# 4. IMPACTS DUE TO CURRENT MINING OPERATIONS

## 4.1 Criteria for the Assessment of Impacts

Mining may be defined as the removal of minerals from the earth's crust for use in the service of man. It is therefore axiomatic that all mining activity causes some change in the natural environment and therefore has an environmental impact. The extent of this impact can range from scarcely perceptible to highly obtrusive and the nature of the impact can similarly vary widely depending on the mineral worked, the method of mining and the characteristics of the mine site and its surroundings (Down & Stocks, 1978).

In order to assess and remedy any environmental disruption that can be attributable to a particular mining operation, a logical sequence of procedures would be to:

(a) Express the nature and extent of the impact (or problem) with reference to a rational and consistent system of measurement,
(b) Define acceptable standards and criteria in a comparable manner,
(c) Compare the measured (or predicted) impact with the relevant standards,
(d) Implement remedial measures, if necessary, to reduce the impact to conform with the accepted standards, and
(e) Design and implement an appropriate monitoring programme to ensure compliance with agreed standards.

However, it is often difficult to carry out this idealized sequence of procedures. The particular difficulties are:
(a) The lack of accepted techniques with which to quantify the extent of the impact. This is particularly evident when loss of amenity occurs, and assessment is frequently qualitative and subjective.
(b) The absence of well-defined and generally accepted criteria for particular types of environmental problems. Visual impacts, for example, are inevitably concerned with subjective criteria. Other cases, such as the quality of potable water, are well suited to measurement and yet there exists an enormous range of differing national and international standards.
(c) The absence of a known remedy capable of reducing a particular problem to generally acceptable levels. In this instance, a choice has to be made whether or not to accept the situation in favour of the expense of depriving society of important raw materials.

The majority, although not necessarily all, of the environmental problems associated with mining tend to diminish with increasing distance from the mine. Consequently, the most severe environmental problems or hazards commonly arise adjacent to the mining operation. Whilst those most affected are likely to be the mining employees, the full environmental impact of a mining operation will extend far wider. In this context, therefore, this evaluation of the environmental impacts caused by the Rössing Uranium mine encompasses both localized and dispersed impacts.

During the life of any mining operation, the early exploration and development activities are usually quite different in scale, and often have different impacts, from the activities that take place during the later, full-scale operations. For convenience, therefore, the impacts resulting from the different phases of development at Rössing are considered separately. The detailed description of mining activities at Rössing given in Chapter 3 forms the basis for evaluating the scale of impact that each type of activity has had on the physical, biological and socio-economic environment described in Chapter 2. For clarity, the system used to assess the scale and importance of impacts, as well as the evaluation of impacts on physical and biological systems and the socio-economic environment is described below.

### 4.1.1 The Scale and Importance of Impacts

Ideally, the degree or severity of a particular impact should be expressed in quantitative terms, against a quantitative assessment of the conditions that pertained before a particular activity commenced. In addition there must also be some expression as to whether or not a particular impact is desirable or not. Clearly, the desirability of an impact will depend largely on the attitude of the assessor; therefore, there is always an unavoidable component of subjectivity in the analysis.

An eight-point scale has been used as a convenient means of scaling impacts in this study (Table 4.1). In this system, seven scores are allocated from +3 indicating a very important positive (i.e. desirable) impact, through 0 where impacts are benign or absent, to -3 for a very significant or severe negative (i.e. unwanted) impact. Where insufficient information is available to correctly assign a score, then an eighth point, the symbol "?", is used. This system allows a reasonable degree of distinction to be made between "mild" and "severe" impacts. In the present study, mild impacts can be those in which either a very small proportion of a very large community is affected or, in the case of a particular activity which covers a large area, causes very little disruption of the affected systems within that area. Similarly, "severe" or "significant" impacts are those where a particular activity causes a complete and irreversible change in the original characteristics or components of a unique biological system occupying a small area or, causes very extensive, though not necessarily catastrophic, changes over a wider area. Activities which have little or no impact are considered to be benign.

**TABLE 4.1**: Scale used to denote the significance or severity of an impact, as well as its desirability.

| | |
|---|---|
| +3 | Important/significant positive impact |
| +2 | Moderate positive impact |
| +1 | Mild positive impact |
| 0 | Benign (or no) impact |
| -1 | Mild negative impact |
| -2 | Moderate negative impact |
| -3 | Important/significant/severe negative impact |
| ? | Unknown impact (or impact cannot be assessed as positive or negative with current knowledge) |

Any assessment of the impact of a particular activity must take into account the type of activity, the location or site in which the activity takes place and its extent (in comparison to the area or habitat affected). Very often, a single activity can have both strongly positive and strongly negative effects on different components of the system. An excellent example of this situation is provided by the construction of a roadway, where the scale of the impact is expressed in terms of the degree of change to the existing environment. In the case of the road construction example, the road will have a strongly negative impact on local vegetation, though this could be in direct proportion to the size of the road and its associated fringe areas and borrow pits. In contrast, the same road could have a strongly positive impact on regional communications and infrastructure, quite out of proportion to its size. For convenience, the degree of impact for each activity is listed in a tabular matrix. This allows easy comparison of the impacts shown by different activities. It is important to note that these impacts should not be added arithmetically; each matrix merely serves to facilitate comparisons.

