A total of 75 bird species have been recorded from around the Rössing Mine. Of these, 21 were associated with artificial waterbodies, whilst nine species of bird were thought to be breeding in the area (Colahan, 1987).

A total of 34 species of reptiles and 2 species of amphibians have been recorded from around the Rössing Mine (Berger-Dell'mour, 1985), with an additional 7 to 10 species also expected to occur in the area. Two species of tortoise (*Geochelone babcocki* and *Psammobates occulifer*) were recorded from the Swakopmund area (Greig & Burdett, 1976) and may also occur further inland near the Rössing Mine.

4.5 General demographic and land use characteristics

The region forms the central part of the West Coast Recreational Area and most of the infrastructure is designed to provide access to and between recreational areas, mining operations and the main service and urban centres (Department of Government Affairs, 1987).

The major urban centres in the region are Walvis Bay and Swakopmund, located on the Atlantic coast. Smaller urban centres are located at Henties bay and Wlotzkas Baken to the north of Swakopmund, and Arandis near the Rössing Mine. The major sources of income and activities in the urban centres are:

- *Walvis Bay*: Salt, guano and granite exploitation, as well as commercial fishing and canning, plus the related harbour activities associated with its status as the major export harbour for Namibia. The estimated total population in 1995 was 35,000 (KfW, 1996).
- *Swakopmund*: The economy of Swakopmund centres around the tourist industry. Since the development of the Rössing Mine in the mid-1970's, the town also provides logistic support services for the mine and accommodation for Rössing staff. The town is the premier holiday resort in Namibia and provides all amenities for residents (approximately 18,300 (KfW, 1996)); the influx of visitors during the holiday season can more than double the town's population. Other important local industries included beer brewing and the production of a variety of meat and other fresh and processed food products. Outside the town limits of Swakopmund, farmers occupy small-holdings along the lower Swakop River. Major farming activities include dairy herds and the cultivation of asparagus.
- *Henties Bay*: This coastal and retirement resort consists of approximately 1,400 dwellings, and supports some 2,700 permanent residents plus up to 10,000 visitors during the holiday season (KfW, 1996).
- *Wlotzkas Baken*: This small community consists of some 5 permanent residents and a few holiday homes. No infrastructure is available and water is supplied

by tanker from Swakopmund. Approximately 500 holiday makers visit the site in season.

Arandis : Located some 65 kilometres inland from Swakopmund, Arandis was originally built to house the families of about half the staff at the nearby Rössing Mine. It is an independent town with its own municipality and town council. Arandis possesses well-developed infrastructure and several small secondary industries, as well as a semi-State hospital, primary and secondary schools, sports club and cultural centre. In a recent study (KfW, 1996), the population of Arandis was estimated to be about 3,800.

Much of the Namib Desert falls within conservation areas, for example the Namib-Naukluft and Skeleton Coast Parks. The game populations in these conservation areas is highly variable, with the animals migrating into and out of the area in response to seasonal rainfalls. Those areas of the Central Namib Desert which have not been proclaimed as conservation areas usually have no surface water and little or no potable ground water available. Consequently, they are generally of very low agricultural potential and cannot support formal farming activities.

Towards the interior portion of the Central Namib Desert, informal farming is conducted along the courses of most of the rivers due to the presence of fodder plants (mainly *Prosopis glandulosa*, *Faidherbia albida* and *Acacia erioloba*) and sub-surface water supplies. Perhaps the greatest effect that this informal farming has is the competition that domestic stock provide for the food and water resources used by wild animals (Department of Government Affairs, 1987).

In 1977, some small-holdings along the Swakop River were acquired by the State and the land incorporated into the Namib-Naukluft Park. However, informal farming is still continued along the rivers to the north of the Swakop River.

Prior to the start of mining operations at Rössing, several small- to medium-scale prospecting and mining operations were located in the Central Namib region. These endeavours were focused mostly on the recovery of copper, tin and semi-precious stones (Department of Government Affairs, 1987).

4.6 Study area characteristics

4.6.1 The KARS Dam site

The proposed KARS dam site is located close to the north-eastern boundary of the mining grant and accessory works area operated by Rössing Uranium Limited, and adjacent to the northern boundary of the Namib-Naukluft National Park. In the area upstream of the Rössing mining licence area, farms are located along both sides of the Khan River. Limited small stock and game ranching are the only farming activities which take place on these farms due to the shortage of water and harsh climatic conditions.

A large surface deposit of decomposed gneiss is located at the fringe of the hilly terrain outside the Khan River, and some 6.5 kilometres North of the KARS Dam site. Geotechnical tests have shown that this material is suitable for construction of the KARS Dam wall and that sufficient material is available for this purpose. It is intended to excavate this material with standard earth-moving equipment and transport it to the dam site by dump truck. These vehicles will travel along the bed of small tributary gorge which joins the Khan River some 400 metres upstream of the KARS Dam wall site.

Apart from the infrastructure associated with the Rössing Mine, there is no well-developed infrastructure around the dam site. Access is via informal tracks for four-wheel-drive vehicles along the bed of the Khan River and linking with similar gravel-surfaced tracks along some of the gorges. The original access track to the Khan River via Dome Gorge has been modified by the extensions to "Waste Dump 7", and access is restricted to mine personnel. All access to the Khan River via Panner and Pinnacle Gorges is restricted by fences and locked gates erected by Rössing. Just north of the KARS dam site a broad tributary provides access to the dam site from the north.

