Nahanni National Park Reserve
PO Box 348, Fort Simpson, NT
X0E 0N0

9 March, 2001

Mackenzie Valley Environmental Impact Review Board
200 Scotia Centre, PO Box 938
Yellowknife, NT
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Attn: Luciano Azzolini

RE: Technical Report - Canadian Zinc (CZN) Development Proposals

Dear Mr. Azzolini,

Please find attached the Technical Report from Nahanni National Park Reserve to the Review Board, regarding the Environmental Assessment Reports for the two Canadian Zinc proposals: Cat Camp Fuel Cache Retrieval, and Diamond Drilling Program.

If there are any further questions, please contact our office at (867)695-3151, or (867)695-2446 (Fax).

Sincerely,

Chuck Blyth
Superintendent, Nahanni National Park Reserve

Prepared by:
Douglas Tate
Conservation Biologist
Nahanni National Park Reserve

Technical Report (Part I):

An Assessment of Canadian Zinc Corporation's (CZN) Proposal and EA Report
Cat Camp Fuel Cache Recovery Program - Prairie Creek Mine
Land Use Permit Application MV2000C0030

9 March, 2001

Prepared for:
Mackenzie Valley Environmental Impact Review Board

Prepared by:
Parks Canada, Nahanni National Park Reserve

Parks Canada, Nahanni National Park Reserve (NNPR) is pleased to provide its technical knowledge and assistance to the Review Board, on the aforementioned proposal and Environmental Assessment Report by Canadian Zinc Corporation (CZN). We hope that the following information is of assistance to the Board in making its decision.

Summary:

Although the EA Report on the Cat Camp Fuel Cache Recovery Program appears to cover the required topics, a number of inaccuracies and deficiencies have been identified, and are discussed below.

NNPR is of the opinion that the alternative cleanup methods, including flying the fuel out and the use of a winter road, are rejected without adequate justification. As the EA Report states on page 4, "*the sole objective of this program is to mitigate a known environmental risk*". If environmental risk mitigation is the sole objective, then environmental impact considerations should be the deciding factor on the methods of removal, and a fly-out or winter road removal appears to have the least impact on the environment, and are the preferred options for maintaining ecological integrity.

Project and EA Report Analysis:

Executive Summary
The description of the history of Cat Camp, as described in the EA Report, seems somewhat inconsistent with earlier verbal and newspaper reports. NNPR was informed that during a routine inspection in August 1999, DIAND field staff noted a significant (~30%) drop in fuel level at one of the tanks, and that samples of soil and water from Sundog Creek contained hydrocarbons. It was only after this inspection that CZN staff did repairs on the site. This is in contrast to the 'no significant losses' described in the EA Report summary. As the original documents of these inspections are not currently available to NNPR, we cannot comment on the relative accuracy of reports.

A major shortfall of the CZN EA Report is evident in the section titled 'Impact of the Development on the Environment' (page 9). Throughout the following sections, in particular those regarding Terrain, Vegetation and Plant Communities, and Wildlife and Wildlife Habitat, the statement is made that impacts are expected to be negligible. In each case, this appears to be based largely on the fact that the area has been previously developed. However, this previous development was based on use as a winter access road, not summer use. The impacts of summer construction and use has the potential for greater impacts on terrain, vegetation and wildlife than the former use as a winter road.

Water Quantity and Quality

One aspect of water quality has not been well addressed. The EA Report assumes that the bermed fuel farm and tanks at Prairie Creek, where they propose to store the fuel from Cat Camp, "*are in good condition with no upgrades or maintenance necssary to make them serviceable*" (page 6). This statement is not supported or referenced with any inspections of the site.

The fuel farm is in a potentially unstable location. It is immediately adjacent to Prairie Creek, where a flash flood could conceivably erode the berms very quickly. The area is also subject to frequent seismic activity, according to the NRCan Earthquake Database. There is no reference made to precautions taken against such an event. Failure of the containment system at the minesite could result in a hydrocarbon spill directly into Prairie Creek, and thence to the South Nahanni River.

Aquatic Habitat

In the EA Report section Aquatic Habitat, page 12 states that "*headwaters appear to be utilized by Dolly Varden (Bull Trout) and Rocky Mountain Whitefish... Limited use appears to be made of Prairie Creek in the vicinity of the minesite, or downstream of the minesite above the mouth*". Bull Trout are a migratory species, hence they do likely pass by the area of the minesite seasonally, and may be affected by siltation at creek crossings. This species has been found to be very sensitive to industrial disturbance, according to studies in the East Slopes of the Rocky Mountains (N. Mochnacz, University of Manitoba, pers. comm.).

Wildlife and Wildlife Habitat

In the Wildlife and Wildlife Habitat sections, the EA Report also makes some questionable assertions. Page 12 concludes that the road will not present any major problems to woodland caribou, however, research in northern Alberta has found that caribou do avoid linear disturbances, including roads, and even seismic cutlines (S. Dyer, University of Alberta, MSc Thesis, 1999). Therefore, some disruption to caribou movement patterns is likely to occur from road developments and increased use.

