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THE UNIVERSITY OF BRITISH COLUMBIA

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November 19, 1973

Mr. Joe Castrilli
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Toronto, Ontario M5S 2J5

Dear Mr. Castrilli:

Herewith is a photocopy of the Agassiz Centre Workshop Paper No. 2 entitled "A Methodology for Prediction of Environmental Effects". Please excuse the last minute changes which were done in handwriting.

Best regards.

Sincerely yours,

I. McT. Cowan, Dean
Faculty of Graduate Studies

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Encl.

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AGASSIZ CENTRE WORKSHOP

PAPER NO. 2

A METHODOLOGY FOR PREDICTION OF ENVIRONMENTAL EFFECTS

The proposed Mackenzie Valley pipeline would pass through arctic and sub-arctic lands whose flora, fauna, soils and waters are only sketchily known. Its construction would require techniques previously untried. To predict its effects on the northern environment one cannot rely on precedent or on small extrapolation from a substantial body of cause and effect relationships. Moreover, the economic realities of the project will force the proposal to go to federal regulatory agencies within three years of its announcement. These are the conditions. How do we predict impact?

The time constraints and the limitations on research effort made it necessary to decide initially which components of the northern environment the pipeline project would most likely affect and how much and what kind of research would be required to predict impacts on these components. Here the Board members' experience in arctic research and engineering figured prominently. Its members together decided what the major environmental concerns about the pipeline project were likely to be and laid out research programs required to gather baseline data about these concerns.

Our approach to the identification of environmental concerns is based upon the major conclusion that for a gas pipeline the construction operations are the most likely to have significant impact. This may not be true of an oil pipeline or certain other operations but we felt and still feel that this is true for a gas pipeline.

The next step was to construct a matrix of the construction operations versus the environmental components. This was done for four general regions crossed by the pipeline and by weighing and compiling these concerns into one matrix we were able to identify our major concerns which at that time included the following:

(a) Caribou, because the large Porcupine herd is an important resource to native peoples, it is wide-ranging in its habits over a large part of the pipeline route, it is generally not much influenced to now by white man, and furthermore, it is the last major intact herd on the continent.

(b) Fish, because of the large numbers of stream crossings and the prospective removal of gravel and the siltation of spawning beds.

(c) Vegetation, because of the prospective timber use, and its importance to the esthetic and wilderness qualities of the area, to the control of erosion and to the habitats of animal populations.

(d) Certain migratory birds, because of the importance of the Mackenzie River as a corridor and staging area and the Mackenzie Delta and the Arctic coast as summer habitat.

(e) Terrain degradation, which is not only a threat to the integrity of a pipeline but which outside the right-of-way can have large detrimental effects on other environmental components.

(f) Archaeology because man's historical record constitutes a very important unexplored, and certainly non-renewable, resource. Furthermore there was already evidence that the Yukon area straddles what was probably the earliest route of man's entry into this continent

(g) Rare and endangered species of any component of the environment, because they are a part of our heritage and, as part of a national trust, require the highest concern for their survival.

Since our initial concerns were defined we have added to our list the evaluation of impact on recreational potential and upon esthetics. Also we have added a component on the native use of the environment because such use is an important part of the culture of the original peoples of the north which cannot be compensated merely by giving them money.

Since identification of environmental concern was pre-preparatory to initiating research programs related to them the Board made an early decision that research resources and capabilities would certainly be finite. It followed that there should be certain exclusions from consideration. For example, it was decided that some furbearers, passerine birds, or other animals which occur widely over the territories involved, should be excluded from detailed study if conditions are such that the environment can in a reasonably short time recover from temporary alterations.

A professional scientific staff to carry out the required research was retained through Inter-disciplinary Systems Ltd. These people carried out the field research and provided the Board with a first hand knowledge of conditions along the pipeline routes. *Individual members of the board made personal visits to the area for specific purposes.*

As the previous speaker noted, the Board has three roles: The first is to advise the Sponsor of potential sources of environmental damage within the proposed project and to suggest ways of doing things differently to lessen the damage. Second, to predict the overall impact of the project if it is built as the Company intends and is advised (by the Board and its own environmental consultants). The final function is to monitor the project to determine the accuracy of the prediction and to discover principles to be applied in the future.