The areas disturbed directly by each facet of the construction and current operation phases at the Rössing Uranium Mine have been estimated and are shown in Table 4.2. These data form the basis for descriptions elsewhere in this report of the extent and impact of activities carried out at the Rössing Uranium Mine. Whilst many of the figures relating to the current mining operations are direct measurements of the areas affected, the areas impacted during the exploration phase are only approximate. At the completion of the exploration phase, the housing sites were restored whilst the drilling sites, pilot plant and access roads were covered by subsequent mine developments.

The impacts associated with the disposal of tailings derived from the metallurgical process are considered to be distinct from those related to domestic and industrial rubbish disposal systems. Therefore, impacts due to tailings disposal are dealt with in Section 4.4: 'Tailings Disposal', whilst those relating to domestic and industrial rubbish disposal are dealt with in Sections 4.2.6 and 4.5.

### 4.1.2 Evaluation of Ecosystem Impacts

Impacts on ecological systems may result in an increase in species diversity, which is usually regarded as a favourable or positive impact. Conversely, a decrease in species diversity, would be a negative impact. However, biological responses to an altered ecosystem are far more complicated than a simple change in species diversity. They include the loss and gain of species or indeed of whole communities and also changes in the abundance (or population size) of individual species.

The importance of changes in species composition or of communities depends on the conservation status both of the species or community which is replaced and of the "new" species or community which becomes established. If a change results in the decrease or loss of a rare or endangered species or community, it is important and negative. If it results in an increase in a rare or endangered species or community, it is important and positive. If the changes do not involve rare or endangered species or communities, the impact is considered to be benign.

The importance of impacts which result in changes of population sizes depends also on the secondary effects these population changes may have on other ecosystem components. For instance, the creation of a reedbed as a result of plant colonization of seepage from the slimes dam, in an area where such habitat did not exist before, could provide suitable habitat for indigenous bird, insect and reptile species. This, in turn, could result in an increase in previously scarce or seldom-seen species and an increase in the biotic diversity of the area. The importance of this type of change is usually evaluated in terms of mankind's perceived direct interests. Thus a change which resulted in the disappearance of a noxious weed is regarded as important and positive, whereas an increase in the abundance of a nuisance organism (e.g. housefly) is regarded as important and negative. Changes in the abundance of many species would likely be benign or of little consequence to the ecosystem.

In common with other desert ecosystems, the terrestrial fauna and flora of the Namib Desert are known to be very sensitive to a variety of environmental changes, including climatic variations. Plant and animal communities that existed at the site of the present open pit, for example, must be considered to be totally degraded under present conditions. The open pit can therefore be considered to have had a severe negative impact on any biological components that may have existed at the site. The complete disappearance or extinction of any of these fragile communities as a direct or indirect result of mining activities would be considerable cause for regret; this is regarded as an extremely important negative impact. Indeed, the loss or displacement of communities or species from the environs of the Rössing Uranium Mine must always be considered as a negative impact in the context of ecosystem fragility in the Namib Desert. However, if similar communities occur commonly nearby, then the impact would be considered as localized and therefore much less severe.

**TABLE 4.2**: Areas of disturbance for each facet of the exploration and current mining operations at Rössing Uranium Mine; (N.B. the areas given are totals, rounded to the nearest hectare, for each activity, which may be composed of scattered components).

| Activity | Area of disturbance (hectares) |
|---|---|
| <u>Exploration Phase</u> | |
| Exploration camp | 2 |
| Construction camp | 4 *1 |
| Geological survey (drilling sites) | 35 *2 |
| Pilot plant | 4 *2 |
| Waste disposal area | <1 |
| Road construction | 16 *2 |
| <u>Current Mining Activities</u> | |
| Open pit and margins | 400 |
| Coarse ore stockpile | 11 |
| Fine ore stockpile | <1 |
| Waste Rock dumps | 535 *3 |
| Processing plant | 100 |
| Borrow pits | 50 *4 |
| Mine offices and gardens | 25 |
| Powerlines | 15 *5 |
| Railway line | 7 |
| Airstrip and hangars | 15 |
| Water supplies | |
| Freshwater supply + pump stations | 70 *6 |
| Khan River pipelines + pumps | 2 |
| Khan River 3 temporary dam walls | 20 |
| Dewatering trenches and wells | 1 |
| Drainage ditches and culverts | 1 |
| Seepage dams and reedbeds | 2 |
| Security fencing | 4 *7 |
| Roads (gravel surface) | 43 |
| (tarred surface) | 26 |
| Housing and recreation facilities | |
| Arandis (total) | 135 |
| Namib Lodge and Rossec Lodge | 20 |
| Swakopmund suburbs | 75 *8 |
| Rössing Country Club | 100 |
| Tailings dam and periphery | 585 *3 |
| Sewage treatment plants (+ ponds) | 7 *9 |
| Industrial waste disposal | <1 *10 |
| Sanitary landfill | <1 *10 |

