BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

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B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES
LAND RESOURCES SUBGROUP

WILDLIFE ASSESSMENT REPORT

PREPARED BY:

THE TERA ENVIRONMENTAL RESOURCE
ANALYST LIMITED

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5.0 RESOURCE IMPACT

5.1 WILDLIFE RESOURCE PROJECTION WITHOUT THE PROJECT

(a) Summary of Anticipated Environmental Change

Two factors appear to be most critical in determining the future wildlife resource in both the local and regional study areas: the habitat available for wildlife and human intervention (especially the killing of game and problem species).

(i) Habitat

Without the Hat Creek project, the types and variety of habitat available to wildlife in the local study area are expected to remain essentially unchanged. The reason for reaching this conclusion is that, at present, no single land use in the local study area appears to have great potential for expansion, intensification and/or diversification. Livestock grazing is currently heavy in most areas and could not be intensified under the present management approach. Intensive agriculture has already expanded to what appears to be a limit imposed by the supply of irrigation water. In forestry, logging and fires have removed most of the mature stands of desirable forest species, so little logging would be anticipated in the near future. Beyond 1990, logging may increase again, as stands of trees begin to reach marketable size. Recreational capability is generally low and, except for sport hunting, is largely confined to Marble Canyon and the Thompson River. Details are available in the appropriate report (Physical Habitat and Range Vegetation, Forestry, Agriculture or Recreation) on the Hat Creek Detailed Environmental Studies.

The major factors affecting the vegetation (e.g., climate, topography and soils) are expected to remain unchanged, therefore, the theoretical climax vegetation over most of the local and regional study area is also expected to remain unchanged. However, most forested lands are now in a successional state and would develop towards a climax community unless a disturbance, such as fire, forest insect outbreak or forest harvesting returns the community to an earlier successional state.

Fires are common, although current fire control confines most fires to small parcels of land. Forest harvesting would be expected to continue as forest lands reach maturity. Thus, although individual areas would change in successional state, the overall pattern would remain more or less the same as at present.

Unforested lands, including wetlands, have been and still are heavily grazed and, as a consequence, have reached a zootic climax. Additional grazing is unlikely, but could cause further deterioration of range conditions. Reduced grazing would allow an extremely slow recovery (30 - 40 years) of range lands. Thus, range lands would be expected to remain virtually unaltered.

Regional study area environmental changes, even though more complex, would exhibit the same general trends. Most environmentally-modifying land uses, e.g., forestry, grazing and agriculture, appear to have little margin for expansion. In forestry, for example, most of the allowable annual cut has already been allocated and, therefore, very little potential exists for major forest industry expansion. Increased urbanization would be localized and would occur adjacent to the currently settled areas of Ashcroft and Cache Creek[78].

Mining, an activity capable of drastically altering the environment, is the major exception. Increased open pit mining activity is planned for the Highland Valley area southeast of the local study area, and these activities (plus expansion) could have major impacts on wildlife habitat.

(ii) *Mortality*

Wildlife mortality induced by humans is expected to be restricted to those species which are hunted for sport, trapped for profit, regarded as vermin, or accidentally killed in collision with vehicles. Such mortality is primarily the result of human demographic changes, but can be modified by resource management. With adequate resource management, wildlife population levels could be maintained at a sufficiently high level to allow continued sport hunting at current levels of harvest or higher.

Very little fur is harvested from an underutilized resource in the regional study area. The limiting factors are primarily fur prices, the attitudes of trappers and government policy. Currently, would-be trappers who do not own a trapline find considerable difficulty obtaining both a licence or a registered trapline (Section 4.8). Most trappers who already own a trapline put little effort into harvesting fur (Section 4.8). Thus, considerable opportunity could exist for an increase in fur harvest if economics dictate and policy allows.

Demographic changes in three areas are expected to affect hunting within the local and regional study areas. Hunter survey data collected by the B.C. Fish and Wildlife Branch[13] indicate that up to 40 percent of the hunters come from the Lower Mainland. Another 50 percent come from the regional study area. For certain types of hunting, such as small game, many hunters are unwilling to travel far, therefore, human population changes in the local study area could significantly alter annual harvests of various game species. Increased human numbers also increase the number of game species harvested incidental to other activities. For example, people out for a drive may carry a shotgun or rifle to take game or other animal species. Grouse and black bear are particularly vulnerable to this kind of hunting.

Expected demographic changes in the local and regional study areas, until the year 2020, and in the Lower Mainland, until the year 1991, have been supplied by Strong Hall et al[80] (Table 5-1). The Lower Mainland population growth

TABLE 5-1

PREDICTED DEMOGRAPHIC CHANGES IN LOCAL AND REGIONAL STUDY AREAS AND IN THE LOWER MAINLAND FOR THE WITHOUT THE PROJECT CASE

Year	Predicted Local Study Area Population	Percent Change From 1976	Predicted Regional Study Area Population	Percent Change From 1976	Predicted Lower Mainland Population	Percent Change From 1976
1976	7 500	-	77 300	-	1 277 000	-
1978	7 615	1.5	81 400	5.3		
1980	8 080	7.7	85 900	11.1	1 357 000	6.3
1982	8 990	19.9	91 000	17.7		
1984	8 990	19.9	95 700	23.8		
1986	9 370	24.9	100 800	30.4	1 479 000	15.8
1988	9 665	28.9	106 300	37.5		
1990	9 960	32.8	111 700	44.5	1 557 000	21.9
2000	11 600	54.7	140 000	81.1	1 756 000	37.5
2010	13 400	78.7	175 700	127.3	1 955 000	53.0
2020	15 600	108.0	221 000	185.9	2 155 000	68.7

Data Source: Strong Hall and Associates, Ltd. [80]

between 1976 and 1991 has been forcast to increase linearly at a rate of about 19,930 people per year*. This rate of increase has been extrapolated to the year 2020 to provide demographic data until the end of the project.

(b) Resource Use Projection - Without the Project

(i) Non-consumptive Wildlife Use

Very little information exists on non-consumptive wildlife use in the local study area. Currently, non-consumptive wildlife use appears to occur at a very low level in the Hat Creek Valley despite a high potential for such use. The reason for this discrepancy is judged to be a combination of factors: Hat Creek is not a destination in itself; a fairly long, time-consuming detour is necessary to see the valley; and once one is in the valley, very little opportunity exists to stop or to gain access to the natural features of the valley.

In the foreseeable future, very little change would occur to the factors that appear to limit non-consumptive wildlife use. Access to the valley via Oregon Jack Creek may be improved, attracting more drive-through visitors, but opportunity to stop and enjoy nature outside of one's vehicle would be unlikely to increase substantially without a change from the current agricultural land use. The current trend in attitudes regarding wildlife seems to be changing from consumptive use towards non-consumptive use. However, little potential for increased non-consumptive wildlife use exists unless the limiting factors mentioned above are altered.

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* Barry Hall, personal communication - letter dated February 20, 1978.

(ii) *Consumptive Wildlife Use*

A. Waterfowl

Expected changes in demand for waterfowl appear to be primarily a function of access. Currently, local residents constitute the majority of waterfowl hunters in the Hat Creek Valley (Appendix B). Some duck hunting opportunity for non-local residents is available near McLean Lake and in the Cattle Valley in the Trachyte Hills. However, access is through Indian Reserve land, and the ranchers and native peoples in the past have worked together to restrict hunter access to the Trachyte Hills.

Hunter access would not be expected to improve over the next 40 years unless the number of valley residents increases or the number of people who are allowed to hunt on their land increases. Hence, very little increase in hunter opportunity is expected to occur, and local consumptive wildlife use would be insulated against an increase in hunter demand outside the Hat Creek Valley itself. Little change from the current waterfowl consumptive use pattern would be expected in the immediate foreseeable future if the project does not proceed.

B. Upland Gamebirds

Upland gamebird hunter opportunity is much more diffuse than is waterfowl hunter opportunity and, hence, cannot be easily controlled by local ranchers. Consumptive use of upland gamebird resources is assumed to be more a function of an increase in human population.

Approximate increase in demand (hunter effort) for local upland gamebird resources can be gained from a knowledge of expected population increases[80] and hunter origin distribution (Appendix B). In both the local and regional study areas, approximately 60 percent of upland gamebird hunters reside within the regional study area, 30 percent reside in the Lower Mainland and 10 percent reside elsewhere in the province. Demographic projections indicate an anticipated growth by the year 2020 of approximately 150 percent in regional hunters (averaging Strong Hall results for "local study area" and "regional study area" to account for the effect of closer proximity of local hunters to Hat Creek[80]) and an anticipated population growth of 70 percent in the Lower Mainland*. No information is available for the remainder of the province, but if an annual growth rate of one percent per year is assumed, a 50 percent increase is anticipated within 40 years. The total increase in demand could then be calculated as the sum of the products of proportional population changes by hunter distribution (change in demand = 0.6 x 2.5 + 0.3 x 1.7 + 0.1 x 1.5 = 2.16) and amounts to a 116 percent increase by the year 2020. This increase is equivalent to a yearly increase in demand for upland gamebirds of approximately 1.9 percent.

If demand increases as has been postulated, two results are possible. Either harvests would increase proportional to the increase in demand, or the success rate per hunter would decline. The latter seems to be more likely because habitat conditions and accessibility of hunting areas, factors which control game availability, would remain the same. In all likelihood, additional hunting pressure would result in a greater proportion of the available game resource being harvested, increasing total harvest. However, such an increase would be minor compared to the increase in hunter effort. Thus, more hunters would harvest the same or a slightly increased amount of game, creating a situation of gradual decreased success rate for upland gamebird hunters.

C. Furbearers

As was noted in Section 4.8, furbearer harvests are currently relatively low within the regional study area and almost nil within the local study area. No traplines are registered within the local study area. Fur harvest within the regional study area is most abundant in the northeast portion of the study area (Economic Analysis Sector D2) with additional harvest occurring in

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* Barry Hall, personal communication - letter dated February 20, 1978.

the southeast portion (Economic Analysis Sector D3). Most traplines in these portions are lightly used, but a few are trapped intensively. In contrast the southwest and northwest portions (Economic Analysis Sectors D4 and D1) have many traplines but almost no harvest. The potential, therefore, exists to greatly increase the fur harvest from the existing regional traplines.

Regional economics appear to be such that trapping is not a viable economic alternative for most people. Economics could change; a new interest in trapping, an increase in fur prices, or the granting of additional traplines could all increase furbearer harvest. The level of the harvest is so low that it would be unlikely to drop. Any changes in future harvests from registered traplines would be extremely difficult to predict.

D. Big Game

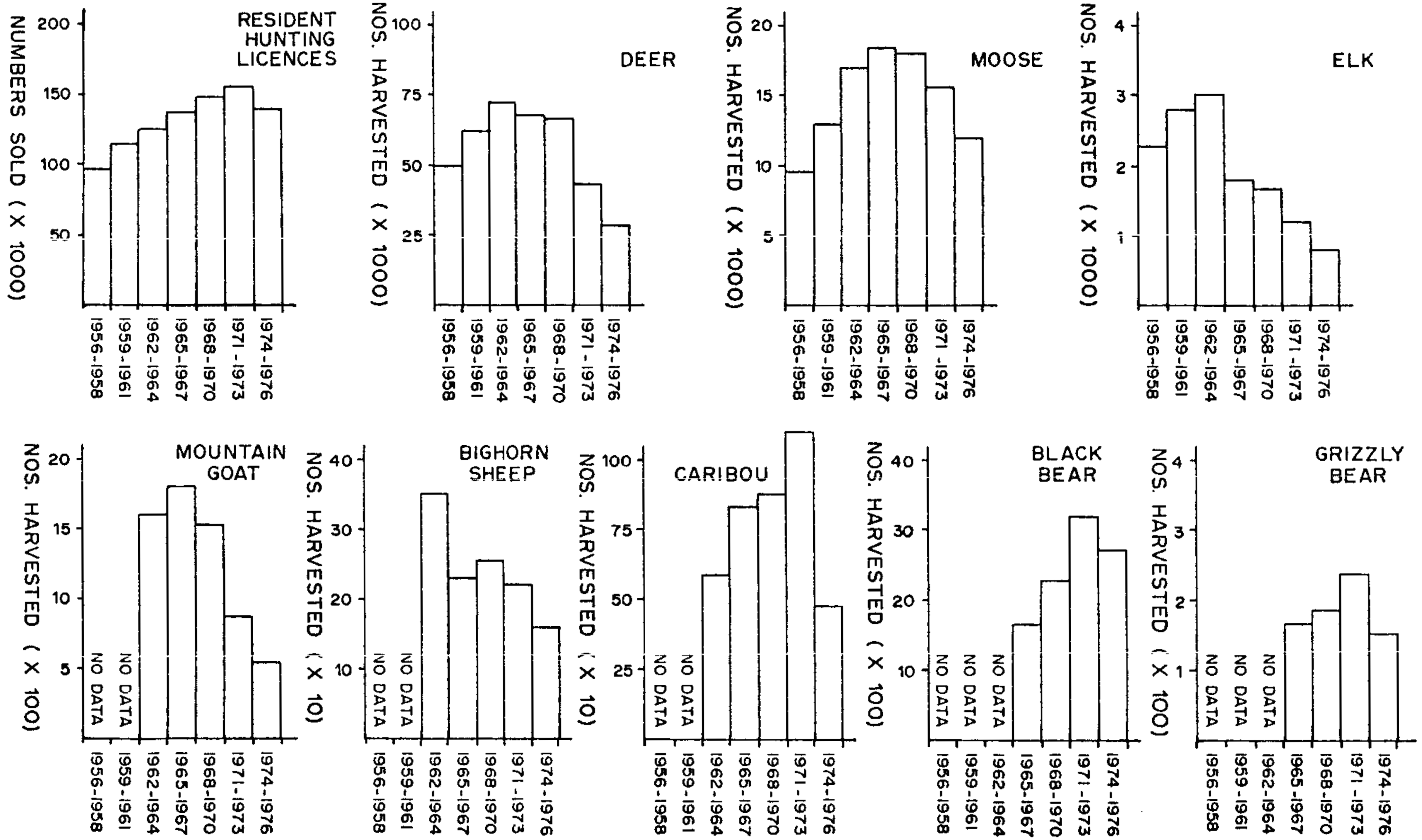
B.C. Fish and Wildlife Branch game harvest questionnaires reveal that from 1950 to 1970 the number of moose and deer harvested in B.C. increased 450 percent and 280 percent, respectively. Increased game harvests are attributed to the introduction of antlerless seasons in 1954, and to improved moose and deer habitat created by logging. The game harvest questionnaire analysis report for 1970 noted that, "At the present time it would appear that deer and moose populations are capable of sustaining further large increases in hunting pressure, not only without damage, but with benefit to the populations, through the reduction of intra-specific competition for food and shelter during critical periods."[43]

In contrast to such optimism, actual harvest data (Figure 5-1) show that harvests by resident hunters of all big game species except bear have declined since 1970. This figure also presents licence sales and estimated big game harvests by B.C. residents averaged over 3-year periods between 1956 and 1976. Examination of these data reveals a gradual increase in the number of licences sold between 1956 and 1973. The rise in licence sales was more rapid than the general rise in population while the increases in harvest of deer and moose were greater than the increase in the numbers of hunters[43]. This implies

FIGURE 5-1

MEAN YEARLY HUNTING LICENCE SALES AND ESTIMATED BIG GAME HARVEST IN BRITISH COLUMBIA BY RESIDENT HUNTERS BETWEEN 1956 AND 1976

Three Year Averages of B. C. Fish and Wildlife Branch Hunter Sample Information



that hunting as a form of outdoor recreation in British Columbia had increased in popularity between 1956 and 1973.

Hunting licence sales continued to increase as long as sustained and/or increasing numbers of animals, particularly deer and moose, were being harvested. Harvest data (Figure 5-1) reveal that estimated bighorn sheep harvests apparently peaked prior to 1962, while mountain goat and elk harvests peaked between 1962 and 1967. Estimated deer harvests maintained an average level of approximately 60 000 animals per annum from 1958 to 1971, and moose harvests at approximately 22 000 animals in 1968. A decline in general hunter success, initiated in the late 1960's, was followed by a decline in licence sales in the mid 1970's. It is worthy to note that the decrease in licence sales had a lag period of several years behind declining hunter success, and that deer, moose, elk, mountain goat and bighorn sheep harvests have steadily and sharply declined since the early 1970's. Based on this apparent relationship between hunter success and licence sales, it is speculated that licence sales will continue their decline until at least several years after big game harvests stabilize.

Over the past several years, B.C. has experienced increasingly restrictive hunting regulations and reasonably mild winters. As well, beef prices have risen sharply. The first two factors have the potential to enhance big game numbers, while the third factor tends to stimulate licence sales. It is anticipated that the combined effect of these variables will be a leveling of the declines in hunter success rates and licence sales. However, based on our present resource management approach, the economic situation and the inevitability of at least one harsh winter, it is speculated that increases in big game harvests, if they occur at all, over the next decade would not come close to reaching the past peak levels as illustrated in Figure 5-1.

Deer and moose harvests in the local and regional study areas may have peaked earlier than the dates calculated for provincial averages. Sections 4.8(a) and (b) indicate that regional study area moose numbers peaked in the late 1940's. Road access and settlement patterns during this period were probably insufficiently developed to allow hunters to take full advantage of the abundance of moose. However, it is likely that regional study area moose harvests peaked in the 1950's.

Deer numbers were reported to peak in the early 1960's. By this time, access was well developed and interior communities were rapidly expanding. Regional study area deer harvests peaked as animal abundance increased.

Information on harvests of the remaining big game species found in the regional study area (elk, caribou, bighorn sheep, black bear, grizzly bear, cougar and wolf) is minimal because records were not kept by the F.C. Fish and Wildlife Branch until relatively recently. Elk and caribou numbers declined in the mid 1800's and early 1900's, respectively (Section 4.8(a)(ii)). Harvests of these two species in the regional study area was likely maximized during the influx of gold miners in the 1850's and 60's. Due to low animal numbers (Section 4.8 (a)(ii)), bighorn sheep harvests were likely maximized prior to implementation of restrictive hunting regulations enforced by the Provincial Game Commission in the 1930's. Wolf and cougar populations likely peaked in numbers along with their prey species, moose (late 1940's) and deer (early 1960's). Whether or not harvests of those predators peaked at these times is unknown.

The reader should note that every wildlife category illustrated in Figure 5-1 has increased in value, peaked, and then declined in the 20-year period between 1956 and 1976. Within this overall pattern, large year-to-year variations exist. Maximum yearly fluctuation in numbers of licences sold was 160 percent, while estimated elk harvests fluctuated 380 percent, goat 330 percent, deer 250 percent, caribou 235 percent, sheep 220 percent, moose 196 percent, black bear 195 percent, and grizzly bear 160 percent. The magnitude of these past fluctuations lend some uncertainty to the projected hunter demands and harvests.

Game abundance, itself affected by many factors (see Section 5.1(b)(vii)), strongly influences consumptive use of big game. Other major influences include assessibility, human demography, changes in public opinion towards hunting, and government regulation of hunting. In addition, a great many subtle factors, such as the cost of hunting licences, gasoline, or beef, also influence hunting licence sales.

Both the local and regional study areas offer many attractive features to resident hunters. The large metropolitan Lower Mainland area is relatively near, as is the fast-growing community of Kamloops. Both population centres are connected to the study area by the Trans-Canada Highway and access to the southwestern portion of the regional study area would be greatly increased by development of the Vancouver-Pemberton-Clinton transportation corridor. In addition, the regional study area contains 10 of the big game species found in B.C., with the local study area containing seven.

Table 5-2 presents the estimated local and regional study area big game harvests for 1976. Deer were the most frequently harvested species, followed by moose, black bear and bighorn sheep. As previously suggested, the annual number of these animals harvested has been on the decline. Over the next decade, harvests may level off or show slight increases. However, peak harvests, as revealed in Figure 5-1, are unlikely to be achieved on a local study area, regional study area, or provincial basis without major revisions in our present resource management approach. The harvests listed in Table 5-2 would, therefore, be representative of long-term average big game harvests from the local and regional study areas in the foreseeable future.

In summary, demand for big game appears to be regulated by two major factors: population growth and popularity of hunting. In recent years, hunting activity has decreased with the increase in human population. This waning interest is presumably in response to the recent drop in big game harvests. The human populations of the local and regional study areas, and of the Lower Mainland are expected to increase substantially in the next few decades. Thus, hunting demand is expected to increase. However, big game harvests appear to be anchored to current levels, so any increase in the numbers of regional and local hunters would cause a decrease in success rate. Neverthe-

TABLE 5-2

ESTIMATED BIG GAME HARVESTS DURING 1976
IN THE LOCAL AND REGIONAL STUDY AREAS BY RESIDENT HUNTERS

(Data on estimated wolf and cougar harvests were not available)

Species	Study Area	
	Local	Regional
Deer	124	1460
Moose	20	361
Black Bear	6	144
Mountain Sheep	3	14
Mountain Goat	0	39
Grizzly Bear	0	4
Elk	0	2
Caribou	0	0

Figures taken from Section B3-3(a), Tables B3-7 through B3-13, Detailed Environmental Studies Land Resources Subgroup Wildlife Report.

less, because of the close proximity to Vancouver and Kamloops, the existing and possible future highway connections, and the existence of good diversity and numbers of big game species, it is unlikely that hunter effort would drop. Hunter effort is expected to increase at an undetermined rate, which is slower than the rate of population growth, while big game harvest is expected to generally maintain present levels or decline slightly.

(c) Resource Projection - Without the Project

(i) Reptiles and Amphibians

No significant changes are expected in the local or regional study area reptile or amphibian resources. These species are not harvested and would not be directly affected by social or demographic changes. The habitats in which reptiles and amphibians are found (i.e., riparian and aquatic) would not be expected to be removed or significantly altered between now and the year 2020; anticipated changes to wetlands are discussed in the following waterfowl section.

(ii) Waterfowl

Habitat for waterfowl (i.e., wetlands) would be expected to remain more or less unchanged between now and the year 2020. Some flooding or minor draining of wetlands for agriculture should have minor impacts with both positive and negative effects that may well cancel each other. Overgrazing of wetland margins can and has in places severely limited the ability of wetlands to support breeding and migrating waterfowl. Potential for improvement of waterfowl habitat exists within the Hat Creek Valley.

If, as anticipated, waterfowl habitat remains largely unaffected, the numbers of ducks breeding in both the local and regional study areas should also remain approximately the same (with year-to-year variation) in future years. The number of waterfowl using the Hat Creek Valley as a stopover during spring and fall migration is primarily a function of events which occur at *the wintering and breeding grounds and are, thus, not affected by local or* regional events. The ability of Hat Creek wetlands to support migrating waterfowl would be expected to remain approximately the same as it is now.

(iii) Upland Gamebirds

Long-term changes in populations of upland gamebirds would not be expected to occur in the absence of the Hat Creek project. The habitats utilized by these birds would remain virtually unchanged, and concommitantly their capability to support gamebirds would remain the same. Hunter effort has been calculated to increase by as much as 116 percent by the year 2020. Such an increase in hunter effort could significantly increase the rate of upland gamebird mortality during the hunting season. However, experimentation has shown that autumn mortality of grouse has little effect on the population dynamics of grouse[81]; grouse appear to be limited by other factors. Hence, no significant impact would be expected on upland gamebird populations.

(iv) Non-Game Birds

No significant changes are expected in the local or regional study areas for non-game birds. These species are usually not harvested. Research has repeatedly shown that bird species presence and diversity can be predicted on the basis of habitat and vegetation physiognomy[82]. Because very few changes are expected in the Hat Creek local and regional study area physical and biotic environment, very few changes are to be expected in the avifauna.

(v) Furbearers

Furbearers are harvested and some, e.g., wolf and coyote, are also regarded as game species and can be harvested by those with hunting licences as opposed to those with trapping licences. Beaver are sometimes regarded as pests and may be trapped on private land on request of the landowner by a licenced trapper or by a provincial biologist, or might even be surreptitiously removed by the offended landowner.

Harvesting of furbearers is currently low; hence, populations are probably nearly maximal (within the year-to-year variation typical of many furbearers). An exception would be coyotes which have been harvested in large numbers. For example, one Hat Creek rancher reported that 36 coyotes had been shot on his land in one winter (1975-1976). However, the following summer, coyotes were still very much in evidence on that rancher's property. Current levels of harvest do not appear to appreciably diminish coyote populations.

Without drastic changes in habitat or harvest, no changes in furbearer populations are expected.

(vi) Small Mammals

As with other non-economic species, no changes are expected to local or regional small mammal populations if the project does not proceed. Minor changes that would occur as the result of habitat succession or other natural phenomena would probably be inconsequential.

(vii) Big Game

The regional study area has experienced major changes in big game species composition and numbers since the turn of the century. Moose were expanding their range in B.C. at this time and were first reported in the regional study area around 1910. Rocky Mountain elk and mountain caribou numbers declined drastically after the 1930's while moose and mule deer numbers increased to peaks in the late 1940's and early 1960's, respectively. Rocky Mountain bighorn sheep (1932) and elk (1972) were transplanted back into areas they had disappeared from, and an expanding human population has continually increased pressure on the numbers and habitat of all big game species, particularly mountain goat and grizzly bear. Reasons for the shifts in species composition and numbers can only be speculated, and it is conceivable that these changes may seem insignificant to those which may occur in the area over the next half century as big game management techniques improve, better land use practices are developed, and human demands change. The following big game resource projection is made in light of the above. Big game habitat requirements are presented in Section 4.8(a). Over the long term, healthy populations of ungulates in B.C. depend upon the availability of good quality winter range. Additionally, mountain goats are very susceptible to hunting pressure and require stringent harvest restrictions. Grizzly bears require large tracts of remote habitat, and populations of large predators (wolf and cougar) fluctuate in response to population fluctuations of their ungulate prey.

The most obvious conflicts between land use and wildlife involve logging, mining, and agriculture. These land uses provide access to remote areas and usually drastically alter vegetation. Through proper planning, these land uses often have the potential to enhance wildlife habitat. Unfortunately, in B.C. history, this has been the exception rather than the rule. However, in the past several years, various planning procedures have been developed to alleviate at least some of these problems. The Resource Folio System, the Environment and Land Use Committee guidelines and, in the Kootenay Region of B.C., the Co-ordinated Land Use Planning System, incorporate wildlife considerations into logging, mining and agricultural practices, respectively. These are relatively new programmes but even in their infancy they appear to be successful from a wildlife point of view.

A considerable number of big game species is harvested every year by hunters in B.C. Following the hunting season, wildlife species must contend with the critical conditions of winter, a second factor which accounts for considerable big game mortality. The combination of these two factors has serious repercussions on animal numbers. The major control that the B.C. Fish and Wildlife Branch has over these mortality factors is hunting regulations devised and enforced to regulate the numbers and sex of game animals harvested.

As habitat and mortality play major roles in big game abundance, the manipulation of these two factors over the next 40 years would obviously have a significant effect on future wildlife resource availability. Realistically, the land use planning processes now being developed have the potential to benefit most big game species in the local and regional study areas.

Table 5-3 illustrates the big game species present, conflicting land use and the potential for increasing animal numbers in the future. The contents of the table are subjective in nature and are based on impressions formulated by the author. The table suggests that within the local study area the potential to increase deer numbers is high, while the potential to increase mountain sheep and elk numbers is moderate. In the regional study area, it is proposed that a moderate potential to increase deer, moose, mountain sheep and elk numbers exists.

Realization of increases in big game numbers are dependent upon a multitude of factors. Some of these have been outlined above. Whether or not political, economic and social conditions coalesce to produce increased numbers is another matter. However, at the present time, the option to increase numbers of certain big game species appears to be available in both the local and regional study areas.

(viii) Rare and Endangered Species

Predicting the future for rare and endangered species is difficult. The mere fact that a species is endangered means, by definition, that its continued existence is imperiled. The local and regional study areas are of very little consequence to total populations of any of the rare or endangered species listed in Table 4-44. Environmental changes that would significantly affect the ability of the local and regional study areas to support most of these rare and endangered species are not expected. However, cougar, wolf and grizzly bear are affected by intrusions into their remote habitat and by changes in prey abundance, both of which would be affected by the projected increase in human populations (Table 5-1). Hence, these species may decline

TABLE 5-3

LAND USES CONFLICTING WITH BIG GAME SPECIES
IN THE LOCAL AND REGIONAL STUDY AREAS
AND THE POTENTIAL FOR INCREASING ANIMAL NUMBERS

Species	Conflicting Land Uses		Potential for Increasing Animal Numbers in the Study Area	
	Major	Minor	Local	Regional
Deer	AG, FOR, EHP	MIN, AD	High	Moderate
Moose	FOR, AD		Low	Moderate
Mountain Sheep	AG, EHP, AD	MIN, FOR	Moderate	Moderate
Mountain Goat	AD, EHP		None	Low
Elk	AG, FOR	EHP	Moderate	Moderate to Low
Caribou	FOR, AD		None	Low
Black Bear			Low	Low
Grizzly Bear	AD, FOR, MIN, EHP	AG	Very Low	Low
Wolf			Low	Low
Cougar			Moderate	Moderate

AG = Agriculture
FOR = Forestry
MIN = Mining
AD = Access Development
EHP = Excessive Hunting Pressure

further or even disappear. Grizzly bear are especially likely to succumb to such changes.

5.2 WILDLIFE RESOURCE PROJECTION WITH THE PROJECT

The proposed Hat Creek project or any other project, can affect the environment in a great variety of subtle and complex ways. Such effects generally fall into one of three categories with respect to the impact upon wildlife: habitat alienation, direct interaction, or alteration of ecological processes.

Habitat alienation means that lands which were previously productive of wildlife are no longer so. Loss of habitat can have a severe impact upon populations of some species. Habitat alienation is, to some extent, defined by a reference species. For example, the erection of a 3 m (13 ft.) high chain-link fence would alienate lands from use by ungulates, but would not alienate lands from use by birds or by small mammals.

Direct interaction between man and wildlife can take place in many ways. It can range from the benign observation of wildlife to the total extinction of a species by relentless exploitation. Noise, increased activity, and increased hunting are all examples of project activities that potentially interfere with wildlife. In this report, these types of effects are discussed under the headings "noise and harassment" and "direct exploitation".

Alteration of ecological processes covers a very wide range of sometimes poorly understood phenomena. The addition of toxic substances to the environment is perhaps the most obvious and most studied type of alteration. However, a change in any environmental parameter can induce a large biological response if some critical limiting factor is involved, e.g., the eutrophication of aquatic ecosystems. Alterations of ecological processes can have trivial impacts, extremely deleterious impacts, or beneficial impacts, and can be local or far-reaching. The magnitude and extent of this type of impact can be difficult to predict. In this report, these types of effects are discussed under the headings "dust and air emissions" and "indirect changes".

The project itself has been divided into four categories: preliminary site development, construction, operation and decommissioning. Preliminary site development consists of those facilities and activities necessary to formulate definitive plans for development. Most of these activities have been completed. The actual operation and maintenance of the previously installed facilities constitutes the operation of the Hat Creek project. The most notable items are emissions from the stack and cooling towers, some of the mining activities, and the creation and gradual enlargement of ash disposal dumps. The mine is somewhat problematical in that it is in essence a hole plus piles of crushed rock and dirt, all of which are gradually enlarged and, thus, cannot be naturally divided into "construction" and "operation" phases. We have arbitrarily included 15 percent of the pit, the north valley waste dump, the coal blending area near the pit mouth, the temporary topsoil stockpile, the conveyor system, and the shop and maintenance buildings in the list of facilities associated with the "construction" of the mine. The other mine facilities are arbitrarily considered to comprise the "operation" of the mine.

Decommissioning concerns the process of changing from coal production and electricity generation to other land uses. All reclamation and revegetation has been considered under this heading.

(a) Preliminary Site Development

(i) Drilling Programme

The drilling programme commenced before the wildlife sampling programme began, and continued until after the wildlife sampling programme ceased. Sufficient information regarding the numbers of holes drilled, the location of these holes, or the amount and type of ancillary activities has not been available to derive any realistic assessment of the net impact of the drilling programme upon wildlife.

In excess of 300 test holes have been drilled in the Hat Creek Valley. Each hole was surrounded by a small circle (approximately 10 m or 20 ft. diameter) of disturbed land which was often barren of vegetation and had metal pipes and wooden stakes protruding in various places. A small mudhole was often created adjacent to the bore hole. Access to the drilling sites was by existing roads or by newly constructed temporary roads.

In addition, a considerable amount of noise and activity has accompanied the drilling programme. Again, no quantification of noise or activity has been made available. The baseline wildlife inventory was done concurrent with the drilling programme and, thus, surveyed only that portion of the wildlife resource which was tolerant of the disturbance wrought by the preliminary site development. Such noise and activity have probably had a minor impact upon local wildlife species.

(ii) Bulk Sampling Programme

The anticipated impact of the bulk sampling programme has been previously described (June 27, 1977)[83]. The actual impact of the programme has been described in a preliminary report by B.C. Hydro and Power Authority[84]. From information received to date, the actual environmental impact of the bulk sampling programme upon wildlife has been consistent with expectations and appears to have been minor and restricted to the immediate vicinity of the excavations. The B.C. Hydro and Power Authority report summarizes:

> *"Environmentally, results to date have been consistent in confirming that environmental impacts have been restricted to the immediate areas of the trenches and related (waste and coal storage) areas. There have been no project-related alterations to air or water (Hat Creek) quality. Noise has in no way been a major issue with the local residents almost unaware of the mining activities. Dusting from the trench workings proved to be a local, operational problem. Initial results would indicate no increase in ambient suspended particulate which could be attributed to this program. The transport-*

ation phase proceeded almost unnoticed by local residents; truck covers were effective in eliminating dust problems."[84]

(b) Construction

(i) Environmental Changes

This section lists changes to the environment which are expected to result, either directly or indirectly, from the construction of the Hat Creek project facilities. Project actions and the extent of their influence are described. Additionally, the functional response of wildlife organisms to each type of environmental alteration is discussed. The functional response, the extent of environmental alteration, and the wildlife resources are incorporated together to produce an estimate of net impact, or numerical effect, in the subsequent "Resource Projection" section.

A. Habitat Alienation

This section identifies, classifies and, where possible, quantifies environmental changes which are directly attributable to the installation of facilities for the proposed Hat Creek project. The impact of these changes upon the wildlife resources is discussed in the subsequent "Resource Projection" section. Official project descriptions[85, 86, 87, 88] were used to produce a list of project facilities (Table 5-4), and to produce working maps which show the approximate size, location and configuration of each facility in relation to wildlife habitats (Map 5-1). The areas directly affected by each facility were either obtained from official documents and verified by planimetry or were estimated by planimetry.

The alignment, precise location and configuration of all project facilities currently cannot be determined. However, in our opinion, this information is not necessary to assess adequately the environmental impact of the proposed Hat Creek project. In most instances, a small change in location or configuration of a facility would have a negligible effect on the overall impact of

TABLE 5-4

LIST OF PROJECT FACILITIES

	Facility Code
a) Mine Construction Facilities	
Mine Construction Camp Housing and Parking	CM1
Mine Construction Camp Sanitary Effluent Treatment Plant	CM2
Mine Construction Camp Effluent Treatment Basin	CM3
Mine Construction Camp Substation	CM4
Mine Construction Camp Water Storage Reservoir	CM5
Mine Construction Camp Water Supply Pipeline	CM6
Open Pit #1, Initial Stages	M1
North Valley Waste Dump	M3
Coal Blending Area	M14
Temporary Topsoil Stockpile	M16
Conveyors	M17
Shop and Maintenance Buildings	M18
b) Plant Construction Facilities	
Power Plant Construction Camp Housing and Parking	CP1
Power Plant Construction Camp Sanitary Effluent Treatment Plant	CP2
Power Plant Construction Camp Effluent Treatment Plant	CP3
Power Plant Construction Substation	CP4
Power Plant Construction Camp Water Storage Reservoir	CP5
Power Plant Construction Camp Water Supply Pipeline	CP6
Power Plant Site, entire area within fence	P1
Craft Parking Lot	P2
Office Parking Lot	P3
Make-up Water Reservoir and Dams	P4
Water Pipeline between Reservoir and Power Plant	P5

	Facility Code
c) Offsite Facilities	
Headworks Reservoir and Dam	OD1
Hat Creek Diversion Canal	OD2
Hat Creek Diversion Canal Discharge Conduit	OD3
Pit Rim Reservoir and Dam	OD4
Pipeline, Pit Rim Reservoir to Diversion Canal	OD5
Site 2 Storage Reservoir and Dam	OD7
Possible Pipeline from Diversion Canal to Make-up Reservoir	OD8
Finney Creek Diversion Canal	OD9
Make-up Water Pipeline from Thompson River	OW1
Booster Pumping Station I	OW2
Booster Pumping Station II	OW3
Water Intake Station	OW4
Summit Surge Tank	OW6
One-way Surge Tank	OW7
Drainage Pipeline	OW8
69 kV Transmission Line to Construction Substation	OT1
Twin 69 kV Transmission Line between Construction Substations	OT2
69 kV Transmission Line between Rattlesnake Substation A and Booster Pumping Station II	OT3
69 kV Transmission Line between Rattlesnake Substation A and Booster Pumping Station I	OT4
69 kV Transmission Line Tie-in	OT5
Rattlesnake Substation	OT7
Airstrip, Site A	OA1
Airstrip, Site C	OA3
Airstrip Access Road, Site A	OA4
Airstrip Access Road, Site C	OA6
Offloading Area	OF1
Offloading Railroad Spur	OF2
Offloading Access Road	OF3
Main Access Road	OR1
Power Plant Site Access Road	OR2

	Facility Code
c) Offsite Facilities (Continued)	
Water Intake Station Access Road	OR3
Booster Pumping Station I Access Road	OR4
Booster Pumping Station II Access Road	OR5
Spoil Areas	OR6
Borrow Pits	OR7
d) Mine Operation Facilities	
Open Pit #1, to 600 ft. Excavation	M1
Medicine Creek Waste Dump	M2
Houth Meadow Waste Dump	M4
Lagoon 1	M5
Lagoon 2	M6
Lagoon 3	M7
Lagoon 4	M8
Lagoon 5	M9
Lagoon 6	M10
Topsoil Stockpile, Mine Entrance	M11
Topsoil Stockpile, Landing Strip	M12
Topsoil Stockpile, South Medicine Creek	M13
Low Grade Coal Stocking Area	M15
Drainage Ditches	M19
e) Plant Operation Facilities (Ash Disposal Options)	
Wet Ash Disposal Scheme Ash Pond and Dam	P6
Wet Ash Disposal Scheme Ash Conveyance System	P7
Wet Ash Disposal Scheme Alternative Bottom Ash Dump	P7.5
Dry Ash Disposal Scheme I, Ash Dumps	P8, P9
Dry Ash Disposal Scheme II, Ash Dumps	P10, P11, P12

the project; the same types and proportions of lands would be affected in the same way. The approach has been to generate a reasonable and probable picture of the proposed Hat Creek project. Whenever this has not been feasible, an attempt has been made to use a worst case analysis so that the actual project impact would be less than or equal to the estimated impact.