Well-developed infrastructure exists at the Rössing Mine, with road and rail links as well as the nearby Arandis Airport. A series of water extraction boreholes and monitoring wells is located in the bed of the Khan River. These are not accessible to the public.

4.6.2 *Farming activities along the lower Swakop River*

Along the lower Swakop River a large number of small holdings have been developed on the terraces adjoining the dry river bed (**Figure 4.15**). Typical locations are shown in **Plates 2 and 3**. Fresh produce for Swakopmund is produce under irrigation using mainly ground water extracted from the alluvial aquifer of the Swakop River. The water used for irrigation has a TDS which varies between about 3,500 mg/ℓ to more than 11,000 mg/ℓ.

Predictions made of the increase in salt content of the ground water by as much as 15% as a result of the KARS project (Metago Environmental Engineers, 1997b), prompted an investigation into the effect increased salinity irrigation water will have on crop production and soil salinity. The present and expected water quality were further investigated to assess their effect on soil permeability and to identify the preferred irrigation method. This specialist study was conducted by Mr H M du Plessis, a soil and irrigation specialist from the Water Research Commission of South Africa. The full specialist report on this study is appended as **Appendix 2**.

The main conclusions of his study can be summarised as follows:

- The water currently extracted from the alluvial Swakop River aquifer would normally not be regarded as suitable for irrigation. However, a number of factors combine to make irrigation possible. These are:

Plate 2: Aerial view of extensive asparagus cultivation at the Rössing Foundation farm on the north bank of the lower Swakop River (Photo: H. Pepler).

Plate 3: Aerial view of the large wetland at Nonidas on the lower Swakop River, showing extensive vegetation in the river bed (Photo: H. Pepler).

- The irrigated soils of the farming area are of an alluvial nature and generally appear to be well drained. Well drained soils are a prerequisite for sustainable irrigation with high salinity waters.

- Generally only salt tolerant crops are being cultivated.

- Water is applied in such a way that crop leaves are not wetted.

- The EC of the irrigation water is high enough to counteract the dispersive properties of the Sodium Adsorption Ratio. Soil physical properties are thus not expected to be negatively affected.

- The local climate is such that asparagus producers gain a competitive edge over other production areas in that they are the sole suppliers during the peak demand period. There is also a growing local market for high quality fresh produce.

- Water quality shows significant variation in the farming area. However, there is a general increase in salinity from east to west. The ionic ratio of waters sampled from extraction points are fairly constant, which indicates that they have a similar or the same origin and that their increasing concentrations are a function of the degree of concentration which took place as a result of evapotranspiration.

- Crop yield reductions as a result of a predicted 15 % increase in salinity following on the commissioning of the KARS project would result in yield reductions which will show considerable variation, but would mostly be less than 15 %. The yield decrease of crops with a high salt tolerance will be minimal. The increase in irrigation water salinity is expected to result in a continuation and acceleration of the trend to switch to salt tolerant crops as it becomes increasingly difficult to produce economically viable yields of less tolerant crops.

- Although several options exist to mitigate against the present high salinity of water used for irrigation, and the potential salinity increase in future, these effects are expected to be incremental rather than once-off. One of the attractive options which needs to be further investigated is to make more use of drip irrigation.

The main recommendations resulting from the investigation are:

- farmers could benefit from exposure to explanations of the theoretical reasons behind their experience in order to assist them in helping themselves even better;

- the long term sustainability of the irrigation practice should be investigated and more specifically the effect of irrigation on water quality degradation;

- tests should be conducted to ascertain that soil physical conditions are not negatively affected by the prevailing high SAR values; and

- the Rössing Foundation, which displayed considerable courage and vision to initiate the asparagus project, should be encouraged to continue with their efforts. While their present initiatives have demonstrated the potential for asparagus production, their continued involvement to solve problems which are bound to occur, will not only benefit the local farming community, but probably also other potential asparagus production areas in Namibia and further afield.

In conclusion, it should be remembered that this evaluation of present and expected water quality was largely based on the results of a desk study. Its assumptions and implications need to be evaluated by conducting the necessary follow-up surveys.

4.6.3 Sediment transport and deposition in the lower Swakop River and its influence on coastal beaches

The history of sedimentation and erosion patterns at the Swakop River mouth can tentatively be deduced from a combination of historical records and evidence obtained from thermo-luminescence dating techniques. All the direct and circumstantial evidence suggests that the Swakop River experiences relatively high rates of sedimentation and erosion associated with flood events. Full details are included in the Specialist Report by Woodborne (**Appendix 5**).

Whether sediments erode from, or are deposited in the Swakop River appears to be dependent on the size of a particular flood. Relatively "large" (> 30 Mm^3) floods bring down large quantities of sediment from the upper, steeper river reaches and deposit this uniformly over the bed of the river channel where river gradients are low. The very large floods (> 100 Mm^3) also discharge large quantities of sediment at the river mouth. In contrast, "small" floods (< 10 Mm^3) carry smaller loads of sediment from the upper river reaches, and, instead, erode those sediments which have been deposited by previous floods. This reduces the depth of alluvial material in the river bed, and only very small quantities of sediment are deposited at the river mouth.