Page 14 of this report states that "*no impacts are expected on migratory bird populations as no usage of the minesite area by such populations has been identified*". This comment is very difficult to accept, because many species of migratory birds are present in the region. In nearby NNPR, Scotter et. al (1985) recorded 170 bird species, of which 19 were considered permanent residents, and 4 were of unknown status. Therefore at least

147 species exhibit migration of some sort, and the vast majority of these would be international migrants, covered by the *Migratory Birds Convention Act*.

Although the variety of habitats represented in NNPR do not all occur in the minesite area - and this would serve to reduce the species diversity somewhat - it is extremely unlikely that there are no migratory bird populations in the area. This omission calls into question the quality (accuracy and completeness) of wildlife inventories for the area.

Land and Resources Use

The EA Report section on impacts to Land and Resources Use (pages 15-18) contains a number of inaccuracies. The final paragraph of page 16 states that "*The Cat Camp fuel cache, at Km 41, is located approximately 2 km north of the northern boundary of the Nahanni Karst candidate area*", and that only short stretches of the former winter road alignment overlap the boundary. Contrary to CZN's claims, the map of proposed candidate areas in the NNPR Park Management Plan (1987; page 46) clearly shows that both the Cat Camp site and a long stretch of the former winter road alignment are well within the Nahanni Karst candidate area.

Another aspect of this section of the EA Report is of greater concern. CZN's reference to karst features on page 17 misinterprets what karst landforms really are, and this suggests a serious lack of understanding of these features, and their potential sensitivity to disturbance, on the part of the company. The CZN EA report inaccurately states that:

> "*... only subdued appearances of karst features exist in the area of the access road corridor. The most representative areas of high value in terms of karst development exist to the northeast of the candidate boundary, and the access road, in the area of the Ram Plateau where surface expressions occur over an approximate 400 km2 area.*"

In fact, the Ram Plateau does contain excellent examples of mountain plateaux and river canyons, but it is not karst.

Karst landforms are described by Dr. Derek Ford, Professor of Geography, McMaster University, in Chapter 4 of the Nahanni National Park Reserve Resource Description and Analysis (RD&A). Page 4-82 states:

> "*Karst landforms are created by the aqueous solution of comparatively soluble rocks... Karst landforms may be divided into; (1) surficial features, and (2) underground channels (cave systems). The surficial features mainly function to feed water underground.*"

With regard to the extent and significance of the karst features within the candidate area boundaries, Dr. Ford writes (RD&A; page 4-83):

> "*A belt of karst terrain developed in Rock Unit 8 extends from the eastern end of First Canyon 45 km northnortheast to the valley of Sundog Creek. It is the most rugged or accentuated karstland known anywhere in Canada or the United States. Brook and Ford (1975) described it in great detail and termed it 'The North Karst'.*

"Geographically most of the North Karst lies outside of the present Park boundaries. Its hydrological extent is indicated in Figure 4-22, where it will be seen that it drains to two major sets of springs. The southern set is Whitespray, First Canyon; the southern half of the Karst is thus a part of the South Nahanni basin".

More detail on the formation and types of karst features is provided in the RD&A. A copy of some of the pertinent pages have been appended and faxed to the Review Board as part of this report. It is noteworthy that the international significance of its geology, including karst features, is part of the reason Nahanni National Park Reserve was designated as a World Heritage Site, yet "*the Park contains only a small and unrepresentative sample of the surficial landforms*" (RD&A, page 4-86).

Construction of a permanent road on this sensitive terrain could have serious, potentially irreparable impacts. The underground passages found in karst terrain are often modified by mechanical erosion, *i.e.* collapse of walls or roofs (RD&A, page 4-83). Total avoidance of heavy vehicle traffic is therefore preferable. If vehicle traffic is unavoidable, use of a winter road would likely serve to reduce impacts, as the solution processes of karst landscapes will presumably be reduced or entirely halted at this season. The corresponding likelihood of collapse and damage to features will likely be lessened by restricting use to the winter season. Such a collapse could also have serious worker safety implications. These factors are not even mentioned in the CZN EA Report section on impacts to terrain (pages 9&10).

Cumulative Impacts

The Report's section on cumulative effects is very weak, and lacking in detail. The definition of cumulative effects used in the draft Cumulative Effects Assessment and Management Framework (CEAMF) for the NWT is the following:

" 'Cumulative effects' can be defined as changes to the environment caused by the combination of past, present and 'reasonably foreseeable' future actions. 'Environment' is broadly defined to include not only the natural or biophysical environment, but the social, economic and cultural aspects also."

The consideration of 'reasonably foreseeable future actions' is not addressed at all in this section, although there is a reference elsewhere (page 29) to "*the all-weather road proposed in conjunction with plans for re-development of mining operations at Prairie Creek... the route will be required in support of future operations*". Therefore, there are 'reasonably foreseeable activities', which need to be considered as having relevance in this assessment.

The report seems to take the opinion that since development has occurred in the past, additional new construction on site will have no impact. However, it could also be argued that an area previously impacted is even more sensitive to additional industrial activity. The EA Report makes an unsubstantiated claim (page 30) that "*residual impacts [of previous activity] are principally visual and aesthetic, and confined to*

physical disturbance directly associated with the construction development of the existing facilities". There is no data analysis presented to verify this claim.