Proportions of wildlife habitats within the total area affected by each facility were estimated by planimetry or, for roads, pipelines, canals, conveyors and transmission lines, by linear measurement. Estimates of areas of wildlife habitats affected by each project facility were obtained by multiplying the habitat proportions by the total area occupied by each facility.

Mine

The habitat alienated during the construction phase of the mine is listed by facility and by wildlife habitat in Table 5-5. The total amount of land alienated would be 293 ha (742 acres) or 0.2 percent of the local study area. Most of the mining activity would be concentrated at the valley bottom in the northern portion of the Upper Hat Creek Valley.

Almost all of the land alienated by the mine facilities would become temporarily totally barren. The impact is not subtle; piles of broken rock, disturbed topsoil, and exposed faces of rock and coal are not productive or supportive of wildlife. Plans are being formulated to restore most of the area disturbed by the mining activity to a state of biological productivity. This reclamation process will be discussed under the heading "Decommissioning" (Section 5.3(d)), and one could expect a temporary habitat loss followed by a permanent habitat alteration. Such a habitat alteration could be detrimental to some wildlife species, but advantageous to others.

The greatest relative impact of the early stages of the mine would be on sagebrush habitat of which 144 ha (356 acres) or 21.5 percent of the local study area resource would be lost. Riparian (1.3 percent), mid elevation grassland (0.6 percent) and ponderosa pine - Douglas-fir/bunchgrass (0.5

TABLE 5-5

LAND AREA ALIENATED BY CONSTRUCTION OF PROPOSED HAT CREEK COAL MINE

Facility	Total Facility Area (ha)	Subalpine Krummholz (1)	Engelmann Spruce Lodgepole Pine (2)	Douglas-fir/ Pinegrass (3)	Ponderosa Pine-Douglas-fir/ Bunchgrass (4)	Aspen (5)	Riparian (6)	High Elev. Grassland (7)	Mid Elev. Grassland (8)	Low Elev. Grassland/ Saline Depression (9)	Sagebrush (10)	Big Sage (11)	Brush (12)	Bog (13)	Cultivated Field (14)	Waterbodies (15)	Exposed Rock (16)	Urban (17)
CM1	5.1				5.1													
CM2	0.02				0.02													
CM3	0.07				0.07													
CM4	0.02				0.02													
CM5	0.06				0.06													
CM6	3.3			0.2	2.9					0.2								
M1	115.0				10.0		9.0				96.0							
M3	48.0			2.9	17.8		3.8		20.6		2.9							
M14	29.5			18.3	5.0		1.2				5.0							
M16	59.1				19.1						40.0							
M17	30.5			5.5	12.2				12.8									
M18	2.6					1.3			1.3									
Subtotal	293.3			26.9	72.3	1.3	14.0		34.7	0.2	143.9							
% Local Study Area Affected	0.2			<0.1	0.5	<0.1	1.3		0.6	<0.1	21.5							

percent) habitats would also be affected (Table 5-5).

Plant

Plant facilities would be constructed on a knoll northeast of Harry Lake. Table 5-6 lists the land alienated by the construction of the power plant facilities. Most of the power plant construction camp facilities would eventually be included within the fenced power plant site.

The power plant would be located in an area which is predominantly aspen and mid elevation grassland. The make-up water reservoir would flood a small valley which is vegetated predominantly by a lodgepole pine forest.

We have conservatively considered that the entire area within the fenced power plant site would be alienated from all wildlife use. The make-up water reservoir would alienate land from use by terrestrial wildlife but may provide additional habitat for waterfowl. The value of the make-up water reservoir to waterfowl would be dependent upon the amount of marsh edge that would develop. This in turn, would be dependent upon the water level fluctuations, the nutrient content of the water, water temperature, adjacent land uses and other factors. Since the pond would be managed exclusively to supply water for the power plant, it cannot be expected to become a reliable waterfowl habitat. However, it may become a suitable waterfowl staging area, especially as the pond would be within a no shooting zone.

An estimated 169 ha (417 acres) or 0.1 percent of the local study area would be affected by the plant facilities. The largest relative impacts would be upon aspen (7.2 percent), mid elevation grassland (0.6 percent), and Engelmann spruce - lodgepole pine (0.15 percent) habitats (Table 5-6).

TABLE 5-6

LAND AREA ALIENATED BY CONSTRUCTION
OF PROPOSED HAT CREEK THERMAL GENERATING PLANT

Facility	Total Facility Area (ha)	Subalpine Krummholz (1)	Engelmann Spruce Lodgepole Pine (2)	Douglas-fir/ Pinegrass (3)	Ponderosa Pine-Douglas-fir/ Bunchgrass (4)	Aspen (5)	Riparian (6)	High Elev. Grassland (7)	Mid Elev. Grassland (8)	Low Elev. Grassland/ Saline Depression (9)	Sagebrush (10)	Big Sage (11)	Brush (12)	Bog (13)	Cultivated Field (14)	Waterbodies (15)	Exposed Rock (16)	Urban (17)
CP1*	[13.2]					[13.2]												
CP2*	[0.02]					[0.02]												
CP3	0.06								0.06									
CP4*	[0.02]			0.02														
CP5*	[0.06]					[0.06]												
CP6	3.1			1.1	1.2				0.8									
P1	92.0			9.2		59.8			23.0									
P2	1.1								1.1									
P3	0.3								0.3									
P4	67.3		57.2	3.4					6.7									
P5	4.8			4.1		0.5			0.2									
Subtotal	168.7		57.2	17.8	1.2	60.3			32.2									
% Local Study Area Affected	0.1		0.2	<0.1	<0.1	2.2			0.6									

* *Facility overlaps with P1, areas not included in subtotal*

Offsite

The offsite facilities would be distributed over a wide area, but concentrations are found near Hat Creek (the Hat Creek diversion systems) and in the Thompson Valley. Table 5-7 lists the land alienated by the construction of the offsite facilities. The offsite facilities would be concerned with the transport of water, people and equipment, coal, waste rock and electrical energy. These transport facilities would be found in a broad corridor running between the mine pit and the Thompson River near Ashcroft. Storage of water for the Hat Creek diversion is also considered to be part of the offsite facilities.

A diversity of environmental changes would follow construction of the offsite facilities. The relative magnitude of impact (impact per unit of affected area) ranges from almost nil to total permanent loss of value to all wildlife species.

Transmission lines (69 kV) would be necessary to supply power to the mine and plant construction activities and to the make-up water pumping stations, but would have relatively little direct impact upon wildlife. The rights-of-way must be cleared of tall, woody vegetation. Much of the 69 kV transmission system passes through land in which trees are absent and shrubs are sufficiently short that no clearing is necessary. Except for the land lost where the power line poles are put in place, and for maintenance and construction access, no direct adverse environmental changes would accompany 69 kV transmission line installation in these habitats. In forested areas, trees within the right-of-way must be cut down and removed. Because most of the forest land affected by the Hat Creek 69 kV lines is sparsely treed, the impact of this habitat alteration would be minimal.

Other linear facilities have significant impacts upon the environment. Water pipelines must be buried below the frost line. The right-of-way must be dug up, the pipeline laid and reburied, and then the right-of-way is reseeded or allowed to revegetate naturally. As a result, the right-of-way would be

TABLE 5-7

LAND AREA ALIENATED BY CONSTRUCTION
OF PROPOSED HAT CREEK OFFSITE FACILITIES

Facility	Total Facility Area (ha)	Subalpine Krummholz (1)	Engelmann Spruce Lodgepole Pine (2)	Douglas-fir/ Pinegrass (3)	Ponderosa Pine-Douglas-fir/ Bunchgrass (4)	Aspen (5)	Riparian (6)	High Elev. Grassland (7)	Mid Elev. Grassland (8)	Low Elev. Grassland/ Saline Depression (9)	Sagebrush (10)	Big Sage (11)	Brush (12)	Bog (13)	Cultivated Field (14)	Waterbodies (15)	Exposed Rock (16)	Urban (17)
OD1	7.3						1.8			5.5								
OD2	30.1			2.7	10.8					16.6								
OD3	6.3			1.1	5.1		0.1											
OD4	11.5						10.4				1.1							
OD5	0.6									0.3					0.3			
OD7	120.0						22.8			82.9					14.4			
OD8	7.7		0.2	2.6					4.9									
OD9	6.9			0.3						6.6								
OD10	?																	
OW1	39.0		2.3	14.5		0.8			1.2			16.7	0.8		2.7			
OW2	2.0											2.0						
OW3	1.6			1.6														
OW4	nil																	
OW6	0.02			0.02														
OW7	0.02			0.02														
OW8	1.6											0.2			1.4			
OT1	2.4			0.9	1.3		0.2											
OT2	10.8			2.2	5.2	0.3			3.1									
OT3	12.2											11.0			1.2			
OT4	21.2											21.2						
OT5	2.7						0.2					1.8			0.7			
OT7	3.2											3.2						
OA1	45.3											45.3						
OA4	4.5											4.5						
OF1	3.0											3.0?						
OF2	-																	
OF3	-																	
OR1	120.0		4.4	49.2	16.8	2.9	1.2		26.3			12.0	4.8		2.4			
OR2	4.5			3.6					0.9									
OR3	0.8											0.8						
OR4	1.6											1.6						
OR5	9.6			1.0								8.6						
OR6	-																	
OR7	-																	
Subtotal	476.5		6.9	79.8	39.2	4.0	36.7		36.4	111.9	1.1	131.9	5.6		23.1			
% Local Study Area Affected	0.3		<0.1	0.1	0.3	0.1	3.5		0.7	2.4	0.3	0.7	0.2		0.8			

substantially altered from its original condition; it would be temporarily lost to most wildlife. Over the long term (100 to 200 years), the land would revert by succession to its approximate original state.

The paved portion of the airstrip and main access road would permanently alienate land from all wildlife use. Substations, pumping stations, surge tanks and the railway offloading area would permanently alienate land from biological productivity.

The graded portion of the roadway and airstrip would be disturbed and modified by cut-and-fill. This could result in a permanent habitat change, which over the long term could be advantageous to some wildlife species and detrimental to others. Borrow pits and soil areas could also result in permanent habitat alteration. At the very least, the road right-of-way, spoil areas and borrow pits would be temporarily lost from most wildlife productivity.

At present, two locations are being considered for the airstrip. The site preferred by B.C. Hydro (Site A) would be located just west of Highway 1 and just south of Cornwall Creek in a big sage wildlife habitat. The alternative site (Site C) would be in a cultivated field in the Semlin Valley. The airstrip configurations are similar, so that total area alienated would be approximately the same for both sites.

The presence of the mine pit in the valley floor would necessitate the diversion of Hat Creek around the mine. Two environmental modifications could result from the Hat Creek diversion. First, Hat Creek and Finney Creek would be channelized. The creek bed below the point of diversion would dry up and much of the riparian habitat would disappear. The Hat Creek diversion canal would traverse the pit and then descend to the original creek bed enclosed in a culvert.

As a result, the riparian zone of Hat Creek would be cut in two: upstream of the diversion and downstream of the diversion. Animals would no longer be able to move along a continuous thread of riparian habitat. The net effect would be to block the movement of riparian animals such as mink, otter, beaver, shrews and snakes.

The second environmental modification necessitated by the diversion of Hat Creek would be the construction of a series of two or three water storage reservoirs upstream of the diversion in order to regulate the flow of water in the Hat Creek diversion canal. These storage reservoirs would fill with water in the spring and empty throughout summer, fall and winter. The lands flooded by these reservoirs would be lost to upland wildlife production. Some compensating benefit may accrue to aquatic wildlife, such as beaver, or waterfowl, but this is unlikely. The expected water level variation would be too great to allow for development of a fringe of marsh vegetation.

The offsite facilities would alienate an approximate 477 ha (1179 acres) or 0.3 percent of the local study area. The largest impacts (relative to the local study area resource) would be upon riparian (3.5 percent) and low elevation grassland/saline depression habitats. Cultivated fields (0.8 percent), big sage (0.7 percent), mid elevation grassland (0.7 percent), ponderosa pine - Douglas-fir/bunchgrass (0.3 percent), sagebrush (0.2 percent) and brush (0.2 percent) habitats would also be affected (Table 5-7).

Summary - Construction

The construction of mine, plant and offsite facilities would alienate an approximate 939 ha (2244 acres) or 0.6 percent of the local study area by the time the Hat Creek project begins generating electrical power. The impact of this alienation would be spread unevenly among the wildlife habitats. Table 5-8 lists the affected habitats in order of the total amount of habitat alienated. The proportional impact, expressed as the percent of the local study area resource, is also listed.

The greatest absolute impact in terms of the total area affected, would be upon sagebrush, big sage, Douglas-fir/pinegrass, ponderosa pine - Douglas-fir/bunchgrass, and low and mid elevation grassland habitats. The greatest

TABLE 5-8

SUMMARY OF WILDLIFE HABITAT ALIENATION
DURING CONSTRUCTION OF THE HAT CREEK PROJECT

Wildlife Habitat	Local Study Area Resource Base (ha)	Affected Area (ha)	Percent of Resource Base
Sagebrush	670	145	21.6
Big Sage	19,990	132	0.7
Douglas-fir/Pinegrass	62,560	124	0.2
Ponderosa Pine - Douglas-fir/Bunchgrass	13,420	113	0.8
Low Elevation Grassland	4,760	112	2.4
Mid Elevation Grassland	5,460	103	1.9
Aspen	2,720	66	2.4
Engelmann Spruce - Lodgepole Pine	39,020	64	0.2
Riparian	1,040	51	4.9
Cultivated Fields	3,030	23	0.8
Brush	2,870	6	0.2
Subalpine Krummholz	1,100	-	-
High Elevation Grassland	3,240	-	-
Bog	650	-	-
Miscellaneous	1,580	-	-
TOTAL	162,110	939	0.6

relative impact, by far, would be upon sagebrush habitat (21.6 percent of the resource) followed by riparian, followed by aspen and low and mid elevation grassland habitats.

B. Noise and Harassment

The effects of noise on animals have been studied for many years, but relatively few studies have been done regarding the reactions of free ranging wildlife to noise. Most studies have emphasized the effects of very intense noise on laboratory animals, the impact of noise on the productivity of domestic animals, and the ability of sounds to repel undesirable animals[89].

The literature regarding the effects of very intense noise on laboratory animals has little relevance to the Hat Creek project. Noise levels sufficient to produce an acute reaction, either hearing loss or reproductive failure in laboratory animals, are extremely high, ranging from more or less constant noise at 100 decibels (dB or, if weighted in terms of human sensitivity dBA) to brief bursts at 160 dB to achieve threshold impairment[90]. Such high intensities of sound energy would not accompany the Hat Creek project.

Studies of the effects of noise on domestic animals are somewhat more relevant to the question at hand. The most careful and relevant study of this type was done by Brewer[91] on the effects of sonic booms (which are similar to blasting noises) on chickens and ranch mink. Sonic booms, which produced sound pressure levels of 85 to 140 dBA inside housing structure, had no effect on brooding chickens[91]. Similar real and simulated sonic booms also had no adverse impact upon naive (i.e., animals which had never before heard a sonic boom) whelping mink or the growth and survival of their kits[91]. Similarly, aircraft noise has been shown to have relatively little effect on swine, dairy cattle and turkeys[90]. In conclusion, Brewer states: "These and other studies indicate that animals quickly adapt to usual, unusual, scheduled, and unscheduled noise - including sonic boom(s)."[91]

The use of noise and disturbances to scare undesirable wildlife is pertinant because it records which factors are effective and which are ineffective in disturbing some wildlife species. Loud, sudden noises (bangs of at least 85 dBA), electronic warbles, and sounds with a biological context (distress calls) have been successfully used to repel wildlife species, including bats, rabbits, deer and several species of birds[90]. Birds habituate quickly to noises, even noises to which they are innately sensitive (such as distress calls), if the noise is repeated frequently, if the noise is predictable, and if the implied threat represented by the noise is not reinforced by a real danger[92]. Different species respond differently to noise. For example, acetylene exploders, producing a loud bang, are effective at scaring starlings but are ineffective at scaring robins[93]. Thus, reactions to noise can vary greatly among species, habituation occurs even to the most innately disturbing noises, and unpredictability of noise (in terms of location, timing and relationship to perceived danger) diminishes the animals' ability to habituate to it[93].

The reaction of wildlife to harassment depends upon a large number of factors: the species of wildlife; age, sex and condition of the wildlife; the biological context of the harassment; previous exposure to similar harassment; intensity of the harassment; site specificity of the harassment; season and perhaps other factors. Aircraft elicit startle or escape responses from deer, moose, sheep, caribou, antelope, wolves, waterfowl, songbirds and raptors[94, 95, 96, 97, 98, 99]. Pronghorn antelope in New Mexico begin to respond to helicopter noise when the noise levels approach 60 dBA and show alarm (panic running) when the noise levels approach 77 dBA[94]. In contrast, white-tailed deer in Texas have completely habituated to the presence of a heliport and will browse directly underneath low-flying helicopters[90]. A moving noise source is more disrupting than is a stationary one[99, 100].

Opinions regarding the effects of harassment also vary. One paper claims: "To date (1976) no one has conclusively demonstrated a drop in population levels of any wild species due to noise alone."[94] In contrast, a 99 percent decrease in breeding success of sooty terns has been attributed to sonic booms[101]; bald eagles are reported to abandon nests as a consequence of harassment[77]; noise has been used to control crows by frightening them from their nests, causing eggs to chill and subsequent reproductive failure[102]; and deer can be killed as a result of stress induced by noise and harassment from snow-mobiles[103].

The effect of noise and disturbance upon an animal depends upon the response elicited. Very loud noises can induce hearing loss and repeated distressful events can induce an acute stress syndrome[92, 104]. The most common wildlife responses to noise would be avoidance, abandonment of activity, or excitation and fleeing.

If an animal becomes excited and suspends its normal activity, or replaces its normal activity with an energy-consuming activity such as walking, climbing, running or flying, then that animal will have experienced an increased cost of living. Food that would have been eaten is not; energy is expended that need not have been and which has not contributed to the animal's well being. Geist states that "as a rule of thumb chronic excitation increases metabolism some 25 percent above that of maintenance. The cost of excitation can temporarily exceed twice maintenance cost."[92] The cost of rapid locomotion is very high; for a fast running, climbing or flying animal, it can exceed the cost of basal metabolism by a factor of 20[105]. Lower levels of exertion are also expensive, causing an increase of approximately eight times basal metabolism[106]. The energetic cost of harassment depends upon the intensity and duration of excitation, the physical work done while attempting escape, and the decrease in food intake as the result of abandoning foraging. The significance of this energetic cost depends on the energy balance of the affected wildlife. In general, needless expenditure of energy is more serious in ruminants than in other wildlife because of the comparative inefficiency of energy assimilation in ruminants[92]. This energy expenditure is more serious because it is more likely to put the animals into a negative energy balance (a common situation during stressful seasons among wild ungulates), the energy lost is temporarily unrecoverable and may contribute to the animal's reproductive failure or death. Harassment of white-tailed deer in winter by snowmobiles has been reported to adversely affect the deer's energy balance, at times causing death[103].

The actual response expected by Hat Creek wildlife in response to noise generated by the construction of the Hat Creek project is difficult to predict. An anthropomorphic perception of noise can be very misleading because different animals have evolved sensitivities to different stimuli. For example, the discrepancy between human perception of noise and the reaction of wildlife can be seen in contrast between the sight of large mammals standing placidly in national parks mere meters away from the noisiest road traffic and the sight of caribou vigorously attempting to escape from the barely perceptible noise (and sight) of warble flies and nose botflies[92, 107]. The difference in response can be attributed to the fact that noise from the flies is associated with physical irritation and health hazard while the traffic noise is not associated with irritation or danger. Thus, below some undetermined threshold, the biological message which a sound conveys is much more significant than the sound intensity of a noise, per se.

Animals can successfully cope with noise in one of two ways: they can move away from harassing stimuli and avoid the area or circumstances in which a stimulus was encountered, or they can habituate to strange but sufficiently frequent stimuli. Animals which habituate have successfully coped with harassment unless the noise causes physiological harm (hearing impairment) or the habituation endangers the animal under a different set of circumstances. For example, wildlife that have habituated to human presence or to loud bangs may become easy prey during the hunting season. Animals which react to harassment by fleeing can, as discussed, suffer severe energetic stress. Areas which are avoided by animals are essentially alienated from the use of these animals, and the net effect on that species is the same as for any other habitat alienation.

Detailed studies of expected noise levels associated with the proposed Hat Creek project are reported in the Hat Creek Detailed Environmental Studies, Noise Report[115]. Our assessment of impact has been based on this report and supplementary data received from Harford, Kennedy, Wakefield Ltd. Their analysis has indicated that construction noise would be centred at the plant site, at the northern end of the valley (north valley dump), and along the new access road.

The noise levels associated with construction are expected to be fairly constant and continuous, but except for blasting noise not particularly loud. Except for regions very close to the plant, road, mine or other facility under construction, average noise levels should rarely exceed 60 dBA. In the vicinity of the plant and mine, most animals would be expected to habituate rapidly to the site-specific and relatively constant construction noise source.

The state-of-the-art is not advanced sufficiently to predict which species may be affected, what noise levels would be effective, or what the impact upon the population dynamics might be. However, some of the more shy avian species (e.g., eagles and falcons) may be excluded from the noisier areas, and noise and harassment may induce energetic stress upon ungulates in the winter. Based on reports on the reaction of wildlife to other mining activity in B.C.[184], noise from the Hat Creek project is expected to have a negligible impact on wildlife.

C. Direct Exploitation

Direct exploitation of wildlife resources would be expected to be, in part, a function of changes in human demography. The underlying assumption is that hunting demand is proportional to human population. Other factors such as population age structure, economics, sociological factors and historical events may modify this relationship. The relationship between harvests and hunter demand or effort is more problematical. At low levels of exploitation, harvest and hunter effort are directly correlated; an increase in effort produces a corresponding increase in harvest. At high levels of exploitation this relationship breaks down, and a very large increase in effort is required to produce even a small increase in harvest. Over the long term, the relationship can be negative (over-harvesting) when an increase in effort causes a decrease in subsequent harvests.

The expected change in demography for the local and regional study areas as a result of the Hat Creek project has been formulated by Strong Hall and Associates Ltd.[80]. These data are summarized in Table 5-9. The projected increase in hunter activity days attributable to the Hat Creek project has been calculated by the recreational consultants for the Hat Creek project[114] and is given in Table 5-10.

According to the schedule upon which these projections are based, construction would begin in 1978 and continue to 1986, while operation of the first boiler unit would begin in 1984[85]. If project commencement is to be delayed, the same pattern of population increase could be expected, but would be set back the appropriate length of time.

The projections in Table 5-10 are for total hunter involvement; they do not indicate what species would be hunted or where the hunting would take place. Hunters are expected to prefer not to travel any more than necessary, so that hunting would tend to be concentrated around the centre of hunter residence. The projections in Table 5-10 also indicate that hunting pressure would be maximal during construction and that at this time the majority of hunters would reside in the construction camps in the Hat Creek Valley.

The effect of the Hat Creek camp residents on local hunting may be less than estimated in Table 5-10. Solitary males living in a semi-isolated construction camp have no means of using the game carcass should they succeed in their hunting ventures. Killed game must be given away to those who live outside the camp. Even more frustrating to would-be hunters among the construction

TABLE 5-9

PREDICTED DEMOGRAPHIC CHANGES
RESULTING FROM THE PROPOSED HAT CREEK PROJECT

Year	Local Study Area: Predicted Population Without Project*	Local Study Area: Predicted Population With Project	Local Study Area: Percent Change	Regional Study Area: Predicted Population Without Project*	Regional Study Area: Predicted Population With Project	Regional Study Area: Percent Change
1976	7,500	7,500	0	77,300	77,300	0
1978	7,615	7,685	0.9	81,400	81,480	0.1
1980	8,080	9,165	13.4	85,900	87,080	1.4
1982	8,990	11,930	32.7	91,000	94,190	3.5
1984	8,990	12,690	41.1	95,700	99,690	4.2
1986	9,370	12,840	37.0	100,800	104,530	3.7
1988	9,665	13,450	39.2	106,300	110,360	3.8
1990	9,960	13,830	38.9	111,700	115,850	3.7
2000	11,600	15,610	34.5	140,000	144,305	3.1
2010	13,400	17,285	30.0	175,700	179,880	2.4
2020	15,600	19,460	24.7	221,000	225,150	1.9

* From Table 5-1
Data Source: Strong Hall and Associates, Ltd.[80]

TABLE 5-10

ESTIMATED INCREMENTAL HUNTING DAYS
ATTRIBUTABLE TO THE HAT CREEK PROJECT
(Data from Hat Creek Recreation Report[114] Table 8-6)

ORIGIN	1980	1982	1984	1986	1988	1990
Hat Creek Camps*	2,080	7,040	5,090	1,490	90	90
Ashcroft/Cache Creek**	1,380	3,750	4,720	4,430	4,800	4,940
Clinton**	170	440	560	520	570	580
Other Areas**	80	220	280	260	290	290
TOTAL	3,710	11,450	10,650	6,700	5,750	5,900

* Assumes that 75 percent of residents hunt an average of 4.1 days

** Assumes that new residents participate at same rate as existing population.

work force is the possibility that firearms would be banned in the Hat Creek construction camps. Such a ban is in effect at the Mica Dam construction camp and is under consideration at Revelstoke. A ban on firearms would severely curtail hunting by Hat Creek construction camp residents. Hence, the assumed 75 percent participation in hunting for camp residents may be unreasonably high.

D. Dust and Air Emissions

Dust

Many aspects of the construction of the Hat Creek project involve operations that produce dust, including excavation, hauling, blasting, trenching, scraping, bulldozing, crushing, grading and paving. A quantitative analysis of the expected amounts and distribution of potential air contaminants released into the atmosphere by the Hat Creek project has been done by Environmental Research and Technology, Inc.[108]. The ERT report states that during construction "temporarily high particulate concentrations may occur in the immediate vicinity of many dust-producing operations. However, with properly implemented control procedures (e.g., watering of haul roads), such problems would be minor and certainly insignificant compared to emissions during operations of the power plant and mine."[108]

All facilities would be sources of fugitive dust during construction, but the extent of the dusting would be strongly restricted in terms of both the area affected and the duration of the dusting. The open pit mining operation which includes large-scale stripping, transport and dumping would be expected to be by far the greatest source of project dust. Dusting from the mine and waste dumps is also expected to be a chronic operational problem. The second most significant source of dust would be vehicular travel along unpaved roads. All other dust generation should be sufficiently localized and short-lived so that significant environmental degradation would be avoided.

Fugitive dust generated by construction would be non-toxic; the concentrations of all trace elements in fugitive dust is expected to be well below the recommended desirable levels of trace elements in suspended particulate matter in British Columbia[108].

The concentrations of particulate materials expected from the mining activities have been modelled by ERT[108]. The airborne particles would be transported into the atmosphere by wind erosion and dry equipment operation. The results of the ERT modelling indicate that the average annual geometric mean could be as great as 50 $\mu g/m^3$ above ambient and that the worst case 24-hour mean could go as high as 700 $\mu g/m^3$. These estimates appear to represent a pessimistic analysis. The dust model used by ERT does not account for the deposition of particles (all dust is assumed to remain suspended), terrain features are ignored (including the mine pit itself), and the average wind speed is overestimated[108].

Animals could be affected primarily by irritation of the lung by inhalation of particulates (eye injury is known to occur with larger particle sizes, but this phenomenon is poorly understood and little or nothing can be said about its relevance to Hat Creek dust)[109]. Inert particulate materials can apparently be tolerated by experimental mammals in far greater quantities than those anticipated in the Hat Creek Valley; most respiratory irritations correlated with ambient airborne particulates appear to be associated with toxic qualities of the particulates[109]. Prolonged exposure to carbon black at 1600 and 2400 $\mu g/m^3$ have been tolerated by a variety of experimental mammals (rodents and monkeys) without any apparent adverse effects[110]. Experimental mammals were exposed to smoke, coal dust, and silica and feldspar mineral dust at very high levels (indeterminate, but smoke levels were approximately 570,000 $\mu g/m^3$) for periods ranging from 2 to 165 days, without increasing susceptibility to pneumonial infection[111, 112].

The lungs of mammals have clearing mechanisms that appear to be able to cope with levels of inert dust far in excess of those expected from the Hat Creek project[109]. Although mammals can cope with the inhalation of non-toxic dust, no data are available on how they would, in fact, respond to chronic elevated levels of suspended particulates. Although dust can be physiologically tolerated, it may be sufficiently unpleasant such that dusty areas are avoided by some species.

The effects of the inhalation of particulates by birds may well be much more severe than those observed in mammals. In contrast to mammals, the nasal passage of birds have little ability to remove particulates before they reach the lung, and the overall structure and dynamics of the avian lung make it analogous to the high volume samplers designed to concentrate airborne particulates[113]. Birds, therefore, may be much more severely affected by particulates than are mammals.

The effects of the ingestion by wildlife of particulates that settle and accumulate on vegetation are unknown.

Other Air Emissions

Emissions of sulfur, carbon monoxide and hydrocarbons would result from fossil fuel powered vehicles and construction equipment. Temporary emissions would occur from asphalt plants during the paving of road surfaces. Traffic along the access road is estimated to be 200 to 300 vehicles per day with weekend peaks of 500 to 700 vehicles per day[108]. Quantifiable estimates of these emissions is not possible, but any environmental changes would certainly be insignificant compared to emissions during power plant operation[108].

E. Waste Disposal

During construction, waste disposal is anticipated to be a relatively minor problem. The major sources of potential contaminants would be the north valley waste dump, the construction camps, the plant construction site, and the vehicle maintenance buildings[114]. The magnitude of the waste disposal problem would be vastly greater during project operation.

Sewage from the mine and plant construction camps would first be treated in a sewage treatment plant. Subsequently, liquid wastes would be disposed of in part by deep well injection and in part by spray irrigation[114]. Two deep wells would be sunk, one near each construction camp. No adverse environmental effects to wildlife would be expected from the sewage disposal; the deep well material would be unavailable to biota, and the spray irrigation may increase wildlife resources by adding to soil moisture and nutrients.

The plant construction site and the vehicle maintenance buildings would be operated in such a way that no liquid discharges are released into the environment. In actual practice, some minor amount of spillage or leakage would likely occur, but one would assume that such accidents would be sufficiently minor that significant environmental damage would not result.

Solid waste disposal would be landfill in the vicinity of the mine[114]. It is unclear whether this landfill is within one of the designated waste dumps or is additional to them. If the landfill is within a waste dump, then no additional impact would be expected. If the landfill is separate, a problem of toxic leachates may develop. The question of the impact of potentially toxic leachates from waste dumps will be discussed under "Operation" (Section 5.2(c)(i)E.).

F. Indirect Effects

Indirect effects of construction of the Hat Creek project are expected to be limited to problems of erosion as a result of soil disturbances. Soils which are susceptible to erosion or to salinity/alkalinity problems have been identified in the Physical Habitat and Range Vegetation Report. Temporary disturbances such as road, pipeline or transmission line construction could have more serious environmental ramifications if located on these soils. Much of the area disturbed by the mine and waste dumps would be sensitive soils, but the alienation of these lands would be complete, hence the salinity/erodability limitations would not be relevant.

Based on soils mapping in the Physical Habitat and Range Vegetation Report, erodability and salinity problems would be restricted to the lower one-third of the water pipeline right-of-way and to the 69 kV transmission line to booster pumping station I. If proper care is exercized during construction and if revegetation occurs promptly, indirect effects on wildlife should be negligible during project construction.

(ii) Resource Use Projection - Impact of Construction

The Hat Creek area is conducive to both consumptive and non-consumptive use of wildlife. This is emphasized by the fact that of the 12 big game species found in British Columbia, 10 inhabit the regional study area. In addition, the area supports a wide variety of non-game animal species. Due to these attributes, it is assumed that the use of the wildlife resource by people associated with the Hat Creek project would be high. That is, new residents who have traditionally enjoyed the use of wildlife as a form of recreation would continue to do so. Many new residents who have not taken advantage of British Columbia's wildlife as a form of recreation would likely become interested because of the attractiveness and availability of the local wildlife resource.

A. Non-consumptive Use

The construction phase of the Hat Creek project would be expected to increase non-consumptive wildlife use as a result of the large numbers of people working, visiting and living in the Hat Creek Valley. A proportion of these people would be expected to be at least marginally interested in observing wildlife; particularly with species such as bighorn sheep, grizzly bear and mountain goat inhabiting areas close by. Human encounters with wildlife would also be expected to increase as employees and their families participate in outdoor activities, such as hiking, horseback riding and cross country skiing. Even a small proportion of the Hat Creek workforce engaging in some non-consumptive wildlife use would substantially increase the total non-consumptive wildlife use of the valley and the surrounding areas.

B. Consumptive Use

The impact of project construction upon hunter demand in the local and regional study areas can be estimated by use of hunter distribution patterns determined by the B.C. Fish and Wildlife Branch 1976 Hunter Survey (Appendix B) and predicted changes in human demography with and without the project. We have assumed that whatever factors are currently operating to determine hunter distribution patterns will continue to operate.

We have calculated increase in hunter demand as follows. Four residence categories have been selected: the local study area, the regional study area (as approximated by subregions 3C and 3D of the Thompson-Okanagan region), the Lower Mainland (B.C. Fish and Wildlife Branch Region 2) and the remainder of B.C. The residence of hunters using the local study area (approximated by Management Unit 3-17) and regional study area can be determined from data presented in Appendix B. For the regional analysis, future demand is estimated as the sum of the products of the anticipated population of each residence category times the proportion of hunters from that residency category in 1976. The local analysis is done identically except that the number of regional residents must be divided into local and non-local residence categories. Because the boundary between subregions 3C and 3D bisects the local study area, this task requires that some assumptions regarding residency be made. These assumptions have been made pessimistically; that is, the numbers have been chosen so that error would over-estimate the impact of the project on hunter demand rather than underestimate it. We have arbitratily assumed that:

1) for waterfowl hunters, 100 percent of the residents of Subregion 3C and 75 percent of the residents of Subregion 3D reside within the local study area;

2) for upland gamebird hunters, 50 percent of the residents of Subregion 3C and 33 percent of the residents of Subregion 3D are local residents; and

3) for big game hunters, 50 percent of the residents of Subregion 3C and 25 percent of residents of Subregion 3D are local residents.

The increase, thus calculated, applies only to hunter demand. In actual practice increased local population could result in overhunting or in restriction of hunter privileges (by regulation or by restriction of access to privately controlled lands) causing hunters to disperse further or hunt less than they previously did.

Waterfowl

Using the above values and values for demographic changes obtainable from data presented in Tables 5-1 and 5-9, the impact of the Hat Creek project during the construction peak period (1983) would be to increase local study area waterfowl hunter demand by 38 percent (Table 5-11). However, this increase in demand would have little actual impact on local study area harvests because waterfowl harvest is probably limited by access rather than demand. The hunting and harvesting is done primarily by local residents because only local residents have access to most of the local waterfowl hunting opportunity. Because construction workers would probably be denied access to waterfowl hunting areas on private land holdings in the Hat Creek Valley and because hunting would probably be banned on B.C. Hydro controlled property, very little hunter opportunity would exist for Hat Creek project employees. A small but constant number of ducks would be sought after by an increasingly large number of sportsmen, causing a rapid decline in success rate.

The impact of construction on regional waterfowl hunter demand during the expected construction peak period in 1983 is expected to be fairly small, approximately four percent (Table 5-12). The impact of such an increase would also be minor, probably below detection by current resource management techniques.