1 = Site restored after mine came into operation.
2 = Most sites now covered by open pit and dumps.
3 = Estimated from aerial photos and maps.
4 = Many now covered by tailings dam and open pit.
5 = Length of line with 10 m wide access strip.
6 = Length of pipeline with 10 m wide access strip.
7 = Length of fence with 5 m access strip.
8 = Averaged at 0.1 ha plot size.
9 = Includes Rössing, Arandis, RCC.
10 = Buried in waste rock dumps.

### 4.1.3 Evaluation of Socio-Economic Impacts

The wide variety of sociological and economic problems which can arise from mining can be categorized in a number of different ways. Ideally, however, the system used must be identical to, or directly comparable with, that used to express the severity of impacts on environmental components.

In the present study, therefore, the same eight-point scale has been used to express sociological and economic impacts in terms of their desirability and severity. Once again, the same constraints of subjectivity apply. Clearly, where a particular impact poses a direct or indirect hazard to the safety of man, this is considered to be severely negative. Such impacts would include emission of toxic effluent and gases, high levels of radiation, excessive noise, vibration and dust levels, loss of income or arable land and extreme visual intrusion. Strongly positive impacts would include improved health and welfare services, creation of additional job opportunities with associated advanced training, the construction of housing, hospitals, schools and recreational facilities for local communities.

Additional features of a large-scale activity such as mining, are the direct and indirect socio-economic impacts which are manifest most clearly in a regional and national context. Very often these impacts are not easily assessed, and include improved regional and national literacy levels, a broader taxation base and improvements to regional infrastructure.

## 4.2 Exploration and Construction Phases

The environmental impacts that occurred during these phases of development at the Rössing Mine are summarized in Table 4.3. The type of activity and the extent and importance of the resulting impacts are described more fully below.

### 4.2.1 Construction and Exploration Camps

The main exploration camp was constructed at the upper end of Panner Gorge, to the south of the present airfield, and occupied a total area of some 2 ha. Accommodation consisted of mobile homes, pre-fabricated dormitory units and temporary tents. Electrical power was provided by diesel generators and supplies of drinking water were brought in by tanker as no suitable water was available locally. Negative impacts in this area were moderate during the period when the camp was occupied, and included the collection of dead *Acacia erioloba* trees for firewood; these impacts have now decreased to zero as the site has been abandoned and restored.

Additional, temporary, campsites were also used during the exploration phase. These were located at several points on areas that are now covered by waste rock dumps or the open pit. While these campsites would have caused local disturbance to indigenous plant and animal communities, these effects would have been outweighed by the impacts of drilling and blasting activities. Any impacts are thus considered to have been negligible.

The first construction camp built at Rössing was sited at a point opposite the present-day Rossec and Namib Lodges, and occupied an area of approximately 2 ha. Buildings consisted of both prefabricated structures and mobile homes, with chemical toilet facilities and electrical power supplied by diesel generators. Once again, water supplies had to be brought on to the site by tanker. The site was used heavily during the earlier phase of activities and, once the decision had been taken to continue with full-scale mining operations, additional pre-fabricated housing units were added to

**TABLE 4.3:** Matrix of environmental impacts resulting from activities during the exploration and construction phases of development at the Rössing Uranium Mine.

| Environmental Characteristics | | Activities causing environmental impact (See list of activities in footnote) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Category | Element | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Geology | Regional System | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Local System | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Special Features | 0 | -1 | -1 | 0 | -1 | 0 | 0 |
| Geomorphology | Soil Quality/Type | 0 | 0 | 0 | -1 | -1 | 0 | +1 |
| | Erosion Status | -1 | -1 | -1 | -1 | -2 | ? | +1 |
| Climate | Climatic Pattern | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Microclimate | 0 | 0 | 0 | ? | ? | 0 | 0 |
| Hydrology | Surface Waters | | | | | | | |
| | (Perennial) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (Temporary) | -1 | 0 | -1 | 0 | -1 | -1 | 0 |
| | Underground Water | -1 | 0 | -1 | -1 | -1 | 0 | +1 |
| Vegetation | Regional Zonation | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Local Patterns | -1 | -1 | -1 | -1 | -2 | +1 | ? |
| | Variations (season) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Endangered Species | -1 | ? | ? | -1 | -1 | ? | 0 |
| | Alien Vegetation | -1 | -1 | -1 | -1 | -1 | ? | -1 |
| Animals & Bird Life | Corridors | ? | ? | ? | ? | ? | 0 | 0 |
| | Habitat Variety | 0 | 0 | 0 | 0 | -1 | 0 | 0 |
| | Habitat Extent | -1 | 0 | -1 | -1 | -1 | 0 | 0 |
| | Endangered Species | -1 | -1 | -2 | -1 | -2 | ? | ? |
| Aquatic Life | Variety | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Air Quality | Dust | -1 | -1 | -1 | -2 | -2 | 0 | 0 |
| | Radio-nuclides | 0 | 0 | ? | -2 | -2 | 0 | 0 |
| Noise | Intensity | -1 | -1 | -1 | -2 | -2 | 0 | 0 |
| | Duration >40 db | ? | 0 | -1 | -1 | -2 | 0 | 0 |
| Aesthetics | Landscape Diversity | -1 | -1 | -1 | -1 | -2 | 0 | 0 |
| | Scenic views | -1 | -1 | -1 | -1 | -2 | -1 | +1 |
| Social | People at Home | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | People at Work | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | People at School | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | People at Play | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Vehicle Occupants | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pedestrians | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Socio-economic | Regional Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Education Standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Demographic pattern | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Land values | 0 | 0 | 0 | 0 | 0 | 0 | +1 |