Such data could include quantified wildlife inventories, vegetation plots or fisheries assessments, to determine conditions before and after use, and thereby indicate whether or not there are effects beyond the 'visual and aesthetic'. Although there is a listing of some fisheries studies, no reference is made to analyses thereof.

With respect to the Cat Camp site itself, there is evidence that residual impacts go beyond the 'visual and aesthetic'. NNPR was informed that during a routine inspection in August 1999, DIAND field staff noted a significant (~30%) drop in fuel level at one of the tanks, and that samples of soil and water from Sundog Creek contained hydrocarbons. It was only after this inspection that CZN staff did repairs on the site.

The statement regarding water quality testing and the CanTung mine (page 31) is misleading. It suggests that this operation never had water quality effects. However, as noted in the Report, the water quality monitoring program began in 1988 – two years after the CanTung mine shut down. With no baseline data before mine operation, or samples taken during mine operation, there is no way this program could have found mining-related impacts on water quality, so it is not known what impacts that operation may have had.

Alternatives
The assessment of Alternatives (page 26-28) appears to be more of a defense of CZN's preferred method than a genuine assessment of other methods. Their conclusion of a summer road haul as the best option is not really supported.

Flying the Fuel Out - One of the cited disadvantages of flying the fuel out is that bulk tanks and other structures onsite would be left in place (page 27). However, this is not really a significant disadvantage, as the summer road option does not remove the tanks for disposal either, it merely moves them over to Prairie Creek. Flying is cited as too expensive, but the $50,000 estimate for flights would be the vast majority of the cost. There is no mention of whether or not CZN has investigated the option of selling the fuel for use in diesel generators at Nahanni Butte.

The fly-out option requires no construction; therefore less equipment, fewer equipment operators, and other field personnel are needed. The fly-out option would complete the program much more quickly, and thereby reduce the number and length of contracts required. The operation could be carried out from Nahanni Butte or another base, thereby eliminating the need to re-open a winterized camp. All of these factors could serve to reduce costs.

In the experience of NNPR staff, winter is typically a good time for flying, with clear weather and excellent lift capacity in the colder air. This option would have the least environmental impact, as no road construction is required.

Winter Road Haul – The list of advantages to a winter road haul (page 28) includes only one reference to impacts of a potential spill. This point is valid, but the analysis misses several additional important advantages, beyond potential spill impacts. Avoiding construction and traffic in summer will reduce impacts on terrain (construction and subsequent erosion), reduce impacts to vegetation, reduce siltation of creeks, reduce wildlife disturbance (esp. migratory species – large mammals and birds), and reduce disturbance to fish habitat at the numerous creek crossings which would be required.

The disadvantages cited are primarily based on safety of personnel. Although this is certainly a valid consideration, the former road access was originally designed, built and operated as a winter road. Reuse of part of this alignment should therefore not create undue safety risks for personnel.

Closure and Reclamation

A document pertaining to restoration models for the Prairie Creek site, prepared by Indian and Northern Affairs Canada, was requested by NNPR on February 8, 2000, to provide further information on restoration options. NNPR had been informed that this document was a comprehensive modeling exercise, including assessment of environmental restoration options. Subsequent communications to the Review Board from DIAND (March 01 & 06) and CZN (March 08) have stated that this document deals only with the financial aspects of reclamation, does not examine environmental operation and cleanup methods, and is therefore not relevant to the Environmental Assessment.

In light of this information, and the concerns expressed regarding the confidential nature of information therein, NNPR is of the opinion that it is not necessary for park staff to review the document. At this stage of the EA process, we would not be able to make a thorough assessment of the document prior to the March 12 deadline for submission of technical reports. NNPR does, however, urge the Review Board to examine the document as a neutral third party, to determine if information relevant to the assessments is contained therein.

Conclusion

Much of the anticipated information on rehabilitation and site restoration options was not available to NNPR for analysis. In the absence of such detailed information, NNPR has attempted to evaluate alternatives as presented by CZN and in light of other available information sources.

NNPR's analysis of the EA Report has determined that the alternative fuel cache cleanup methods, including flying the fuel out or the use of a winter road, are rejected without adequate justification. As the EA Report states on page 4, "*the sole objective of this program is to mitigate a known environmental risk*". Therefore, the establishment of an all-weather road for other subsequent uses cannot be a consideration. If environmental risk mitigation is the sole objective, then environmental impact considerations should be the deciding factor on the methods of removal, and a fly-out or winter road removal program has been determined to have less impact on the environment.

Flying the fuel out, or using a winter road haul, are the preferred options for maintaining ecological integrity, and are the options recommended by NNPR.

Attachments:

Appendix 1. Karst and Pseudokarst landforms. In: Ford, D. 1983. Nahanni National Park Reserve Resource Description and Analysis. Section 4: Geomorphology. Pp.4-82-86.

Figure 1. Map of Nahanni National Park Reserve and candidate areas for expansion. In: Parks Canada. 1987. Nahanni National Park Reserve Management Plan. P. 46.