TABLE 5-11

ESTIMATION OF INCREASE IN LOCAL STUDY AREA HUNTER DEMAND FOR WATERFOWL DURING CONSTRUCTION PEAK PERIOD (1983)

	Local Study Area*	Remainder of Regional Study Area**	Lower Mainland	Remainder of B.C.***	Total
1976 Hunters (from Table B3-2)	59	7	-	3	69
Percentage Increase Without Project (from Table 5-1, 1983 values)	20%	20%	10%	7%	-
1983 Hunters Without Project	71	8	-	3	82
Percentage Increase With Project (from Table 5-9, 1983 values)	64%	21%	10%	7%	-
1983 Hunters With Project	97	18	-	3	108

(i) Increase without project = 82 - 69 = 13 = 19%

(ii) Increase with project = 108 - 69 = 39 = 57%

(iii) Additional increase due to project = 108 - 82 = 26 = 38%

* Estimated - see text

** As approximated by subregions 3C and 3D of Thompson-Okanagan region

*** Assumed annual growth of one percent per year

TABLE 5-12

ESTIMATION OF INCREASE IN REGIONAL STUDY AREA HUNTER DEMAND FOR WATERFOWL DURING CONSTRUCTION PEAK PERIOD (1983)

	Regional Study Area*	Lower Mainland	Remainder of B.C.**	Total
1976 Hunters (from Table B3-2)	1079	306	186	1571
Percentage Increase Without Project (from Table 5-1, 1983 values)	20%	10%	7%	-
1983 Hunters Without Project	1295	337	199	1831
Percentage Increase With Project (from Table 5-9, 1983 values)	25%	10%	7%	-
1983 Hunters With Project	1349	337	199	1885

(i) Increase without project = 1831 - 1571 = 260 = 17%

(ii) Increase with project = 1885 - 1571 = 314 = 20%

(iii) Additional increase due to project = 1885 - 1831 = 54 = 3.5%

* As approximated by subregions 3C and 3D of Thompson-Okanagan region

** Assumed annual growth of one percent per year

Upland Gamebirds

The hunter residence pattern for upland gamebirds is significantly different from that of waterfowl. Approximately 60 percent of local upland gamebird hunters reside in the regional study area, and most of these reside outside that Hat Creek Valley. The remainder of local hunters reside elsewhere in British Columbia (especially the Lower Mainland) and their numbers would not be significantly affected by the Hat Creek project. The expected additional increase in local hunter demand as a result of project construction has been calculated at approximately 10 percent (Table 5-13).

The impact of a 10 percent additional increase in local demand as a result of the project depends upon the current level of resource utilization and upon the expected total increase in demand. The data which are available do not allow a calculation of the maximum sustained yield of upland gamebirds from the local study area. Hence, the relationship between current and maximum sustainable yields is unknown, it is risky to assess whether or not the additional mortality caused by a 26 percent increase in demand (Table 5-13) could be accommodated. However, because access and hunter opportunity for upland gamebird hunters are not expected to improve during project constuction, the remoteness of much of the local study area would preclude excessive over-harvesting of the resource except adjacent to current access routes.

The impact of construction on regional upland gamebird hunter demand predicted to be an increase of approximately 3 percent (Table 5-14). This would be accompanied by an increase in harvest of a similar magnitude, one so small as to be probably undetectable.

Furbearers

No changes are expected in the consumptive use of furbearers as a result of the Hat Creek project. No registered traplines would be affected by the Hat Creek project facilities. The influx in population would have no impact

TABLE 5-13

ESTIMATION OF INCREASE IN LOCAL STUDY AREA HUNTER DEMAND FOR UPLAND GAMEBIRDS DURING CONSTRUCTION PEAK PERIOD (1983)

	Local Study Area*	Remainder of Regional Study Area**	Lower Mainland	Remainder of B.C.***	Total
1976 Hunters (from Table B3-5)	313	504	452	120	1389
Percentage Increase Without Project (from Table 5-1, 1983 values)	20%	20%	10%	7%	-
1983 Hunters Without Project	376	605	497	128	1606
Percentage Increase With Project (from Table 5-9, 1983 values)	64%	21%	10%	7%	-
1983 Hunters With Project	513	610	497	128	1748

(i) Increase without project = 1606 - 1389 = 217 = 16%

(ii) Increase with project = 1748 - 1389 = 359 = 26%

(iii) Additional increase due to project = 1748 - 1606 = 142 = 10%

* Estimated - see text

** As approximated by subregions 3C and 3D of Thompson-Okanagan region

*** Assumed annual growth of one percent per year

TABLE 5-14

ESTIMATION OF INCREASE IN REGIONAL STUDY AREA HUNTER DEMAND
FOR UPLAND GAMEBIRDS DURING CONSTRUCTION PEAK PERIOD (1983)

	Regional Study Area*	Lower Mainland	Remainder of B.C.**	Total
1976 Hunters (from Table B3-6)	8450	4556	1426	14432
Percentage Increase Without Project (from Table 5-1, 1983 values)	20%	10%	7%	-
1983 Hunters Without Project	10140	5012	1526	16678
Percentage Increase With Project (from Table 5-9, 1983 values)	25%	10%	7%	-
1983 Hunters With Project	10563	5012	1526	17101

(i) Increase without project = 16678 - 14453 = 2246 = 16%

(ii) Increase with project = 17101 - 14432 = 2669 = 18%

(iii) Additional increase due to project = 17101 - 16678 = 423 = 3%

* As approximated by subregions 3C and 3D of the Thompson-Okanagan region

** Assumed annual growth of one percent per year

on furbearer harvests because few, if any, new people would be able to obtain trapping privileges.

Big Game

The hunter residence pattern for big game species indicates that 47 percent of the estimated big game hunters hunting in Management Unit 3-17 reside in the Thompson - Okanagan region (Appendix B, Tables B3-15 and B3-16). Thirty percent of these hunters are from the Kamloops - Merritt region (3D), while 15 percent reside in the Fraser River area (3C)(Figure B2-2). The Lower Mainland region is given as the residence of the second largest group (46 percent of hunters) hunting in Management Unit 3-17.

Based on the assumptions previously outlined in this section, the expected additional increases in local and regional deer and moose hunter demand attributable to the construction phase of the Hat Creek project are calculated in Tables 5-15 through 5-18. Only deer and moose have been considered in these calculations because they account for the largest numbers of animals harvested in the local study area (Table 5-2). Increases in local study area hunter demand for deer and moose attributable to the construction peak period (1983) have been calculated to be 7 and 9 percent, respectively (Tables 5-15 and 5-16).

Given several more mild fall and winter seasons, these demands may be met. However, removal of wildlife habitat as required by the proposed project in conjunction with severe winter conditions could reduce game numbers, particularly deer. This latter situation would result in decreased deer, moose and bighorn sheep harvests in the local study area.

Decreases in regional study area big game harvests would not be as marked because overall increased demands associated with the proposed project are not as large as those for the local study area (Tables 5-17 and 5-18).

TABLE 5-15

ESTIMATION OF INCREASE IN LOCAL STUDY AREA HUNTER DEMAND FOR DEER DURING CONSTRUCTION PEAK PERIOD (1983)

	Local Study Area*	Remainder of Regional Study Area**	Lower Mainland	Remainder of B.C.***	Total
1976 Hunters (from Table B3-15)	142	280	443	84	949
Percentage Increase Without Project (from Table 5-1, 1983 values)	20%	20%	10%	7%	-
1983 Hunters Without Project	170	336	487	90	1083
Percentage Increase With Project (from Table 5-9, 1983 values)	64%	21%	10%	7%	-
1983 Hunters With Project	223	339	487	90	1149

(i) Increase without project = 1083 - 949 = 134 = 14%

(ii) Increase with project = 1149 - 949 = 200 = 21%

(iii) Additional increase due to project = 1149 - 1083 = 66 = 7%

* Estimate - see text

** As approximated by subregions 3C and 3D of Thompson-Okanagan region

*** Assumed annual growth of one percent per year

TABLE 5-16

ESTIMATION OF INCREASE IN LOCAL STUDY AREA HUNTER DEMAND FOR MOOSE DURING CONSTRUCTION PEAK PERIOD (1983)

	Local Study Area*	Remainder of Regional Study Area**	Lower Mainland	Remainder of B.C.***	Total
1976 Hunters (from Table B3-15)	16	32	13	25	86
Percentage Increase Without Project (from Table 5-1, 1983 values)	20%	20%	10%	7%	-
1983 Hunters Without Project	19	38	14	27	98
Percentage Increase With Project (from Table 5-9, 1983 values)	64%	21%	10%	7%	-
1983 Hunters With Project	26	39	14	27	106

(i) Increase without project = 98 - 86 = 12 = 14%

(ii) Increase with project = 106 - 86 = 2- = 23%

(iii) Additional increase due to project = 106 - 98 = 8 = 9%

* Estimated - see text

** As approximated by subregions 3C and 3D of Thompson-Okanagan region

*** Assumed annual growth of one percent per year

TABLE 5-17

ESTIMATION OF INCREASE IN REGIONAL STUDY AREA HUNTER DEMAND
FOR DEER DURING CONSTRUCTION PEAK PERIOD (1983)

	Regional Study Area*	Lower Mainland	Remainder of B.C.**	Total
1976 Hunters (from Table B3-16)	3575	4585	1234	9394
Percentage Increase Without Project (from Table 5-1, 1983 values)	20%	10%	7%	-
1983 Hunters Without Project	4290	5044	1320	10654
Percentage Increase With Project (from Table 5-9, 1983 values)	25%	10%	7%	-
1983 Hunters With Project	4469	5044	1320	10833

(i) Increase without project = 10654 - 9374 = 1260 = 13%

(ii) Increase with project = 10833 - 9394 = 1439 = 15%

(iii) Additional increase due to project = 10833 - 10654 = 179 = 2%

* As approximated by subregions 3C and 3D of Thompson-Okanagan region

** Assumed annual growth of one percent per year

TABLE 5-18

ESTIMATION OF INCREASE IN REGIONAL STUDY AREA HUNTER DEMAND
FOR MOOSE DURING CONSTRUCTION PEAK PERIOD (1983)

	Regional Study Area*	Lower Mainland	Remainder of B.C.**	Total
1976 Hunters (from Table B3-16)	835	721	331	1887
Percentage Increase Without Project (from Table 5-1, 1983 values)	20%	10%	7%	-
1983 Hunters Without Project	1002	793	354	2149
Percentage Increase With Project (from Table 5-9, 1983 values)	25%	10%	7%	-
1983 Hunters With Project	1044	793	354	2191

(i) Increase without project = 2149 - 1887 = 262 = 14%

(ii) Increase with project = 2191 - 1887 = 304 = 16%

(iii) Additional increase due to project = 2191 - 2149 = 42 = 2%

* As approximated by subregions 3C and 3D of the Thompson-Okanagan region

** Assumed annual growth of one percent per year

(iii) Resource Projection - Impact of Construction

A. Reptiles and Amphibians

The construction of the Hat Creek project is anticipated to have little adverse effect on the reptile and amphibian resource. Noise and harassment would be unlikely to bother snakes (which are nearly deaf) or amphibians (which are largely immune to all but the most specific stimuli). Direct exploitation might occur in the form of road kills. Road kills would be uncommon unless a road bisects an annual migration path of amphibians, an unknown, unforeseeable and unlikely situation. Very little information is available regarding the tolerance of reptiles and amphibians to dust and air emissions, but the low levels of pollutants expected during the construction phase is expected to produce very little or no adverse impact on reptiles or amphibians. The disposal of wastes could lead to pollution of waters and subsequent poisoning of breeding amphibians. However, no known significant amphibian breeding areas are located downstream from waste dumps. No significant indirect impacts to reptiles or amphibians are foreseen at this time.

Major impacts of habitat alienation on reptiles and amphibians are unlikely. Reptiles are almost entirely found in the valley bottoms within riparian zones; a few garter snakes and perhaps an occasional appearance of one or two other species of snake are expected to be at the northern end of Upper Hat Creek Valley. Hence, the Hat Creek Valley is only marginal reptile habitat and its loss would be insignificant, in comparison to the reptile resource in the lower Hat Creek and Bonaparte River riparian zones, and trivial when compared to the regional or provincial resource.

Amphibians would also be affected to a minor degree. Wetlands which are valuable as breeding ponds to amphibians are either permanent or semi-permanent, and are usually found at higher elevations in the forested areas. Very few suitable amphibian ponds would be lost as a result of project construction (see subsequent waterfowl section for detailed list of affected wetlands).

B. Waterfowl

The construction of the Hat Creek project would be expected to alienate a small amount of waterfowl habitat. The impact of the physical alteration of the environment has been analyzed by comparing the location of facilities (Map 5-1) with the wetland inventory (Map 4-2). Only three construction facilities appear to directly impinge upon waterfowl habitat: the power plant itself (P1), the water supply pipeline (OW1) and the Site 2 reservoir (OD7). The numbers and types of wetlands directly affected by these facilities are listed in Table 5-19.

The water supply pipeline between the Thompson River and the make-up water reservoir is depicted, possibly in error, as intersecting two wetlands. A very minor realignment of the right-of-way could result in no wetlands being affected. If the present alignment through the wetlands is intended, very little impact on waterfowl would accrue because the two wetlands are isolated and are of limited value to waterfowl. Unless these wetlands are drained, a pipeline adjacent to or even through them would not unduly alter their character. The power plant site overlaps with one isolated permanent pond. This pond appears productive, but it is only one small, isolated pond and, therefore, has limited value to waterfowl.

The only serious resource conflict with waterfowl during construction comes from the Site 2 reservoir. This reservoir would overlap with at least 19 small wetlands and would flood a considerable amount of riparian habitat. The actual impact of the reservoir could be substantial. Most of the affected wetlands appear to lie just below the maximum water level planned for the reservoir, and their value to waterfowl would not necessarily be destroyed depending on how often, how long and at what time of year each of the wetlands were flooded. If flooding were limited to a brief period during the early spring freshet, some wetlands would possibly be improved by the flushing of excessive solutes. Reservoir water could possibly be used to flush additional wetlands or to create new ones, thereby, compensating for the loss of others. The Finney Creek diversion canal (OD9) affects no wetlands, but does

TABLE 5-19

WETLANDS LOST AS A RESULT OF
CONSTRUCTION OF HAT CREEK PROJECT FACILITIES

			Pipeline OW1	Power Plant P1	Site 2 Reservoir OD7	Total Construction	Percent
A:	Temporary and Ephemeral	Number of Wetlands					-
		Area (ha)					-
		Edge (km)					-
B:	Semi-Permanent	Number of Wetlands	1		2	3	2.2
		Area (ha)	0.10		0.11	0.21	1.4
		Edge (km)	0.16		0.36	0.52	2.5
C:	Permanent with edge vegetation	Number of Wetlands		1	4	5	11.1
		Area (ha)		1.05	0.45	1.50	7.0
		Edge (km)		0.72	0.69	1.41	9.2
D:	Permanent without edge vegetation	Number of Wetlands	1		8	9	10.6
		Area (ha)	2.10		0.44	2.54	1.9
		Edge (km)	1.17		0.95	2.12	4.9
E:	Saline	Number of Wetlands			5	5	6.8
		Area (ha)			0.24	0.24	4.7
		Edge (km)			0.58	0.58	6.5
F:	Bog	Number of Wetlands					-
		Area (ha)					-
		Edge (km)					-
Subtotal B+C+D		Number of Wetlands	2	1	14	17	6.3
		Area (ha)	2.20	1.05	1.00	4.25	2.5
		Edge (km)	1.33	0.72	2.00	4.05	5.1
Total		Number of Wetlands	2	1	19	22	5.2
		Area (ha)	2.20	1.05	1.24	4.49	2.2
		Edge (km)	1.33	0.72	2.58	4.63	4.1

provide the potential for improving adjacent wetlands by flushing.

No breeding waterfowl censuses have been done in the vicinity of the Site 2 reservoir, but 1-day aerial surveys have been taken in April 1977 and in September 1976. The relevant data (Survey Areas 22, 25 and one-third of 29, Tables 4-8 and 4-9) show that in 32 wetlands, 20 ducks or 5.4 percent of the total number of ducks counted during the April survey, and 12 ducks or 2.3 percent of the total counted during the September survey, were in this area.

A quantitative comparison between the affected wetlands and the total wetland resource within the site-specific study area reveals that approximately five percent of the waterfowl habitat would be alienated by project construction. In the Hat Creek Valley, breeding waterfowl have been observed to be associated with semi-permanent wetlands and with permanent wetlands, a somewhat anomalous situation. In the prairies, permanent ponds are of extremely limited value to waterfowl; semi-permanent and temporary ponds are preferred by diving ducks and dabblers, respectively[65]. In the Hat Creek Valley, breeding waterfowl, especially those with broods, have been observed to be more closely associated with the more permanent ponds. If the quantity of wetland resource (expressed as number of wetlands, area covered by wetlands, or amount of edge) is compared for semi-permanent plus permanent wetlands (Table 5-19), one sees that between 2.3 and 6.3 percent of the resource is affected.

Approximately five percent of the capability of the site-specific study area to produce and support waterfowl would be lost to the construction of the proposed Hat Creek facilities. The same proportion of the local study area resource would be lost because almost all productive waterfowl habitat occurring within the local study area also occurs within the site-specific study area. The five percent estimate is in one sense an overestimate because it has been assumed that no compensatory benefit to waterfowl would accrue from the make-up water reservoir, the pit rim reservoir, the headworks reservoir or the Site 2 storage reservoir. The five percent estimate is, in another sense, an underestimate because losses of riparian habitat and of small, uncountable temporary wetlands have not be considered. These losses have been assumed to be inconsequential; neither small wetlands nor riparian habitat alone appear sufficient to support waterfowl.

Noise and harassment could affect waterfowl, especially during the nesting and brooding seasons. Most construction noise would be relatively constant and predictable and the source regions would be localized to the pit. Waterfowl nesting in nearby wetlands would probably acclimatize to such noises. The plant site and road elevated noise zone is distant from areas of significant breeding waterfowl concentrations and would not affect breeding waterfowl. Unnecessary foot or vehicular traffic could be very disruptive to nesting or breeding waterfowl. Access to such areas (see Map 4-2) should be restricted. A conflict between hunting and blasting noise could exist because hunting would sensitize waterfowl to the very similar blasting noises.

Direct exploitation of waterfowl is an expected result of the influx of people to the Hat Creek Valley. Hunting opportunity appears to be the critical variable. The majority of waterfowl seen in autumn occurred in two strips: the Cattle Valley between Gallagher Lake and McLean Lake, and a long, broad strip along the west side of the Hat Creek Valley between the forest edge and Hat Creek itself, and between Aleece Lake on the north and Yet Creek on the south.

The Cattle Valley contains relatively few lakes, each with intensive autumn waterfowl use. The access route currently running through Indian Reserve land is not good (four-wheel drive) and could be semi-controlled (at the eastern end near Cache Creek) by the Indians and ranchers. On the west side of the main valley, a large number of smaller lakes and ponds are each less intensively used by waterfowl. Most of the fall migration ducks were sighted in this area (Table 4-9). Access is diffuse and is well controlled by the Hat Creek Valley residents. The access roads are private and constitute part of the ranching operation.

Without changes in land use or residence pattern, no increase in hunter access to private land would be expected and no consequent increase in harvest would be realized. Four areas appear to be the most susceptible to increased waterfowl hunting: the Cattle Valley, Fishhook Lake, Langley Lake and vicinity, and that portion of the Hat Creek Valley west of Hat Creek, north of Anderson Creek, south of Aleece Lake and east of the forested area. Fishhook and Langley lakes are adjacent to the main Hat Creek Valley road and are open to road-side hunting. Currently, the Cattle Valley is somewhat remote and, hence, is only lightly hunted, but would not be remote to the approximate 2000 people living in the construction camps. The Aleece Lake - Anderson Creek area would be sufficiently close to the eventual pit rim that it may become B.C. Hydro and Power Authority controlled property and, thereby, lose the access protection it has hitherto been given. Protection of this latter area from overhunting is especially important because of its proximity to the blasting noise and because it is one of the few areas with waterfowl production in the Hat Creek Valley that could escape alienation should the second coal deposit be developed.

If access could be successfully limited to most areas and hunting prohibited in critical areas where access cannot be limited, then the waterfowl resource would be protected from excessive exploitation. Special consideration should be given to limiting access to the Cattle Valley and to extending a no hunting zone south from the pit, possibly as far as Anderson Creek.

No significant adverse impact to waterfowl is expected from air emissions during construction because of the low predicted levels of pollutants[108]. Based on ERT projections[108], dust may become a chronic problem to birds, but the claim of successful dust suppression during the bulk sampling programme[84] precludes making conclusions. Certainly the potential for damage exists if birds are subjected to high levels of suspended particulates.

Waste disposal would be expected to adversely affect waterfowl only where contamination of surface waters occurs. No such contamination is expected during project construction.

C. Upland Gamebirds

Habitat alienation from construction is expected to have a measurable, but low magnitude impact upon upland gamebird populations. The total habitat alienation due to the construction of the Hat Creek project would be approximately 939 ha (2320 acres)(see Table 5-8). Of this alienated land, approximately 132 ha (326 acres) would be big sage habitat on the east side of the Trachyte Hills. This region is the only portion of the local study area in which chukar and sharp-tailed grouse can be found. The loss would amount to only 0.7 percent of the big sage habitat in the local study area, and because chukar and sharp-tailed grouse are relatively sparse in that region, the alienation of 132 ha (326 acres) of big sage would have a negligible impact on their regional abundance. Also, much of the habitat would be "lost", in that it occurs along a transmission line, road or pipeline right-of-way. Another 360 ha (890 acres) of alienated land is grasslands in the Hat Creek Valley, which are, except for a very few mourning doves, devoid of upland gamebirds.

Spruce grouse habitat in the Engelmann spruce and lodgepole pine forests would be decreased by only 64 ha (158 acres) of isolated patches of marginal habitat in the Trachyte Hills. This loss of between 0.1 and 0.2 percent of the local study area total would represent a small impact on local spruce grouse populations.

The remaining 383 ha (946 acres) of land which would be alienated by project construction is good quality ruffed and blue grouse habitat (Douglas-fir/pinegrass, ponderosa pine - Douglas-fir/bunchgrass, aspen, bog, brush, cultivated fields, subalpine krummholz and riparian habitats) and represents approximately 0.4 percent of the local study area resource. A concommitant drop of 0.4 percent in ruffed and blue grouse populations would be the expected consequence of alienation of this land.

Based on experimental studies of the effects of noise on domestic *Galliformes* (chicken-like birds), and based on the observable placidness of wild grouse when confronted by humans, one would expect very little, if any, adverse impact from construction phase noise and harassment on upland gamebirds.

Direct exploitation of grouse would certainly occur as a result of the Hat Creek project. Grouse are difficult to find, but easy to kill when found. They are, therefore, very susceptible to hunting which is ancillary to other activities. A total increase in local study area demand for upland gamebirds is estimated to be 13 percent (Section 5.2(b)(ii)B.), but could be much higher.

Autumn mortality of grouse has been shown to have little or no effect on the size of next year's grouse population[81], but extremely intensive hunting, such as could occur as a corollary of intensive non-hunting activity, could have an impact on grouse populations, as could out-of-season hunting of any magnitude. The extreme hunting pressure potentially exerted on local grouse populations by the large local work force associated with the Hat Creek project could be avoided if hunting in work areas or along major access roads is prohibited. The hunting pressure would then be spread over a sufficiently large area to prevent overharvesting.

No significant adverse impact to upland gamebirds is expected from construction air emissions because of the low predicted levels of pollutants. Dust may be a problem, but the magnitude of the problem cannot be predicted at this time.

Waste disposal would not be expected to adversely affect upland ecosystems or surface waters during the construction phase. Therefore, upland gamebirds would not be adversely affected.

D. Non-Game Birds

Habitat alienation is expected to be the only major adverse impact on non-game birds. In total, 939 ha (2244 acres) or 0.6 percent of the local study area would be alienated. The alienation would be dispersed over a large geographical area and among a wide variety of typical local study area habitat types. The impact, even though minor, would be expected to affect nearly all species.

Of the habitats surveyed, the most significant in terms of avian diversity is the riparian habitat, of which nearly five percent would be alienated. The most significant of the affected habitats, in terms of avian abundance, is the ponderosa pine - Douglas-fir/bunchgrass habitat (0.8 percent) while the least significant for birds is the open range habitat (Table 4-17).

The construction of the Hat Creek project would result in a loss of approximately one percent of the local study area avifauna. Some species, especially those associated with riparian habitat, could experience a loss of up to five percent. These losses would not be a simple mortality factor, but rather would be a loss in the ability of the land to support and sustain bird populations.

Noise and harassment associated with the Hat Creek project may have a significant impact on some of the more sensitive avian species. Falcons (except kestrels) and eagles are considered to be sensitive species to noise and disturbance, but exactly what this means in terms of noise levels and type of disturbance is unclear. The zone of noise influence does not overlap with any known or probable nest sites for the larger raptors. Very few data exist which would allow one to rank the remaining species in terms of sensitivity to noise, although much variability in sensitivity probably exists. Avian species are most vulnerable during the nesting season (May to June) when disturbances may cause birds to abandon nests or avoid otherwise suitable habitat.

In summary, some minor decrease in avian species diversity would be expected in the vicinity of sources of noise generation, but neither the magnitude of the impact, nor the species affected can be determined by existing data.

Direct exploitation of non-game birds would not be an expected outcome of the Hat Creek project. Shooting of almost all of these species is illegal and would not be expected to occur.

Dust may constitute a serious threat to some birds, especially in the vicinity of the mine and waste dumps. The reality of the potential for injury and the likely extent of injury cannot be assessed on the basis of available information.

Other air emissions from the construction of the Hat Creek project are expected to be sufficiently low so that no adverse impact upon birds is anticipated.

Waste disposal during construction would not be expected to adversely affect the terrestrial ecosystem. Upland birds would not be adversely affected by either the liquid waste disposal (injection well and irrigation spraying) or the solid waste disposal (incorporated into the area already alienated by dumping of mine wastes). Irrigation spraying may prove to be of minor benefit to some birds.

E. Small Mammals

The major impact of the construction of the Hat Creek project on small mammals would be the loss of habitat. Approximately 0.6 percent of the local study area would be alienated during construction of the Hat Creek project (Table 5-8) but the impact upon small mammals would probably be of greater magnitude because those habitats which are found to contain a high density or diversity of small mammals would be affected to a greater degree than those habitats which are relatively devoid of small mammals.

The best habitats for small mammals are riparian and open range. Riparian habitat appears to be the sole or primary habitat for a number of small mammals and is characterized by a high species diversity and overall density of small mammals. Open range contains a very high density of animals, but diversity is low. Forested areas (Douglas-fir/pinegrass and Engelmann spruce - lodgepole pine habitats) have very low densities of small mammals. Open forests (ponderosa pine - Douglas-fir/bunchgrass) are intermediate between open range and the denser canopy forests, in terms of density, and have low species diversity (see Table 4-21).

Nearly five percent of the local study area riparian habitat would be alienated as would approximately 1.4 percent of the open range. Only 0.7 percent of the semi-open canopy forests would be alienated and a mere 0.2 percent of the dense canopy forests would be alienated. The net loss would probably amount to about two percent of the small mammal resource base, but some species might experience a decrease of up to five percent.

Noise and harassment would probably not affect small mammals. Much of their activity and breeding occurs underground or under snow cover and would, thus, be well-insulated against air-transmitted noises. Noise studies on laboratory-raised small mammals indicate that anticipated ambient noise levels would be very unlikely to have an affect.

Increased direct exploitation of small mammals would not be an expected result of the construction of the Hat Creek project. Currently, direct exploitation only occurs for furbearers or for problem species. Fur bearers will be discussed in the subsequent section. Mice and rats (including the genera *Mus*, *Peromyscus*, *Rattus* and *Neotoma*) and marmots are the only small mammals that are usually considered as vermin. Old world mice and rats (*Mus* and *Rattus*) are found only as human commensals, and although native deer mice and pack rats (*Peromyscus* and *Neotoma*) can invade human habitation and make pests of themselves, they usually live independent of humans. Removal of these commensals would not affect wild populations. Marmots could be a problem because their presence conflicts with some types of agricultural practices. The Hat Creek project could increase exploitation of marmots only to the extent that it would alter agricultural practices away from the mine and plant site.

The low levels of dust and other air pollutants expected to accompany the construction of the Hat Creek project would preclude injury to small mammals during construction.

Waste disposal from construction camps would be expected to have, if anything, some positive effect. Garbage could provide a food source for some types of small mammals (mostly rats) and the planned irrigation spraying may increase the productivity of irrigated land to small mammals.

F. Furbearers

The impact of construction of the Hat Creek project on furbearer populations is difficult to predict. No habitat surveys could be carried out because of the scarcity of most furbearers and the difficulty in capturing them. However, in general, regional furbearers are either semi-aquatic or are found in the higher elevation forested areas (Table 4-22). Approximately five percent of the local study area habitat for semi-aquatic species would be alienated. Less than 0.5 percent of the forested area would be alienated. Open range, accounting for over half of the alienated land, has essentially no value to furbearers other than coyotes. The net effect of furbearers from habitat alienation by project construction appears to be relatively low.

Some furbearers may be sensitive to noise and harassment. The impact of noise upon furbearers probably parallels that hypothesized for birds; some species may experience stress or a range restriction, while others would not be affected. Ranch mink are not affected by sonic booms[88], but the impact of Hat Creek project noise on wild furbearers cannot be reliably forecasted. However, the impact would not be great as the area affected by increased noise and activity does not include any regions of suspected high furbearer productivity.

Patterns of consumptive use of furbearers would be expected to change little as a result of the Hat Creek project (Section 5.2(b)(ii)). Hence, no change in furbearer populations as a result of direct exploitation would be expected.

Dust and air emissions are expected to occur at low levels during project construction. Thus, little or no impact upon furbearers would be expected.

Waste disposal during construction would occur at localities which are largely devoid of furbearers. Thus, little or no effect would be experienced by furbearers as a result of construction waste disposal.

Environmental modifications during project construction could affect furbearers in two ways. First, the presence of the mine pit would prevent riparian-dwelling furbearers, such as beaver, otter and mink, from moving between the downstream and the upstream portions of Hat Creek. Cutting off the upstream portion of Hat Creek would have the effect of creating a small isolated population of furbearers. Such populations are prone to extinction, thereby leaving the upper portions of Hat Creek unutilized by that species.

Second, changes in ranching practices could affect coyote populations. Livestock carcasses can constitute a significant winter food resource for coyotes, and this resource may be partly responsible for the high coyote populations in Hat Creek. Changes in ranching practices could reduce the availability of winter coyote food. Such a reduction could cause a decrease in coyote populations, and could concommitantly result in decreased mortality from coyote predation on deer fawns.

G. Big Game

The overall impact of construction activities on local study area big game species is dependent on the number of species inhabiting the area and how directly each construction activity would interfere with each species' requirements. The most abundant big game species in the local study area are deer, moose and black bear. Cougar and wolf, predators of deer and moose, respectively, are scattered throughout the area.

Construction activities would alter traditional wildlife use patterns of habitats in and adjacent to the mine and plant sites. The physical removal of habitat (Table 5-8) would force these animals to seek refuge elsewhere, and the influx of large numbers of people and noisy construction equipment would cause many big game species to withdraw. As the animals become accustomed to the sight and sound of the intruders, some big game species would reinhabit the areas that were temporarily vacated.

Construction of the Hat Creek project is expected to alienate habitats presently being utilized by big game animals. The impacts of the physical alterations of the environment has been analyzed by first calculating the areas of individual wildlife habitats alienated by construction of each facility (Table 5-8) and then calculating the percentages of the local resource base affected. These figures were then compared to the capability ratings derived for each of the wildlife affected (Table 5-20).

The areas of wildlife habitats alienated by construction of the Hat Creek project, and the deer and moose capability ratings of these habitats are presented in Table 5-20. Of the 939 ha (2320 acres) alienated, over 77 percent (729 ha) involves the sagebrush, big sage, Douglas-fir/pinegrass, ponderosa pine - Douglas-fir/bunchgrass, and low and mid elevation grassland wildlife habitats.

One of the most significant construction impacts to local deer would be the alienation of the habitats with high and medium to high capability ratings (Table 5-20). Open pit #1 initial stages and temporary topsoil stockpiles would remove 96 ha (237 acres) and 40 ha (99 acres), respectively, of sagebrush habitat (Table 508). A total of 145 ha (358 acres) or over 21 percent of this habitat would theoretically remove an average of 3,915 deer days use annually from the local study area.

The low elevation, the vegetation composition, and the concentration of pellet groups in the sagebrush habitat suggest that it is used by deer as a winter range. During winters with light snow pack, this habitat may only be used lightly. However, during winters with heavy snow pack, it is speculated

TABLE 5-20

DEER AND MOOSE RESOURCE CAPABILITY RATINGS OF HABITAT ALIENATION DURING CONSTRUCTION OF THE PROPOSED HAT CREEK PROJECT

WILDLIFE HABITAT	Local Study Area Resource Base (ha)	Area Alienated (ha)	Percent of Resource Base	Deer Capability Ratings	Moose Capability Ratings
Sagebrush	670	145	21.6	High	Nil
Big Sage	19,990	132	0.7	Medium to High	Nil
Douglas-fir/pinegrass	62,560	124	0.2	Medium	Low
Ponderosa pine-Douglas-fir/Bunchgrass	13,420	113	0.8	Medium to High	Low
Low Elevation Grassland	4,760	112	2.4	Medium to High	Low
Mid Elevation Grassland	5,460	103	1.9	Medium	Low
Aspen	2,720	66	2.4	Medium	Low to Medium
Engelmann Spruce Lodgepole pine	39,020	64	0.2	Medium	Medium
Riparian	1.040	51	4.9	Medium to High	High
Cultivated Fields	3,030	23	0.8	Medium to High	Low

Table 5-20 continued

WILDLIFE HABITAT	Local Study Area Resource Base (ha)	Area Alienated (ha)	Percent of Resource Base	Deer Capability Rating	Moose Capability Rating
Brush	2,870	6	0.2	Low	Low to Medium
TOTAL	162,110	939	0.6		

that this habitat is intensively used by local deer and may provide forage for animals from surrounding areas. Removal of 21 percent of this habitat would negatively affect deer presence in the immediate vicinity of the mine mouth and may also decrease deer numbers in the local study area.

The medium to high capability deer habitats potentially alienated by construction activities include big sage, Douglas-fir/bunchgrass, low elevation grassland, riparian and cultivated field units (Table 5-20). These areas do not support the concentrations of deer found in the sagebrush habitat, but they are considered to be important to local deer.

The riparian habitat displays considerable use by deer and probably serves as escape terrain and as a travel corridor. Removal of almost 5 percent of this habitat from the study area would reduce the availability of important deer habitat and sever a travel corridor.

The 1978 winter aerial survey revealed that Douglas-fir/bunchgrass habitats with southern exposures frequently showed evidence of use by wintering deer. Construction activities would alienate only a small proportion of this habitat directly, however, unfamiliar noises and activities associated with construction may indirectly reduce deer use of these habitats.

An impact to local moose from the construction phase of the project would be the alienation of high and medium capability moose habitats (Table 5-20). The diversion of Hat Creek would remove 51 ha (126 acres) of riparian habitat while other construction activities would alienate 64 ha (158 acres) of Engelmann spruce-lodgepole pine habitat. Indications of use by moose were found in both habitats. However, as density of wintering moose in the Hat Creek Valley is considered to be low, alienation of moose habitat by construction activities is considered to have a relatively minor impact.

Alienation of wildlife habitats by construction acitivites would also affect black bear habitat. Riparian habitat, followed by forested lands, are of particular importance to black bear. Only a small proportion of the total resource base of these habitats would be affected (Table 5-20). Black bear are very adaptable creatures. Thus, the removal of habitat by construction activities is considered to have a minor impact to these animals.

Of the remaining big game species found in the Hat Creek watershed, cougar would be the most seriously impacted by the construction phase. These animals depend directly on deer for winter food, and fluctuations in deer numbers would influence cougar density. Wolf populations are anticipated to experience very minor impacts because construction activities are not anticipated to seriously affect availability of their prey, i.e. moose. Very few elk are present in the local study area and, therefore, impact of construction activities on this species is anticipated to be minor. However, as elk utilize habitats very similar to those selected by deer and because elk were once common in the local study area, should elk numbers increase during the project, the impact of land alienation on elk would become more severe.

Due to the fact that bighorn sheep and grizzly bear are scarce in the Hat Creek watershed, the impact of construction activities on these animals is anticipated to be minor. The impact of land alienation during the construction phase is anticipated to be nil on mountain goat and caribou due to the absence of these species in the vicinity of the disturbance.

Noise and harassment are considered separately in this section of the report. Noise is considered to relate primarily to the levels of sound emanating from construction activities. Harassment involves actions or activities associated with the project which could excite big game animals, causing panic, severe exertion and consequent damage, or even the death of the animal.

Noise levels associated with the construction phase of the project are anticipated to be fairly constant and continuous, and, except for areas very close to the construction activities, noise levels should rarely exceed 60 dBA.

Harford, Kennedy, Wakefield Ltd.[115] speculate that the most disturbing noises to wildlife would be from low-flying aircraft, snowmobiles and other all-terrain vehicles, plant steam venting, and possibly warning signals from the plant and mine.

Based on noise projections received from Harford, Kennedy, Wakefield Ltd.[115] and the literature review of wildlife reactions to noise presented in Section 5.2(b)(i)B. of this report, it is anticipated that the impact of construction noise on local big game species would be relatively minor. Cougar may be the one exception. These animals are normally very cautious and shy, and may avoid the sagebrush habitat (deer winter range) because of increased noise levels associated with construction activities. As this area likely supports only a few cougar, in the worst case, that is construction noise causing all cougar to vacate the area in question, this would affect only a small number of cougar.

