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NOYABRSK, WESTERN SIBERIA

EUROPEAN COMMUNITY WORKING GROUP REPORT ON OIL EXPLORATION AND PRODUCTION ACTIVITIES ON THE ENVIRONMENT

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EXECUTIVE SUMMARY

The Noyabrsk area contains significant oil and gas resources which have only been exploited for a relatively short period of time (since 1976). Already proven reserves (44 discovered and 12 producing fields) indicate that long term oil and gas exploitation activities can continue in this area and the prospect of adding to the already identified reserves is considered as high.

As well as the oil and gas exploitation, a range of other industrial activities related to construction products production and timber extraction and processing are underway. A large population influx (~ 100000 inhabitants over 10 years) with consequent infrastructure development has occurred and, based on current plans, will continue to occur.

All these features have impacts on the environment, notably in the areas of changed land use, water quality and air quality.

Fauna and wildlife changes are also indicated as are the traditional activities of native people.

Oil exploration and production activities are therefore only one element that contributes to these impacts, but are extremely significant as they are the prime reason for exploitation of the region, acting as a catalyst for change.

The environmental awareness practices utilised by the oil and gas operating companies therefore set a precedent for the behaviour of others. It is considered of utmost importance that any operations are based on sound environmental quality guidelines and proven good practices.

Until recently (~1990) it appears that only limited attention has been paid to environmental quality issues which has resulted in unnecessary impacts on the environment.

Specifically the impact on land is considered excessive, and the extent of oil contamination on land and in surface (and possibly) underground waters unacceptably high. Air quality is also impacted, but with the current level of flaring, there has been insufficient time to assess this fully. Overall, housekeeping and environmental awareness practices are considered as insufficient for protecting sensitive areas.

It is believed that these features have primarily occurred due to a maximum oil production philosophy, fragmented, over bureaucratic and over centralised planning and insufficient technology utilisation.

For the future, major changes will only occur if a wholesale cultural and educational attitude change towards environmental issues becomes prevalent. There is an evidence of civic pride that must also be reflected in the workplace.

Work planning and the development or importation of improved equipment to allow extended reach drilling is considered as having the potential for significantly reduced land use.

A great reduction in oil contamination, however, can be very simply achieved by installing effective drainage and oil collection systems around both well sites and production facilities.

Pipeline leaks appear to be another area of significant oil impact into the environment. It is believed that monitoring by through-pipe inspection systems would play a significant role in preventing such occurrences.

Final abandonment of facilities does not appear to have been considered in the past, but must be taken fully into account at the design stage of new developments.

We have confidence that given a sound knowledge of the environment, good management, integrated planning, and effective technology utilisation, the impacts of oil exploration and production can be significantly reduced.

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1. INTRODUCTION

The objectives of the International Expedition of Boreal Forest Researchers were to provide an expert appraisal of ecological conditions in the swamps and forests of the Noyabrsk area.

Particularly the influences of anthropogenic activities on the environment were to be assessed, with specific attention being paid to the oil and gas developments in the area.

The European Community (EC)was invited by the municipality of Noyabrsk through the European Community Energy Center of TYUMEN to participate in the expedition. The EC (DG XVII) provided a team of three multinational experts in the evaluation of the impacts of hydrocarbon technologies (oil and gas exploration, production, and transport) on the environment.

The specific remits of this working group were to:

- evaluate the practices and technologies applied for oil and gas extraction from the point of view of international ecological requirements;
- point out the most important ecological problems requiring solutions;
- advise on methods and equipment to improve the situation taking local conditions into accounts.

This work was conducted during a two weeks period and is based on field surveys, site visits and information supplied by the Noyabrsk community administration and the Noyabrsk Naphta Gas association (NNG).

The report of Forest Ecological Group was also conducted during this period and provides complementary information regarding the state of the Boreal Forest in relation to use and protection. This report is included in full in Appendix 2.

2. AREA AND OPERATIONAL OVERVIEW

2.1 HISTORICAL PERSPECTIVE

The operating area of NNG covers 60000 km^2. This area is located on some of the highest ground in this region of Western Siberia. The elevation is approximately 120m above sea level. The area forms a watershed between rivers flowing to the North and to the South. Approximately 55% of this area comprises lakes and swamps. Aerial surveys (magnetic and gravimetric) began around 1950. Seismic surveys for field development were undertaken during the late 1960's and the first field was discovered 1968.

At present a total of 44 oil fields have being identified of which 12 are being actively produced. The first field was put on stream in 1976. The fields are of Jurassic age and are located at 2200 to 2800m depth. The fields are multilayered sandstone with one to twelve productive zones being present, dependent on the field.

2.2 GEOLOGICAL BACKGROUND

These zones may vary from a few meters to 20m in thickness and have permeabilities ranging from 4 mD to 150-200 mD. The connate water saturation is typically around 30%. Porosity is 15 to 19% and the initial formation pressure varies from 220 to 260 atmospheres. The well head pressure is typically from 16 to 20 atmospheres. Some fields have an active gas cap and an oil water contact, whilst others contain undersaturated oil. Gas oil ratios range from 30 to 50 Nm^3/tonne to 300 Nm^3/tonne. The oil produced is of low viscosity with a specific gravity ranging from 0.80 to 0.85. The oil has only minimum traces of H_2S (unspecified) and CO_2 is also present in low concentrations (also unspecified).

Most production wells are directionally drilled. Typically 6 to 20 wells will be drilled from one location. Lateral displacement is around 1 to 1.2 km and maximum well angles are around 45 degrees. Approximately 11000 wells have been drilled of which 8000 are producing wells. Production from each well ranges from 8 to 40 tonnes/day and the total amount of oil produced by the 12 fields is 70000 tonnes/day; (daily volumes of water and gas produced were not clearly specified).

2.3 WATER INJECTION

Wells may be produced by natural flow or more commonly, by artificial lift utilising beam pumps or electric submersible pumps. Typical completion tubing is from 2 to 2 7/8 inches in diameter. No tubing isolation packers appear to be employed and no subsurface safety valves are used. Some wells appear to be producing by natural flow through the annulus rather then the tubing. Water injection is used to maintain reservoir pressure. There is approximately one injection well for four producing wells. Injection water comes from 3 sources:

- river water
- produced water
- underground aquifer water

The aquifer water comes from a prolific zone at around 1000 to 1200 m. The salinity is 12 to 14 mg/l. This water is relatively compatible with the reservoir water, though some scaling has been indicated.

The type of water used for injection varies from field to field and the exact compositions are unspecified. Generally produced waters are used in greater amounts in fields near the main processing centres where such waters are separated. More distant fields use subterranean water or river water depending on convenience.

2.4 PRODUCTION

Production from the field wells is gathered into feeder pipelines and first processed at satellite degassing and pumping stations. These stations remove gas and pump the residual liquids to the main processing terminals, where the oil and water is finally separated. Gas from the satellite stations may be flared, utilised for power, or sent to the gas processing plant operated by separate organisations. Satellite stations may serve one or more field areas. At the main processing facilities (three in total) oil and water from several fields are separated.

The oil is treated to a "pipeline specification" for ongoing transport into the main distribution system for refineries and consumers. These trunklines are also operated by other organisations. The water separated at the main station is treated to reduce residual hydrocarbons and solids and is then pumped into a field distribution system for water injection.

2.5 ORGANISATION - MANAGEMENT

Although NNG is the prime operating organisation which comprises of four operating divisions, other groups may also operate in this geographic area. Particularly, gas exploration and production is handled by a completely separate organisation called NYEZ. The main distribution pipelines for oil and gas are also handled by separate organisations. Other operating groups similar to NNG can also explore for oil in the area, but we are not certain if such groups are operating. It can therefore be seen that the oil and gas industry in this area is the responsibility of many different organisations, all of which have environmental impacts although this report is concerned primarily with the activities of NNG.

3. TECHNICAL DISCUSSION

This discussion section is based on our investigations and observations through field trips combined with meetings involving local specialists and managers.

This section aims to identify and propose potential solutions for improving environmental protection. The problems are discussed by operational activity. Each section considers the topics listed below:

- organisation
- practices and technology
- safety and environmental protection

3.1 EXPLORATION ACTIVITIES

The prime element covered in this subsection is seismic operations.

To date only 2D seismic has being undertaken although a 3D campaign is planned. The work has been accomplished in winter only using dynamite charges with some vibro surveys in sandy areas. This has resulted in about 5000 hectares of clear corridor ranging in width from 6 - 16 m. Some of the seismic corridors have also been utilised for pipelines and electrical power lines, which has caused enlargement of the corridors to 20-30m width or greater. (Photographs 1 and 2)

The seismic operations have been undertaken with reasonable prudence considering the technology employed. Current technology greatly reduces the seismic corridor width required (1 m minimum). This technology is available in the USA and Europe and uses satellite transmission for data recording. It is also believed to be in use in Eastern Siberia. In addition, it is likely that some of the original corridors can be reutilised.

Some evidence of heavy rutting by vehicles was seen in the original seismic corridors. This we have presumed is due to these corridors being used as access ways for other operations. Future operations should cause only a very limited impact on the environment.

3.2 CIVIL ENGINEERING CONSTRUCTION ACTIVITIES

This section details a wide range of activities which are covered individually in sub-sections below.