The thermo-luminescence dating evidence suggests that a substantial flood occurred in the Swakop River approximately 350 years ago. At this time very coarse gravel layers, indicative of substantially higher energy levels than the 1934 flood, were deposited. Since that time, these coarse gravel layers have been a barrier against continued deeper erosion, and the depositional and erosional cycles in the bed of the Swakop River have all take place above this coarse layer.

The largest floods on record occurred in 1930, 1934 and 1963. The largest of these occurred in 1934 when some 35 Mm^3 of sand was deposited off the mouth of the Swakop River. This caused a rapid progradation of the beach until it extended approximately 1,000 metres outward from the 1930 beach. At the same time, a uniform blanket of sediment up to 2.5 metres thick was deposited in the bed of the Swakop River. The 1963 flood deposited approximately 5 Mm^3 of sediment, prograded the beach by approximately 100 metres and deposited approximately 1 metre of sediment in the bed of the Swakop River (Stengel, 1964).

Between 1934 and 1963 the "delta" that had been formed by the 1934 flood was slowly eroded away. Similarly, between 1963 and the present, the "delta" that was formed by the 1963 flood has also eroded away. Several studies have shown that this is the natural result of wave attrition and longshore transport of the sediment northwards along the coast (Zwamborn, 1969; CSIR, 1976, 1982, 1985, 1990, 1993, 1994; Ward and Seely, 1989).

A summary of the available literature and reports dealing with sediment transport along the Namibian coast was done by Meyer (1997) and is appended to this report as **Appendix 6.** All Swakop River floods which reach the sea deposit their sediment load off the mouth of the river and prograde the beach in the short-term. In the medium-term, the average rate of wave attrition of the beach exceeds the average rate of progradation from small floods. If this were not the case the beach would progressively prograde and expand.

Old records (CSIR, 1976) show clearly that the beaches can be altered dramatically, depending on the availability of sand for deposition and the changing forces of longshore drift. Periods of sediment "starvation", which result in significant changes in the appearance of beaches, are well known along the Namibian coast. A prime example is the change currently occurring at Sandwich Harbour to the south of Walvis Bay where beach barrier bars are migrating landwards at a rate of 50-100 metres/year (Ward & Seely, 1989; Ward, personal communication, 1997). The erosion visible at the beach north of the Mole in Swakopmund, where an old slipway is now exposed (**Plate 4**), is attributed to a deficit in sediment available for deposition (The Windhoek Observer, 10/05/1997; Ward, personal communication, 1997).

4.6.4 *Sand mining activities*

The alluvial deposits in the bed of the lower Swakop River represent the only easily-accessible source of building sand for contractors in Swakopmund and Walvis Bay (**Plate 5**). Contractors started excavating building sand from the river bed at around the late 1970s. By 1980, about 6 hectares of river bed had already been affected (1980 Orthophotos). This activity has increased substantially and now also takes place on or near the farms Lilof, Richthofen and further upstream near Nonidas.

The mining process appears to take place in an uncontrolled, un-licensed and unmanaged manner, using standard earth-moving equipment. The top layers of finer sediments are removed to get rid of roots and plant material, and then the next 2.5 to 3 metres of coarser material is mined as building sand. Excavations usually stop about 0.5 metres above the water table.

Plate 4: Example of severe beach erosion at The Mole in Swakopmund. The old slipway is now visible in the foreground (June 1997).

Plate 5: Aerial view of the Swakop River mouth, showing the positions of sand-mining activities in relation to the road bridge and dunefields to the south (Photo: H. Pepler).