Technical Report (Part II):

An Assessment of Canadian Zinc Corporation's (CZN) Proposal and EA Report
Mineral Exploration Drilling Program - Prairie Creek Mine
Land Use Permit Application MV2000C0030

9 March, 2001

Prepared for:
Mackenzie Valley Environmental Impact Review Board

Prepared by:
Parks Canada, Nahanni National Park Reserve

Parks Canada, Nahanni National Park Reserve (NNPR) is pleased to provide its technical knowledge and assistance to the Review Board, on the aforementioned proposal and Environmental Assessment Report by Canadian Zinc Corporation (CZN). We hope that the following information is of assistance to the Board in making its decision.

Summary:

Although the EA Report on the Mineral Exploration Drilling Program appears to cover the required topics, a number of inaccuracies and deficiencies have been identified, and are discussed below. NNPR is of the opinion that the program is proposed in an inappropriate place for this type of development. The activities could compromise the ecological integrity of Nahanni National Park Reserve - a Canadian Heritage River and World Heritage Site - and the South Nahanni Watershed.

Project and EA Report Analysis:

Shortfalls of this CZN EA Report are evident in the analysis of 'Impacts of the Development on the Environment' (page 9-21). Throughout the following sections, in particular those regarding Terrain, Vegetation and Plant Communities, and Wildlife and Wildlife Habitat, the statement is made that impacts are expected to be negligible. In each case, this appears to be based largely on the fact that the area has been previously developed. The report seems to take the opinion that since development has occurred in the past, additional new construction on site will have no impact. However, it could also be argued that an area previously impacted is even more sensitive to additional industrial activity.

Terrain
The statement regarding the occurrence of permafrost – "*If encountered, appropriate measures will be taken to preserve its integrity*" (page 10) – is so vague as to have little value. There is no explanation of the 'appropriate measures' referred to, nor is there any cited reference to support, or allow an evaluation of, these measures.

Aquatic Habitat

In the EA Report section Aquatic Habitat, page 12 states that "*headwaters appear to be utilized by Dolly Varden (Bull Trout) and Rocky Mountain Whitefish... Limited use appears to be made of Prairie Creek in the vicinity of the minesite, or downstream of the minesite above the mouth*". Bull Trout are a migratory species, hence they do likely pass by the area of the minesite seasonally, and may be affected by siltation at creek crossings. This species has been found to be very sensitive to industrial disturbance, according to studies in the East Slopes of the Rocky Mountains (N. Mochnacz, University of Manitoba, pers. comm.).

Wildlife and Wildlife Habitat

In the Wildlife and Wildlife Habitat sections, the EA Report also makes some questionable assertions. Page 13 concludes that this proposal will not impact caribou populations, however, research in northern Alberta has found that caribou do avoid linear disturbances, including roads, and even seismic cutlines (S. Dyer, University of Alberta, MSc Thesis, 1999). Therefore, the reopening of roads and construction of new roads associated with this proposal, in addition to the increased activity on site, some disruption to caribou movement patterns is likely to occur.

The statement (page 13) that Dall's sheep "*seem generally unperturbed by ongoing site activity*" is unsupported. There are no data or references presented to quantify or corroborate this claim. NNPR staff have observed Dall's sheep showing escape behaviour even when overflown in helicopter at high cruising altitudes, therefore the lower flights and ground machinery associated with this proposal are likely to cause greater disturbance. Drilling activity could also cause noise disturbance, potentially lessen habitat quality, and cause displacement of herds.

Similar displacement could be caused to wolverines, a COSEWIC listed species, which require large home ranges, and are known to occur in the Prairie Creek area.

The EA Report's reference to Grizzly Bears (page 13) also implies that there will be no effects. However, studies in the Rocky Mountains (*i.e.* Banff-Bow Valley Study, 1999) have shown that Grizzlies are very susceptible to disturbance, and are often forced out of habitat as human use increases. With an increasing number of workers in camp, there is also an increasing risk of bear-human conflict resulting from poor waste disposal practices and lack of knowledge regarding bear safety practices. Any such conflicts are likely to have a negative impact on bear populations, and have worker safety implications as well. No mention is made of bear safety training for work crews – this should be included in the orientation & training programs of all field workers.

Page 14 of this report states that "*no impacts are expected on migratory bird populations as no usage of the minesite area by such populations has been identified*". This comment is very difficult to accept, because many species of migratory birds are present in the region. In nearby NNPR, Scotter et. al (1985) recorded 170 bird species, of which 19 were considered permanent residents, and 4 were of unknown status. Therefore at least

147 species exhibit migration of some sort, and the vast majority of these would be international migrants, covered by the *Migratory Birds Convention Act*.

Although the variety of habitats represented in NNPR do not all occur in the minesite area - and this would serve to reduce the species diversity somewhat - it is extremely unlikely that there are no migratory bird populations in the area. This omission calls into question the quality (accuracy and completeness) of wildlife inventories for the area.

Closure and Reclamation

In the Terms of Reference for this EA, the Review Board requested information on plans for closure and reclamation of the site. The EA Report fails to address this question, avoiding it by merely stating that reclamation is not proposed at this time.

