Oldman River Dam Environmental Assessment Panel

Interim Report
on Dam Safety
and Design

June 21, 1991

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Federal Environmental Assessment Review Off ice
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Cat. No. En106-17/ 1991

ISBN O-662-58492-9

Federal Environmental Assessment Review Office
Bureau federal d'examen des evaluations environnementales

June 21, 1991

The Honourable Jean Charest
Minister of the Environment
Room 511 -S Centre Block
House of Commons
Ottawa, Ontario
K1A OH3

The Honourable John Crosbie
Minister of Fisheries and Oceans
Room 418-N Centre Block
House of Commons
Ottawa, Ontario
K1A OA6

The Honourable Jean Corbeil
Minister of Transport
Room 707, Confederation Building
House of Commons
Ottawa, Ontario
K1A 0A6

Dear Ministers:

Re: Oldman River Dam Environmental Assessment Panel

In accordance with the mandate provided to the Panel in November, 1990, the Environmental Assessment Panel has completed a preliminary review addressing the matters of safety and design of the Oldman River Dam. We are pleased to submit to you, the Panel's conclusion and recommendations on these matters.

The dam's safety performance to date is entirely satisfactory. The process used to design the dam was consistent with high Canadian and world standards. While this does not assure that the dam will be problem-free, the Panel heard nothing to convince it of any immediate safety problems. Dam performance will likely continue to be satisfactory if suitable monitoring, evaluation and management practices are adopted.

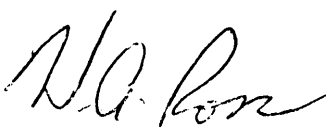
The Panel recommends that the probable maximum flood (the flood for which the spillway was designed) should be recalculated to include a conservative allowance for the effect of global climate changes. Global warming is expected to increase the size of this flood well within the life of the project.

The Panel found that the Emergency Preparedness Plan developed as part of the province's licenses for the dam and the evacuation plan for the residents of the Peigan Reserve downstream are inadequate and incomplete. Suggestions have been made to improve the situation.

The Panel believes that the owner of the dam should arrange for regular independent safety reviews of the dam and that the results of these reviews should be made available to the public.

Please note that not all of the recommendations made in the attached report can be implemented by agencies of the federal government. The Panel asks that, where relevant, these recommendations be passed on to the responsible authorities.

Yours truly,



William A. Ross
Chairperson

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1.0 PANEL MANDATE

In November, 1990, the then federal Minister of the Environment, Robert de Cotret appointed a six-member Panel to conduct an environmental assessment of the Oldman River Dam project in southern Alberta. The Panel has the mandate to evaluate and make recommendations on the design and safety of the dam, the significance of potential environmental and socio-economic effects of the dam and its operation, and options for mitigating these effects.

In order to deal as quickly as possible with the dam safety and design issue, the Panel decided to hold public hearings into this matter in June, 1991, rather than waiting until additional information could be gathered to address the environmental and socio-economic issues. Hearings on the environmental and socio-economic issues will be held in November, 1991.

The Panel has not undertaken a comprehensive engineering review of the dam. Rather, the Panel has hired three technical specialists with expertise in the main aspects of dam safety and design to evaluate the design and review process followed by the Government of Alberta to ensure the safety of the dam.

2.0 GENERAL PROJECT DESCRIPTION AND STATUS

The Oldman River Dam project is being built by Alberta Public Works, Supply and Services. Once construction is complete and the dam is fully operational, it will be turned over to Alberta Environment. The Government of Alberta is considered to be the proponent of this project. The project was approximately 95% complete at the time of public hearings on June 5 and 6, 1991. The project site is ten kilometres northeast of Pincher Creek, Alberta. The dam itself is located just downstream of the confluence of the Crowsnest, Castle and Oldman Rivers; a location often referred to as the three rivers site. Construction of the dam followed a five-year schedule and cost approximately $350 million (1986 dollars).

In October, 1990, the earth and rockfill dam reached its full height of 76 metres and length of 3,070 metres. As of June 4, 1991, the reservoir was storing approximately 323 million cubic metres of water and water had begun passing over the spillway. When at full supply level (expected in July of 1992), the reservoir will store 490 million cubic metres of water and will extend 24 kilometres in length. The concrete spillway was completed in time to allow closure of the diversion tunnels and retention of the 1991 spring run-off. The spillway gates will be installed by the fall of 1991. The spillway is 352 metres long, with a crest width of 85 metres narrowing to 40 metres for the chute and flip bucket. The spillway crest elevation is 1,110 metres, while the full supply water level is 1118.6 metres. The seven spillway gates are each 10 metres wide by 9.8 metres high. There are two diversion tunnels each with a diameter of 6.5 metres. One tunnel has now been converted to a low level outlet with the installation of a 2 metre diameter valve. Conversion of the second tunnel is in progress and is expected to be completed by the fall of 1991. The low level outlets have a discharge capacity of approximately 100 cubic metres per second-each at full supply level.