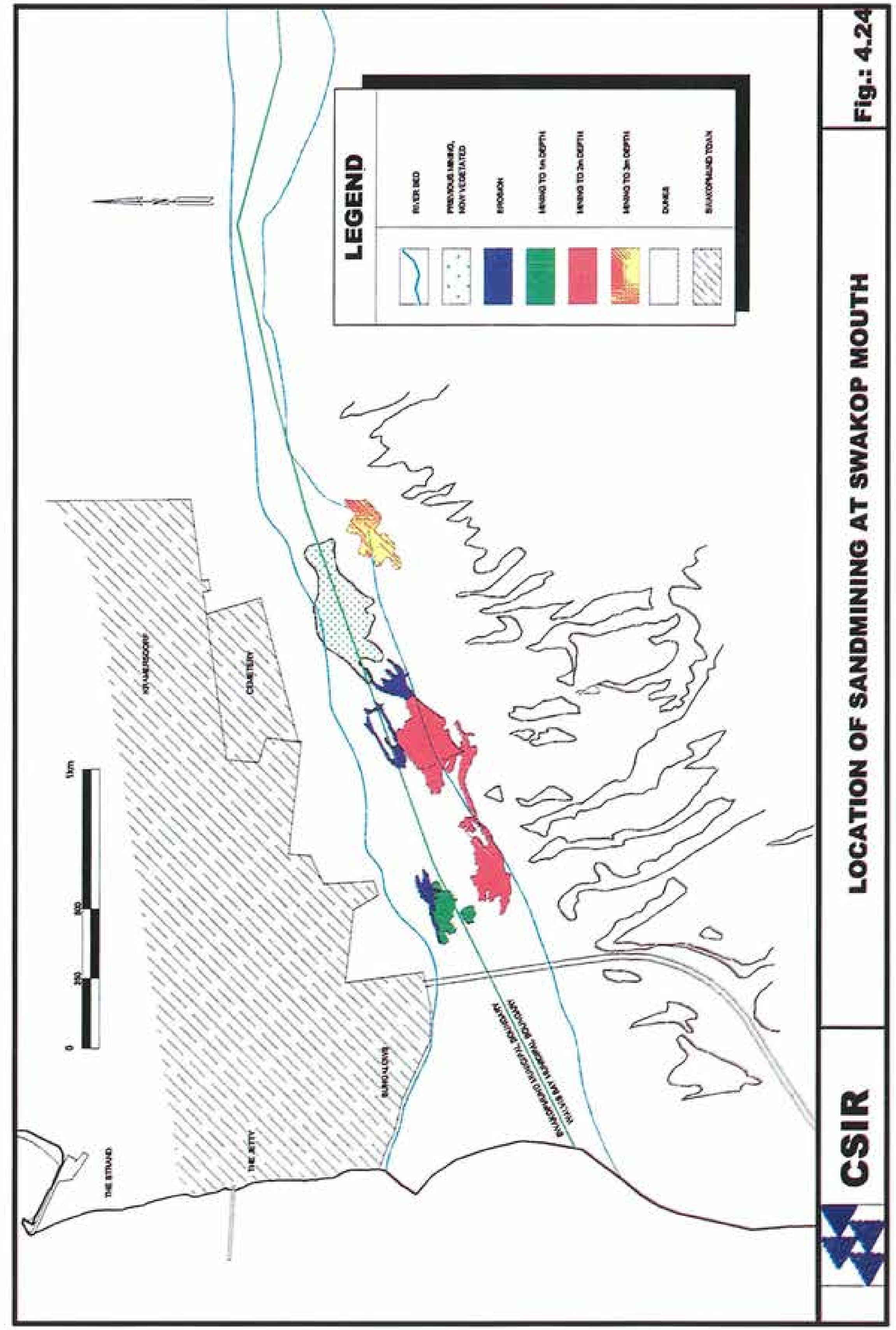
Apart from the 1980 orthophoto maps, no surveyed information was available on the sand mining activities near the mouth of the Swakop River. Based on field observations and areal photographs of the sand mining area taken after the second flood of the 1996/97 season, it is estimated that a surface area of 11 hectares has been mined out and that 230,000 m^3 of sand have been removed. During the relatively small floods of early 1997, approximately 18,000 m^3 of sand has been eroded. It is also estimated that a volume of some 56,000 m^3 of sand has either been redeposited or brought down by the floods. It was also established that should the ground water level rise above the pit floor, an area of 81,500 m^2 will be exposed to evaporation. The area affected by mining was mapped in March 1997 and the different units identified are shown on **Figure 4.24**.