3.2.1 <u>Main Roads</u>

All the main roads are built above the ground level, presumably to minimise flooding and aid snow clearance. We assume that these features dictated the level of the road. The main roads are constructed by installing a sand embankment covered by geotextile on which concrete panels are placed. Typically three panels, each of 2m width and 6 m length, are laid side by side. A further 2 to 3 m of sand verge exists on each side of these panels. In many areas visited, these panels have being subsequently covered by ~4 inches of asphalt. In some of the remote areas, only 2 of the concrete panels have been laid side by side, though the verge width remains the same.

It is not clear as to whether the native vegetation has been totally, partially, or not removed prior to sand placement.

The road system is extensive (~1200 km of road laid down by 1992) and appears to be based on continued long term industrial activity.

We can not comment on whether this road network is necessary, or has been optimised for the industries served, since we have not been able to review any development plans.

What has being noted however, is that these roads have caused alteration to drainage due to non existent or incorrectly placed culverts. This has a visible effect on the hydrology and hydrogeology of the area, the seriousness of which we can not comment.

The use of adjacent sand to build roadways has also caused hollows, allowing ponding to occur. Washout of the verges has caused gullying, with consequent redeposition of road materials in the environment. (Photograph 3)

For the future, far greater attention should be paid to hydrogeological patterns and we would suggest that stabilisation of the verges by use of geotextiles, mulches or sand bags, to which grass seeds and fertilisers can be added, would minimise damage and promote "natural" regeneration. This may have the advantage of reducing road maintenance, and perhaps minimise the total quantity of sand that has to be used for the embankments.

3.2.2 Well Sites and Access Roads

There are numerous well sites and access roads in the area. The mode of construction depends on terrain. In swampy areas, sand embankments and sand pads are utilised (generally 1 to 2 m above the surrounding ground area). Wells in dry forest areas or sand dunes are formed primarily by simple bulldozing and grading techniques, and tend to follow the natural topography.

In essentially all cases, no surface consolidation materials are used, resulting in heavy rutting and road widening due to the heavy vehicle traffic (Photograph 4). Additional material placement and/or regrading is undertaken periodically.

Multiple roads are provided to some sites while others have a single access. Two accesses are required when H_2S occurs for safety reasons. The reasons for some of the multi-access to sites is unknown. On dry and sandy areas, excess heavy vehicle tracks are spread through a wide general area in the vicinity of the site causing unnecessary damage (Photograph 5). In swampy areas, the comments as for main roads regarding hydrogeology applies to access roads and drilling locations. Consolidation of the embankment of both site location and road is recommended. Additionally, honeycomb type geotextiles are recommended for the road and site surface to provide good load bearing capacity. These materials are widely used in arctic, desert and swampy locations to minimise road damage and maintenance. They also greatly reduce the amount of road making material required.

In dry areas, poor marking of the 'official' access road, combined with the all terrain capabilities of the vehicles and non environmentally conscious drivers, has led to unnecessary disturbances.

Well locations, either for a single exploration well, or for multiple exploration wells are large compared to international standards, and very large compared to European standards. We would suggest that for multiple well sites a norm of 10000 m^2 should be considered.

For single exploration wells, such sites may not be required if they are drilled in winter. Roads and sites prepared with snow have proven very successful in Arctic areas for such operations. This has resulted in minimum damage and no permanent material placement.

Drainage aspects will be treated under the production and drilling sections that follow. Likewise, the requirements for large numbers of production sites is detailed under the drilling section.

3.2.3 Processing Areas

These comprise of gathering stations, separating and pumping facilities and oil-water separation facilities.

These are generally constructed near main roads and are not significantly higher than the surrounding ground level. We presume that they are therefore on areas less liable to flooding. The sites are generally graded with natural materials and are essentially flat.

Concrete panels are sometimes used for internal roadways and some equipment is set on poured concrete plinths while others are set on block or tubular supports.

Many of these facilities also have extensive workshop and repair areas for field construction, maintenance and servicing. The area used is relatively large compared with international standards, but this may be accounted for by phased building and the desire to maximise the separation between units for safety reasons (e.g. fire, explosion). Without having detailed plans, we are not able to draw any conclusions regarding land utilisation based on our inspections.

Drainage and waste handling for these facilities is covered in detail in the production section.

3.2.4 Utilities

We have only had a little opportunity to look at this activity, particularly with regard to water supply (produced aquifer water and distribution systems). We are also uncertain about communication and instrumentation between various locations. We had anticipated radio communication and instrument telemetry systems but these did not appear to be common. Time constraints have precluded a more detailed investigation.

An extensive electricity distribution system exists. In some cases, as noted previously, existing tracks such as seismic corridors have been utilised. From the aerial surveys, the actual distribution system appears to cross the countryside in a random manner. Tracks of heavy vehicles are clearly visible from the air and a relatively large number of cable support structures appear to be redundant. This suggests a fairly random and uncoordinated approach to construction. Substations also appear to be placed on separate pads with separate accesses even though they are very close to other utilised sites.

Our perceptions are of a lack of integrated planning between land users. If correct, there is a large degree of environmental disturbances which could be minimised with a more co-ordinated approach.

All gathering and distribution pipelines are handled under the distribution section.

3.3 DRILLING

Most drilling and workovers are carried out from single multi-wells locations. The basic drilling equipment utilised dates from designs of the 1950's. The standard drilling equipment is a winterised skid-mounted unit termed the M 3000. These units are of Russian manufacture and have a 3000 m depth capability (Photograph 6).

Bearing in mind the depth of the reservoir, this size of unit allows only a limited scope for extended reach drilling with only 1.2 km lateral displacement being possible. The power supply is from a central power system with lines which run to the site (i.e. no on-site power generating capability). Drawworks and mud pumps are AC powered. The drawworks are powered by a single 500 KWatt synchronous motor. Two mud pumps, each driven by a 600 KWatt AC motor, are normally employed. The pumps are of duplex type, each giving 36 l/min at 160 bar. The mud system comprises of 4x40 m^3 active mud tanks incorporated into a skid-mounted module.

A further 2x40 m^3 mud tanks are used for reserve mud and are located remotely from the drilling package. Typically 2x40 m^3 tanks are also remotely located for drill water. The mud/solids separation equipment comprises of one shale-shaker (single deck, double screen), two or three desanders and a bank of desilter cones (generally 6 to a bank). No centrifuges appear to be employed.

Drilling is mostly accomplished utilising multistage turbines and roller cone bits (generally of fairly long mill tooth design). Only 2 casings are set on a typical well. The first is essentially a conductor of approximately 9 5/8 inches set at circa 300 m. The hole size for this conductor is believed to be 14 3/4 inches and the conductor is cemented to surface. Drilling then continues to TD utilising an 8 1/2 inch bit. A 5 inch casing is set at TD, but we do not know if it is cemented to surface. Tubing size used is from 2 to 2 7/8 inches.

The drilling fluid used is termed a "native" mud. Water is used from the surface and the natural clay picked up from the formation forms an integral part of the drilling fluid. Water used to prepare the drilling fluid normally comes from a shallow (120-160 m) subterranean aquifer. This also provides potable water for the crew quarters.

Polymers such as CMC or PAC are also used, but the extent is not known. Maximum mud weight is 1.17 kg/l. Apparently barite is not used as a weighting agent as it requires high chemical utilisation to keep in suspension. Carbonates are used instead for weighting agents. No on-site laboratory equipment was observed. Some experimentation has been undertaken using oil based mud though it cannot be ascertained if such fluids were invert emulsions. The type of oil was not identified but apparently was not a diesel oil. The system used was termed as an 'asphaltic system'. We were informed that this was only used on one well and we gained the impression that this fluid was not highly successful. The fate of the cuttings and the mud used for the operation was not ascertained.

Deviated drilling practices appear to be technology limited. Angle and azimuth are measured periodically but the frequency cannot be ascertained. A magnetic multishot is generally run at total depth (TD). Measurement while drilling (MWD) equipment is not used, and MWD units of Russian design are unlikely to be available for 2 years according to the given information.

Drilling is usually conducted without the use of BOP's. Even though the surface pressure is low, this is not an internationally accepted practice from either a safety or environmental protection view point.

Material handling practices both for tubulars and chemicals should be improved, as the current practices are liable to cause damage or waste of the materials. Particularly the methods of handling or moving tubulars on the racks increase the risk of failure in service.

3.3.1 Drilling Waste Disposal

The pits receiving drilling waste are presently unlined and extensive in size. They are often poorly defined and bunded, and there is no facility for oil removal (Photographs 7 and 8). These pits are formed by sand placement on top of native vegetation. This system is not in accordance with international practices or regulations. All these pits should have an impermeable liner to stop fluid percolating into the subsoil. It is recommended that the pits are segregated and operated in series.

The first pit should receive the drilled cuttings (approximately 120 m^3/well) and solids from the mud equipment separation as well as the drilling rig and mud module drains. This pit should overflow through an oil skimmer into a second clarification pit. Preferably this clarified liquor should flow into a third pit for neutralisation or treatment prior to reuse of the water for mud mixing or, if of an acceptable quality, discharged into surface water courses.

Site run-off should be directed into the first pit. As noted previously the sites are made of uncompacted sand and rapidly become churned up by heavy vehicles. This allows fluids to percolate into the soil. The site should be protected by an impermeable membrane covered by a load bearing mesh or sand consolidation geotextile to provide a firm working surface for vehicles. The membrane should be retained at the perimeter of the site and overlap the liner in the first pit. The site should have a continuous bund wall to which the liner is retained except at the entrance to the first pit.