1 = Construction and exploration camps; 2 = Roads and access routes
3 = Survey and exploration activities; 4 = Pilot plant
5 = Mining activities; 6 = Waste disposal system
7 = Site reclamation activities

expand the camp in order to cope with the increased labour force; the final area affected by the camp amounted to approximately 4 ha. The negative impacts of human activities at this site were intense during the period of occupation but now no longer occur as the site has been abandoned and restored.

### 4.2.2 Roads and Access Routes

Prior to and during the early exploration phase, vehicular traffic was able to move about relatively easily in the Rössing mine area by driving along the flat-bottomed, sandy gorges (Ostrich, Khan, Panner, Pinnacle and Dome Gorges) leading to the Khan River. These natural roadways were extensively used by surveyors, prospectors and geologists, who had to proceed on foot when negotiating the rugged ridges between these gorges. Negative impacts were extensive in terms of the area covered (approximately 14 hectares). However, despite the volume of traffic and the dust generated by the passage of vehicles, it appears that very little permanent damage was done to indigenous plant and animal communities. Therefore, the only negative impacts worthy of note would have been the disturbance of game animals due to noise from vehicles, drilling and blasting.

During the early prospecting and exploration phases, a few single-width tracks were cleared to permit vehicle travel away from the gorges into the terrain now covered by the mine plant and the open pit. These could have had significant negative impacts on ecological communities, though this cannot be resolved satisfactorily since almost all of these early roads have been obliterated by subsequent developments at the mine. A few remaining tracks amounting to a total area of some 2 ha in the area to the north-east of Panner Gorge are occasionally used to this day. These impacts would have been of slight importance.

### 4.2.3 Survey and Exploration Activities

The early survey and exploration activities around the site of the present Rössing Mine were concerned primarily with assessments of the geological formations and the extent of uranium ore reserves. The scope of activities ranged from aerial and land-based radiometric scans, to topographical surveys and the collection of surface and underground geological samples. These surveys were followed by extensive drilling and limited blasting of rock in the area of what is now the site of the open pit. The total area impacted is estimated to have been approximately 35 ha. However, most of the areas impacted during this period have now been excavated to form the open pit. Therefore, whilst the negative impacts are likely to have been locally intense, the limited evidence available suggests that they were only of moderate importance.

One of the most important negative impacts that would have occurred during this period would have been disturbance due to noise and vibration. This would have ranged from low intensity and very short duration in the case of aerial surveys, to much more prolonged and higher intensity in the case of drilling operations. These would have disturbed large and small game animals in the area and are therefore considered to have been moderately important.

Possible secondary negative impacts could have included some contamination of groundwaters with nitrogen from the explosive charges. There is also a small chance that the groundwater might have contained slightly higher levels of uranium through increased leaching in blast holes. Blasting would also have caused some local shattering of rock formations with possible changes to the rates and directions of groundwater flows. However, these secondary impacts are likely to have been very localized and were probably confined to the general area of the present open pit. These secondary impacts are therefore considered to have been of minor importance.

### 4.2.4 Pilot Plant

The pilot plant was constructed during 1970 on the site of the present mine plant. The works were on a relatively large-scale, covering an estimated area of 4 ha, in order to reduce the problems of scale-up to final production. All facets of the operation, from crushing to product recovery, were contained in the pilot plant. Negative impacts would have been very varied, including periods of intense noise and high dust levels. Technicians and engineers working in the final stage of product recovery would also have been exposed to slightly higher levels of radiation than other workers. However, these are not expected to have been significantly higher than those registered under current operational conditions. Nevertheless, careful attention to safety reduced the risk of excessive exposures to radiation and harmful dust levels. During the period that the pilot plant was in operation, negative impacts on the workforce would therefore have been moderate though localized to the immediate vicinity of the plant. They are therefore considered to have been of moderate importance.

