13 Terrain Considerations

Ground Surface Preparation

Terrain disturbance is an inevitable consequence of a construction project such as the proposed pipeline, but this disturbance need not be environmentally unacceptable if adequate mitigative measures are followed. In this and the following sections, I discuss clearing and grading techniques that will reduce environmental damage. Attention is concentrated on the pipeline right-of-way and on access roads to borrow pits, quarries and the sites of facilities associated with the pipeline.

The borrow pits, quarries and the sites of pipeline facilities are themselves not of great concern in this context. By their very nature, these locations will be reshaped and they will, therefore, require major rehabilitation measures that will go well beyond the ameliorative measures required by areas that have been cleared and graded. The pits and quarries will not normally be opened in materials that are erosion- or thaw-sensitive. The sites of facilities can be relocated to some extent to minimize terrain damage, and, in addition, the surface of these sites will be protected by pads of granular fill.

The pipeline right-of-way and the access roads to it are different: they are continuous and they must have smooth, hard, working surfaces throughout their length to permit the transportation of supplies and the operation of specialized mechanical equipment. They will cross areas of sensitive ground and areas with vegetation that are important either as wildlife habitat or as commercial timber. Sometimes such areas can be avoided by changing the alignment of the pipeline, but often other solutions, such as those I discuss in this section, are required.

1. *Some disturbance to terrain is inevitable, so the environmental objective during clearing and grading shall be to adapt the methods and schedules of work to minimize disturbance to the vegetation and the ground surface. Particular attention shall be given to areas in which cuts are required in the crest of slopes, in valley walls and in the banks of rivers and streams.*

The first step towards minimizing disturbance is the construction of the pipeline during winter. The many advantages of winter construction are discussed throughout this report, but the principal advantage is that the ground is frozen and snow covered and it is, therefore, able to withstand the passage of heavy traffic without severe damage to vegetation and terrain.

The usual procedure for laying pipe in winter begins with the removal of vegetation and grading to provide a suitable ground surface on which to work. This procedure is unsuitable in the North because of widespread fine-grained and ice-rich soil. There, care must be taken to preserve the lower vegetation and organic mat so that disturbance of the permafrost is kept to a minimum. In this way it is possible to avoid engineering and environmental problems associated with slumping and thermal degradation of the ground surface. Other special procedures, such as snow access roads and snow working surfaces, have been developed to avoid damaging the permafrost. These procedures are essential principles of what Arctic Gas has called arctic construction.

Although the purpose and methods of arctic construction are clear, the specific locations at which it will be used are still a cause of concern. Sensitive terrain occurs all along the proposed route, a fact borne out by the experience of constructing the Mackenzie Highway: problems related to slope stability and erosion occurred, even though special construction methods were used. Because conventional construction methods are simpler and cheaper than the special procedures mentioned above, there will be an understandable tendency for engineers to use them despite sensitive local conditions and therefore, to create environmental problems.

2. *All working areas shall be prepared by use of clearing and grading techniques that minimize disturbance to the ground and surface vegetation. Construction plans shall minimize cuts and grading of the ground surface, and the area disturbed shall be the minimum necessary for the execution of the*

project in a safe manner. Arctic construction techniques, such as snow roads and snow work surfaces over ungraded ground shall be the standard procedure for all construction spreads working North of 60. Conventional procedures that involve grading may be permitted by the Agency for selected stable areas on the basis of site-specific terrain data provided by the Company.

3. Construction of the pipeline at any time of the year other than winter and construction from a gravel-fill work pad shall not be permitted, except when specific approval has been granted by the Agency. The Company shall demonstrate to the satisfaction of the Agency the need for, and the advantages of, such a departure from arctic construction practices.

Clearing

The Forest: Resource, Habitat and Aesthetic Values

Trees must be felled if the pipeline and facilities are to be built, but the loss of wildlife habitat within the project area need not be of major concern, provided certain precautions are taken.

4. Habitat change caused by clearing operations shall be minimized by limiting the extent of clear-cut areas, by avoiding critical habitat areas wherever practicable and by managing the disposal of debris. Particular attention shall be given to protecting fish populations and their habitat from the adverse effects of siltation caused by erosion of cleared areas and by the disposal of debris adjacent to watercourses. Special considerations shall be given to reducing or modifying clearing activities within areas of particular concern to wildlife, such as raptor protection zones. (See Wildlife: Birds.)

Northern forests may be described as patchy, slow growing, and difficult to reach for lumbering. (See Renewable Resources.) Nevertheless, stands of timber of use to local communities may occur on the pipeline lands.

5. Community interests shall be served by avoiding stands of timber that are valuable for local use. If merchantable timber is felled, local communities shall be offered first refusal of it. The timber shall be suitably cut and transported by the Company to easily accessible locations as defined by the Agency in consultation with the communities.

Serious environmental damage can be caused by disturbance of the surface organic layer, particularly on slopes, where the organic layer and a network of plant roots combine very effectively to resist water erosion. In permafrost areas, this protective cover also limits the depth of the active layer (the layer that thaws during summer) and prevents the underlying permafrost from melting, thereby preserving the stability of the terrain and guarding against a variety of hazardous erosion processes.

6. Because trees are an important element in the aesthetic quality of the landscape or scenery, as well as important in controlling drainage and erosion, stands of undisturbed timber shall be preserved within cleared areas wherever practicable. For example, stands of undisturbed vegetation should be left between cleared areas and waterbodies, and trees should be preserved near buildings and roads, and at campsites, compressor station sites and other facilities.

Clearing Procedures

The clearing procedures proposed by the pipeline companies are expected to be adequate because they resemble present regulated practice in the region, but the scheduling of clearing operations and the use of machines, rather than clearing by hand, are of serious concern. For instance, if the right-of-way is cleared a year or more in advance of construction, there will be a disturbed surface exposed to at least one spring thaw and summer melt. This exposure will be especially critical on slopes where there could be subsidence, slope instability and stream siltation.

7. The period between the beginning of disturbance by clearing and the implementation of erosion control procedures shall be as short as practicable. Where the right-of-way will be cleared a year in advance of construction, temporary erosion control measures should be implemented immediately after clearing, and there should be no clearing of vegetation from river and stream banks, valley walls or erosion-sensitive slopes, except to allow the movement of men and equipment. The clearing of sensitive permafrost areas should be delayed until immediately prior to construction.

8. Only the minimum area essential for the construction of the pipeline or of a particular facility shall be cleared.

9. Trees and shrubs may be cleared either by hand or by machine, depending on the locality. Where it is necessary to maintain an undisturbed organic cover on sensitive soils clearing shall be by hand, unless otherwise approved by the Agency. Clearing by hand may be done at any season, but clearing by machine should be restricted to the winter construction season. It shall not begin until the frost has penetrated deep enough and the snow cover is sufficient to permit use of clearing equipment without adverse effects on terrain. (See Terrain Considerations: Snow Roads.) *The shut-down of machine-clearing operations in the spring shall be at the discretion of the Agency.*

10. The blades of bulldozers used in clearing shall be equipped with mushroom shoes, except in areas where grading will be allowed. In permafrost areas, bulldozers shall use high-blading techniques to minimize disturbance of the ground surface during clearing operations.

