PROJECT NAME	CONSULTING SERVICES FOR THE ESTABLISHMENT AND MONITORING OF THE INSTREAM FLOW REQUIREMENTS FOR RIVER COURSES DOWNSTREAM OF LHWP DAMS
PROJECT NUMBER	LHDA 648
REPORT SERIES	TASKS 4 AND 5
TITLE	Animal Health and Production
COMPILERS	Daniel Phororo
REPORT STATUS	Final
LHDA REPORT NO	LHDA 648-F-10
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DATE OF FINAL REPORT	1.7.00

E. EXECUTIVE SUMMARY

E.1 Objectives

The objectives of the study are broadly as follows:
Identify animal disease and animal health aspects that could be related to river flows.

- Determine the impact of four river-release scenarios on animal health and production.
- Recommend measures for mitigation and compensation for the release scenarios

E.2 Animal health aspects of the socio-economic survey

The detailed socio-economic survey identified the animal population at risk in the river reaches of the Senqu and Senqunyane Rivers downstream of LHWP dams. The boundary limit of 5 km from the river on each side of the river was adopted based on the fact that animals within this distance were most likely to be taken to the river for watering and grazing during various times of the year. The key aspects of animal health that were examined included:

- population of the range animals (cattle, sheep, goats, horses and donkeys – equines) and other domestic animals (pigs and poultry) linked to each IFR reach,
- types of disease affecting the animals (river-related and not river-related diseases),
- diseases causing animal deaths,
- medicinal plants found along the river used for treatment of animal diseases,
- grazing patterns.

E.3 Animal health aspects

Lesotho is fortunate in not having major epizootic diseases. This is due to the high altitude, low temperatures in winter and the protective buffer provided by South Africa with its highly developed disease control measures, which surrounds Lesotho. The important animal health aspects that may be related to river flows are as follows:

- Anthrax and Blackquarter, which are the two serious and important bacterial disease outbreaks that occur sporadically in the lowlands and foothills of Lesotho (and to a less extent in the mountains). These mainly affect cattle, sheep and goats. Anthrax and Blackquarter are controlled by vaccination.
- Strangles, a bacterial disease that occurs in horses, also occurs in the study area. Strangles is treated with antibiotics.
- Pulpy Kidney, which is a bacterial disease of importance affecting sheep. Like Blackquarter and Anthrax, it is caused by clostridial spore-forming organisms which, in the case of Pulpy Kidney, are found in the digestive tract of sheep. The disease affects animals that are in good condition when they are subjected to sudden change of feeding or grazing pattern, e.g., from poor to nutritious pasture. Annual vaccinations prevent the disease effectively.
- Bluetongue, caused by a virus, is also common in unvaccinated sheep. It is transmitted by gnats/midges during wet autumn months when animals are at the cattle posts, or grazing along riverbanks.
- Of more economic importance in range animals are parasitic diseases. A wide range of internal parasites is found in range animals and they contaminate the pasture areas. The impact of internal and external parasitism is greatest when animals lack adequate feed and are in poor condition. Riverbanks, wetlands and sponges are more risky grazing areas with respect to parasitic infestation as they are the only green patches in early spring or during drought, and are thus liable to overstocking. The animals congregating in these areas are also more likely to pick up Liver Fluke parasites, which have aquatic snails as intermediate hosts. Regular dosing of animals at strategic times, i.e., before lambing and dipping and in critical seasons (early spring and summer) helps prevent the disease
- The most important external parasites are sheep scab, ticks, lice and fleas. While sheep scab damages wool and mohair, ticks, lice and fleas suck blood, ticks also transmit protozoal diseases such as Anaplasmosis and occasionally Redwater. Dipping controls sheep scab and trials are being conducted by the Department of Livestock Services using injectable remedies.
- Newcastle Disease in poultry, which is the cause of major disease outbreaks.

- Diseases of pigs are uncommon, with the exception of measles (larval stage of tapeworms). Tapeworms and Anthrax can also infect human beings.
- The social impact of diseases is greatest for sheep and goats as they reduce the yield and quality of wool and mohair. These products represent the main agricultural exports of Lesotho and contribute to the livelihood of many rural households. Similarly, diseases reduce productivity of cattle and poultry that are kept by smallholders, and dairy cattle kept under commercial and range conditions.

E.4 Summary of health risks linked to biophysical changes

Following is the summary of animal health risks associated with biophysical changes:

- A decrease in the quantity and quality of riparian grazing, resulting in reduced nutrition, is an animal risk. However, the decrease in the majority of reaches is low to moderate. In some cases, monitoring will be required, in order to establish a clear relationship between changes in the riparian vegetation and animal health. The impact is expected to be most severe in the Treaty Scenario.
- The combined effect of severe increase of mud and clay and macrophytes in IFR Reach immediately downstream of the dams in the Treaty Scenario could significantly increase the potential of Bluetongue Disease outbreaks in sheep and goats. The biophysical changes in the Treaty Scenario include the formation of stagnant backwaters and pools, which are a favourable habitat for breeding of Bluetongue-vector midges. This could also apply to African Horsesickness, but the degree of its incidence in the reaches has not been determined with certainty. However, the risk to animal health predicted to be moderate for the Treaty Scenario and monitoring should precede any mitigation/compensation considerations. It should be noted here that monitoring is not a condition for compensation, but a requirement for refinement of assessed impacts.
- For other directly river-related components, e.g., medicinal plants, slippages and bogging, algal diarrhoeas (which may also be associated with Pulpy Kidney), the biophysical change decreases are severe in the Treaty Scenario. However, the risk to animal health predicted to be low and monitoring should precede any mitigation/compensation considerations.
- Many diseases are indirectly river-related, such as internal parasites and Pulpy Kidney (through grazing), Anthrax, Blackquarter and Foot Rot (through mud and clay). The animal health risk is low for these diseases, whether the biophysical changes are severe or moderate. Monitoring is required in the reaches where there is a potential direct threat to animal health, e.g., Anthrax.

E.5 Mitigation and compensation

The recommendations for mitigation of disease infections and compensation for resources lost were based on four factors:

- direct relationship of the disease to the river and flow regimes,
- level of risk of the disease to animal health,
- the extent to which the disease affects the households,
- the present status of the disease, and estimated cost of meeting the additional burden caused by flow changes.

The recommendations are:

- The change in riparian vegetation will impact the resources available for grazing and thus compensation is recommended.
- All aspects relating to animal diseases should be mitigated. Monitoring of 3-5 years will be needed before mitigation could accurately be quantified. However monitoring is for the purpose of refinement of quantification of impacts and not a condition for compensation.

The summary of health impact of Design Limitation, the Treaty and Fourth scenarios on animal health and reproduction is given in Table E.1.

Table E.1 Summaries of the public health impacts for the Treaty, Design Limitation and Fourth Scenarios**.**

CS = critically severe, Min. = minimal, Mod. = moderate, Ni. = negligible. 4a = with Mashai Dam in place; 4b = without Mashai Dam in place.

HEALTH ISSUES	Whole study area	Reach 1			Reach 2			Reach 3			Reach 4a			Reach 4b		
		Predicted future risk			Predicted future risk			Predicted future risk			Predicted future risk			Predicted future risk		
	BASELINE RISK	Treaty	Design Limit.	Fourth	Treaty	Design Limit.	Fourth	Treaty	Design Limit.	Fourth	Treaty	Design Limit.	Fourth	Treaty	Design Limit.	Fourth
Diarrhoeal disease	Mod.	CS	Severe	Severe	CS	Severe	CS	Mod.	Severe	Severe	Severe	Severe	Severe	Mod.	Min	Min.
Skin and eye diseases	Mod.	Severe	Mod.	Mod.	Severe	Mod.	Severe	Mod.	Mod.	Mod.	Mod.	Mod.	Mod.	Mod.	Min	Min
Anthrax	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
Malaria	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.
Schistosomiasis	Ni.	Mod.	Min.	Mod.	Mod.	Min.	Min.	Min.	Min.	Min.	Mod.	Min.	Mod.	Min.	Min.	Min.
Nutrition	Mod.	CS	Mod.	Mod.	CS	Mod.	Mod.	CS	Mod.	Mod.	CS	Mod.	Mod.	Severe	Min.	Mod.

HEALTH ISSUES	Whole study area	Reach 5			Reach 6			Reach 7			Reach 8		
		Predicted future risk			Predicted future risk			Predicted future risk			Predicted future risk		
	BASELINE RISK	Treaty	Design Limit.	Fourth	Treaty	Design Limit.	Fourth	Treaty	Design Limit.	Fourth	Treaty	Design Limit.	Fourth
Diarrhoeal disease	Mod.	Severe	Mod.	Severe	Mod.	Mod.	Mod.	CS	Mod.	CS	Mod.	Mod.	Mod.
Skin and eye diseases	Mod.	Mod.	Mod.	Mod.	Mod.	Mod.	Mod.	Severe	Mod.	Severe	Mod.	Mod.	Mod.
Anthrax	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
Malaria	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.	Ni.
Schistosomiasis	Ni.	Min.	Min.	Min.	Min.	Min.	Min.	Mod.	Min.	Mod.	Min.	Min.	Min.
Nutrition	Mod.	Severe	Mod.	Mod.	Mod.	Mod.	Mod.	Severe	Mod.	Mod.	Mod.	Mod.	Mod.

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LIST OF ABBREVIATIONS

ADF	African Development Fund
AGRER	Agricultural and Environmental Development Studies Firm (Brussels, Belgium)
CID	Consortium for International Development
CS	Critically severe
DLS	Design Limitation Scenario
GOL	Government of Lesotho
HH	Household
IFR	Instream Flow Requirements
LASA	Lesotho Agricultural Sector Analysis Project
LHDA	Lesotho Highlands Development Authority
LHWP	Lesotho Highlands Water Project
Min.	Minimal
Mod.	Moderate
Ni.	Negligible
SA	Republic of South Africa
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WNS	Was Not Sampled

SECTION 1:
INTRODUCTION

The aim of the animal health and production study was to analyse information derived from the socio-economic survey, technical visits and biophysical data, in order to:

- assess the potential impacts of the biophysical scenarios on animal health,
- determine priorities for appropriate mitigation and compensation.

The relevant activities that were undertaken, consistent with the workplan that was approved by LHDA (see Section 1.2), appear in Appendix 1.

Raising livestock is a major economic and social activity in the mountain region of Lesotho, providing a source of livelihood and social benefits to many people. Livestock productivity is largely influenced by the level of nutrition derived from natural grazing, water availability, and health status of the animals. Streams and tributaries of the main LHWP river systems provide a considerable proportion of the water requirements of range animals (cattle, sheep, goats, horses and donkeys). The rivers also play a major role where the immediate surrounding areas are densely populated by livestock-owning households, and where rivers traverse the rangeland.

1.1 THIS REPORT

This report provides the technical findings relating to the Animal Health and Production component of the study. The findings are based on the following:

- biophysical consequences of the four scenarios presented in Report No 648-F-04 to 07,
- relevant aspects of animal health and production in Lesotho, and,
- the findings of the Socio-Economic Survey (Report No 648-F-08).

The impacts of the Minimum Degradation Scenario on animal health are considered minimal, thus no consequences have been provided. The details of consequences of the other three scenarios, namely the Treaty, Design Limitation and the Fourth Scenario, for animal health and production are provided in Section 5 of this report. The costs of mitigation and compensation are given in the Economics Report (Report No 648-F-22). The monitoring activities required for this component are detailed in the Monitoring Protocol (Report No 648-F-23).

1.2 OBJECTIVES

The objectives of the study are broadly as follows:

- Identify the animal disease and animal health aspects that could be related to river flows.
- Determine the impact of four IFR scenarios on animal health and production.
- Recommend measures for mitigation and compensation for the impacts resulting from any of the four IFR scenarios.

1.3 TERMS OF REFERENCE

The study area incorporates the areas in the vicinity of the rivers downstream of the proposed or extant LHWP dams. These dams are Mohale Dam, Katse Dam, Matsoku Diversion Weir, Mashai Dam, Tsoelike Dam, and Ntoahae Dam.

The animal production and health expert on the IFR Team for LHDA 648 was expected to take full responsibility for the completion of the following tasks:

1. Review all the animal health data in relation to prevalent livestock production in Lesotho.
2. Identify animal diseases and production systems in Lesotho that are dependent on river flow, and prepare a qualitative assessment of the effect on animal health of river flows associated with four release scenarios from the LHWP dams.
3. Collaborate with the project sociologist to ensure that the socio-economic questionnaire will allow an assessment of the number of animals that use the main river as a source of drinking water and/or how their health and production is affected by the quantity and quality of flows in the river.
4. Determine the effect of reduced flows and possible changes in water quality, on livestock diseases of economic importance and on water supply used in dip tanks, and suggest mitigation measures where

appropriate.

5. Quantify the effect of reduced flows on the animal production identified in 4.
6. Suggest mitigation measures such as vaccination and dosing animals to reduce the incidence of flow-dependent diseases and to counteract the potential negative effects of downstream changes on draught power, meat, wool and mohair production.
7. Attend the IFR Workshop, and participate in the proceedings.
8. Attend the Social Scenario Workshop, and participate in the proceedings.
9. Provide detailed recommendations on animal health and production aspects including mitigation measures for inclusion in the project

recommendations.

10. Advise on any monitoring actions required with respect to animal health and production [for inclusion in the Monitoring Report].
11. Adhere to standard formatting, font and layout specifications provided by the Consultant for written submissions.

1.4 PREVIOUS STUDIES

A comprehensive animal health and production study was undertaken by the Consortium for International Development (CID; 1993) for LHDA in the Katse Catchment area – IFR Reach 1. The study provided a basic measurement of livestock productivity within specific areas of the Katse Catchment and an indication of the diseases affecting that productivity. Additionally, the survey provided a partial set of methods for assessing livestock disease and productivity that would be useful in developing the information to perform an in-depth quantitative assessment over a longer time period.

The above livestock field survey consisted of two phases, a pilot study conducted during the winter and a comparative summer study. Because many of the effects of the dam construction on future livestock diseases could not be anticipated, an important objective of the survey was a collection of serum, blood, skin scrapings and fecal samples to establish the level of infections with viral, bacterial and parasitic diseases. A selected subset of samples was analysed. The results of the findings are discussed in Section 3.