Portions of the pilot plant were enlarged and incorporated into the present- day mine plant. Borrow pits and rock piles used in levelling the site of the pilot plant have been filled in or flattened during construction of existing roadways, offices and mine plant. Any negative impacts that the pilot plant might have had on local ecosystems will have been masked by the impacts of the present facilities. While these impacts may have been important at the time, they are now considered to be negligible.

### 4.2.5 Mining Activities

Mining activities carried out during the early exploration phase consisted largely of underground works. A 3.5 m diameter shaft was sunk to a depth of 115 m, followed by an underground development of approximately 2750 m at this level, from which an extensive programme of underground bulk sampling was conducted. Impacts would have included noise and shock disturbance due to prolonged periods of diamond drilling as well as blasting. Whilst these negative effects would have been greatest in the immediate vicinity, they would certainly have been perceptible even at a distance of 1 kilometre.

Negative impacts on the workforce would have been moderate though restricted largely to those in the immediate vicinity of the activities. They are therefore considered to have been of moderate importance. Negative impacts on nearby plant and animal communities would have been severe during this period and are therefore considered to have been important. However, the incorporation of the site within the open pit has removed any sign of these activities.

Similarly, the transport and stockpiling of ore samples and waste rock from the early underground workings are likely to have caused severe levels of disturbance to nearby plant and animal communities. These negative impacts would have mainly taken the form of increased dust and noise levels, and are therefore considered to have been important. Whilst the sites of these activities have been incorporated into the present mine workings, their original impact has now been accentuated by the far greater impacts of the current operations.

### 4.2.6 Waste Disposal System

Wastes generated during the exploration and construction phases consisted of sewage as well as domestic and industrial refuse. All refuse and waste or disused building materials were removed from the sites by truck or buried under rock and sand as filler material. The total extent of waste disposal areas is estimated to have been less than 1 hectare and the impacts of the buried wastes are considered to have been negligible.

All sewage from the exploration and construction camps was treated in septic tanks which drained into Panner and Dome Gorges, respectively. While the nitrogenous material in the sewage caused some localized greening of perennial vegetation downstream of the sites, no subsequent contamination of the groundwater was detected. The impacts are therefore considered to have been benign.

During the later construction phase from 1974 to 1976, a conventional activated sludge sewage treatment plant with a capacity of 750 $m^3$ $day^{-1}$ was built to treat the sewage from the construction workforce. This treatment plant is located some 600 m east of the main road entering the mine, and is now known as the central sewage plant. All sludge was dried in drying beds, stockpiled and buried. The final effluent from this plant was used in dust control on road surfaces and the small amount of excess was drained into Dome Gorge. Once again, the impacts were confined to localized greening of vegetation and the impacts are considered to have been of minor importance.

### 4.2.7 Site Reclamation Activities

The only significant site reclamation activities undertaken to date have been the restoration of the original exploration and construction camps. The areas impacted by other activities have now mostly been covered by the site of the present-day open pit and mine plant.

The exploration camp consisted mainly of mobile homes and temporary structures, and was therefore dismantled with relative ease. All man-made structures and materials were removed and the site levelled with local materials using a grader. The original disturbed area has been partially re-colonized by a few indigenous grasses and no further remedial work is necessary. Impacts are therefore assessed as zero or benign.

The construction camp was dismantled after the mine had reached full production; all man-made structures and materials were removed or buried on site using local soil and rock. The remaining disturbed area has largely recovered and has been colonized by indigenous grass and shrub species. No alien plants were found during ground surveys conducted in 1989 and 1990 and the impacts have decreased to near zero after reclamation. No additional remedial work is required though the area could easily be examined for the presence of alien plants at annual or bi-annual intervals.

## 4.3 Current Mining Activities

The environmental impacts that have already occurred or continue to occur during the current mining activities at the Rössing Mine are summarized in Table 4.4. Each type of activity and the extent and importance of the resulting impacts are described more fully below.

### 4.3.1 Open Pit

The Rössing open pit has been developed since 1974 in a series of "benches" or levels, each 15 m high and inter-connected by a system of haulroads. By 1990, the pit bottom has reached bench 18, equivalent to a depth of approximately 270 m, with the total area that has been impacted by the excavations amounting to approximately 400 hectares (Table 4.2). Features of the original landscape on the site have been entirely removed, The large-scale drill, blast, load and haul operations at

Rössing have required the development of sophisticated control systems for ensuring that the correct quantities of appropriate ore grades are processed at the right time. At Rössing, approximately 150 000 tonnes of rock are removed from the open pit each day, of which, some 40 000 tonnes of low grade ore are processed each day. In this study, the impacts of all activities within the open pit have been considered together.

The most severe negative impacts of open pit activities are those due to elevated noise, dust and radiation levels, together with the loss of scenic diversity. Other moderately important negative impacts include loss of plant, animal and bird species in the area, changes to the groundwater chemistry and microclimate, and an increase in the erosion potential of the sandy soils and untarred road surfaces.