3.0 TECHNICAL SPECIALISTS

In order to assist with the review of highly technical material, the Panel appointed three technical specialists. Mr. Graham C. Morgan, P.Eng., Victoria, B.C., carried out a review of the geotechnical matters related to dam safety and design and the reservoir area. Mr. Clifford D. Smith, P. Eng., Saskatoon, Saskatchewan, reviewed matters related to the hydraulic engineering aspects of the project. His review focused on the spillway and low level outlet works. Mr. Charles R. Neill, P.Eng., Edmonton, Alberta, reviewed matters related to hydrology.

4.0 PUBLIC HEARINGS

Public hearings into dam safety and design were held on June 5 and 6, 1991 in Lethbridge, Alberta. Afternoon and evening sessions were held on both days. The Government of Alberta chose not to participate in the hearings.

Because the hearings took place without a proponent, the Panel and other review participants relied heavily on the expertise of the Panel's technical specialists. The technical specialists had access to the designers and builders of the dam, allowing them to provide accurate responses to questions.

5.0 PUBLIC INPUT TO THE HEARINGS

Presentations by members of the public included those by Mr. Fabian North Peigan of the Peigan Indian Band; Mr. Cliff Wallis, President, Friends of the Oldman River Society; Phil Handcock, P.Geol.; Mr. William Arsene, resident of Coalhurst; Mr. Kirk Hofman, Councillor of Nobleford; and Mr. John Nikkel, President, Alberta Soft Wheat Producers Commission. The Panel also asked questions of Mr. Hilton Pharis, Chairman of the Oldman River Dam Local Advisory Committee. Attendance was low, as is often the case in highly technical hearings. Transcripts were made of the hearings and are available, as are all documents received by the Panel, from the Executive Secretary.

6.0 TOPICS REVIEWED BY PANEL AND REVIEW PARTICIPANTS

The Panel has reviewed all written submissions and has identified the key issues. However, before moving on to the key issues, it is important to note the full range of topics covered by the Panel. These are noted below in point form.

6.1 HYDROLOGY

- 1991 spring freshet
- Probable Maximum Flood (PMF)
- Relationship of Oldman PMF to other Alberta design floods
- PMF in the context of Canadian and worldwide flood experience
- Consideration of the Simonette River flood
- Implications of the greenhouse effect for PMF calculations
- Updating of PMF values over time
- Dam failures in Montana

6.2 HYDRAULIC ENGINEERING

- Spillway: approach channel, spillway crest, spillway gates, chute, flip bucket, discharge channel, and drainage below the chute
- Outlet Works: diversion tunnels, operating and emergency valves, energy dissipation and cavitation

6.3 GEOTECHNICAL ENGINEERING

- Description of dam
- Comparison to Teton Dam
- Initial performance of the dam
- Instrumentation and monitoring
- Foundation rock shear strength
- Stability of the dam under normal operating conditions
- Stability of the dam under earthquake conditions
- Stability of rock slopes
- Stability of concrete works
- Performance of the core
- Drainage

6.4 DAM SAFETY PROCEDURES

- Dam failure statistics and associated risks
- Warming time and its effect on fatalities due to dam failure
- Emergency Preparedness Plan
- Dam inspection
- Dam safety monitoring program
- Independent review of dam safety
- Public access to information and involvement in decision-making

6.5 RESERVOIR AREA

- Description of reservoir
- Anticipated performance under reservoir operating conditions
- Extent of field study undertaken by Alberta Environment
- Reservoir shoreline regression due to landslides
- Reservoir shoreline regression due to wave erosion
- Reservoir boundary line
- Monitoring of shoreline performance
- Railway and highway bridges
- Dangerous rock outcrops in relation to potentially high use areas

7.0 MAJOR ISSUES

The key issues identified by the Panel are discussed below. Where appropriate, the Panel has drawn conclusions and provided recommendations.