Channel drains of either steel or concrete may be included to assist surface run-off if desired. Such a design should serve for all subsequent workover operations and last for the life of the field. Should the first pit accumulate excessive solids these may be removed periodically for suitable treatment and disposal.

Alternatively, cuttings grinding, slurrying and reinjection into subterranean formations is widely practised in environmentally sensitive areas. We have not been able to fully evaluate the feasibility for use, but recommend that this technique be assessed.

3.3.2 Horizontal and Extended Reached Drilling (ERD)

A significant reduction in the number of well locations could be achieved by utilising these techniques. As noted earlier, the current reach is around 1.2 km whereas, for a comparable depth, 5 km is now considered normal internationally and 10 km is the target for the near future (the current world record is ~ 7.3 km). These techniques should also allow greater productivity per individual well. A figure of 3 to 6 times vertical well productivity are rough guidelines for ERD or horizontal wells.

This has the potential for developing new fields with a 95% decrease in the number of sites required compared to the practices employed at present. Although the individual sites may require to be larger, the potential for minimising land use is great. This also significantly reduces the number of highly damaging sand quarries currently used to provide construction materials.

To achieve these objectives, we believe it would be necessary to significantly upgrade the capabilities of the drilling units and to buy-in specialist drilling and directional control services from outside the CIS for a limited period of time. Changes may also be required for casing design and drilling fluid specifications.

3.4 WORKOVER AND PRODUCTION OPERATIONS

3.4.1 Workover Activities

As noted in section 2, the wells may be produced by natural flow or artificial lift. Currently the trend appears to be towards downhole submersible pumping, with both Russian and American units utilised.

All artificial lift systems generally require more maintenance/intervention activities than wells which flow naturally.

As the wells are not dead, a weighted fluid has to be used to kill them. It is believed that salt brines are used (specific gravity 1.17), though this could not be confirmed. In the case of submersible pumps, where the tubing provides the flow conduit (to which the power cable is also attached), the string must be removed entirely.

A range of track mounted and truck mounted masts were seen conducting these operations. Occasionally a cement truck was present on site. As in the case of the drilling equipment, the design does not appear to have changed much since the 1950's.

These operations are a source of site contamination. Presently there is no drainage in or around the wellheads that allows this oil to be collected and effectively treated; the site itself forming a "soakaway" for the contaminants. Removal and disposal of the kill fluid at completion of the operations was also unclear. Such practices are unacceptable. Site design and drainage has already been covered in the drilling section. It is also good practice to use drips trays or catch pans around the wellhead for such operations to provide a safer working environment whilst easing contamination collection (Photographs 9 and 10).

Acidisation and fracturing fluids were also noted as being used for reservoir stimulation and scale removal on water injection wells.

The frequency of such operations is unknown and lack of time precluded any detailed assessment. Likewise, what happens to the spent acids and chemicals prior to when the well is put back on line could not be ascertained. It was suggested that such fluids were either disposed of to the processing plants or to the site waste pits.

We would consider the latter to be the more likely disposal route. No recognisable disposal pit was visible at many sites and, in some instance, wells appear to have been 'cleaned up' by flowing to the environment.

Workover operations should not be allowed to proceed unless an effective drainage, collection and treatment system for wastes is available.

The quality of well maintenance is also questionable. Incompatible equipment had often been field modified to allow assembly and compatible flanges connections often had missing connection bolts (Photograph 11).

It is also of concern that during both drilling and workover operations, much heavy plant is working in and around exposed wellheads. It would not require a large collision to completely remove a wellhead and allow the well to flow until it could be killed, as no subsurface valves or tubing isolation packages are used.

Apparently a wellhead was removed in one of the fields during our visit though no information was provided regarding the cause or the extent of contamination, and we had no opportunity to visit the site.

The possibility for underground communication between zones was also considered, but insufficient information was gained to provide a rigorous assessment. Communication between reservoir zones due to poor cement jobs was intimated. Cross flow to higher formations due to casing leaks or poor cement was not determined.

From the limited information available, corrosion of wellbore tubing does not appear to be a severe problem so the casings may be satisfactory. Corrosion calliper logs do not appear to be routinely run during workover operations, therefore the potential for downhole contamination of non reservoir zones exists. It is recommended that such logs are run periodically to assess the casing integrity.

3.4.2 Production Operations

At several well sites leaks/seepage from the rod packing boxes of beam pumping units was noted. In most instances this was not severe, though they form a continuous low input source of hydrocarbons to the site (Photograph 12).

Shielding of the wellheads in summer and winter would prevent "wind blow" and act as a collector for a drip pan or localised drain around the base of the tree.

In some fields, burn lines to pits were in evidence and appeared to have been recently used. An acknowledgement of these systems for either well testing or well clean up or the frequency of use, was not obtained. Prior to our aerial survey, it appeared that one well was being 'flared off'.

A small, packaged manifold and test separator exists at many sites. This appears to have the capability of gas removal and measurement of total liquid flow. Drain lines also exist from this unit and the test manifold. In all cases seen, the lines disappeared into the site. We were informed that liquids from these units go to the processing plant. Whether these lines tie into the main line from the site, or have another routing, could not be assessed.

In general, the reservoir engineering aspects of field production practices (and any associated problems) could not be ascertained in the time available. This is unfortunate as we would have liked to gain an insight into these areas, especially for the water injection system. Despite being informed about wide spread water injection, we never encountered a single injection well on any of the sites visited. Considering the number of wells this surprised us. Control of water flooding seems limited by technology (e.g. lack of seismic and computer equipment). Water cuts appear to be ascertained by taking wellhead bottle samples. Production logging operations seem very limited in scale.

We estimate that water flooding techniques could be optimised. This has the potential for extending field life and maximising hydrocarbon recovery.

The separation and treatment of hydrocarbons can broadly be described as following 1950's and 1960's Middle Eastern practices. Mixed flows from the well sites are collected at "out stations" or "gathering stations" where the streams are separated into gases and liquids. Originally the associated rich gas was flared by a mixture of high and low level pipe flares. These practices have caused localised environmental impacts (e.g. tree burn and part pyrolysed hydrocarbons causing ground and foliage contamination (Photograph 13)). Several of these flares also had liquids lines running into the bunded area surrounding the flares.

We were informed that waste soil and sludges were directed to these areas for "destruction".

The flaring of rich associated gas is now limited, and although no figures were made available only very limited flaring was noted. Rich gas demister separators are utilised after first stage separation, with the liquids being returned to the oil and the wet gas sent to the gas processing facilities (operated by others). The much lower volumes of second stage separator gas are still combusted.

Liquids are pumped by electrically driven multistage centrifugal pumps to the main processing and water separation facilities (3 such facilities serve all 12 producing fields).

Apart from the flares, some waste pits were observed at the out stations as well as localised bunded ponds to collect vessel drains and plant leakage (Photographs 14 and 15). These again are unlined and on natural ground. They show signs of continued use with new bunded areas being prepared at some sites. Evidence of overflow from such areas was noted.

Solids from separator vessels and tanks, we believe, are periodically removed and also disposed of to these pits.

Overall, this scheme of drainage is considered unacceptable and a cause of water course pollution. Localised hard standing which is bunded and drainage for vessels is considered necessary. Impermeable lined pits with oil skimming or retention methods are also considered necessary. Oily solids should not be disposed of into such systems, but be handled separately and treated (e.g. by thermal destruction or stabilisation techniques).

Some of these out stations also have "well sites" for producing aquifer water for field water injection. Time constraints did not allow for assessment of these facilities, but water treatment (e.g. filtration) is not highly visible.

All electricity comes from the central power distribution system. Local tankage for temporary storage of liquids is present at these sites. These tanks are surrounded by low earth or sand bunds. The bunds appear to be very low for the tank size, but could not be assessed as the operating level of the tank was not given.

One of the three main stations was visited and the process system briefly reviewed. Basically, multitrain electrostatic dewatering is undertaken to obtain a "pipeline specification" oil which is then pumped into the main distribution trunk lines (operated by others). The limited amount of gas separated (which was originally flared) is now treated in a similar manner to the out stations and utilised. Evidence of past flaring activities with environmental effects as for the out stations was noted.

After degassing the crude/water mixture is heated in gas fired heaters to approximately 38°C prior to entering the electrostatic coalescers. Apparently no chemical demulsifier or wax inhibitors are required. Neither is fresh water required to be added for desalting the oil to the pipeline specification.

The separated water goes to a series of settlement tanks (4x10000 m^3) for dispersed oil removal and residual gas separation. Three tanks are used in parallel with the fourth taking all the fluid and functioning as a final polishing and distribution system pump holding tank. This system provides water with an oil content of approximately 60 ppm. It was stated by the plant personnel that they would desire to reduce this level to 40 or 20 ppm. The normal tanks were under repair with "back up" tanks in use (Photograph 16). Tank corrosion and scale formation necessitates frequent replacement of internal pipe work (~ every 4 years). The tanks were in the process of being lined with concrete applied to a wire mesh support to minimise corrosion.

The roof vents on the tanks appears to allow oxygen to contact the water. This would assist in the corrosion process within the tank and of the field distribution pipe work, which has an unacknowledged short life time. The oxygen content of the treated waters was not ascertained.