Continuous noise disturbance is most intense in areas near to the drilling operations and the loading shovels and is considered to be an important negative impact. However, this is frequently accentuated by the engine noise of road scrapers, water trucks employed on dust control and haul trucks. The incorporation of an electrical trolley-assist system for the haul trucks has partly reduced noise levels on the haulroads. The twice weekly blasts causes intense noise disturbance that is audible for several kilometres for very short periods on Tuesdays and Thursdays. All open pit personnel and vehicle operators are equipped with hearing protectors to reduce the impacts of noise.

All blasting and rock loading areas, as well as all haul roads, are watered down to reduce dust levels in the open pit. While this reduces ambient dust levels, it can have a moderate negative impact through the contamination of seepage water due to increased levels of dissolved salts and radionuclides. However, this secondary impact is reduced considerably through the system of seepage trenches and water extraction wells (Section 4.6). The bi-weekly blasting schedule causes a marked rise in dust levels for short periods in the open pit and nearby and is thus considered to have a moderately negative impact. The strong east winds that characterize the winter months also cause a dramatic increase in ambient dust levels in the open pit and surrounding areas. Under these conditions, dust originating in the open pit area is considered to be above tolerable levels and therefore has a negative impact. However, even though some of the dust to the south west of the open pit originates in the open pit, a far greater proportion is derived from the surrounding arid countryside and the tailings dam surface.

Blasting activities in the open pit also contribute to elevated levels of radiation in the dust and atmosphere (Dames & Moore, 1984a), a serious negative impact. Watering-down markedly reduces the aerial dispersion of uranium ore dust though it does not reduce the exposure of open pit personnel to radon inhalation. All vehicles and machinery cabins are equipped with air conditioning systems to reduce dust and radiation exposures.

Mining activities in and around the open pit have had moderately negative impacts on habitat availability and diversity. This will have had important negative consequences for plant, animal and bird life in the area, despite the availability of similar habitat nearby. The prolonged noise disturbance has undoubtedly had a moderately negative impact on animal and bird communities in the region of the open pit and has accentuated the impacts caused by loss of habitat. These impacts are considered to have important negative effects in the case of rare or endangered species.

The erosion potential of the open pit area has been increased with the construction of untarred roads. While this potential is only likely to be realized during very occasional high-intensity rainfall events, the current dust suppression activities do lead to minor cases of wash-off along road margins. Since any erosion that occurs in the open pit will not affect outside areas, the open pit must therefore be considered to have only a minor negative impact on erosion potential.

**TABLE 4.4** Matrix of environmental impacts resulting from current mining activities at the Rössing Uranium Mine.

| Environmental Characteristics | | Activities causing environmental impact (See list of activities in footnote) | | | | | |
|---|---|---|---|---|---|---|---|
| Category | Element | 1 | 2 | 3 | 4 | 5 | 6 |
| Geology | Regional System | 0 | 0 | 0 | 0 | 0 | 0 |
| | Local System | -1 | 0 | 0 | 0 | 0 | 0 |
| | Special Features | -2 | 0 | ? | ? | ? | 0 |
| Geomorphology | Soil Quality/Type | -1 | -1 | 0 | 0 | +1 | 0 |
| | Erosion Status | -2 | 0 | -1 | -1 | 0 | +1 |
| Climate | Climatic Pattern | 0 | 0 | 0 | 0 | 0 | 0 |
| | Microclimate | -1 | 0 | -1 | 0 | ? | 0 |
| Hydrology | Surface Waters | | | | | | |
| | (Perennial) | 0 | 0 | 0 | 0 | 0 | 0 |
| | (Temporary) | -1 | 0 | 0 | 0 | 0 | 0 |
| | Underground Water | -3 | -1 | -1 | -1 | ? | +2 |
| Vegetation | Regional Zonation | 0 | 0 | 0 | 0 | 0 | 0 |
| | Local Patterns | -2 | -1 | -2 | -1 | -1 | 0 |
| | Variations (season) | 0 | 0 | 0 | 0 | 0 | 0 |
| | Endangered Species | -2 | ? | ? | -1 | -1 | 0 |
| | Alien Vegetation | -1 | 0 | -1 | -1 | -3 | 0 |
| Animals & Bird Life | Corridors | ? | ? | ? | ? | ? | 0 |
| | Habitat Variety | -1 | -1 | -1 | -1 | -1 | 0 |
| | Habitat Extent | -2 | -1 | -1 | -1 | -1 | 0 |
| | Endangered Species | -3 | -1 | -1 | -1 | -2 | ? |
| Aquatic Life | Variety | 0 | 0 | 0 | 0 | 0 | 0 |
| Air Quality | Dust | -3 | -2 | -2 | -2 | 0 | +3 |
| | Radio-nuclides | -2 | -2 | -3 | 0 | 0 | +3 |
| Noise | Intensity | -3 | -1 | -2 | -1 | 0 | +3 |
| | Duration >40 db | -3 | -1 | -1 | 0 | 0 | +3 |
| Aesthetics | Landscape Diversity | -2 | -2 | -2 | -1 | -1 | 0 |
| | Scenic views | -3 | -2 | -2 | -1 | -1 | 0 |
| Social | People at Home | 0 | 0 | 0 | 0 | 0 | +1 |
| | People at Work | 0 | 0 | 0 | 0 | +1 | +2 |
| | People at School | 0 | 0 | 0 | 0 | 0 | +1 |
| | People at Play | 0 | 0 | 0 | 0 | 0 | +1 |
| | Vehicle Occupants | 0 | 0 | 0 | 0 | +1 | +2 |
| | Pedestrians | 0 | 0 | 0 | 0 | +1 | +1 |
| Socio-economic | Regional Income | 0 | 0 | 0 | 0 | 0 | 0 |
| | Education Standard | 0 | 0 | 0 | 0 | 0 | +1 |
| | Demographic pattern | 0 | 0 | 0 | 0 | 0 | 0 |
| | Land values | 0 | 0 | 0 | 0 | 0 | +1 |