A document pertaining to restoration models for the Prairie Creek site, prepared by Indian and Northern Affairs Canada, was requested by NNPR on February 8, 2000, to provide further information on restoration options. NNPR had been informed that this document was a comprehensive modeling exercise, including assessment of environmental restoration options. Subsequent communications to the Review Board from DIAND (March 01 & 06) and CZN (March 08) have stated that this document deals only with the financial aspects of reclamation, does not examine environmental operation and cleanup methods, and is therefore not relevant to the Environmental Assessment.

In light of this information, and the concerns expressed regarding the confidential nature of information therein, NNPR is of the opinion that it is not necessary for park staff to review the document. At this stage of the EA process, we would not be able to make a thorough assessment of the document prior to the March 12 deadline for submission of technical reports. NNPR does, however, urge the Review Board to examine the document as a neutral third party, to determine if information relevant to the assessments is contained therein.

Cumulative Impacts

The Report's section on cumulative effects is very weak, and lacking in detail. The definition of cumulative effects used in the draft Cumulative Effects Assessment and Management Framework (CEAMF) for the NWT is the following:

> *" 'Cumulative effects' can be defined as changes to the environment caused by the combination of past, present and 'reasonably foreseeable' future actions. 'Environment' is broadly defined to include not only the natural or biophysical environment, but the social, economic and cultural aspects also."*

The EA Report (page 27) states specifically that the scope of the assessment was limited to " *the narrow spatial boundaries of the minesite*". Cumulative effects tied to this proposal, however, are much broader in scope. Elsewhere in the document (page 18) there is reference made to road construction right out to the Liard River, and other CZN documents have promoted the construction of additional airstrips and a tourism facility. The scope of 'reasonably foreseeable' actions is therefore much broader than indicated. These activities need to be considered as having relevance in this assessment.

The report seems to take the opinion that since development has occurred in the past, additional new construction on site will have no impact. However, it could also be argued that an area previously impacted is even more sensitive to additional industrial activity. The EA Report makes an unsubstantiated claim (page 28) that "*residual impacts [of previous activity] are principally visual and aesthetic, and confined to physical disturbance directly associated with the construction development of the existing facilities. No impacts on the surrounding environment are apparent or have been identified*". There is no data analysis presented to verify this claim.

Such data could include quantified wildlife inventories, vegetation plots or fisheries assessments, to determine conditions before and after use, and thereby indicate with some type of scientific backing whether or not there are effects beyond the 'visual and aesthetic'. Although there is a listing of some fisheries studies, no reference is made to scientific analyses thereof.

In fact, impacts of previous activity are widespread. The network of roads around the minesite is very extensive, and numerous creek crossings are present with little or no mitigation used in their construction. Leftover mining equipment can be found in various locations, over a wide area on both sides of Prairie Creek.

The statements regarding water quality testing and the CanTung mine (page 28) are misleading. It suggests that this operation never had water quality effects. However, as noted in the Report, the water quality monitoring program began in 1988 – two years after the CanTung mine shut down. With no baseline data before mine operation, or samples taken during mine operation, there is no way this program could have found mining-related impacts on water quality, so it is not known what impacts that operation may have had.

Conclusion

There are many deficiencies identified in this EA Report. Several unsupported assertions are made regarding negligible environmental impacts, where the impacts may in fact be highly significant. These include potential impacts on wildlife, vegetation, terrain, aquatic habitat and water quality. The location of the minesite and operations base to be used for this proposal, which is immediately adjacent to a creek valley subject to flash floods, in an active seismic area, is of great concern.

Cumulative effects are not adequately addressed in this EA Report. The current proposal is clearly linked to additional subsequent developments, as noted in other areas of the Report, yet these are not dealt with in the cumulative effects assessment.

From the information provided, it appears that the proposed activities do have the potential to cause significant environmental impacts, and are proposed in an inappropriate place for this type of development. The activities could compromise the ecological integrity of Nahanni National Park Reserve - a Canadian Heritage River and World Heritage Site - and the South Nahanni Watershed.

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From / De: Steve Catto

Date: March 09/2001

Pages: 18

Message

Louie

Ref 113

Please find attached a technical report pertaining to CZN Development Proposals, which has been prepared by Doug Tate.

We can provide the main text of the report electronically if you wish, but the 2 attachments to Part I are not available in an electronic format.

Steve

10. Karst and Pseudokarst Landforms

10.1 The Definition of Karst and Pseudokarst

Karst landforms are created by the aqueous solution of comparatively soluble rocks. In descending order of solubility, the latter are salt, gypsum and anhydrite, limestone, and dolomite. Salt is so soluble that it rarely survives at the surface. Gypsum displays good karst wherever it outcrops in Canada, and also where it is shallowly buried by other rocks, as in parts of Wood Buffalo National Park. At a global scale, limestone is the most important karst rock. It hosts the greatest extent and variety of features.

It is the important karst rock in Nahanni National Park. Good karst forms are comparatively rare on dolomite because of its lesser solubility, but it may channel water efficiently underground, creating the lack of surface channelled drainage that is characteristic of karst areas. The largest spring in Nahanni National Park, White Spray, flows from dolomite.