Drainage of the plant is variable. Some of the later equipment is set on continuous concrete bunded plinths (Photograph 17), while others are set on supports above open ground. Storage tanks are bunded but no liners are used as was the case for the out stations. Build up of solids in the coalescers was an unacknowledged problem. Approximately every 2 years the vessels are opened up and the solids jetted out. Some vessels were open and the solids level was approximately half of the vessel volume (Photograph 18). It was stated that these solids were flushed to two small " concrete slab lined" waste pits equipped with an oil skimmer system (Photograph 19). It is believed that other vessel drains as well as the oil removed from the water treatment tanks is also directed to these pits. The full extent of the drainage system could not be ascertained in the available time on-site.

The pits are considered as of limited volume and incapable of holding the cumulative (and relatively large) amount of solids from the electrostatic coalescers. The final fate of these solids could not be ascertained.

Clear evidence of surface oil contamination around the site was seen, mostly in the vicinity of plant entry and exit pipelines (Photograph 20). Again time precluded a full assessment as the plant area is large (~ 4 km^2).

Power for the plant comes from the central electricity system and the plant has to import gas for the heaters during the winter, but is self sustaining during the summer with some gas exported to the gas processing companies.

In all the sites visited, there was an absence of the smell of H_2S. Apart from localised areas of the well sites and oily waste areas of the processing plants, there was no distinct smell of hydrocarbons even though the storage tanks have atmospheric vents. It was noted that some studies of air contamination by hydrocarbons have been undertaken and that tank vapour recovery systems have been considered.

Overall, plant problems appear to be a lack of inbuilt drainage and an uncertain oily solids disposal capability. An effective collection system for spillage when working on, or modifying, pipelines in and around the plant appears to be another requirement.

The use of extended reach drilling generating large well sites could radically alter the design of all processing for new fields, especially if multiphase pumping was employed for line transfer. Multistage pumping is now coming to the end of its testing phase and the prospect of pumping two phases over distances of 50 to 150 km considered a reality. It was also noted by the chief engineer of NNG that a local associated gas utilisation system was under active consideration. Although no specific details were given, it is believed that at least one of the objectives was localised power generation.

Such systems may require the transfer or import of technology. This may be especially effective for water treatment where closed system hydrocyclones may prove extremely beneficial for effective oil removal. Oily waste treatment and disposal techniques would also, in our opinion, fall into this category.

3.5 GATHERING AND DISTRIBUTION SYSTEM

A wide variety of pipelines have been laid in the operating areas. These include the in-field and inter-field gathering systems put in place by the NNG operating divisions, as well as the pipeline distribution systems for gas and oil operated by others.

Several methods of construction have been employed comprising of surface laying (with or without soil cover) or subsurface burial. Pipelines may be partially exposed, totally exposed, or totally buried. The reasons for the exposed sections could not be determined and could have been intentional, caused by natural erosional forces, or surface rise due to buoyancy in the case of gas lines.

Stabilisation of lines appears to be by trenching, though some discrete concrete anchor blocks were seen on our visits. In the covered sections geotextiles may have been used for stabilisation as this is a recognised Russian technique. This latter technique is more likely for gas lines.

Some lines have been laid without any external corrosion protection whilst others had plastic wrappings applied. In several of the exposed sections of lines (all sizes) these plastic coating were often totally destroyed. How the coatings are performing in the buried sections cannot be ascertained (Photographs 21, 22 and 23).

Apparently no cathodic protection systems are used on the field gathering or distribution lines, though it is understood that both impressed current and sacrificial anode systems were used on the interstate trunk lines.

The routing of pipelines is often not clear and although some run adjacent to main roads, they are often at a considerable distance from the roadway. Spacing between parallel lines is also highly variable, ranging from a few meters to several tens of meters.

In general, pipeline corridors in wooded areas are wide compare to international practices. Some pipelines also appear to have a somewhat random routing, especially when viewed from the air.

It also appears that a number of redundant lines or line sections have been left in place, complicating interpretation.

Localised drainage changes were often noted where surface covered lines have been used. This causes channels and water courses in the gullies along the lines and precludes cross-flow of waters. This seem to be a particular practice of this area and the CIS in general.

Most European lines are completely buried and the original ground contours maintained. In other areas, particularly the Middle East, above ground lines are widely used. Above ground insulated lines are also used in Arctic areas. Both these techniques would prevent major changes to drainage patterns.

From the records provided, pipeline ruptures by mechanical breakage during construction activities and leakage due to corrosion are prime causes of oil contamination in the environment (Photograph 24).

Figures of 147 pipeline failures since 1982 were given to us for the gathering systems alone (indicating approximately 1 oil spill per month), and the current failure rate was stated as approximately 20 incidents per year. It is possible that this frequency will increase as the infrastructure becomes older. Lifetimes of 10 years for oil lines and 2-5 years for produced water lines were stated.

Only limited corrosion monitoring is undertaken on the main gathering lines and there are no obvious pig launchers that would allow the use of 'smart' pigs.

It is strongly recommended that this method of "in pipe monitoring" is evaluated for adoption as it has proved excellent at preventing failures. This technology is mostly European and it is believed to be in use in other parts of the CIS.

None of the main lines visited had any visible signs of cathodic corrosion protection systems and no data was made available to us.

Corrosion inhibition was noted as being employed in both gathering and distribution systems but we did not see any injection systems or what types of chemicals were being used.

Effective inhibition is considered as requiring closer study and evaluation. It was noted from conversations with operating personnel that a lack of chemical availability and cost precluded routine use.

Mechanical breakage (as noted previously) is to a large extent in the vicinity of well sites. These lines are generally of 8" diameter (feeding into the main lines) and may be from a few hundred meters to several km length (~ 3 km maximum).

Such breakages are generally indicative of poor marking or identification on maps. Overall, data provision is considered a problem. Accurate topographic maps and engineering drawings and the easy reproduction for distribution, would probably preclude such failures.

Isolation valves also appear to be limited which does not assist in easily minimising losses once a leak is detected. Underground leak detection, especially in winter was indicated as a problem. Several technologies such as aerial hydrocarbon sensing or thermal imaging may be applicable, but these require further investigation for suitability. Sniffer dogs have also been used in the USA with success and would also merit investigation.

As noted in the preceding two sections, a change in the design of field developments could greatly reduce the number of lines which in time would reduce pipeline costs and ease the inspection and maintenance workload.

3.6 CLEAN-UP AND ABANDONMENT

The figures provided to us for oil contaminated land around oil and gas facilities and pipeline routes was given as ~ 1300 hectares of surface oily contaminated land.

This excludes the low level or patchy contamination spread throughout the area in general (Photographs 25 and 26). Contamination of subsurface water and soils has never been investigated and is therefore a prime area of concern, especially as near surface aquifer water layers are used for human consumption.

Periodic water sampling for hydrocarbons has been undertaken during 1992 in ~ 40 rivers or streams at fixed locations in the vicinity of oil exploration activities. It appears that no sediment from the river beds, or soil core samples from around oil and gas facilities, has yet been undertaken. This gives us a cause for concern as the work to date does not provide the full picture of the overall pollution problem.

It is also evident that water flows during the spring thaw can give rise to significantly elevated river water levels and extensive land flooding. Up to 5 or more meter changes in river level between seasons is not considered abnormal.

This allows contamination to be widely redistributed from initial "point source" polluted sites. (Photographs 27 and 28) Likewise, the effect on ground water changes due to increased water levels during the thaw period are unknown. All these points need investigation in order that a true assessment can be made of the existing areas, and should be a prerequisite requirement prior to development of new areas (e.g. a full environmental baseline study is required so that reliable and consistent data interpretation may be undertaken in the future).

3.6.1 <u>Clean Up</u>

Where contamination occurs, either through regular operations or from failures (human or equipment related), only limited clean-up actions are undertaken. In the case of large spills (e.g. from ruptured pipelines) a temporary bund is either bulldozed or laid in place to try to minimise the spread of contamination. This is about the best that could be achieved in such a situation.

Recovery of oil by suction or skimming is then attempted, although there appears to be only a limited amount of specialised equipment suitable for this purpose.

Home-made boom systems (made from geotextiles) have also been utilised. In some cases a weir system has been employed in the bund to allow low levels of contaminated water to be discharged in natural water courses.

Visible contamination on the land has sometimes been attempted to be stabilised by ploughing and mixing either native or imported soil into the residual oil contamination. This seems to have had variable effects. It probably stops wholesale washing of contamination into the surrounding area, but provides a potential for long term, low leachate into the environment.

It was noted that some areas treated three years ago by these techniques could still have oil squeezed out by hand (Photograph 29). This is probably due to the fact that most of the material used is sand with a very low clay content which consequently has a very low absorbency capacity. The use of natural materials such as peat or sawdust are considered as such more suitable materials for absorption. This is due to the internal structure of the plant material. In all cases, these materials can be washed into water courses and accumulate in the sediments in periods of heavy rain or seasonal flooding.

Total removal of contaminated soil does not appear to be practised. We have attributed this to the volume and transport costs of the amount of material to be removed as well as the lack of treatment facilities and secure landfill sites. Some of these oily materials may actually be beneficial (e.g. stabilisation of mobile sand dunes). There is almost a complete lack of any data or evaluations regarding whether these techniques are feasible for this region and climatic conditions. There is also uncertainty over regeneration of the polluted site once the polluted materials have been removed. These areas are worthy of scientific study.