7.1 HYDROLOGY — Probable Maximum Flood

Mr. Neill introduced the topic of Probable Maximum Floods (PMF) by stating that, “A key safety item in the design of an embankment dam is the selection and determination of the flood that is going to be used for the design of the spillway, because it is essential that the spillway should be able to carry any possible flood so that water will not go over the main part of the embankment and threaten to wash it out.” Mr. Neill defined the PMF as "... the flood resulting from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.”

In his presentation to the Panel, Mr. Neill concluded that:

1) The PMF study for the Oldman Dam is consistent with the international practice and with the current philosophy of dam design as practised by the engineering profession [internationally-known experts were reported to have reviewed the PMF studies];

2) The PMF value that has been used for design is very high in relation to historical floods on the Oldman River;

3) The PMF is not an absolute upper limit to possibilities that could be conceived; and

4) There is no objective answer to the question “how much is big enough?". The risk of a flood greater than the PMF is extremely small, but yet it is not zero. He added that "... there is no known case where a dam has experienced a flood greater than the probable maximum.”

On advice from his technical specialists, Mr. Wallis, of Friends of the Oldman River Society, stated that, "... given the current standards, they’ve probably done an adequate job in determination of the probable maximum flood.” He added that "... probably an even more conservative approach to probable maximum flood should be used in the spillway design.”

Two inter-related issues that pointed to a re-evaluation of PMF studies over time were the fact that PMF values have historically increased over time as new information becomes available and the implications of the greenhouse effect on PMF calculations.

7.1.1 Increasing PMF Values Over Time

Mr. Neill addressed the historical upward progression of PMF values and the subsequent enlargement of spillways on old dams. Reference was made to earlier PMF estimates for the Oldman River by the Prairie Farm Rehabilitation Administration, which were much smaller than the current estimate. Mr. Neill suggested that it would be reasonable to re-evaluate the PMF every 10 to 20 years in light of new experience and more data.

7.1.2 Greenhouse Effect

Mr. Neill pointed out that the 1985 PMF study did not make allowance for the effect of global warming and if global warming were taken into account, the PMF would increase. A technical paper written by Mr. Figliuzzi (Alberta Environment) suggests that "... each one degree Celsius increase in temperature for the Gulf of Mexico will manifest itself in at least a 10 % increase in PMP [Probable Maximum Precipitation] and PMF estimates for Alberta.” (Figliuzzi, Sal, Alberta Environment “Estimations of Probable Maximum Floods in Alberta”, 1989)

Conclusions:

The Panel acknowledges that the PMF was calculated in a manner consistent with international standards. However, the Panel is convinced that the methods used are not conservative due to their failure to consider climate warming, which would result in an increase in precipitation and, therefore, an increase in PMF.

Recommendations:

Within the next two years, the PMF should be recalculated. The revised estimate for PMF should include a conservative allowance for global warming within the expected lifetime of the dam. Ability of the dam to withstand such a recalculated PMF should be a condition of any license granted under the Navigable Waters Protection Act.

The PMF should be re-evaluated every five to ten years thereafter to reflect improved information.

7.2 HYDRAULIC ENGINEERING -Spillway and Outlet Works

Mr. Smith examined the design of the spillway and the low level outlet works. In his presentation to the Panel, he concluded that:

1) The designs conformed to acceptable practice in hydrotechnical engineering;

2) There are precedents for the choices made for most of the structure components on the spillway and outlet works;

3) The designs do not represent an extrapolation beyond the range of existing experience;

4) There are appropriate back-up features included for most of the mechanical systems; and

5) There was a high degree of correlation between the performance indicated by the physical hydraulic models and the performance predicted by analytic methods.

7.2.1 Monitoring, Evaluation and Management

During the hearings, Mr. Smith reported to the Panel that "... we can expect some things to develop due to vibration, cavitation, movement or something like that. Any evidence of cavitation damage or a joint opening would have to be addressed as a part of a regular inspection and maintenance program ." Given a regular program of inspection to monitor performance, and remedial action when required, such maintenance items would not be expected to limit the operation or compromise the safety of the structures.

7.2.2 Operation of Spillway Gates Under Ice Conditions

The Friends of the Oldman River Society (FOR) raised the concern about operating the spillway gates under ice conditions. Mr. Smith indicated that the gates are designed to carry a full ice load, which would result from having the reservoir frozen against the gate and having a full ice thrust due to thermal expansion of the sheet when the temperature rises during a chinook, for example. In addition, Mr. Smith pointed out that there are several back-up mechanisms to ensure that the gates would be operable under winter conditions. These include methods to melt ice such as a compressed air bubbler system to bring warmer water from lower depths, heaters to warm up the gates, and pressurized steam hoses.