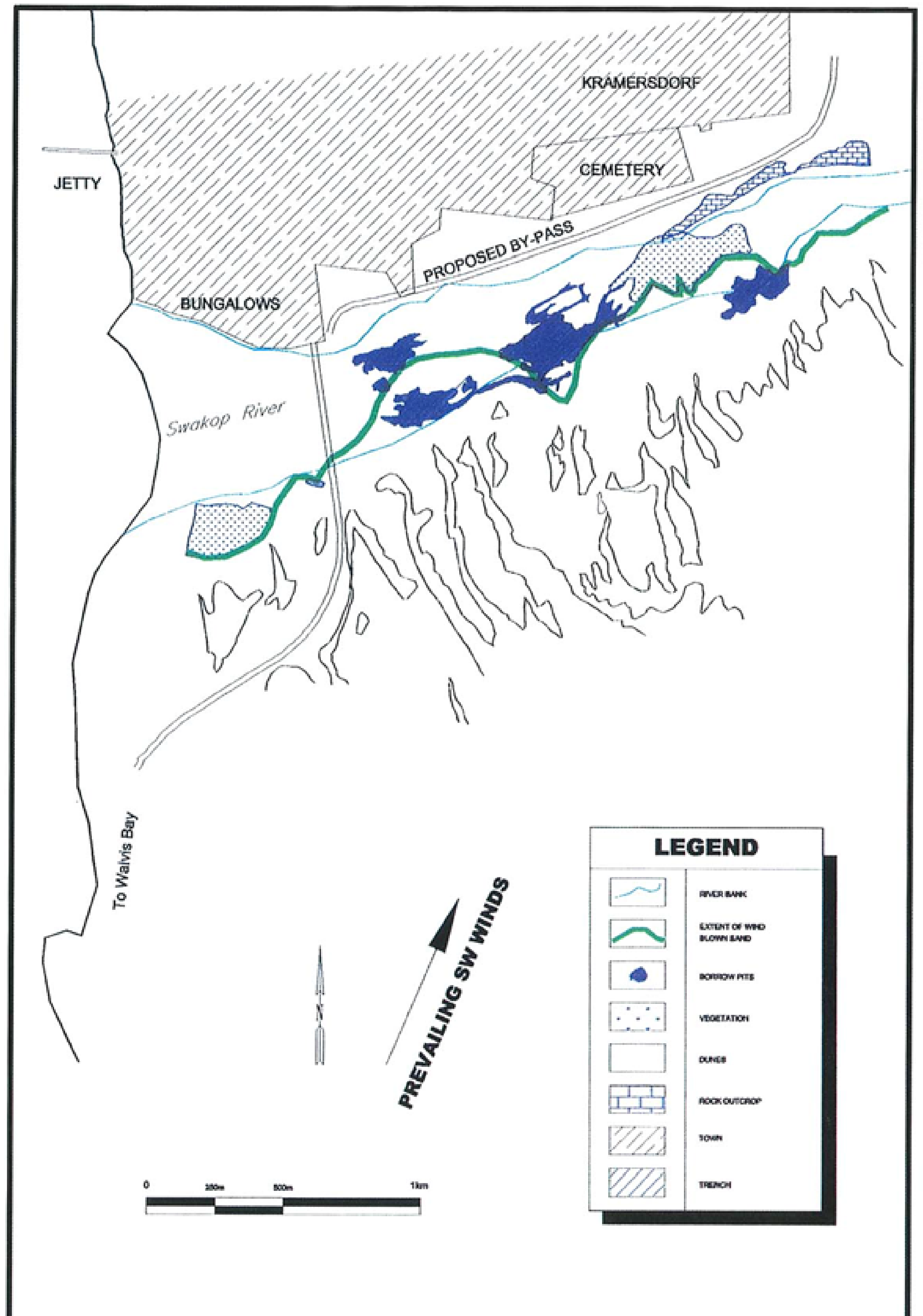
In the farm area upstream of Swakopmund, approximately 13 hectares of river bed have been excavated to an average depth of 2.5 metres. The total volume sand that has been mined is estimated at 247,000 m^3. Should the water level rise to above the pit floor, an area of 51,000 m^2 will be exposed to evaporation. Strong erosion occurred in these upstream areas during the 1997 floods, resulting in long and narrow erosion dongas that are approximately 1 metre deep. In the downstream areas large sections have been filled almost to their original level by silt and sand deposited by the recent floods. This material appears to consist of both new sand brought down from upstream areas and material which has been eroded from the upstream edge of the sand mining excavations.

4.6.5 *Sand dunes to the south of the Swakop River*

A permanent barchan dune field a few hundred metres wide is present to the south of the Swakop River, on the landward side of the road to Walvis Bay. By comparing the 1966 aerial photography, 1982 orthophoto maps and 1997 colour air photos, no detectable movement of the main dunes can be recognised over this 30 year period. This must be attributed to relatively low wind speeds along the major movement axis. However, whilst the main barchan dunes have not shifted their position, considerable quantities of wind-blown sand have been blown across the Swakop River by the prevailing south-westerly wind systems. The position of the dunes in relation to the sand mining areas, is shown in **Figure 4.25**. Literature and reports on the aeolian processes operating along the Namibian coast have been summarised by Meyer (1997) and are included in **Appendix 6** of this report.

Physical obstructions, such as vegetation, reduce surface wind speeds and cause windblown sand to be deposited. Situations where up to 2 metres of sand has already accumulated behind vegetation can be seen in the area near the main road bridge over the Swakop River. Many of the sand mining pits also trap and accumulate windblown sand. However, this only occurs on a small scale and it is unlikely that the mined sand pits will be filled by wind-blown sand. The calcite cliffs on the northern bank of the Swakop River also form a natural barrier and will prevent dune sand from progressing further north.





CSIR

POSITION OF DUNE SAND AT SWAKOP MOUTH

FIG.4.25

It is concluded that any northward migration of the of the main dunes is restricted by relatively low wind speeds and by topographical features. Also, the available evidence suggests very strongly that floods in the Swakop River are not the main mechanism which prevent the these barchan dunes from spreading further northward and encroaching into the town of Swakopmund.

5. EVALUATION OF ISSUES ASSOCIATED WITH THE KARS PROJECT

5.1 Introduction

This Chapter describes and evaluates the impacts expected to occur should the KARS Dam be constructed. The issues that will be addressed in this chapter follow from the public meetings held during January 1997 in Swakopmund and Arandis, written and verbal comments received from I&APs, and general impacts associated with projects of this nature. These issues have been categorised into several sections, and within each of these, a number of potential impacts are addressed.

The lay-out of the chapter followed is similar to the one used in the Omdel EIA report (Department of Water Affairs, 1991a), whilst the approach used to evaluate the significance of environmental impacts is a combination of the techniques used by Ashton *et al.* (1991) and Department of Water Affairs (1991a). The approach used to identify impacts and the criteria used to assess their significance has been described in **Chapter 4** of this Report.

Within each of the main sections of this chapter, the impacts are described under a standard set of headings to facilitate comparisons, as follows:

- Impact statement
  This comprises a brief statement of the type and form of impact and, where appropriate, identifies the parties likely to be affected.