11. Machine clearing shall be discontinued if clean breaks of

trees cannot be achieved, or if the number of uprooted trees exceeds the limit deemed environmentally acceptable by the Agency.

12. To minimize drainage and erosion problems, alteration of the ground surface, such as by removal of the organic mat and by levelling of hummocks to facilitate vehicle movement, shall be delayed until construction is about to begin.

13. All cleared trees, brush and other woody material shall be cut so that the stumps are no higher than six inches, measured from the ground on the uphill side. All trees, snags, brush and other woody material resulting from clearing operations should be disposed of by burning, with the exception of survey lines and winter trails, where lopping and scattering will be sufficient. The use of chippers may be authorized by the Agency. The disposal of cleared woody material shall be concurrent with clearing, except where burning would be hazardous, such as in summer, in which case disposal shall be as specified by the Agency.

14. Debris from clearing operations shall be burned on racks or sleds designed for the purpose, on rock surfaces, or in any other area where there is no danger of subsidence because of thawing of permafrost. To minimize the impact on the aquatic environment, burning sites shall be at least 300 feet away from rivers, streams or lakes, except where burning sleds or racks are used.

Snow Roads

Except for preconstruction activity and for the construction of major water crossings and compressor stations, the pipeline companies propose to build the pipeline in winter so that they can move heavy equipment along the right-of-way when the ground is frozen, thereby making all-weather roads unnecessary. All-weather roads are expensive to build and maintain. Moreover, their environmental and social impacts may be greater than those of the pipeline itself because of the increased access into remote areas, permanent effects on land and waters, and the use of gravel, which is a scarce resource in many parts of the North.

To protect the vegetation and the permafrost from heavy traffic, both pipeline companies propose to use snow roads and snow work surfaces. Snow pavements for the pipeline will have to be built to a higher standard than the conventional winter roads that are used in the North. They will be made of snow densely compacted over the naturally frozen, but undisturbed, ground surface. Adjacent to the snow road on the right-of-way there will be a snow work surface along the ditch line; it will be similar to the snow road, but its pavement will not need to be so densely packed because it will have to sustain only a few passes by slow-moving equipment, such as a ditcher.

I described in some detail in Volume One my fundamental concerns about the use of snow roads and snow work pads, but I have no doubt that, once in place, these snow surfaces will work and that they will limit terrain damage and environmental disturbance in permafrost regions. If a pipeline is built in the Mackenzie Valley, the use of snow roads and snow work surfaces in place of conventional, temporary, graded winter roads will be essential. Their use will help to overcome the problems caused by the complex distribution of permafrost in the southern part of the Mackenzie Valley.

15. Snow roads shall be adopted for all construction related to the proposed pipeline North of 60, except where a different mode (for example, a graded winter road) is specifically approved by the Agency.

In theory, the winter construction scheme seems to be an ideal solution to terrain degradation problems. In practice, however, the performance required to minimize terrain degradation from the construction and use of snow roads and snow work surfaces will be difficult to achieve. There are two assumptions underlying the winter construction concept. The first is that the pipeline trench can be backfilled and the right-of-way restored with frozen material in winter, thus preventing thermal degradation and controlling erosion. The second is that the operation and maintenance of the pipeline system can be carried out without permanent road access to the compressor stations and other facilities. These assumptions have yet to be substantiated. (*See* Location, Construction Plan and Scheduling.)

Scheduling and Sufficiency of Snow

There are two problems related to the construction and operation of snow roads that are different from those related to the possible effects they may have on the terrain, once they are built.

The first is scheduling: can the snow roads be ready early enough and can they be used long enough to enable the season's construction program to be completed on schedule? There is a definite and limited period of time for winter construction, determined on each side by the start of freezing in the fall and thawing temperatures in the spring. If the pipeline company tries to follow a fixed schedule in preparing snow roads, there may be considerable damage to terrain and consequent disruption of construction plans. Schedules must take into account regional and annual variations in climate, snowfall and frost penetration.

Before snow roads can be prepared in the fall, the ground must be frozen deep enough to support heavy vehicles and there must be sufficient snow to protect the surface vegetation. Frost penetration varies from place to place and from year to year. Streams, drainage channels and wet areas will delay road preparation because they freeze more slowly than the drier, intervening areas. If it is impossible to wait until the frost has gone deep enough in wet areas to support the

movement of vehicles, temporary crossings will have to be built.

Construction activity in the spring will also be of great environmental concern. There will be compelling reasons to try to extend the use of snow roads as long as possible, particularly if the project is running behind schedule. But the shut-down date of a snow road will depend on the onset of spring weather, which varies from year to year. Construction activity must be able to stop at short notice without harm to the environment.

16. *The Company shall demonstrate to the satisfaction of the Agency, that its construction schedules based on snow roads and snow work surfaces take into account regional and annual variations in the frost penetration and in the temperatures that are essential for snow road construction and maintenance. The Company shall also tailor its construction plans so that, in the spring, pipeline construction can stop at short notice, before the environment is damaged by the use of deteriorating snow roads.*

The second concern is the quantity of snow: in the northernmost parts of the region, particularly in the Mackenzie Delta, early winter snowfalls may not give enough snow to build the road and the work surfaces required by the construction schedule. Snow fences, snow harvesting from lakes, and snow manufacture have all been proposed to supplement the available natural snowfall, but these measures have had only limited testing on a small-scale.

17. *For each construction spread year, the Company shall demonstrate to the satisfaction of the Agency the technical feasibility and environmental acceptability of accumulating, harvesting and manufacturing snow, assuming fall weather conditions as defined by the Agency. Some aspects to be considered are the location, method of placement and orientation of snow fences, the anticipated rate of snow accumulation, the uses of the accumulated snow, and the method and time of removal of snow fences; snow harvesting techniques on land and waterbodies, including details of location and of times and means of access to harvest locations; snow manufacturing techniques, including details of quantities of water, locations of water sources, and the times and means of access to those sources; and the impact of snow fencing, harvesting and manufacturing operations on terrain and waterbodies and on wildlife and fish and their habitats.*

Overall Plan

To coordinate planning and consultation by both the Company and the Agency, Commission Counsel has suggested that overall plans should be prepared for various aspects of the pipeline work. (See Project Regulation and Review.) Such a plan for the construction and use of snow roads and snow work surfaces would provide an excellent means of tying together some of the logistical, scheduling and technical problems that were raised during the hearings and, at the same time, it would provide essential background for the recommendations I have made above.