Attempts at in-situ bioremediation have been undertaken on some oil spill sites (~ 15 hectares). This work has been done on a "trial and error" basis over the whole of the contaminated area (Photograph 30). Essentially no scientific prestudy was undertaken prior to bacterial application and control plots have not been applied. Piezometric measurements, hydrocarbon degradation analysis, plant growth and recolonisation, or soil dwelling insects and invertebrate analysis have not been undertaken.

Laboratory test work and controlled field experiments are required before any conclusions can be drawn with regard to the potential effectiveness of any bioremediation techniques.

Localised site spillages are generally treated (if at all) by dumping and blending fresh sand into the spilled oil (Photograph 31). Again, this has the effect of reducing immediate run off, but still leaves the problem of low persistent leachate as noted previously. We do not consider such techniques as a substitute for a properly constructed and well designed site.

Housekeeping (i.e. removal of miscellaneous material and equipment) is poor. Redundant elements of equipment, packaging, or construction materials are liberally scattered around the landscape or poorly buried on site (Photograph 32 and 33). Other than visual effects, the overall impact on the environment is limited.

This does, however, demonstrate that the ethic of respect for the work place environment is in contradiction with what occurs in the city environment of Noyabrsk. Highly visible efforts are being made to keep the city clean in order to provide an attractive living environment.

3.6.2 Abandonment

The ultimate abandonment of oil facilities does not appear to be considered except in the case of well plugging. Other basic questions such as drilling pad and access road removal, processing plant removal and pipeline removal have not, to our knowledge, been addressed at all. In some instances, it may be argued that removal would cause more environmental damage than leaving some facilities in place. This may be particularly relevant to pipeline routings where natural regeneration has occurred. Removal of plant and equipment during the winter months may also be preferable, especially where no roads exist. There has being insufficient time to consider these aspects in detail. The costs of abandonment are highly dependent on the design of the initial installation (i.e. if decommissioning/removal techniques are not considered at the initial design stage, the cost for such operations tends to be higher at the end of the operation).

At present, we can not offer concrete advice on abandonment policies. A far wider debate on abandonment issues must be started now to define an acceptable environmental quality in the post oil production time period.

4. CONCLUSIONS AND RECOMMENDATIONS

These conclusions and recommendations are based on what is a very short overview assessment. Although every effort has been made within the time constraints and remit of the objectives to ensure that the conclusions are based on sound and representative data, errors or omissions may, however, have occurred and this has to be born in mind when reading this section.

We trust that this report will provide useful information and act as a catalyst for ongoing discussion and analysis.

Conclusions

- The oil industry practices employed are very similar to those of other countries which have a large land area and where the perceived value of the land is very low or "worthless".
- Economic growth has been used as a basic criteria for natural resource development instead of determining a balanced, ecologically prudent approach.
- A range of practices and technologies exist so that the current level of land use and discharges to air and water can be significantly reduced.
- There are a range of potentially severe environmental impacts which have not being quantified (e.g. ground water, hydrocarbons accumulated in soil and air quality).

- The use of environmental impact assessments through to abandonment, environmental risk analysis and environmental contingency plans are not applied. Such practices are generally required by legislation in EC member countries or North America.
- The "precautionary principle" and internationally accepted working practices are not being applied in this area.
- There is as yet, no formal system through which the public can object to any development project. This right is also guaranteed by legislation in the EC and the USA.
- Prevention is better than cure. This is the basic philosophy that should be adopted for all development projects.

Recommendations

We propose the following items as areas that should be considered to reduce the observed impacts on the environment:

- Seismic technology that requires only narrow corridors should be employed.
- A detailed hydrographic and topographic profile should be utilised for all civil engineering activities. This particularly relates to the placement of culverts to allow natural drainage patterns to be broadly maintained.
- The extraction of construction material (primarily sand) should be more controlled. A detailed environmental assessment, including abandonment and restoration, should be undertaken prior to quarrying activities commencing.
- Stabilisation of roadways and sites should be undertaken.
- Geotextile and soil consolidation practices should be investigated in detail to minimise spreading of unpaved road surfaces and well sites.
- Common corridors for utilities, roads and pipelines should be utilised as far as possible. This involves integrated multi-user planning and development.
- High angle and horizontal drilling techniques should be fully evaluated as an aid to minimising land use and maximising recovery per well drilled.
- Two phase pumping and single site oil and gas processing should be investigated for new field developments.
- Effective drilling waste handling facilities that preclude the potential for groundwater contamination should be employed.
- BOP's should be employed on all wells that can naturally flow. This is the internationally recognised standard practice based on a "two tested barrier" concept.
- Adequate surface site drainage must be maintained during the producing life of the wells.

- Adequate site drainage and vessel drainage should be provided for all processing locations.
- Effective handling, treatment and safe disposal facilities should be developed for oily sludges.
- Hydrocyclones should be considered for oily water treatment.
- Improved corrosion monitoring using through pipeline investigation methods should be employed for major flow lines and wellbore casings.
- Chemical inhibition and improved protective coatings should be investigated for fluid handling lines and water treatment systems.
- Environmental impact assessments are considered a prerequisite for all industrial developments.
- Monitoring of groundwater and soil contamination should be undertaken as a matter of priority.
- Abandonment policies should be developed from now for all industrial activities.
- General housekeeping in industrial areas should be improved.
- Environmental education and awareness training should become routine for management, employees and the general population.
- Clean-up technologies require scientific study and development.
- Remote sensing equipment or techniques for detecting the leakage of hydrocarbons (especially under snow cover) must be assessed, and if necessary, developed.
- International comparability and harmonisation of methods used for analysis and inspection should be undertaken.
- Russian input into the harmonisation of international standards with regards to the oil industry and environmental assessments should be encouraged.

APPENDIX I

FIELD PHOTOGRAPHS

APPENDIX II

REPORT OF THE FOREST ECOLOGICAL GROUP "ECOLOGICAL IMPACTS"

forrus2.doc
August 28, 1993

Report of Working Group: "Ecological Impacts":

Core group:

Dr. Mike Apps (forest ecosystem/climate change scientist)
Dr. Jim LaBau (forest health/mensuration)
Dr. Don Leckie (forest remote sensing)
Mr. Valery Mosalevsky (forest scientist)
Ms. Julia Sedykh (interpreter)
Dr. Anatoly Shvidenko (ecologist)
Dr. Sergey Vasiliev (geobotanist)
Dr. Bob Nisbet (forest ecosystem scientist)

Additional inputs received from:

Acamedician Alex Isaev
Dr. V. Sukhykh
Mr Pavel Yelagin

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1. Introduction

1.1. Goals, tasks, reasons
1.2. Organizers and participants
1.3. Overview of works
1.4. Fields visits
1.5. Sponsors and organising agencies

[this section will be added in Novosibrsk]

2. State of Environment

2.1. Forest

2.1.1. Common characteristics forest and productivity

Soils are generally nutrient poor except on well-drained but loamy soils in the river flood-plains. Generally, there is a lack of nitrogen. Overall, productivity is constrained by short growing seasons and low mean annual temperatures; trees are a good indicator of long-term climatic conditions.

A forest soil classification exists (Pogrebnyak) which is based on nutrient vs moisture regimes. This two-parameter description may not be adequate for permafrost areas.

Leaves of many young birch trees were discoloured due to insect damage (sawfly) at disturbed areas (also in Noyabrsk). This may be an indicator of nutrient stress, which would make them more susceptible to attacks by sawfly and other insects/diseases. Russian experts agreed that the discolouration was insect-caused and occurred mainly in young birch on disturbed areas

2.1.2. Forest harvesting

There is only limited existing capacity for processing small materials (16 cm dbh is the smallest they handle, lengths appear to be ~10m), there is no pulp processing in the region. In the Krasonselkup area, however, up to 30% of the sawmill wood-chip waste is used as a filler material for concrete construction locks.

We do not believe, on the basis of what we saw, that the area can maintain a significant timber or pulp industry on a sustainable basis. On well-drained loamy sites, limited operations may be possible, but care will be required to prevent damage to the hydrological and/or nutrient regimes (e.g., swamping and erosion). Research will be necessary to develop the most appropriate methods.

2.1.3. Forest operations

Hydrological and nutrient management will be essential. The use of sewage sludge as fertilizer is being explored in North America and may be an opportunity for research application here. Also, the use of oil emulsions for stabilising disturbed areas and to encourage microbial activity may be valuable in this regard.

We were told that experimental trials have been conducted with the use of "Potidol", a bacterial preparation for oil spill rehabilitation. These trials proved to be unsuccessful: treated plots did not differ significantly form the untreated control plots. Russian expeerts suggested that these trials failed because of the following reasons:

1. lack of appropriate technology for preaparation of the working solution
2. Inadequate temperatures for bacterial activity
3. Moisture deficiency (oil spill reclamation trials were carried out on dry areas)

Such experimental development should continue but they should incorporate experience gained in other parts of the world.

One area that must be examined is the tendency for forestry operations on the more productive sites to result in swamps. Research may be necessary to avoid conversion of upland forests to swamps if these sites are exploited for forest applications.

>>possible research topic

Salvage operations should be encouraged after cutting corridors for roads. drill pads. pipelines etc...