- Impact description
  A description of the effects of the impact and, where possible, the provision of quantitative data on the magnitude of these effects and the groups, communities or individuals affected by the impact.

- Impact significance
  An evaluation of the importance (significance) of the impact is given, based on the criteria described in **Section 4** and the specific considerations in **Sections 3.3 and 3.4** for evaluating ecosystem impacts and socio-economic impacts.

- Impact mitigation
  A summary of the management actions required to prevent or reduce the negative effects of a given activity. Where appropriate, suggestions are also given for enhancing any positive benefits of the project action.

- Research and monitoring needs
  Suggestions as to which aspects require the collection of additional information or data should the project proceed.

5.2 Categories of issues

5.2.1 Need and desirability of the project

5.2.1.1 Impact of the KARS Project on the economic viability of the sea water desalination project at Walvis Bay

Impact statement
There has been relatively widespread public concern that, by pursuing the KARS Project, Rössing Uranium will not contribute to other water resource development options being considered for the Central Namib Area.

Impact description
Rössing Uranium is one of the largest single water users in the Central Namib Area. If Rössing does not contribute to the planned desalination scheme at Walvis Bay, this scheme may become too expensive for the other water users.

Impact significance
The planned desalination scheme at Walvis Bay has been designed for the anticipated growth in demand by all water users in the Central Namib. Furthermore, the costs of producing and delivering potable water from this scheme have been based on the assumption that all water users will participate proportionately in the scheme. If one or more of the larger water users does not participate, the costs of water will escalate for the remaining users.

Impact mitigation
Rössing Uranium Management have frequently and openly supported the desalination concept as a strategy for meeting the water demands of the Central Namib Area. In this regard, they are actively co-operating with, and assisting, the authorities in this regard. The KARS Project provides an additional opportunity to obtain industrial grade (brackish) water and thereby reduce the existing pressures on the scarce regional water resources. Rössing Uranium still requires large quantities of potable water which cannot be supplied from the KARS Project.

Research and monitoring needs
None required.

5.2.1.2 Regional water supply and management

Impact statement
The ground water resources of the Central Namib Area have been over-exploited to such an extent that they will be unable to sustain the projected demands for the region.

Impact description
Over-exploitation of the Kuiseb and Omaruru aquifers during the last twenty years

has seriously depleted these water resources. As one of the major water users in the Central Namib Area, Rössing Uranium has been perceived to contribute to this situation. Despite the relatively small size of the proposed KARS Project, it is very likely that it will help to reduce the pressure on these existing water resources if it is implemented.

Impact significance
It has been projected that the Kuiseb and Omaruru aquifers will not be able to meet anticipated water demands by the end of the twentieth Century. However, similar to the benefits to be gained from the Omdel aquifer recharge scheme, the KARS Project will help to reduce the existing demand and thereby help to prolong the useful life of these water resources, without giving rise to significant negative impacts downstream.

Impact mitigation
If implemented, the KARS Project should seek to maximize the quantity of brackish water that Rössing Uranium can utilize. This must be achieved without compromising the baseflow of the Khan aquifer or the integrity of the salt and water balances on the mine.

Research and monitoring needs
Namibian water resource managers should continue to monitor all freshwater and brackish water usage in the Central Namib Area. In addition, greater attention should be paid to determining natural rates of recharge and the sustainable yield of all alluvial aquifers in the Central Namib Area.

5.2.1.3 Improved knowledge of aquifer functioning and recharge

Impact statement and description
This project will provide a considerable body of information on the dynamics of the Khan River aquifer. The effectiveness of the retention dam option for aquifer recharge can also be evaluated. The expected environmental impacts of this type of scheme on an ephemeral river in a sensitive ecological region can also be quantified and applied to other schemes in future.

Impact significance
The potential benefits of this knowledge could be of major significance in an arid country like Namibia, since some of the most important water resources in Namibia are alluvial aquifers. The knowledge and experience gained may also benefit other arid countries, both in southern Africa and elsewhere in the world.

Impact mitigation or optimization
Devise a means of monitoring, recording and documenting the progress and results of this project through all the construction stages and throughout the lifespan of the reservoir. This information should be carefully documented and referenced to permit easy access by Rössing staff and the Namibian Department of Water Affairs.

Research and monitoring needs
As given under benefit optimization.

5.2.1.4 Impact on water management systems upstream of KARS

Impact statement
The residents of Usakos will not benefit from the KARS Project.

Impact description
The residents of Usakos rely heavily on ground water drawn from alluvial aquifers in the upper reaches of the Khan River; this resource is not sufficient to meet the growing demands. If a dam similar to the KARS Project is constructed at Usakos within the twenty-year lifespan of the KARS Project, it would undermine the viability and objectives of the KARS Project, thereby eliminating any possible benefit to Rössing Uranium.

Impact significance
The supply of water to the town of Usakos is the responsibility of National Government. The KARS Project will not influence either the quantity or quality of ground water in the vicinity of Usakos.

Impact mitigation
It is anticipated that the demand for water in Usakos will have to be met from either local ground water resources or by an extension to the Karibib pipeline.

Research and monitoring needs
None required.