It is clear that all of these roles require baseline data on the northern environment. What is not so clear is that
are difficult to obtain, even impossible to obtain over a short span of years, And basic
baseline data alone are not sufficient. How do we go from baseline data to impact predicition?

The actual process of impact prediction draws on a variety of information which is very unequal in its precision. The most precise prediction comes when we have knowledge of underlying cause and effect. This occurs most commonly in the engineering and physical science fields. For example, the

equations for frost heaving of a chilled pipeline predicted the results of the Sans Sault test site almost exactly over the first two years. Such precise prediction is usually impossible at this time where biological systems are concerned. For example we may know the population size and structure of the Porcupine caribou herd very accurately, yet we cannot predict what the population dynamics of the herd will be because we do not know how close this population is to the capacity of ranges, nor how weather, predators, and social behavior will interact to influence the population.

We will now take a brief look at some of the methods that are being utilized in order to predict impact. We cannot illustrate the problems of all the many diverse scientific fields involved in the ecosystem studies but a few examples will be cited.

1. <u>Prediction of Effects on Birds</u>

More than 240 species of birds are known to occur along the proposed pipeline route. These species vary in sensitivity to effects resulting from pipeline construction and operation because of spatial and temporal differences in their distribution, population density, behavior, habitat requirements, and reactions to disturbance, among other considerations. In conducting base line studies not all birds were considered of equal significance so criteria were utilized to identify either species or groups of species more subject to environmental change than are others. The criteria are as follows:

(a) Rare and/or endangered species.

(b) Local populations which represent large segments of continental populations.

(c) Small and/or local populations occurring almost exclusively in the region.

(d) Species nesting, molting, staging, or feeding in dense flocks in restricted areas.

(e) Species critical to the structure and function of the ecosystem or those which are good environmental indicators.

(f) Species exhibiting high sensitivity to disturbance.

Impact predictions are being made for some 14 species or groups of species. These predictions require information on bird life histories, with special emphasis on those phases (such as spring migration, nesting, non-breeding concentrations, molting, pre-migration staging, and fall migration) which could potentially interact with pipeline construction or operation, be identified and documented as to areas used, characteristics of areas making them attractive or necessary, uniqueness of these areas in the region, arrival and departure dates, and numbers of birds using the area.

Project components with impact potential have been identified and defined and four broad categories are being assessed. These are habitat destruction, disturbance, pollution and subsequent mismanagement. Habitat destruction includes actual physical disruption or alteration as well as any habitat made unavailable or unsuitable by other factors such as physical disturbance or pollution. Disturbance includes stationary and mobile land-based equipments, aircraft and human presence. Pollution factors include oils, line-testing fluids, insecticides, herbicides, and the like. Mismanagment can arise where the responsible local government fails to respond adequately to the new conditions of access brought about by the development.

Biological impact is expressed in terms of changes in population numbers whenever biological and project data permit, under the assumption that habitat destruction results in the loss of any birds occupying that habitat. Disturbance and pollution factors that do not cause the habitat to be totally unavailable or unsuitable will be defined, the biological effects identified and the probability of impact expressed in qualitative terms. Secondary effects on other environmental components or systems, or on the economic, subsistence or recreational uses of bird populations will be discussed when applicable. Some investigations by the Sponsor's scientists have included an experimental approach to the effects of man's activities on bird behavior. For example, the effects on nesting birds of different types of aircraft overflying at different altitudes. Similarly, sound simulation tests have produced quantitative data which test the potential effects of compressor stations along the pipeline right-of-way. Such experiments provide advice to the Sponsor so that undesirable environmental changes may be avoided by proper timing, alternative routing, improved procedures and control measures.

2. Prediction of Effects on Caribou

The proposed pipeline route crosses the range and migration routes of the Porcupine herd of barren ground caribou which is one of the few herds that have not been drastically altered by man. These animals' social and economic value to northern natives and their symbolic character assure that disturbance or reduction of the herd would result in a justifiable public outcry. For these and other reasons the herd was selected for field studies designed to describe the population, its range, seasonal distribution and the habits of the animals.