Pseudokarst landforms are karst-like features created by processes other than rock solution. These processes are usually physical or mechanical, for example, the melting of ground ice or formation of underground pipes in unconsolidated sediments by groundwater flushing processes. At the global scale, pseudokarst landforms are comparatively rare and minor features; but in Nahanni National Park both melting forms (Sub-section 9.11) and flushing (or "piping") forms are well developed.

10.2 Karst Landforms

Karst landforms may be divided into; (1) surficial features, and (2) underground channels (cave systems). The surficial features mainly function to feed water underground. There are three principal classes: (i) Karren are small-scale solution pits, grooves and runnels in bedrock. Individuals are rarely greater than 10 m in length or depth, but they may cluster to cover surfaces of many square km. Such surfaces are termed 'limestone pavements'; (ii) Dolines are cylindrical-, funnel-, or bowl-shaped sinkholes, generally 10-1,000 m in diameter or length. In most karst areas, these are the predominant surficial forms. Also of intermediate scale are residual rock towers; and (iii) Dry valleys, dry gorges, and poljes are normally greater than 1,000 m in length. Valleys and gorges are of fluvial origin but have lost their channel drainage into sinkholes and caves in the floor. Poljes are very large sinkholes, with flat floors that are often shielded by accumulations of residual clay; the features expand by corrosion of surrounding limestone cliffs. Most are seasonally inundated.

Cave systems comprise interconnected solution passages. Patterns may be very complex. Most solution passages are too small for human entry, but many systems of enterable passages have now been mapped

for more than 100 km. As they enlarge, passage form may be modified by mechanical erosion (as in a river channel), or by wall or roof collapse.

Two passage forms predominate; phreatic: (i) forms are developed in sub-watertable (fully submerged) passages where solution can attack walls and ceilings as readily as floors. They tend to be smoothly rounded or elliptical, sometimes with deep blind recesses (solution pockets); and (ii) vadose forms develop above a watertable where there is normal gravity drainage. They are underground canyon forms.

Many cave systems display a multi-storey development. Higher galleries are created first, but are drained when lower levels develop in response to external erosion agents (e.g. entrenching rivers) lowering the spring points. In this manner, originally phreatic passages may be left drained and relict. With one exception, explored caves of Nahanni National Park are relict features. Most currently active Nahanni cave systems are phreatic (i.e. fully flooded). Their exploration, if it ever occurs, will require the hardiest cave diving specialists.

10.3 "North Karst" of Nahanni

A belt of karst terrain developed in Rock Unit 8 extends from the eastern end of First Canyon 45 km northnortheast to the valley of Sundog Creek. It is the most rugged or accentuated karstland known anywhere in Canada or the United States. Brook and Ford (1975) described it in great detail and termed it "The North Karst".

Geographically most of the North Karst lies outside of the present Park boundaries. Its hydrological extent is indicated in Figure 4-22, where it will be seen that it drains to two major sets of springs. The southern set is White Spray, First Canyon; the southern half of the Karst is thus a part of the South Nahanni basin.

The Karst contains a great variety of surface forms. There are extensive tracts of limestone pavement and some hundreds of sinkholes, including shaft, funnel and bowl types. There are 14 residual rock towers, the greatest being 50 m in height, and at least 50 small natural bridges, another residual feature. There are three excellent examples of poljes (certainly the best reported in North America), and eight major dry canyons. The most unusual features we have termed "karst streets" (Brook and Ford 1975). These are long and deep solutional corridors following vertical joints. Their walls are now frost-shattered and their floors obstructed with the frost debris. The greatest is a semi-continuous feature 9 km in length. The streets intersect to form small natural labyrinths, and are widened by solution, frost and colluvial action at their junctions to create very large sinkholes with residual towers. The genetic pattern of these features is illustrated in Figure 4-23.