Harassment of big game animals from construction activities of the Hat Creek project could take many forms. Low-flying aircraft frighten wildlife and this form of harassment is often prolonged by passengers wanting a closer look or photographs. This can be a very stressful situation for big game species, particularly when helicopters are involved. Access road constuction and use is another serious form of wildlife harassment. Construction and traffic noise, wildlife-vehicle collisions and near collisions, and improved hunter access are some of the harassment problems that roads create for wildlife. In addition to the above, recreationalists, such as skidooers, cross country skiers, hikers, horseback riders, etc., can also harass wildlife. These forms of harassment are most serious when the animal is experiencing a stressful situation, such as during the calving season or a severe winter.

Many animals habituate to strange, but frequent stimuli which are not associated with an obvious danger. For example, Geist[92] points out that there are Dall sheep living in active strip mines, and elk, moose, mule deer and bighorn sheep which tolerate dozens of people in close proximity. However, Geist warns that, "Habituation cannot readily take place if the harassing stimulus orients itself towards and follows the animals, if it appears and reappears unpredictably, if it is associated with or confused with a stimulus that experience has taught the animals to avoid (e.g. hunters reinforce the escape response of deer to hikers), or simply if it is so rare that habituation cannot occur."[92]

At the present time, the state of the art is not sufficiently advanced to predict what overall impact noise and harassment would have on local wildlife species. The season of the year, animal condition, and length and intensity of the stress situation are all factors influencing impact severities.

A positive impact of the construction phase of the project which would reduce harassment of local big game species would be the implementation of a no shooting zone around construction sites. The area of this zone was not known at the time of report preparation, but is expected to extend at least one mile beyond the periphery of all construction sites. The enforcement of this regulation would create a "reserve" where wildlife species would not be exploited.

Increased direct exploitation of big game species is an anticipated result of the proposed Hat Creek project. In addition to employees and their families, tourists and prospective employees would visit the Hat Creek Valley and adjacent environs throughout the construction phase of the project. Increased access to the general area would be provided to residents and visitors by construction of a new main road and access roads for the 69 kV transmission lines, the water pipelines and other offsite facilities. The combination of increased numbers of people and better access would undoubtedly increase the opportunity for big game exploitation.

A large proportion of the deer and moose harvested in the Hat Creek watershed are taken from the Medicine Creek area (Section 4.8(c)(i)). Concentration of construction activities and large numbers of people in this area would likely disperse many of these big game species. The animals remaining would be actively pursued by a drastically increased number of hunters.

Increased direct exploitation of the big game resource is also anticipated in the regional study area. The overall impact, however, would not be as severe as in the local situation because the use of the resource would be more dispersed. Bighorn sheep, grizzly bear and mountain goat are highly prized big game trophy species. It is anticipated that the availability of these species in combination with increased numbers of hunters would, in turn, increase the general hunting pressure on these three species, as well as on deer, moose, elk, black bear, cougar and wolf. The magnitude of this increase is expected to be relatively small (about three percent of 1976 levels) and would be difficult to detect considering the large yearly variations in hunter effort and harvest.

Dust and air emissions are anticipated to have a minor impact on local big game species. This statement is based on information presented in Section 5.2(b)(i)D.

Waste disposal during construction would involve a total land area of 48.17 ha (119 acres)(Tables 5-5 and 5-6). Deer capability of habitats within this area has been rated as follows:

High	2.9 ha (7.2 acres)
Medium to High	21.69 ha (53.6 acres)
Medium	23.58 ha (58.3 acres)

The sagebrush map unit is the highest rated deer habitat usurped by waste disposal during construction. Moose capability of habitats within this area has been rated as follows:

High	3.8 ha (9.4 acres)

Medium to Low	0.02 ha (0.05 acres)
Low	41.45 ha (102.4 acres)
Nil	2.9 ha (7.2 acres)

The riparian map unit is the highest rated moose habitat that would be usurped by construction waste material.

In comparison to both the total project and the area of wildlife habitats available in the Hat Creek watershed, the impact on big game of land utilization for waste disposal during construction is anticipated to be minor. However, it is important to note that present plans for waste disposal would remove land classified as high capability deer and moose habitat.

The method and/or location of disposal of garbage from construction camp kitchens was not known at time of report preparation. Improper disposal of such material would undoubtedly be an attraction to local bears. As the animals become accustomed to this food source, they become increasingly belligerant and bear/people problem encounters usually result. The solution to the problem would involve disposal of garbage in such a manner that it is unattractive or not available to bears. This practice would avoid most of the bear problems around construction sites. Improper garbage disposal, on the other hand, would invite confrontations with bears around the construction sites and garbage dump. This latter situation has the potential to severely impact local bear numbers, because once the problem develops it would be virtually impossible to solve without illiminating the bears.

H. Rare and Endangered Species

Very little impact would be expected on rare and endangered species by project construction. Such impact as would occur would affect locally rare species which are abundant elsewhere. With the exception of the prairie falcon and common loon, none of the rare and endangered species listed in Table 4-44 would be expected to be regularly encountered in the local study area during the breeding season; most of these species use the local study area only transiently. The local study area would be at best of marginal significance. The common loon is abundant throughout Canada and is listed as endangered only because loons may be vulnerable to pesticide bioaccumulation, a problem unrelated to the construction of an open pit coal mine and thermal generating plant.

The prairie falcon is the only endangered species known to breed in the local study area which has been recorded as being susceptible to noise and harassment. Because prairie falcon nests have only been reported along the cliffs on the banks of the Thompson River, they would not be affected by habitat alienation, noise and/or harassment, air emissions or waste disposal associated with the construction of the Hat Creek project.

Four big game species in the rare and endangered species table (Table 4-44) are subjected to direct exploitation: cougar, grizzly bear, wolf and bighorn sheep. Whatever hunting of these species does occur is very strictly regulated by the B.C. Fish and Wildlife Branch. Because of this strict harvest regulation, no additional impact on them is expected as a result of population ingress to the local study area.

(c) Operation

(i) Environmental Changes

A. Habitat Alienation

Mine

The mine has been arbitrarily divided into construction and operation facilities. The operation of the mine would entail considerable physical disturbance in the northern portion of the Hat Creek Valley. The pit would be expanded and large amounts of overburden subgrade coal and topsoil material would be transported to waste dumps and stockpiles.

A series of drainage structures around the mine would be required to prevent surface and near surface waters from flowing into the pit, and a similar series of ditches and pipes would be required to intercept runoff water from the waste dumps and stockpiles. An estimated six lagoons would be needed to collect and settle water from these drainage ditches. The lands alienated by the facilities associated with the operation of the mine are listed in Table 5-21.

The impact of most of the mine facilities on wildlife would be relatively severe. The pit, waste dumps and stockpiles all constitute areas which would represent a loss of habitat to all forms of wildlife, followed in most cases by a permanent habitat alteration. The process of land reclamation would commence contemporary with the operation of the mine, but most of the reclamation would occur during the decommissioning phase. The net effect would be to lose land to wildlife production for a number of years and then to re-establish a biologically productive ecosystem which would probably differ from the one which was lost.

The total area alienated by the operation of the mine would be 2097 ha (5182 acres) or 1.3 percent of the local study area. The wildlife habitat with the greatest area alienated would be Douglas-fir/pinegrass, but the relative impact upon this habitat (1.4 percent of the local study area resource) would be less than the relative impact expected for sagebrush (47.0 percent), mid elevation grassland (5.5 percent), low elevation grassland (3.1 percent), ponderosa pine - Douglas-fir/bunchgrass (2.8 percent), aspen (1.9 percent) or exposed rock (1.8 percent) (Table 5-8).

Plant

Lands alienated during the operation of the plant would be those which would be affected by solid waste disposal. Large quantities of fly and bottom ash would be produced by the thermal generating plant. If sulfur dioxide scrubbers

TABLE 5-21

LAND AREA ALIENATED BY

OPERATION OF PROPOSED HAT CREEK COAL MINE

FACILITY	Total Facility Area (ha)	Subalpine Krummholz (1)	Engelmann Spruce Lodgepole Pine (2)	Douglas-fir/ Pinegrass (3)	Ponderosa Pine - Douglas-fir/ Bunchgrass (4)	Aspen (5)	Riparian (6)	High Elev. Grassland (7)	Mid Elev. Grassland (8)	Low Elev. Grassland/ Saline Depression (9)	Sagebrush (10)	Big Sage (11)	Brush (12)	Bog (13)	Cultivated Field (14)	Waterbodies (15)	Exposed Rock (16)	Urban (17)
M1	652.0			130.4	158.8		10.2			53.6	287.5			7.7		3.8		
M2	487.2			219.2	121.8	14.6			131.6									
M4	615.1			387.5	73.8	24.6			116.9								12.3	
M5	1.2								1.2									
M6	0.4				0.4													
M7	0.4			0.4														
M8	0.8			0.8														
M9	0.5				0.5													
M10	0.5						0.5											
M11	22.8			20.1	2.7													
M12	61.8									35.8	26.0							
M13	99.4			28.8		12.9				57.7								
M15	123.5			66.7	7.4				49.4									
M19	35.0			18.0	8.4	0.1			5.1	1.9	1.2						0.3	-
SUB-TOTAL	2,100.6			871.9	373.8	52.2	10.7		304.2	149.0	314.7			7.7		3.8	12.6	
Percent Local Study Area Affected	1.3			1.4	2.8	1.9	1.0		5.5	3.1	47.0			1.2		0.5	1.8	

are to be incorporated into the plant design, a large volume of limestone slurry would also require land disposal. Ash disposal plans only have been studied, while the impact of the disposal of solid wastes associated with scrubber units has not been specifically considered in this report.

Four basic plans have been advanced for disposal of ash: the base scheme of one wet ash pond for both fly and bottom ash, an alternative scheme using the same wet ash pond for fly ash and adding a bottom ash dump, and two configurations of separate dry fly and bottom ash dumps. The lands under each proposed ash disposal site would be temporarily lost to all wildlife use and, after reclamation, would be permanently altered.

Table 5-22 compares the wildlife habitats alienated by four ash disposal schemes, including provision for land which would be alienated by the ash transportation system. In total, the base scheme would alienate approximately 674 ha (1665 acres), including substantial amounts of mid elevation grassland, Engelmann spruce - lodgepole pine, Douglas-fir/pinegrass and aspen habitats, and a small amount of bog habitat. The wet plus dry alternative would alienate the same area, plus an additional 180 ha (445 acres), for a total of 854 ha (2111 acres). Most of the additional alienated land would be mid elevation grassland.

The dry ash schemes would alienate substantially less land than the wet ash schemes. Dry Ash Scheme I would alienate 304 ha (750 acres), most of which (approximately 227 ha or 561 acres) is mid elevation grassland with the remainder mostly Douglas-fir/pinegrass. Dry Ash Scheme II would alienate an area of 261 ha (744 acres), located in the same general area, alienating approximately the same proportion of wildlife habitats as Scheme I.

Offsite

All habitat alienation expected from the offsite facilities has been considered under "Construction".

TABLE 5-22

COMPARISON OF LAND AREAS
ALIENATED BY ASH DISPOSAL SCHEMES

FACILITY	Total Facility Area (ha)	Subalpine Krummholz (1)	Engelmann Spruce Lodgepole Pine (2)	Douglas-fir/ Pinegrass (3)	Ponderosa Pine - Douglas-fir/ Bunchgrass (4)	Aspen (5)	Riparian (6)	High Elev. Grassland (7)	Mid Elev. Grassland (8)	Low Elev. Grassland/ Saline Depression (9)	Sagebrush (10)	Big Sage (11)	Brush (12)	Bog (13)	Cultivated Field (14)	Waterbodies (15)	Exposed Rock (16)	Urban (17)
Base Scheme Ash Pond Plus Conveyance System	673.6		218.0	149.0		60.8			232.6					13.2				
Wet Alternative Ash Pond for Fly Ash; Dry Dump for Bottom Ash	854.2		218.0	176.5		63.7			381.5					13.2		1.3		
Difference from Base Scheme	-180.6		-	-27.5		-2.9			-148.9					-		-1.3		
Dry Ash Scheme #I	303.6			72.9		2.9			226.5							1.3		
Difference from Base Scheme	+370.0		+218.0	+76.1		+57.9			+6.1					+13.2		-1.3		
Dry Ash Scheme #II	260.5			45.8		2.9			210.5							1.3		
Difference from Base Scheme	+413.1		+218.0	+103.2		+57.9			+22.1					+13.2		-1.3		

Summary of Habitat Alienation

The total amounts of wildlife habitats affected by the operational aspects of the Hat Creek project are presented in Table 5-23. The greatest absolute impact in terms of the total area affected would be to Douglas-fir/pinegrass, mid elevation grassland, ponderosa pine - Douglas-fir/bunchgrass and sagebrush habitats. The greatest proportional impacts are on sagebrush (47 percent of the local study area resource.), mid elevation grassland (9.8 percent), aspen (4.2 percent), bog (3.2 percent), low elevation grassland (3.1 percent) and ponderosa pine - Douglas-fir/bunchgrass (2.8 percent) habitats.

The total land alienation expected to result from implementation of the Hat Creek project base plan, construction plus operation, is summarized in Table 5-24. The greatest absolute impacts would be on the same four wildlife habitats listed in the preceding paragraph, reflecting the relatively large areas alienated by the mine and ash disposal system. The sagebrush habitat would be severely depleted, with an expected 62.6 percent of the local study area being alienated. Mid elevation grassland would also be substantially depleted (11.7 percent of the total would be alienated). Three other wildlife habitats would have more than five percent of their area alienated: aspen (6.6 percent), riparian (6.0 percent) and low elevation grassland (5.5 percent). Four additional habitats would have more than one percent of their area affected: ponderosa pine - Douglas-fir/bunchgrass (3.5 percent), bog (3.2 percent), Douglas-fir/pinegrass (1.8 percent) and exposed rock (1.8 percent).

B. Noise and Harassment

Most noise associated with the operation of the project is anticipated to be similar to construction noise. The major difference would be that operation noise would be more steady and continuous than during construction, and the noise sources would be more confined to the plant and mine sites. The normal operation of the plant and mine would be expected to have very little impact on most wildlife (see Section 5.2(b)(i)A. for a discussion of why this

TABLE 5-23

SUMMARY OF ANTICIPATED WILDLIFE HABITAT ALIENATION
DURING OPERATION OF THE PROPOSED HAT CREEK PROJECT (BASE PLAN)

WILDLIFE HABITAT	Local Study Area Resource Base (ha)	Affected Area (ha)	Percent Affected
Douglas-fir/pinegrass	62,560	1,021	1.6
Mid elevation grassland	5,460	537	9.8
Ponderosa pine - Douglas-fir/Bunchgrass	13,420	374	2.8
Sagebrush	670	315	47.0
Engelmann spruce - Lodgepole pine	39,020	218	0.5
Low elevation grassland	4,760	149	3.1
Aspen	2,720	113	4.2
Bog	650	21	3.2
Miscellaneous	1,580	16	1.0
Riparian	1,040	11	1.1
Subalpine krummholz	1,100	-	-
Alpine and High elevation grassland	3,240	-	-
Big Sage	19,990	-	-
Brush	2,870	-	-
Cultivated Fields	3,030	-	-
TOTAL	162,110	2,775	1.7

TABLE 5-24

SUMMARY OF TOTAL ANTICIPATED WILDLIFE HABITAT ALIENATION
BY OPERATION AND CONSTRUCTION OF THE PROPOSED HAT CREEK PROJECT (BASE PLAN)

WILDLIFE HABITAT	Local Study Area Resource Base (ha)	Affected Area (ha)	Percent Affected
Douglas-fir/pinegrass	62,560	1,144	1.8
Mid elevation grassland	5,460	640	11.7
Ponderosa pine - Douglas-fir/Bunchgrass	13,420	469	3.5
Sagebrush	670	420	62.6
Engelmann spruce - Lodgepole pine	39,020	282	0.7
Low elevation grassland	4,760	261	5.5
Aspen	2,720	179	6.6
Big Sage	19,990	132	0.7
Riparian	1,040	62	6.0
Cultivated Fields	3,030	23	0.8
Bog	650	21	3.2
Miscellaneous	1,580	16	1.0
Brush	2,870	6	0.2
Subalpine krummholz	1,100	-	-
Alpine and High elevation grassland	3,240	-	-
TOTAL	162,110	3,655	2.3

conclusion has been reached). The open pit mine would be fairly noisy at the edge of the pit, but wildlife species have been reported to habituate to noise and activity of open pit mines and can be observed at the very edge of the source of noise and activity[92, 184]. We see no reason why a similar habituation should not occur near the proposed Hat Creek mine and thermal generating plant.

Sources of intermittent noises would be the blasting at the mine, and circuit breakers and steam blow-off at the plant. Blasting and the tripping of circuit breakers produce a loud sound, but one with a very short duration. Blasting is expected to occur once every day, and circuit breakers may trip up to five times per day. These noises are similar to the natural sounds of thunder, thus, most species should have no difficulty habituating. Sonic booms at much higher sound intensities than those anticipated for Hat Creek blasting had no adverse effect on ranch mink[91]. However, species that are hunted and sensitized to shooting noises may not be able to habituate. Waterfowl, especially, may be startled by sudden noise because they may not spend enough time in the valley to habituate to blasting noise.

Steam blow-off is expected to contribute to ambient noise in two instances: tripping of the electromatic pressure release valves on each boiler unit (accidental) and blowing-out of the lines, a cleaning procedure. Information regarding the frequency of opening of electromatic valves is that: "The frequency of valve opening is indeterminate, but ... each unit will likely trip about four times per year for a total of 16 ventings per year. This figure does not anticipate the venting of boilers as part of a regular load varying procedure. Each venting will last about 15 seconds."[115]

The ambient noise levels associated with the opening of the electromatic valves depends on wind attenuation. The critical noise level necessary to disturb Hat Creek wildlife is unknown, but one study of antelope response to helicopter noise in New Mexico indicates that a noise level of 60 dBA causes some reaction and that a level of 77 dBA usually precipitates an escape response[94]. Under normal atmospheric conditions, noise from electromatic valves would exceed 60 dBA only in the immediate vicinity of the plant. Under calm conditions, the worst case condition which could be expected five percent of the time, the noise level could exceed 77 dBA immediately adjacent to the plant and could exceed 60 dBA up to a 30 km² area[115]. This sound would be of a quality such that it may disturb wildlife; it is unnatural and not sufficiently regular to allow habituation.

Blowing-out of the boiler unit would produce a noise which is also capable of disturbing wildlife. The sound would be louder than that produced by the electromatic valves and would be frequent (10 times per day) over a 2- or 3-day period. Habituation would be unlikely for many species, and the prolonged nature of the disturbance allows for the potential harm to sensitive species. Nesting birds and wintering ungulates could be adversely affected by this noise. Blowing-out of lines would occur prior to unit start-up at the beginning of the project operation and, presumably, after shutdown for major repairs and maintenance. With no wind attenuation, the sound could be heard over a very large area: a level of 60 dBA could be exceeded within a 200 km² area and a level of 77 dBA could be exceeded within a 20 km² area[115]. Sound levels would drop considerably if wind attenuation is present: 60 dBA might be exceeded within approximately 20 km² and 77 dBA within only a 4 km² area of land[115]. The noise levels would be eccentric, being loudest on the side of the plant from which the steam is vented (probably east side).

The construction of a new main access road, and pipeline and transmission line rights-of-way and access roads, could create a problem of wildlife harassment which is not directly related to the project. Hat Creek project workers and other members of the public would have access to areas which were previously inaccessible. The effect could be to increase harassment of wildlife but the magnitude of this problem cannot currently be determined.

C. Direct Exploitation

Direct exploitation of wildlife resources as a result of project operation would be expected to be primarily a function of changes in human demography attributable to the presence of the project work force. Change in hunter demand should be roughly proportional to change in population. The expected changes in demography for the local and regional study areas as a result of the Hat Creek project are summarized in Table 5-9 and predicted additional hunter demand is presented in Table 5-10.

Operation, which would begin in 1984 according to the schedule used for this report, would result in an increase of approximately 4000 people (40 percent) in the local study area. The relative increase in the regional study area population would be approximately 4.2 percent in 1984. Most of this increase would occur in the Cache Creek-Ashcroft area. In contrast to construction, relatively few people would reside within the Hat Creek Valley. Only a very minor increase (perhaps 300 people) would occur outside the local study area and within the regional study area as a result of the Hat Creek project.*

Operation is predicted to result in less project-related incremental hunting pressure than is construction, and the hunters would be dispersed among local communities rather than concentrated in the work camps (Table 5-10). The operation of the proposed Hat Creek project is estimated to result in the generation of approximately 6000 hunter recreation days[114].

D. Dust and Air Emissions

Fugitive Emissions

Fugitive emissions (those which are not emitted in a defined stream flow) during operation would consist almost entirely of dust. Additional fugitive

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* Strong Hall and Associates Ltd. personal communication - letter dated February 20, 1978.

emissions of sulfur, carbon monoxide and hydrocarbons would result from the operation of vehicles in the mine, along haul roads, along access roads, and in the vicinity of the airport, but these emissions are expected to be minor and of no environmental significance[108]. Fugitive dust emissions during operation would be restricted to the mine operation in the Hat Creek Valley. The dusting problem and its anticipated effect on the environment has been discussed under "Construction" (Section 5.2(b)(i)D.).

To summarize, the inhalation of dust is not anticipated to be directly harmful to wildlife, with the possible exception of birds. Dust may have an indirect adverse impact on wildlife by settling on vegetation, thereby reducing photosynthesis and community productivity. The existence of suspended particulates in the atmosphere may have the effect of diminishing incident solar radiation, causing a cooling of average temperatures[108]. Any such micro climatic changes would result in a minor change in vegetation and consequent minor change in consumers (i.e. wildlife).

Stack Emissions

Exhaust gases from the burning of Hat Creek coal would constitute the major source of atmospheric pollutants from the proposed Hat Creek project. As such, the composition of these gases and the way in which they are expected to disperse in the atmosphere have been the subject of intensive study. Environmental Research and Technology, Inc. (ERT) developed models which predict ground-level concentrations of sulfur dioxide throughout the year for both the local and regional study areas[108]. Sulfur dioxide (SO_2), although a minor constituent of the exhaust gases, is the major atmospheric pollutant from the stack and was chosen as a "marker" for all stack emissions of concern[108]. The concentration of any other stack emission can be determined on the basis of a known ratio between SO_2 and other pollutants[108].

The ERT modelling for the regional study area is based on uncontrolled emissions from a 366 m (1200 ft.) stack[108]. The ERT modelling for the local study area (25 km radius) is more detailed than that for the regional study area. The local model predicts, on the basis of one year's weather data, hourly values of sulfur dioxide concentrations for 128 sites within a 25 km radium of the stack throughout a year for each of three alternative control strategies[108].

The three air quality control strategies which are under consideration are described in detail elsewhere[117]. For the purposes of this report, it is sufficient to describe them only briefly and to comment on those features which have a direct bearing on the wildlife impact assessment.

One strategy involves the use of partial Flue Gas Desulfurization (FGD). The proposed system involves passing a portion of the flue gas through wet scrubbers. The result of this procedure is that approximately half of the SO_2 is removed from the stack emissions[117]. One disadvantage is that the temperature of the exit gas is decreased, decreasing the buoyancy of the plume; the present assessment of impact is based on a 366 m (1200 ft.) stack system. The FGD system would have the advantage of also reducing other stack emissions such as low boiling point hydrogen flouride and water soluble constituents such as hydrogen fluoride. However, quantification of such reductions in emissions have not been provided.

The remaining two strategies involve Meteorological Control System (MCS). MCS models have been developed for two stack heights: 244 m (800 ft.) and 366 m (1200 ft.). An MCS is a system of defined procedures designed to result in a reduction in the emission of airborne pollutants whenever meteorological forecasts indicate that high ground-level concentrations are likely to occur[117]. In the case of the proposed Hat Creek project, two pollution reduction procedures could be utilized: load reduction and fuel switching[117]. Load reduction results in a decrease in the amount of coal being burned and a concommitant decrease in stack emissions of all atmospheric pollutants. Load reduction has the advantage of being able to decrease the production of airborne pollutants within a matter of minutes. Fuel switching entails substituting coal with a below-average sulfur content in place of the normal mine coal. Fuel switching takes longer to implement (up to 8 hours to make a complete switch-over) and does not necessarily result in a decrease in the output of any airborne pollutants other than SO_2.

Oxides of Sulfur

Sulfur exists in appreciable amounts in Hat Creek coal. When the coal is burned, some of the sulfur content is emitted through the stack primarily as sulfur dioxide (SO_2) which subsequently undergoes atmospheric oxidation, ultimately forming sulfuric acid aerosols and fine particulate sulfates[108, 118]. The oxidation reactions are highly dependent upon atmospheric conditions and upon the relative abundance of other atmospheric contaminants, and may result in the formation of a whole family of potentially toxic compounds[119]. To date, however, most studies have addressed only the toxicity of sulfur dioxide, a few have investigated specific sulfate aerosols (mainly sulfuric acid mists), but very few have questioned the effects of mixtures of SO_2 and other pollutants.

Information on the effects of sulfur dioxide and sulfate on animals comes primarily from two sources: epidemiological studies and studies of the physiological affect of these irritants on laboratory animals, mainly rodents. Ecological effects are largely unstudied. A major series of investigations of the ecological effects of airborne contaminants is in progress at Colstrip, Montana, but final conclusions from these studies will be unavailable until their anticipated completion in 1980[120].

Experimentation has shown that the major physiological consequence of sufficiently high levels of sulfur dioxide[121] and sulfuric acid aerosols[122] is broncho-constriction resulting in increased pulmonary resistance. The mechanism for this reaction, although not completely understood, is believed to be related to a decrease in pH[123]. Chronic exposure produces histological changes in tissues lining the respiratory tract, but these pH-dependent effects seem to be completely reversible once exposure has ceased[119]. Sulfur dioxide has been shown to suppress experimental animals' resistance to bacterial infections, but the levels involved (0.02 mg/l or 20,000 $\mu g/m^3$)[119] are vastly greater than any anticipated to occur in conjunction with the Hat

Creek project.

The determination of threshold levels for physiological effects of SO_2 is impossible with the current level of knowledge. Insufficient data preclude the determination of a dose-response curve, and interpretation of those data which have been collected is handicapped by a lack of understanding about atmospheric reactions, synergistic relationships, and interrelationship of variables influencing toxicity response[119]. It can be generally stated, however, that sulfur dioxide alone is not considered to be especially toxic or irritating[123]. This fact can be partly explained by the water solubility of SO_2 and $SO_4^=$ which do not reach the sensitive gas-exchange tissues because they are absorbed by the mucous membranes of the upper respiratory tract[123]. Birds generally lack the complex nasal passages characteristic of mammals and, hence, may be more susceptible to low levels of SO_2[123]. Some evidence exists which suggests that birds (doves) sustain lung damage from atmospheric pollutants at levels which are only one-tenth of those required to produce comparable effects in humans[123].

Epidemiological studies provide the most useful information relating to threshold levels of atmospheric pollutants. Epidemiological studies have the advantage of dealing with both hyper-susceptible and normal individuals during actual exposure patterns. This natural variability in susceptibility constitutes a more realistic test than do studies on strains of laboratory-raised and genetically similar mice. These studies have the disadvantage of providing an after the fact analysis only. A great number of variables may be involved during exposures, and no way exists to determine whether an observed correlation between SO_2 concentrations and health is causal or coincidental. Signs of respiratory stress disease and mortality of extremely susceptible individuals have been correlated with chronic exposures (at least 24 hours) of between 105 and 1500 $\mu g/m^3$[124]. In all cases, SO_2 was only one of an unknown number and variety of airborne contaminants. The U.S. National Air Pollution Control Administration has summarized studies of exposure of healthy adults to SO_2 by concluding that occupational exposure (eight hours per day for up to seven years) of 2 ppm (5700 $\mu g/m^3$) or less has no significant effect on human health or respiratory functions[124].

Ecological effects of realistic exposures of ambient airborne contaminants, including SO_2 and derivatives, on vertebrate animals are highly conjectural. Some idea of the expected response of vertebrates to air pollutants on wildlife can be gained by looking at the ecological effects of SO_2 on other organisms.

Stickel[125] lists several ecological effects which apply to a wide variety of ecosystems and are produced by different classes of pollutants. These effects are:

(1) simplification of ecosystems; loss of species;

(2) alteration of species composition such that hardy, broadly-adapted "weedy" species predominate (e.g. a change from native fauna to starlings, pigeons, house sparrows, rats and house mice);

(3) preferential loss of carnivores; carnivores are often more sensitive to pollutants and are more heavily exposed to pollutants that can be passed through the food chain;

(4) reduction of primary production and subsequent ecosystem energy flow. All trophic levels are eventually affected; and

(5) long-term or permanent loss of nutrient base which is tied up in the standing crop of biota.

Some of these effects have been recorded or are expected as a result of airborne contaminants from coal-fired generating facilities. Hillman and Benton[126] noted that SO_2 emissions induced an undesirable change in the insect species composition. Pests, such as aphids, increase in abundance while populations of desirable insects such as parasitic wasps and pollinators declined. Minor changes in species composition and ecosystem function have been noted among plants and invertebrate consumers as a result of controlled experimental SO_2 fumigation[127]. Lewis et al[128] state that "if a coal-fired power plant has a measurable impact on the environment, there is every reason to believe that it will be registered as an alteration of community structure."

An assessment of impact as the result of fumigation by the stack emissions from the Hat Creek project can only be stated in the most general terms. Specific predictions require the use of deductive logic, and an ignorance of the relationship among a large number of variables such as atmospheric conditions, dose-response relationships, synergism, variability in response within and between species, and trophic interrelationships precludes the prediction of specific responses.

The impact of SO_2 and other lung irritants could be greater on birds than on mammals, and secondary effects of SO_2 fumigation on wildlife (e.g. changes in vegetation) are expected to be more significant than are primary effects (e.g. lung or eye irritation and toxicity). Changes in plant species composition may alter ecosystem structure and function in subtle ways[129, 130]. Such changes could be expected to ultimately cause changes in faunal species composition and abundance.

The maximal levels predicted by ERT to occur within the local study area for the three air quality control strategies are listed in Table 5-25. These levels refer to specific receptor sites only, not to the entire study area; most areas would have significantly lower ambient SO_2 concentrations. The maximum level expected for one hour is 1730 $\mu g/m^3$ for the 244 m stack MCS option (Table 5-25). This value is well below the level of 14,000 $\mu g/m^3$ at which most laboratory animals begin to show any response to short-term SO_2 exposures[124]. Acute injury to wildlife (with the possible exception of some birds) as a result of hourly peak exposures to SO_2 is, therefore, not anticipated.

Long-term exposures may be more significant. The maximum predicted 24-hour average is 260 $\mu g/m^3$ (Table 5-25) which is higher than the minimum threshold

TABLE 5-25

MAXIMAL GROUND LEVEL CONCENTRATIONS PREDICTED FOR SO_2 WITHIN THE LOCAL STUDY AREA

Averaging Time	Maximum Concentration ($\mu g/m^3$)		
	366m FGD	366m MCS	244m MCS
1-hour	729	1644	1730
3-hour	366	647	622
24-hour	208	260	260
Seasonal:			
winter	3.5	6.0	5.8
spring	6.8	13.1	17.2
summer	5.1	9.9	10.9
fall	7.2	7.5	9.2
Annual	4.5	7.0	9.3

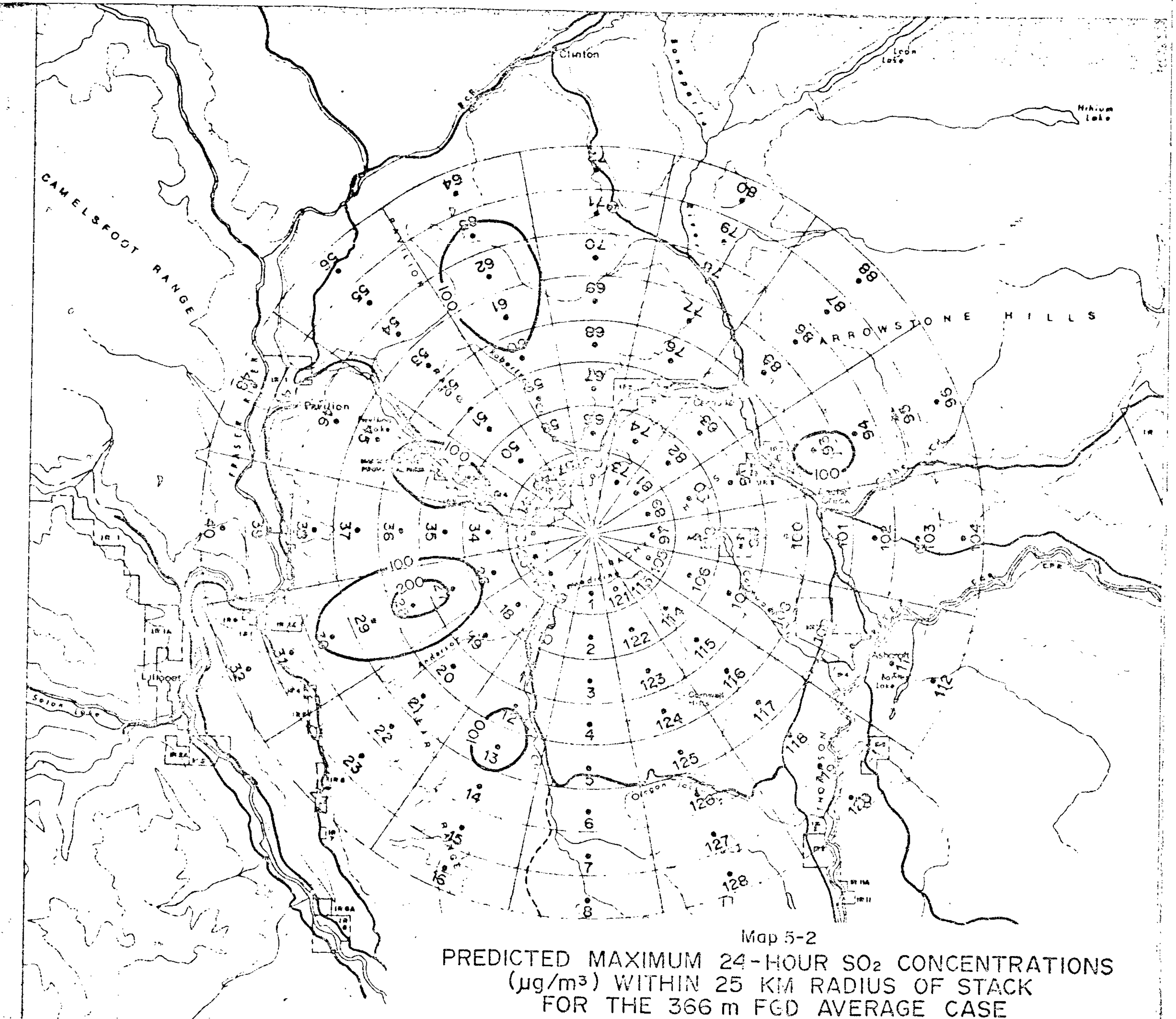
* Data from ERT[108]

of 100 $\mu g/m^3$ suggested by epidemiological studies[124]. The low predicted seasonal averages (3.5 to 17.2 $\mu g/m^3$) indicate that high daily averages would not occur over an extended period of time. Because the 100 $\mu g/m^3$ threshold applies to hypersensitive individuals and to unknown mixtures of polluted air, of which SO_2 is only one constituent, the ambient SO_2 at ground level in the local study area would be expected to have little or no direct effect on all but the most sensitive wildlife species.