Foreign experts are sceptical that full scale forestry operations (harvesting, plantations) would be sustainable on this region....with the sandy, nutrient poor soils, only extensive, long-rotation and low-level forestry would likely be sustainable (economically and environmentally). At the northern sites in Krasniselkup, higher productivity sites were observed and there was a well developed forestry utilization infrastructure. However, there were many unused cut log piles indicating theta more timber was cut than could be used. This indicates a poor level of coordination and planning and development in the Noyabrsk region, if undertaken, should strive to be more organised.

2.1.4. Reforestation and Reclamation

The delegation questioned whether there will be enough planting to justify establishing a nursery. It is unlikely that a large scale forest operation will develop for the reasons outlined above. However, small nurseries may be appropriate for city landscaping, etc.

There is a very fragile environment on the edge of dunes. So, by definition, reclamation will be difficult. Dunes need to be protected from all traffic. Avoid putting borrow pits in areas susceptible to duning. Researeh is needed to develop indicators of dune susceptibility (e.g. sand grain size, nutrients, moisture regime, geomorphological status, etc.)

We do not recommend that efforts be expended to reclaim 'natural dunes' - effort should rather be to avoid creating new ones by human activities. Mitigation techniques have been developed for other sand dune problem areas. We recommend that disturbed areas be monitored for natural regeneration and if anthropogenic sand duning requires mitigation, these existing foreign technologies be examined.

2.1.5. Forest fire and fire protection

Development of the area started in 1940-1950. It was not oil and gas development, but other activities (railroad and road system) that opened the area. Fire records dating back to 1670 (fire scars) show large cycles with 30-60 year return frequency. These were large area burns. Since 1940-1950, there have been more fires but they have been smaller, leading to a patchy territory. This situation probably prevails over most of the northern and central Siberian Taiga. It was noted that widespread wetlands also act as fire barriers to reduce size of fires.

Anthropogenic induced fires appear to be more frequent along roads, probably due to human activity along these roads. This change in the natural fire pattern has a number of ecological impacts including a change in the carbon storage of the forest ecosystems (e.g., thinner litter layer, younger forest age-class structure, change in forest species associations ... all of which result in less stored carbon.)

Meteorological Data shows that this region is not susceptible to dry storms so dry lightening fires are not common here--therefore most fires are man made. This agrees with the observation of an uneven aged structure of most forests (other than pine-lichen) we have looked at in the region.

Fire maps are maintained for protected and forest areas but we were uncertain whether such maps and databases are available for the entire area.

Well-timed fire protection is technically poorly equipped but the attempt is made to extinguish all fires including catastrophic ones by enlisting the assistance of non-specialists as well as professionals (4000 people were moved to fight one large series of fires recently).

Burned area restoration proceeds naturally and additional reclamation measures are not required.

It was also noted that simple changes in practises and attitudes can reduce the incidence of human-started fires. For example, a lack of spark arrestors on the exhaust systems of most oil field equipment was noted by the Technical group. This could be a significant reason for fires around development sites and along roads.

2.1.6. Forest pest and disease

Ips sexdentatus (bark beetle) in felled pine stems was observed at several disturbed sites. It was feared that these felled trees can provide food for a potential bark beetle epidemic as in Alaska. For this reason it is necessary for forest protection and forest management. There was lack of agreement amongst the Russian experts on this point -- however page 9 of the expedition's introductory notes refers to insect problems and the recent Alaska experience is relevant. This is a potential problem if a series of warm winters occurs such as was experienced in Alaska, e.g., under climate change. It was noted that east Siberia may experience +10C in winter and + 7C in summer (although less change is expected in European parts). If such changes occur, the insect epidemics may become a serious problem and will be worsened by present practises. Such an explosion of insect populations was seen in Siberia during the warm periods following the second world war.

The Russian experts did not think this is a priority issue. We all agree, however, that it is an area of uncertainty. The region on the whole is characteristic of harsh climatic conditions and significant anthropogenic impact. Throughout the region, trees have relatively shallow root systems and are easily subject to wind throw damage. In any forest plot there are a significant number of weakened trees and dead snags through self-thinning processes -- this situation is common throughout the global boreal forest zone. Top-dried trees found commonly throughout the region: burns, patches and individually-stressed trees can be observed everywhere. These represent a permanent, and natural, habitat for forest pests.

No appreciable increase of needle pests has been observed in the region under investigation. In all the accumulations of fresh dead stands, wind-fallen stands, twigs and branches, dense and very dense settlements of stem pests such as Ips sexdentatus on pine and cedar pine (up to 3 families), Ips typographus on spruce (up to 7 families), Monochamus galloprovincialis and M. sutor on pine, spruce, cedar pine and larch (up to 5 holes per linear meter) were observed. Everywhere in pine-shrub- white moss and -lichen forests patches and individual pine trees infested by Dentroctonus micans were noted. Gallfly larvae were found in pine cones and Dioryctria abietella in spruce cones.

Over the entire territory under investigation, mass sawfly increases (Tenthredinidae, Gen.?, sp.) proceeds in young birch trees. Sawfly larvae skeletonize young birch leaves, leaving them yellow and desiccated.

Fungi play an important forest plant pathology role in this territory. Fomes pinicola prevails among wood-attacking fungi for all tree species. Young pine trees that appeared along the roads, sand-pit and other engineered construction areas suffer badly from Facidium infestans. In some places the spruce undergrowth is infested by Lophodermium, causing desiccation of branch tips and eventual mortality of young plants.

Based on the Alaska experiences, we consider that large accumulations of unremoved wood slash may potentially be dangerous and may serve as a factor influencing mass insect increases.

2.1.7 Conifer seed production

Conifer seed formation proceeds normally within the limits of several growing seasons and is triggered by definite combinations of weather conditions (e.g., two-year cycles for larch, spruce, fir and three-year cycles for cedar pine and pine). Under the continental climate of the West Siberia these conditions are not always obtained and this results in insufficient formation of generative organs, incomplete pollination, and irregularities in seed development. On the whole this leads to a decrease in cone and seed size, a decrease in their quantities on seed trees and frequently even to a complete absence of seed production

Under extreme cold conditions, larch suffers most significantly and its yield capacity in the most of the surveys conducted amounts to 5-15 cones per tree, while in some facies (profile 3, facies 1; profile 7, facies 7,9) production reached 60-110 cones per tree (as a rule, this occurred only on rather large trees of H = 16 m, D = 22-32 cm). For cedar pine, the yield capacity in favourable years is also low, 20-25 cones per tree on average, although individual trees form up to 40 cones. A lower yield is generally observed in sphagnum forest types, with, for example, a mean cedar pine cone production of 7.

Spruce seed production is less depressed: for small tree sizes (H=10-12 m, D=14-16 cm) approximately 50 cones per tree are formed, but in wet facies this value decreases to 5-10.

Pine is better adapted to local conditions. Small trees (D=8-10 cm) in lichen and green moss pine forests yield 50-90 cones while larger ones (D=16 cm) produce as much as 700. In sphagnum-pine forests the yield is significantly decreased up to 5-20 cones per tree.

Larch and spruce form small-size cones, their mean length (22.4 mm and 50.4 mm for larch and spruce respectively) is the lowest limit found for the species (22-30 mm and 50-80 mm for larch and spruce respectively), although judging by the range, these are normal-sized cones. Seed scale number is normal (see Table).

Pine cone size is as small as 34,1 mm. in the middle taiga cone length is 41,1 mm and even in forest steppe pine cones are larger, e.g. 40,6 mm. Values which are close to those observed here, have also been obtained for the Northern Urals (e.g., 29-36 mm). In Sphagnum facies cone sizes are even lower (27,4 mm).

Normal sized cedar pine cones are as long as 62,6 mm but some cedar pines cones are up to 74,8 mm long --this is within the normal range of 39-86 mm. The mean value is to be compared with that observed in the southern taiga (68 mm).

More in-depth seed production evaluations should be conducted later to ascertain the ripening and gemination potential of the seeds as well as their quantity, as cone abundance is known to not result in a high cone yield (especially in the North).

2.2. Wetlands

2.2.1. Changes in wetland communities

The area of wetlands is considerably larger when compared to that of drained forests. Many types of wetlands can be seen here. On inter-river areas and ancient terraces, flat mounded swamps with frozen peat and frozen ground underlying oligotrophic hummocks and ridges have formed. These swamps are of three forms:

A part of them, covered with lichen, are regarded as important reindeer habitat.

On young terraces in older valleys, along swamp borders, we find mesotrophic sedge/sphagnum moss, as well as Betula nana/sphagnum moss swamps.

Finally, many types of swamp forests are present.

For the most part, the status of wetlands of the region is normal. In the region of oil and gas activities, local changes in hydrology have had an impact on their function but as far as we can determine this impact has been fairly localized so far.

2.2.2. Permafrost

The swamps of the region under question are often underlain with permafrost. Permafrost occurs predominantly in wetland systems and in the Noyabrsk region. permafrost occurs only in the association with the hummocks of some wetland areas. These areas are surrounded by a border of unfrozen peaty soil. This border contains no permafrost and is a natural phenomenon - that is, it is probably not due to melting of permafrost as a result of human activity.

It is impossible to always predict withe certainty if the permafrost will thaw or not as a result of industrial activity. There is a limited data base relative to permafrost melt and these data are located in many separate files in different locations. When laying the pipelines it is easy to induce thawing and frost heaving of pipelines often occurs. One might perceive permafrost to be stable, but permafrost melting may still occur at a very slow rate.