7.2.3 Ability For Rapid Draw Down of Reservoir

The Friends of the Oldman River Society suggested that there should be enough outlet capacity to drain the reservoir rapidly during a crisis. Mr. Smith indicated that usually in a crisis situation, such as an earthquake or a piping condition, it would only be a matter of hours before the dam washes out, and rapid draining of the reservoir in that time frame is not technically feasible.

Conclusions:

The Panel concludes that the hydraulic engineering aspects of the dam have been adequately addressed and that there are no safety concerns of any significance relative to hydraulic engineering matters on the Oldman River Dam.

7.3 GEOTECHNICAL ENGINEERING

Agreement was reached during the hearings amongst the Panel's technical specialists that "... there is nothing wrong with this dam. It's a great dam. Well designed and well constructed." The Friends of the Oldman River Society (FOR) also stated that during the hearings that with respect to dam safety, "We feel far more comfortable now than we ever did before." In his initial review submitted to the Panel, the FOR's technical specialist, Tim Abbe concluded that "The analysis and design of the dam's embankment appear to meet present-day standards and we have found no major safety concerns."

In his submission to the Panel regarding geotechnical engineering, Mr. Morgan concluded the following:

1) The performance of the completed dam to date has been satisfactory.

2) The experience accumulated on the project to date is supportive of the design assumptions concerning available foundation strength.

3) Notwithstanding the development of high pore water pressure in the core and concerns over the gradation of fill in the upstream shell, the design requirements for the stability of the dam under normal operating conditions have been satisfied.

4) There is a consensus that the selection of a maximum design earthquake of 0.13 g by the designers is adequately conservative.

5) The performance of the dam under an earthquake of this intensity is assured. There is no evidence to suggest that excessive deformation or liquefaction will occur.

6) The continuing performance of the drains beneath the spillway headworks is important to ensure that creep under sustained reservoir load does not occur.

7) The design of the core and the nature and specified placement conditions of the core material, together with a well designed filter drain, point to a satisfactory performance with respect to cracking, piping and pore pressure abberations. Satisfactory adherence to the design specifications required for the filter and drain zones is reported.

Conclusions:

The Panel has concluded that the performance of the dam to date has been satisfactory and consistent with design expectations. The process used to design the dam was found to be consistent with high Canadian and world standards. While this does not assure that the dam will be problem free, the Panel heard nothing to convince it of any immediate safety problems. Moreover, information provided led the Panel to believe that the dam performance would likely continue to be satisfactory if suitable monitoring, evaluation and management practices are adopted.

7.4 DAM SAFETY PROCEDURES

Despite the Panel's above-stated conclusion that there are no major safety concerns regarding the design and construction of the dam, it is nevertheless important to adopt operation and review procedures for the dam which will continue to ensure its safety over the long term. The major dam safety issues that

were discussed during the hearings were the Emergency Preparedness Plan, a dam inspection and monitoring program, the independent review of the dam, and public access to information.

In his submission, Mr. Morgan concluded that:

1) An operational exercise to test the Emergency Preparedness Plan [and local evaluation plans] should be undertaken. Emphasis needs to be placed on the changing nature of the consequences of an assumed failure, as one proceeds downstream.

2) A thorough and well organised inspection programme and review of instrumentation results for all aspects of the dam and spillway is an essential keystone to public safety.

3) A detailed [dam safety] review in the third year by engineers who are independent of the owner (Alberta Environment) and the designer is also strongly endorsed.

7.4.1 Historical Dam Failures

Although Mr. Morgan emphasized that historical dam failure statistics should not considered directly applicable to the well designed and well constructed Oldman River Dam, he provided the following information. The risk of a particular dam failing in a given year is approximately 1 in 10,000 for North American conditions. This risk also depends on the age of the dam; it increases to as much as 1 in 1000 for the first two years of operation of a dam and them drops to around 1 in 20,000. While the 1 in 20,000 risk falls within the range of other comparable risks that society imposes on its members, the 1 in 1,000 risk is excessive.

7.4.2 Emergency Preparedness Plan

An Emergency Preparedness Plan (EPP) was prepared and issued in February, 1991 by Alberta Environment in cooperation with Alberta Public Safety Services. This EPP allocates responsibilities and indicates who would be contacted in the case of an emergency at the dam site. It does not contain detailed emergency response or evacuation plans for downstream communities. Mr. Morgan stated that this document should have been made available one year prior to the first filling of the reservoir. Evacuation procedures would be required for each community and would have to be coordinated with the EPP. It does not appear that this has been carried out as yet. Mr. Morgan emphasized that any emergency preparedness plan and community evacuation plans should be tested prior to the filling of a dam.