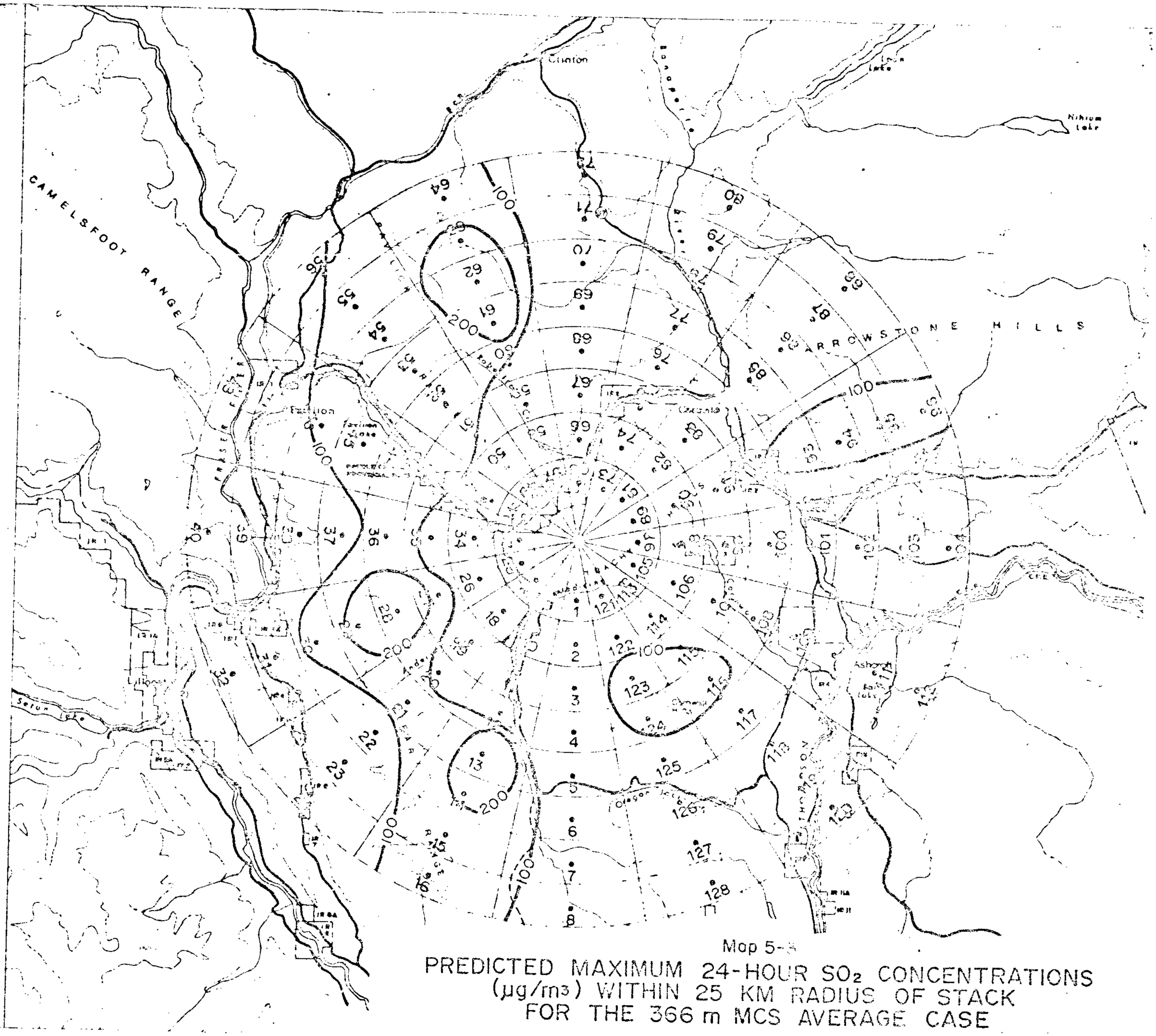
The patterns of exposure of 24-hour averages of 100 $\mu g/m^3$ or more of SO_2 for the three air quality control strategies are illustrated in Maps 5-2, 5-3 and 5-4. These maps present isopleths of expected maximum 24-hour average SO_2 concentrations but do not present frequency of excursions. However, frequency of excursions above 160 $\mu g/m^3$ are presented in the ERT report (ERT Figures 5-13, 5-31, and 5-46)[108] and appear to be closely correlated with maximal values.

The FGD option is predicted to produce fewer harmful episodes than would either MCS option, with the 366 m MCS option affecting less area than the 244 m MCS option. For the FGD strategy, maximal 24-hour SO_2 levels would exceed 100 $\mu g/m^3$ only in higher elevations in the Arrowstone Hills, Pavilion Mountain north of Robertson Creek, Marble Canyon, Chipuin Peak, and Mt. Blustry (Map 5-2). The PCB level "A" standard of 160 $\mu g/m^3$ would be exceeded only on Chipuin Peak.

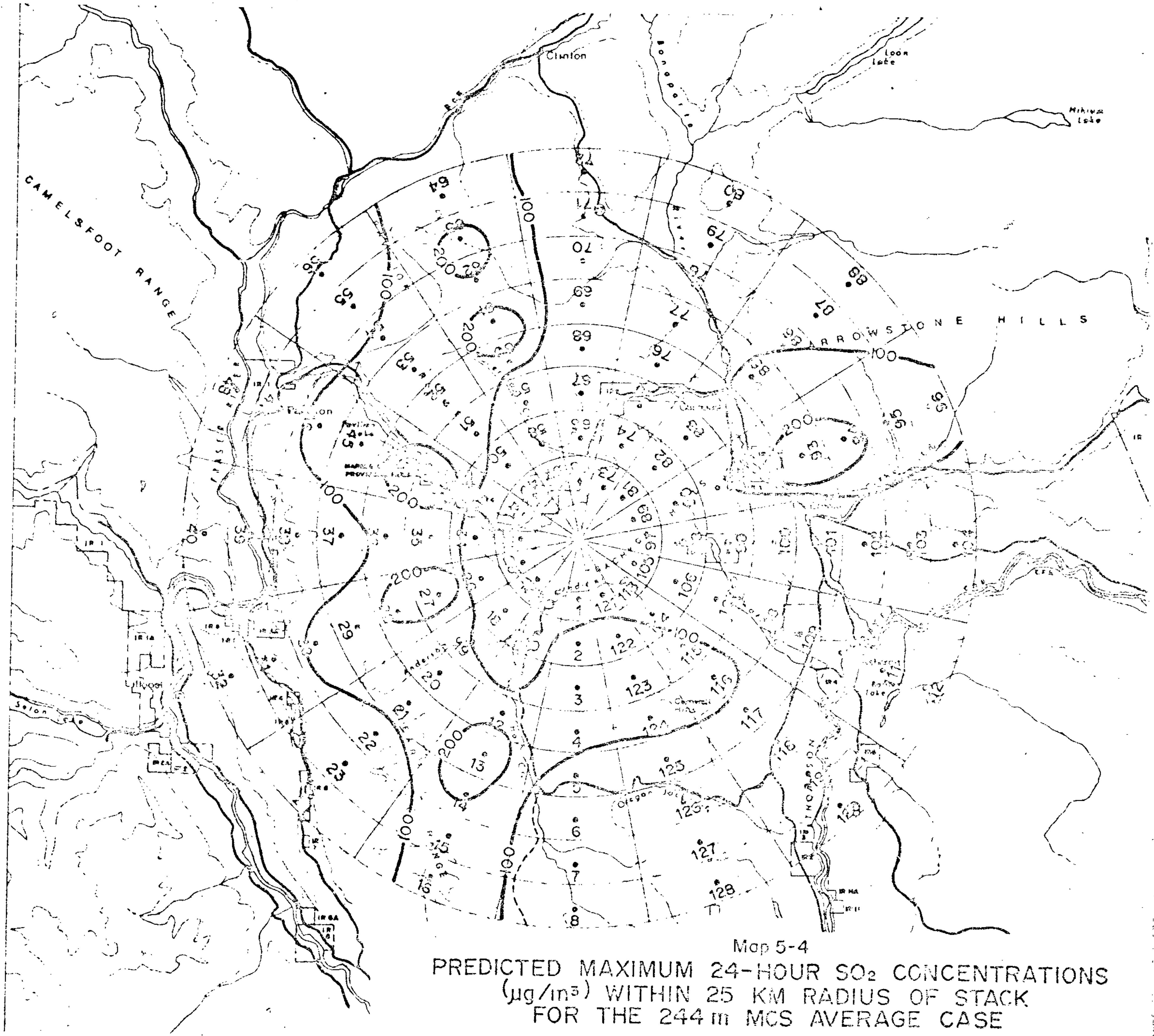
The MCS strategy with a 366 m stack would result in a much larger area experiencing levels of SO_2 100 $\mu g/m^3$ or greater. The Arrowstone Hills would again be affected as would the entire Clear and Pavilion ranges and the Cornwall Hills (Map 5-3). The PCB level "A" standard of 160 $\mu g/m^3$ would be exceeded on Mt. Blustry, Chipuin Mountain, Marble Canyon, the Pavilion Range north of Robertson Creek and the Arrowstone Hills. The MCS strategy with a 244 m stack shows essentially the same fumigation pattern as the MCS with a taller stack, except that the area which would experience 100 $\mu g/m^3$ or more maximal SO_2 concentrations is larger, especially in the Arrowstone and Cornwall hills (Map 5-4).



Map 5-2
PREDICTED MAXIMUM 24-HOUR SO_2 CONCENTRATIONS ($\mu g/m^3$) WITHIN 25 KM RADIUS OF STACK FOR THE 366 m FGD AVERAGE CASE



Map 5-3
PREDICTED MAXIMUM 24-HOUR SO_2 CONCENTRATIONS
($\mu g/m^3$) WITHIN 25 KM RADIUS OF STACK
FOR THE 366 m MCS AVERAGE CASE



Map 5-4
PREDICTED MAXIMUM 24-HOUR SO_2 CONCENTRATIONS ($\mu g/m^3$) WITHIN 25 KM RADIUS OF STACK FOR THE 244 m MCS AVERAGE CASE

The impact of SO_2 on wildlife is expected to occur primarily, if not exclusively, within the local study area, regardless of the air quality control strategy chosen. ERT has indicated the possibility that high 1-hour exposures (maximum of 388 $\mu g/m^3$) may occur at high elevations to the south and southwest of the stack[108]. Such excursions could impinge on bighorn sheep range in the Scarped Range west of Spences Bridge or on mountain goat range in the Coast Range in Management Unit 3-16. If the levels of exposure indicated for the Pavilion Range extend a little further to the northwest into the Marble Range, a second herd of bighorn sheep could be affected. The impact of such infrequent, low-level SO_2 excursions on these big game species or their habitats may be imperceptible.

The effects of acid precipitation upon wildlife are unknown. No reason exists to expect a direct effect of acid rain on wildlife, but any changes in vegetation or ecosystem function that may occur as a result of $SO_4^=$ outfall would eventually have effects on primary and secondary consumers including wildlife species. A special committee, the Acid Rain Committee, is studying the possible long range effects of Hat Creek sulfates.

Oxides of Nitrogen

Nitrogen is emitted from the stacks of coal-fired burners in the form of nitric oxide (NO). However, once freed into the atmosphere, NO begins to oxidize to form appreciable quantities of nitrogen dioxide (NO_2). The speed and completeness of this reaction depends upon atmospheric conditions and upon the presence of other reactive airborne contaminants[119]. For the purpose of the Hat Creek analysis by ERT, NO and NO_2 have been assumed to occur in equal molar amounts in the local study area (although NO_2 has 1.8 times the molecular mass of NO) and to be 80 percent NO_2 and 20 percent in NO in the regional study area[108].

Nitric oxide (NO), although toxic at high concentrations, is far less toxic than nitrogen dioxide[119, 131], and at ambient atmospheric levels NO is not an irritant and has not demonstrated adverse health effects[119]. The primary danger presented by NO is its tendency to oxidize into the more virulent NO_2.

Nitrogen dioxide (NO_2) is not only more toxic than nitric oxide, but appears to be more toxic to animals than is SO_2. Previous studies on NO_2 are similar to those for SO_2 except that NO_2 seems to have received less attention. Synergism between NO_2 and SO_2 does not seem to have been studied despite the prevalence of physiological studies on SO_2 alone, NO_2 alone, or either in combination with particulates.

NO_2 is relatively insoluable in water, so it is not absorbed by the naso-pharyngeal mucosa[119]; the lungs are not protected from irritation by NO_2 as from SO_2. Exposures to high concentrations of NO_2 have been demonstrated to decrease the ability of lungs to clear itself of particles and debris[132], and to profoundly affect the histological structure and the functioning of the lungs[132, 133, 134]. Chronic exposure, at levels of NO_2 as low as 940 $\mu g/m^3$, produces permanent emphysema-like injury[119, 131, 135]. Four-hour exposures of rabbits to 470 $\mu g/m^3$ of NO_2 for six successive days result in irreversible changes in lung collagen[131].

A potentially more serious effect of NO_2 exposure is the inhibition of the lung antibacterial defense mechanisms making affected animals more susceptible to lung infections[119, 131]. Exposure to NO_2 could have serious implications on wild populations which are already susceptible to lung disease. No adequate dose-response information can be given because of the disparity in physical condition which may exist between well-fed, unstressed laboratory mammals and free-living wild animals.

Epidemiological studies have shown that lung-related health problems begin to be observed at NO_2 levels of between 117 and 205 $\mu g/m^3$, and at 118 and 156 $\mu g/m^3$, and at 113 $\mu g/m^3$ (24-hour averages)[131]. No adverse human health effects appear to have been correlated with ambient levels of 94 $\mu g/m^3$ or less[119].

The authors are not aware of any specific ecological studies relevant to the effects of NO_2 on wildlife. Expectations are that adverse ecological effects of NO_2 would be essentailly similar to those discussed for SO_2.

NO_2 appears to present more of a direct threat to wildlife than SO_2 because:

(1) the effects of NO_2 occur at lower concentrations;
(2) the physiological effect of NO_2 is often irreversible;
(3) NO_2 has been proven to lower resistance to lung infections; and
(4) these effects have been demonstrated at levels which could realistically occur in polluted ambient air.

The specific levels of NO_2 expected to occur as a result of stack emissions from the Hat Creek project are somewhat difficult to predict because the two control strategies, FGD and MCS, during fuel switching would be expected to alter NO_2/SO_2 ratio such that NO_2 would be more prevalent than would be predicted on the basis of the concentration of SO_2. The FGD case may be especially misleading in this regard. Nevertheless, the predicted maximum NO_2 concentration for various averaging times are presented in Table 5-26.

The predicted concentrations of NO_2 listed in Table 5-26 indicate that the minimal NO_2 levels, which have been recorded to produce irreversible changes to experimental animals (470 $\mu g/m^3$), would be exceeded by only 1-hour averages. One-hour averages are predicted to reach at least 675 $\mu g/m^3$[108], nearly 50 percent higher than the experimental minimum. Whether a repeated series of such 1-hour exposures would occur, or if it did occur would produce harmful effects on wildlife species cannot be ascertained, but it should be remembered that some wildlife may, by virtue of genetics or physical condition, be much more sensitive than experimental laboratory mammals. Free-living, exercising animals would respire more than would sedate laboratory animals and, hence, would be exposed to more molecules of pollutant and would show effects at lower ambient levels; this principle has been experimentally verified in the laboratory[136]. Maximum 3-hour and 24-hour averages are also anticipated to exceed the 94 $\mu g/m^3$ dosage but, on the basis of epidemiological

TABLE 5-26

MAXIMAL GROUND LEVEL CONCENTRATIONS PREDICTED FOR
NO_2 WITHIN THE LOCAL STUDY AREA*

Averaging Time	Maximum Concentration ($\mu g/m^3$)		
	366m FGD**	366m MCS***	244m MCS***
1-hour	284	641	675
3-hour	143	252	243
24-hour	81	101	101
Seasonal:			
winter	1.4	2.3	2.3
spring	2.7	5.1	6.7
summer	2.0	3.9	3.6
fall	2.8	2.9	3.6
Annual	1.8	2.7	3.6

* Data from ERT[108]

** Values probably too low because FGD would probably alter SO_2/NO_2 ratio in a manner which has not been adjusted for in ERT concentration estimates.

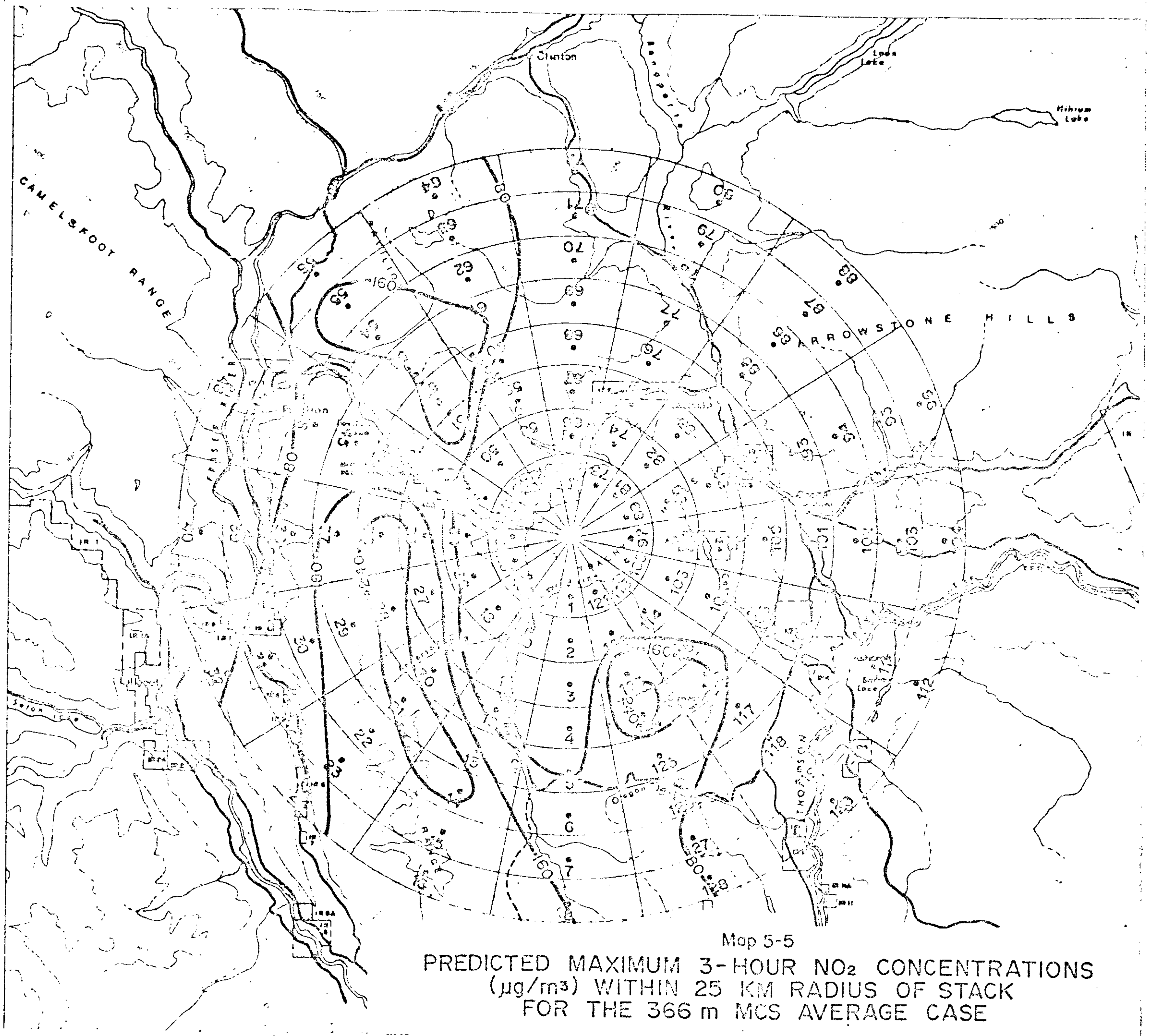
*** Values probably marginally low because use of coal-switching option would lower emissions of SO_2 but not of NO_x. These values are based on an assumed constant SO_2/NO_2 ratio.

studies, appear to be safe for humans. Again, the reponse relationship cannot be ascertained for wildlife. It is impossible, however, to give assurance that no direct injury to wildlife would occur as a result of fumigation from NO_2 from the proposed Hat Creek Power plant.

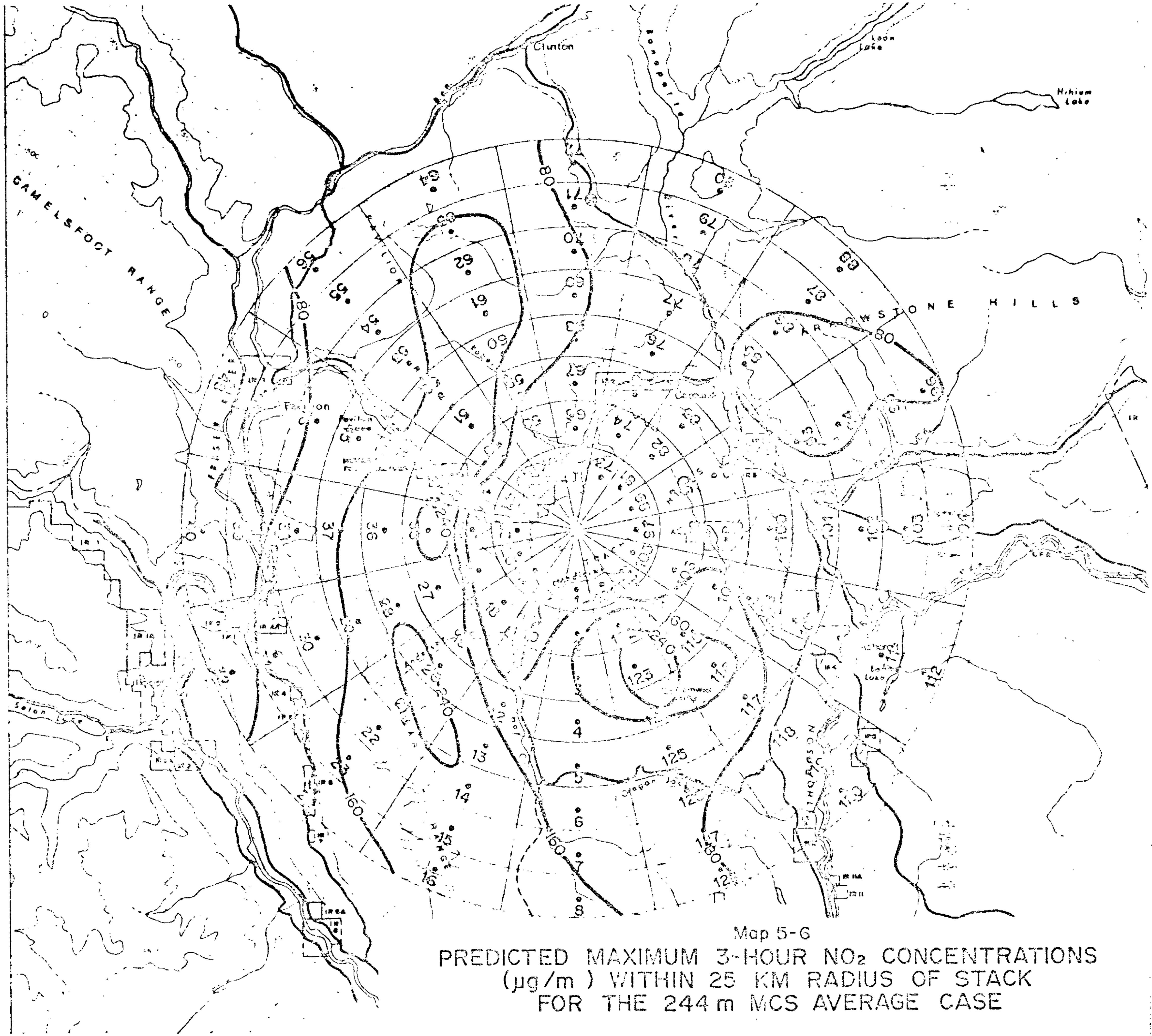
An especially pertinent data gap is the lack of knowledge about the synergistic effects of SO_2, NO_2 and particulates. High levels of all stack emissions are expected to be strongly correlated; in fact a correlation coefficient of 1.0 has been assumed in the ERT air quality modelling[108]. Even though fumigation by SO_2 alone or NO_2 alone may not be sufficient to injure wildlife, the combination may be.

The pattern of NO_2 fumigation is therefore, similar to the pattern of SO_2 fumigation presented in Maps 5-2 to 5-4. However, because NO_2 has been shown to produce acute, irreverisble injury for repeated exposute time as short as four hours[131], 3-hour averages of NO_2 have been mapped to obtain an idea of the area potentially affected by this component of stack emission. The specific pattern of 3-hour exposures for the proposed Hat Creek project is depicted for the 366 m stack MCS on Map 5-5 and for the 244 m stack MCS on Map 5-6. The FGD with 366 m stack has not been mapped, but would presumably resemble the 366 m stack MCS exposure pattern.

The value of 80 $\mu g/m^3$ for a 3-hour average has been arbitrarily chosen, partly on the basis of the level of 94 $\mu g/m^3$ of NO_2 being the threshold of response indicated by epidemiological studies[131], and below which direct injury to most wildlife species would not be expected. It is an ulta-conservative figure. Maps 5-5 and 5-6 indicate the portion of the local study area in which this level could be exceeded. The mountainous terrain to the west and south would be affected, including the Pavilion Range, Clear Range and Cornwall Hills. The elevated NO_2 levels appear to bextend a little to the northwest into the Marble Range, an unknown distance to the south and southwest in the Clear Range, and perhaps across the Fraser River to the Coast Mountains. Concentrations of at least 160 $\mu g/m^3$ for three hours are expected to occur in



Map 5-5
PREDICTED MAXIMUM 3-HOUR NO_2 CONCENTRATIONS ($\mu g/m^3$) WITHIN 25 KM RADIUS OF STACK FOR THE 366 m MCS AVERAGE CASE



Map 5-6
PREDICTED MAXIMUM 3-HOUR NO_2 CONCENTRATIONS
(µg/m) WITHIN 25 KM RADIUS OF STACK
FOR THE 244 m MCS AVERAGE CASE

the Pavilion Range, Cornwall Hills and throughout most of the Clear Range. Three-hour concentrations of 240 μg/m^3 for three hours are expected in the higher elevations of the Clear Range and Cornwall Hills. The 244 m stack MCS shows essentially the same pattern as does the 366 m stack MCS option, except that the 244 m case shows a greater area affected by NO_2, indicating that the Arrowstone Hills may also be affected by low (between 80 and 160 μg/m^3) levels of NO_2 fumigation.

Hydrocarbons

The effects of residual hydrocarbons on terrestrial fauna have apparently not been investigated[119]. Some evidence exists to suggest that some power plant hydrocarbon emissions, polycyclical aromatic hydrocarbons, may be carcinogenic[137]. However, the dosage required to produce experimental tumors has been enormously greater than those occurring in severely polluted ambient air[119]. Based on the predicted 0.017 ratio of total hydrocarbon/SO_2 emissions[108], the maximum predicted 1-hour ground-level hydrocarbon concentration for the 366 m stack MCS is 28 μg/m^3 and the maximum annual average is 0.12 μg/m^3[108]. These values are extremely low in comparison to levels which are suspected to be harmful on the basis of tests on laboratory animals[137]. Therefore, no reason exists to expect harmful ecological effects from predicted levels of hydrocarbon emissions from the Hat Creek project.

Carbon Monoxide

Emissions of carbon monoxide from the stack are assumed to be 5.6 percent of the uncontrolled SO_2 emissions[108]. Based on this ratio and on the ambient SO_2 levels predicted by ERT[108], the maximum predicted ground-level concentrations of carbon monoxide are:

1-hour	97 μg/m^3
3-hour	36 μg/m^3
24-hour	15 μg/m^3
annual	0.5 μg/m^3

At low levels such as these no impact would be expected on terrestrial ecosystems from carbon monoxide emissions[119].

Ozone

Ozone is a highly reactive compound which can be formed in the presence of NO_2 and ultraviolet light. Because of the expected NO/NO_2 ratio and low level of ultraviolet radiation, ozone levels in the Hat Creek plume are not expected to rise above ambient levels[108]. Therefore, terrestrial ecosystems would not be affected.

Particulates and Trace Elements

Particulates are predicted to be emitted from the stack at the rate of approximately 40,000 kg (88,000 lbs.) per day; the predicted particulate/SO_2 ratio is 0.12[108]. Based on this ratio and on the ERT projections for maximum ambient SO_2 concentrations[108], the maximum ground-level particulate concentrations for the worst case analysis are:

1-hour average	208 $\mu g/m^3$
3-hour average	75 $\mu g/m^3$
24-hour average	31 $\mu g/m^3$
annual average	1.1 $\mu g/m^3$

These maximal levels are insignificant when compared to the particulate levels expected from fugitive sources, and any effects would be expected to be overshadowed by dust from other sources. There is no evidence to suggest that wildlife would be affected by particulates or by the specific trace elements present within them[138]. However, some evidence exists which suggests that particulates may potentiate the effects of other gaseous irritants, perhaps by catalytic oxidation of a gaseous irritant, e.g. sulfur dioxide to sulfuric acid[119].

Fluorine

The emission of fluorine from the Hat Creek power plant is an issue of potential environmental concern. Airborne fluorides have caused more worldwide damage to domestic animals than any other air pollutant[139]. The primary pathway for fluoride intoxication of animals is the ingestion of contaminated food and water. Inhalation of fluoride from the atmosphere contributes a negligible amount to the total fluoride intake[140]. Fluorine intoxication of animals is, therefore, expected to be the result of chronic, low-level environmental exposure to fluoride resulting in bioaccumulation of fluoride.

Chronic environmental exposure to elevated levels of airborne fluoride results in the accumulation of soluble fluoride in the leaves, stems, pollen and other parts of tolerant vegetation. This fluoride, plus fluoride which may be ingested as dust on the surface of plants, is then absorbed by herbivores or pollinators which consume the plants.

In vertebrates, fluorine is accumulated almost exclusively in skeletal tissues and not in soft tissues[140]. Excess fluorine which is not incorporated in skeletal tissues is rapidly excreted[140]. Carnivores which consume vertebrate prey and tend to receive less environmental exposure to fluorine than do their prey because the accumulated skeletal fluorine is relatively insoluble and, hence, not absorbed. This situation is an exception to the rule for trophic transfer of trace elements; carnivores are usually exposed more than are their prey species[125].

Entomological studies of environmental contamination indicate that pollinators have the highest body burdens of fluorine[141, 142], but that herbivorous and carnivorous insects also have elevated fluorine levels[141]. Hence, fluorine appears to be trophically transferable via invertebrates, a conclusion which indicates that insectivorous vertebrates, such as birds, could be susceptible to environmental fluorine accumulation. Fluoride poisoning of wildlife, when it occurs, seems to affect ungulates before it affects most other species[140], affecting them in such a way as to provide a warning of impending damage.

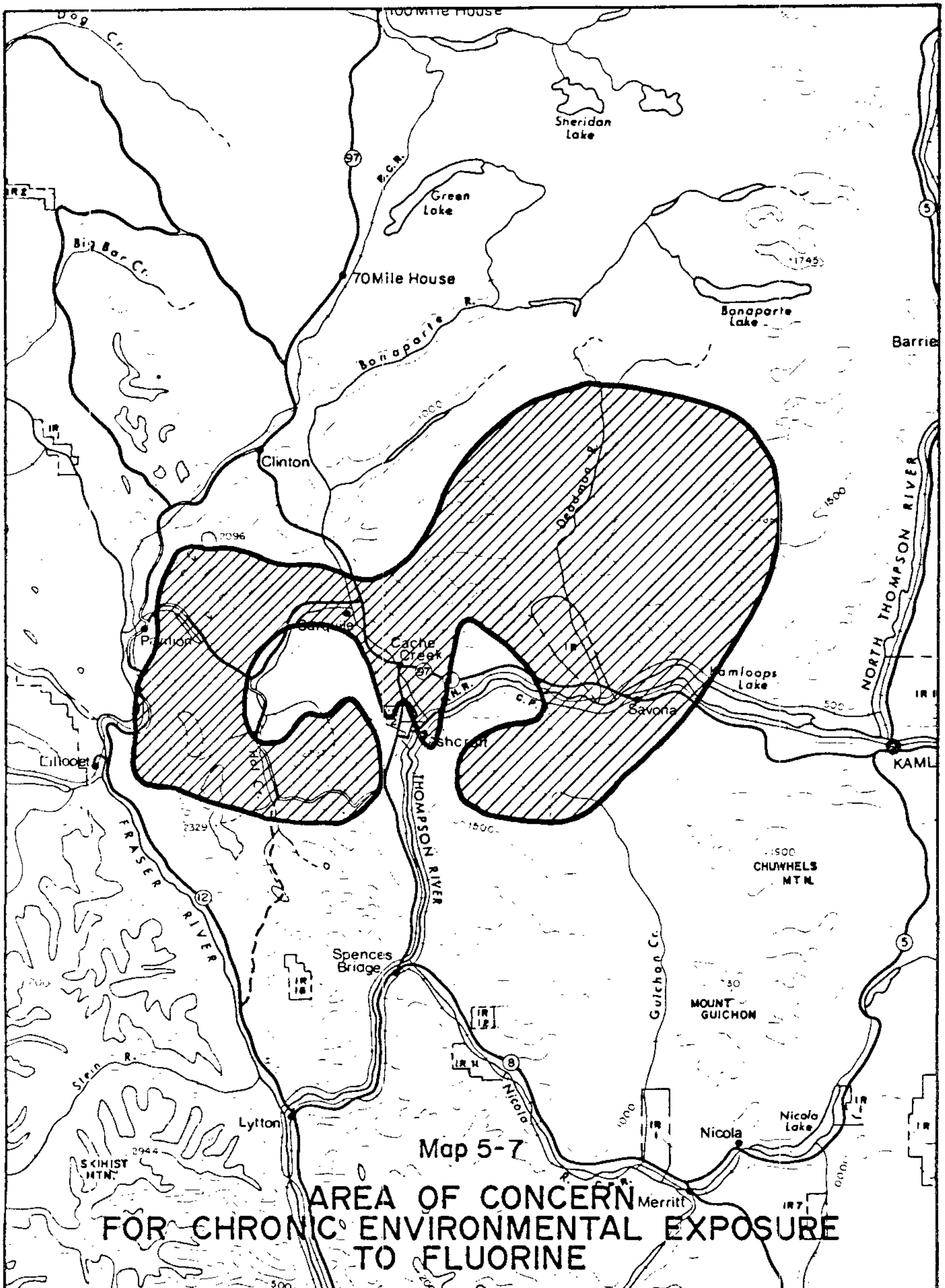
Ungulates vary in inherent sensitivity to fluoride ingestion, but all show the same pattern of response to chronic, sub-lethal, excessive fluoride ingestion[140]: Mottling of tooth enamel appears in animals exposed before tooth development occurs, followed by dental lesions and dental abnormalities which can cause difficulty in obtaining and processing food[140]. Ingestion of fluorine can cause bone lesions and mineralization of tendons resulting in lameness[140]. If fluorine ingestion is sufficiently high, appetite impairment occurs and the animal ceases to eat properly, a situation which then leads to a rapid deterioration of health[140]. Fluoride levels in feed should be kept below 40 ppm to ensure the health of beef cattle, a sensitive species[143].

The area expected to receive the highest annual average concentration of fluorine is illustrated in Map 5-7. This map shows that the area potentially affected by fluorine extends outside the local study area to the Arrowstone Hills and on beyond the Deadman River to the Tranquille Plateau. The operation of a coal-fired thermal generating plant which emits 18 kg/day (40 lb/day) from a 160 m (525 ft.) stack has been shown to cause elevated fluorine levels in wildlife.

The precise amount of fluorine which would be emitted from the stack cannot be currently determined. However, worst case analyses indicate that environmental damage from Hat Creek fluoride emissions would be minor (see Forestry Report). Because environmental fluorine accumulation is difficult to predict[183], fluorine should be monitored in the Hat Creek ecosystem if the project proceeds.

Cooling Tower Emissions

The cooling towers associated with the generating station would utilize water from the Thompson River[85]. Waste heat would be dispersed by evaporative cooling. Ideally, heat and water vapour would be the only emissions from cooling towers, but the actual operation of such towers inevitably results in the entrainment of droplets of cooling water containing dissolved solids, particularly salts, in the stream of air and water vapour which the towers



Map 5-7

AREA OF CONCERN FOR CHRONIC ENVIRONMENTAL EXPOSURE TO FLUORINE emit[145].

Cooling of the plume causes condensation which would result in a visible plume. The plume would contain saline aerosols whose chemical composition would reflect that of the cooling water used and whose deposition would occur around the site of the cooling towers. ERT has provided a prediction of the maximum deposition for four alternative cooling tower designs[145].

Four round mechanical draft towers	51,400 kg/km^2
Four rectangular mechanical draft towers	24,150 kg/km^2
Two natural draft towers	4,717 kg/km^2
Four natural draft towers	8,760 kg/km^2

In all cases the deposition rate would drop to 560 kg/km^2/year within three km of the towers. It should be noted that all four options result in the same amount of solids being emitted; the difference is in the pattern of deposition. Natural draft cooling towers would disperse the solids over a wider area than do mechanical draft towers, resulting in a greater area being affected but a lower maximum deposition rate[145].

The effects of salt deposition on the environment is dependent upon the composition of the component salts[116]. Because of the lack of information on the effects of cooling tower salts on ecosystems and a total lack of information on the effects of salts with the specific ionic composition of the expected Hat Creek project cooling tower drift, very little quantitative information can be generated concerning the environmental impact of the cooling towers. Little or no direct, adverse impact would be expected on wildlife. Cooling tower drift deposition may in fact provide a source of salts and minerals to wildlife species and, in this respect, may have a positive impact on wildlife.

Indirect impacts from cooling tower drift is expected to be much more significant than is direct impact. The moisture and heat in the cooling tower plume could create a marginally different micro climate near the towers, which could result in changes in vegetation. Any such changes would eventually affect the wildlife resource. Such an alteration in community structure would be difficult to describe based on available data. Predicted salt deposition rates[145] suggest that some adverse effects on vegetation could occur up to 3 km from the towers, and that some effects could reach greater distances[116]. It is not possible to quantify either the vegetational response or the subsequent wildlife response to cooling tower drift deposition on the basis of available data.

E. Waste Disposal

The operation of the mine and plant would produce large volumes of waste materials that require disposal. The mine would produce overburden, waste rock and subgrade coal. If a coal beneficiation plant is required, plant tailings would also need disposal. The power plant is expected to generate large quantities of fly ash and bottom ash. If a flue gas desulfurization scrubber system is employed, a large quantity of scrubber sludge would also be produced and require disposal. Scrubber sludge and beneficiation plant tailings disposal are not considered in this report.