1.5 ANIMAL HEALTH AND PRODUCTION SITUATION IN LESOTHO

Lesotho is fortunate in not having major epizootic diseases. This is due to the high altitude, low winter temperatures and the protective buffer provided by South Africa, with its highly developed disease-control measures. The important animal health aspects, which may be related to the river flows, were as follows:

- Anthrax and Blackquarter are serious and important bacterial disease outbreaks that occur sporadically in the lowlands and foothills of Lesotho (and to a lesser extent in the mountains). These mainly affect cattle, sheep and goats. Anthrax and Blackquarter are controlled by vaccination.
- Strangles, a bacterial disease that occurs in horses, also occurs in the study area. Strangles is treated with antibiotics.
- Pulpy Kidney, which is a bacterial disease of importance affecting sheep. Like Blackquarter and Anthrax, it is caused by clostridial spore-forming organisms which, in the case of Pulpy Kidney, are found in the digestive tract of sheep. The disease affects animals that are in good condition when they are subjected to sudden change of feeding or grazing pattern, e.g., from poor to nutritious pasture. Annual vaccinations prevent the disease effectively.
- Bluetongue, caused by a virus, is also common in unvaccinated sheep. It is transmitted by gnats/midges during wet autumn months when animals are at the cattle posts, or grazing along riverbanks.
- Of more economic importance in range animals are parasitic diseases. A wide range of internal parasites is found in range animals and they contaminate the pasture areas. The impact of internal and external parasitism is greatest when animals lack adequate feed and are in poor condition. Riverbanks, wetlands and sponges are more risky grazing areas with respect to parasitic infestation as they are the only green patches in early spring or during drought, and are thus liable to overstocking. The animals congregating in these areas are also more likely to pick up Liver Fluke parasites, which have aquatic snails as intermediate hosts. Regular dosing of animals at strategic times, i.e., before lambing and dipping and in critical seasons (early spring and summer) helps prevent the disease
- The most important external parasites are sheep scab, ticks, lice and fleas. While sheep scab damages wool and mohair, ticks, lice and fleas suck

blood; ticks also transmit protozoal diseases such as Anaplasmosis and occasionally Redwater. Dipping controls sheep scab and trials are being conducted by the Department of Livestock Services using injectable remedies.

- Newcastle Disease in poultry, which is the cause of major disease outbreaks.
- Diseases of pigs are uncommon, with the exception of measles (larval stage of tapeworms). Tapeworms and Anthrax can also infect human beings.

The social impact of diseases is greatest for sheep and goat production as they reduce the yield and quality of wool and mohair. These products represent the main agricultural exports of Lesotho and contribute to the livelihood of many rural households. Similarly, diseases reduce productivity of cattle and poultry that are kept by smallholders, as are dairy cattle, under commercial and range conditions.

SECTION 2:

SOCIO-ECONOMIC SURVEY RESULTS

2.1 STUDY AREA

The socio-economic data gathered in the areas related to the eight biophysical IFR Sites. Data were gathered within a corridor that was 5-km wide on either side of the study rivers. The eight lengths of river (i.e., reaches) represented by each IFR site, and thus representing the different socio-economic data areas (sections) are (Figure 2.1):

IFR Reach 1. Matsoku River from the site of the proposed Matsoku Weir to the confluence with the Malibamatso River,
IFR Reach 2. Malibamatso River from Katse Bridge to the confluence with the Matsoku River,
IFR Reach 3. Malibamatso River from the confluence with the Matsoku River to the confluence with the Senqu River,
IFR Reach 4. Senqu River from the confluence with the Malibamatso River to the confluence with the Tsoelike River,
IFR Reach 5. Senqu River from the confluence with the Tsoelike River to the confluence with the Senqunyane River,
IFR Reach 6. Senqu River from the confluence with the Senqunyane River to the Lesotho/South African border,
IFR Reach 7. Senqunyane River form the site of the proposed Mohale Dam to the confluence with the Lesobeng River,
IFR Reach 8. Senqunyane River from the confluence with the Lesobeng River to the confluence with the Senqu River.

The boundary limit of 5 km was chosen because this is the maximum distance that stock can be driven in a day to be watered at the river, or to graze along its reaches. The key aspects that were examined included:

- population of the range animals (cattle, sheep, goats, horses and donkeys – equines) and other domesticated animals (pigs and poultry) linked to each IFR reach,
- type of disease affecting the animals (directly river-related and not directly river-related diseases),
- diseases causing animal deaths,
- medicinal plants found along the river used for treatment of animal diseases, and,
- grazing patterns.

2.2 LIVESTOCK POPULATIONS

The total livestock population, which is owned by 20 426 households in the eight IFR reaches, is shown in Table 2.1. The range-animal population linked to the IFR reaches represents 19% of the corresponding mountain livestock population. The range animals linked to the three IFR Reaches 4, 5 and 6, along the Senqu River, comprise 79% of the animals in the entire Senqu Valley (GOL, Bureau of Statistics, 1996; see Report No 648-F-08). These comparisons are significant for monitoring purposes, since animals residing in the IFR reaches with infectious diseases may infect others where animals from different areas mix, for instance at cattle post grazing areas, and *vice versa*, (GOL, 1999). Population dynamics in the short and medium term (five years) could indicate whether animal increases are a result of mitigation measures (e.g., vaccination and therefor a greater life expectancy) or animals brought in from other areas.

In terms of total livestock population, Table 2.1 reveals that goats represent the highest number of animals (about 131 000), followed by sheep (77 000) and cattle (68 000). While this is generally consistent with the national pattern (Bureau of Statistics, 1996), the number of goats in the eight reaches comprises 98% of the total goat population in the Senqu River Valley. This is expected because the valley is a habitat of trees and shrubs, more relished by goats than by other classes of range animals. However, the data show that the ratio of goats to sheep is higher in the IFR reaches than elsewhere in the valley. For instance, in the whole of the Senqu River Valley the sheep population is *c.* 162 000 and the goat population *c.* 133 500 (i.e., 55% sheep), whereas in the IFR reaches, sheep numbers are *c.* 78

000 and goats *c*. 131 000 (i.e., 37% sheep). This suggests that the conditions in the IFR reaches impart relatively more important economic significance to goat owners resident in the IFR reaches than to sheep owners.

IFR Reach 6 has the highest number of livestock because the reach is more heavily populated by humans (60 104 persons representing 38.9% of the total reaches population – Table 2.2) than other reaches.

The socio-economic survey also obtained three sets of data related to livestock population:

- households owning livestock, mean number of livestock per household, and ranges of animal numbers reported as owned by the average household,
- broad age categories of cattle (< 6 months, > 6 months), and of sheep and goats (< 4 months, > 4 months), and,
- ownership by altitude and distance from river.

The first data set is useful for mitigation and compensation considerations, while the second data set is useful from the disease and grazing aspects, and hence also for mitigation measures. The third data set is essential for justifying the corridor of five kilometres from the river.

Of the total number of households (32 682) in the study area, 62.5% (20 426) own livestock (Table 2.3). A higher percentage of households own animals in IFR Reaches 5, 4 and 6 than in the other reaches. The mean number of livestock per household (HH) in each of the IFR reaches is provided in Table 2.4. These data are important for assessing mitigation and compensation measures. Table 2.4 indicates that households tend to have a higher number of cattle, sheep and goats, horses, pigs and chickens. The means of livestock in different reaches is shown in Table 2.4. An indication of the distribution of the mean is provided in Table 2.5, which shows the percentage of households with different numbers of animals.

Table 2.5 shows the skewness of livestock holding in the IFR reaches. Most of the animals are in the hands of only a few households for all types of livestock. However, the majority of households own some kind of livestock, albeit in small numbers. The exception is that cattle are owned by about 40% of households. The significance of this skewness is that only a smaller number of households would be affected for purposes of mitigation as shown in the first column. With the exception of goats, the pattern of ownership confirms projections by the Lesotho Agricultural Sector Analysis Project (GOL, LASA, 1982) and Hunter (1987) that livestock ownership will tend to be progressively concentrated in fewer households (e.g., in 1985, 42% HHs had no cattle, 53% no sheep, 56% no goats).

Altitudes above, and distance from, the river play a significant role in determining river utilisation in relation to livestock ownership, as do the prevailing climatic conditions, as shown in Table 2.6.

For instance, 49% of the households within 100 m of the rivers own stock, and of those 44% use the rivers to water their stock in the dry season, and 64% will use the river in times of drought. It is clear from Table 2.6 that, although river use drops with increasing distance and altitude from the river, the rivers are still used considerably, even when people have to move their animals down from altitudes higher > 400 m and/or distances > 3000 m, especially during drought.

Table 2.1 Population by IFR Reach, type of animal and percentage of the total population of the study area.

IFR Reach	TOTAL NUMBER OF LIVESTOCK BY CLASS AND PERCENT OF TOTAL											
	Cattle		Sheep		Goats		Equines		Pigs		Poultry	
	No	%	No	%	No	%	No	%	No	%	No	%
1	5996	8.8	4576	5.9	4261	3.2	2051	8.6	158	3.6	3629	6.7
2	1481	2.2	2992	3.8	1405	1.1	640	2.7	25	06	1001	1.8
3	5720	8.3	8137	10.4	4361	3.3	1659	7.0	32	0.7	4235	7.8
4	10450	15.3	17525	22.5	13824	10.5	4684	19.7	76	1.7	10072	18.6
5	8889	13.0	11211	14.4	20825	15.8	3495	14.5	524	11.9	5743	10.6
6	26498	38.8	18090	23.3	68320	52.1	7468	31.4	3264	74.0	22847	42.2
7	8147	11.9	14197	18.2	13997	10.7	3015	12.7	242	5.5	4690	8.7
8	1197	1.8	1145	1.5	4116	3.1	777	3.3	95	2.2	1953	3.6
Total	68378	100	77803	100	131109	100	23781	100	4416	100	54170	100

Source: Report No 648-F-08.

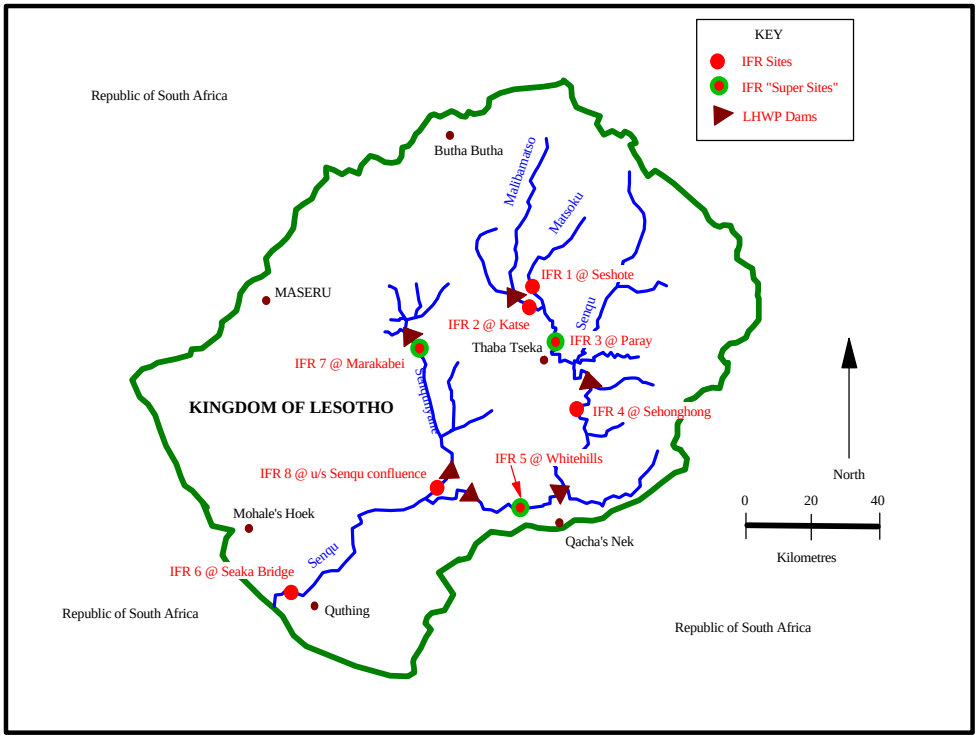

Figure 2.1 Location of the IFR Reaches and Sites.

Table 2.2 Human population in the IFR reaches.

IFR Reach	1	2	3	4	5	6	7	8	Total
Population	7462	2879	15367	28719	27749	60104	10819	3488	154587

Source: Report No 648-F-08.

Table 2.3 Households (HHs) owning livestock by reach and percentage.

IFR Reach	1	2	3	4	5	6	7	8	Total
HHs with animals	1256	408	1556	3229	3385	8450	1676	458	20426
% HHs	6.1	2.0	7.6	16.2	16.6	41.4	8.2	2.2	100
% of Total HHs	3.8	1.2	4.8	10.1	10.4	25.9	5.1	1.4	62.5

Source: Report No 648-F-08.

Table 2.4 Mean number of livestock per HH per IFR Reach.

	IFR Reach								
Animals	1	2	3	4	5	6	7	8	Total
Cattle	3.8	2.4	1.7	1.8	1.6	2.0	3.6	1.7	2.1
Sheep	2.9	4.8	2.4	3.1	2.1	1.4	6.2	1.6	2.4
Goats	2.7	2.3	1.3	2.4	3.9	5.2	6.1	5.7	4.0
Equines	1.3	1.1	0.5	0.8	0.7	0.6	1.3	1.1	0.7
Pigs	0.1	0.04	0.09	0.01	0.09	0.25	0.11	0.13	0.14
Poultry	2.3	1.6	1.2	1.8	1.1	1.8	2.1	2.7	1.6

Source: Report No 648-F-08.

2.3 ANIMAL DISEASES

The socio-economic data obtained concerning classification of cattle and sheep according to age categories, revealed that diseases reported by households affecting young animals (cattle less than six months, sheep less than four months) were insignificant. For example, only 5.4% of 1141 reporting households reported diseases in young cattle and 1.7% reported illness of young sheep. Even in total the incidence of diseases reported in the IFR reaches was low as shown in Table 2.8, as were deaths of animals.

The occurrence of disease and deaths in cattle appears higher than in other classes of livestock (Table 2.7). This could be due to the fact that cattle play a more important socio-economic role. For instance, they are used for draft power, as an indication of wealth, in ceremonies and to pay the bridal price. Thus, cattle are relatively more valuable than other livestock (Tshabalala, 1994). Cattle are also held in smaller numbers than other range animals, and thus their owners are possibly able to recall disease and deaths are more readily. Deaths are higher than disease in pigs and poultry, suggesting that these animals receive little or no treatment for disease. This

could be because pigs and poultry are kept mainly for household consumption, whereas cattle, sheep and goats are valued for the sale of wool, mohair and meat, as well as for household consumption.

The most common causes of disease and deaths are reported as being internal and external parasites, diarrhoea and bacterial diseases. The type of diseases and reasons for deaths reported by households, as per Table 2.7 for all IFR reaches, are shown in Table 2.8.

Where the diseases are known, external parasites cause more disease and deaths than any other disease conditions in cattle, sheep and goats. Internal parasites are the major cause of disease in horses. However, the causes of between 55 – 100% of diseases and deaths are attributable to other factors (up to 70 different causes of death were recorded). These include a wide range of disease conditions reported in small percentages (under 1%). Some of these conditions are in fact a manifestation of conditions reported as known – e.g., emaciation, starvation and lung problems – or related to them. The distribution of diseases and deaths according to individual IFR reaches appears in Appendix 2. The main differences, in terms of assessed importance are.

Reach 1 has the highest occurrence of external parasites (34.4%) in cattle, diarrhoeas from unknown causes (OT) (65.3%) in goats,

Reach 2 has the highest occurrence of external parasites in goats (33.4%) and highest internal parasites in sheep (45.5%).

Reach 3 has the highest occurrence of diarrhoeas (83.3%) from unknown causes in sheep.

Reach 7 has the highest incidence of internal parasites (63%) in goats.

By comparing diseases that are directly related to the river and those that are not, it appears that young cattle, pigs, equines, adult cattle and horses (in that order) are least affected by IFR-related diseases. On the other hand, sheep, particularly lambs, and goats are significantly affected as shown in Table 2.9.