This is a particular problem in the areas to north awaiting potential development.

Construction in permafrost areas should be avoided if at all possible. If construction is necessary, the use of insulating materials to prevent permafrost thaw is essential.

2.2.3. Changes in swamp water levels

There is flooding associated with road construction which act like dams. Drainage systems appear to be unplanned, in the wrong place or non-existent. Culverts appear to be installed for protection of roads and not to minimize ecosystem damage. Two problems appear to result-- 1) flooding on one side, 2) drying out of wetland on the other. In both cases a change of wetland function results. Drying wetlands introduces increased fire problems and CO2 release through aerobic decomposition of the peat deposits. Flooding causes bigger problems - vegetation is drowned - including trees whose roots are in the flooded area. Wetland forest becomes replaced by open wetland. In some cases, changes in hydrology may not lead to an obvious flooding or drying out. Instead , a small change in water table may occur and this may result in significant changes in wetland structure (vegetation community).

Construction Borrow pits result in a permanent change from well drained site to low drainage sites. Excavation in such pits may be down to the level of ground water, in which case new ponds are formed. In other cases, the borrow pits are situated below the water table (or dredges are used in lakes or flooded borrow pits), and these may cause other problems with local hydrology and aquatic habitat (e.g., expanding the lake size and changing the shoreline habitat).

Is the swamp area increasing? Or does the reverse (swamp-to-forest succession) occur? Considerable data suggests that there has been an increase in the swamp area over the last millennia (and a corresponding decrease in the upland forest area). There appears, however, to be little change in amount of permafrost area.

An increase in wetland area is also associated with flooding and changing of the swamp hydrology due to road construction. Increases in sand-pits also results in transforming the well drained sites into swamps and artificial lakes. A series of mechanical actions, such as overturning peat, peat mineralization, peat saturation with mineral particles (sand and clay), and superficial silting have a slight reforestation effect on some swamps. However, this slight increase in forest area does not compensate for the greater loss due to increased swamp formation.

2.2.3. Contamination of wetland

The potential contamination of wetlands is a major concern for this region. Where wetlands occur in drainage areas, spilled contaminants, such as oil and production water, etc., tend to concentrate in them. Oil spills are likely a main source of contamination. In terms of the total oil field area, the amount of land directly impacted by oil patches is small. Depending on the depth of the oil spill, the entire plant community may die. When the oil spill is not large, mature trees, mosses, and small birch (Betula nana) die first. In some instances, the undergrowth survives.

There are several possible explanations for the observed mortality. First, tree mortality may occurs as a result of insufficient aeration of the rhizospheric (rooting) layer. This is the simplest explanation and probably is a factor in most cases, if not the major one.

A second possible reason for tree mortality is due to heavy hydrocarbons penetrating the roots causing hydrocarbon blocking of the vascular system. Willow mortality is known to occur for this same reason on islands in the middle of the Ob River even where continuous oil film was not present on the soil surface. However, the wood of willow roots and of the lower stem were saturated with oil (the sample was not analyzed for hydrocarbons, however).

A third possible reason is mortality due to toxic effects of oil substances, but this hypothesis requires further disciplined study.

The area contaminated by salts is considerably larger than the area contaminated by hydrocarbons. Salts are dissolved from oil and spread through subsurface water flow. Oil, in contrast, does not move freely through the peat. The influence of substances which are dissolved from the oil and spread beyond the area of oil spill proper is different for various plant species. In the vicinity of the Karamovskoye field the following were observed by the Russian experts (not all these were seen by the foreign experts due to lack of time):

1) Mortality of sphagnum mosses, Betula nana and other small shrubs were observed in a zone s around the oil spill itself;
2) Late in July some birch had yellow, senescent leaves, indicating possible early seasonal change. However the wood increment increased;
3) In spruce, terminal shoot mortality and re-growth occurred four years ago (probably during the year of oil flooding), but Russian experts noted that height increments did not decrease;
4) Needle life on pine was reduced. Only two-year old and occasionally, three-year old needles could be found on the branches. However, radial growth rates (tree rings) increased 400% to 500% during the same period.
5) The sedge population in an impacted wetland community was greatly increased.

In general. when swamp eutrophication occurs site productivity improves and the sedge/Sphagnum swamp is replaced by sedge. Peat-decomposing processes increase. resulting in increased CO_2 efflux to the atmosphere. Although one sees an increase in the productivity of these swamp sites. such sites will not sustain forest production at satisfactory industrial standards. Thus. overall, there is an adverse impact on these wetland communities and their ecological function.

Another source of the wetland contamination is drilling mud pits. The contaminants they contain seep through mud pit dams or are leaked out directly when the dams are washed out. The composition of drilling mud pit solutions varies greatly, but available observations indicate negative impacts on plant cover. For example. moss mortality occurs and wood increment decreases in willows. or they may die altogether. There is yellowing and dying of the sedges. Such contaminated areas are generally near most of the drill pads. Within the boundaries of most fields contamination is widespread. The Karamovskoye field is as an example.

2.2.4. Short issues

When compared to forests, wetlands suffer to a greater extent from impacts from the Oil and Gas industry resulting from chemical pollution. The forests are mainly subject to mechanical impacts which are associated with human activity on developing areas.

Increased peat decomposition results in increased CO_2 efflux and a contribution to the green house effect.

Within the immediate vicinity of certain individual oil fields the wetland ecosystem condition is unsatisfactory. At a minimum it is necessary to use newer, available technologies to reduce future impacts. These changes are possible and most are easily implemented (see the technical working group report).

It is also necessary to investigate the consequences of existing disturbances as well as to study regeneration and reclamation techniques. Mitigation measures for the reclamation of the most seriously contaminated ecosystems to prevent regional spreading of the contamination.

2.3. Aquatic systems

Wetlands are connected with the rivers and hydrologically they form a single system. Therefore, wetland ecosystem disturbances may contribute to impacts throughout the total aquatic ecosystem. Wetland displacement changes the intensity and direction of wetland water flows, and may therefore affect the normal functioning of an enormous region.

2.4. Wildlife

An apparent lack of water fowl, and other mammals was noted. Local experts indicated that animal activity has decreased as human activity has increased. Animals have moved away (they told us) because of people, noise and machinery and disturbance to their habitat; this is consistent with our observations and our experience in other northern systems. There were no local studies of migratory bird behaviour presented to us but large flocks were noted to be no longer seen near town. These migratory routes appear to have moved East and/or west. Similarly, migratory reindeer herds no longer come near the area. East-west roads (probably vehicle noise) has interrupted their migratory route. If roads interrupt all routes, this will introduce potentially serious problems. Such situations have been observed in other northern countries and the phenomenon is not unique to Oil and Gas activity.

There are additional problems of environmental ethics which arise from migrant/temporary workers; long-term residents and indigenous population are not as much of a problem. Again this phenomenon is common to northern frontiers around the world.

Hunting is popular but often illegal.The natives of Siberia (aboriginal) have unlimited hunting rights while temporary workers have a less well-developed conservation ethic. It was noted that there are only 6 or 7 wildlife enforcement officers for a 3.5 Mha area.

There is an opportunity for coordinating environmental ethics with new ecological programs. Such coordination would assist in the implementation of a more adequate enforcement
structure. Educational programs for young people including the establishment of nature centres, workshops, etc. could prove supportive in this process.

The main impacts are not specific to the oil and gas industry (except for aquatic habitat); they are associated with the infrastructure (roads etc)

Local expert does not think oil on water is a serious problem for migratory birds because of the existence of considerable remaining habitat. However, this may change if cumulative regional impacts continue.

Fish populations appear to be declining. Anecdotal evidence suggests that the decreases are due to pollution: fish caught in some locations are not edible and smell of oil. Actual chemical analysis to support this explanation was not, however, available. Additional stresses on the fish population include, for example, increased fishing.

Although there is uncertainty in the effect on fish and fauna, fish populations are believed to be adversely affected (studies in other oil development areas 300 Km to the South East of this region have shown reductions of 50% to 2.5% of normal populations). However, detailed study and data are sparse.

With respect to land animals, a trapping study of small rodents has been performed (see page 11 of the expedition introductory notes) in flood plain, bottom land but the results have not yet been compared with baseline data. Scientists at Novosibersk (Dr. Yuri Solomonovich) have studied the affects of oil spills on animal populations.

2.5. Cumulative regional impacts

The effects of cumulative, chronic exposure to oil contamination are largely unknown. Moreover, as development of new fields continues, there will be an increasing region-wide impact. One specific example of this is the fractionation of the landscape by the network of roads, pipeline, power lines etc..

North America experiences may help to address some of these questions, but we do not have data at our disposal here. In addition, the Siberian ecosystems are not exactly the same and a precautionary policy should be adopted.

3. Mitigation of Anthropogenic Impacts (Disturbed areas)

3.1. Contaminated areas

The procedures outlined by the technica working group should be followed. We have alread indicated the importance of isolating the contaminated areas to prevent extensive and cumulative regional impacts.