18. *Before the final design phase, the Company shall prepare for approval by the Agency an overall plan for all snow roads, snow work surfaces and winter trails that are expected to be used during the construction, operation and abandonment of the proposed pipeline. Subject to the direction of the Agency, the overall plan shall be in cartographic form, and it shall be compatible with the other overall plans requested elsewhere in this report. The Agency may request the Company to resubmit parts of the overall plan that do not meet with its approval. The Company shall undertake to keep the overall plan up to date so that it reflects the latest policies and actions of the Company, the Agency and government.*

19. *In addition to the requirements of recommendations listed under Scheduling and Sufficiency of Snow above, the overall plan shall specify such items as the general timing and extent of pipeline activities; the location of all snow roads, snow work surfaces and winter trails, and where they cross streams and rivers; the design standards to be applied, including those for stream and river crossings, snow pavement properties, and maximum grades; and the water withdrawal requirements for snow road construction.* (See Water Withdrawals.)

20. *The overall plan shall be approved by the Agency before site-specific applications are submitted for construction activities.*

Site-specific Information

21. *The Company shall file with the agency separate site-specific information for the use of snow roads and snow work surfaces for each winter by construction spread, or as specified by the Agency. This information should include such items as the exact location of snow roads, potential water sources, and snow harvesting locations; the methods and equipment to be used for right-of-way preparation (including enhancement of frost penetration), snow harvesting and hauling, snow compaction and ice capping; the date when snow road construction can be expected to begin, the date when it will be required for use, and the flexibility of this date. The information should also detail the nature, number and location of wet areas (including, but not limited to, rivers and streams) that will require special measures during the construction, maintenance or abandonment of a snow road, the methods to be used to cross these areas, and the required crossing dates for each area; the methods and equipment to be used for the construction of ice bridges and the approaches to them; and the methods and equipment to be used to maintain snow roads. The information should include the anticipated date when use of each snow road will be terminated at the end of the winter construction season, and should detail the procedures for terminating their use, for abandoning them and for rehabilitating the areas over which they have passed;*

in particular, the procedures for ensuring that snow roads that cross rivers and streams do not interfere with normal break-up and that overland drainage is not blocked or concentrated shall be specified.

Where it is necessary to augment natural snowfall, the site-specific information shall specify the access routes to all water sources and snow harvesting areas; the equipment to be used, and how it will be placed and used so that it does not cause unacceptable terrain damage. Where snow harvesting is planned, the location, dates and methods of harvesting, and the measures to be taken to protect wildlife and fish and to rehabilitate any area so used, especially damaged lake margins, shall be given. Fences to collect snow shall be placed so they do not interfere with wildlife movements and shall be removed by the end of each construction season, unless otherwise approved by the Agency.

Snow Road Guidelines

I have heard a great deal of evidence about snow roads, and I think that it is important to summarize here some of the pertinent guidelines. I do so, of course, in the belief that continued research by the Company and by the Agency will lead to further refinement.

22. *Snow road preparation shall not begin until frost has penetrated at least eight inches into the ground and four inches of snow has accumulated on it. However, the Agency may approve plans to accelerate frost penetration and to manufacture or haul snow in advance of its planned use. All types of equipment for the preparation of snow roads and the uses to which they are put shall be approved by the Agency.*

23. *Snow roads will be maintained to prevent contact between the wheels or tracks of vehicles and the ground surface. Generally, snow roads must have a compacted thickness of 10 inches of snow and a density of at least 0.5 gms per cubic centimeter before traffic other than low ground pressure vehicles will be allowed. In areas of hummocky terrain, the depth of compacted snow will be measured from the crests of the hummocks.*

24. *Frozen stream crossings shall be made of snow or ice or both. No earth, timber or brush shall form any part of such crossings.*

25. *An Agency-approved technique or structure for a temporary crossing shall be required for the crossing of any unfrozen stream, both during the preparation of snow roads and during the construction of the pipeline.*

26. *Access to waterbodies for the purpose of snow harvesting or water removal shall not damage their margins or banks unduly. Cuts should not be allowed, and all fills should be made of snow or ice or both. Terrain damage shall be repaired as soon as practicable.* (See Water Withdrawals.)

27. *When the snow road pavement begins to deteriorate, the Company shall be ready to terminate its winter construction activities on a week's notice and shall be prepared to cease using the road on 48 hours' notice.*

28. *Unless otherwise approved by the Agency, the Company shall remove all material and equipment from the work areas that are serviced by snow roads before the roads deteriorate. If such removal is not practicable, the Company shall store such material and equipment at a location approved by the Agency. Stored material and equipment shall not be moved from such a location without the Agency's approval.*

29. *All snow roads and temporary winter crossings of streams and rivers shall be removed to the satisfaction of the Agency before spring break-up.*

30. *In areas where the concentration or diversion of overland flow in spring could result in erosion, snow roads shall be cross-ditched before spring break-up.*

31. *Terrain damaged during the construction, operation and abandonment of snow roads shall be repaired as soon as practicable.*

Drainage and Erosion

Measures to control drainage and erosion are especially important in the construction of a pipeline because, to a large extent, they will ensure the pipeline's uninterrupted service. Such measures, therefore, normally receive careful consideration in the design and maintenance phases of the pipeline. Obviously the construction of a chilled gas pipeline in the North poses special problems because of special geotechnical considerations, such as permafrost and the growth of a frost bulb around the pipe. I think there is ample evidence to show that engineers understand how to protect the pipe: my main concern is not with the safety of the pipeline itself, but with the protection of the environment from adverse effects that may be caused by drainage and erosion.

One of the most important means of mitigating the adverse environmental effects of pipeline construction and operation will be the effective implementation of measures to control drainage and erosion. Terrain damage, obstruction and alteration of watercourses, and siltation must be viewed, not just from the point of view of the pipeline's integrity, but also from the broad perspective of their effects on the physical and living environment. A wash-out on a cut river bank, for example, may not threaten the pipe itself, but it could lead to siltation and thereby threaten important fish-spawning or overwintering habitat.

32. *During design, construction, operation and abandonment of the pipeline, measures to control drainage and erosion shall take into account protection of the physical and living environment as well as traditional considerations of design and cost that are associated with the pipeline's safety.*

I recognize that the selection and design of measures to control drainage and erosion are complex matters that involve a wide variety of site-specific, physiographic factors. These decisions must, by necessity, be left until late in the design and construction process. Nevertheless, there must be a clear methodology and a timetable for implementing them.

33. *The Company and the Agency shall agree on the schedule, the level of detail, and the scale of presentation, review and approval of submissions regarding measures to control drainage and erosion before the final design phase.*

I have heard a great deal of evidence on the environmental aspects of drainage and the control of erosion. I summarize this evidence and present my recommendations below under the headings: Surface Drainage and Erosion, and Subsurface Drainage. The next section, Revegetation, deals with a particular mechanism for rehabilitation.