River-related diseases include:

- diseases/illness caused by or transmitted by water insects, e.g., *Simulium* species (biting blackflies) and Ceratopogonidae (biting midge);
- diseases caused by internal parasites (round and tape worms, liver fluke, and coccidia),
- bacterial diseases infecting animals as a result of ingestion_of contaminated water (Blackquarter) or grazing lush riverine vegetation (Pulpy Kidney),
- diarrhoeas caused by ingestion of algae,
- physical conditions such as being stuck in the mud resulting in lameness and a predisposition to foot rot.

The majority of some of these diseases are reported by households as unknown or other diseases (Table 2.8).

Table 2.5 Range of livestock ownership by HHs.

Livestock Class	% of HHs owning different numbers of livestock				
Cattle	None	1–5 animals	16–30 animals	> 30 animals	
	59.8%	25.6%	10.8%	3.7%	
Sheep	None	1–5 animals	16–30 animals	> 30 animals	
	83.6%	12.3%	2.3%	1.8%	
Goats	None	1–10 animals	11-20 animals	2 1-40 animals	> 40 animals
	73.9%	16.0%	4.2%	4.1%	1.8%
Equines	None	1 -5 animals	> 5 animals		
	71.3%	26.5%	2.2%		
Pigs	None	1 animal	> 1 animals		
	90.9%	6.3%	2.8%		
Poultry	None	1 –5 animal	6-10 animals	> 10 animals	
	78.1%	11.8%	5.9%	4.2%	

Source: Report No 648-F-08.

Table 2.6 Percentage of HHs owning animals and watering them at the study rivers in relation to altitude and distance from the study rivers.

	Altitude above the study river (in metres)				
	0-100	100-200	200-300	300-400	>400
Ownership per HH	49	64	65	65	56
Watering in dry season (per HH)	44	28	26	42	38
Watering in drought (per HH)	64	55	52	66	56
	Distance from the study river (in metres)				
	0-500	500-1000	1000-2000	2000-3000	3000-5000
Ownership per HH	60	63	67	55	65
Watering in dry season (per HH)	48	43	35	19	17
Watering in drought (per HH)	67	66	55	51	47

Source: Report No 648-F-08.

Table 2.7 Percentage of HHs that own animals who reported diseases and deaths from April 1998 to April 1999.

	% of HHs reporting						Total%
	Cattle	Sheep	Goats	Equines	Pigs	Poultry	
Disease	14.4	6.6	5.7	7.2	0.2	2.4	36.5
Death	7.5	5.6	5.8	2.6	0.3	4.4	26.2

Source: Report No 648-F-08.

Table 2.8 Percentage of HHs reporting cause of disease and death in different livestock classes.

	Livestock Class	Cause of disease/death reported by% of HHs				
		Internal parasites	External parasites	Diarrhoea Cause unknown	Bacteria	Unknown (U) Other (O)
Cattle > 6 months	Disease	3.0	55.1	2.5	1.7	37.7 (U)
	Death	1.3	25.0	3.2	0.8	69.7 (O)
Sheep >4 months	Disease	6.7	16.6	11.4	0.6	64.7 (U)
	Death	2.8	16.4	8.3	-	72.6 (O)
Goats	Disease	7.6	19.6	19.5	1.4 (Viral)	51.9 (O)
	Death	11.6	21.9	7.3	1.3	57.7 (O)
Equines	Disease	30.6	14.1	-	0.2	55.2 (O)
	Deaths	8.8	10.3	-	6.5	74.4 (O)
Pigs	Disease	-	-	-	-	100 (O)
	Deaths	-	-	-	-	100 (O)
Poultry	Disease	-	9.2	6.5 (Viral)	0.6	83.9
	Deaths	-	10.4	-	24.7 (Viral)	64.9

Source: Report No 648-F-08.

Table 2.9 Percentage made up of river-related disease of the total diseases reported in different animals from April 1998 to April 1999.

Cattle	Sheep	Goat	Equines	Pigs	Poultry
Months %	Months %	%	%	%	%
0-6 0.0	0-4 45.0	27.1	1.8	0.0	6.5
6+ 4.0	4+ 19.6				

2.4 RIVER UTILISATION

2.4.1 Grazing

The most significant correlation between riverine grazing and animal diseases is the likelihood of sudden deaths caused by Enterotoxaemia (Pulpy Kidney) in sheep. This occurs when animals over-engorge themselves with lush growth on the riverbanks. Since such grazing is usually limited, especially during drought periods, animals will tend to spend more time at the riverbanks, resulting in the build-up of parasitic infestation of the pasture. Both the bacterial and parasitic diseases are preventable. The shrubs along the river also provide essential nutrition, especially to the goats, and the willow trees are a critical source of feed to cattle during drought. Food is of importance from the disease aspect since low or poor nutrition makes animals more susceptible to worm infestation and infections, and thus lowers the production of wool, mohair and meat. Table 2.10 shows the mean number of months that animals were present along the rivers as determined by social survey. However it should be pointed out that all the needs of animals that graze along the rivers is not solely met from the riverine areas affected by change in flow. The grazing vegetation loss to the communities was thus assessed based on estimate of riverine areas affected by reduction in flows. The grazing area (See Table 2.10) that could be potentially affected was computed based on river length and estimate of width of river that is assessable to animals.

The estimates of loss of grazing vegetation that was used in economic analysis combined the effect of change in vegetation based on biophysical scenarios (See reports 648-F-04 to 648-F07) and area affected based on values given in Table 2.10.

Grazing is related to villages in the vicinity of the river, mainly near watering points and areas within the reach of flow regimes. Most parts of the riverbanks are deep rocky gorges, which are inaccessible to animals except goats, and have little grazing.

Although there is some variability regarding mean months the animals were on riverine grazing, generally young sheep spend more time along the river than do adults. This may account for the higher incidence of river-related diseases in young sheep than in adult ones shown in Table 2.9. Animals in IFR Reach 3 and 4 spent more time along the river than in other reaches. This is

because the reaches have more grazing. Although Reach 7 is also large, it is mainly rocky. Reach 2 is also steep and rocky.

Riparian grazing is utilised mainly in the dry winter months and early spring. Both the field livestock staff and the farmers reported a higher incidence of disease during these periods, particularly worm infestations during spring because of contamination of the limited grazing available to large animal populations. Farmers do not send their animals to cattle posts for fear of stock theft, but also because they believe the cattle posts are more degraded than their riverine grazing to which they have exclusive rights compared to communal grazing at the cattle posts.

2.4.2 Medicinal plants

An average of 37.4% and 12.7% households at altitudes of between 100 and > 400 masl and distances of between 100 and 500 m, respectively, reported using medicinal plants gathered from riparian areas for treating animal diseases. However, only two medicinal plants were found to be significant, namely, 'hloenya' (*Phygelius capensis*) for treatment of tick fever in cattle, and 'mofifi' (*Rhamnus prinoides*) for treatment of internal parasites). Others were collected by less than 1% of households. The roots of *hloenya* (mean annual amount of 7.4 roots per household) are collected by 17.3% of all households, while *mofifi* (mean annual amount of 5 handfuls of leaves per household) is collected by 1.2% of all households.

2.4.3 Animal watering

Households are dependent on the river for watering of animals, particularly during the dry season and drought when rivers become a life-supporting resource for a large number of animals (Table 2.11).

As can be expected, a higher percentage of households use the river for watering their animals during drought than during the dry season. This suggests that other water sources, such as springs and streams, dry up during drought and that greater numbers of animals spend more time than near the main rivers. This, of course, also has a negative impact on riverine grazing and increases the risk of disease infections as animals mass together on limited grazing. The highest usage in drought and the dry season is in IFR Reach 1 (80.8% and 64.1%, respectively). Thereafter the high use areas are, in order of decreasing level of use, IFR Reaches 7, 3 and 5.

The health status of animals and overall production depends on an adequate drinking water supply, which is adequately allowed for daily in l/c/d (see Water Supply Report No 648-F-11): cattle 45, equines 38, sheep/goats/pigs 3 l/c/d. The nearer the households owning animals are to the river, the more they use it for watering their animals.

Table 2.10 Mean number of months (per year) and total numbers of livestock on grazing in the riparian areas. Grazing area refers to riparian vegetation suitable for grazing.

IFR Reach	River length (km)	Grazing area* (Km^2)	Mean numbers present								
			Cattle			Sheep			Goats	Goats	Equines
			Age class		Total number	Age class		Total number	All ages	Total number	All ages
			< 6 months	> 6 months		< 4 months	> 4 months				
1	30	19.1	3.61	4.82	3843	3.8	5.63	2933	4.53	2731	5.45
2	17.5	0.8	3.07	3.72	352	2.62	3.96	695	3.38	334	3.70
3	35	13.4	6.33	5.33	2768	6.00	6.07	3935	7.29	2111	6.30
4	115	10.1	3.50	4.73	4671	6.00	5.84	7834	5.34	6179	5.85
5	90	7.7	5.00	4.26	2027	4.00	4.30	2556	4.23	4748	4.93
6	150	1.7	4.15	3.95	5512	3.00	4.41	3763	4.22	14211	3.00
7	90	5.9	5.38	5.38	3381	4.25	4.53	5892	5.10	5809	5.38
8	40	4.1	3.22	3.94	332	4.00	4.21	317	4.15	11140	4.48
Mean			4.14	4.56		3.98	4.97		4.58		4.98
Total	567.5	63.0			222886			27928		47263	

*Estimated by Vegetation Specialist.

Table 2.11 Dependency of HHs with animals in IFR Reaches on river during dry season (DS – 3 months) and drought (D).

Dependency	IFR Reaches and Percent							
	1	2	3	4	5	6	7	8
% HHs During DS	64.1	23.8	48.4	44.7	22.8	20.8	41.5	27.5
% HHs During D	80.8	55.8	59.5	64.6	59.1	53.8	65.5	55.3

Source: Report No 648-F-08 and raw data.

SECTION 3:

TECHNICAL FINDINGS AND ASSESSMENT

In order to supplement the information generated by the socio-economic survey, field visits were made to all the IFR reaches (Appendix 1), as well as sourcing relevant information in the Department of Livestock Services (Animal Health and Animal Production Divisions) of the Ministry of Agriculture and LHDA. Farmers and Department officers nearer to the IFR reaches provided information with respect to animal diseases and their impact on production. It was confirmed during the field visits that the high percentage of unknown or other diseases (Table 2.8) are generally disease conditions or manifestations of the known reported cases with the exception of some diseases of importance that will be discussed below.

3.1 PARASITIC DISEASES

3.1.1 External parasites and insect vectors

External parasites and insect vectors are listed below:

- Ticks (*Boophilus)*. They suck blood and transmit the commonly reported protozoal diseases mainly in cattle. These are 'nyooko' (Anaplasmosis) and occasionally Redwater (Babesiosis). Both diseases are characterised by tick fever.
- Sheep Scab (*Psoroptes ovis*). Parasites cause 'lekhoekhoe' and destroy wool and mohair of sheep and goats. The itching causes further damage of fleece by scratching.
- Mange *(Psoroptes equi var bovis*) in cattle and horses, *Sarcoptes scabiei var. bovis* in cattle only. The parasites feed on skin debris and cause itching and scratching. Commonly referred to as 'matsetse' although the term may also include fleas.
- Lice (Mallophaga – biting, Anoplura – blood sucking). They are irritating and cause anaemia in all classes of livestock.
- Blackflies (*Simuliidae* spp*)*. Highly irritant to cattle and large numbers can cause sudden death caused by toxin injected by the flies. Known as 'seboba' in Sesotho.
- Midges (*Ceratopogonidae).* Transmit Horsesickness and Bluetongue (in sheep) viruses. The insects are active in autumn and at night.
- Mosquitoes (Psorophora and Aedes spp*)*. Irritant and active in autumn.

As shown in Table 2.8, parasitic diseases account for the highest incidence of infestation and deaths of animals with respect to cases identified by households in the IFR reaches. Although external parasites and insects cause the most harm to animals, the majority of them are not strictly
river-related. The survey by the Consortium for International Development (CID, 1993) showed tick infestations to be more a problem in cattle (67%) than in goats (3%) and sheep (30%) in winter. There were hardly any ticks on sampled sheep and goats in summer, but 65% of cattle were infested.

Sheep Scab is the most important external parasitic disease in Lesotho. Dipping the sheep and goats controls the disease. There are 202 dip tanks strategically located throughout Lesotho. The disease is indirectly river-related in two aspects.

1. Depending on the proximity of the dip tank from the river, the effluent from the tank may be hazardous to aquatic life. A study was undertaken to survey dip tanks in IFR Reach 1 – 3 in 1992 (Qheku, 1995) by the Environmental Division of LHDA. The toxicity of the remedies was evaluated in relation to the siting of the dip tanks. The study showed that:
   - the commonly used organophosphate dip (diazinon) was more effective than the less used pyrethroids,
   - dip residues were found within a distance of 5 km from the dip tank, and thus likely to poison river waters.

   The study recommended re-siting of three dip tanks and that an intensive study of all dip tanks in the catchment be made to assess location relative to the main rivers and to check dip tank design for safety measures. Furthermore, the study recommended that boreholes and wells be considered to replace streams as the source of water for the dip tanks, or that a pour-on dip study be undertaken. A pour-on study was subsequently

undertaken by the Department of Livestock Services, but dipping has been found to be more effective.

2. The second aspect of relevance to riverine areas concerns river crossings associated with dipping and shearing. Sheep and goats in downstream villages that are far from bridges in IFR Reaches 4, 5, 7 and 8 have to cross the main rivers to be dipped and shorn. While the animals can swim easily depending on the flow and level of the current, they have to wait for a couple of days to dry before they are shorn. This interferes with the shearing programme. Similarly, the dip is washed off if sheep swim back, the effectiveness of the dip is reduced and the dip pollutes the rivers.

These two problems can be tackled by assessing the siting of dip tanks as recommended by the Environmental Division of LHDA study (Qheku, 1995).

The macroinvertebrate study identified two significant river-related pests, namely *Simulium* (blackflies) and disease carrying snails (Report No 648-F-17). The immature stages of *Simulium* are aquatic and require swiftly flowing water for successful development of larval and pupal stages. The eggs of the species are laid at the water's edge on stones, vegetation or debris, so that they are kept moist or occasionally submerged. *Simulium chutteri* sucks blood of cattle, horses and sheep and is such a nuisance that the animals, spend more time running away than grazing. In this manner, the presence of flies reduces animal productivity. The herdboys reported that many injuries occurring in cattle are a result of cattle running 'amock' as a result of *Simulium chutteri* flies biting them. The study identified *Simulium chutteri* in all IFR Reaches except Reach 1 and 8. It is noteworthy that the Consortium for International Development (CID) (1993) which carried out extensive tick study, did not mention any *Simulium*. This suggests that the insects were not considered a major problem by the authors of that report.

The macroinvertebrate study also identified *Simulium nigritarse* and *S. adersi* in IFR Reaches 1, 2, 3, 7 and Reach 4, respectively. These two species attack poultry (although *S. adersi* has been recorded as having bitten people in South Africa). In South Africa, they are a nuisance to farmers along the rivers. The herdboys confirmed that these flies are a pest and that the only means of prevention is to avoid river locations where flies are known to be prevalent. *S. adersi* is also an intermediate host of the protozoan poultry disease, *Leucocytozoon*.