To understand the herd it is necessary to place it in relation to other herds as to the size and structure of its historic and current population. It is necessary also to know its productivity, habitat utilization and management opportunities. Since the impact is different at different times of the year, such matters as the northward spring migration, calving, summer mustering, southward autumn migration, and winter feeding, must be understood. Considerable experience with censusing and following caribou herds has been accumulated in the past by Canadian and Alaskan biologists and some preliminary information on this herd existed. Thus it proved possible in two years of areal surveys to quantitatively census the herd with some accuracy and to delineate its migrations

Certain aspects of the research have been conducted simultaneously by the Board staff, by consultants and staff of the Sponsor, and by the government. Hence, extensive data are available for use in impact prediction. Quantitative data are available, for example, for the total population, for productivity, and for the age and sex structure of the herd. As with birds, some experimental work has been done by the Sponsor's investigators, and by the Board on the effects of fixed wing and rotary wing aircraft at different altitudes on the behavior of the animals. Sound simulation studies have given some measure of the impact of compressor stations on animal behavior. Such studies provide advice and guidance to the Sponsor in order to avoid or mitigate the effects of such disturbances.

The more important impacts include direct mortality resulting, for example, from hunting or vehicle collisions and from disturbance as a consequence of human presence, blasting, compressor stations, operation of various kinds of equipment and aircraft harassment. Further impact results from the erection of physical barriers such as pipe strung along the ground, berms over-buried pipe, railways, access roads and open trenches. Habitat destruction may prove serious, especially in the case of fire which destroys range, and especially winter range, which provides the lichen diet for the winter season and which is very slow in recovery.

The impact of hunting mortality and range destruction from accidental fire will depend upon control which the pipeline

3. <u>Rare species:</u>

Within the region to be traversed by the proposed pipeline there exist relatively undisturbed populations of a number of rare birds & mammals either almost unique to the area or of special importance in terms of national or international concerns. Whooping crane, trumpeter swan peregrine falcon, gyrfalcon, barren ground grizzly & two species of shorebirds fall into this category. Some of these have required specially focussed studies & these have been undertaken. Others, such as the grizzly have not been amenable to the kinds of studies we could generate & require unusual concern & attention because of the meagre data base available.

4. Vegetation & revegetation:-

Our concern first to relate the type of plant cover to the characteristics of the substrate, & topography & micro-climate & then to relate these factors also to the potential for natural or artificial revegetation gave rise to a long series of studies both exploratory & experimental. Particular emphasis has been given to identifying the species most suitable for artificial revegetation & any treatments that can be used to speed recovery of a vegetative cover. The results we believe will be most useful in predicting the nature of impact & the potential for mitigation.

consortium can or will exert over its workers and their activities. The probable behavioral responses of caribou to various changes are difficult to predict. Up to the present, predictions have been based on extrapolation from the behavior of caribou and reindeer and other ungulates in other apparently analogous situations. Such quantitative data that are available at least state the magnitude of the problem of herd protection, provide a basis for post-construction evaluation of population size, migration routes and range utilization and give clues which permit prediction of impact on the short range. There is so little known of the basic biology of caribou, particularly of the forces which direct and time movement their behavioral traits, and the long term impact of disturbance, for example, that it will not be possible to predict in the long range.

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3. Winter Roads

A methodology for predicting environmental impact upon the terrain resulting from winter road use and misuse has also been developed. The many terrain types to be traversed by winter roads have been identified and delineated to the extent that available data from drill borings and air photo interpretation permits. Review of the literature has provided insight into the response of these various terrain types to surface disturbance including those expected from winter roads.

During the same time, field experimentation was proceeding to determine the limits of protection offered to the terrain by various types of winter roads subjected to simulated pipeline traffic. In addition, it was desired to establish the initial impact from clearing rights-of-way and from constructing winter roads. The types of surface disturbance that might initiate terrain degradation, through an increased depth of active layer leading to thaw settlement, were documented. The magnitude of increased depth of active layer and thaw settlement are being measured as they progress in time.

Emphasis throughout this experiment, however, was placed upon prevention of terrain disturbance through the use of properly constructed winter roads, and clearing and construction techniques which experience had indicated to be acceptable.

From an understanding of the types of surface disturbance resulting from clearing, construction and normal use of winter roads (causal effect), the resulting impact (response) of various terrain types to surface disturbance can be predicted along the pipeline route.

As with most singular experiments, it was not possible to incorporate all facets of the problems associated with winter roads. For instance, the extra wear and tear on the surface of steep grades and severe cross slopes by pipeline traffic was not investigated. Traction of construction vehicles on sloping ground could also be a problem. However, these most important considerations are to be investigated (by experimentation) during the current winter season. The response of particular slopes and terrain types to surface disturbance will be possible, once the character and severity of surface disturbance resulting from winter road construction and operation on grades has been documented.