The vast quantities of waste materials from the mine would require large waste dump areas. Groundwater, rainwater or snowmelt could become contaminated with leachates if allowed to flow through the crushed rock or rock-coal mixture. Consequently, dumps have been designed to minimize the flow of potentially contaminated water into the surrounding land. A system of drainage ditches has been planned around the perimeter of each waste area[86]. These ditches would catch surface and near-surface runoff waters and funnel them into lagoons (six of which are currently planned) which would serve as sedimentation basins. Some treatment of the water may be necessary in these lagoons and some of the lagoon water would be used for industrial purposes, but the remainder would be discharged into Hat Creek[146].

Several schemes have been devised to dispose of ash from the plant[85] (see Section 5.2(c)(i)A. and Figure 5-1 for descriptions of alternatives). Dry ash dumps would be similar to waste dumps and would be treated accordingly. A perimeter drainage ditch would be constructed to catch runoff and seepage waters and channel them into treatment lagoons.

If the wet ash disposal pond option is chosen, the ash would be transported in slurry form to a large settling pond[86]. Supernatent water would be lost by evaporation or reused for the sluicing of ash. Presumably the bottom of the ash pond would be lined with a layer of impervious clay to prevent seepage of ash pond liquids into existing ground aquifers[146]. The ash pond would also have a perimeter ditch but this ditch is intended to divert unpolluted waters away from the ash pond[146].

The plant itself would operate in a "no liquid discharge mode"; under normal conditions make-up water used would equal water lost to evaporation plus water used during the conditioning of "dry" waste materials[85]. All waste water from the plant drainage systems would be collected in a deep retention pond and evaporated[85].

The yard and plant floor drains would be kept separate[85]. Waste water from the plant floor drains would be collected in a deep retention pond and evaporated[85]. The yard drainage is not considered to be a waste and, therefore, would not be treated[85]. If an emergency coal pile is necessary at the plant site, drainage from it would be treated and then discharged to receiving waters or reused in the power plant[85].

Neither the plant nor the mine, as currently planned, would release toxic liquid wastes directly into a terrestrial ecosystem. Any impacts on wildlife at this phase would be expected to be a direct result of consumption of polluted waters or the consumption or organisms growing therein. Later, during revegetation, the problem of consumption of toxic vegetation may apply to upland ecosystems (discussed under "Decommissioning" (Section 5.2(d)(i)C.)).

Several bodies of potentially polluted water exist, the most notable of which are the ash pond, drainage ditches, lagoons and any additional retention ponds.

These waters may contain chemicals leached from the coal, ash, overburden or waste rock. The potential for these runoff waters to include toxic concentrations of trace elements would exist during operation before the exposed materials could be covered by a layer of topsoil, plus till or clay, and in ash settling ponds where evaporation can concentrate solutes.

The precise concentrations of solutes contained in runoff and seepage waters cannot be accurately predicted because of the large number of variables involved in the leaching process[138]. Similarly, the toxicity of a given element would also depend upon a large number of unknown factors, such as the chemical form of the toxicant, species, age, sex and physiological state of the organisms, past history of exposure, and the presence of synergistic or antagonistic chemicals. Hence, one can make no definitive statements regarding impacts, but potential toxicant problems could be isolated now and monitored to assure against environmental degradation.

To begin with, toxicity problems associated with waste disposal would be expected to stem primarily, if not solely, from trace elements for all drainage waters except perhaps those from the plant. Drain systems of the plant may also contain hydrocarbons from spilled lubricants or other products.

In order to determine which trace elements present the greatest potential environmental problems, the trace elements listed in the ERT trace element report have been sorted out on the basis of their biological effects. Eighteen elements have been considered: antimony (Sb), arsenic (As), beryllium (Be), boron (B), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), lead (Pb), lithium (Li), mercury (Hg), nickel (Ni), selenium (Se), thallium (Tl), tin (Sn), vanadium (V) and zinc (Zn). These elements were first categorized according to their known toxicity to vertebrates into one of three classes: high, medium or low. The biological persistence of the elements was also considered. Some elements can be excreted more rapidly than they are absorbed through the gut, while others are excreted relatively slowly in comparison to uptake. Those which are retained the longest tend to accumulate in vertebrates even when ambient levels are quite low (bioaccumulation); some of these bioaccumulative compounds also become increasingly concentrated as they pass upwards in a food chain (biomagnification). Although bioaccumulation and biomagnification are both functions of the rates of assimilation versus excretion and can vary greatly in degree, the trace elements have been scored either yes or no, depending upon whether bioaccumulation has been recorded for that element. Finally, the trace elements were scored according to their relative toxicity to plants and animals. This characteristic allows for the likelihood of elements to be found in toxic accumulations in plant tissues.

Eight of the 18 trace elements (As, Be, Cd, Hg, Pb, Se, Tl and V) are considered to be highly toxic to vertebrates; seven (B, Co, Cr, F, N, Sb and Sn) moderately toxic; and three (Cu, Li and Zn) of low toxicity[138, 147]. Only five elements (As, Cd, Hg, Pb and Tl) are characterized by having high potential for bioaccumulation in terrestrial vertebrates[13, 147]. These elements can be naturally grouped into four categories of toxicity (Table 5-27).

Elements in toxicity Class A have a very high potential for serious environmental contamination through a multiple of contamination routes. Class B elements are excreted relatively more rapidly than they are absorbed and, consequently, insidious chronic effects of low-level dosages are not expected to be as much a problem as with Class A elements. However, Class B elements may reach toxic levels in vegetation, even though the levels in soil and water are low enough for safe direct consumption by wildlife. Classes C and D elements would require high ambient levels before impacts on wildlife would be expected to occur.

Types and concentrations of trace elements possibly occurring in runoff and leachate waters are obtainable by comparing the leachate tests by Acres[146] with known toxic levels of trace elements (Table 5-28). Actual expected field concentrations are unknown, but ERT[138] reported potential leachate concentrations of As, Cr, Cu, V and Zn that indicate trace element concentrations could be up to four times the values reported in Table 5-28.

TABLE 5-27

CHARACTERISTICS OF TRACE ELEMENT TOXICITY
TO VERTEBRATES

Toxicity Class	Toxicity to Vertebrates	High Potential for Bio-accumulation in Terrestrial Vertebrates	Elements
A	High	Yes	As, Cd, Hg, Pb, Tl
B	High	No	Be, Se, V
C	Moderate	No	B, Co, Cr, F, Ni, Sb, Sn
D	Low	No	Cu, Li, Zn

TABLE 5-28

TRACE ELEMENT CONCENTRATIONS IN LEACHATE TESTS COMPARED TO KNOWN TOXIC OR LETHAL LEVELS

Element	Toxicity Class	Leachate Test Concentrations (ppm) ACRES[116] * Overburden	Waste Rock	Coal	Low Grade Coal Waste	Fly Ash	Bottom Ash	Hat Creek Water Ambient Levels; ERT Oct. 1976	Known Effect on Mammals Through Oral In estion
Hg	A	0.002	0.001	0.001	0.001	0.0004	<0.0002	0.0001	18 ppm lethal[148] **
Cd	A	<0.016	<0.016	<0.016	<0.016	0.0004	0.012	0.001	5 ppm - 10 ppm toxic[149, 150] **
Pb	A	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	0.05	1 - 7 ppm toxic[151,152]
As	B	0.1-0.25	0.2	0.08-0.16	0.16	0.86	0.62	0.002	0.4 - 10 ppm toxic[149]
Se	B	0.04	0.04	0.12	0.18	0.004	<0.002	0.002	0.4 ppm necessary, 4 ppm toxic[153]
Be	B	-	-	-	-	-	-	0.001	No data
Tl	B	-	-	-	-	-	-	0.001	0.8 - 50 ppm toxic[138]
V	B	<0.04	0.04	0.04	0.06	0.28	0.76	0.002	25 ppm toxic[154]
F	C	<0.08	0.48	0.08-0.28	0.3	11.04	1.36	0.5	10 - 40 ppm toxicity threshold[155]
Cr	C	0.2-0.3	<0.2	0.2	<0.2	<0.2	<0.2	0.01	>5 ppm toxic, 1 ppm toxic to bacteria[156]
Sn	C	-	-	-	-	-	-	0.001	20 - 1200 ppm toxic[157]
Sb	C	-	-	-	-	-	-	0.001	20 - 4000 ppm lethal[157]
Co	C	-	-	-	-	-	-	0.001	70 - 670 ppm toxic[157]
Ni	C	-	-	-	-	-	-	0.003	5 - 1000 ppm safe[158]
B	C	0.2	0.4	0.2	0.2	1.26	0.14	0.001	2.2 ppm in water, 2000 ppm in feed[157] toxic
Zn	D	1.36-2.16	1.76	1.44-3.0	3.0	8.	16.	0.02	500 - 2500 ppm safe[149]
Cu	D	0.44-0.68	0.8	1.0-1.4	1.2	0.04	0.04	0.006	330 - 775 ppm toxic[159]
Li	D	<0.06	<0.06	0.06-0.12	0.12	0.06	0.06	0.001	no data

* Concentrations derived by multiplying ACRES dry weight ratio data for factor of 0.2.

** Data given are for inorganic compounds. However, environmental toxicity is much greater for organic compounds of these elements. Most serious environmental problems with Hg and Cd concern organically bound chemical forms (e.g. methyl mercury) and not inorganic forms.

\- Indicates potential toxicity problems to terrestrial vertebrates at four times the reported concentration (see text).

Potential toxicity problems could be expected from a number of elements. Arsenic levels, in particular, exceed known toxic concentrations for drinking water, and boron and fluorine levels in fly ash leachate approach toxic levels. Chromium levels in overburden leachate may become sufficiently high to affect bacterial systems[156] and, thereby, adversely affect ruminant digestion. Lead levels cannot be assured to be below toxic levels from currently available data. Selenium and tin have been recorded to be near or at potentially toxic levels in the Hat Creek ecosystem[138]; a further minor increase in these metals would not cause direct wildlife injury, but vegetation growing near or in waters of high selenium content could accumulate enough metal to become toxic to herbivores. No information on tin levels was gathered from the leachate tests. Similarly, levels of thallium, beryllium, nickel, antimony and cobalt concentrations in leachates have not been reported.

Whether or not the actual runoff waters would attain similar or higher levels of dissolved trace elements is not known. However, ponds such as the ash pond and retention ponds in which evaporation is the major means of water loss could become toxic. Projected ash leachate quality calculated by BEAK Consultants Limited[185] based on the ACRES leachate tests, indicate that only arsenic and boron are likely to reach levels that would be toxic to terrestrial vertebrates. Sediments on the bottom of the settling lagoons could have high concentrations of heavy metals. All runoff water should be monitored for the 18 elements in Classes A to D of Table 5-27 until it can be reliably ascertained whether or not problems of heavy metal toxicity develop. BEAK Consultants Limited[185] have indicated that it would take "many years" for the quality of leachate waters to "level off". Some provision would be necessary to prevent wildlife poisoning through consumption of polluted waters.

F. Indirect Effects

Indirect effects of the proposed Hat Creek project on wildlife are expected to occur primarily by means of alterations to vegetation or to ecosystem dynamics such as nutrient or energy flow. These alterations could, in turn, alter ecosystem structure including the distribution and abundance of wildlife species. Indirect effects to wildlife could occur as the result of changes in:

(1) nutrient availability;
(2) photosynthesis (reduced or increased biomass); and/or
(3) plant species composition.

Changes in micro climate could result from suspended particulates or from the operation of the cooling towers. Suspended particulates intercept incident solar radiation, but do not absorb the long wavelength radiation emitted from the ground[119]. Therefore, suspended particulates could cause a decrease in ambient temperature. Such a decrease would be expected in the Hat Creek Valley in the vicinity of the mine and waste dumps, but the magnitude of the decrease is not known[108].

Cooling towers release primarily heat and water vapour. Under certain weather conditions water vapour can condense into an aerosol creating a visible plume or contributing to ground fogging. The cooling tower plume may change the temperature regime; in some instances heat could be released from the plume, in others fog could intercept incident solar radiation causing a drop in temperature. The release of water from the plume may change the local moisture regime. Because the dynamics of a grassland ecosystem appear to be controlled or regulated to a large extent by the vagaries of the water cycle[160], changes in the moisture regime of the water-limited ecosystems in the local study area would probably produce noticeable changes to vegetation.

In summary, minor micro climatic changes are probable in the Hat Creek Valley near the mine and in the Trachyte Hills. These micro climatic changes could induce changes to the vegetation and subsequent changes to wildlife distribution and abundance. It cannot currently be stated whether these charges would be beneficial or detrimental to local wildlife.

Changes in nutrient availability could accompany cooling tower drift, low levels of SO_2 fumigation or trace element fallout. Nutrients would be added and could have beneficial effects on plant growth. These changes would occur in regions where the dosage of salts or SO_2 were below toxic levels and where the supplied nutrients were limiting to plant growth. Increased primary productivity would be expected to have a positive effect on the abundance and diversity of avian species[161] and presumably other species as well.

Decreases in photosynthesis and possible changes in plant species composition are possible outcomes of stress induced by stack emissions of SO_2/NO_2 and fluorine, saline aerosols from cooling towers, and suspended particulates (see Physical Habitat and Range Vegetation Report, Appendix F). Any such decrease in primary productivity would be expected to have an adverse impact on consumer organisms including wildlife.

Particulates and saline aerosols are anticipated to have an adverse environmental impact only in the Hat Creek Valley near the mining operation[108] and within 3 km of the cooling towers. The magnitude of the adverse impact is impossible to predict because of uncertainty regarding climatic changes and because of a lack of specific information regarding the response of local study area vegetation to these stresses[116].

The impact of SO_2 and NO_2 combined has been studied in some detail[116]. A semi-quantitative approach has been used based on the ERT air quality modelling[108] and available literature regarding the response of plant species to known levels of fumigants[116]. These vegetation studies, summarized in the Physical Habitat and Range Vegetation Report, have identified plant species susceptible to injury by stack emissions, the geographic regions in which injury may occur, and the possible severity of such injury.

The consequence of vegetational injury to wildlife probably depends upon the magnitude of injury. If vegetational injury for any given species of plant is small (five percent or less per year), then the net impact of the vegetational injury on wildlife would probably be negligible because the plants would be able to fully recover. When vegetational injury is more severe, the affected plants may be killed, show die-back, or be put at a competitive disadvantage. The end result would be a habitat change which could then be followed by changes in wildlife abundance.

The possibility of vegetational changes that would affect wildlife can be determined from data presented in the Physical Habitat and Range Vegetation Report. A comparison of possible indirect wildlife impacts among the three air quality control strategies can be gained by extracting information from Tables 5-17, 5-19, and 5-21 of that report. Such a comparison has been presented in Table 5-29 in terms of areal cover of plant species which may suffer up to five percent injury per year and areal cover of species which are likely to suffer more than five percent injury per year. The injury estimates are representative rather than comprehensive in that insufficient data exist to estimate the impact of airborne contaminants on many plant species[116]. These data (Table 5-29) indicate that indirect impact on wildlife would likely occur much less with the FGD option than with either MCS option; the MCS option with the taller stack (366 m) would likely cause less indirect impact on wildlife than would the shorter stack (244 m).

These impacts would be concentrated on certain plant species within specific geographic areas. Table 5-30 presents the expected impacts of the three air quality strategies on selected plant species. These data indicate that willow (*Salix spp.*) would be heavily affected. As much as 40 percent injury to willow would be expected at some localities if an MCS control system is adopted. Willow is a species which is of prime importance as browse for deer and moose. Ground-level plumes would impinge most often at higher elevations, primarily affecting alpine, subalpine krummholz and Engelmann spruce - lodgepole pine wildlife habitats. Maps of areas of potential vegetation injury are included in the Physical Habitat and Range Vegetation Report, indicating that impact on vegetation and concomitantly on wildlife is most likely to occur in the Clear Range, especially between Mt. Blustry and Chipuin Peak, the Cornwall Hills, and the Pavilion Range, with

TABLE 5-29

A COMPARISON BETWEEN AIR QUALITY CONTROL STRATEGIES
OF AREAS (IN KM^2) OF VEGETATIVE COVER
WHICH COULD BE ADVERSELY AFFECTED BY SO_2/NO_2
FROM THE HAT CREEK THERMAL GENERATING PLANT

	Air Quality Control Strategy		
	366 m FGD	366 m MCS	244 m MCS
Area in which Predicted Impact on Plants $\leq$5% (No Adverse Effect on Wildlife Probable)	10.5	96.1	117.2
Area in which Predicted Impact on Plants >5% (Adverse Effects on Some Wildlife Probable)	0.1	5.3	15.5

Data derived from Physical Habitat and Range Vegetation Report, Tables 5-17, 5-19 and 5-21.

TABLE 5-30

POSSIBLE ADVERSE EFFECTS OF STACK EMISSIONS OF SO_2 AND NO_2 ON SELECTED PLANT SPECIES EXPRESSED AS TOTAL ESTIMATED COVER OF EACH SPECIES (km^2) POTENTIALLY INJURED DURING ONE YEAR

Plant Species	Air Quality Control Strategy		
	366 m FGD	366 m MCS	244 m MCS
Abies lasiocarpa		1.2	1.6
Picea engelmannii		14.2	15.6
Pinus contorta		13.8	16.9
Pinus ponderosa		0.3	1.8
Pseudotsuga menziesii		8.0	16.7
Populus tremuloides		0.1	0.5
Populus trichocarpa			0.2
Salix spp.	1.0	26.7	34.4
Amelanchior alnifolia		0.7	1.7
Poa pratensis	0.2	1.7	2.2
Pleurozium schreberi	9.4	32.0	38.4
Alectoria jubata		2.7	2.7
Total	10.6	101.4	132.7

Data derived from Physical Habitat and Range Vegetation Report, Tables 5-17, 5-19 and 5-21.

possibility of the Arrowstone Hills also affected existing for the 244 m MCS option.

The indirect environmental impact of SO_2/NO_2 emissions on most wildlife is expected to be undetectible or perhaps mildly advantageous at the lowest air pollution levels[162, 163]. Increased pollution levels could cause a decrease in primary productivity resulting in a decreased biomass and a change in species composition of both plants and animals[162, 163]. Extreme pollution levels would have severe environmental ramifications[162], but are not anticipated to occur as a result of the Hat Creek project[116].

Most wildlife species would be at a marginal disadvantage in areas of heaviest pollution levels, but some could temporarily benefit (e.g., insectivorous birds could benefit from outbreaks of forest insects). Some wildlife species could be at a severe disadvantage (e.g. those that depend heavily on willows at high elevations). Very little or no adverse indirect impact of SO_2 and NO_2 on wildlife is expected outside the local study area[116].

Impacts for fluorides are probably similar to those for SO_2 and NO_2. However, no specific information can be generated at this time for fluoride. Ecosystem damage from fluorides could be the result of chronic exposure to low ambient levels rather than the result of damage from acute injury from short duration as is the case for SO_2 and NO_2. Fluoride could affect ecosystems outside of the local study area, especially in the Arrowstone Hills.

(ii) Resource Use Projection - Impact of Operation

A. Non-consumptive Use

Non-consumptive wildlife use in the Hat Creek Valley would be expected to increase as a result of additional workers and visitors to the valley. As suggested in the Resource Use Projection - Impact of Construction section, both the local and regional study areas have many wildlife amenities. The resident populations living in the construction camps would no longer be there, but more visitors and curiosity-seekers attracted by the existence of the plant and mine would be able to gain access to the valley. Operation employees, their families and friends would also find the Hat Creek Valley and surrounding areas attractive for non-consumptive enjoyment of wildlife. Recreational activities are discussed in detail in the Hat Creek Detailed Environmental Studies, Recreation Report.

B. Consumptive

The anticipated increase in population attributable to the operation of the Hat Creek project is nearly identical to the peak population increase associated with construction although the population work-force is less. The pattern of settlement would differ because most operation workers would disperse and settle with their families in the local communities rather than living alone in the project camps. The Hat Creek project would induce an increase in the local study area population during the life-time of the project, however, the population of the local study area would also grow, irrespective of the Hat Creek project. Because of this natural population growth, the impact of the project on local population size and consumptive use demands would be proportionally greatest at the beginning of the project and would proportionally decrease through time. The total increase in consumptive wildlife demand from the Hat Creek project would remain relatively constant.

The expected changes in hunter demand pattern can be estimated by combining the population increase estimates (Tables 5-1 and 5-9) and the distribution of hunter residences from the local and regional study area approximations (Appendix B), using the same methodology as was described previously (Section 5.2(b)(ii). The year 2000 was chosen as the point in time that will be used to estimate the impact of project operation on hunter demand, because it is close to the mid-point of the projected operation phase.

Waterfowl

The anticipated changes in hunter demand for local study area waterfowl are calculated in the same manner for operation and for construction (Table 5-11), except that population forecasts to the year 2000 have been used. The operation of the Hat Creek project is anticipated to increase hunter demand for local study area waterfowl by approximately 46 percent (Table 5-31). This increase, added to the increase in demand expected irrespective of the Hat Creek project, would amount to a total increase in local waterfowl hunter demand of over 100 percent (Table 5-31). The waterfowl resource would probably be unable to sustain this increase in pressure, especially since up to 25 percent of the local wetlands could be alienated by project facilities.

In actual practice, the unalienated wetlands would be protected against excessive hunter pressure. Many wetlands would be within no hunting zones and would receive no hunting pressure, while access to most of the remainder of the wetlands would be privately controlled and unavailable to the public. Hence, local waterfowl harvests would probably decrease through loss of wetlands, loss of hunting opportunity on some wetlands, and lack of increase of hunting opportunity on any but a few of the remaining wetlands. Increased hunter demand would either be frustrated or applied outside the local study area.

The large expected increase in hunter demand underlines the importance of game management including control of seasons, harvests and access. No new hunter access to significant waterfowl areas would be created by the Hat Creek project, although access to the Cattle Valley would be greatly improved.

A large increase in regional waterfowl hunter demand is also expected by the year 2000, but the net impact of the project on regional waterfowl consumptive use would be relatively small. Without the project, regional waterfowl demand would be expected to increase by 66 percent, and the project would add a four percent increase on top of this (Table 5-32). The effects in terms of harvest of the four percent increase in demand attributable to project operation would be barely detectible. The natural growth within the

TABLE 5-31

ESTIMATION OF INCREASE IN LOCAL STUDY AREA HUNTER DEMAND FOR WATERFOWL DURING MID OPERATION (YEAR 2000)

	Local Study Area*	Remainder of Regional Study Area**	Lower Mainland	Remainder of B.C.***	Total
1976 Hunters (from Table 5-11)	59	7	-	3	69
Percentage Increase Without Project (from Table 5-1, 2000 values)	55%	81%	38%	27%	-
2000 Hunters Without Project	91	13	-	4	108
Percentage Increase With Project (from Table 5-9, 2000 values)	108%	81%	38%	27%	-
2000 Hunters With Project	123	13	-	4	140

(i) Increase without project = 108 - 69 = 39 = 57%

(ii) Increase with project = 140 - 69 = 71 = 103%

(iii) Additional increase due to project = 140 - 108 = 32 = 46%

* Estimated - see text

** As approximated by subregions 3C and 3D of Thompson-Okanagan region

*** Assumed annual growth of one percent per year

TABLE 5-32

ESTIMATION OF INCREASE IN REGIONAL STUDY AREA HUNTER DEMAND
FOR WATERFOWL DURING MID OPERATION (YEAR 2000)

	Regional Study Area*	Lower Mainland	Remainder of B.C.**	Total
1976 Hunters (from Table 5-12)	1079	306	186	1571
Percentage Increase Without Project (from Table 5-1, 2000 values)	81%	38%	27%	-
2000 Hunters Without Project	1953	422	236	2611
Percentage Increase With Project (from Table 5-9, 2000 values)	87%	38%	27%	-
2000 Hunters With Project	2018	422	236	2676

(i) Increase without project = 2611 - 1571 = 1040 = 66%

(ii) Increase with project = 2676 - 1571 = 1105 = 70%

(iii) Additional increase due to project = 2676 - 2611 = 65 = 4%

* As approximated by subregions 3C and 3D of Thompson-Okanagan region

** Assumed annual growth of one percent per year

regional study area is such that increases in regional waterfowl hunter demand and harvests would be so large that any effects of the Hat Creek project would be overshadowed.

Upland Gamebirds

The anticipated increases in demand for upland gamebirds would be less than those computed for waterfowl. Based on the hunter residence patterns discussed in Appendix B, upland gamebird hunters appear to be more mobile than waterfowl hunters and, hence, the highly localized impact of the project work force would not be as severe. By the year 2000, the hunter demand for upland gamebirds in the local study area would be expected to increase by 56 percent (Table 5-33). Upland gamebird hunter demand in the regional study area would have increased by 62 percent and the Hat Creek project would add an extra 3.5 percent by 2000 (Table 5-34).

These project-related increases in demand are of approximately the same magnitude as those calculated for construction. However, the impact on gamebird harvests may differ because the upland gamebird resource is likely to be more intensively hunted by the year 2000, irregardless of the Hat Creek project. Hence, the increase in demand is more likely to be perceived as a decrease in success rate than an increase in harvest.

Access to new hunting areas for upland gamebirds would be provided by the main access road along Cornwall Creek. Increased hunting could be especially severe along both sides of the access road. Temporary and service roads associated with pipelines, transmission lines and other facilities could also provide hunter access to previously inaccessible areas.

Furbearers

No changes are expected in the consumptive use of furbearers as a result of the Hat Creek project. No registered traplines would be affected by the project, nor would an increase in human population affect the distribution

TABLE 5-33

ESTIMATION OF INCREASE IN LOCAL STUDY AREA HUNTER DEMAND
FOR UPLAND GAMEBIRDS DURING MID OPERATION (YEAR 2000)

	Local Study Area*	Remainder of Regional Study Area**	Lower Mainland	Remainder of B.C***	Total
1976 Hunters (from Table 5-13)	313	504	452	120	1389
Percentage Increase Without Project (from Table 5-1, 2000 values)	55%	81%	38%	27%	-
2000 Hunters Without Project	485	912	624	152	2173
Percentage Increase With Project (from Table 5-9, 2000 values)	108%	81%	38%	27%	-
2000 Hunters With Project	651	912	624	152	2339

(i) Increase without project = 2173 - 1389 = 784 = 56%

(ii) Increase with project = 2339 - 1389 = 949 = 68%

(iii) Additional increase due to project = 2339 - 2173 = 166 = 12%

* Estimated - see text

** As approximated by subregions 3C and 3D of Thompson-Okanagan region

*** Assumed annual growth of one percent per year

TABLE 5-34

ESTIMATION OF INCREASE IN REGIONAL STUDY AREA HUNTER DEMAND FOR UPLAND GAMEBIRDS DURING MID OPERATION (YEAR 2000)

	Regional Study Area*	Lower Mainland	Remainder of B.C**	Total
1976 Hunters (from Table 5-14)	8450	4556	1426	14432
Percentage Increase Without Project (from Table 5-1, 2000 values)	81%	38%	27%	-
2000 Hunters Without Project	15295	6287	1811	23393
Percentage Increase With Project (from Table 5-9, 2000 values)	87%	38%	27%	-
2000 Hunters With Project	15802	6287	1811	23900

(i) Increase without project = 23393 - 14432 = 8961 = 62%

(ii) Increase with project = 23900 - 14432 = 9468 = 66%

(iii) Additional increase due to project = 23900 - 23393 = 507 = 3.5%

* As approximated by subregions 3C and 3D of the Thompson-Okanagan region

** Assumed annual growth rate of one percent per year of trapping privileges.

Big Game

Demand for consumptive use of the provincial wildlife resource has fluctuated considerably since 1950. It is anticipated that these fluctuations would continue to 2020 (project completion), with the trend being upward. As harvests of many big game species peaked in the late 1960's and have declined since that time, under our present natural resource management system, big game harvests may have been maximized during this period and would not be expected to increase.

Based on estimated numbers of big game hunter days expended in 1976 (Appendix B, Table B3-14) and the proportional population increases anticipated as a result of the project, it is possible to calculate estimated increases in demand for hunter days in the local and regional study areas. The figures calculated on this basis are presented in Table 5-35. The contents of this table rely on several assumptions, the major two of which are:

(1) increases in hunter demand would increase proportional to population increases, and
(2) indigenous big game populations would keep pace with the hunter demand.

However for big game populations to keep pace with hunter demand, deer, moose, bear and other big game populations would have to double in the local study area and triple in the regional area (assuming access and hunter success remain approximately constant). Increases of this magnitude are not considered possible.

Based on the assumptions outlined in Section 5.2(b)(ii)F, only the expected additional increases in local and regional deer and moose hunter demand attributable to the operation phase of the Hat Creek project have been cal-

TABLE 5-35

ESTIMATED INCREASES IN DEMAND FOR HUNTER DAYS
IN THE LOCAL AND REGIONAL STUDY AREAS WITH THE PROJECT

	Predicted Population Increases	
Year	Local Study Area	Regional Study Area
1986	1.7	2.6
2020	1.3	2.9

Increase in Big Game Hunter Days Demand
Local Study Area

Year	Deer	Moose	Black Bear	Bighorn Sheep	Mountain Goat	Grizzly Bear	Elk
1976	4872	511	150	62	0	0	0
1986	8282	869	255	105	0	0	0
2020	12667	1329	390	161	0	0	0

Increase in Big Game Hunter Days Demand
Regional Study Area

Year	Deer	Moose	Black Bear	Bighorn Sheep	Mountain Goat	Grizzly Bear	Elk
1976	53851	12051	1881	532	614	105	55
1986	70006	15666	2445	692	789	137	72
2020	156168	34948	5455	1543	1781	305	160

culated. These two species account for the largest numbers of animals harvested in the local study area (Table 5-2). Increases in local study area demand for deer and moose attributable to the operation period have been calculated to be 8 percent and 9 percent, respectively (Tables 5-36 and 5-37).

As was stated previously, harvest is, at best, expected to remain at current levels regardless of changes in hunter effort. Local harvest may decrease by as much as one half because of loss of habitat and hunting opportunity or by instigation of more restrictive hunting regulations. Participation in hunting would tend to decrease as hunter success decreases within the local study area.

Within the regional study area, expected increases in demand attributable to operation of the proposed Hat Creek project are relatively small, amounting to two percent for deer (Table 5-38) and three percent for moose (Table 5-39). These increases are trivial when compared to the large increase in big game hunter demand expected to occur irregardless of the Hat Creek project.

(iii) Resource Projection - Impact of Operation

A. Reptiles and Amphibians

During the wildlife inventory, it was noted that reptiles in the Hat Creek Valley are restricted to the riparian zone. The gradual enlargement of the mine during project operation would remove another 1.8 percent of the local study area riparian habitat. By the end of the project, approximately six percent of the local study area resource base would be lost (Table 5-24). An additional, undetermined amount of riparian habitat would be affected by alterations in surface drainage diversion schemes. Because summer temperatures in the Hat Creek Valley are cool in comparison to the Thompson and Fraser river valleys, the affected reptile resource is considered to be of relatively low quality. Hence, an estimated six percent decrease in reptile populations

TABLE 5-36

ESTIMATION OF INCREASE IN LOCAL STUDY AREA HUNTER DEMAND FOR DEER DURING MID OPERATION (YEAR 2000)

	Local Study Area*	Remainder of Regional Study Area**	Lower Mainland	Remainder of B.C.***	Total
1976 Hunters (from Table 5-15)	142	280	443	84	949
Percentage Increase Without Project (from Table 5-1, 2000 values)	55%	81%	38%	27%	-
2000 Hunters Without Project	220	507	611	107	1445
Percentage Increase With Project (from Table 5-9, 2000 values)	108%	81%	38%	27%	-
2000 Hunters With Project	295	507	611	107	1520

(i) Increase without project = 1445 - 949 = 496 = 52%

(ii) Increase with project = 1520 - 949 = 571 = 60%

(iii) Additional increase due to project = 1520 - 1445 = 75 = 8%

* Estimated - see text

** As approximated by subregions 3C and 3D of the Thompson-Okanagan region

*** Assumed annual growth of one percent per year

TABLE 5-37

ESTIMATION OF INCREASE IN LOCAL STUDY AREA HUNTER DEMAND FOR MOOSE DURING MID OPERATION (YEAR 2000)

	Local Study Area*	Remainder of Regional Study Area**	Lower Mainland	Remainder of B.C***	Total
1976 Hunters (from Table 5-17)	16	32	13	25	86
Percentage Increase Without Project (from Table 5-1, 2000 values)	55%	81%	38%	27%	-
2000 Hunters Without Project	25	58	18	32	133
Percentage Increase With Project (from Table 5-9, 2000 values)	108%	81%	38%	27%	-
2000 Hunters With Project	33	58	18	32	141

(i) Increase without project = 133 - 86 = 47 = 55%

(ii) Increase with project = 141 - 86 = 55 = 64%

(iii) Additional increase due to project = 141 - 133 = 8 = 9%

* Estimated - see text

** As approximated by subregions 3C and 3D of the Thompson-Okanagan region

*** Assumed annual growth of one percent per year

TABLE 5-38

ESTIMATION OF INCREASE IN REGIONAL STUDY AREA HUNTER DEMAND FOR DEER DURING MID OPERATION (YEAR 2000)

	Regional Study Area*	Lower Mainland	Remainder of B.C.**	Total
1976 Hunters (from Table 5-16)	3575	4585	1234	9394
Percentage Increase Without Project (from Table 5-1, 2000 values)	81%	38%	27%	-
2000 Hunters Without Project	6471	6327	1567	14365
Percentage Increase With Project (from Table 5-9, 2000 values)	87%	38%	27%	-
2000 Hunters With Project	6685	6327	1567	14579

(i) Increase without project = 14365 - 9394 = 4971 = 53%

(ii) Increase with project = 14579 - 9394 = 5185 = 55%

(iii) Additional increase due to project = 14579 - 14365 = 214 = 2%

* As approximated by subregions 3C and 3D of the Thompson-Okanagan region

** Assumed annual growth of one percent per year

TABLE 5-39

ESTIMATION OF INCREASE IN REGIONAL STUDY AREA HUNTER DEMAND
FOR MOOSE DURING MID OPERATION (YEAR 2000)

	Regional Study Area*	Lower Mainland	Remainder of B.C.**	Total
1976 Hunters (from Table 5-18)	835	721	331	1887
Percentage Increase Without Project (from Table 5-1, 2000 values)	81%	38%	27%	-
2000 Hunters Without Project	1511	995	420	2926
Percentage Increase With Project (from Table 5-9, 2000 values)	87%	38%	27%	-
2000 Hunters With Project	1561	995	420	2976

(i) Increase without project = 2926 - 1887 = 1039 = 55%

(ii) Increase with project = 2976 - 1887 = 1089 = 58%

(iii) Additional increase due to project = 2976 - 2926 = 50 = 3%

* As approximated by subregions 3C and 3D of the Thompson-Okanagan Region

** Assumed annual growth of one percent per year

is probably too high.

Amphibians are also found in the riparian zone, but their critical habitat consists of ponds which do not have excessive concentrations of solutes. In the local study area, these ponds are usually found at higher elevations (above the forest/open range interface) or have a rapid flushing rate (i.e. are impountments of streams). The impact of project operation on amphibians is anticipated to be of much greater magnitude than is the impact of construction because of the possible destruction of suitable amphibian wetlands in the vicinity of Finney and Aleece lakes and, to a lesser extent, in Houth Meadows. Precise quantification of the impact on amphibians is not possible, but it would not be unreasonable to assume that the project would decrease the local study area amphibian resource by between 10 and 20 percent.

The net impact of the project on amphibian habitat may be diminished because of the compensatory creation of new amphibian habitat in the storage reservoirs. The potential suitability of these reservoirs (Map 5-1; items OD1, OD4, OD7 and P4) for amphibians cannot be currently established. If the reservoirs were conducive to the maintenance of amphibian populations, they could partially offset the loss of amphibian habitat in the Aleece Lake vicinity.

Noise and harassment are expected to be less disturbing to wildlife during operation than during construction. No impact from operation noise or harassment is anticipated because of the relatively small area affected by elevated noise levels and because of the relative insensitivity of reptiles and amphibians to noise.

Direct exploitation of amphibians or reptiles is not an anticipated result of the proposed Hat Creek project. Some reptiles and amphibians may be accidentally killed as they cross roads, but such road kills would be expected to be uncommon.

The impact of dust and air pollution on reptiles and amphibians cannot be predicted because of an almost total lack of information regarding the response of these species to air pollutants. Reptiles occur mainly in the valley bottoms and would be exposed mainly to elevated levels of suspended particulates. Amphibians occur at higher elevations and would be subjected to elevated levels of SO_2, NO_2 and other stack emissions. Amphibians, therefore, have a greater potential to be adversely affected by air pollutants than do reptiles, but whether any impact would occur or how severe such impact might be is not known.

The disposal of waste has the potential of profoundly affecting amphibians by polluting their breeding ponds. However, the project description[86] includes plans to intercept drainage from all waste dump or coal storage areas. Potentially toxic runoff and seepage waters would be kept separate from other surface waters in holding lagoons until assurance of adequate water quality can be given, whereupon the water would be allowed to flow into Hat Creek downstream of the project[146]. Thus, contamination of amphibian breeding ponds would be avoided.

No specific predictions regarding indirect effects of project operation on reptiles or amphibians can be made (Section 5.2(c)(i)F.).

B. Waterfowl

The operation of the mine and thermal generating plant would result in a significant portion of the Hat Creek wetlands being lost. Large areas of land would be removed by the mine pit or covered by waste dumps, topsoil stockpiles and ash disposal areas. The numbers and types of wetlands within this land area are listed in Table 5-40.