The EPP indicates that in the event of a dam failure, the water in the reservoir would reach the community of Brocket on the Peigan Indian Reserve in one to two hours and Fort MacLeod in six hours. Mr. Morgan discussed the importance of the period of timely warning, the time of day an event occurs (ie. day vs. night), the reluctance on the part of dam operators to give a warning and the reluctance of those living downstream to heed a warning. To address these important factors in the nearby community of Brocket, he suggested a yellow and red alert system. A yellow alert would be given when complications arise and the dam operators are concerned about the potential for a failure, and a red alert would be given when a dam failure is very likely going to occur. By having a two-phased alert, there is an increase in the period of warning and, accordingly, a reduced risk of lost human life.

Mr. North Peigan, representing the Peigan people, expressed their concern over the fact that the dam and spillway are operating and they do not yet have an evacuation plan. They also expressed concern over the order of notification in the event of a failure as it is currently expressed in the EPP. Another concern of the Peigan was the short time frame for evacuating the 35 families that currently live in the river valley. It was reported that there has been very little in the way of contact with the Alberta Government regarding emergency preparedness and what has been carried out has been done only in the last two months. Mr. North Peigan reported that little in the way of assistance has been provided to the Peigan for the preparation of an evacuation plan.

Mr. Morgan indicated that a very site-specific plan would be required for the low lying areas of the Peigan Reserve because the residents in the river valley are spread out and because not all of them are on the telephone system. A yellow and red alert system might prove more effective in assuring the evacuation of people in this area.

A comment by Mr. Morgan concerning the EPP's proposed response to an impending piping failure suggests that the technical review of this document has been inadequate.

7.4.3 Dam Inspection, Monitoring, Evaluation and Management

Concerns were expressed by Mr. Wallis of the Friends of the Oldman River Society and by Mr. Morgan that, although there was a good instrumentation program, there did not appear to be a set plan for reading the instruments and evaluating the results. On the second day of the hearings, however, the Panel was presented with the "Oldman River Dam Reservoir First Fill Inspection and Instrumentation Manual," April, 1991, prepared by UMA Engineering. Mr. Morgan briefly reviewed the manual and stated that the inspection program and the threshold values used for evaluation appeared reasonable.

7.4.4 Independent Review

During the hearings, Mr. Morgan and Mr Wallis expressed concern over the fact that the organization responsible for dam safety, in this case, Alberta Environment, is also the owner of the dam. In Mr. Morgan's words, "... people who are responsible for inspecting dams should not own them." Although it is a standard practice of Alberta Environment to arrange for an independent review of the dam after five years, Mr. Morgan stated that it should take place after two full operating years. This is partially due to the fact that dams tend to be most vulnerable to failure in their first and second years.

7.4.5 Public Access to Information

In his presentation on behalf of the Friends of the Oldman River Society, Mr. Wallis indicated several times, the lack of access to information regarding dam safety and design. Mr. Morgan and Mr. Pharis of the Local Advisory Committee discussed the usefulness of providing the public with monitoring data. Although neither thought that these data could be interpreted by the public in a meaningful way, Mr. Pharis stated that it should be available upon request. Mr. Morgan suggested that having an independent review of this highly technical data would be more useful to ensuring dam safety.

Conclusions:

Even for a well designed and well constructed dam such as this, history suggests that there is a residual risk borne by those living downstream of the dam. The risk is greatest during the first two years of the operation for those living in the river valley closest to the dam, ie. the residents of the Peigan reserve.

The Panel is most distressed at the present state of the EPP, particularly given that the dam is retaining water to the spillway level. There are some residual technical problems associated with the EPP which require correction; the EPP is not yet to the stage of being an operational procedure and has not been tested. In addition to the inadequacies of the EPP, there is not yet an evacuation plan for residents of the Peigan Reserve.