Surface Drainage and Erosion

From our everyday observations, most of us can understand the problems associated with surface drainage and erosion. The ponding of water, the flooding of land because of interference with natural drainage courses, the gullying effect of rainwater on cleared slopes, and the siltation of waterbodies by increased erosion are not uncommon events. On a limited scale, these effects do not cause alarm, but the pipeline and its numerous ancillary facilities will have the potential to disrupt surface drainage on a scale that could lead to unacceptable environmental damage to both land and water.

My concern about surface drainage focuses on three interrelated issues: the approach to the design of the pipeline, the methods of its construction, and the nature of the control methods. I shall deal with each of these issues in turn.

DESIGN APPROACH

The volume of surface run-off dictates to a great extent the measures to control drainage and erosion that must be employed. But the prediction of run-off in the North is not an easy task because of the lack of long-term meteorological data and because of permafrost, which alters the standard coefficients of run-off used by engineers in the South. To surmount these problems, both pipeline companies have devised their own methods to arrive at a general approach and an estimate of the cost of controlling drainage and erosion.

One of the main disputed issues is the selection of criteria to determine surface run-off. My discussion of this topic in the chapter on River and Stream Crossings and the principles I advance there for the selection of the project-flood apply to this problem. This theoretical dispute must be resolved to the satisfaction of the experts involved, but it is apparent that, as with the construction of conventional pipelines elsewhere, the criteria are based almost completely on capital cost and the maintenance cost associated with the pipeline's integrity. I am not satisfied that environmental concerns have been adequately integrated.

34. *The selection of design criteria and the theoretical approach to the design of works to control drainage and erosion shall be on the basis of principles agreed to by the Company and the Agency before final design. In developing such principles, the usual economic considerations that are associated with pipeline integrity shall be augmented to include considerations that are associated with the preservation of the physical and living environment, with emphasis on the elements of the environment that are critical for populations of mammals, birds and fish or are otherwise important from a local land use perspective.*

CONSTRUCTION CONSIDERATIONS

Different approaches to the control of drainage and erosion and to the maintenance of surface stability will be required along various sections of the right-of-way, depending on the sensitivity of the terrain and on the degree of ground disturbance. Areas in which arctic construction techniques are used will probably present less serious problems than areas in which conventional winter construction techniques are used because, in the former case, a smaller area of ground will be disturbed – only the ditch line – whereas most of the right-of-way will be disturbed in the latter. However, the consequences of erosion and the difficulty of stopping it, once started, may be much greater in areas of arctic construction techniques because of the sensitive nature of the terrain there.

35. *Design and construction plans shall reflect the potential dangers of erosion and the necessity to select sites with minimum slopes. The plans shall show the measures to be taken to minimize disturbance to the ground surface during clearing and construction, particularly in sensitive areas with permafrost and fine-grained soils.*

36. *Measures to control drainage and erosion shall be implemented as construction proceeds from the first clearing and site preparation through to project completion. In particular, enough stilling ponds, settling basins, sediment traps and other devices shall be installed to ensure that sediment created by construction activities does not adversely affect aquatic habitat.*

37. *Separate proposals for the control of drainage and erosion along the pipeline right-of-way shall be prepared for areas in which different construction modes are proposed to be used. Proposals shall be prepared for areas of arctic construction, in which the pipeline will be built from a snow road along the right-of-way; areas of conventional winter construction, in which the pipeline will be built from a graded winter road; and areas of summer or fall construction, in which the pipeline will be built from a gravel work pad.*

38. *Particular attention shall be paid to the maintenance of works to control drainage and erosion at all sites that are used during the construction of the pipeline but that are then closed*

down and not used during the operation or maintenance of the pipeline. Such sites include, but are not limited to, borrow sites, spoil disposal sites, wharves, stockpile sites, and work pads used during the construction of major river crossings.

SURFACE INSTALLATIONS

The objective in controlling drainage and erosion at all surface installations along the pipeline is to maintain, as far as is practicable, existing natural drainage patterns. Many methods to control drainage and erosion are derived from conventional engineering practice in the construction of highways and piplines, and they can be expected to work along a Mackenzie Valley pipeline if they are conscientiously applied. Extensive research has been devoted to revegetation as a primary method of controlling erosion, and I deal with this aspect in the following section. However, other methods will also be required to maintain drainage and to prevent erosion especially during and after construction of the pipeline and before revegetation is effective.

39. *To avoid the adverse environmental effects of ponding water and of mechanical or thermal erosion that may be caused by channelized overland flow, natural drainage patterns shall be maintained, so far as practicable, in all aspects of the proposed construction.*

40. *Structures to control drainage and erosion shall be designed not only to complement the stabilizing effect of revegetation, but also to achieve the required control unaided by new vegetation. These structures shall be kept in good repair until their function has been completely taken over by vegetation.*

Recent experience during construction of the Mackenzie Highway northwest of Fort Simpson and around Inuvik has provided examples of methods to control surface drainage and erosion in northern conditions that are applicable to the pipeline and its ancillary facilities. Concern for the environment led to the use of fill over sensitive soils, the avoidance of ditch excavation for road drainage, the use of ditch blocks to prevent water from flowing parallel to the road berm, and the use of non-erosive blankets and of ditch checks to prevent erosion. In addition, the use of vehicles away from prepared gravel surfaces was strictly controlled and kept to a minimum to avoid the disruption of drainage on sensitive soils and permafrost.

These and similar methods must be used during construction of the pipeline. Probably the best way to handle surface run-off caused by the spring melt or by summer storms is to guide the water across the right-of-way by low diversion dykes that have breaks in the backfill mound over the ditch. In addition, the sides of the diversion dykes, the backfill mound, and the floors of the mound breaks will have to be specially treated to inhibit the erosive action of running water. This treatment will be supplemented with baffles and diverters to break up and disperse any concentrated flow of water before it drains onto undisturbed land off the right-of-way.

Gravel pads for such facilities as compressor stations, stockpile sites and airfields must be given special consideration. The areal extent of these installations will cause some disruption of surface drainage and may lead to ponding, thermokarst failures and erosion, each of which would have its effects on the local environment. Drainage from such pads may contain considerable quantities of fine sediment, and it must be prevented from reaching any waterbodies. If there is any risk that this drainage contains toxic chemicals, such as fuel or other petroleum products, the problems will be greatly aggravated. Permanent gravel roads present similar problems.

Pipelines and facilities in the northern part of the Mackenzie Delta will be subject to flooding either by storm surges or by ice jams during spring break-up. This danger, of course, will be of particular concern in the design of gas plants and feeder lines, and in any proposal, such as that put forward by Foothills, that requires an extensive gravel work pad for construction purposes. Because all above-ground structures in the Delta area, including structures to control drainage and erosion, will have to withstand the damaging effects of waves and ice jams, there will have to be extensive use there of gravel and riprap. This demand in itself could have a considerable impact through increased use of borrow pits, of blasting and of the necessity for long roads to acceptable borrow sites.