The macroinvertebrate study did not identify any biting midges in the IFR Reaches because the larvae develop in stagnant water. These biting midges transmit Bluetongue Disease and breed in wet places. They are known to occur in Africa, Israel and Australia (Yeruham and David, 1997). It must be noted that 1998 autumn was one of the driest seasons in Lesotho (Lesotho Department of Metereological Services, 1999), with drying up of small pools along the riverbanks. This may be why the midges were not found in this study. The midges are active at dusk and at night and are found in large numbers in low-lying parts in marshes and around pans, and dams (du Preez, 1996).

Similarly, no mosquitoe larvae were recorded from the river by the macroinvertebrate study. Like midges, mosquitoes infest wet places and prefer low-lying river valleys. Mosquitoes are also an irritant to Lesotho animals. They cause blood losses and transmit pox diseases in cattle and poultry. However, the harm done by mosquitoes to livestock is less severe than that caused by midges.

3.1.2 Internal parasites

Internal Parasites include:

- Roundworms (*Nematodes)*: The most important species in cattle, sheep and goats are: *Haemonchus contortus, Strongyloides, Trichostrongylus, Bunostomum, Nematodirus, Ostertagia, Oesophagostomum; in* horses: *Gasterophilus (Papisi), Stronyloides, Parascaris. Trichostrongylys;* in pigs: *Ascaris, Strongyloides, Oesophogostomum dentaum.*
- Flatworms: cattle, sheep and goats: (*Cestoda) – Moniezia expansa;* in cattle, sheep and goats: *(Trematodes) - Fasciola hepatica* (liver fluke) and *paramphistomum microbothrium* (pear-shaped stomach flukes).
- Coccidiosis: *Coccidia spp* in all animals but more serious in calves, lambs, kids and poultry.

Internal parasites can be grouped into three categories: roundworms, flatworm protozoal parasites, and *coccidia* but they are collectively known as 'manyooa' by Basotho farmers. There are several internal parasites that exist in Lesotho. An epidemiology of Helminthes (internal parasites) Disease complex was undertaken by the

Helminthiasis Research Programme in Lesotho from 1967 to 1970 (GOL, Ministry of Agriculture, 1971). While the incidence of internal parasites is widespread through Lesotho, the research findings indicated that wet conditions in sponges, around springs and along riverbanks are favourable reaches for completion of worm life cycles. This finding has been confirmed by other researchers (McCulloch, Dalbock and Kahm, 1986).

Internal parasites (roundworms) cause disease by sucking blood and nutrients from the intestines of their animal hosts. The Helminthiasis Research Programme also found that parasitic diseases reduce wool and mohair growth by up to 25%. Other work has confirmed this finding (Gordon, 1958). Of significant importance for animals grazing along riverbanks is the incidence of liver fluke (*Fasciola hepatica)*, which was reported by farmers in IFR Reaches 4 to7. Some of them claimed that they "had not tasted cattle and sheep livers for years" as a result of infestation with 'maphela' (liver fluke), besides the parasite causing deaths.

Unlike the roundworms, tapeworms and *Coccidia*, which are indirectly river-related diseases, the eggs of liver fluke hatch in water and develop into a first larval stage (*miracidum)* and infect lymnaead snails in which development and multiplication occur through three larval stages. The final stage *(cercaria*) emerges from the snail and encysts on aquatic vegetation. When animals ingest the *cercaria* together with the vegetation, the wandering immature flukes move to the liver and destroy tissue. Paraphistomes are flukes that are found in the stomachs of cattle, sheep and goats. Their life cycle in the snail host resembles that of liver fluke. Although older animals appear to develop resistance, which however breaks down if animals are emaciated, young animals are more susceptible and become anaemic, and suffer diarrhoea and extensive mortalities.

Intermediate hosts of liver fluke are snails (*Lymnaea trunculata, Bulinus tropicus)*. The Helminthiasis Research (1970-1971) found that the density of the *Lymnaea* population in the mountains is highest at altitudes between 2 100 m and 2 400 m in isolated swamps/bogs and riverbanks. *Bulinus* occurs mainly at lower altitudes of between 1 600 m and 2 000 m (Prinsloo, 1973). The macroinvertebrate study did not record the disease-carrying snails in IFR reaches (Report No 648-F-04-17).

The control of internal parasites, for which broad-spectrum effective remedies are available (See Section 5.2), has been undertaken by the Department of Livestock Services over the past years. Internal parasites present the most problems for sheep and goats and young animals. Thus, the remedies are sold to sheep and goat farmers, and to cattle farmers for use for the treatment of young cattle. However, because of poverty in the mountains (Report 648-F-08), not all farmers dose their animals according to the recommended tactical and strategic dosing schedules. Furthermore, many of the farmers cannot afford the remedies. For instance, 306 sheep and 220 goats per household are required to generate the equivalent of the national average minimum wage of M5876 per annum from wool and mohair (Phororo, 1999). Thus, poverty results in persistent contamination of the communal grazing pastures with parasites from animals belonging to the poorer farmers.

The Helminthiasis Research Programme (1967–1970) carried out field trials to control snail populations in selected streams and swamps by spraying these areas with Frescon at 0.5 kg ha^{-1} (Prinsloo, 1973, 1976). The compound was very effective for controlling *Lymnaea trunculata*, while a much stronger concentration was needed to kill *Bulinus*. The costs of spraying were not calculated. Liver fluke and stomach flukes were mainly reported by farmers in the IFR Reach 1, and by veterinary field officers.

The control of other flatworms (*Trematodes)* and tapeworms (*Cestoda*) can be done concurrently with roundworm treatment using broad-spectrum anthelmintics (worm remedies). While coccidiosis may be a problem in poultry raised on the range, and therefore likely to pick up the parasites along riverbanks, its importance in other range animals becomes significant if there is a heavy roundworm burden. Thus the control of coccidiosis is more critical where other infestations are heavy.

The faecal samples examined by the CID survey (1993) recorded 65% roundworm infestation in cattle in winter (other animal classes were not sampled). In summer the worm burden was 43% in cattle, 36% in goats and 18% in sheep. *Trematodes* (liver fluke) was found only in 2% of cattle and none in sheep and goats. Stomach flukes were found to be prevalent. The worm burden could have been higher if treatment of the animals had not been provided by the owners. Cattle treated in summer represented 54% of the sampled animals, 96% goats and

92% sheep. In winter no cattle were treated, but 45% goats and 33% sheep received treatment.

3.2 BACTERIAL DISEASES

Many disease conditions mentioned by households as unknown or other diseases in the socio-economic survey were found, during technical visits, to be caused by a number of bacteria. However, only three bacterial diseases are indirectly river-related:

- Pulpy Kidney or Enterotoxaemia in sheep caused by *Clostridium perfringens* Types D. Sudden change of feeding regime predisposes to proliferation of the organism in the intestines and production of a toxin,
- Blackquarter or Quarter Evil/Blackleg in cattle, sheep and goats caused by *Clostridium chauvoei*. Gasy swelling on muscles of limbs and back, lameness, high temperature and death,
- There is only one river-related disease. This is anthrax in cattle, sheep and goats caused by *Bacillus anthracis*. The disease causes sudden death.
- Foot rot in sheep, as well as lameness in cattle, sheep and goats, caused by *Sphyrophorus* organisms. Lesions in the hoof, pain, lameness and loss of hood. Deaths result from secondary infections.

The biophysical scenarios (Report Nos 648-F-04 to 07) predicted an increase with flow reductions in colloidal (clay) deposition and the quality of fine sediments in the system, e.g., mud. Mud is an excellent vector for many disease pathogens. In addition, an increase in mud can lead to an increase in bogging of animals. This, in turns, increases the chance of animals with anthrax getting stuck and dying at or near the rivers. Since the rivers are a focus area for livestock (drinking and grazing), the chance of other animals then contracting the disease increases.

An investigation of the incidence of the three main bacterial diseases (Pulpy Kidney or Enteretoxaemia, Anthrax and Blackquarter) was not included in the CID study (1993). In LHDA 648, veterinary officials interviewed by the social team expressed concern about the diseases, as did farmers interviewed at Sehlabathebe Range Management Area (South of Reach 4). Farmers in Reaches 1 and 2 made no mention of the diseases.

3.2.1 Pulpy Kidney

Pulpy Kidney is caused by spore-forming clostridial bacteria. As already mentioned, Pulpy Kidney occurs in animals that have sudden access to flush grazing which, in the IFR reaches, is often along riverbanks in early spring, particularly during dry years. Outbreaks of the disease were reported by farmers during these dry periods. These outbreaks have reportedly occurred sporadically over the past three years, and farmers are well acquainted with the symptoms. These are sudden flock deaths in healthy sheep of all ages, but commonly in lambs two to six weeks of age and in weaned lambs, and pulpy kidneys when the animals are opened up. Other clostridial infections, whose spores can be picked up from the ground and herbage, are responsible for diarrhoeas in lambs.

3.2.2 Blackquarter

Blackquarter is indirectly river-related in that the ubiquitous spores may be carried by streams and rivers and deposited along the banks during low flows. Although incidence of the disease is common in the lowland areas, sporadic cases have been reported by the Department of Livestock Services in IFR Reach 6–8 and by farmers in Reach 4. Serious outbreaks in sheep usually follow farm operations such as shearing, dipping, docking (cutting of tails) and castration, while in cattle the majority of illnesses and deaths develop spontaneously and are characterised by swellings in the muscles of the limbs.

3.2.3 Anthrax

Associated with clostridial infections (Blackquarter) is Anthrax (*Bacillus anthracis*), also a spore-forming bacterium. The spores can exist for many years (up to 50 years) in marshy land or in soils that are rich in decomposed vegetable matter – conditions that exist in riverine environments. Although the disease occurs annually in the lowlands, where humans also are infected and die from the disease, no cases have been reported recently in the mountain areas. The last serious outbreak occurred in IFR Reach 1-3 in 1966, resulting in the sudden deaths of 23 people and 240 cattle, and 57 illnesses among people who ate the meat of dead animals (Phororo, 1966).

3.2.4 Foot Rot

Foot Rot commonly affects cattle and sheep. *Sphaerophorus* organisms gain entry in the hoof as a result of injury or maceration from continuous exposure

to mud or following other non-specific secondary bacterial infections, e.g., *Staphylococcus* and *Streptococcus*. The latter infections are also predisposed by muddy conditions. These infections usually affect individual animals rather than a herd or a flock.

3.2.5 Preventive methods

The above clostridial infections can be effectively controlled through vaccination. A single Pulpy Kidney Type D vaccine is available and a combined Blackquarter/Anthrax vaccine is commonly provided by the Department of Livestock Services for sale to farmers. In order to minimise Blackquarter outbreaks, the Department also advises farmers to adopt appropriate animal husbandry practices in shearing and other operations. Anthrax-infected carcasses are supposed to be buried according to law, but compliance is poor thus resulting in human infections by eating meat of infected animals. Since foot rot affects individual animals, treatment of the disease is left to individual animal owners.

The CID survey showed that 15% of the sampled cattle were vaccinated against Blackquarter in the winter study, while 14% of the cattle and 9% of the sheep were vaccinated in the summer study. Enteretoxaemia vaccinations covered 4% of goats and 16% of sheep in the winter and summer study.

3.3 VIRAL DISEASES

Serological test samples for viral diseases were collected from randomly selected animals by CID (1993) in Reach 1 and processed by the Onderstepoort Veterinary Research Institute. Indirectly river-related diseases that tested positive were: Wesselsbron's Disease in cattle (57% of samples), African Horsesickness (57 %), Bluetongue in sheep and goats (9 %), and Rift Valley Fever in cattle (2%).

The study warned that test results must be interpreted with caution because no test is 100% specific (the probability that disease-negative animals test negative) and 100% sensitive (the probability that disease-positive animals test positive). This may explain the positive results with respect to Rift Valley Fever, which mainly occurs in very warm, low-altitude climates, e.g., Natal and East Africa. Rift Valley Fever is transmitted by *Aedes* mosquitoes. Serological test specificity and sensitivity may also apply to Wesselsbron's Disease, transmitted by *Aedes* mosquitoes. Aedes was not found in the macroinvertebrate study (Report No. 648-F-17), and is not predicted to occur under any of the scenarios (Report No.s 648-F-04 to 07).

3.3.1 Bluetongue

The only significant river-related viral disease is Bluetongue, which affects only sheep and goats. It is transmitted by midges/gnats, which makes the disease seasonal in occurrence. Bluetongue disease has been one of the most important highly infectious diseases in Lesotho recognised by the Department of Livestock Services and farmers (Annual Report, 1998) who were interviewed. Farmers and livestock extension staff in all IFR reaches reported the disease having occurred over the past five years during wet autumn seasons, with the origin of the disease having been traced to animals residing in the valley villages including the Senqu Valley and its tributaries. For unvaccinated animals, the Bluetongue virus causes fever, attacks the tongue tissue so that the animal cannot feed, and spreads to other tissues, resulting in lameness and death from secondary infection.

3.3.2 African Horsesickness

African Horsesickness disease is river-related, as the causal virus is transmitted by midges. However, its prevalence in Lesotho has not been conclusively confirmed. Some farmers in Reach 4 reported deaths of horses three years ago from a disease with symptoms similar to those of African Horsesickness – nasal discharge, swelling of the face, eyes and belly, and eventual death. The farmers thought the disease was the commonly occurring Strangles Disease, which is caused by bacterial organisms (*Streptococcus equi*). A recent test for horsesickness was undertaken, in IFR Reach 5, by the Onderspoort Veterinary Institute (Prof. Guthre, Sept 1999) in collaboration with the Maseru Central Laboratory (Dr Lerotholi). Of the 15 horses that were tested, 2 reacted positively. No conclusions can be made regarding the prevalence of the disease due to the small number of horses tested.

3.3.3 Preventive methods

Both Bluetongue and Horsesickness can be prevented by annual vaccinations, as is routinely done for Bluetongue by farmers who can afford the vaccine. Except in the lowlands, where riding horses for leisure and race horses are vaccinated, neither the farmers in IFR reaches reported any vaccination of their horses nor

have the Department of Livestock Services sold the vaccine in the mountain areas during the past two years.

3.4 GRAZING AND ANIMAL HEALTH

Grazing is an important factor affecting the animal health aspect of the project from the following perspectives:

- Animals in poor condition as a result of inadequate forage are more susceptible to diseases, especially parasitism, than well-conditioned animals. Range in Lesotho is generally overgrazed and it is even more so in the riparian zone, which is frequently utilised when animals go for water. Since it provides the only green belt from late autumn to early spring, the riparian zone tends to be more overgrazed than surrounding areas. Thus, a decrease in the quantity and quality of grazing will have a negative impact on the health status of animals. However, as will be shown in Section 4.3.1, there are also positive aspects related to a reduction in flow levels, which could neutralise the negative impacts.
- Trees and shrubs are an important component of the riparian grazing resource. They contribute to better animal health by supplementing the nutritional value derived from grasses, especially during periods of drought or critical early spring months.
- The direct relationship between the river and diseases such as Pulpy Kidney and internal parasites (flukes) is linked to riverine grazing. Pulpy Kidney occurs as a result of a change from poor grazing in the surrounding areas to relatively better green pasture in the riparian zone. As already mentioned, the final larval forms of fluke attach to vegetation leaves and thereby ingested by grazing animals. The moist riparian vegetative cover also provides a favourable micro-climate for hatching of eggs of the indirectly river-related roundworms (nematodes) and flatworms (cestodes).
- Although aquatic algae are sometimes grazed by animals, especially when good grazing is not available, they are not relished by animals. Algae cause diarrhoeas and the common mode of ingestion is swallowing of the plants during drinking. The disturbance in the digestive tract may precipitate the onset of Pulpy Kidney.