5.2.2 Design and engineering features of the dam and aquifer recharge mechanism

5.2.2.1 The ideal capacity for the proposed dam

Impact statement
The general public have expressed concern that the capacity of the proposed dam in the Khan River may not be ideal for the purpose of recharging the Khan aquifer and could also interfere with processes of fresh water flood flows and aquifer recharge that many downstream users rely on.

Impact description
If the proposed dam is too small it would not function efficiently. A large capacity dam would be able to trap major floods and release this water for the benefit of downstream users. If water is not released downstream than farmers along the lower Swakop River would have to contend with a progressive deterioration in ground water quality.

Impact significance
A deterioration in ground water quality along the lower Swakop River, caused by reduced rates of recharge from flood waters, would have adverse economic consequences for irrigation water users.

Impact mitigation
The capacity of the dam under consideration was examined against stringent technical criteria, as well as economic criteria based on projected future water costs in the West Coast area of Namibia. The techno-economic study has shown that the ideal capacity for the dam is limited by capital constraints rather than aquifer capacity. This is because of the differential between the cost of Khan River water and the cost of potable water. These calculations have indicated that a capacity of the order of 9 million cubic metres (9 Mm^3) is likely to strike the best balance between capital, the project life of the scheme and net savings. This results in a dam wall of 25 metre maximum height and includes a 5.5 metre allowance for freeboard during flood events. The full supply level which coincides with the level of the main spillway would therefore be at a height of 19.5 metres above the river bed.

This size of dam would trap almost all of the smaller floods (with a volume less than 10 Mm^3) during the early years of its life. Floods larger than 10 Mm^3 would have their volumes reduced by the available capacity of the KARS Dam. only portions of larger floods would be trapped. As silt accumulates within the dam basin, its capacity will also reduce. Thus, the impact of the KARS Dam on floodwaters along the Khan River will decline over time as its capacity diminishes.

Research and monitoring needs
Volumes of floodwaters that are trapped within the dam basin should be carefully recorded. In addition, those floods with higher flows (greater than the KARS Dam capacity) which are discharged via the spillway system should also be monitored.

5.2.2.2 How can the wider public benefit from the KARS proposal ?

Impact statement
There is a perception that the wider public in and around Swakopmund will not benefit directly from the KARS Project, and that the only beneficiary from the use of a "public" or "National" resource will be Rössing Uranium.

Impact description
The KARS Project has been designed specifically to meet the brackish (non-potable) water needs of Rössing Uranium and thereby reduce the mine's demand for potable water. No specific provision has been made in the KARS Project to meet the water needs of other users.

Impact significance
Given the very specific chemical characteristics of ground water in the Khan River

aquifer, the water has very limited use outside of certain industrial processes if it is not treated. This quality of water is of limited use to other users.

Impact mitigation
Whilst this aspect has not been specifically studied, it is likely to be feasible provided additional infiltration management was implemented upstream of Swakopmund. Ideally, a wider public involvement to extend the potential benefits of the KARS Project to more downstream users should be matched by a willingness on the part of the public to contribute to the additional capital and operating costs.

Research and monitoring needs
None required.

5.2.2.3 Can the proposed dam withstand major floods ?

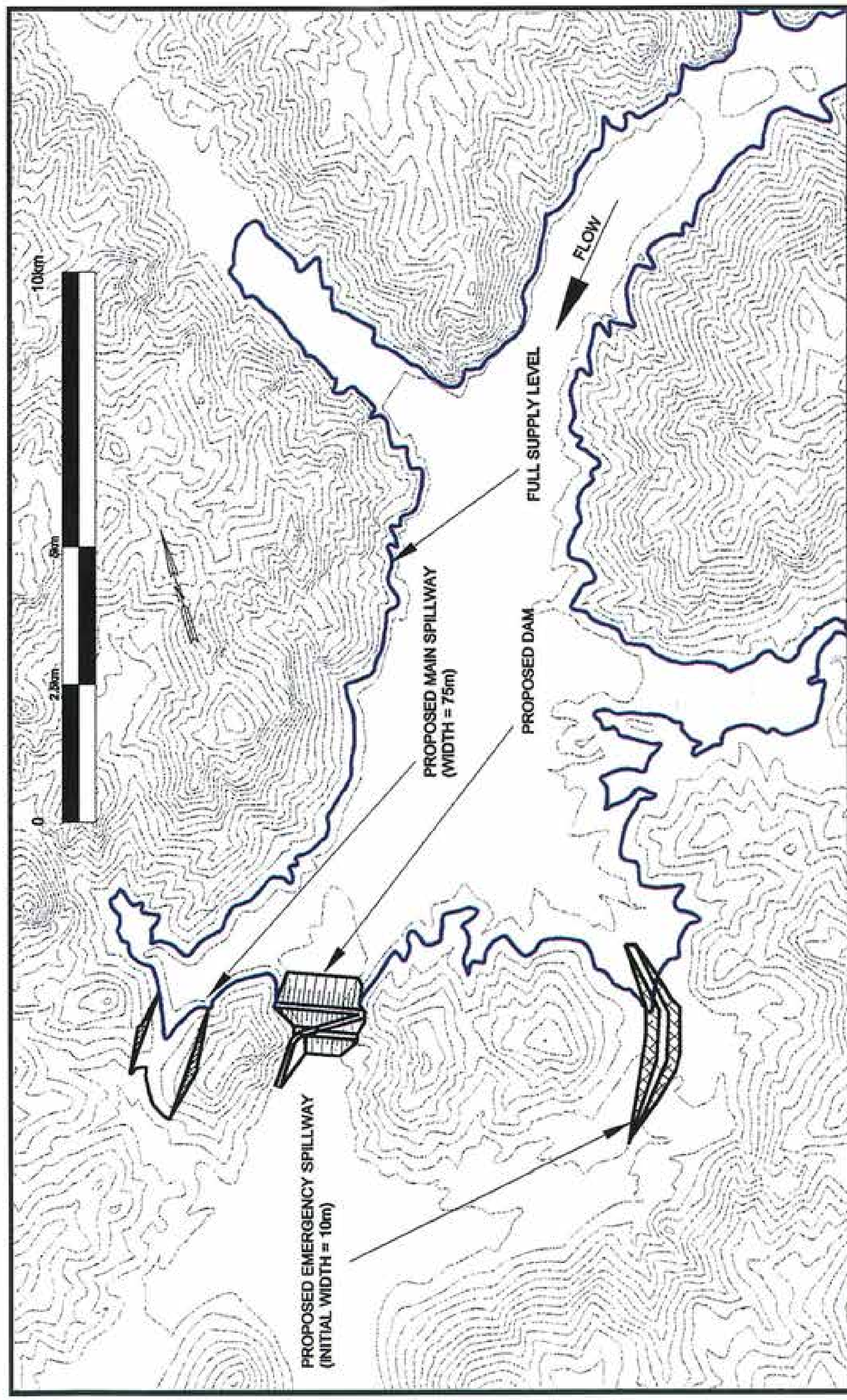
Impact statement
Major flood events are considered to be the most likely cause of dam wall failure. Given that the KARS Dam would be constructed of alluvium, the public perceive this to be a serious risk to downstream residents.