41. *Surface drainage shall be provided across the backfill mound of the ditch, the surcharge berm and the gravel work pad along the right-of-way and elsewhere for roads, airstrips and similar structures according to criteria approved by the Agency.*

42. *Permanent project roads and temporary roads that are to be in place during the summer shall incorporate the best design standards for the control of drainage and erosion practised in northern highway construction. In particular, enough through-grade culverts or bridges shall be installed to allow overland drainage and fish to move freely.* (See Fish.) *Each culvert should be equipped with a ditch block or diversion structure to minimize the flow of water along the road berms, and ditches shall incorporate measures to prevent erosion.*

43. *Plans shall be presented for the design and installation of measures to control erosion at all stream crossings designated by the Agency. In particular, plans will be required for all crossings of major rivers during summer construction.*

44. *Enough stilling ponds, settling basins, sediment traps or other devices shall be installed to ensure that sediments, particularly silt particles, in water flowing from the right-of-way or from facilities do not adversely effect the surrounding terrain or waterbodies. Particular attention shall be paid to the*

prevention of erosion on the banks of rivers and streams, valley slopes, cut-slopes, and in cuts along the right-of-way.

45. *All drainage water that contains petroleum products or other chemicals shall be trapped, contained and disposed of according to the provisions outlined in the chapter entitled Management of Fuels and Hazardous Substances.*

46. *The structures to control drainage and erosion shall be carefully maintained and observed each year as part of the procedure for patrolling the operating pipeline. The Company shall be responsible for constructing and maintaining devices to control drainage and prevent erosion on all lands that have been disturbed during the construction of the pipeline, including not only lands under lease by the Company, but also lands not under lease, such as borrow sites or stockpiles. In some instances, the Company's responsibility may extend to land adjacent to the land under its care, even though this land was not directly disturbed during the construction or operation of the pipeline.*

47. *Drainage and erosion control devices shall be designed and constructed in a manner that will facilitate travel along the right-of-way. These devices must not be rendered ineffective by the passage of operation and maintenance vehicles.*

48. *All drainage ways and control structures shall be designed and maintained in a manner that will accommodate any changes in ground level that might be caused by frost heave, growth of the frost bulb, thawing of the ground or surface subsidence along the right-of-way. Allowance shall also be made for disruption of drainage patterns by the growth of stream icings and surface icings along the right-of-way.*

Subsurface Drainage

The problems associated with subsurface drainage for a refrigerated gas pipeline remain controversial, and because a technical solution is lacking, they give rise to a number of environmental concerns.

The frozen ground around a buried refrigerated gas pipeline will create an underground barrier along the length of each section of refrigerated pipe that passes through previously unfrozen ground. This barrier will block the movement of shallow subsurface water across the pipeline's route. Ponds or surface icings might be created, or water might begin to move along or parallel to the pipe. Such movement of groundwater on sloping terrain could lead to erosion or to slope instability and, at certain places, it could create problems related to pipe buoyancy. In addition, many rivers and streams have flow within their granular beds. When the pipeline passes beneath such watercourses, the frost bulb created by the chilled pipe could block or divert flow in the streambed. Where streams freeze to the bottom, this streambed flow of water may be vital to the survival of fish that overwinter in the stream's deeper pools.

49. *Before the final design phase, the Company shall demonstrate to the satisfaction of the Agency that the frost bulb created by a buried refrigerated pipeline will not create adverse effects on drainage or on terrain, waterbodies or aquatic habitat. Documentation shall include theory, site-specific appraisals and tests, construction techniques, and plans and procedures for operation, maintenance and monitoring. Particular attention shall be given to the maintenance of subsurface flows that may be essential to aquatic resources in winter.*

Revegetation

Vegetative cover, with its underlying organic mat and network of roots, plays a vital role in terrain stability and hence in the control of drainage and erosion. In permafrost areas where soils are fine-textured and ice-rich, disturbance of the vegetative cover can cause thawing and lead to problems of instability, such as subsidence and slumping. In both permafrost and non-permafrost areas, the plant cover prevents wind erosion and various kinds of water erosion. Therefore, the maintenance of plant cover is a key to the mitigation of terrain damage and related impacts such as silted watercourses.

Erosion of disturbed surfaces can be prevented by revegetation, but only in conjunction with the non-biological measures to stabilize the surface that I have described in the preceding section. Permafrost degradation cannot be prevented in the short term by newly established vegetation. Other means must be used.

50. *Revegetation shall be planned and implemented as a complement to non-biological measures to control drainage and erosion.*

The objective of a revegetation program is to control erosion by promoting the re-establishment of plant communities natural to the area. There are, however, fundamental differences between the proposals of the two pipeline companies. Arctic Gas propose to depend primarily on agronomic varieties of grasses to provide the initial ground cover, and on shrub cuttings to revegetate slopes. Native species have only a limited and secondary role in this plan. Foothills, on the other hand, propose to use only native species in their revegetation programs, and to rely to a greater extent than Arctic Gas on vegetative methods of erosion control, including cuttings. In neither case is the effectiveness of large-scale revegetation programs on the right-of-way and at abandoned borrow areas, stockpile sites and other disturbed areas fully proved.

51. *The Company shall revegetate all lands disturbed by the construction, operation, and maintenance of the pipeline, first, to control erosion and its environmental impacts, and*

secondly, to re-establish native plant communities and to restore aesthetic values.

52. *Before the final design phase, the Company shall submit for Agency approval a general plan for implementing the revegetation program on all lands disturbed by the project. Evidence on the effectiveness of the revegetation program to control erosion, together with criteria and a schedule for evaluating the effectiveness of the revegetation program, shall be included in the plan. The use of native grasses, shrubs and naturalized varieties of introduced grasses is encouraged. The plan shall specify the various types and conditions of terrain to be revegetated and shall incorporate the vegetative methods and schedules, the types and mix of seeds, the types and quantities of fertilizers, and the types of equipment to be used. The revegetation plan shall also describe how the procedures, seed mixes and fertilizers will be adjusted to accommodate changes in topography, soil and drainage. Information shall also be provided on the source of supply of the plant material required for revegetation, on manpower and aircraft requirements for these plantings, and on support camp locations, timing, and potential conflicts with wildlife populations.*

Revegetation plans shall include measures to be implemented following forest fires on lands under permit to the Company. (See Terrain Considerations: Forest Fire Prevention and Suppression.)