3.5 USE OF TRADITIONAL MEDICINES

Many farmers in all IFR reaches reported the use of traditional medicines gathered from the riverine area for treatment of parasitic, bacterial and viral diseases. While they and the field staff acknowledged the effectiveness of traditional remedies for treatment of internal parasites and limited number of external parasites, they were uncertain about the efficacy of such remedies against bacterial and viral diseases. The poorer livestock-owning households reported using traditional remedies more than the 'wealthy' (in terms of livestock numbers). Even for some 'wealthy' farmers, the tendency was to use traditional medicines as a first option and to resort to modern remedies if traditional ones did not bring about any improvement in the disease.

SECTION 4:

THE IMPACT ON ANIMAL HEALTH OFBIOPHYSICAL RIVER CHANGES

The biophysical components of the study provided information on the main changes in key species, communities and features in the study rivers as represented by the eight IFR sites. This information has been used to predict the likely impacts on domestic animal health and productivity. It should be noted that making such a link is new and largely untested at the global level, and no methods were available to aid the process. Quantifying the impact of health as a result of biophysical changes of rivers for the purposes of predicting the risks to animal health is a new venture. To a large extent the appropriate kinds of data do not exist, as animal health specialists usually collect their data for quite different purposes. So, as with the biophysical specialists, new kinds of data collection and analyses will have to evolve to enhance the predictions of impacts of river changes on animal health. This will take time. For this project, the available data have been synthesised in this report. The assumptions and considerations used in making animal-health predictions will be stated (Section 4.3) and the actual predictions of animal health changes covered in Section 5 of this report. The assumptions and considerations used in making animal-health predictions will be stated (Section 4.3) and the actual predictions of animal health changes will then be based on expert opinion.

Four of the biophysical components have major relevance on animal health and production, namely:

- geomorphology,
- water quality,
- vegetation, and,
- macroinvertebrates.

Mammals and birds would only be important for domestic animal health if changes in the flow regimes resulted in the deaths of these fauna, which is unlikely to be the case. Similarly, changes in herpetofauna are unlikely to affect domestic animal health.

4.1 BIOPHYSICAL CHANGES IN THE DIFFERENT SCENARIOS

The biophysical components are influenced by varying river flow regimes, which in turn may impact on animal health and production at the IFR reaches. Tables 4.1, 4.2 and 4.3 give a summary of the predicted biophysical changes relevant to animal health (see Report No.s 648-F-04 to 07 for details) for the Treaty, Design Limitation and Fourth Scenarios, respectively. The biophysical changes in the Minimum Degradation Scenario are generally low or negligible, and are not dealt with here.

Table 4.1 Biophysical changes in the Treaty Scenario, where: None = 0% change; negligible = 0–10%; low = 10-20%; moderate = 20-40%; severe = 40-80%; critically severe = 80->100%. The sub-components of each biophysical component relevant to animal health, which were used to produce the summary are also given.

Relevant aspects / IFR Reach	Geomorphology	Vegetation	Macroinvertebrates	Water Quality
	Bio-film growth, colloidal sediment deposition; quantity of fines, e.g., mud; pool depth.	Aquatic zone macrophytes; wetbank shrubs and trees (*Salix* zone); dry bank (tree/shrub zone, lower dynamic, back dynamic).	Potential disease carrying snails; midges.	Nutrients and Total Suspended Solids (TSS); nutrient and TSS magnitude; and nutrient and TSS mobilisation.
1	Critically severe	Critically severe	Critically severe	Critically severe
2	Critically severe	Critically severe	Low	Critically severe
3	Severe	Severe	Low	Severe
4*	Critically severe	Critically severe	Moderate	Critically severe
4**	Moderate	Moderate	Low	Moderate
5	Critically severe	Severe	Low	Moderate
6	Moderate	Low	Low	Moderate
7	Critically severe	Severe	Moderate	Severe
8	Moderate	Moderate	Low	Moderate

- *With Mashai Dam in place. ** Without Mashai Dam . Source: Report No 648-F-05.*

Table 4.2 Biophysical changes in the Design Limitation Scenario (DLS), where: None = 0% change; negligible = 0–10%; low = 10-20%; moderate = 20-40%; severe = 40-80%; critically severe = 80->100%. The sub-components of each biophysical component relevant to animal health, which were used to produce the summary are also given.

Relevant aspects / IFR Reach	Geomorphology	Vegetation	Macroinvertebrates	Water Quality
	Bio-film growth, colloidal sediment deposition; quantity of fines, e.g., mud; pool depth.	Aquatic zone macrophytes; wetbank shrubs and trees (*Salix* zone); dry bank (tree/shrub zone, lower dynamic, back dynamic).	Potential disease carrying snails; midges.	Nutrients and Total Suspended Solids (TSS); nutrient and TSS magnitude; and nutrient and TSS mobilisation.
1	Severe	Moderate	Low-moderate	Moderate
2	Severe	Moderate	Low-moderate	Moderate
3	Moderate	Moderate	Low-moderate	Moderate
4	Moderate	Moderate	Low-moderate	Moderate
5	Moderate	Moderate	Moderate	Low
6	Moderate	Low	Low-moderate	Low
7	Severe	Low	Low-moderate	Low
8	Low	Low	Low	Negligible

Source: Report No 648-F-06.

Table 4.3 Biophysical changes in the Fourth Scenario, where: None = 0% change; negligible = 0–10%; low = 10-20%; moderate = 20-40%; severe = 40-80%; critically severe = 80->100%. The sub-components of each biophysical component relevant to animal health, which were used to produce the summary are also given.

Relevant aspects / IFR Reach	Geomorphology	Vegetation	Macroinvertebrates	Water Quality
	Bio-film growth, colloidal sediment deposition; quantity of fines, e.g., mud; pool depth.	Aquatic zone macrophytes; wetbank shrubs and trees (*Salix* zone); dry bank (tree/shrub zone, lower dynamic, back dynamic).	Potential disease carrying snails; midges.	Nutrients and Total Suspended Solids (TSS); nutrient and TSS magnitude; and nutrient and TSS mobilisation.
1	Severe	Severe	Moderate	Moderate-severe
2	Severe-critically severe	Severe	Low-moderate	Moderate-severe
3	Severe	Severe	Low-moderate	Moderate-severe
4	Severe-critically severe	Severe	Low-moderate	Negligible
5	Severe	Moderate-severe	Moderate	Moderate
6	Moderate	Moderate	Moderate	Negligible
7	Severe	Severe	Moderate	Moderate-severe
8	Moderate	Low-moderate	Low	Negligible

Source: Report No 648-F-07.

In summary, changes predicted for the Treaty Scenario (Table 4.1) are more severe than those for the Fourth Scenario (Table 4.3), which are more severe than those for Design Limitation Scenario (Table 4.2). These changes are discussed in more detail in the following sections.

4.2 HOW BIOPHYSICAL CHANGES RELATE TO ANIMAL DISEASES

Only the relevant biophysical aspects are discussed below. The reader is referred to Report Nos 648-F-04 to 07 for details of the full spectrum of biophysical changes expected under each IFR scenario and explanations thereof.

4.2.1 Geomorphology

Bio-film growth, the quantity of fine sediment, and colloidal sediments in the system will all increase under the three IFR scenarios reported in Section 4.1. Together these will increase the slipperiness of riverbed rocks and the areas of mud, which in turn increase the risk of injuries and bogging of animals, and result in difficulties for animals crossing the rivers. Animals that spend long periods in muddy conditions are also vulnerable to foot rot disease, and soiling of wool and

mohair, which reduces the clean yield percentage of the fibre. This percentage is an important factor in the purchase price of wool and mohair.

4.2.2 Vegetation

A significant increase in algae and macrophytes is predicted from the following reaches:
Treaty: All except 4 without Mashai and 6;
Design Limitation: 1, 2 and 7;
Fourth Scenario: 1, 2, 3, 4, 5 and 7.

Accidental ingestion of the algae as animals drink the polluted water could result in diarrhoeas, and obviously, the more algae there are the greater is the risk that it will be ingested.

A reduction in drybank tree/shrub zone at all reaches, except 8, will result in reduced available feed for goats and cattle, thus negatively affecting their nutrition and productivity lower down the banks. Predicted changes in the wetbank annuals, sedges and grasses are generally low, and many species that are palatable to stock are expected to increase, e.g., *Hyperrhenia hirta, Cynodon dactylon,*
C. transvalensis, and *Themeda triandra.* This increases the risk of Pulpy Kidney, however, and the potential for worm infestation would also increase as more animals would crowd onto the limited available grazing.

4.2.3 Macroinvertebrates

In general, the increased risk of disease carrying snails becoming established in the study rivers are low to moderate for the Design Limitation and Fourth Scenarios. For the Treaty, the changes are critically severe in Reach 1 while at all other sites immediately downstream of the dams the expected increase in risk is low or moderate.

The low to moderate changes do not preclude the occurrence of liver fluke disease in cattle, sheep and goats, since the final larval forms of the parasite, emerging from the host snail, can affect many animals. However, in most reaches under all scenarios, the likely increase impact on animal health will be low, with the exception of Reach 1 of the Treaty Scenario, where there is likely to be a significant increase in risk.

4.2.4 Water quality

Variations in nutrients and TSS concentrations and increases in the actual concentrations of these variables are significant primarily for their influence on algal growth (see Section 4.2.2). Apart from algal growth it is not anticipated that the concentration of any variables will reach levels that will affect the suitability of the water for animal consumption.

4.3 ASSUMPTIONS AND CONSIDERATIONS USED TO ASSESS THE RISK TO ANIMAL HEALTH OF BIOPHYSICAL CHANGE

The biophysical changes described above generally have low impact on animal diseases, and thereby a low health risk to animals. The predicted consequences of the Treaty, Design Limitation and Fourth Scenarios for animal health and production are given in Section 5 of this report. This section outlines the assumptions and considerations that were used to determine these consequences.

4.3.1 Riparian vegetation-related diseases

Changes in riparian vegetation would influence the nutrition and health status of the animals grazing along riverbanks. The river-related diseases that are linked to vegetation comprise flukes (which are hosted by aquatic snails), Enteretoxaemia (caused by clostridal bacteria), and diarrhoeas (resulting from ingestion of algae).

The moist conditions of the riparian vegetation provide a favourable micro-climate for hatching of parasitic eggs and multiplication of the **internal parasites**, *Coccidia*. The potential for infestation of animals by parasitic larvae is affected by a combination of factors, *viz.:*

- the more green vegetation that is available (infested with larvae), the more greedily the animals will graze it,
- if green vegetation is scare, then animals tend to graze it down to its base, where more larvae tend to occur as this is a protective environment for them (Helminthiasis Research, 1970).

Despite these interactions in the vegetation/parasitic larvae and grazing animal dynamics, the risk to animal health of the four scenarios is unlikely to be significant given the following:

- animals in the IFR reaches do not graze exclusively on the riverine vegetation – it is supplementary to other available grazing areas (except in IFR Reach 4 where animals are on riverine grazing throughout the year),parasites can be picked by animals in any area and, during the summer, the conditions of infestation may be as favourable in other areas as along the riparian zone. Thus, internal parasitism is

only indirectly related to the study rivers. However, the economic importance of internal parasites is such that a record of their incidence should form part of the Monitoring Programme (see Report No 648-F-23).

Pulpy Kidney is directly related to conditions in the riparian zone, since the green vegetation that results in the disease is found in the riparian zone. Also, increases in wetbank annuals and/or grasses were predicted for many of the IFR reaches. The grasses comprised some of the palatable species that will be readily grazed by animals (*Themeda triandra, Hyperrhenia hirta* [in its early growth stage] and *Cynodon* species). However:

- The above grass species are also found in non-riparian grazing area and could just as likely precipitate Pulpy Kidney as those found in the riparian zone.
- The risk of disease incidence will be higher if the grazing is reserved (*maboella)* and animals introduced to it suddenly. The risk of this happening is greater with reserved riparian grazing than with non-riparian grazing, because of its relatively more lush growth.
- A relationship also exists between Pulpy Kidney and the incidence of algae. Under extreme conditions of drought algae is also grazed, which can lead to Pulpy Kidney. Algae can also cause sudden digestive disturbances, which in turn may trigger proliferation of Pulpy Kidney toxins. However, algae is not a favoured food source.

Consideration of these factors resulted in the likely increases in the present number of Pulpy Kidney outbreaks being predicted as low to negligible under the conditions described by the four IFR scenarios, except when the riparian areas are reserved. Having said that, Pulpy Kidney affects entire flocks and not just individual animals and, as such, is a potentially serious condition. Thus, it is suggested that the incidence of Pulpy Kidney in relation to changes in the riparian vegetation be included in the Monitoring Programme (see Report No 648-F-23).

Animal nutrition is also potentially affected by changes in riparian vegetation (see Section 3.4). Reductions of riparian vegetation for the three scenarios were predicted to range from critically severe (80 – 100%) to moderate (20 – 40%). Factors that were considered in arriving at a prediction for the impact on animal nutrition were:

- although the wetbank and drybank shrub/tree zones provide important sources of food, these are supplementary to grasses, which form the bulk of the diet, except for goats, which prefer shrubs. Nonetheless, riparian shrubs and trees can be a major source of nutrition in critical periods such as droughts,
- the Senqu River system is a major site for shrubs and trees – this vegetation is either minimal or absent in other river reaches due to topography or over-harvesting.

Diarrhoeas can result from accidental ingestion of algae while drinking. However, increased algal growth does not necessarily pose a risk to animal health given the low preference of animals for this vegetation. Young animals are more susceptible the first time they have access to the algae, before they are accustomed to its unpalatability.

The predicted increase in aquatic macrophytes could increase the risk of **Bluetongue Disease** (See Section 4.3.2).

4.3.1.1. Medicinal plants

The following vegetation changes were noted with respect to medicinal plants:

- *Phygelius capensis*, which is commonly used for treatment of tick-borne diseases in cattle and is expected to increases marginally (wetbank sedges and grasses) in all reaches for all scenarios. Thus, there is no health risk.
- *Rhamnus prinoides* (wetbank and drybank shrubs/trees zone), which is used for treatment of internal parasites, decreases moderately and severely. However, the socio-economic survey indicated that the leaves of *Rhamnus prinoides* are used by only 1% of households. The risk to animal health is thus low. It is expected that approximately 326 households could be affected but of these only about 30% own livestock (cattle, sheep and goats).