6. Hydrology

One of the most important components of the environment is water. Alterations to drainage to the surface or subsurface channels can have serious effects in the Arctic. This can occur from the construction activities or from the presence of a chilled pipeline with its accompaning frost bulb. To estimate the impact of the pipeline and its operations on the terrain and natural regime of water movement, it was necessary to simulate the conditions because few data were available. The work involved review and analysis of available climatic and topographic data to permit definition of runoff characteristics of approximately 750 watersheds through application of mathematical modelling and computer simulation. Methodology included determination of probability density functions describing rainfall and simulated snowmelt, calculation of channel-climate and land-climate parameters to classify watersheds hydrologically, and verification of analysis by comparing theoretical flood frequencies with those obtained from recorded streamflows.

Each watershed was classified according to one of the six possible land and channel categories. This uniquely defines flood frequency distributions and describes flow characteristics in the channel and overland. Aereal stereo-scopic photographs were reviewed for all watersheds to assist in interpreting the significance of the categories. Results showed the relative importance of differences in climate over the approximately 10-degrees of latitude and the effects of topography within any region of uniform climate.

In addition to providing biologists with a concise description of the aquatic physical setting, the methodology would have application to cost-effective design of hydrometric networks including climatological and streamflow stations, estimation of flood frequencies on ungauged watersheds and preliminary analysis of effects of changing land use or channel modifications on hydrology.

INTER-DISCIPLINARY RESEARCH AND THE PREDICITION PROCESS

All of the foregoing investigations, as well as other Board studies conducted by the staff, are within a few weeks of completion of phase I. In planning of the field research, stress was placed upon the major interrelationships within ecosystems and the necessity for individual disciplines to contribute to understanding of these interrelationships. This requires inter-disciplinary planning, field research and analysis so that a synthesis of results can be accomplished. Inter-disciplinary research, however, is easier to talk about than to accomplish. Especially in the field it has been difficult to keep investigators together for integrated studies. This means that the input of data of one study, let us say vegetation, has to be provided to others, such as caribou or fish studies, after the field work is accomplished. The integration of results thus depends quite heavily upon close cooperation and coordination among the scientists at home base. There is a clear advantage in having the staff closely associated.

While the individuals as scientists are responsible for their working contacts with others there are many benefits to be gained from group interchange of ideas, critical appraisal of results, identification of new interrelationships, designation of new research questions, evaluation of environmental impact, especially the more obscure secondary effects, and other concerns.

The Board, as part of its methodology has encouraged the staff to hold group interaction meetings and at times Board members have participated. Such meetings provide motivation and lines of communication and keep the scientists working toward the same goals. The members have an opportunity to contribute ideas and to have them critically scrutinized by others. The idea is to achieve a maximum of integration of research, to examine the environmental complex with reference to the presently available knowledge of the pipeline project design and plans, and to produce an assessment of environmental impact. The group interaction gives maximum assurance that the impacts on individual components of the environment are evaluated realistically, but perhaps more importantly, achieves a balanced assessment of the overall impact on the total environmental system. That is, a group concensus can be achieved which eliminates the extreme positions which often typify the opinions of individuals.

THE BOARD'S ASSESSMENT

The staff reports are the raw material of the Board's assessment, and will appear as identified appendices to its final report. All staff reports and assessments and similar materials from other groups working on the project, both government and private, will be evaluated by the Board, and an overall assessment and prediction prepared. We are concerned with what effects are acceptable or unacceptable on different time scales and what can be done to avoid or mitigate impacts that would otherwise be unacceptable. We are sensitive that acceptability is a relative & subjective term capable of widely different interpretations. At this time the Board is planning to use the following criteria in rating each impact:

Impact Rating	Time-Impact Relations	Management
Compatible Impact	Would immediately recover	No management required.
Moderate Impact	Recovers in time	No managment required.
		Management would speed recovery.
Severe Impact	Will not recover	Management ~~would~~ might initiate recovery.
Threshold	Will not recover	Unecomonical or results very uncertain.