53. *The Company shall ensure that revegetation, together with the necessary clean-up, regrading, and preparation of drainage and erosion control structures, is completed promptly after the termination of pipeline construction activity or other use of land.*

The speedy establishment of a continuous cover of new vegetation along the right-of-way and in other disturbed areas is the best long-term protection against the adverse effects of erosion and sedimentation. However, it may be some years before the vegetation cover is sufficiently thick and continuous to provide this protection. The success of a revegetation program depends on a stable soil surface. Although there have been some small-scale tests, neither of the pipeline companies has demonstrated that a stable surface for revegetation can be achieved everywhere, especially on slopes or in cuts through ice-rich soils. It appears that a large-scale test of any proposed revegetation procedure should be carried out on slopes in an area that has a high potential for erosion.

54. *Before the final design phase, the Company shall demonstrate to the Agency, by means of approved field tests in the project area, the suitability of its proposed revegetation procedures for the control of erosion on slopes and in cuts through ice-rich permafrost soils.*

Because the initial revegetation program will not at once establish a complete vegetation cover, follow-up programs will be required. These programs will take place primarily in the summer, and they may possibly disturb wildlife populations. In any adjustments to the revegetation program because of such conflicts, or for any other reason, priorities should be established to protect the areas that are most susceptible to erosion.

55. *In all revegetation programs, priority shall be given to the areas that are most susceptible to erosion. Where there may be conflicts between revegetation activities and the disturbance of wildlife, the Company shall prepare for Agency approval special techniques to minimize such disturbance.*

56. *As an integral part of its revegetation program, the Company shall monitor the success of the initial revegetation program and shall repeat the measures required for revegetation until they are successful.*

57. *The Company shall monitor, as part of its construction, operation and maintenance program, the success of its revegetation program. To limit the long-term persistence of non-native species along the right-of-way and to encourage the re-establishment of native plant species, supplementary seedings will be limited to those that are required to control erosion; they will not be allowed solely for aesthetic reasons.*

Forest Fire Prevention and Suppression

In the Mackenzie Valley where forest fires are common, a cross-country construction project such as the pipeline will inevitably become involved with forest fires and their control. My concerns focus on environmental impacts during and after a fire, especially with respect to thermal disturbance of permafrost areas, to slope stability and drainage, and to the destruction of critical wildlife habitat; and on the people, especially with respect to indirect impact of fires on renewable resource harvesting.

There are two main issues – fire prevention and fire suppression – and a corollary issue – the restoration of areas after a fire. Let me deal with each in turn.

Fire prevention during the construction and operation of a pipeline is, in general, the application of technical procedures and the control of employees in a manner that is good practice anywhere. Most of these procedures are routine and do not warrant extensive discussion here. However, the scale of the pipeline project and the nature of its activities, which will be scattered along a corridor through remote and uninhabited areas, parts of which comprise critical wildlife habitat, will add to the normal problems of controlling activities and of educating workers in the use of preventive measures. There is also the very real possibility that some summer construction or maintenance activities will have to be curtailed or delayed when the risk of fire is high. The greatly increased risk of fire

during summer must be recognized in all construction planning.

Fire suppression must consider the possibility that forest fires may be caused by project activities, either through carelessness or accidents, such as a ruptured line, or by natural or other causes not related to the pipeline. Obviously fires, whatever their cause, must be suppressed if the pipeline and its facilities are threatened, yet the matter seems to have received less than adequate attention by the pipeline companies. I am concerned by the lack of agreed procedures for the suppression and control of fires, because hasty and improvised measures, such as bulldozing fire-guards (a common approach in the South), can cause extensive environmental damage in permafrost areas.

The restoration of burnt areas, particularly those underlaid by ice-rich permafrost, also concerns me. Fire can reduce the insulating effect of the surface cover and lead to terrain instability; increased erosion could lead to problems of siltation in adjacent waterbodies; and, of course, the pipeline itself could be threatened, in which case extraordinary corrective measures might be, without careful planning, the cause of serious consequences to the environment.

The proposals made by the pipeline companies for fire prevention and suppression do not deal adequately with these issues. The consequences of forest fires go well beyond the project to involve government, local people and local industries. Clearly, there is a need here for a comprehensive and coordinated plan to deal with such fires. The following recommendations, developed from the evidence before me, should serve as the basis for such planning, at least in the area affected by the pipeline.

58. *Before the commencement of any construction activity related to the pipeline, the Company shall submit for approval by the Agency a plan for the prevention, detection and suppression of forest fires that are related to or that may affect the construction and operation of the pipeline. This plan should be developed in collaboration with the Northwest Lands and Forests Service and, where applicable, with the Yukon Forest Service. Because wildlife is of greater value as a resource than timber in the North, the primary environmental object of the plan should be the protection of wildlife habitat, not timber-harvesting interests.*

The plan shall detail fire prevention measures, such as employee education and training; operation and maintenance of equipment; conduct of all pipeline activities associated with burning to minimize fire hazards, with special attention given to preventive measures in summer and winter; and restriction of personnel and curtailment of activities during periods of high risk.

The plan shall detail fire suppression measures, such as fire detection and reporting procedures that take into account existing practices in the North; placement of the necessary equipment and the availability of properly trained teams for fighting fires at construction sites, camps, stockpile areas and all lands adjacent to the pipeline right-of-way; and availability of on-site personnel of both the Company and its contractors to fight fires, if required.

59. *The Company shall keep the fire prevention and suppression plan up to date to reflect conditions along the right-of-way, changes in government operations and procedures, and the success or failure of fire prevention and suppression methods that have been applied on the project or elsewhere.*

60. *In conjunction with the fire prevention and suppression plan, the Company shall prepare measures designed to protect particularly sensitive components of lands under permit to the Company from degradation following a fire.* (*See* Terrain Considerations: Revegetation.)

Blasting

Blasting is fundamental to construction of any pipeline, and the Mackenzie Valley pipeline will be no exception. Blasting will be extensive and will occur in all seasons for a variety of activities that include quarrying, construction of facilities and river crossings, preparation of the right-of-way and excavation of parts of the pipeline trench. The variability of terrain conditions and the need to make decisions in the field combine to make certain that blasting will occur at unanticipated places at unforeseen times. All blasting has the potential for causing unacceptable disturbance to terrain, wildlife and fish.

Existing standards, which mainly relate to aspects of engineering and human safety, already exist for blasting, and they will certainly apply to the extensive construction operations that have been described to the Inquiry. However, if we are to protect the northern wildlife and fish, then environmental standards are needed for blasting, too. The definition of most of these standards will follow naturally from the sensitivities that I have described in the chapters on Wildlife and Fish and the use of these resources by native people. I have offered specific recommendations for fish, many of which apply equally to aquatic mammals, such as muskrats, beavers and whales. In this section, I expand the subject to include wildlife and to human use of wildlife resources.

My primary concern is that blasting will disturb wildlife – particularly raptors, waterfowl and whales – during the sensitive periods of their life cycles when they are concentrated in certain areas, and that it will disturb aquatic furbearers. Destruction of habitat is also involved.