The mine pit (including the dewatering zone), Houth Meadow dump, landing strip topsoil stockpile and wet ash pond all present resource conflicts with wetland-dependent wildlife (see figure 5-1, items M1, M4, M12 and

TABLE 5-40

WETLANDS LOST AS A RESULT OF OPERATION AND CONSTRUCTION OF HAT CREEK PROJECT FACILITIES

		Mine Pit and Drainage Ditches M1, M19	Houth Mead-ow Dump M4	Top-Soil Stock-Pile M12	Top-Soil Stock-Pile M13	Ash Pond P6	Ash Dumps P7,5 P8,P11	Oper-ation Total	Con-struc-tion Total	Pro-ject Total	Percent*
A: Temporary and Ephemeral	Number of Wetlands	1	2	1	1	1		6	-	6	12.0
	Area (ha)	0.98	1.61	0.02	0.37	0.03		3.01	-	3.01	24.3
	Edge (km)	0.49	0.88	0.08	0.34	0.03		1.82	-	1.82	19.0
B: Semi-Permanent	Number of Wetlands	7	1	3		5		16	3	19	13.8
	Area (ha)	1.67	0.14	0.26		1.10		3.17	0.21	3.38	22.7
	Edge (km)	1.41	0.19	0.45		1.11		3.16	0.52	3.68	17.6
C: Permanent with edge vegetation	Number of Wetlands		5					5	5	10	22.2
	Area (ha)		1.29					1.29	1.50	2.79	13.0
	Edge (km)		1.16					1.16	1.41	2.57	16.7
D: Permanent without edge vegetation	Number of Wetlands	10	2			1	1	14	9	23	27.1
	Area (ha)	18.23	0.16			3.74	1.15	23.28	2.54	25.82	19.5
	Edge (km)	5.11	0.30			0.98	0.71	7.10	2.12	9.22	21.3
E: Saline	Number of Wetlands			2				2	5	7	9.6
	Area (ha)			0.12				0.12	0.24	0.36	7.1
	Edge (km)			0.25				0.25	0.58	0.83	9.3
F: Bog	Number of Wetlands					5		5	-	5	16.1
	Area (ha)					2.44		2.44	-	2.44	12.1
	Edge (km)					1.99		1.99	-	1.99	14.8
Subtotal B+C+D	Number of Wetlands	17	8	3		6	1	35	17	52	19.4
	Area (ha)	19.90	1.59	0.26		4.84	1.15	27.74	4.25	31.99	19.0
	Edge (km)	6.52	1.65	0.45		2.09	0.71	11.42	4.05	15.47	19.4
TOTAL	Number of Wetlands	18	10	6	1	12	1	48	22	70	16.6
	Area (ha)	20.88	3.20	0.40	0.37	7.31	1.15	33.31	4.49	37.80	18.3
	Edge (km)	7.01	2.53	0.78	0.34	4.11	0.71	15.48	4.63	20.11	18.0

* percent of Hat Creek Site Study area totals (from Table 4-5)

P6). The mine pit, especially along the extreme southwest perimeter, presents the largest resource conflict with waterfowl. A number of temporary and semi-permanent ponds would be affected and almost all the larger permanent lakes and ponds near Aleece and Finney lakes would be lost. The landing strip topsoil stockpile alienates some smaller, temporary, semi-permanent and saline wetlands in the same vicinity. Together, the mine pit and the topsoil stockpiles remove most of the productive wetlands in an area in which 34 breeding pairs of ducks were counted by Ducks Unlimited and B.C. Fish and Wildlife Branch[05] in 1975 (Table 4-7).

Based on a comparison between the numbers and types of wetlands which would be alienated with the number present in the Hat Creek Valley (see Section 4.3(c)), the mine and topsoil stockpile could cause a productivity loss of up to 17 percent of the waterfowl breeding in the Hat Creek Valley.

The Houth Meadow dump overlaps with a series of wetlands which appear to be attractive to waterfowl, but insufficient data are available to assess their absolute or relative value to waterfowl. Similarly, the ash pond (P6) would alienate a series of wetlands in upper Medicine Creek of unknown waterfowl potential. These wetlands appear to be less suitable to breeding waterfowl than most of the wetlands in the valley because they are surrounded by shrub and forest, and would thaw late in the season. Harry Lake would be eliminated by some ash disposal alternatives. Harry Lake is isolated and has almost no edge vegetation and, therefore, has very little potential for breeding waterfowl, but it was observed to be used by migrating waterfowl.

The actual proportion of the total Hat Creek site study area wetland resource that would be lost to project development was estimated to be between 18 and 19 percent (Table 5-40), but the loss of an area with good interspersion of ponds and known high breeding utilization near Aleece Lake makes the proportional impact of the loss slightly greater. The breeding potential within the Hat Creek site study area would be diminished by at least 15 percent of the current potential. One-day migration survey counts have indicated that in the relevant survey areas (one-half of 16, 17, 18, 19, 24 and 30), 67 ducks or 18.2 percent of the total have been counted in these survey areas (Table 4-8) in April 1977, and 60 ducks or 11.5 percent of the total have been counted in these survey areas in September 1976 (Table 4-9). If counts from wetlands that would be affected by construction are also included, then the proportions of total migrating ducks within the affected areas increase to 23.6 percent in April and 13.8 percent in September.

In summary, the total loss of wetland habitat from both construction and operation of the proposed Hat Creek project could mean the loss of between 20 and 25 percent of the site-specific study area capability to produce and/or support waterfowl. The loss of breeding habitat is probably more severe than the loss of migration stop-overs because the creation of reservoirs could compensate for some migration habitat loss, but would not create any new breeding habitat.

Noise and harassment associated with project operation are expected to be less severe than those associated with project construction. By project operation, most of the noise generation would be restricted to the pit or the plant site. Much of the remaining noise would have settled into a pattern. These constant, repeated and predictable noise sources should allow waterfowl to habituate. Unnecessary foot or vehicular traffic could be disruptive to breeding or nesting waterfowl, and should be carefully regulated between April and October in the vicinity of breeding ponds (primarily south of the pit and west of Hat Creek itself). The potential conflict between blasting noise and hunting has been previously mentioned under construction and would continue to apply during operation.

Direct exploitation of waterfowl in the local study area has the potential of overharvesting the local resource. As was mentioned under construction, waterfowl hunting opportunity in the local study area is very localized, making waterfowl vulnerable to overhunting, but also making the resource relatively easy to manage. Access is the key. If access can be restricted to most of the wetlands and if other vulnerable wetlands are included within a "no shooting" zone, most duck hunters would be forced to go outside the Hat Creek Valley to hunt, thereby, spreading the increase in hunter effort over a region large enough to support the additional harvest.

The impact of dust and air emissions on waterfowl is unknown. In general, birds are expected to be very sensitive to lung irritants (Section 5.2(c)(iii)D., following), but the probability of injury to waterfowl from the predicted fumigation levels specific to the Hat Creek project cannot be estimated. Breeding waterfowl occur at lower elevations and would be exposed mainly to dust. Migrating waterfowl could be subjected to short, but very high exposures of SO_2 and NO_2 as the birds fly through the stack plume.

The waste disposal areas could present environmental hazard in terms of toxic leachates in runoff and seepage waters. The concentrations of potentially hazardous elements cannot be reliably predicted, but leachate tests have indicated that arsenic, boron, fluorine and chromium may reach toxic levels (Table 5-28). Insufficient data are available on other potentially toxic elements (Table 5-28). The ash pond (Map 5-1, item P6) is especially likely to become toxic to wildlife.

Waterfowl would be more susceptible to poisoning from toxic waters than would many other wildlife species. Waterfowl are attracted to small ponds, and would consume water and aquatic organisms from these ponds. If the water or organisms were contaminated, waterfowl could be poisoned. The ash pond because it is large, warm and permanent, could be attractive to waterfowl, especially in colder months when other waterbodies have frozen.

Toxic waterbodies could act as a lethal or debilitating trap for waterfowl or other wildlife. Some means of limiting wildlife access to the ash pond and to runoff water from waste dump and storage pits should be incorporated as a mitigative measure. Waterfowl normally gain access to a pond from the air. Preventing aerial access to a large waterbody such as the ash pond could be a difficult task.

No specific predictions regarding indirect effects of project operation on waterfowl can be made. The impact of air pollutants on food organisms of waterfowl is not known[116] (see Section 5.2(c)(i)F.).

C. Upland Gamebirds

Project operation is expected to alienate more upland gamebird habitat than would project construction. The enlargement of the mine pit and the establishment of ash and waste dumps would make large areas of land unproductive for upland gamebirds. Project operation is anticipated to alienate 2775 ha (6860 acres) or 1.7 percent of the local study area (Table 5-23). Of this total, 218 ha (540 acres) would be preferred spruce grouse habitat (Engelmann spruce - lodgepole pine habitat), 1540 ha (3800 acres) would be preferred blue or ruffed grouse habitat (Douglas-fir/pinegrass, ponderosa pine - Douglas-fir/bunchgrass, aspen, bog, brush, cultivated fields, subalpine krummholz and riparian habitats), and the remaining 1017 ha (2510 acres) would be largely unproductive of upland gamebirds. In total, project construction and operation would alienate approximately 282 ha (700 acres) or 2.2 percent of the preferred blue or ruffed grouse habitat, and another 1469 ha (3630 acres) of land which is relatively unproductive of upland gamebirds (Table 5-24). The loss of this habitat would be expected to be accompanied by a concommitant drop in grouse populations of between one and three percent.

Noise and harassment from project operation are unlikely to have a significant impact on upland gamebirds. Noise would originate mainly from two stationary sources, the mine and power plant. This noise would be repeated and predictable. Hence, upland gamebirds, if at all similar to domestic *Galliformes* (chicken-like birds), should have no problem accommodating to the noise generated by the Hat Creek project.

Direct exploitation of upland gamebirds (grouse) would be expected to increase with the increased numbers of people (including hunters), improved access, and increased travel through the area. The operation of the Hat Creek project is predicted to create a yearly demand of approximately 6000 hunter days[114], but the proportion of these days spent hunting upland gamebirds is not known. Grouse hunting is believed to be often a secondary activity, that is, hunters travel to a region primarily for other reasons (e.g., hunting big game) and while there also spend time hunting gamebirds. The distribution and regulation of grouse hunting would, therefore, be somewhat dependent upon the distribution and regulation of other types of hunting.

Some hunters hunt specifically for upland gamebirds. Most of these hunters would be unlikely to travel great distances from their residences (mainly from the Ashcroft - Cache Creek area) in order to hunt. These local residents could exert an intense hunting pressure on grouse populations. Access to the Trachyte Hills would be improved by the new access road along Cornwall Creek. Transmission line and water pipeline rights-of-way could also provide new hunter access to the Trachyte Hills south of McLean Lake.

It is believed that if hunting is prohibited in the immediate vicinity of Hat Creek project facilities and centres of activity, then the additional hunting pressure from the Hat Creek work force would be spread out over a sufficiently large area such that resource depletion would not result. Good upland gamebird areas exist close to the Cache Creek - Ashcroft area. Grouse are relatively difficult to overharvest but, if harvests began to decrease, hunters could readily shift their efforts to other areas, giving the original population time to recover.

The impact of dust and air emissions on upland gamebirds cannot be accurately forecast. In general, birds are expected to be sensitive to lung irritants (see subsequent section), but no specific data are available on the dose-response relationships between air pollutants and upland gamebirds. Upland gamebirds would probably be exposed less than some other types of birds, because they normally remain at ground level and are less active than birds such as chickadees or warblers.

Waste disposal would not be expected to significantly affect upland gamebirds. Upland gamebirds could be adversely affected if they were to consume polluted runoff waters. This adverse effect could be prevented by restricting upland gamebird access to the ash pond or to settling lagoons or other impoundments.

Upland gamebirds may be significantly affected by degradation of habitat as the result of fumigation damage to vegetation. Fumigation episodes would be more frequent and more severe at higher elevations, affecting spruce grouse and blue grouse. Spruce grouse, in particular, feed on willows[164] which would be more severely injured than would other plant species[116]. The effect of air pollutants on blueberries (*Vaccinium spp.*) and other important spruce grouse food[164], is not known[116]. Blue grouse occupy the high elevation treeline habitats and could be affected by injury to Douglas-fir, their most important food item[164]. The magnitude of these impacts cannot be quantified, but if severe local damage occurs to upland gamebird food species, it could cause a subsequent decline in the numbers of upland gamebirds.

D. Non-Game Birds

The largest habitat alienation resulting from project operation is expected to occur in the open range and Douglas-fir/pinegrass habitats. Approximately 1000 ha (2500 acres) (Table 5-23) of each would be alienated during project operation, which represents less than two percent of the Douglas-fir/pinegrass habitat and approximately 10 percent of the Hat Creek Valley grasslands (mid and low elevation grasslands and sagebrush habitats). Project operation would also alienate more than one percent of the local study area resource of ponderosa pine - Douglas-fir/bunchgrass, aspen, bog and riparian habitats (Table 5-23).

The net effect of the expected habitat alienation on the local avifauna is difficult to quantify because each of the 200 or more local bird species would be affected differently. If one makes the assumption that loss of habitat would result in a loss of birds of equivalent magnitude, then a reasonable projection may be made regarding the effect of habitat alienation from the Hat Creek project. This assumption is probably valid in the breeding season for most species, but would be overly conservative at other times of the year when the effect of habitat loss would be the compression of the same number of birds into a smaller area. This drop in bird population could range from nil to up to 12 percent (Table 5-24). The average decrease would be expected to be approximately 2.3 percent. The most significant habitat in terms of avian species diversity, the ripairan habitat, would decrease by six percent. The open range habitat, which would show the largest area loss could be restored by the reclamation process. Most breeding bird species would be expected to experience a minor decrease in population as the result of a loss of productive habitat. Within the local study area, a six percent decrease would be the maximum possible loss of any given species, and a two percent decrease would be the average probable loss.

The impact of noise and harassment during project operation on birds is expected to be less than that of construction noise. The sources of operation noise would be restricted essentially to the mine and plant site, with the predictability of the noise making habituation relatively easy. Some sensitive species may be excluded from the regions closest to the mine and plant sites. Steam blow-off during the nesting season (May to June) may cause unnecessary disturbance to nesting birds. Such sudden loud noises could startle nesting birds off their eggs, an event which could lead to cooling of eggs and subsequent egg mortality or nest abandonment.

Direct exploitation of non-game birds would not be an expected outcome of the Hat Creek project. Killing of almost all non-game species is illegal and should not increase with or without the project.

Air pollutants would be expected to affect birds more than any other form of wildlife. Pollutants of concern would be NO_2, SO_2 and particulates. Birds have many characteristics which make them susceptible to air pollutants:

(1) birds have high metabolic rates and consequently high respiratory rates;

(2) avian lungs are small yet highly efficient. Avian lungs constitute part of a high-performance system, able to process relatively large volumes of air by virtue of a unique anatomy which allows a 1-way air flow over the gas exchange surfaces[165]. As such, avian lungs may be highly susceptible to injury;

(3) avian lungs lack the production afforded by the complex nasal passages of mammals;

(4) birds are active and roost above ground receiving full 24-hour exposures to ambient pollutants; and

(5) birds, especially during migration, may fly at elevations considerably above the ground. The ambient levels of pollutants where the birds are actually flying may be significantly higher than those indicated by the ERT modelling.

Although the evidence suggests that birds are more likely to be adversely affected than other wildlife at a given level of air pollution[113], no data exist to definitively determine the presence or absence of injury to birds as a result of the proposed Hat Creek project. Any assessment of injury is speculative. Monitoring for air pollution injury should include both investigation of tissue (lung) damage and monitoring of ecological (community) parameters, such as indices of abundance, species diversity or species evenness (see Section 7.0).

Waste disposal is anticipated to have an adverse environmental impact through the creation of potentially toxic waterbodies. Birds would be affected only in as much as they consumed water or food from these waterbodies. Most birds would not be affected if prevented from gaining access to potentially toxic waterbodies.

The proposed Hat Creek project is likely to induce environmental changes which would ultimately affect wildlife. Birds, in particular, have been studied in connection with the environmental modifications. Changes in primary productivity, plant species composition, or vegetation structure would be expected to produce measurable changes in the avifauna. Because of the environmental sensitivity of birds and because avian community parameters may be easily and inexpensively monitored, birds may provide an excellent indexing method for monitoring ecosystem response to chronic pollution[113].

Collisions between birds and tall objects, resulting in avian mortality, have been documented many times. Bird collisions can occur under a wide variety of circumstances, but large scale mortality is associated with certain circumstances, as outlined below.

Large numbers of birds must be moving sufficiently close to the ground to encounter an artificial prominence. This usually occurs only during migration when a low cloud ceiling or inclement weather forces migrating birds to descend closer to the ground than usual. Under such circumstances birds apparently follow linear topological features such as shoreline, river or ridge, and structures adjacent to these topological features are more likely to be struck by birds than are structures which are further away[166].

The critical factor common to documented large scale collision incidents is artificial light. Most collisions occur at night during conditions of very poor visibility. At these times, the object with which the birds collide is usually lit, either directly or indirectly. The hypothesis is that under conditions of very poor visibility, birds migrating at night become disoriented upon encountering an articifial light source. Mortality ensues when the birds either crash into the object (lit or unlit portions) or flutter around it until they fall from exhaustion[166].

The proposed Hat Creek project has two structures which are potential sources of avian mortality: the stack and, if chosen, natural draft cooling towers. Under some circumstances, transmission lines can be lethal to birds, especially larger birds such as herons or ducks which cannot quickly dodge the wires. It has been reported that existing transmission lines in the Kamloops area have not been a problem in this regard*. Therefore, one would not expect new transmission lines to be lethal to birds either. Depending on design construction, smaller transmission lines (4 to 69 kV) can electrocute larger birds, especially golden eagles[167]. However, the electrocution of large raptors is unlikely to be a significant consideration with respect to the Hat Creek project because of the low numbers of such raptors in the local study area, the mountainous topography, and the absence of documented concern about electrocutions by transmission lines in B.C.

The stack, which would be either 244 m (800 ft.) or 366 m (1200 ft.) tall, is sufficiently high to encounter migrating birds even under clear skies. If natural draft cooling towers are selected, two towers 116.4 m (383 ft.) or four towers 91.4 m (300 ft.) in height would be used. These towers could be encountered by migrating birds under adverse weather conditions.

Thermal plant stacks, natural draft cooling towers, or similar prominences could be a significant source of bird mortality when lit. Mortality could be significantly reduced by eliminating the lighting or by reducing its intensity during the migration period. Dramatic success has been achieved extinguishing illumination on a 151 m (495 ft.) natural draft cooling tower in Ohio near Lake Erie[168, 169] and on 199 m (653 ft.) chimneys of a fossil fuel fired thermal generating station in Ontario[170, 171, 172, 173, 174, 175].

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* Sandy MacDonald, personal communication - Habitat Protection Biologist, B.C. Fish and Wildlife Branch, Kamloops.

Some success has also been achieved by switching from white light to dim red light or by switching from constant lighting to a strobe system. However, the strobe lighting system installed during 1975-76 on the CN Tower in Toronto, Ontario has not prevented kills in spite of confident predictions made about the system at the time of its installation[176]. In September 1976 it was necessary to darken the tower completely.

Thus, a potential problem exists, the magnitude of which cannot be determined until after the event. It is impossible from data on hand to predict how many birds would migrate over the plant site and under what weather conditions. As far as is known, Hat Creek is not on any major migration flyways and would not receive exceptionally high densities of migrating birds. Regardless of the magnitude of the problem, a number of mitigative measures could be undertaken (see Section 6.0).

E. Small Mammals

Habitat alienation is expected to be the one environmental modification associated with the proposed Hat Creek project which would induce a significant adverse impact upon small mammals. Approximately 1.7 percent of the local study area would be alienated by project operation and 2.3 percent by construction plus operation. However, the overall impact on small mammals would be expected to be proportionally greater because the habitats which were found to have the highest density and diversity of small mammals would be affected to a greater degree than would other habitats.

Of those habitats sampled in the local study area, riparian habitat was found to be the most significant for small mammals. Overall density and diversity were high (Table 4-21); several species were captured only in riparian habitat and would be expected to be restricted to this habitat. Riparian habitat would be only moderately affected by project operation (one percent decrease) but the overall project would cause a six percent loss of local study area riparian habitat. Some species could, therefore, suffer a six percent habitat loss.

Open range habitats were also productive of small mammals, although the species diversity was low. Alienation of open range habitat from project operaton would be extensive, with approximately 1156 ha (2857 acres) or 3.1 percent of the local study area resource potentially alienated (Table 5-23). Cumulative habitat alienation by project completion would include the alienation of 1476 ha (3647 acres) of open range or 4.0 percent of the local study area resource (Table 5-24).

Noise and harassment would probably not affect small mammals. Much of their activity and breeding occurs underground or under snow cover and would, thus, be well-insulated against extraneous air-transmitted noises. Noise studies on laboratory-raised small mammals indicate that expected ambient noise levels would be unlikely to affect small mammals.

Direct exploitation of small mammals would not be an expected result of the proposed Hat Creek project. Except for furbearers, small mammals are not normally exploited and no reason can be foreseen why the proposed Hat Creek project should cause them to be exploited unless they interfere with the revegetation process.

The impact of dust and air emissions on small mammals would probably be minimal. Most small mammals spend a very large proportion of their time underneath snow or soil, which would intercept the pollutants. Therefore, small mammals would be exposed less than would other wildlife. Active, surface-dwelling animals such as squirrels and chipmunks would be the most exposed while burrowing animals, such as moles, the least. Bats may prove to be especially susceptible to airborne contaminants. The lack of exposure and the relative insensitivity of most laboratory small mammals to pollutants combine to suggest that predicted levels of Hat Creek air pollutants would not be harmful to most small mammals.

Waste disposal is not expected to exert adverse environmental impacts directly upon upland ecosystems. Small mammals would be affected by waste disposal only by habitat alienation (discussed previously) or by consuming polluted waters. Preventing small mammals from gaining access to polluted waters would be nearly impossible. However, few small mammals would come into contact with polluted runoff or leachate waters. Only those with home ranges in close proximity to the ash pond or settling lagoons would have opportunity to consume polluted waters. An exception might be bats, which are extremely mobile.

Indirect impact on small mammals as a result of project operation would be primarily a result of injury to vegetation. The response of small mammals to minor habitat alteration is not well documented, but would presumably parallel that of birds. Indirect impact cannot be quantified, but some adverse impact is expected especially at higher elevations and near the cooling towers. This impact would be perceived in terms of decreased abundance, and diversity.

F. Furbearers

The distribution of furbearers within the local study area is disjunct. One group of furbearers (beaver, mink and river otter) are associated entirely with waterbodies or riparian habitat. Another group (bobcat, lynx, fisher, marten and red squirrel) are found in the forested regions. Coyotes and weasels are ubiquitous but would probably be most common where the mice are common, within open range and riparian habitats. The remaining species would be very rare or non-existent in the local study area.

Habitat alienation of local study area forested lands is expected to be relatively minor. Project operation would alienate an estimated 1726 ha (4265 acres) or 1.5 percent of the local resource base (Table 5-23). Cumulative habitat alienation of forested lands would total 2074 ha (5125 acres) or 1.7 percent of the total (Table 5-24). The loss of these lands is presumed to be associated with a loss of supportive capability of approximately the same magnitude of forest-dwelling furbearers.

Riparian habitat would be only marginally affected by project operation. Most of the damage would have been done during project construction. Project operation would alienate an estimated 11 ha (27 acres) or 1.0 percent of the resource base (Table 5-23). Including construction, an estimated 62 ha (153 acres) or 6.0 percent of the riparian habitat would be lost.

Noise and harassment are not expected to have a measurable impact on furbearers. Ranch mink were shown to be unaffected by sonic booms[88]. If other furbearers have similar sensitivities to noise, then levels associated with the proposed Hat Creek project should not adversely affect them.

Direct exploitation of furbearers would be expected to remain the same with or without the project (Section 5.2(b)(ii)). Therefore, no impact on furbearers is anticipated as a result of project-induced exploitation.

The effects of dust and air emissions on furbearers would be similar to those described for small mammals. Furbearers spend more time on the surface than do most small mammals and thus, may be exposed to more episodes of elevated levels of airborne pollutants. Furbearers could avoid short-term irritating atmospheric conditions by staying underground or within shelter. Very little, if any direct impact of air pollutants would be expected on furbearers.

Waste disposal may have a measurable impact on aquatic furbearers. The potentially lethal ash pond and settling lagoons would not be suitable habitat for beaver or muskrat because of a lack of suitable vegetation, but furbearers such as mink or river otter which follow watercourses could ascend Hat Creek to reach the lagoons. The ash pond would be less likely to be colonized by furbearers because it would have no outflow. Upland furbearers would not be expected to encounter contamination from waste disposal.

The effect of habitat alteration on furbearers is purely conjectural. Some adverse impact would probably occur, especially at higher elevations. Decreases in the availability of plant material such as Kentucky bluegrass, willow or of conifer seeds could cause a drop in the populations of mice, hares and squirrels, and a concommitant drop in their predators (weasels, martens, bobcat, lynx and wolverine). Quantification of these changes is not possible with the current state-of-the-art.

G. Big Game

Land alienation during operation would involve ten wildlife habitats and a total of 2775 ha (6857 acres) of land (Table 5-23). The deer and moose capability ratings of these wildlife habitats are presented in Table 5-41.

Discussion of the importance to deer and moose of habitats classified as high and medium to high capability have been presented in Section 5.2(b)(iii)G. In Table 5-25 it is important to note that in addition to the 145 ha (358 acres) of sagebrush habitat alienated in the construction phase, an additional 315 ha (778 acres), or 48 percent of the resource base of this habitat would be removed during the operation phase of the project. Combined construction and operation phases of the proposed project would alienate a total of 420 ha or 62.6 percent of the available sagebrush habitat (Table 5-24). Based on pellet group transect results, this represents removal of approximately 6,900 deer days usage annually from the Hat Creek Valley. In addition to high capability land, the operation phase would alienate 534 ha (1319 acres) of land classified as medium to high capability deer range.

The magnitude of the impact of the removal of the high quality deer range is difficult to predict in the absence of such information as the location and extent of the summer range of deer which winter in the Hat Creek Valley and the availability and condition of alternative deer winter ranges. However, based on the proportion and quality (420 ha or 62.6 percent of the available high capability deer winter range and 534 ha, or 2.8 percent of the available medium to high capability deer winter range) of the habitat removed, it is

TABLE 5-41

DEER AND MOOSE RESOURCE CAPABILITY RATINGS OF

HABITATS ALIENATED DURING OPERATION OF THE HAT CREEK PROJECT

WILDLIFE HABITAT	Local Study Area Resource Base (ha)	Area Alienated (ha)	Percent of Resource Base	Deer Capability Rating	Moose Capability Rating
Douglas-fir/pinegrass	62,560	1,021	1.6	Medium	Low
Mid elevation grassland	5,460	537	9.8	Medium	Low
Ponderosa pine - Douglas-fir/bunchgrass	13,420	374	2.8	Medium to High	Low
Sagebrush	670	315	47.0	High	Nil
Engelmann spruce Lodgepole pine	39,020	218	0.5	Medium	Medium
Low elevation grassland	4,760	149	3.1	Medium to High	Low
Aspen	2,720	113	4.2	Medium	Low to Medium
Bog	650	21	3.2	Medium	High
Riparian	1,040	11	1.1	Medium to High	High
Miscellaneous	1,580	16	1.0	Low to Nil	Low to Nil
TOTAL	162,110	2,775	1.7		

speculated that at least one-half of the deer normally wintering in the Hat Creek Valley would be placed in a stressful situation during the harsh winter conditions which periodically occur in the area. This predicament would result in the starvation of deer within Hat Creek and adjacent winter ranges, the latter as a result of the influx of deer that may have normally wintered in the Hat Creek Valley. A general deterioration in the condition of forage species on Hat Creek and adjacent deer winter ranges would be the result of overuse. It should be emphasized that major losses would occur primarily during severe winters. During mild winters with low snow accumulation it is possible that no deer losses would result from the habitat alienation of the proposed Hat Creek project.

The wintering deer population in the Hat Creek Valley may be as high as 200 animals (Section 4.8(b)). A loss of over 50 percent of these animals would be comparable to the 1976 estimated harvest by deer hunters in the local study area (Table 5-2) and would be considered a loss of major proportion to the Hat Creek Valley deer herds. On a regional study area basis, the loss of approximately 100 deer would be equivalent to 6.8 percent of the 1976 estimated harvest by deer hunters and would be considered a minor to moderate loss.

Impact to local moose from the operation phase of the project would be the alienation of high to medium capability moose habitats. Operation activities would remove 21 ha (52 acres) of bog habitat and 13 ha (32 acres) of riparian habitat, both of which are considered high moose capability habitats. Two hundred and eighteen ha (539 acres) of Engelmann spruce - lodgepole pine forest, considered to be medium moose capability habitat, would also be removed during operation of the project. The overall impact on local moose numbers of removal of the above habitats is considered relatively minor due to the fact that Hat Creek Valley winter moose densities are low and only small percentages of the available resource base is being removed.

Alienation of wildlife habitats by the operation phase of the project would affect the remaining big game species in the Hat Creek watershed in a manner similar to that described for the construction phase (Section 5.2(b)(iii)G.).

A literature review on wildlife reactions to noise is presented in Sections 5.2(b)(i)A. and 5.2(c)(i)B. of this report. Sources of noise during the operational phase of the project would be the mine, conveyor system, power generation plant and offsite facilities.

The major noise sources associated with operation of the mine would include blasting and operation of heavy machinery. Blasting would occur approximately once a day. This noise is anticipated to have very little effect on local big game species because of its similarity to thunder. The majority of the mine machinery would be operating in open pit #1 and between the pit and coal stockpiles, waste dumps and topsoil stockpiles. Local big game species would have become accustomed to this kind of activity during the construction phase and very little additional impact is anticipated due to initiation of operation activities.

The proposed conveyor system, including motors and gears would be completely enclosed. Harford, Kennedy, Wakefield Ltd.[115] anticipate that the conveyor system would not be a serious noise source and on this basis the noise impact on local big game species is anticipated to be minor.

The major noise sources associated with the operation of the power plant would be the accidental tripping of circuit breakers and electromatic pressure release valves (Section 5.2(c)(i)B.). The impact on local big game species is not known at this time. However, considering that project noise in locations beyond the plant yard would be below those levels considered harmful to human hearing and based on literature descriptions of animal reactions to noise, it is anticipated that plant operation noise would have little or no impact on local big game species.

Harassment of big game animals during the operation phase of the Hat Creek project would be similar to that experienced during construction acitivites.

Some of the sources of harassment include low flying aircraft, access road construction and use, and non-consumptive and consumptive recreational uses of wildlife resource. The number of people associated with the operation of the plant (approximately 1000 employees[80]) is considerably fewer than the number required for construction purposes (peak numbers would exceed 2000 employees[80]). However, operation employees and their families may become permanent residents, whereas construction workers would be in the area for up to six years.

Direct exploitation of big game resources associated with project operation is anticipated to increase as a result of the increased numbers of people attracted to the area. Immigrants would be made up of project employees and their families, as well as visiting tourists. The increased numbers of people would result in increased pressure on local big game species and may temporarily increase harvests. This increase would be temporary because of habitat lost by project alienation. Alternatively, the present harvests may be limiting big game (especially deer) populations. If such is the case, increased hunting pressure may quickly result in decreased populations and decreased harvests.

The overall impact on big game species of dust and air emissions is difficult to predict. However, expected dust emissions are anticipated to have relatively minor impacts on local big game species (see Section 5.2(c)(i)D.). Similarly, the impacts of emissions of hydrocarbons, carbon monoxide, ozone, particulates and trace elements are anticipated to be minor.

However, similar statements cannot be made for stack emissions of sulfur or nitrogen oxides. Expected concentrations of sulfur and nitrogen oxides and/or the known effects of these gases on wildlife have been presented in Section 5.2(c)(i)D. The direct impact of SO_2 on big game species would probably be negligible, but such assurance cannot be given regarding NO_2.

Exposure to high concentrations of NO_2 have been demonstrated to decrease the lung's ability to clear itself of particles and debris[135], produce emphysema-like injury[119, 131, 132], and inhibit the lung's antibacterial defense mechanism, making affected animals more susceptible to lung infections[119, 131]. Predicted concentrations of NO_2 (Table 5-26) indicate that the minimal levels which have been recorded to produce irreversible changes to the lungs of experimental animals (470 $\mu g/m^3$) would be exceeded for 1-hour averages. Some evidence exists to suggest that bighorn sheep may be exceptionally susceptible to lung irritants.

The susceptibility to pneumonic conditions of these sheep has been tragically illustrated in the East Kootenay area where, during the first three months of 1965, almost an entire population of Rocky Mountain bighorn sheep on the Bull River winter range were lost. "Poor range conditions, severe winter weather, an abnormally heavy infestation of lungworm (*Protostrongylus*), and heavy loads of other parasites combined to depress the resistance of the sheep to disease[117].

It has been estimated that 3200 bighorn sheep, out of the total population of 4000, died in the 1965 East Kootenay epidemic[178]. It should be stressed that the above situation resulted from a combination of factors triggered by a period of winter stress. Nevertheless, it is important to note that NO_2 is known to adversely affect the respiratory system and that bighorn sheep are known to be susceptible to pneumonic conditions. (Information on other big game species is unavailable.) On this basis it should be noted that gaseous emissions of NO_2 have the potential to affect bighorn sheep and possibly other big game species. Fortunately, big game wintering habitat and regions of highest expected NO_2 concentrations from Hat Creek project emissions do not coincide. On the basis of available data, no adverse impact would occur as the result of direct exposure of big game to ambient atmospheric pollutants from the proposed Hat Creek project.

The indirect effects of airborne pollutants on wildlife, via their effects on vegetation, may be more significant than the direct effects. No data are available on the effect of sulfur or nitrogen oxides on important bighorn sheep forages such as bluebunch wheatgrass or fescue (*Festuca ovina*).

However, stack emissions of sulfur dioxide could be injurious to species of willow, a major moose browse and to Kentucky bluegrass, a major sheep forage species[116]. Injury is not expected to Kentucky bluegrass in any areas where sheep are known to frequent, but injury to willow could have an impact on moose winter ranges. In the Clear Range and Cornwall Hills, willow could be injured to the extent that 25 to 75 percent foliar loss would occur within any given year if an MCS air quality strategy were adopted[116]. An FGD air quality strategy would decrease the injury rate to between 5 and 25 percent[116]. Rates of injury greater than 25 percent would most probably reduce the value of the plants as winter browse and repeated injury over several years might cause willow to become scarce or disappear from some high elevation sites. The wintering population of moose in the affected areas is not large, but it could be seriously affected by loss of willow as a result of decreased air quality.

The possibility of elevated levels of SO_2 (maximum of 288 $\mu g/m^3$) occurring at high elevations in bighorn sheep and mountain goat habitat outside the local study area to the south, southwest, and northwest has been identified by ERT[108]. The exposure is expected to be of sufficiently low concentration and to occur sufficiently infrequently that injury to vegetation would be avoided[116]. Thus, no impact would be expected from stack emissions on bighorn sheep or mountain goat forage species.

Disposal of waste during operation of the project involves land alienation and possible pollution of some standing waterbodies. The extent and impact of mine and plant waste disposal have been discussed in the section on habitat alienation.

Garbage disposal is a land alienation problem associated with operation of the facility. Employees living in the Hat Creek Valley would require a garbage disposal site and this facility would have the potential to attract both black and grizzly bears. The site should be located in a remote area and garbage should be treated in such a manner that it is unattractive (by burning) or unavailable (by fencing and/or burying) to bears. The impact of garbage disposal on local bear numbers would be directly related to the efficiency with which the garbage disposal area is being operated and how effectively the garbage is made unavailable to bears.

The identities and sources of water pollutants anticipated to be associated with plant operation have been discussed in Section 5.2(c)(i)E. Seven trace elements (Hg, Cd, Pb, V, Tl, Se and Be) are considered to be highly toxic to vertebrates and five elements (Hg, Cd, As, Tl and Pb) are categorized as having high potential for bioaccumulation. It is not possible at this time to predict the concentration levels of trace elements which may accumulate in leachate waters. However, if toxic concentrations of these elements developed and if big game species are allowed to consume polluted water, poisoning of wildlife could occur.

H. Rare and Endangered Species

Habitat alienation by the proposed Hat Creek project is not expected to have a significant impact on most rare and endangered species. Most species listed in Table 4-44 occur only sporadically in the local study area and are not dependent upon affected habitat resources. Among the possible exceptions are cougar, falcons, common loons and trumpeter swans.

Cougar may be marginally affected as a result of a drop in prey populations, but in general this impact would be completely overshadowed by other factors, such as hunting of cougars and competition for ungulate prey by humans.

The peregrine falcon is associated with its prey, migrating waterfowl. Any environmental modification which decreases the local occurrence of migrating waterfowl would also be expected to decrease the local occurrence of migrating peregrine falcons. The falcon population would not be affected, only their movement patterns. Peregrine falcons probably do not nest anywhere within the local study area.

Prairie falcons do occur in the local study area, but they occur primarily, if not exclusively, in the Thompson River Valley, where they nest on cliffs overhanging the river. Habitat alterations associated with the project would not affect this population of falcons.