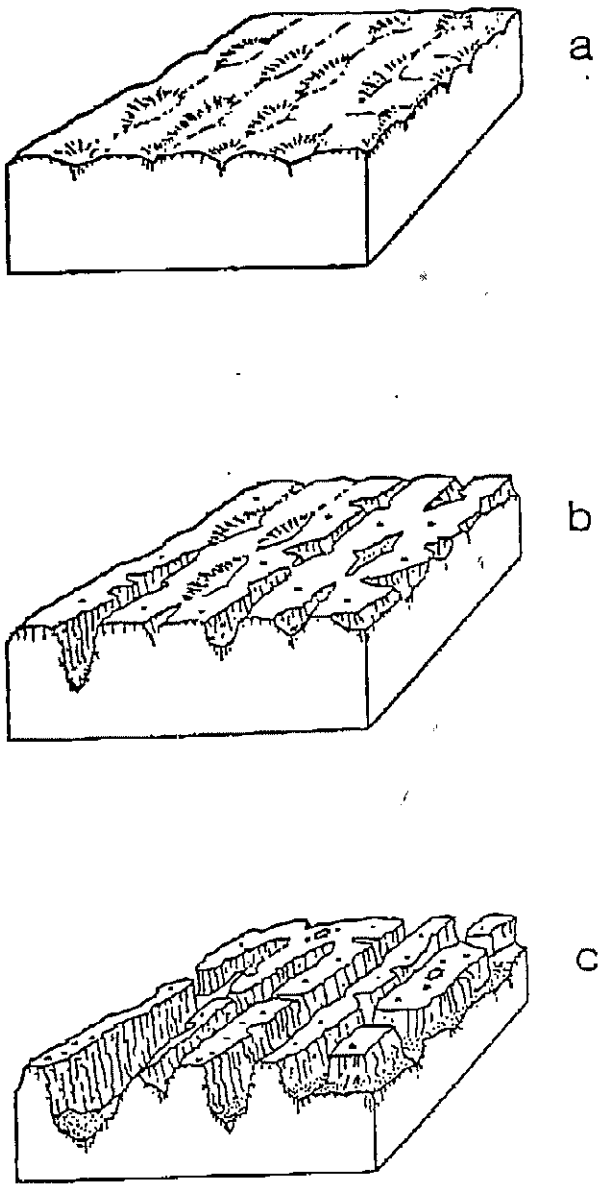


Figure 4-23. Three stages in the development of a natural rock labyrinth in a highly fractured limestone surface
a) Strings of elliptical dolines
b) Coalesce along the host fractires, until eventually become
c) Elongated vertical walled karst streets.

Unfortunately, the present Park contains only one example of a karst street and a few small patches of limestone pavement. The remainder of the surface features, including the best examples of all of them, lie to the north.

More than 200 cave entrances have been located in the North Karst. The great majority are relict phreatic forms. Most of them can only be explored for a few metres before becoming obstructed with silt or ice. Three of them have been explored for distances greater than 1,00 m; two of these, the Grotte Mickey system and Grotte Valerie, are in First Canyon.

10.4 Surface Karst Landforms in the Park

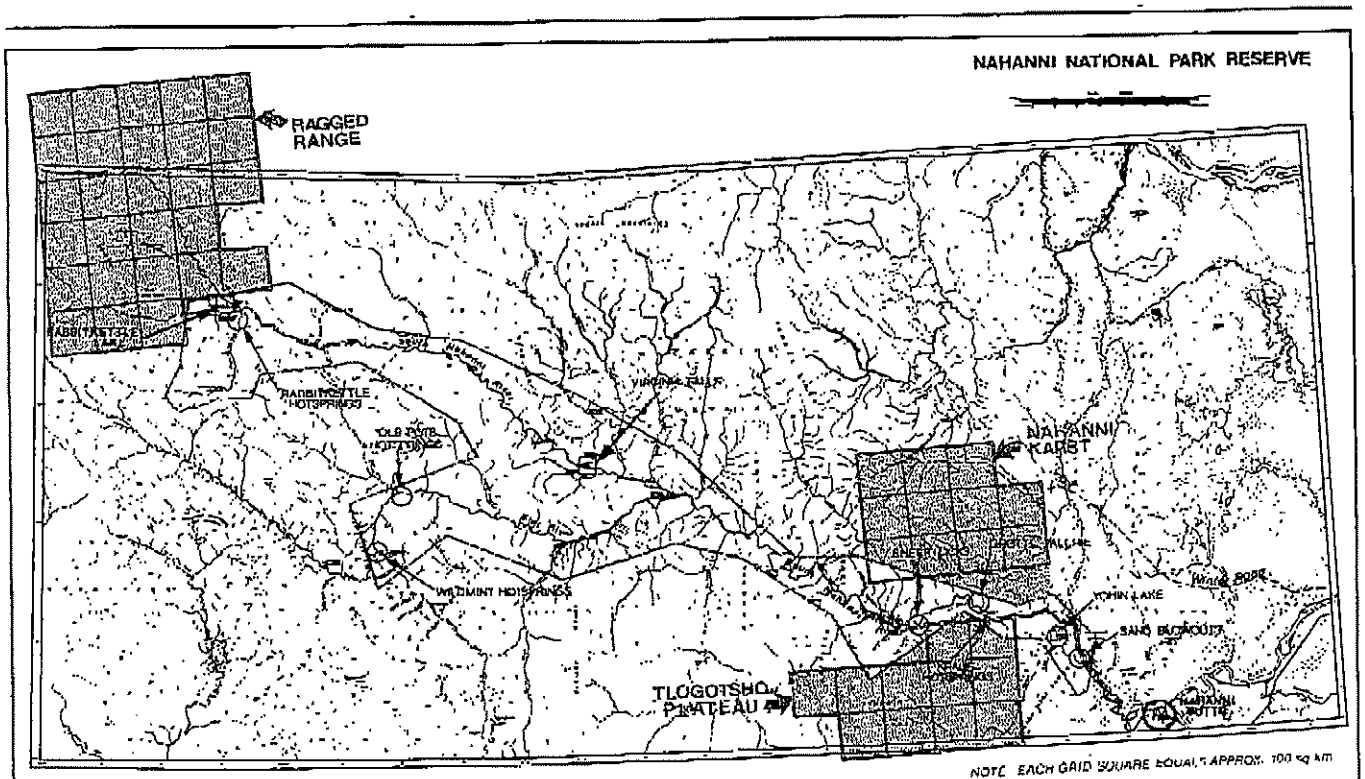
As noted, the Park contains only a small and unrepresentative sample of the surficial landforms. There are a few small patches of solution pavement on limestone close to the north and south rim of First Canyon. A single example of a street extends like a knife-slash from the north rim to the south wall of Lafferty Canyon. It is 1,200 m in length and deepends to 60 m in its central parts. It is rarely wider than 30 m. Slickensides that indicate the presence of a fault that the street follows can be seen in the north wall at one place. Several fragments of cave walls are preserved in half-relief elsewhere on the walls. The street floor is of irregular piles of rock debris. Water ponds in depressions there and filters downwards into the underground.