61. *The adverse effects of blasting on wildlife shall be kept to a minimum, either by scheduling blasting when vulnerable species are not in the area or by controlling the frequency and level of the blast.*

62. *The Company shall confine all of its blasting operations to lands covered by permit from the Agency.*

Throughout the North, the native people are concerned over the effects of blasting on wildlife because of their past experience with the petroleum industry's seismic operations. At the community hearings, the Inquiry heard many complaints about the adverse effects of this blasting. The native people fear that blasting activities associated with the pipeline will further ruin the land and upset the natural conditions for their traditional pursuits.

63. *In planning any blasting activities, the Company shall take into account traditional pursuits of the native people. This consideration shall not be limited to areas in which people hunt and trap, but it shall also include consideration of harvested species during periods when the animals are concentrated or are otherwise sensitive to disturbance.*

With these broad principles in mind, I propose the following recommendations to mitigate the adverse effects of blasting on wildlife, fish, birds and the traditional use of the land by native people.

Overall Plan

64. *Before the final design stage and before any site-specific approvals are granted, the Company shall prepare for approval by the Agency an overall plan for blasting during construction of the pipeline. The form and content of the plan shall be subject to the direction of the Agency, but generally it should outline the Company's proposals to minimize adverse effects of blasting on the environment. The overall plan should indicate such items as: the approximate locations, dates, charge sizes and duration of blasting activities; general land use in the surrounding area, particularly as it may be related to wildlife and to traditional use by local people; methods and procedures that will be used to prevent damage, defacement or destruction of the landscape and waterbodies by eliminating the scatter of blasted material beyond the immediate working area; procedures to minimize shock or instantaneous peak noise levels that may be disruptive to local people, wildlife and fish; and plans to train personnel (who must be qualified to carry out blasting work under existing regulations) in the special environmental impacts that blasting may have and in the mitigative measures that are to be employed in the field. The Company shall undertake to keep the overall plan for blasting up to date and to reflect the latest policies and actions of the Company, the Agency and government.*

65. *The overall plan for blasting shall be approved by the Agency before the Company submits any site-specific construction plans that involve blasting.*

Site-specific Information

Although site-specific applications for blasting *per se* may not be required by the Agency, the Company will have to submit information on blasting as part of the other site-specific applications required elsewhere in this report.

66. *Details on blasting locations, dates, charge size, duration and environmental procedures shall be submitted to the Agency as part of the site-specific construction plans.*

Blasting and Traditional Activities

Land use by northern native people is extensive, and it should not be unduly interrupted, altered or prevented by blasting activities. It is the Company's responsibility to develop a blasting schedule and a program of local communications to ameliorate this problem to the satisfaction of the Agency.

67. *The Company shall notify local people at least one month in advance of any blasting operations planned for areas that are used by the people. Where unforeseen circumstances make such notice impossible, the Company shall notify local people as soon as possible and, in any event, at least 48 hours in advance of actual blasting.*

68. *If a blasting operation in any way puts at risk a camp, trap line or any other aspect of the local people's land-based activity, the Agency shall prohibit it or shall prevent it from taking place until adequate compensation is made.*

Blasting and Wildlife and Fish

69. *Blasting operations shall not be permitted within 1,000 feet of rivers, lakes or streams that are frequented by fish or aquatic mammals without site-specific approval from the Agency. Therefore, the Company must apply to the Agency for permission to blast any site that is within 1,000 feet of a waterbody and demonstrate either that fish and aquatic mammals are not present, or that the proposed blasting activity will not have significantly adverse effects on the fish and mammal populations, fish-spawning beds and overwintering areas, bank stability, silt load, and other components on the specific waterbody.*

70. *The Company shall limit and otherwise appropriately control its blasting activities at times and in areas that are important for wildlife. Unless otherwise approved by the Agency, the following recommendations shall apply to protect particular wildlife species.*

Blasting activity within raptor protection zones shall be prohibited during sensitive periods and at other times, if blasting would damage the nest site. (See Wildlife: Birds.)

Blasting activity in areas used by concentrations of nesting, moulting or staging waterfowl shall be prohibited or severely constrained to limit disturbance so that the birds' normal activities are not interrupted in any way. As a general

guideline, blasting within five miles of waterfowl concentration areas shall be considered to be potentially disturbing. (See Wildlife: Birds.)

Blasting activity shall not occur within one mile of marine or estuarine waters when they are being used by schools of migrating, calving or nursing white whales. (See Wildlife: Mammals.)

Blasting activity shall be prohibited in any location where it might disturb or alarm migrating, calving or nursing caribou or Dall's sheep or any herd or band of either animal. As a general guideline, any blasting within five miles of concentrations of these species shall be considered to be potentially disturbing. (See Wildlife: Mammals.)

Blasting activity in habitat populated by aquatic furbearers shall be conducted in a manner that assures the continued well-being of the local populations of furbearing species and the continued harvest of these populations by native people. (See Wildlife: Mammals.)

Borrow Operations

In the North, borrow pits are generally of two kinds: pits in upland areas and pits in river channels. Both kinds were discussed extensively at the Inquiry. In his final submission, Commission Counsel dealt at great length with borrow operations in river channels, largely because Arctic Gas proposed to mine gravel from rivers in the Northern Yukon. Borrow pits in river channels are not a cause of concern in the Mackenzie Valley: their use was prohibited in the guidelines prepared by Dryden and Stein (1975) for construction and operation of the Mackenzie Highway, and those guidelines have become generally accepted practice. The discussion that follows focuses, therefore, on upland pits.

In general, there should not be any serious shortages of borrow materials, but because they are unevenly distributed over the landscape, in terms of quantity and quality, there could be local shortages. And such local shortages could be exacerbated by competing demands from community development, for construction of the Mackenzie and Dempster highways, and from such things as petroleum exploration and development in the Mackenzie Delta and Mackenzie Valley.

The development and operation of borrow pits and quarries must, by their very nature, disturb terrain and they may also have secondary, but severe, impacts on waterbodies, aquatic organisms, mammals and birds. An enormous amount of borrow material from a large number of pits will be needed if the pipeline is to be built: this cannot be avoided. It will not be possible, therefore, to eliminate all impacts on the land and the environment. But if the pits are properly developed and operated, these impacts can be controlled and kept to an acceptable level.

71. *The Company shall select, develop, operate, close and restore all pits and quarries in a way that minimizes disturbance to land and the environment and that minimizes the amount of land used and the amount of materials extracted.*

Impacts of borrow operations depend on the local terrain and biota and on the proximity of the pit to communities or other developments. Terms and conditions for borrow operations should, therefore, be designed to meet particular concerns about individual pits and their operation. Unfortunately, site-specific recommendations of this kind cannot be made now because neither pipeline company has made a final decision on which pits to use and on how they should be developed and operated. As a result, my recommendations take the form of advice for those persons who will be responsible for developing and reviewing site-specific plans.