Recommendations:

The Government of Alberta should undertake an immediate technical review **of the EPP. Furthermore, we suggest the following process to make the EPP an operational procedure. We recommend that the proponent, in collaboration with downstream communities, develop local emergency evacuation procedures. With respect to the Peigan Indian Band, the federal Department of Indian Affairs and Northern Development should provide such support as is necessary to protect the interests of the Peigan people. Consideration should be given to the yellow — red alert concept presented at the hearings. Upon completion, the EPP and the local emergency evacuation procedures should be given a dry run.**

The owner of the dam should arrange for periodic independent safety reviews, with the first review to be carried out in late 1994. This review should include such matters as the monitoring results; the monitoring, evaluation and management program; the instrumentation for the dam; the operating procedures for the spillway; and the EPP. Results of all such reviews should be made available to the public.

7.5 THE RESERVOIR AREA

The issues which emerged regarding the reservoir area related primarily to the relationship between the boundary line and future development plans and to hazardous rock outcrops in potential high use areas.

In his submission regarding the reservoir area, Mr. Morgan concluded that:

1) The banks of the Oldman River reservoir will regress due to reservoir induced sliding in overburden and rock, and beaching by wave action. Over a long period of time the banks will approach a condition of equilibrium.

2) Although the threat to land and property is considerable, no rapidly moving large slides are anticipated and thus the threat to the dam or public safety from slide generated waves is minimal.

3) There are no definitive procedures for predicting shoreline regression of new reservoirs. Based on experience elsewhere, those procedures used on the Oldman River Project have provided generally reasonable predictions.

4) The project reservoir study has concluded that throughout the reservoir, slides may result in localised regression of the shoreline which may exceed that due to beaching alone. There is at least one exception [where beaching may be more important than sliding], the west facing exposed slope on the north side of the reservoir 2 km upstream of the dam site.

5) A project boundary line has been established to allow for the effects of sliding and beaching. The review has concluded that in the light of dam site studies of sheared rock strengths carried out subsequent to the completion of the project reservoir study (1987), occasional slides may develop which could exceed the boundary line allowance. Furthermore, where slides do occur, the destruction of any beach slope equilibrium could result in some additional regression by beaching, particularly in exposed areas, which may also extend beyond the boundary line;

6) These limitations of the boundary line should be addressed by any land use plan relating to residential potential, and should be clearly recognised in the development bylaws of the Municipal District of Pincher Creek. The Area Structures Plan under preparation by the Oldman River Regional Planning Commission (currently in draft form) would appear to be an appropriate vehicle for ensuring this.

7) A regular schedule for monitoring shoreline performance, particularly during the first 10 years of operation is an important requirement.

7.5.1 Planning and Development Around the Reservoir

Mr. Morgan stated that activities such as wave erosion, beaching and slides will in some cases take place beyond the boundary line surrounding the reservoir. He added that it is important for people making decisions with respect to planning and development around the reservoir to be aware of this possibility. As indicated in conclusion six above, Mr. Morgan suggested that consideration of the boundary line be formally incorporated into planning processes. He added that there should be "... a workable definition of the restricted development zone beyond that boundary line, because some slides are going to extend beyond the specified reservoir boundary line." He suggested that it would also be helpful to classify the shoreline according to how it will perform; for example, whether beaching, wave erosion or sliding will be important, the probability of these event occurring and the magnitude one might expect.

7.5.2 Rock Outcrops in Relation to Potentially High Use Areas

During the hearings, Mr. Handcock identified extensive vertical jointing in one of the cliffs in the Castle River's Horseshoe Canyon. Of particular concern was a rock outcrop. Mr. Handcock was concerned about the possibility that this outcrop would topple over in the reservoir. Mr. Watkins of Transport Canada was also concerned about the possibility of this particular area being used heavily by archaeologists carrying out dives in the area and by recreational boaters. Mr. Morgan suggested that the outcrop be examined further to determine the extent of the hazard or that one restrict use of the area during the first one or two years when the probability of a failure is the greatest.

Conclusions:

There appear to be some modest potential safety hazards associated with the reservoir, one of which is the rock outcrop referred to above. These should be examined for proper treatment to ensure the safety of those using the reservoir.

The Panel accepts conclusion six of Mr. Morgan, ie. that the "... limitations of the boundary line should be addressed by any land use plan relating to residential potential, and should be clearly recognised in the development bylaws of the Municipal District of Pincher Creek. The Area Structures Plan under preparation by the Oldman River Regional Planning Commission (currently in draft form) would appear to be an appropriate vehicle for ensuring this."

Recommendations:

As a condition of issuing a license under the Navigable Waters Protection Act, public safety in the vicinity of rock outcrops should be assured.

The local planning authorities should be made aware of the limitations and implications of the reservoir boundary line in consideration of planning and development in the reservoir area.