will destroy part of and may influence negatively other parts of Turnstone habitat. Consequences for the local population are uncertain.

(II) May exclude Svalbard reindeer from good pasture close to and west of the harbour. However, the importance of these pastures is cur

rently unknown. Also, reindeer have shown good capacity to adapt to installations and settlements.

(III) Will destroy part of and may influence negatively other parts of Ringed plover habitat. The species is probably able to adapt to the situation.

(III) Will destroy part of and may influence negatively other parts of Purple sandpiper habitat. The species is probably able to adapt to the situation.

(III) Will destroy part of and may influence negatively other parts of Arctic tern habitat. The species is probably able to adapt to the situation.

(III) Will cause permanent changes in currents and possibly sediment and benthos-fauna. The significance of the effect is probably small, although unknown.

(III) May disturb breeding (Gåsøyane) and foraging eiders. Effect probably largely dependent on infrasound level from the harbour area, and eider sensitivity to this. Eiders can move to other foraging areas, and are more robust towards disturbance than e.g. geese.

(-) The alternative harbour location, on the Gips-hukodden headland, would cause significantly larger conflicts (vegetation, geese, Gåsøyane Bird Sanctuary) than the alternative treated here.

The road and conveyor

The conveyor and road (assumed location as proposed on the western side of the valley, somewhat above the valley floor to avoid snow problems):

(I) Will intersect one or more areas of surface material that is vulnerable to wear between Gipsvika and Norströmfjellet, and possibly areas that are greatly vulnerable to wear and subsequent erosion (east slope of Usherfjellet, south of Leirflata, north of river fan from Stenhousebreen) (Fig. 3). It should be possible to avoid many of the areas, but some damage will probably occur.

(I) Will intersect areas with vegetation of high and very high conservation value in north Gipsvika (area B, Fig. 7, enclosed). Some of the vegetation (small stands) will be destroyed, and there is danger for subsequent erosion and altered drainage patterns. It might be possible to cross the Tverråa river fan and follow a major, broad beach ridge to a suitable harbour area.

(I) Will intersect areas with vegetation of high and very high conservation value in the slopes under Usherfjellet (area F, Fig. 7, enclosed). Some of the vegetation (small stands) will be destroyed, and there is danger for subsequent

erosion and altered drainage pattern. The possibility to pass the area on the upper side should be investigated.

(II) May affect one or more of a few small areas with surface material that is vulnerable to wear, further up in the valley (Fig. 3). Alternatives should be possible to find.

(II) May act as a "fence" for reindeer migration to valleys and mountain areas in the western side of Gipsdalen. Svalbard reindeer have a good capacity to habituate to human installations. The impact on the reindeer, and the speed and degree of habituation, will depend on factors such as sound level from the conveyor system, traffic on the road and how easy it is physically to pass the installations.

The mine entrance area

The mine entrance, with stores, etc. (at the base of Norströmfjellet; specific location is not proposed):

(II) May affect or destroy two small areas of high vegetation conservation value east of the river and/or a larger area of intermediate conservation value west of the river (area G, Fig. 7, enclosed).

(II) Affect areas on both sides of the river with surface material that is vulnerable to wear (Fig. 3).

Ship transport

Ship transport through Isfjorden and into Gipsvika:

(III) May cause disturbance of Barnacle and Pink-footed geese due to high dB levels of long ranging infrasound. Geese are sensitive to infrasound. Sound level from the ship and possible effect is not known.

(III) May cause disturbance of Ringed seals due to propellar and engine noise being reflected by the ice cover. Sound level, sensitivity to such sound and possible effect is not known. A literature survey is being carried out.

Hovercraft transport

Hovercraft transport in the Gipsdalen valley (assumed route: valley floor, as the hovercraft is presumably dependent on relatively flat terrain):

(I) Will cause serious disturbance of breeding, foraging and moulting Pink-footed and Barnacle geese in the valley. The geese will probably not tolerate this degree of disturbance (sound and visual), and be permanently displaced from the valley.

(I) Will cause serious disturbance of breeding Red-throated divers, and most probably displace them permanently from the valley.

(II) May cause serious disturbance of Turnstone and possibly displace them from most or all of the valley.

(II) May disturb reindeer in lower - mid parts of Gipsdalen and affect energy balance and possibly calving. All year, but primarily March - May. It is conceivable that reindeer can habituate to a certain degree to a low-noise hovercraft.

Hovercraft transport between Longyearbyen and Gipsvika:

(II) May disturb seabird colonies (eider, kittiwake, Brunnich's guillemot) in Templet and Gåsøyane Bird Sanctuary. Dependent on actual sound level of hovercraft. "Flight" corridors well off the coast will reduce the problem.

Other activity

Other activity on the road, in the harbour and mine entrance areas, use of amphibious craft, occasional helicopters, leisure-time skidoo trips and hiking by crew members, etc.:

(II) Will create an increased activity level in the whole area, which will contribute to the impacts on sensitive species. The degree and effect of "total" disturbance is strongly dependent on the general operation of construction and mining.

(II) May increase wear on areas with vulnerable surface material if traffic on skidoos, wheeled vehicles and on foot outside the road increases.

(II) May increase wear on areas with vegetation of high conservation value if traffic on skidoos, wheeled vehicles and on foot outside the road increases.

Pollution/littering

Pollution and littering is not included in this study. However, conceivable conflicts are:

(II) Seepage of nutrient-rich water may affect plant species adapted to nutrient-poor conditions (applies to most Gipsdalen species) negatively.

(II) Leakages of oil/diesel or similar fluids in Gipsvika or any area in Isfjorden will affect seabirds, ducks, geese, waders and possibly marine mammals. Any leakage or spill in the proposed harbour area close to both Gåsøyane Bird Sanctuary and the birdcliffs in Templet may have severely negative effects.

(II) Leakage or spill of oil, diesel, hydraulic oil or toxic fluids into the Gipsdalen river will seriously affect geese, waders, gulls and other birds that stay close to the river.

(III) Littering (smelling food or containing edible parts) will attract arctic fox, which may increase local predation pressure on birds, and may imply increased danger for the crew in the event of a rabies outbreak.

(III) Littering (smelling food or containing edible parts) may attract polar bears, which may imply danger for the crew.

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