Overall Plan

Because many decisions still have to be made with regard to borrow pits and their operation, an overall plan, similar to those I have described elsewhere in this report, will be needed. This plan will enable the Agency to review borrow pit operations in the context of overall project activities, to make proper environmental assessments and to request site-specifc ameliorative measures.

72. *Before the final design phase, the Company shall prepare for approval by the Agency an overall plan for borrow operations. Subject to the direction of the Agency, the overall plan shall, as far as possible, be in cartographic form and it shall be compatible with the other overall plans requested elsewhere in this report. The Agency may request the Company to resubmit parts of this overall plan that do not meet with its approval. The Company shall undertake to keep the overall plan up to date so that it reflects the latest policies and actions of the Company, the Agency and the government.*

73. *The overall plan shall list all the sources of borrow material proposed for use, the quantities and grades that will be taken from each source, the time of year that the sites will be worked, the general purpose, timing and point of use of the materials removed, and the plans for access, development, closure, restoration and abandonment of borrow sites. In addition the overall plan, shall include such items as the mitigative measures that will be used to control the adverse effects on the physical and living environment, and non-pipeline requirements for borrow materials in the project area.*

74. *The overall plan shall be approved by the Agency before site-specific applications are submitted for use of borrow pits.*

Site-Specific Applications

The Department of Indian Affairs and Northern Development is at present revising the Territorial Quarrying Regulations that govern the opening and operation of pits and

quarries in the Northwest and Yukon Territories. The stipulations made by Dryden and Stein (1975) that relate to the operation of borrow pits for the Mackenzie Highway have become generally accepted practice. And the Department of the Environment, Fisheries and Marine Service has also developed guidelines to control borrow pit operations, such as *Guidelines Concerning Applications to Remove Gravel From or Adjacent to Streams Frequented by Fish.* These documents, together with our extensive experience with northern borrow operations, provide a solid basis for the implementation of practicable, site-specific terms and conditions. There are, however, a number of points that need to be dealt with in the context of the very large scale that will apply to borrow operations on the pipeline project.

The pipeline project will require large volumes of borrow materials and a wide range of those materials. To ensure that the most appropriate sources are exploited, an exhaustive search and categorization of borrow sources is necessary. Some geotechnically suitable and conveniently located sources may not be acceptable from an environmental standpoint. Other sources may be inappropriate because they conflict with the needs of communities in the region. In many cases, trade-offs will be necessary to ensure that sufficient high-quality borrow material is left for future developments in the Mackenzie Valley and Western Arctic. To enable the Agency to judge if the Company's pit operations are the best possible, in terms of local needs and conditions, site-specific plans for borrow extraction must be submitted for review.

75. *The Company shall file with the Agency a separate site-specific application for permission to open and develop each borrow pit or quarry necessary for the construction of the pipeline and associated facilities. Each application shall be accompanied by a site plan, a mining or extraction plan and sufficient geotechnical and other information so as to demonstrate clearly the viability of the proposed borrow pit development. In particular, the Company shall carry out sufficient geotechnical investigations in the area to ensure, to the satisfaction of the Agency, that the borrow site it has chosen is the most appropriate for the purposes intended.*

The site-specific application should include details on such matters as the borrow source area; the thickness, quantity and grade of materials; test pit and bore hole data; the placement of the pit and its boundaries with estimates of the quantities and grades proposed to be used and to be left behind; the occurrence of permafrost, ground ice and ground water, and the location of the water table. The applications should also give details of the machinery the Company proposes to use; the timing of the various operations; the details of any processing operations that may be used; details of access to the pit, and from the pit to the point of use of the material; plans to control drainage, erosion and sedimentation during operations; the final form of the pit or quarry; restoration proposals, including spoil disposal, and revegetation; and any other information requested by the Agency.

Guidelines for Borrow Operations

The following nine recommendations apply to all proposed pits and quarries. They are followed by recommendations that apply to operations in river channels and flood plains.

76. *Wherever possible, existing borrow sites shall be used in preference to the opening of new sites.*

77. *In developing access to borrow sites, the Company shall use existing roads, trails or cutlines wherever possible. Temporary access roads shall be constructed of packed snow or ice.* (See Terrain Considerations: Snow Roads.) *An all-weather, gravel access road with culverts shall be provided to any pit designated for summer operation or for continued use during the operations phase of the pipeline.*

78. *The Company shall operate its borrow sites in accordance with the principles detailed in "General Criteria For Gravel Borrow Pits in Upland Areas" and in "General Criteria for Quarry Sites" (Canadian Arctic Gas Pipeline Limited,* Responses to Pipeline Application Assessment Group, Requests for Supplementary Information, *Appendix A, pp. 45-49 and 59-62).*

79. *Deposits of high ice-content material, of material covered with high ice-content overburden or of borrow material overlying high ice-content silts and clays shall be used only if no other material is available.*

80. *Where processing of borrow materials is necessary, it shall be done in an environmentally responsible manner either in the borrow area or at the site of use of the material. Where processing at these sites is not possible, it shall be done at sites approved by the Agency.*

81. *To protect the physical and living environment borrow sites shall be selected, operated and restored in locations and in a manner that complies with the recommendations in Part II of this report.*

82. *Unless otherwise approved by the Agency, buffer zones of not less than 300 feet shall be left between all waterbodies and the perimeters of pits and quarries; buffer zones of not less than 100 feet shall be left between all public roads and the perimeters of pits and quarries.*

83. *When closing or abandoning borrow sites, the Company shall promptly stabilize and rehabilitate the area and all access roads so that the pit is not left in a derelict state. The rehabilitation of any pit or quarry shall not unduly hinder other parties from re-opening the sites for future use. Any part of a closed borrow pit or quarry where waste material other than spoil or slash has been buried shall be permanently marked.*

84. *Borrow pits and quarries shall be opened and used in a way that permits archaeological surveys to be carried out during all stages of development.*

BORROW OPERATIONS IN RIVER CHANNELS AND FLOOD PLAINS

Special concerns arise over the proposals to extract gravel from the channel zones and flood plains of some rivers and streams. (The terms "channel zone" and "flood plain" are defined in the chapter River and Stream Crossings.) Borrow operations in such areas pose threats to aquatic resources and river regime stability. From a fisheries viewpoint, watercourses, particularly the channel zone, are a highly undesirable source of gravel because that gravel is important for spawning beds and as habitat.

85. *The Company shall not open any borrow pits in river channel zones in the Northwest Territories.*

86. *Where a borrow site is opened in a flood plain, dykes and river training works shall be constructed to ensure that the pit does not become connected with the river and to prevent the river from changing its course through the pit. A 300-foot wide buffer zone of undisturbed flood plain terrain shall be left between the channel zone and the pit.*

87. *Because flood plains are occasionally inundated, future water levels shall be taken into account in planning the rehabilitation of abandoned pits on flood plains.*