3.2. Drilling pads

The technical advice of environmental assessment experts in the oil and gas industry throughout the world should be sought...however; our opinion is that:

> On non-contaminated areas, it is adequate to wait for natural revegetation. A faster response will be expected on loamy soils, but amelioration may be required for sandy soils. The need for active reclamation should be monitored until regeneration is complete.
>
> On oil-contaminated areas, determine and use best available technology --the technical working gorup has separate recommendations for these areas. We recommend that these areas bw given some priority to prevent the seepage of contaminants into the awautic systems and adverse impacts on the larger, regional system.

3.3 Sludge pits

On sludge pits, existing, known reclamation technology should be used.

3.4. Corridors and roads

Natural regeneration will probably be suppressed for monitoring purposes during their periods of use. For this reason they should be kept as narrow as possible. When they are no longer used, natural regeneration should be adequate in most places.

After abandonment, the areas should be monitored for regeneration success and, where needed, active reclamation introduced.

It was noted that corridors and roads act as firebreaks. Justifying pipeline locations as fire breaks is, however, a minor consideration, because the area already has natural fire breaks formed by the wetlands. We think that it is better to consolidate corridors so as to minimise the area which must be disturbed.

Sensitive areas should be avoided where possible. In particular, the risk of oil spills (probability of frost-heaving breakage and ecosystem damage from the resulting oil spill) are probably lower on sandy and loamy soils than in wetland areas. As a result, we believe that wetlands should be avoided where possible.

Roadside restoration/stabilization can be facilitated by using mesh, straw or woodchip mulch to help retard erosion and provide a matrix for seed establishment. Broadcasting of grass seed can be used on such areas to further stabilize the disturbed area and prevent erosion.

3.4. Construction Borrow pits

If excavation is not down to the water table, in sand areas reclamation often will be difficult because of low nutrients, low water holding capacity, and lack of humus.

If excavations are carried out below the water table, full reclamation will proably not be possible -- a new pond will form.

3.5. Sand dune areas

Reclamation will be difficult and probably not necessary. It is preferable that effort be devoted to avoiding the devlopment of new dune areas by human activity. We have the following recommendations:

- protect such dune areas from all traffic (whether of natural or of anthropogenic origin)
- avoid putting borrow pits in areas susceptible to duning.

There is a need to develop indicators of dune susceptibility (e.g. based on sand grain size, nutrients, moisture regime, geomorphological status, etc.). Mitigation techniques have been developed for other sand dune problem areas and if anthropgenic sand duning requires mitigation, these technologies should be examined.

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The following section is a write-up of observations on the field vist to Krasnoselkup...They must be woven into the previous text somehow, but time did not permit this to happen during the expedition.

Recommendations and Suggestions

The Krasnoselkup region is relatively pristine. It is home to a range of ecological zones that show little influence of large scale human activity; these include tundra, forest-tundra, northern taiga, and areas resembling central taiga. Industrial development in the area is very modest. and roads and other infrastructure are comparatively minimal.
Discovery of significant oil and gas deposits in the region could change the current character of the region significantly, however. Local populations and their administrators recognize this fact, and wish to preserve the ecological character of their area. The following discussion is addressed to Krasnoselkup's future economic development within the context of real concern for the natural environment.

There are a number of natural resources in the Krasnoselkup region that are highly valued by the people of the region. The health of any one of them may be considerably dependant on the health of others: thus fishery resources are dependant on water resources. Nevertheless we list some of them separately, as follows:

a) Hydrological resources. We have been told that the Krasnoselkup region is the only region in Western Siberia that still has water that is truly pure.
b) Fish resources. We understand that the people of the region depend on the very healthy fisheries of the region for both food and, to some extent, trade. Moreover, we have been told that the tributaries in the Devils lake region are very important spawning grounds for fish of the region.
c) Forest resources. We were informed that only a fraction of the annual allowable cut is currently harvested, and that the current economic activity of the forest industry is of import to the region. It is unclear, however, what the impact would be of large scale industrial use of the forests on the region's indigenous peoples, on water quality, on wildlife, and so on.
d) National parks. Currently there is a zapovednik in the Krasnoselkup region -- one of the more recently created national parks in Russia. The park is of considerable scientific import. Moreover, because of the pristine nature of much of the Krasnoselkup region, other areas may be suitable for being set aside as national parks.

e) Wildlife. Hunting is a significant source of revenue for the professional hunters of the region.

f) Indigenous peoples. While not an economic resource, as are the previous items on the list, the administration of the Krasnoselkup region stressed to us that they see these peoples as an important cultural resource, and desire to protect their cultures.

We believe that oil and gas development can significantly the value of each of these resources. The adverse impacts of such development can be synergistic, and over time their comulative weight can wreck very considerable havoc. Therefore, in light of the desire to protect these natural resources, we make the following suggestions in hope that they will insure the compatibility of the future economic development in the region.

We do not have the degree of specific information to make concrete suggestions as to how development in the region should proceed. At the same time, there appears to be a lack of clarity on the part of local administrators as to what their priorities for future economic activity in the region are; this is all the more pressing as some development activities may simply be incompatible, and no amount of technological planning may be able to reconcile them. Therefore, we believe that it would be wise to undertake two processes:

1) <u>Conduct a thorough ecological study</u> of the region. Little is known about the area and without knowledge of the climate, hydrology, geology, soil, vegetation, and wildlife, their structure, and how they function together as a whole, it is not possible to make informed development decisions. A long term and thourough study would also provide a unique opportunity to do scientific study of a relatively pristine area.

Such a study would:

* allow recommendations for development to be derived from within a sound theoretical framework.
* provide important baseline data for performing ecological impact statements for future

development projects;

* provide the basis for conducting land use plans, which would allow one to decide how and where development should occur;
* provide the material that would help avoid generating the kinds of ecological impacts that have been engendered by industrial development in other areas.

The study could be designed to facilitate Russian and foreign scientific cooperation. It might be well to concentrate investigations in four ecological regions -- tundra, tundra-taiga, northern taiga, and in the south of the Krasnoselkup region -- while at the same time evaluating the ecological character of the region as a whole. Finally, the scientific assessment might be well served if it is continually working towards developing practical suggestions, so that if economic pressures dictate development before the study is complete, guidance for how that development might least harmfully proceed can be given.

We believe that an environmental impact assessment be performed for industrial development projects.

2) Work with local administrators and the population of the region to help them get a clearer picture of their priorities for development. It may well turn out that certain valued natural resources simply cannot be protected while others are developed, regardless of the technolgies or methods employed. Coming to terms with the local values and priorities is an important process that needs to be done in an ongoing and dynamic way if future economic activity is to best correspond with local desires. At the same time, local administrators may not have the information they need to begin this process. Therefore, we suggest that a useful approach may be an iterative one, in which values and priorities are assessed as new information becomes available.

We believe that these processes could most effectively be carried out if there were a 10 year moratorium on oil and gas development in the region. The need for augmented economic activity might be facilitated through efforts to promote ecological tourism, as well as scientific tourism.

Russia has developed its oil and gas in order to establish permanent and self- sustaining populations in areas that have previously lacked cities, infrastrucure and industry. We can admire and appreciate this effort. However, oil and gas does not have to be developed in this manner; indeed, the operations in the Nojbrsk region could well be supported by only 1% of its current population. The Krasnoyselkup region provides an opportunity for an alternative manner of oil and gas development, if this is what the people of the region and the Republic desire.

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TO GO SOMEWHERE IN THE INTRODUCTION

The following section forms part of what the foreign delegation would like to see in an introductory section to the final report:

Western members of the working group would like to put in context their contribution to the ecological section of this report. During the two-week expedition they learned much about the natural environment of Western Siberia and the way that the people of the region interact with it. They are grateful to the expedition organizers for this exposure. But it was essentially a first-order review; Western members of the group had limited experience in the region (although most members of the group had experience in similar regions), limited time, and limited data. They are not qualified to make a complete assessment of the state of the environment of the region, or of the environmental impact of the oil and gas industry; a thorough assessment of this nature would take months, if not years, of scientific work. This report should not be seen as a detailed set of proposals for future environmental protection and development, although it does offer some specific recommendations in this regard.

Western members-of the working group also could not respond fully to some of the questions put by their Russian colleagues, including:

- how to implement sustainable development in Tyumen,
- legislation to regulate the relationship between the oil and gas industry and the environment.

There is no simple set of guidelines to achieve sustainable development. The concept is essentially not scientific. Rather, in any given society, it is a question of the values, ethics, and priorities of the people and their institutions. In recent decades Western society has begun a slow and often difficult transition to a new set of environmental ethics and values. Russia has begun moving in this direction; this expedition is evidence that many of the people of Western Siberia are seriously concerned about the state of their environment, now and in the future.

Regarding the question of legislation and regulation, the non-Russian members of the group would restrict themselves to a few general comments. First, any legal or regulatory restrictions and performance targets must be realistic: attainable and enforceable. Higher standards are not necessarilly better standards. Historically, the formerly socialist countries often had higher standards for air and water quality than western countries; some countries in Central Europe now face the politically difficult problem of lowering their air quality standards to the (attainable) best levels in Western Europe.

Regulations and standards must be enforceable, given a realistic level of monitoring. Individuals and institutions must know that they can and will suffer meaningful penalties if they violate them (legislation in many Western countries now provides for imprisonment for serious environmental offences).

Monitoring and enforcement agencies should be independent. The Western experience suggests that in-house reviews are not a sufficient environmental check. In-house environmental impact assessments of proposed projects often become little more than another paper hurdle.