10.5 Catalogue and Classification of Limestone Solution Caves in and near First Canyon.

More than 120 apparent cave entrances have been noted in the Nahanni Formation limestone outcrops of First Canyon and its flanks, Prairie Creek Canyon, Lafferty Canyon and the unnamed canyon to the north of Lafferty. Distribution of those within the Park that are partly or wholly of solutional origin (true karst caves) is plotted in Figure 4-24; their extent and typology is recorded in Table 4-4.

Exploration of the caves began in 1970 with Jean Poirel's party. They numbered each entrance according to the chronologic sequence of sighting or visiting. Because on successive days they visited or spotted entrances in different localities or came upon others they had overlooked, this resulted in an erratic geographic pattern of numbering. The up-to-date catalogue of cavities was produced by Jacques Schroeder, who maintained the same number convention to avoid worse confusion. His numbers are used in Figure 4-24 and Table 4-4.

It will be seen that the numerical series, 1-108, of Table 4-4 has many gaps. This is because a) some 15 caves in Schroeder's catalogue are located north of the Park, and are omitted here and b) more than 40 apparent entrances that were numbered in the series proved to be largely or entirely frost pockets (discussed below, 10,6) and not true caves. Schroeder has dropped these from his location mapping.

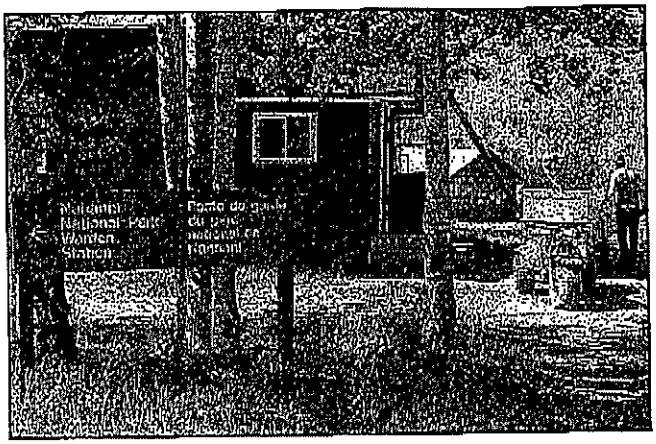


MAP 13
BOUNDARY CANDIDATE AREAS. *AREAS SHOWN ARE NOT FINAL BOUNDARY PROPOSALS. THEY REPRESENT AREAS OF HIGH VALUE FOR PARK PURPOSES WITHIN WHICH ENVIRONMENT CANADA, PARKS MAY SEEK BOUNDARY ADJUSTMENTS.*

Map 13. Boundary Alteration Areas.

7.0 ADMINISTRATION AND OPERATIONS

Nahanni presents special operational and administrative concerns relevant to the management plan. The park is relatively remote given its northern setting and the absence of direct road access. Visitation is concentrated in July and August with very limited shoulder season use. Nahanni is basically a linear corridor set aside largely with river recreation in mind. Consequently, wildlife and habitat management is more involved. The need for co-ordination with other agencies outside the park boundary is essential if successful wildlife, vegetation, and watershed management is to be achieved.



Nahanni Butte Warden Station.

The geographical realities of the park's location also influence administration and operations. The park's Administration Headquarters is located over 200 air kilometres away in Fort Simpson, while a year-round operational presence is maintained at the Nahanni Butte Warden Station.

Visitation based almost exclusively on river recreation requires a specialized form of management of both people and resources. Compatible commercial guiding and outfitting services are essential if a broader spectrum of the public is to have access to the park. At the same time, the wilderness nature and objectives of Nahanni demand that the management of visitors and the park's social carrying capacity be handled as carefully as the park's natural resources.

These and other park and regional characteristics dictate the careful administration required for effective and efficient park management, and reveal areas where adjustments must be considered.

7.1 NAHANNI BUTTE WARDEN STATION/OPERATION CENTRE

Since the establishment of the year-round station at Nahanni Butte and the transfer of administrative responsibility from Wood Buffalo National Park to the Fort Simpson office in 1976, the locations of these two centres were considered to be of a "temporary" nature. Factors such as the planned Liard Highway, the possibility of a spur road to Nahanni Butte, and a few years experience in the management and administration of this new park were considered sufficient rationale to delay final decisions on operational and administration centre locations.