1 = Open pit
2 = Ore dumps and stockpiles
3 = Ore processing facilities
4 = Borrow pits
5 = Mine offices, gardens and security
6 = Environmental monitoring procedures

4.3.2 Ore Dumps and Stockpiles

At the Rössing Uranium Mine, trucks loaded with rock extracted from the open pit are graded with radiometric scanners to determine whether the ore grade is suitable for direct crushing. Waste rock containing insufficient uranium grades to justify economic extraction is dumped in one of the designated dumping areas. Ore with the appropriate uranium grade and calc index is crushed directly and transported to the coarse ore stockpile which has a basal area of some 11 hectares. From the coarse ore stockpile, the ore is transported to further crushers, after which it is delivered to the covered fine ore stockpile, which has a basal area of less than 1 hectare (Table 4.2).

Where uranium grades are potentially economically recoverable, but the calc index is unsuitable, then the load is dumped on one of three designated high calc dumps. These high calc dumps are located on top of waste rock dumps. Where the grades of suitable calc index material are not economically recoverable at present, but could be economical in the future, the material is dumped on one of four designated low grade dumps. These low grade dumps are normally located on top of waste rock dumps.

The six ore dumps are located next to, or on top of waste rock dumps, near the perimeter of the open pit and cover a total area of some 80 hectares. Each dump is easily accessible by haultruck and all roads leading to these dumps are watered down to reduce dust levels.

The coarse and fine ore stockpiles have environmental impacts that are essentially similar to those of the ore dumps, with the exception that the ore stockpiles will be likely to have greater impacts on mine personnel due to their closer proximity. For convenience, the impacts of both are therefore considered together (Table 4.4).

The most severe negative impacts of the ore dumps and stockpiles are those due to elevated dust and radiation levels, together with the loss of scenic diversity. Impacts of minor negative importance include loss of plant, animal and bird species in the area, elevated noise levels, increased erosion potential and potential contamination of groundwater supplies. The small extent of the dumps and stockpiles suggests that their impact on special features of geomorphological interest is negligible. The negative impacts of high dust and radionuclide levels in the vicinity of the ore dumps and stockpiles are considered to be moderately important, though the extent of these impacts is usually localized. During the winter months high east wind speeds extend the area of impact and accentuate their importance. The application of appropriate safety procedures will reduce the importance of this impact to moderate levels.

To most observers, the ore dumps and stockpiles are visually intrusive, hence the moderately negative impact. The high percentage of live storage in the dumps and stockpiles is, however, the key to maintaining this negative impact at moderate levels.

The loss of plant, animal and bird species in the areas affected by the ore dumps and stockpiles has a minor negative impact due to the relatively small area involved. Additional disturbance due to elevated noise and dust levels accentuates this negative impact locally. A secondary negative impact is the contamination of groundwater with salts and radionuclides leached from the dumps and stockpiles. This impact will be of minor importance and its effects will largely be neutralized by the system of seepage drains and water recycling. Some changes to local soils can be expected due to inputs of dust, but these are considered to be negligible. Similarly, the increased erosion potential of wind-blown dust originating from the dumps is unlikely to have more than minor negative impacts.

### 4.3.3 Ore Processing Facilities

The facilities and procedures used for ore processing include all the processes from crushing to final product recovery, and cover an area of some 100 hectares (Table 4.2). With the exception of the primary crusher and conveyors, the plant and process facilities are located in close proximity to one another and their impacts are therefore discussed together.

Once again, the most important negative impacts are those due to elevated dust, noise and radiation levels, together with emissions of harmful gases such as sulphur dioxide from the acid plant. These are followed by moderately important aesthetic effects due to the visual impact of the facilities and the loss of scenic diversity (Table 4.4). Any negative impacts due to elevated dust, noise and radiation levels are particularly acute in close proximity to the sources and diminish with distance. Careful training of personnel and the use of appropriate safety equipment and procedures has reduced these impacts to more moderate levels.