Common loons nest on Aleece and Finney lakes. These lakes would be drained as part of the mine pit dewatering scheme. In total, two or three nesting pairs of loons would be affected.

Trumpeter swans migrate in the vicinity of the Hat Creek Valley and have been recorded at Fishhook Lake. Any loss of wetlands could cause trumpeter swans to fly elsewhere to find suitable resting stops during migration. Only the movement patterns of swans would be affected by the proposed habitat modification in the local study area.

Noise and harassment can have adverse effects upon rare and endangered species, especially birds of prey. However, these adverse effects are usually associated with the disturbance of nesting birds. Prairie falcons and common loons are the only rare or endangered species which nest locally. Neither species occur near the centres of noise generation from project operation. Therefore, no impact on rare and endangered species from noise and harassment is expected.

Direct exploitation of rare and endangered species is strictly regulated by law. Because of this regulation, the Hat Creek project is unlikely to have any impact on consumptive use of rare and endangered species.

Dust and air emissions have the potential to injure rare and endangered species within the regional study area. Ground-level concentrations could reach potentially dangerous short-term levels in mountainous areas (i.e. higher elevations within or immediately adjacent to the local study area[116]).

Many of the rare and endangered species listed in Table 4-44 are birds occurring in the regional and local study areas only as transients during migration. However, these birds could encounter the plume during flight and if avoidance of the plume contaminants does not or cannot occur, the birds may sustain injury.

Some rare and endangered species may be susceptible to environmental contamination from waste disposal. Birds, such as trumpeter swans or common loons, which are associated with water, or birds such as peregrine falcons, bald eagles or osprey, which prey on aquatic organisms, could be adversely affected by heavy metals from the waste disposal runoff waters. Many of the rare and endangered species listed in Table 4-44 are endangered because they are susceptible to pollutants passed along the food chain. Monitoring of waste disposal waters and adjacent ecosystems for heavy metals and isolating toxic materials from biotic ecosystem components should be undertaken. To ensure environmental quality, toxic materials must be kept unavailable to both plants and animals. Otherwise, toxicants would eventually reach the top carnivores in the trophic chain with potentially harmful consequences.

Indirect impacts of the Hat Creek project on rare and endangered species are doubtful. No rare or endangered species appear to be critically limited by the productivity of terrestrial ecosystems which are likely to suffer vegetational injury.

(d) Decommissioning

Decommissioning of the Hat Creek project pertains to the change from coal mining and power generation to other land uses. Decommissioning would commence 40 years after project commencement. In 40 years, technology, economics and social attitudes could substantially change (the atomic age is less than 40 years old) and, hence, plans which are currently being advanced may be obsolete in 40 years. A detailed consideration of decommissioning is not currently possible because of the myriad of available options. Nevertheless, some characteristic changes would accompany the decommissioning process and will be discussed at this time. Decommissioning plans were taken from B.C.

Hydro and Power Authority plans[86] and from the Hat Creek land reclamation study[146].

(i) Environmental Changes

A. Pit Reclamation

Pit reclamation cannot begin until the completion of mining in open pit #1. We have assumed that the completion of open pit #1 is also the completion of Hat Creek coal mining. A decision to mine a second coal body south of the proposed open pit #1 could allow a refilling of the pit with waste rock, but would necessitate a complete reconsideration of pit reclamation plans. Without further mining, the pit would not be refilled with waste materials because of prohibitive cost[146].

Instead, the pit walls, except for the bottom three benches, would be covered with a layer of waste material, and be recontoured and graded to side slopes not exceeding 26^{0} (50 percent slope). Exposed residual coal deposits close to the pit floor would also be covered with waste materials. The side slopes would then be revegetated and the pit allowed to fill with water[146].

At the anticipated rate of filling, the bottom three benches would be covered within five years and the lake would reach its final level of 853 m (2800 ft.) within 26 years[146]. Between year five and year 26, much of the revegetated pit wall would be inundated. The final anticipated area of the lake is 230 ha (568 acres)[86]. When the lake is filled, the Hat Creek diversion canal would no longer be needed to maintain a minimum downstream flow and would be reclaimed; the creek would be directed into the reservoir and reservoir outflow would supply downstream water. The upstream reservoirs would be left to assist irrigation[146].

Currently, plans have been advanced for mine buildings to be demolished, their foundations to be removed, and the land to be reclaimed. Ultimately, the mine site would be fully reclaimed; no equipment or materials would be left on the surface[146].

Power plant site reclamation plans have not yet been developed in sufficient detail to allow for an adequate evaluation. One would assume that the power plant site might be completely reclaimed, converted to an alternate use, or simply abandoned. The total area is relatively small (less than 100 ha or 247 acres) and its ultimate reclamation is not a matter of great environmental significance.

The waste dumps, ash dumps, topsoil stockpiles, and coal storage and blending areas combined comprise nearly all of the total alienated land. Hence, the reclamation of these areas would play a major role in determining the ultimate project impact on the wildlife resource in the local study area.

The waste and ash dumps would be constructed nearly flat-topped and would be graded to a slight (one percent) continuous slope to encourage controlled drainage and discourage ponding. Berms, engineered to retain less stable waste materials, would edge the dumps and have a maximum side slope of 26^{0} (50 percent slope). The waste dumps would be underlain with a layer of water-permeable wastes. This layer is designed to intercept seepage water and minimize stability and toxic leachate problems. Disturbed areas, other than waste and ash dumps, would be contoured and graded such that the maximum slope is less than 26^{0} (50 percent)[146].

The surface of all disturbed zones would be covered by a layer of overburden approximately 2 m (6 ft.) thick and then surfaced with soil materials and revegetated. The surface overburden would be selected from those portions of the total overburden expected to provide the best substrate for plant growth (e.g., glacial till). Reclaimed surfaces would be covered by a system of ditches in a herringbone pattern to control surface runoff and minimize erosion. Reclamation would proceed concurrent with project operation whenever a disturbed area reaches a final or long-term temporary configuration.

After contouring, areas to be reclaimed would be surfaced with topsoil materials and revegetation would commence. The problem of potentially toxic leachates in surface waters has been discussed in Section 5.2(c)(i)C.

B. Revegetation

The revegetation programme would bring the alienated land back into biological productivity. The type of vegetation that is reestablished on disturbed areas would determine, to a large extent, the types and numbers of wildlife that would utilize those areas. Detailed plans of the revegetation programme have not been finalized, nor can they be until years of field experimentation have been completed.

Several characteristics of reclamation put severe constraints on revegetation and, thereby, allow an analysis of some generic aspects of revegetation of Hat Creek waste areas. The initial flora would be established by seeding. Grasses and legumes would almost certainly predominate seed mixtures.

The topography would be simplified; the current rolling and undulating terrain would be replaced by large, nearly flat areas bordered by steep, uniform slopes. Drainage and seepage patterns would also be uniform. Ponding and stagnation are considered to be undesirable because of the potential accumulation of toxic leachates in standing waters; the topography and subsoil conditions would be designed so that all soil substrates would be well drained. Despite precautions, some seepage receiving areas would probably form. These sites would be located near the bottom of steep slopes and may be a receiving site for toxic seepage.

In short, uniformity is the key word to describe vegetation. A uniform seed mixture would be applied over a uniform soil substrate with uniform drainage characteristics on a small number of uniform slopes. One would, therefore, expect very little variation in the vegetation which establishes on revegetated areas.

Successional change from the expected original grass-legume community would be very slow. Succession on the reclaimed areas would be primary succession which could take a long time, perhaps 40 to 100 years. Once the original seed mixture of plants is established forming a continuous cover, the invasion of other plants would be difficult because of competition for water with the roots of previously established vegetation. Trees are some of the least likely species to invade, especially on well-drained areas with fine soil texture. The Physical Habitat and Range Vegetation Report describes the expected regrowth vegetation in detail. The amount of available weathered topsoil material is extremely limited. Topsoil from the pit area would be sufficient to cover reclaimed land to an average depth of only 1.4 cm (0.6 in.)[146]. Even if suitable topsoil material is scraped from waste dump areas and stockpiled, the total topsoil would probably provide only a thin covering. Hence, the rooting zone in all revegetated areas would consist essentially of unweathered, crushed rock. A problem may develop with respect to the toxicity of plants growing primarily in overburden or other mine wastes.

C. Environmental Toxicity

The vegetation that would grow in the revegetated area would be rooted in soil (overburden) which may have relatively large amounts of trace elements. The possibility exists, then, that this vegetation may contain quantities of trace elements that would be toxic to wildlife. The assimilation of trace elements in vegetation which is available to wildlife (e.g. stems, leaves and seeds) is a function of the availability of these elements in the soil (the total water-soluble trace element) and the ability of the plant to assimilate and translocate the element. Plants differ greatly in their tolerance to trace elements, and some elements are much more likely to be trophically transferred than are others[138]. *The toxicity of a plant to animals is difficult to predict.* Overburden leachate tests (see Table 5-28) provide data that show which trace elements may be available for uptake by plants. Soil conditions may vary significantly from leachate test conditions, however, and field tests are necessary before the toxicity of regrowth vegetation to wildlife can be reliably assessed.

Hat Creek regrowth soil conditions are likely to be alkaline and low in organic material[146]. These anticipated soil conditions can be used to predict those trace elements which are likely to be assimilated by plants and those which are not. In most soils, the trace elements are largely unavailable to plants because the elements are bound (absorbed) to the surface or organic or inorganic soil particles[138]. The lack of organic material in the revegetated soils may mean that some elements may be more available in recent overburden than in mature soils.

Copper and members of the zinc subgroup (Cd, Hg and Zn) are generally immobile in alkaline soils. Copper is nearly unavailable to plants[179] but zinc subgroup elements may, under some conditions (which are poorly understood), become methylated and, in that form, could be assimilated and translocated by vegetation[138]. Zinc subgroup elements can become highly concentrated in detritus feeders, however, and wildlife which feed on ground invertebrates should be monitored for accumulation of these elements. Fluorine (F) is another element that tends to be immobile in alkaline soils, but under certair conditions can be taken up and translocated[138]. Lead (Pb) is not easily taken up by plants under any conditions, and when it is absorbed it tends to remain in the roots[138].

Arsenic (As) is mobile in alkaline soils, but tends not to be absorbed by plants[197]. Arsenic in soils results in severely reduced plant growth, but does not usually result in serious poisoning of animals[180]. However, because of the relatively high levels of As in the overburden leachate tests, arsenic in the revegetation ecosystem should be monitored.

Chromium (Cr) and vanadium (V) are both mobile in alkaline soils and are accumulated by vegetation[181, 182]. Both elements are relatively non-toxic to vertebrates and should not cause problems. However, as a precaution, Cr and V levels should be monitored in the regrowth ecosystem.

Selenium (Se) is an element which has a very high potential to accumulate in plants to levels toxic to herbivores[154]. Current Hat Creek selenium levels are moderate[138]. Selenium could create a vegetation toxicity problem if plants are grown in a selenium enriched area, such as a seepage receiving site. Selenium presents a potential hazard and that should be monitored. Similarly, tin (Sn) levels in some parts of the Hat Creek ecosystem (shrubs, small mammals) are found to be high[138]. Vegetation growing in overburden might increase the incorporation of tin into biological systems, therefore, tin should also be monitored in the revegetation ecosystem.

(ii) Resource Use Projection

The decommissioning phase of the project would be expected to restore lands to biological productivity. As such, one would also expect an increase in resource use. However, because of the expected quality of the wildlife resource on the reclaimed land, very little increase in either consumptive or non-consumptive wildlife use would be expected.

Non-consumptive wildlife use is oriented towards variety and observability. Wildlife on reclaimed areas would consist of a small number of relatively inconspicuous species (to be reported in more detail in the subsequent section) and, therefore, would not constitute an attractive non-consumptive wildlife resource base.

Consumptive wildlife use on revegetated land may be severely curtailed by low game density or by hunter reluctance concerning the quality of game meat. Neither big game nor gamebirds would be expected to be abundant on reclaimed lands (see following section). Trace element bioaccumulation within the reclaimed ecosystem may occur and, unless assurance can be given that wild game meat would be safe for human consumption, hunters might avoid the area.

(iii) Resource Projection

Much of the land in the northern portion of the Upper Hat Creek Valley would be alienated from biological production. The reclaimed ecosystem that replaces these lands would be significantly different from the original one. Eventually, after 30 years of mining and another 20 years of filling the pit with water, Hat Creek would again flow in its natural channel. At this time, the riparian habitat would begin to reestablish. Otherwise, all alienated habitats would be permanently lost. The replacement habitat expected would be a grassland similar to the current low and mid elevation grasslands, but without swales, aspen clumps or other edaphic variability.

A. Reptiles and Amphibians

Amphibians would be entirely lacking in the reclaimed areas, with the exception of the pit lake. Reptiles were noted to be lacking in the Hat Creek grasslands. Reptiles would be expected to return as a consequence of reclamation only to the extent that the riparian zone is allowed to reform.

B. Waterfowl

The reclaimed areas would be engineered explicitly to avoid the formation of potholes and ponds[146]. No benefit would accrue to waterfowl from upland reclamation. However, the filling of the pit with water may provide some benefit to waterfowl, but this would take at least 30 years. At this time, shoreline conditions may be sufficiently established to attract waterfowl. Such a lake would be of very limited value to waterfowl because of the steep sideslopes. Insufficient shallows would exist to attract or sustain more than a few breeding or feeding ducks. However, the lake may serve well as a loafing or staging ground for waterfowl.

C. Upland Gamebirds

Presently, the Hat Creek Valley is nearly devoid of grassland-inhabitating upland gamebirds. Sharp-tailed grouse, pheasant or chukar could possibly invade the reclaimed lands, but because they are currently absent, they are unlikely to invade after reclamation. Mourning doves are a grassland species, but are relatively uncommon in the Hat Creek Valley. Blue grouse frequent the grassland-forest edge, but would not be regularly encountered in the central portions of the reclaimed area. Ruffed grouse frequent the Douglas-fir forests and the riparian zone, but not the open range. Spruce grouse are restricted to spruce-pine forests.

Based on the current distribution of gamebirds, one would expect very little benefit to upland gamebird populations as a result of land reclamation. Blue grouse may show a slight increase around the margins of the reclaimed area and ruffed grouse would reinvade the restored riparian zone, but otherwise no increases would be expected.

D. Non-Game Birds

Among the non-game birds, only a few species are regularly encountered in the semi-arid grasslands of the Hat Creek Valley. Many of the characteristic species of open range were noted to be attracted to saline depressions or to micro riparian habitats. Only meadowlarks, horned larks, vesper sparrows and American kestrels were noted during the inventory to be regular residents of the open range. Brewer's blackbirds, various swallows, common crows and mountain bluebirds were regularly observed in open range but most of these are associated with some other additional attraction, such as ponds, riparian habitat, aspen clumps, cultivated fields or cliffs. Magpies, mourning doves, western kingbirds and a few raptors (e.g. marsh hawk, great-horned owl and merlin) are grassland species that occur in the Hat Creek Valley, but none were commonly observed during the inventory fieldwork.

In short, the grasslands have relatively few avian species associated with them. Large areas of monotonous upland grassland without fence posts, wires or edaphic variation are populated primarily by two or three species of birds: meadowlarks, vesper sparrows and sometimes horned larks. The reclaimed areas would be expected to have a similar avifauna.

E. Small Mammals

The arid open range grasslands have relatively high densities of deer mice. The moister portions (swales, higher elevation plots, etc.) were observed to contain abundant evidence of present or former occupancy by voles (*Microtus montanus or M. pennsylvanicus*). Chipmunks, weasels and yellow-bellied marmots have been occasionally observed living entirely within a grassland community. Bats have not been surveyed, but some species probably forage over the Hat Creek Valley grasslands. Based on the current distribution of small mammals, deer mice would be expected to predominate in the reclaimed ecosystem and voles, chipmunks, weasels and marmots would occur sporadically or in very low densities.

F. Furbearers

Almost all of the furbearers in the local study area are associated either with forests or with water. The only exceptions are the ubiquitous mouse predators, coyotes and weasels. Hence, almost all reclaimed land would be of no value to most furbearers.

The benefit of decommissioning to coyote and weasel populations cannot be estimated with the data at hand, but because no local traplines exist, the net change in fur harvests would be zero. The eventual reconnection of Hat Creek during project decommissioning via the pit lake may have a positive effect on some aquatic or semi-aquatic furbearers, such as river otter and mink. These animals would again have free access to and from the upper reaches of Hat Creek.

G. Big Game

The overall effect of project decommissioning on big game species would be directly related to the final land reclamation policies. Regardless of what B.C. Hydro and Power Authority does to the disturbed areas, lands would likely support some wildlife. However, if a serious attempt is intended to accommodate local wildlife species, a conscious effort must be made to incorporate their habitat requirements into the early planning stages of the decommissioning programme.

Present decommissioning plans propose well-groomed and efficiently drained slopes seeded to grasses and legumes. Land surface preparation to achieve these ends would produce terrain which is flat or slightly undulating. The plant species used to vegetate these areas would be selected primarily on their ability to reduce soil erosion and, secondarily on their palatability to livestock; coincidentally, some of these forage species may be utilized by local wildlife species.

Riparian vegetation is an important part of habitat requirements of moose, black bear and deer (Section 4.8). The opportunities for development of this kind of habitat under the proposed decommissioning plans appear minimal. Provisions for the development of riparian habitat would undoubtedly benefit moose and black bear, and the encouragement of browse species, particularly willow, along watercourses would enhance moose habitat.

Mule deer would benefit from the development of riparian habitat as well. However, final landscaping and the choice of plant species used in the revegetation programme would also play a large part in determining the eventual use of the area by deer. Site development to enhance deer productivity should include the provision of escape cover through contouring of the land surface, i.e., the creation of large flat fields should be avoided. The inclusion of suitable browse species (woody plants) in the revegetation programme, particularly on deer winter ranges such as the area of the pit, would also enhance deer habitat.

Decisions on the fate of the private lands purchased for the project by B.C. Hydro and Power Authority would also have a considerable effect on future wildlife numbers. More intensive management of important big game habitats and better livestock grazing management has the potential to increase domestic and wild animal numbers. Reverting these lands to heavy grazing by livestock could reduce, or quite possibly eliminate, this potential.

H. Rare and Endangered Species

The reclaimed land may provide habitat that would be attractive to rare and endangered species dependent on grassland. The prairie falcon, least weasel and turkey vulture are the most likely of the species listed in Table 4-44 to utilize the reclaimed lands. The reclaimed land would be peripheral to the range of all three of these species (because of climate) and would not be expected to add significantly to regional numbers or population stability of rare and endangered species.

The formation of a pit lake may provide a more direct benefit to some rare or endangered species. The pit lake may provide new habitat for common loons, ospreys, bald eagles or trumpeter swans. The lake would be stocked with fish and, as such, may provide a new foraging and/or breeding area for loons, ospreys and eagles. Trumpeter swans may find the large size of the lake suitable for stop-overs.

6.0 MITIGATION

This section outlines possible measures which can be taken to eliminate or lessen the adverse environmental impacts discussed in Section 5.0. These measures, if applied, would mitigate environmental harm that might result from the Hat Creek project. Some impacts of the Hat Creek project are impossible to rectify; these constitute part of the environmental cost of developing the coal deposit for electrical power generation. Other predicted impacts could be prevented (i.e. they are mitigable); these also represent part of the cost of power generation, but the option exists as to whether the cost is an economic cost or an ecological cost.

The recommendations within this section are discussed in context with identified mitigable environmental impacts. It should be stressed that all mitigation guidelines should be combined within an integrated resource management strategy. We suggest that a "coordinated land use planning approach" be adopted to integrate all mitigation guidelines and define land use objectives during construction, operation and decommissioning. This approach would bring together agriculture, forestry, mining, fisheries and wildlife interests to establish land use priorities and identify methods of maximizing resource capability. This approach appears to be feasible because B.C. Hydro and Power Authority would impose a dominant influence over a relatively large land area.

6.1 HABITAT ALIENATION

Most of the unmitigable environmental impacts on wildlife are associated with direct habitat alienation. However, additional habitat alienation to that described in Section 5.0 could result from uncontrolled project-related activity. In other words, damage to surrounding habitat could be caused by callous actions of project personnel. Such damage could be prevented by restriction of construction and operation activities to designated areas only.

Some of the more insidious project impacts would be the result of the attitude of workers towards wildlife habitat and wildlife in general. We recommend that education and information programmes be made available to construction and operation personnel. Such programmes should emphasize the worker's role as a responsible protector of the wildlife heritage. An understanding of the value and fragility of some of the wildlife species and their habitats could prevent some ignorant and irresponsible behaviour.

The most valuable habitats to wildlife in the local study area are wetlands (including saline depressions), riparian and sagebrush wildlife habitats (see Section 4.0). In general, we recommend that habitat disturbances be located to avoid these habitats. Ancillary activities, temporary roads and other facilities, to which some lattitude in site selection exists, should be routed away from or located outside of wetland, riparian and sagebrush habitats.

Sagebrush habitat is heavily used by deer and would also be heavily impacted by the project (Table 5-16 indicated that 62.6 percent of the resource would be lost). The impact of this habitat loss could be lessened by eliminating, relocating or redesigning the landing-strip temporary topsoil stockpile (Map 5-1, item M12). This topsoil stockpile alienates an estimated 26 ha (64 acres) of sagebrush habitat (Table 5-13), which represents 3.4 percent of the total sagebrush habitat resource base. Most of the sagebrush habitat would be eliminated by the pit (Table 5-16) and the loss of it is therefore unmitigable. However the impact could be delayed if clearing of vegetation around the pit rim is postponed until absolutely necessary.

The wetlands in the Hat Creek Valley support a significant population of waterfowl, and loss of wetlands is anticipated to constitute the major impact of the project upon waterfowl. Most of this alienation is unpreventable. However, the landing-strip temporary topsoil stockpile impinges on productive waterfowl habitat. It has previously been recommended that this facility (M12) be moved or eliminated because of its adverse impact upon deer; this recommendation is reiterated based on its adverse impact upon waterfowl.

The site-2 reservoir (Map 5-1, item OD7) would also alienate a number of wetlands. The impact of this reservoir on waterfowl and other wetland wildlife would depend on the precise location of the reservoir and on water level fluctuations. Many of the affected wetlands are near the depicted high-water mark. If the site-2 reservoir is constructed, its impact would depend to a large extent upon the pattern of water level fluctuations. It is recommended that water level fluctuations be kept to a minimum and that the reservoir not be allowed to fill to maximum level except very briefly during spring freshet. Consultation with professionals, such as Ducks Unlimited personnel regarding reservoir management, is also recommended.

An alternative means of mitigating project impact on waterfowl would be to improve the waterfowl habitat which would not be adversely affected by the project. The Hat Creek wetlands are not as productive of waterfowl as they could be because of past land use practices (overgrazing) and water quality and topological limitations. With proper management, the productivity of waterfowl in the Hat Creek Valley could perhaps be increased as much as four times (Section 4.0).

Thus, potential for compensatory waterfowl production exists in the Hat Creek Valley. Land use practices could be improved on lands controlled by B.C. Hydro and Power Authority. Water quality and soil fertility limitations could also be alleviated in some wetlands by modifying local hydrology. Hydrological modifications could be implemented by constructing dams, dykes and ditches, and by chanelling or pumping surface waters to or from wetlands. Any such waterfowl habitat improvement would require detailed plans based on local topology and hydrology, and should be developed in conjunction with professionals such as those of Ducks Unlimited.

We recommend against spending time and money to improve waterfowl habitat which, in the foreseeable future, may revert from continued waterfowl production. The entire southern half of the Hat Creek Valley contains another potentially developable coal deposit and, therefore, may be alienated from future waterfowl production. The only area within the Hat Creek Valley recommended for substantial modification of wetland habitat is the area between the pit rim and Anderson Creek. This area is not underlain by a developable coal resource, has a favourable topography with much natural ponding, would probably have an adequate supply of fresh water from the Finney Creek diversion and the dewatering of Finney and Aleece lakes, and would presumably be controlled by B.C. Hydro and Power Authority.

It is therefore recommended that B.C. Hydro and Power Authority compensate the loss of waterfowl habitat by:

(1) fencing livestock from wetlands potentially productive of waterfowl thereby allowing natural edge vegetation to redevelop. Reseeding pond edges with a suitable seed mixture would accelerate the process of reestablishment; and

(2) improving waterfowl habitat southwest of the mine pit and north of Anderson Creek by means of a programme of hydrological modifications.

The adoption of the wet ash disposal plan is recommended against. The alternative dry ash disposal plans alienate substantially less land area (at least 260 ha (640 acres), see Table 5-14), alienate fewer wetlands, and do not interfere with Medicine Creek.

6.2 NOISE AND HARASSMENT

Normal operating noises of the plant and mine are predicted to have relatively little impact on wildlife. However, because of the similarity between the tripping of circuit breakers and blasting noises to gunshots, animals which acquire a learned negative association with gunshots may carry this association to the sound of blasting or circuit breakers. Therefore, hunting in areas close to the pit or plant may prevent game animals from accommodating to noises which they otherwise learn to ignore. We recommend that all shooting be banned within 4 km of the plant and of the eventual pit rim.

The sudden unpredictable (from animal's perspective) release of compressed gasses (such as steam) from the plant would constitute a source of noise to which wildlife would be unlikely to accommodate. When possible, such venting should take advantage of wind attenuation and not be done during calm weather. To avoid disturbing roosting birds, steam blow-out should be minimized during the nesting season (mid May through to the end of July). Ungulates are most sensitive to noise during winter periods when temperatures are expecially low or snow especially deep. A combination of the above factors (e.g. a calm, cold night in June) increases the potential impact on wildlife of sudden loud noise. Alternatively, noise levels from steam venting could be diminished by silencers.

Uncontrolled access could result in unnecessary harassment of wildlife in the Hat Creek Valley. In particular, waterfowl are sensitive to disturbance during the nesting season (May to July), while ungulates are sensitive during the winter. Access to waterfowl breeding areas should be controlled as part of a land management scheme, and activity near wetlands should be minimized between May and July, inclusive. Winter recreational facilities, such as cross-country ski trails and especially snow-mobile trails, should be located in such a way as to avoid areas which have been indicated as being important ungulate winter range (see Map 4-3 for location of ungulate winter range). Transmission line and pipeline construction roads and rights-of-way provide attractive routes for snowmobiles in winter and off-road vehicles in other seasons. Access should be discouraged by use of signs and fencing and, where appropriate, by trenching or erecting other physical barriers to access. However, none of these measures would be effective unless alternative routes and amenities are provided for the recreationalists.

6.3 DIRECT EXPLOITATION

Population influx as a result of the construction and operation of the Hat Creek project has been identified as a significant environmental impact because of an expected increase in local hunting pressure. This hunting pressure should be distributed over a larger area by discouraging hunting in the Hat Creek Valley and along the access corridor of Medicine and Cornwall creeks. This ban on hunting should include waterfowl, upland gamebirds and big game. A "no gun" policy should be adhered to within the construction camps. It should be stressed that the B.C. Fish and Wildlife Branch should be consulted and their management requests regarding hunting regulations followed.

Construction and maintenance roads associated with linear facilities, such as pipelines and transmission lines, could provide easier hunter access to regions which are presently more remote. The provision of access could make resource management difficult by creating a situation in which overharvesting of the resource is difficult to prevent. Hunter access along such roads or along rights-of-way should be discouraged using the methods suggested in Section 6.2.

6.4 DUST AND AIR EMISSIONS

Direct impact of dust and air emissions on wildlife are expected to be relatively minor. The dust supression techniques suggested elsewhere[108] should be implemented to protect wildlife. The flue gas desulfurization option (FGD) would reduce the exposure of wildlife to sulfur dioxide and, possibly, fluorine and certain trace elements in comparison to a meteorological control system (MCS). Nitrogen dioxide, at expected ambient levels, *is potentially the most harmful atmospheric pollutant to which wildlife* would be exposed. Any project modification which reduces the emissions of oxides of nitrogen may be beneficial to wildlife. A taller stack (366 m rather than 244 m) would reduce the exposure of all wildlife to air pollutants by reducing ground-level concentrations. Migrating birds, in particular, may benefit from the taller stack as most birds migrate at an elevation of between 150 and 600 m (500 to 2000 ft.) above ground, with 300 m (1000 ft.) being the approximate median elevation[166].

The greatest impact of project emissions on wildlife would be the result of induced changes in the vegetation. Mitigative measures to protect wildlife habitats are described in the Physical Habitat and Range Vegetation Report

6.5 WASTE DISPOSAL

Waste disposal has the potential of introducing toxic trace elements into the ecosystem. Prevention of environmental harm is contingent on perception of impending damage (sampling of waste runoff waters for trace elements). The list of elements suggested by ERT[138] is sufficient, if thallium is added to the list (see Section 7.0).

The ash pond of the wet ash disposal plan is likely to attain toxic concentrations of trace elements. It is suggested that containment of trace elements in abiotic components would be easier if a dry ash disposal plan were adopted.

Wildlife access to potentially polluted waters, such as ash ponds and holding ponds, should be restricted. Large or mobile wildlife, aquatic wildlife and wildlife that may be consumed by humans are the most important species to exclude. Ungulate movement could be controlled with a two m (7 ft.) high chain link or page wire fence. Waterfowl could be excluded by stringing flagged lines above the surface of the pond to prevent their landing.

6.6 INDIRECT EFFECTS

To minimize collision mortality of migrating birds, stack and cooling tower illumination should consist of dim, red, flashing lights, or of a stroboscopic system of lights (not necessarily red), in which the lights flash for a very short time compared to the time the lights are extinguished. During the months of bird migration (April, May, August, September and October), spotlights should not be used to illuminate the stack, cooling tower, or any other building or prominence. Other studies have shown that under extreme conditions, it is sometimes necessary to extinguish all illumination in order to minimize nocturnal bird strikes[166], but such extreme conditions are unlikely to occur in the Trachyte Hills. Any illumination scheme may require approval from the Ministry of Transport in order to assure aircraft safety.

Fences erected to exclude livestock should be constructed so as not to block or obstruct deer movement. That is, barbed wire fences around the power plant and open pit #1 should allow deer access to the forage which would grow between the plant and the fence.

Construction camp and domestic garbage should be disposed of so that it is unattractive (burned) or unavailable (fenced and buried) to bears.

A possible beneficial impact to wildlife may result from the purchase of large tracts of land and of associated grazing rights by B.C. Hydro and Power Authority. Grazing practices and wild ungulate resource management in parts of the local study area are currently incompatible, but need not be. An integrated resource management plan would require control over grazing rights, and it is recommended that B.C. Hydro and Power Authority attain such rights within the local study area.

7.0 MONITORING

7.1 RATIONALE

Monitoring is a means of verifying the actual project impact after the project has begun. Prediction of expected impact is no substitute for monitoring; prediction is guesswork, whereas monitoring should provide hard facts. The value of monitoring is that it provides information regarding project impact which is otherwise unobtainable. Such information can provide assurance that environmental quality is protected and can also ensure environmental protection by permitting mitigation measures to be adopted or modified during project operation. Monitoring can reduce project costs by allowing superfluous or ineffective mitigation measures to be eliminated. Information gathered from monitoring would also be useful in assessing the environmental impact of similar future projects.

For a monitoring programme to be useful, it must produce valid results. The environmental impact is the difference between the without case data and the with case data. The without case data should be represented by a control. Control information should be obtained from pre-project data and from data gathered outside the zone of influence.

A monitoring programme is desirable when anticipated changes are invisible (such as trace element accumulations), are intangible (such as a change in species composition), may be important to quantify (such as changes in game species abundance or distribution), or are in considerable doubt. Trace element accumulations, the impact of air pollutants on birds, and ecosystem responses to chronic stress are potential project impacts on wildlife which should be monitored.

7.2 TRACE ELEMENTS

Environmental Research and Technology, Inc.[138] has recommended a trace element monitoring programme which, with minor modification and some addition, would adequately monitor trace elements in the ecosystem. However, because of sampling difficulties, ERT does not propose to monitor any animal tissue[138]. We consider some monitoring of trace elements in animal tissue to be essential to the credibility of a trace element sampling programme. Wildlife receive trace elements from a variety of sources (as ERT[138] points out) and may be subjected to bioaccumulation or biomagnification of trace elements, an event which no amount of trace element measurement in abiotic receptors could reveal. Because wildlife are mobile and are exposed to trace elements from a variety of sources, a large number of wildlife sampling sites is unnecessary. Five well chosen sites, monitored once a year (in fall), should suffice. Possible locations of wildlife trace elements would be:

(1) Cornwall Hills;
(2) Trachyte Hills, in the area affected by cooling tower drift; and
(3) the northern portion of the Hat Creek Valley, in the vicinity of the pit and waste dumps and other potentially toxic waste materials.

A partial control should be located in the southern half of the Hat Creek Valley and full control outside the valley, perhaps in the Venables Valley.

ERT has used small mammals for their initial baseline trace element sampling[138]. However, Stickel[125] points out that small mammals are poor choices as indicators of environmental pollution, and suggests that birds are a better choice. We suggest sampling some species of birds in addition to small mammals at the above mentioned sites. Additionally, the monitoring of trace element accumulations in game species taken inside and outside of the Hat Creek Valley could be accomplished by taking tissue samples.

Any animals which are found dead should be analyzed with respect to trace element accumulations and autopsied for evidence of acute or chronic respiratory injury. If possible, it should be determined whether death was related to the project or was due to other causes such as disease.

The list of 12 elements which ERT has suggested be monitored[138] include all elements of potential concern except thallium. Because of its chemical properties and biological effects, thallium, although less notorious than other heavy metals, is no less environmentally dangerous[147] and, therefore, should be added to the initial monitoring programme.

Fluorine is an element which is of particular concern because of its potential to harm wildlife. The environmental exposure of wildlife to fluorine expected from the Hat Creek project is difficult to predict. Hence, fluorine is a prime candidate for monitoring.

An effective means of monitoring environmental fluorine exists through the use of honeybees. Pollinators have been shown to have the highest body burden of fluorine in ecosystems which have been contaminated by exposure to atmospheric fluorides[140, 142]. Bromenshenk[142, 183] has shown that honeybees can be used as a sensitive indicator species for chronic fluoride pollution. Hives could be established in several locations within and around the Hat Creek Valley. Elevated levels of fluorine in these bees would indicate problems of fluorine accumulation before the effects were noticeable in ungulates or gamebirds.

Monitoring of trace element flux in the revegetation ecosystem is strongly recommended. These studies should proceed with the same level of intensity as was used for the initial trace element monitoring programme.

7.3 AIR POLLUTION - DIRECT EFFECTS

The direct impact of air pollutants on most wildlife is expected to be minor. Birds may be an exception to this rule. It is recommended that birds be periodically collected (once or twice a year) and autopsied to determine what acute injury may have occurred to their respiratory system. Chickadees would make a suitable subject for these investigations because they are permanent residents are are relatively common throughout most of the local study area. Methodology should be similar to that used for earlier or concurrent investigations of impact of emission of a coal-fired thermal generating plant on birds[120].

7.4 ECOSYSTEM RESPONSES TO CHRONIC STRESS

Some of the most significant project impacts upon wildlife are expected to be impacts which are mediated by changes to vegetation and ecosystem productivity. A programme to study the impact of the project on vegetation has been presented in the Physical Habitat and Range Vegetation Report. The wildlife monitoring programme would not be dependent on collection of vegetational injury data, but such injury data would be valuable in interpreting observed changes in wildlife. Vegetation and wildlife monitoring programmes should include plots, transects and sample sites within the three habitats, riparian, sagebrush and wetland, which have been identified as important to local wildlife.

We recommend that wildlife be monitored by the use of a roadside breeding bird survey similar to that used in the inventory section of this report. Theoretical considerations and limited data from the U.S. IBP Grassland Biome programme indicate that grassland bird species diversity, equitability and species richness are apparently buffered from response to normally encountered environmental variations, but may respond to ecosystem changes brought about by chronic air pollution[113, 161]. If so, the relatively inexpensive roadside bird census may be an ideal biological indicator, one which would be responsive to the variables in question, but unresponsive to other extraneous variables. The relationship between bird species diversity, equitability, species richness and chronic air pollution from a coal-fired thermal generating plant is being studied in detail as part of the Colstrip, Montana investigations[113]. The adoption of this method would have the advantage of being comparable in methodology to the most comprehensive air pollution study attempted to date.

The exact number and location of routes have not yet been determined. Advice from the Colstrip investigators[113] should be sought before methodology is finalized. Monitoring would consist of an investigator travelling a specified route, making stops at specified locales, and recording the birds observed within a defined time and space. This need only be done once or twice per year in the spring.

The roadside bird census would be valuable as an index of change for all wildlife. However, changes in the distribution and abundance of big game are sufficiently controversial such that an additional monitoring programme for big game is warranted. This monitoring should be done using pellet group transects. Aerial surveys of game animals are costly, can constitute harassment of the animals, and do not provide an adequate picture of the year-round animal habitat relationships. The number and locations of pellet group transects should be related to stack emissions and to habitat (vegetation). It is recommended that pellet group transects be established in conjunction with vegetation monitoring plots (see Physical Habitat and Range Vegetation Report, Section 7.0, for details of numbers and approximate location of plots).

Increased numbers of hunters and increased hunter access could seriously deplete big game numbers. Monitoring hunter numbers, hunter success and hunter distribution during the construction and early operation phases of the project would provide data on the increase in local big game consumptive use demand. Heavy pressure may warrant regulation of access, shortened hunting seasons or implementation of a system allowing hunting by permit only.