The Board's methodology of impact assessment is thus essentially as old as the beginnings of science and there is little in it much newer. The previous speaker has alluded to the fact that in making an assessment one must make certain of the audience to whom it is addressed. This is important because although you can produce a highly sophisticated computer program which turns out good answers the decision makers are often people who do not know or understand computers and are likely to have an inherent suspicion of the biases of the man who made the program. It is essential that the reasoning and conclusions be understandable to the people one is addressing.

We have followed various government agency responses to the U.S. National Environmental Policy Act and have also found nothing emerging that is particularly innovative in methodologies for impact assessment. There is a strong tendency to utilize cost benefit analyses but we find this generally unsatisfactory inasmuch as there are too many components of the environment, such as wilderness values and esthetics, which simply cannot now be quantified in any terms much less in terms of dollars.

The Trans-Alaska Pipeline Impact Assessment has been a guide to the development of our own methodology. Some of our Board members are knowledgeable in the use and limitation of computer programs, and we are still experimenting with procedures such as KSIM which we may yet utilize. The time is growing late however as the Sponsor is working hard toward an early submission of his applications for permits and, as has been previously stated, our own impact assessment is due within the next few months. Whether we use these computer techniques in our final impact assessment is yet to be decided. However going through the reasoning needed to get the program moving ~~is very~~ has been valuable in sharpening ~~your~~ our concept of relationship with the components of the system and possible effects.

We can, through continuing research, gradually build up that background of qualitative and quantitative data which will be absolutely necessary for post-construction evaluation of effects, but before evaluations can be made, the experiment must be performed; in other words, the pipeline be built. Prediction is another matter. Not only will we not have adequate quantitative data but too many environmental values, as pointed out before, cannot be evaluated in quantitative terms.

We must point out that the methods of study and evaluation we use are different at different scales. That is, narrowly defined research problems are subject to more rigorous analysis and computer programs in support of these are regularly used. The problems for which these techniques are most used are in the fields of physical sciences and engineering and in some cases biological problems, such as in the analysis of fish populations, but at present we find such techniques at the ecosystem level essentially impossible. We are exploring a computer program to cope with decision-making at the ecosystem level but in last analysis the inputs to the program are values based on estimates which in turn depend upon the experience and essentially the value judgments of the programmer and it is not yet clear that the program has merit.

To summarize: The method we are now using, and likely to be stuck with using, is simply one in which a Board of people with broad inter-disciplinary knowledge and experience in the northern environment, with mature judgment in various individual disciplines, and with a considerable body of data available, can make value judgments which are not only reasonable but can be demonstrated to be so. Such evaluation and judgments can only be based upon interpretations of available knowledge, upon past experiences in critically seeing and appreciating interrelationships and the consequences of interference with these relationships, and upon knowledge of the history of comparable impacts at similar scales, such as the construction of highway systems.

Such judgments may be quite objective in limited cases but subjective evaluations with the intricate environmental problems involved is likely to be the commoner feature of our decisions. We cannot make apologies for saying we are subjective as it is often the only recourse. All we can do is collect data and by means of analysis, reasoning, and a measure of opinion arrive at our interpretations and conclusions. The greatest difficulties lie in the fact that we so often have to go beyond data in complex environmental cases.

The major criticism of our current modes of planning and environmental impact prediction, including this Board's efforts, is that they are piecemeal. They usually consider only one project within a region, or even one aspect of a project. For example, the Board's comments have been restricted to considering the main gas trunkline although most people agree that the development of gas field will have more environmental effects than the mainline itself. With this approach it is impossible to ~~do~~ do a thorough job of assessing the combined effects of projects, and ~~generally~~ frequently one concludes that the environmental effects of a single project are not very "significant". Some streams are polluted, game populations are imperceptibly decreased or displaced, some visual scars are left on the landscape, some wilderness is opened up, but there is a lot untouched -- ready for the next project to reduce further. The result is not the ecological "disasters" which make headlines, but a process of slow attrition in which year by year, project by project we haphazardly approach subtopia.

The Board realizes that unless a wider framework is considered the piecemeal approach will continue despite the best intentions. We have proposed to government that a larger inter-disciplinary team be formed to consider the broad questions of energy, transportation, and development in the western arctic. Such a group would have the manpower and facilities to consider the interrelationships of various developments and recommend plans which would offer the best solutions to regional problems.

We suggest that the independent Environment Protection Board concept, which has been tried here on a small scale would be a suitable vehicle for other projects and more comprehensive studies because it provides for an inter-disciplinary team insulated politically and economically from the project developers.