4.3.2 Geomorphological-related diseases

Apart from injuries and bogging, the implications of the geomorphological changes are related more to production (reduction of wool and mohair quality) than disease. Furthermore, many of the risks are already being experienced, and the incremental risk, which is brought about by geomorphological impacts on production or disease, appears low. For instance, foot rot can result from wet kraals and wet grazing area just

as easily as from mud alongside a river. Similarly, puddles and pools that support midges can form anywhere, especially during the rain in autumn when the midges are active and breeding. Thus the predicted geomorphological changes in these rivers are not a unique facilitating factor for the outbreak of Bluetongue Disease.

4.3.3 Macroinvertebrate-related diseases

From an animal health perspective, *Simulium chutteri* is the most significant potential blackfly pest. *Simulium chutteri* abundances are expected to decreases in all the scenarios.

The liver fluke is also related to the study rivers. Using *Planorbidae* and *Physidae* as indicators of possible biophysical changes that may also affect lymnaeid snails, health risks only exist in two reaches under the Treaty Scenario. The validity of these assumptions can only be confirmed or disproved by monitoring.

4.3.4 Water quality-related Diseases

The predicted changes in water quality do not present an animal disease risk.

SECTION 5:
MITIGATION AND COMPENSATION

The data provided by the socio-economic survey, technical, hydraulics and biophysical aspects of the study were used to compile recommendations of relevant mitigation and compensation measures. These measures were based on certain criteria, which are explained below. The actual costs of mitigation and compensation are provided in the Economic Report No 648-F-22.

5.1 ANIMAL HEALTH IMPACTS

5.1.1 Process for evaluating animal health impacts

The biophysical components of the study provided information on the main changes in key species, communities and features in the study rivers as represented by the eight IFR sites. This information has been used to predict the likely impacts on domestic animal health and productivity. It should be noted that making such a link is new and largely untested at the global level, and no specific methods were available to aid the process. It is a new venture for animal health specialists to assess biophysical data on predicted changes in rivers at this fine resolution and use them for the purposes of predicting the risks to animal health. To a large extent the appropriate kinds of data linkages do not exist, as animal health specialists usually collect their data for quite different purposes. For this project, the available data have been synthesised in this report

Four of the biophysical components have major relevance to animal health and production, namely:

- geomorphology,
- water quality,
- vegetation, and,
- macroinvertebrates.

For each type of impact at each IFR reach and under each scenario, a baseline disease level (i.e., the present-day probability that an animal will contract the disease or face the health risk) was identified. A level of predicted future risk was then identified based on the relevant biophysical changes. The baseline and future risks were rated on the following scale:

Negligible: 0-10% probability
Low: 10-20% probability
Moderate: 20-40% probability
Severe: 40-80% probability
Critically severe: >80% probability.

The baseline risk levels were assigned based on:

- data available on the status of animal health in Lesotho and particularly in the Senqu and Senqunyane riparian areas,
- social and animal health data collected from the project area during the social surveys,
- technical data collected by the animal health expert in the project area,
- expert judgement used in combining the information from all the available data.

As for public health, if before the dams, the probability was of contracting a disease was moderate and the dams will make little difference, then the future probability will also be moderate. If the dams are expected to make a difference however, then the predicted future probability will be the sum of the additional probability and the baseline probability.

5.1.2 Animal health impacts of the scenarios

The Minimum Degradation Scenario was designed to cause minimal biophysical change. As such it is predicted that it will have no significant animal health impacts.

Table E.1 provides a summary of the animal health impacts of the Treaty, Design Limitation and the Fourth Scenarios. The details of the impacts of these scenarios are provided in Appendices 4, Tables A.4.1, A.4.2 and A.4.3. The present baseline risk and future predicted risk in these appendices is expressed in percentages for use in the economic analysis and is simplified to fit in severity rankings expressed in E.1.

5.2 MITIGATION AND COMPENSATION CRITERIA

The need for mitigation and compensation measures for the downstream impacts of existing and proposed dams with respect to animal health and production was assessed based on five criteria:

(i) number of affected households,

(ii) assets affected (livestock, grazing area and medicinal plants, dip tanks and shearing sheds),
(iii) nature of the disease,
(iv) the present status of the disease per- IFR Reach, and the estimated additional impact resulting from change in disease status expressed in terms present and future risk of disease,
(v) direct relationship of the disease to the river and flow regimes.

These are explained in more detail below.

5.2.1 Number of affected households

- For calculating the mitigation/compensation for reduced or lost communal assets such as grazing or medicinal plants, the **number of livestock-owning households in the study area** was taken as 20 426.
- Since the level of impact, and thus recommended level of mitigation/compensation, is different for different IFR reaches, the **number of livestock-owning households per reach** was also computed (see Table 2.3).

5.2.2 Assets

The following assets were considered:

- The **number of livestock owned by households** was used for estimating compensation related to grazing and for estimating mitigation measures related to disease control. These numbers are subject to slight fluctuations, as is the ratio of different types of livestock owned by a household. For instance, between 1986 and 1999, sheep numbers decreased by 35% and goat numbers increased by 54% (GOL/ADB/AGRER, 1999). However for the purpose of the computation of mitigation and compensation, the animal health data were be based on socio-economic survey data.
- **Grazing area and medicinal plants**. The compensation for loss of grazing resources was assumed to be in direct proportion to the changes in palatable vegetation estimated for each IFR Reach. The impact of Treaty Scenario is the greatest on the grazing resources. The costs of compensating the losses predicted under the Design Limitation and the Fourth Scenarios are also provided in the Economics No. Report 648-F-22.
- **Dip tanks and shearing sheds**. The majority of dip tanks within the 5-km corridor are in the vicinity of shearing sheds as their purposes are complementary. Reduction in flow reduces the amount of water available for dilution. Re-siting of tanks further away from the rivers will reduce the risk of contamination of the study rivers.

5.2.3 Nature of the disease

- The mitigation measures recommended have focused on diseases of economic importance that can be prevented.
- Other diseases such as those that require clinical treatment, e.g., diarrhoeas resulting from ingestion of algae or foot rot, or those that affect only the odd animal, e.g., injuries resulting from being stuck in the mud, are not considered for mitigation.
- Infectious diseases, such as Anthrax, that pose a health hazard to other animals and to humans in the IFR reaches or beyond, should be monitored.
- In terms of level of impact on the general population, It is noted that the flock/herd approach is a more effective way of preventing diseases than treating individual animals.

5.2.4 Present status of the disease

All of the diseases that could be affected by flow changes in the study rivers already exist in Lesotho. In all instances, the present status of the disease in the study area was taken into account when assessing the need for mitigation or compensation and computing the costs thereof.

5.2.5 Direct relationship of the disease to the river and flow regimes

The links between the river and animal health are complex, often indirect and confounded by factors that are not necessarily river-related. Furthermore, diseases that are river-related are not necessarily affected by change in flows. It is therefore recommended that a period of 3-5 years monitoring should be undertaken for animal health and disease aspect before appropriate level of mitigation could be assessed. The economic aspect of this approach is covered in the economic analysis report LHDA-648-F-22 and the monitoring aspects are covered in LHDA 648-F-23.

5.3 RECOMMENDED MITIGATION AND COMPENSATION

It should be pointed out right from the outset that any compensation and mitigation relating to domestic animals which is likely to improve the general health of animals could lead in increase in animal population. This would have a negative impact on grazing areas and would lead to possible destruction of natural resources already under pressure. Recommendation is made here for compensation of resources lost and mitigation against increase in health risks. After a decision is made by the client, on IFR releases, the compensation and mitigation program developed for each of the affected areas should be prepared in consultation with the affected population. The option pursued should include the following:

- cash compensation for reducing the stock to the level that could be sustained with available resources,
- range management options,
- catchement management options.

However the aspects of anima health and production that has been affected and would need compensation are:

- The change in riparian vegetation will impact the resources available for grazing and thus compensation or mitigation is recommended.
- All aspects relating to animal diseases that are affected by change in flow would require mitigation. A period of 3-5 years monitoring before mitigation could accurately be quantified. If the monitoring is not implemented, then compensation should be awarded using the predicted changes (see Section 5 of this report)

5.3.1 Recommended mitigation

5.3.1.1 Animal health aspects

The dynamics between river flow and animal health are complex and difficult to predict accurately. The data in the Appendix 4 give the predicted levels of risk associated with each of the four IFR Scenarios. However, these predictions are based on present day knowledge and it is strongly suggested that 3-5 years of monitoring should follow each new dam closure, in order to determine the exact impact of flow changes on animal disease.

A summary of the diseases that should be monitored, and the aspects of each that should be included in a Monitoring Programme, is given in Table 5.1. Details are provided in the Monitoring Protocol (Report No. 648-F-23).

5.3.1.2 Nutrition aspects

While provision is made for compensation for loss of grazing resources, a long-term solution to the present over grazing would be to establish Range Management Areas.

5.3.2 Recommended compensation

5.3.2.1 Animal Health Aspects

It is assumed that the compensation for animal health aspect would be based on increased risk of disease. The estimates or future risk could be refined after the health aspects have been monitored for 3-5 years after the IFR is implemented.

5.3.2.2 Nutrition Aspects

A reduction in **riparian grazing** could adversely affect entire animal population living in the riparian areas and thus should be compensated for. The reduction in grazing resources is highest with the Treaty Scenario. However in line with other aspect of the project it was assumed that the compensation for this resource would also be in proportion to resources lost. This would mean the computation of compensation would be made for all the reaches and all the Scenarios.

The costs of the recommended mitigation and compensation measures are provided in the Economic Report No 648-F-22. The suggested long-term measure is the establishment of Range Management Areas.

The compensation costs for loss of grazing is presented in the Economic Report No 648-F-22. The area affected is based on values given in Table 2.10. Other data used was based on the following (estimates provided by the Range Division of the Ministry of Agriculture):

- one hectare of Lesotho range produces *c.* 604 kg of forage per annum,
- one animal unit consumes *c.* 4 380 kg of usable forage per annum,
- one animal unit = 1.1 cows = 7.7 sheep or goats = 1.4 horses.

The quantity of forage to be compensated for can be computed for each IFR reach using the information provided in Table 2.10 and Appendix 2. Equines are excluded from the calculations, as the numbers using riverine grazing area are insignificant.

Table 5.1 Disease/Asset recommended as requiring mitigation/compensation in various scenarios/IFR Reaches.

No	Resource/ Asset/Disease		Monitoring action	Mitigation/ Compensation
1	Flatworm	Liver Fluke	Monitoring is required to establish the impact of increase in sledges and palatable plant species on prevalence of Fluke snail and subsequent impact on spread of Liver Fluke.	Mitigation is based on increase in health risk.
2	Pear-Shaped Worms	Stomach Fluke	Same as Liver Fluke given above.	Mitigation is based on increase in health risk.
3	Bacterial Infection	Pulpy Kidney	Monitoring is required to determine the interaction of sledges & grasses and algae and their impact on Pulpy Kidney disease.	Mitigation is based on increase in health risk.
4	Bacterial Infection	Anthrux	Monitoring is required to assess the impact of change in sediment pattern on spread of disease, An outbreak in the catchment may be a critical hazard to animals and humans.	Mitigation is based on increase in health risk.
5	Bacterial Infection	Blackquarter	Monitoring is required to establish the impact in change in sediment on this disease.	Mitigation is based on increase in health risk.
6	Bacterial Infection	Foot rot		No mitigation is recommended
7	Viral Infection	Bluetongue	Monitoring is required to establish link between this disease and change in sediment, clay and aquatic macrophytes.	Mitigation is based on increase in health risk.n
8	Viral Infection	Horsesickness	Monitoring is required to establish link between this disease and change in sediment, clay and aquatic macrophytes.	Mitigation is based on increase in health risk.
9	Grazing		Monitoring is required to establish the effect of change in flow on riparian vegetation	Mitigation/ Compensation is recommended
10	Medicinal plants		Monitoring needs to be undertaken to establish a link between reduced vegetation and impact on animal health.	Not significant
11	Physical Disease Conditions	Slippages		No mitigation is recommended
12	Physical Disease Conditions	Bogging		No mitigation is recommended

SECTION 6:

REFERENCES

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APPENDIX 1:

ANIMAL HEALTH SPECIALIST ACTIVITIES

Period	Activities
Jan – April 1998	• Preparatory activities (meetings, preparation of terms of reference).
Sep – Oct 1998	• Source information in Dept of Livestock Services. • Interview Animal Health and Production Officials. • Start analysis of information.
4 – 6/11/98	• Prepare animal health and production presentation for planning meeting at Ladybrand (5 - 6/11). • Present animal health and production study plan at meeting. • Prepare and submit additional information required by socio - economic team.
26 – 29/11/98	• Field work at Ha Soai, Koma-Koma and Noha.
30/11/98	• Meeting with socio-economic team to review survey field activities.
2 – 4/12/1998 Qacha's Nek (Tsoelike and Auplaas)	• Visit Principal Chief office at Tsoelike and Tsoelike Woolshed and Dip tank. Obtain information from villagers and farmers and staff of Dept of Livestock Services on livestock diseases and wool, mohair cattle and equine production related to Senqu River flows. • Join sociology team at Auplaas and conduct interviews with farmers and villagers.
4 - 5/12/98 Q. Nek-Quthing (Mapote, Sekake, Mt. Moorosi)	• Visit Ha Sekake and nearest Government Woolshed at Mapote where Sekake farmers shear sheep and goats (wool store on south 100 m from Senqu and woolshed on north 400 m from Senqu) and interview staff, villagers and farmers. • Interview manager of Lesotho Cash Stores (Ha Sekake) dealing in Wool and Mohair, farmers and villagers. • Interview Ministry of Agriculture Staff, farmers and villagers at Koali woolshed. • Interview staff and farmers at Quthing woolshed (farmers from Alwyn's Kop - Ha Setoromo were shearing sheep and goats at Quthing shed).
9/12/98 Semonkong	• Visit Semonkong woolshed and interview staff and farmers from Ha Mapoho shearing there. • Interview manager at Frasers Store and farmers (some came from Ha Mapoho).
9 - 12/4/99	• Obtain information related to IFRS from Chief Animal Health Officer and his staff, Dept of Livestock Services. • Prepare for IFRS workshop.
13 – 18/4/99	• Attend and participate in IFRS workshop and follow-up preparation of sections on Animal Health draft report.
21 – 22/4/99	• Consult with Sechaba Anthropologist/Sociologist and prepare list of animal diseases (Sesotho and English names he required).
19/05/99	• Consult Lesotho Traditional Doctors Council re traditional animal medicines and toxic plants. • Meet with Sechaba Consultants re phase II Sociological Survey.
7– 25/8/99	• Consult with Sechaba Consultants re animal data. • Source international literature. • Review biophysical reports. • Attend JPTC meeting.
25/8-9/99	• Consult with Economist. • Finalise and submit 1st draft report (working document).
27/9 – 15/10/99	• Consult with Project Manager and Sociologists. • Revise report and prepare of 2nd draft. • Attend Socio-economic Scenario and Monitoring Workshop.
25/10 – 24/11/99	• Additional review of literature and consultations with Project Manager. • Report revision and preparation of 3rd draft. • Prepare consequence sheets for 3 scenarios in each of 8 reaches. • Review new changes in biological consequences of two scenarios. • Report revision and preparation of 4th draft and submission to Metsi.
24/11 – 10/12/99	• Internal review and correct final draft report for submission to LHDA

APPENDIX 2:

DISTRIBUTION OF DISEASES IN IFR REACHES BY NUMBER (COUNT) AND PERCENTAGE

IP – Internal Parasites, EP = External Parasites, DI Diarrhea , BA = Bacterial, OT = Other unknown , O/U = total of DI, BA and OT

Sheep															
IFR 'Reach	Data	< 4 Months							.> 4 months						
		IP	EP	DI	BA	OT	total others	total all	IP	EP	DI	BA	OT	total others	Total all
1	Count	28	25	11	5	111	127	180	25	0	55	0	78	133	158
	%	23	45.5	16.7	100	65.3		43.1	21.7	0	28.1	0	7		9.2
2	Count	55	25			25	25	105	36	38		11	91	102	176
	%	45.1	45.5			14.7		25.1	31.3	13.3		100	8.2		10.2
3	Count	25	5	55		6	61	91	5	41	55		96	151	197
	%	20.5	9.1	83.3		3.5		21.8	4.3	14.4	28.1		8.6		11.5
4	Count					3	3	3	3	8			179	179	190
	%					1.8		0.7	2.6	3.8			16.1		11
5	Count									83			100	100	183
	%									29.1			9		10.6
6	Count	3						3		36	6		230	236	272
	%	2.5						0.7		12.6	3.1		20.7		15.8
7	Count	11				25	25	36	46	79	25		92	117	242
	%	9				14.7		8.6	40	27.7	12.8		8.3		14.1
8	Count										55		247	302	302
											28.1		22.2		17.6
Total	Count	122	55	66	5	170	241	418	115	285	196	11	1113	1320	1720
	%	29.2	13.2	15.8	1.2	40.7		100.0	6.7	16.6	11.4	0.6	64.7	0.0	100.0

IP – Internal Parasites, EP = External Parasites, DI Diarrhea , BA = Bacterial, OT = Other unknown , total others = total of DI, BA and OT

Goat								Cattle							
IFR 'Reach	**Data**	**IP**	**EP**	**DI**	**BA**	**OT**	**Total others**	**Total all**	**IP**	**EP**	**DI**	**BA**	**OT**	**total others**	**Total all**
1	Count	11	25	166		166	332	368		880		5	262	267	1147
	%	7.8	6.9	46.1		17.3		19.9		34.4		6.3	15		24.7
2	Count	16	121	16		54	70	207	55	224	57	16	164	237	516
	%	11.3	33.4	4.4		5.6		11.2	39.3	8.8	49.6	20.3	9.4		11.1
3	Count		19			5	5	24	16	191	5		239	244	451
	%		5.2			0.5		1.3	11.4	7.5	4.3		13.7		9.7
4	Count			50		36	86	86	25	196			212	212	433
	%			13.9		3.8		4.7	17.9	7.7			12.1		9.3
5	Count		25			109	109	134	19	114		55	201	256	389
	%		6.9			11.4		7.3	13.6	4.5		69.6	11.5		8.4
6	Count	25	38	71		83	154	217	25	147		3	324	327	499
	%	17.7	10.5	19.7		8.7		11.8	17.9	5.8		3.8	18.6		10.8
7	Count	89	74		25	123	148	311		540	53		262	315	855
	%	63.1	20.4		100	12.9		16.9		21.1	46.1		15		18.4
8	Count		60	57		381	438	498		264			82	82	346
	%		16.6	15.8		39.8		27		10.3			4.7		7.5
Total	Count	141	362	360	25	957		1845	140	2556	115	79	1746	1940	4636
	%	7.7	19.6	19.5	1.4	51.9	0.0	100.1	3.0	55.1	2.5	1.7	37.7		100

A.2.1 EXPLANATIONS OF APPENDICES 2 AND 3

Deaths were not included in Appendix 2 because they are unimportant for computing mitigation calculations – deaths are a result of disease, therefore controlling disease is a more appropriate mitigation measure. Although diseases caused by external parasites were included, they should also be disregarded in mitigation computation since they affect mainly individual animals. Insect vectors are important since some of them transmit viral diseases, however, the disease should be controlled rather than the ubiquitous vectors themselves.

Appendix 2 only provides data for cattle, sheep and goats because the data provided by the Socio-economic Survey indicated that diseases of equines, pigs and poultry were insignificant. With the exception of internal parasites, the survey did not distinguish between bacterial and viral diseases and many of these were included in the category of 'unknown or other' diseases. Interviewees mentioned bacterial diseases in IFR Reach 1, 2, 5, 6 for cattle. In reaches 1 and 2 for sheep, bacterial disease were responsible for 16 cases out of total of 256 cases. Similarly, in IFR Reach 7, viral diseases accounted for 25 of 311 total cases.

Appendix 3 provides data for all diseases (river-related and not river-related). Cross-reference of Appendices 2 and 3 could theoretically be used to compute of disease control, however neither appendix distinguishes between river and non-river diseases, which makes this difficult. In order to make this differentiation, considerable additional time and funds would have been required for the socio-economic survey.

The alternative for the economist would be to develop assumptions based on the information Appendix 2 and 3, and to use these for computing IFR reach-by-reach mitigation calculation for bacterial and viral diseases, such as, of the 'unknown and other' diseases (Appendix 2), *c.* 25% are river-related and of those *c.* 60 % of them are viral and *c.* 30 % are bacterial in origin.

APPENDIX 3:

ANIMALS REPORTED SUFFERING DIRECTLY FROM RIVER-RELATED DISEASE AND DEATH IN IFR REACHES

Animal Suffering	Percent Disease and Death at IFR Reaches								No.	Percent
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**		
Cattle										
Disease	0.3	11.0	4.7	5.8	0.8	5.0	6.2	-	187	4.0
Death < 6 months	3.0	7.4	-	-	-	-	-	-	24	4.0
Death > 6 months	1.8	13.3	-	-	-	9.5	-	-	88	4.7
Sheep < 4 months	21.2	52.4	88.9	-	-	100	30.6	-	187	4
Disease > 4 months	41.8	31.4	27.9	1.6	13.7	2.2	29.3	18.2		55
Death < 4 months	31.4	83.3	91.7	-	-	100	43.8	-	336	1
Death > 4 months	36.3	-	31.1	3.0	-	1.2	-	-		9.6
Goats									210	4
Disease	58.0	15.5	-	58.1	-	44.2	28.6	1.4		9.2
Death	40.8	10.4	13.5	20.6	-	22.4	39.6	8.7	127	9.3
									500	2
Equines										7.1
Disease	-	-	-	5.4	-	16.8	-	-	415	22.2
Death	11.8	-	-	-	-	-	-	-	41	1
Pigs										8
Disease	-	-	-	-	-	-	-	-	2.5	2.3
Death	-	-	-	-	-	-	-	-	-	-
Poultry									-	-
Disease	2.8	-	5.8	-	-	34.4	-	37.7	5.0	6.5
Death	-	-	-	-	-	-	-	-	-	-

The Appendix gives the details of Table 2.8. Note that the percentage of households (count, in the last column) that reported disease or deaths was low. These households were asked to report the occurrence of disease or death in the last 12 months. While appreciating that diseases with great impact are more readily recalled, it is possible that even important diseases that occurred longer than 12 months ago were not remembered. The records of the field staff in the IFR areas confirmed this.

Reach 5 and 8 appear to be the most 'healthy' areas and equines, pigs and poultry were reported to have the least diseases or deaths. However, this is possibility a reflection of their perceived lack of economic importance. No deaths in pigs and poultry, or disease in pigs, were reported in any of the IFR Reaches, equine diseases were reported in only two reaches (4 and 8) and deaths in only Reach 1.

More cattle suffered disease than deaths (in Reach 1, 2 and 3 only). Young sheep suffered disease (100, 88.9 %, and 52.4%, respectively) and death more in Reaches 6, 3 and 2, than the other reaches. However, Reach 1 had the highest reported incidence of adult sheep diseases (41.8 %). For goats, the highest diseases were in Reach 4 (58.1 %) and Reach 1 and 6 (48 % and 44.2 %, respectively). Goat deaths were highest in Reach 1 (40.8 %) and Reach 7 (39.6 %).

APPENDIX 4.1:

ANIMAL HEALTH CONSEQUENCES OF THE TREATY SCENARIO

Table A.4.1 Animal Health consequences of the Treaty Scenario.
See Report No. 648-F-05 for details of the biophysical changes referred to below. IFR site 4a = with Mashai Dam in place.

Component affected	Sub-component affected	Scientific name of sub-component	Summary of significant biophysical consequences (for details see Report No 648-F-05).	Reach	Baseline health risk	Predicted health risk
Internal parasites: Flatworm	Liver fluke/snail (snails terrestrial, fluke larvae aquatic)	*Fasciola hepatica (Snails – Lymnaea truncotula*	The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in vegetation that can potentially act as habitat for snail, such as wetbank annuals and palatable species including *Themeda triandra*, *hyperrhenia hirta* and *Cynodon* sp. • Increase in aquatic snails *Physidae and Planorbidae*, which are used as an indicator of conditions suitable for *Lymnaea.*	Reach 1	10-25	20-50
				Reach 2	10-25	20-50
				Reach 3	10-20	20-25
				Reach 4a	10-20	20-50
				Reach 5	10-20	20-50
				Reach 6	10-20	20-25
				Reach 7	10-20	20-50
				Reach 8	10-20	20-25
Internal parasites: Pear-Shaped Worms	Stomack Fluke	*Paramphistomun microbothrium*	Same as flatworms.	Reach 1	5-10	10-30
				Reach 2	5-10	10-30
				Reach 3	5-10	10-15
				Reach 4a	5-10	10-30
				Reach 5	5-10	10-30
				Reach 6	5-10	10-15
				Reach 7	5-10	10-30
				Reach 8	5-10	10-15
Other internal parasites	Other internal parasites	*Nematoda Cestoda*	Same as flatworms.	Reach 1	30-60	60-70
				Reach 2	30-60	60-70
				Reach 3	30-60	60-65
				Reach 4a	30-60	60-70
				Reach 5	30-60	60-70
				Reach 6	30-60	60-65
				Reach 7	30-60	60-70
				Reach 8	30-60	60-65

Component affected	Sub-component affected	Scientific name of sub-component	Summary of significant biophysical consequences (for details see Report No 648-F-05).	Reach	Baseline health risk	Predicted health risk
Bacterial Infection	Pulpy Kidney	*Clostridium Perfringens*	The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in wetbank annuals and/or grasses resulting in flush grazing during early spring by animals. • Increase in algae which is eaten by animal during extreme drought conditions.	Reach 1	15-20	20-40
				Reach 2	15-20	20-40
				Reach 3	15-20	20-30
				Reach 4a	15-20	20-40
				Reach 5	15-20	20-40
				Reach 6	15-20	20-30
				Reach 7	15-20	20-40
				Reach 8	15-20	20-30
	Anthrax	*Bacillus anthracis*	The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in clay and mud providing ground for retaining the spores of the disease but also for increased chances of bogging. • The minimum lowflows for this scenario will exceed the flows that would naturally occur in the river during periods of drought, i.e., the scenario will not create drought conditions. • Considering both factors is thus unlikely that the potential for the survival of Anthrax spores will increase significantly.	Reach 1	0-1	1-5
				Reach 2	0-1	1-5
				Reach 3	0-1	1-2
				Reach 4a	0-1	1-5
				Reach 5	0-1	1-2
				Reach 6	0-1	1-2
				Reach 7	0-1	1-5
				Reach 8	0-1	1-2
Viral Infections	Bluetongue Virus		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in aquatic macrophytes resulting in increase in midges and gnats. • General increase in midges resulting from an increase in stagnant pools.	Reach 1	5-10	10-30
				Reach 2	5-10	10-30
				Reach 3	5-10	10-15
				Reach 4a	5-10	10-30
				Reach 5	5-10	10-30
				Reach 6	5-10	10-15
				Reach 7	5-10	10-30
				Reach 8	5-10	10-15
	African Horsesickness Virus		Same as Bluetongue	Reach 1	1-5	5-30
				Reach 2	1-5	5-30
				Reach 3	1-5	5-10
				Reach 4a	1-5	5-30
				Reach 5	1-5	1-5
				Reach 6	1-5	5-10
				Reach 7	1-5	5-30
				Reach 8	1-5	5-10

Component affected	Sub-component affected	Scientific name of sub-component	Summary of significant biophysical consequences (for details see Report No 648-F-05).	Reach	Baseline health risk	Predicted health risk
Nutrition and grazing	Susceptibility to disease		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Overall decrease in vegetation available for grazing, including trees and shrubs. • Increased potential for overgrazing resulting from decrease in the species listed above.	Reach 1	20-30	30-60
				Reach 2	20-30	30-60
				Reach 3	20-30	30-35
				Reach 4a	20-30	30-60
				Reach 5	20-30	20-30
				Reach 6	20-30	30-35
				Reach 7	20-30	30-60
				Reach 8	20-30	30-35
Medicinal Plants Mofifi	Treatment of internal parasites		The following factors were taken into account when assigning the scenario impact level of this sub-component: • *Phygelius capensis*, which is commonly used for treatment of tick-borne diseases in cattle, is expected to increase marginally (wetbank sedges and grasses). • *Rhamnus prinoides* (wetbank and drybank shrubs/trees zone), which is used for treatment of internal parasites, is expected to decrease. The scores provided here reflect the present risk of contracting diseases that can be treated with mofifi and the predicted (increased) future risk of contracting those diseases given the predicted changes in the abundance of the plants used.	Reach 1	20-30	30-40
				Reach 2	20-30	30-40
				Reach 3	20-30	30-50
				Reach 4a	20-30	30-40
				Reach 5	20-30	20-30
				Reach 6	20-30	30-50
				Reach 7	20-30	30-40
				Reach 8	20-30	30-50
Physical injury from slipping	Injury and death		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in biofilm growth on boulders and cobbles. • Increased mud and fines in the system.	Reach 1	1-2	1-10
				Reach 2	1-2	1-10
				Reach 3	1-2	1-6
				Reach 4a	1-2	1-10
				Reach 5	1-2	1-6
				Reach 6	1-2	1-6
				Reach 7	1-2	1-10
				Reach 8	1-2	1-6
Physical injury from bogging	Injury and death		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in clay and mud resulting in increase in individual animal bogging	Reach 1	1-2	1-10
				Reach 2	1-2	1-10
				Reach 3	1-2	1-6
				Reach 4a	1-2	1-10
				Reach 5	1-2	1-6
				Reach 6	1-2	1-6
				Reach 7	1-2	1-10
				Reach 8	1-2	1-6

APPENDIX 4.2:
ANIMAL HEALTH CONSEQUENCES OF THE DESIGN LIMITATION SCENARIO

Table A.4.2 Animal health consequence of Design Limitation Scenario**.**
See Report No. 648-F-06 for details of the biophysical changes referred to below. IFR site 4a = with Mashai Dam in place.