Impact description
A perception exists that the use of alluvium could render the KARS Dam "unsafe" as it would be vulnerable to a major flood. However, it must be recognized that any dam of the size proposed for the KARS Dam would be severely stressed by a major flood. (It is important to note that there are no earth-fill materials known to man that could withstand over-topping and erosion due to a major flood. Alluvium therefore represents as good a choice as any material).

Impact significance
In the event that a major flood did occur, the low capacity of the KARS Dam would not provide a significant barrier to the flood waters. Provided that the spillways both function correctly, the dam is designed to withstand a flow of 1,100 m^3/second. This impact is considered to have a low significance.

Impact mitigation
The KARS Dam has been designed with two spillways as illustrated in the plan in **Figure 5.1**. No water will flow over the dam wall itself.

A main spillway on the right flank which will be able to handle up to 1:50 year flood events on its own. This spillway will be blasted and excavated into relatively unweathered rock which will form an erosion resistant sill.



CSIR | PORTION OF KHAN RIVER AND PROPOSED DAM SITE | FIG.:5-1

ENVIRONMENTAL IMPACT ASSESSMENT OF THE PROPOSED KHAN AQUIFER RECHARGE SCHEME

An emergency spillway on the left flank which, when operating together with the main spillway, will cater for floods up to the 1:200 year event. Drilling and geophysical investigations to date indicate that the materials in the proposed spillway section comprise alluvial sands and gravels which have been mildly and variably cemented in places. These materials are likely to be highly erodable. It is therefore currently proposed that operation of the emergency spillway take advantage of the potential for erosion of the spillway section by the flood. To this end it is proposed that a channel section of nominal width be preformed in the spillway section to accommodate initial flow. Thereafter discharge capacity will be naturally generated by the flood as this erodes the preformed channel wider and deeper to meet flood requirements.

Final assessment of the viability and reliability of this proposal as well as the extent of sub-surface blasting to disturb mildly cemented layers will be assessed after excavation of a trial section through the spillway. Flow through the emergency spillway would necessitate reinstatement of the spillway section after the event and this has been accounted for in the economic analyses. During operation of the emergency spillway some of the silt within the dam basin would be removed thereby enhancing the storage capacity of the basin.

<u>Research and monitoring needs</u>
A careful check should be maintained on the integrity of the KARS Dam during all floods.

5.2.2.4 Consequences of dam wall failure

<u>Impact statement</u>
There is a perception that if the KARS Dam wall fails during a major flood event, the consequences could be disastrous for downstream residents.

<u>Impact description</u>
Floodwaters released from the KARS Dam as a result of the dam wall failing during a major flood could inundate the full width of the lower Swakop River channel. This could endanger local residents and could destroy existing irrigation activities and livestock.

<u>Impact significance</u>
The KARS Dam has been designed to trap and contain small- and medium-sized floods only; it is too small to trap and contain a major flood. In such an event, a major flood would be routed past the dam wall over the two spillways. In an extremely large flood occurred, the KARS Dam would not withstand such a situation.

<u>Impact mitigation</u>
The consequences of failure of the dam wall are unlikely to be severe due to the virtual absence of people and publicly owned infrastructure along the river all the way down to Goanikontes. There are a few farming properties located upstream of