Loss of habitat for indigenous plant, animal and bird species from the site has had a minor negative impact due to the relatively small area involved. However, the disturbance due to building and construction activities has created small areas that are suitable for colonization by alien plants. This is considered to have had minor negative impacts in the area of the ore processing facilities, which could however be accentuated by further horticultural activities where alien plants are introduced to the area. Clearly, the layout of gardens around a factory will improve the aesthetic appeal of a particular facility; however, the use of alien vegetation will increase greatly the risk of negative ecological impacts.

Virtually the entire area involved in ore processing activities has either been paved, tarred or roofed over. The resulting impermeable surfaces have increased the negative impacts of runoff by acting as collection areas for dust, and by focusing runoff into smaller areas. In turn, this has increased the negative impacts on erosion potential in unlined storm drains and the runoff is likely to have had a minor negative impact on groundwater quality in seepage areas. However, this would have largely been counteracted by the system of groundwater collection wells and seepage trenches.

The discharge or loss of steam, together with emissions of sulphur dioxide from the acid plant during normal operating conditions will have had minor negative impacts on the microclimate in the vicinity of the ore processing facilities. Whilst it is more important to note that increased discharges of sulphur dioxide could cause serious health hazards to mine personnel, this gas can also cause serious corrosion of machinery. The current levels of $SO_2$ emission are of concern since air concentrations can on occassion exceed acceptable international limits, both inside the mine and in the surrounding environment. Recognizing the danger of sulphur dioxide emissions, the frequency of occurrence suggests that this impact is of moderate importance, and must continue to be monitored closely. Various options to control the frequency and extent of $SO_2$ emissions are currently under consideration.

### 4.3.4 Borrow Pits

Borrow pits totalling some 50 hectares in extent have been dug during the current mining operations at Rössing (Table 4.2). The majority have been sited in the bottoms of Dome, Pinnacle and Panner Gorges, the sand and rock being used for the construction of road surfaces, seepage dam walls and the first (basal) portions of the tailings dam. With continued developments at Rössing, most of the borrow pits in Dome and Pinnacle Gorges have been covered by waste rock dumps and are no longer visible. Similarly, three of the four borrow pits near the original tailings dam wall have subsequently been covered by tailings deposits. Active borrow pits are still maintained in Pinnacle Gorge and in the area to the west of the tailings dam.

Elevated dust levels in the vicinity of borrow pits and, to a lesser extent, loss of scenic diversity, are the most important negative impacts (Table 4.4). However, whilst the extent of these impacts has been reduced by the covering of waste rock, the subsequent negative impacts of the waste rock dumps (see Section 4.5.1) has been far greater. Negative impacts due to elevated dust levels near active borrow pits are important during the removal of material.

Borrow pits have additional negative impacts, though these are now only of minor importance, through the clearing of surface vegetation and the loss of plant, animal and bird habitats. Whilst the importance of these impacts would have been roughly proportional to the area cleared, they would have had greater importance in areas where scarce or endangered species previously occurred. The areas of disturbed ground around borrow pits would also provide suitable habitat for colonization by alien plants, and act as rainwater collectors during the infrequent rain storms, focusing the runoff from a far wider area than the pit itself. This runoff can erode the borrow pit walls and gain appreciable levels of dissolved salts. This would have a minor negative impact through increased salt loads percolating into the groundwater.

### 4.3.5 Mine Offices, Gardens and Security

The mine offices and gardens cover a total area of approximately 25 hectares while the security fencing and access road has affected an additional 4 hectares (Table 4.2). All roofing and the stone-paved and tarred areas around the offices would collect and focus rainwater into the drainage ditches. The security fencing surrounding the mine works is designed to prevent theft and deny access to unauthorized persons.

The loss of indigenous plant, animal and bird habitats and communities through construction of the offices and gardens and erection and patrolling of fences is considered to have had moderately important negative impacts (Table 4.4). However, the impact on scarce and endangered species has been somewhat accentuated by the introduction of alien plants into the mine gardens, and the arrival of alien bird (and possibly insect) species.

Significant soil improvements have been achieved through the incorporation of composted sewage sludge and regular watering. These are considered to have had a moderately positive impact, though the overall impact has been to promote the growth of alien organisms. Overall, the positive impact is therefore considered to have been minor.

The visually intrusive security fencing is considered to have a moderately negative impact on aesthetic values. However, this is counteracted to some extent by the lay-out of the roads and buildings, while the attractive appearance of the well designed gardens and offices are considered to have a positive impact on all mine personnel.

### 4.3.6 Environmental Monitoring Procedures

Environmental surveillance procedures at Rössing Mine are designed primarily to identify and quantify any adverse effects that mining activities may have on mine personnel and the surrounding terrain. Wherever practicable, remedial actions are implemented to reduce particular impacts, for example, excessive dust or noise levels. Additional experimental studies are conducted to design