Component affected	Sub-component affected	Scientific name of sub-component	Summary of significant biophysical consequences (for details see Report No 648-F-06).	Reach	Baseline health risk	Predicted health risk
Internal parasites: Flatworm	Liver fluke/snail (snails terrestrial, fluke larvae aquatic)	*Fasciola hepatica (Snails – Lymnaea truncotula*	The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in vegetation that can potentially act as habitat for snail, such as wetbank annuals and palatable species including *Themeda triandra*, *hyperrhenia hirta* and *Cynodon* sp. • Increase in aquatic snails *Physidae and Planorbidae*, which are used as an indicator of conditions suitable for *Lymnaea,*	Reach 1	10-25	20-25
				Reach 2	10-25	20-25
				Reach 3	10-20	20-25
				Reach 4a	10-20	20-25
				Reach 5	10-20	20-25
				Reach 6	10-20	20-25
				Reach 7	10-20	20-25
				Reach 8	10-20	20-25
Internal parasites: Pear-Shaped Worms	Stomack Fluke	*Paramphistomun microbothrium*	Same as flatworms.	Reach 1	5-10	10-15
				Reach 2	5-10	10-15
				Reach 3	5-10	10-15
				Reach 4a	5-10	10-15
				Reach 5	5-10	10-15
				Reach 6	5-10	10-15
				Reach 7	5-10	10-15
				Reach 8	5-10	10-15
Other internal parasites	Other internal parasites	*Nematoda Cestoda*	Same as flatworms.	Reach 1	30-60	60-65
				Reach 2	30-60	60-65
				Reach 3	30-60	60-65
				Reach 4a	30-60	60-65
				Reach 5	30-60	60-65
				Reach 6	30-60	60-65
				Reach 7	30-60	60-65
				Reach 8	30-60	60-65

Component affected	Sub-component affected	Scientific name of sub-component	Summary of significant biophysical consequences (for details see Report No 648-F-06).	Reach	Baseline health risk	Predicted health risk
BACTERIAL INFECTION	Pulpy Kidney	*Clostridium perfringens*	The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in wetbank annuals and/or grasses resulting in flush grazing during early spring by animals. • Increase in algae which is eaten by animal during extreme drought conditions.	Reach 1	15-20	20-25
				Reach 2	15-20	20-25
				Reach 3	15-20	20-25
				Reach 4a	15-20	20-25
				Reach 5	15-20	20-25
				Reach 6	15-20	20-25
				Reach 7	15-20	20-25
				Reach 8	15-20	20-25
	Anthrax	*Bacillus anthracis*	The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in clay and mud providing ground for retaining the spores of the disease but also for increased chances of bogging. • The minimum lowflows for this scenario will exceed the flows that would naturally occur in the river during periods of drought, i.e. the scenario will not create drought conditions. • Considering both factors is thus unlikely that the potential for the survival of Anthrax spores will increase significantly.	Reach 1	0-1	1-2
				Reach 2	0-1	1-2
				Reach 3	0-1	0-1
				Reach 4a	0-1	1-2
				Reach 5	0-1	0-1
				Reach 6	0-1	0-1
				Reach 7	0-1	1-2
				Reach 8	0-1	0-1
Viral Infections	Bluetongue Virus		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in aquatic macrophytes resulting in increase in midges and gnats. • General increase in midges resulting from an increase in stagnant pools.	Reach 1	5-10	10-15
				Reach 2	5-10	10-15
				Reach 3	5-10	10-15
				Reach 4a	5-10	10-15
				Reach 5	5-10	10-15
				Reach 6	5-10	10-15
				Reach 7	5-10	10-15
				Reach 8	5-10	10-15
	African Horsesickness Virus		Same as Bluetongue	Reach 1	1-5	5-10
				Reach 2	1-5	5-10
				Reach 3	1-5	5-10
				Reach 4a	1-5	5-10
				Reach 5	1-5	1-5
				Reach 6	1-5	5-10
				Reach 7	1-5	5-10
				Reach 8	1-5	5-10

Component affected	Sub-component affected	Scientific name of sub-component	Summary of significant biophysical consequences (for details see Report No 648-F-06).	Reach	Baseline health risk	Predicted health risk
Nutrition and grazing	Susceptibility to disease		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Overall decrease in vegetation available for grazing, including trees and shrubs. • Increased potential for overgrazing resulting from decrease in the species listed above.	Reach 1	20-30	30-35
				Reach 2	20-30	30-35
				Reach 3	20-30	30-35
				Reach 4a	20-30	30-35
				Reach 5	20-30	20-30
				Reach 6	20-30	30-35
				Reach 7	20-30	30-35
				Reach 8	20-30	30-35
Medicinal Plants Mofifi	Treatment of internal parasites		The following factors were taken into account when assigning the scenario impact level of this sub-component: • *Phygelius capensis*, which is commonly used for treatment of tick-borne diseases in cattle, is expected to increase marginally (wetbank sedges and grasses). • *Rhamnus prinoides* (wetbank and drybank shrubs/trees zone), which is used for treatment of internal parasites, is expected to decrease. The scores provided here reflect the present risk of contracting diseases that can be treated with mofifi and the predicted (increased) future risk of contracting those diseases given the predicted changes in the abundance of the plants used.	Reach 1	20-30	30-35
				Reach 2	20-30	30-35
				Reach 3	20-30	30-50
				Reach 4a	20-30	30-35
				Reach 5	20-30	20-30
				Reach 6	20-30	30-50
				Reach 7	20-30	30-35
				Reach 8	20-30	30-50
Physical injury from slipping	Injury and death		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in biofilm growth on boulders and cobbles. • Increased mud and fines in the system.	REACH 1	1-2	2-5
				Reach 2	1-2	2-5
				Reach 3	1-2	1-3
				Reach 4a	1-2	2-5
				Reach 5	1-2	1-3
				Reach 6	1-2	1-3
				Reach 7	1-2	2-5
				Reach 8	1-2	1-3
Physical injury from bogging	Injury and death		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in clay and mud resulting in increase in individual animal bogging	Reach 1	1-2	2-5
				Reach 2	1-2	2-5
				Reach 3	1-2	1-3
				Reach 4a	1-2	2-5
				Reach 5	1-2	1-3
				Reach 6	1-2	1-3
				Reach 7	1-2	2-5
				Reach 8	1-2	1-3

APPENDIX 4.3:
ANIMAL HEALTH CONSEQUENCES OF THE FOURTH SCENARIO

Table A.4.3 Animal health consequence of the Fourth Scenario.
See Report No. 648-F-07 for details of the biophysical changes referred to below. IFR site 4a = with Mashai Dam in place.

Component affected	Sub-component affected	Scientific name of sub-component	Summary of significant biophysical consequences (for details see Report No 648-F-07).	Reach	Baseline health risk	Predicted health risk
Internal parasites: Flatworm	Liver fluke/snail (snails terrestrial, fluke larvae aquatic)	*Fasciola hepatica (Snails – Lymnaea truncotula*	The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in vegetation that can potentially act as habitat for snail, such as wetbank annuals and palatable species including *Themeda triandra*, *hyperrhenia hirta* and *Cynodon* sp. • Increase in aquatic snails *Physidae and Planorbidae*, which are used as an indicator of conditions suitable for *Lymnaea,*	Reach 1	10-25	20-25
				Reach 2	10-25	20-25
				Reach 3	10-20	20-25
				Reach 4a	10-20	20-25
				Reach 5	10-20	20-25
				Reach 6	10-20	20-25
				Reach 7	10-20	20-25
				Reach 8	10-20	20-25
Internal parasites: Pear-Shaped Worms	Stomack Fluke	*Paramphistomun microbothrium*	Same as flatworms.	Reach 1	5-10	10-25
				Reach 2	5-10	10-25
				Reach 3	5-10	10-15
				Reach 4a	5-10	10-25
				Reach 5	5-10	10-25
				Reach 6	5-10	10-15
				Reach 7	5-10	10-25
				Reach 8	5-10	10-15
Other internal parasites	Other internal parasites	*Nematoda Cestoda*	Same as flatworms.	Reach 1	30-60	60-65
				Reach 2	30-60	60-65
				Reach 3	30-60	60-65
				Reach 4a	30-60	60-65
				Reach 5	30-60	60-65
				Reach 6	30-60	60-65
				Reach 7	30-60	60-65
				Reach 8	30-60	60-65

Component affected	Sub-component affected	Scientific name of sub-component	Summary of significant biophysical consequences (for details see Report No 648-F-07).	Reach	Baseline health risk	Predicted health risk
Bacterial Infection	Pulpy Kidney	*Clostridium Perfringens*	The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in wetbank annuals and/or grasses resulting in flush grazing during early spring by animals. • Increase in algae which is eaten by animal during extreme drought conditions.	Reach 1	15-20	20-30
				Reach 2	15-20	20-30
				Reach 3	15-20	20-25
				Reach 4a	15-20	20-30
				Reach 5	15-20	20-30
				Reach 6	15-20	20-25
				Reach 7	15-20	20-30
				Reach 8	15-20	20-25
	Anthrax	*Bacillus anthracis*	The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in clay and mud providing ground for retaining the spores of the disease but also for increased chances of bogging. • The minimum lowflows for this scenario will exceed the flows that would naturally occur in the river during periods of drought, i.e. the scenario will not create drought conditions. • Considering both factors is thus unlikely that the potential for the survival of Anthrax spores will increase significantly.	Reach 1	0-1	1-4
				Reach 2	0-1	1-4
				Reach 3	0-1	0-1
				Reach 4a	0-1	1-4
				Reach 5	0-1	0-1
				Reach 6	0-1	0-1
				Reach 7	0-1	1-4
				Reach 8	0-1	0-1
Viral Infections	Bluetongue Virus		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in aquatic macrophytes resulting in increase in midges and gnats. • General increase in midges resulting from an increase in stagnant pools.	Reach 1	5-10	10-20
				Reach 2	5-10	10-20
				Reach 3	5-10	10-15
				Reach 4a	5-10	10-20
				Reach 5	5-10	10-20
				Reach 6	5-10	10-15
				Reach 7	5-10	10-20
				Reach 8	5-10	10-15
	African Horsesickness Virus		Same as Bluetongue.	Reach 1	1-5	5-15
				Reach 2	1-5	5-15
				Reach 3	1-5	5-10
				Reach 4a	1-5	5-15
				Reach 5	1-5	1-5
				Reach 6	1-5	5-10
				Reach 7	1-5	5-15
				Reach 8	1-5	5-10

Component affected	Sub-component affected	Scientific name of sub-component	Summary of significant biophysical consequences (for details see Report No 648-F-07).	Reach	Baseline health risk	Predicted health risk
Nutrition and grazing	Susceptibility to disease		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Overall decrease in vegetation available for grazing, including trees and shrubs. • Increased potential for overgrazing resulting from decrease in the species listed above.	Reach 1	20-30	30-35
				Reach 2	20-30	30-35
				Reach 3	20-30	30-35
				Reach 4a	20-30	30-35
				Reach 5	20-30	20-30
				Reach 6	20-30	30-35
				Reach 7	20-30	30-35
				Reach 8	20-30	30-35
Medicinal Plants Mofifi	Treatment of internal parasites		The following factors were taken into account when assigning the scenario impact level of this sub-component: • *Phygelius capensis*, which is commonly used for treatment of tick-borne diseases in cattle, is expected to increase marginally (wetbank sedges and grasses). • *Rhamnus prinoides* (wetbank and drybank shrubs/trees zone), which is used for treatment of internal parasites, is expected to decrease. The scores provided here reflect the present risk of contracting diseases that can be treated with mofifi and the predicted (increased) future risk of contracting those diseases given the predicted changes in the abundance of the plants used.	Reach 1	20-30	30-40
				Reach 2	20-30	30-40
				Reach 3	20-30	30-40
				Reach 4a	20-30	30-40
				Reach 5	20-30	20-30
				Reach 6	20-30	30-40
				Reach 7	20-30	30-40
				Reach 8	20-30	30-40
Physical injury from slipping	Injury and death		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in biofilm growth on boulders and cobbles. • Increased mud and fines in the system.	Reach 1	1-2	2-5
				Reach 2	1-2	2-5
				Reach 3	1-2	1-3
				Reach 4a	1-2	2-5
				Reach 5	1-2	1-3
				Reach 6	1-2	1-3
				Reach 7	1-2	2-5
				Reach 8	1-2	1-3
Physical injury from bogging	Injury and death		The following factors were taken into account when assigning the scenario impact level of this sub-component: • Increase in clay and mud resulting in increase in individual animal bogging	Reach 1	1-2	2-5
				Reach 2	1-2	2-5
				Reach 3	1-2	1-3
				Reach 4a	1-2	2-5
				Reach 5	1-2	1-3
				Reach 6	1-2	1-3
				Reach 7	1-2	2-5
				Reach 8	1-2	1-3

APPENDIX 5:

LIST OF TITLES IN THE FINAL REPORT SERIES

Report Number	Report Title	Important Contents
648-F-01	Executive Summary	Pending approval of brochure production.
648-F-02	Final Report	Summary of the main results of the study
648-F-03	Volume 1: Terms of Reference, Study Area, Study Team and Programme of Events Volume 2: IFR Methodology	Based on a biophysical workshop to identify the biophysical consequences of changes in flow regimes.
648-F-04	Biophysical Consequences of The Minimum Degradation Scenario	Detailed biophysical description of the baseline (minimum degradation) scenario
648-F-05	Biophysical Consequences of The Treaty Scenario	Detailed biophysical description of the Treaty Scenario
648-F-06	Biophysical Consequences of The Design Limitation Scenario	Detailed biophysical description of a flow scenario imposed by design limitations of the project outflows.
648-F-07	Biophysical Consequences of The Fourth Scenario	Detailed biophysical description of a scenario with flows increased over those specified in the Treaty.
648-F-08	Specialist Report – Sociology	Pilot social and anthropological survey and identification of the population at risk (PAR)
648-F-09	Specialist Report – Public Health	Public health data survey and assessment of the PAR, identification of links between human health and the river
648-F-10	Specialist Report – Animal Health	Overview and assessment of health of domestic animals of the PAR.
648-F-11	Specialist Report – Water Supply	Water use by, and supply to, the PAR.
648-F-12	Specialist Report – Volume 1: Hydraulics Volume 2: Aquatic Habitat Mapping	Detailed hydraulic and aquatic habitat mapping and measurements for each IFR site.
648-F-13	Specialist Report – Hydrology (6 Volumes)	Detailed statistics of hydrology for each river, reach and IFR site.
648-F-14	Specialist Report – **VOLUME 1: SEDIMENTOLOGY** Volume 2: Geomorphology	Preliminary characterisation of the rivers and a selection of eight IFR sites.
648-F-15	Specialist Report – Water Quality	Predictions of biophysical, flow-related changes based on a year-long rivers' research programme by a team of 19 scientists.
648-F-16	**Specialist Report –** **Volume 1: Riparian Vegetation** Volume 2: Social Vegetation	
648-F-17	Specialist Report – Macroinvertebrates	
648-F-18	Specialist Report – Fish	
648-F-19	Specialist Report – Volume 1: Wildlife and Birds Volume 2: Herpetofauna	
648-F-20	Specialist Report – Yield Analysis	
648-F-21	Sociological Impacts of The Four Scenarios	Predictions of social and economic impacts of four scenarios based on linkages to predicted biophysical changes
648-F-22	Specialist Report – Economics	Economic assessment of the current value of all river resources and services used by the PAR and the predicted change in that value under the four IFR scenarios.
648-F-23	Monitoring Protocol	Recommended monitoring programme for confirming and quantifying impacts