CAMERONS CAVE TROGLOBITIC COMMUNITY, CAMERONS CAVE MILLIPEDE AND CAMERONS CAVE PSEUDOSCORPION INTERIM RECOVERY PLAN 2000-2003

by Sally Black, Andrew Burbidge, Darren Brooks, Peter Green, William F Humphreys, Peter Kendrick, Doug Myers, Ron Shepherd and Joanne Wann

A harvestman (*Glennhuntia glennhunti*). Photo: Douglas Elford, W.A. Museum

2001

INTERIM RECOVERY PLAN NO. 76

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

Natural Heritage Trust
Helping Communities Helping Australia

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by

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February 2001

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FOREWORD

Interim Recovery Plans (IRPs) are developed within the framework laid down in Department of Conservation and Land Management (CALM) Policy Statements Nos 44 and 50.

IRPs outline the recovery actions that are required to urgently address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process.

This Interim Recovery Plan covers the Camerons Cave Troglobitic Community and two of its component taxa, the Camerons Cave Pseudoscorpion *Hyella* sp. and the Camerons Cave Millipede *Stygiochiropus peculiaris*. It will also cover any taxa restricted to the Community that may be declared as threatened in the future.

CALM is committed to ensuring that Critically Endangered ecological communities and species are conserved through the preparation and implementation of Recovery Plans or Interim Recovery Plans and by ensuring that conservation action commences as soon as possible and always within one year of endorsement of that rank by CALM's Director of Nature Conservation.

This Interim Recovery Plan will operate from July 2000 but will remain in force until replaced by a full Catchment Recovery Plan.

This IRP was approved by the Acting Director of Nature Conservation on 1 May 2001. The provision of funds identified in this Interim Recovery Plan is dependent on budgetary and other constraints affecting CALM, as well as the need to address other priorities.

Information in this IRP was accurate at 14 February 2001.

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SUMMARY

Name: Camerons Cave Troglobitic Community, Camerons Cave Millipede *Stygiochiropus peculiaris*, and Camerons Cave Pseudoscorpion *Hyella* sp.

Description: Camerons Cave Troglobitic Community (obligatory cave inhabitants) is known only from Camerons Cave (karst index C-452) on the Cape Range peninsula. The community is recognisable by its unique composition of species, of which at least eight are known only from this location. The assemblage is related to those found in caves in Cape Range *sensu stricto*. However, all species with congeneric members in caves in Cape Range proper have, to date, proved to be distinct species. Camerons Cave occurs within the Exmouth townsite. It is unprotected and the area around the cave is subject to various proposed developments. The listed threatened species Camerons Cave Millipede *Stygiochiropus peculiaris*, and Camerons Cave Pseudoscorpion *Hyella* sp. BES 1154.2525, 1546, 2554 are endemic to Camerons Cave.

CALM Region(s): Pilbara

CALM District(s): Exmouth

Shire(s): Shire of Exmouth

Recovery Team: The North West Cape Karst Management Advisory Committee (NWCKMAC). Members represent the Western Australian Speleological Group (Exmouth), CALM (Pilbara Region, Exmouth District, WA Threatened Species and Communities Unit), Shire of Exmouth, Western Australian Museum, Water and Rivers Commission, and the Department of Defence.

Status: Community assessed by WA Threatened Ecological Communities Scientific Advisory Committee on 23 June 1998 as Critically Endangered. To be nominated as a threatened ecological community in the Critically Endangered category in the Australian and New Zealand Environment and Conservation Council's list of nationally threatened ecological communities. If accepted by ANZECC, it will be considered for listing under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. Species assessed by the WA Threatened Species Scientific Committee as Critically Endangered in May 1998.

Habitat requirements: The single known occurrence of Camerons Cave Troglobitic Community occurs within Camerons Cave (karst index C-452), located on the Cape Range peninsula. It relies on particulate and dissolved sources of organic carbon for food. This food source is allochthonous, that is, comes in from outside the cave at the surface. The community is also reliant on the humid conditions in Camerons Cave, which are created through contact with the water table and specific surface conditions.

Critical habitat: Camerons Cave, the doline in which the entrance occurs, the water in the cave, the groundwater feeding the water in the cave and its catchment, and the interstices in the limestone adjacent to the cave in which the terrestrial components of the Community live.

IRP Objective(s): To maintain or improve the overall condition of the community and reduce the level of threat to its survival towards downgrading it from Critically Endangered to Endangered.

Criteria for success:
1. Camerons Cave, and an appropriate buffer zone around it, declared a Class A nature reserve vested in the Conservation Commission of Western Australia.
2. Appropriate land use controls being put in place for land considered to be in or above the catchment affecting the groundwater or surface inflows to Camerons Cave.
3. The continuing existence of *Hyella* sp. and *Stygiochiropus peculiaris* within Camerons Cave.
4. The identification of existing and potential threatening processes affecting the troglobitic community and Camerons Cave habitat, and instigation of actions to ameliorate or reduce them.

Criterion for failure: Failing to detect *Hyella* sp. and *Stygiochiropus peculiaris*, or failing to ameliorate major threats to the habitat.

Recovery Actions:

Established Recovery Actions

1. Establish recovery team.
2. Liaison with other authorities and land users regarding land uses and threatening processes that may adversely impact on Camerons Cave and the troglobitic community.
3. Construction of an appropriate gate at Camerons Cave entrance.

Additional recovery actions

4. Survey further likely areas for additional occurrences of the Camerons Cave Troglobitic Community within the known distribution of elements of the community.
5. Examine and report on hydrology, geology, and drainage around Camerons Cave, and make recommendations as to appropriate reservation and other management steps to safeguard the troglobitic community.
6. Carry out management actions such as signage and fencing of an appropriate reserve at Camerons Cave.
7. Seek to acquire Camerons Cave for addition to the reserve system.
8. Continue to liaise with other authorities and land users regarding land uses and threatening processes that may adversely impact on Camerons Cave and the troglobitic community.
9. Ensure land use planning and development control processes effectively safeguard against potentially adverse impacts of development on Camerons Cave and the troglobitic Community.
10. Monitor Camerons Cave Troglobitic Community and respond to results of monitoring as appropriate
11. Monitor water quality and levels in Camerons Cave to establish long term trends.
12. Liaise with stakeholders to continue to monitor and manage groundwater quality and levels for the Cape Range peninsula.
13. Report on success of management strategies for the Camerons Cave and the troglobitic community.

1. BACKGROUND

1.1 History, defining characteristics of ecological community, and conservation significance

Recent investigations of coastal karst in Western Australia have led to the discovery of a distinct troglobitic community (obligatory cave inhabitants) endemic to Camerons Cave (karst index C-452). Camerons Cave occurs on the eastern coastal plain of the Cape Range peninsula, an area also known as the North West Cape. Camerons Cave is a Doline about 10 m x 15 m in diameter, with a hole in the middle that drops into a horizontal cave that goes down to and beyond the watertable.

The Camerons Cave Troglobitic Community is recognisable as a unique composition of terrestrial and aquatic hypogean species, of which at least eight are known only from this location.

Camerons Cave Troglobitic Community is related to assemblages found in caves in Cape Range *sensu stricto* (papers in Humphreys 1993). However, all species with congeneric members in caves in Cape Range proper have, to date, proved to be distinct species. A number of caves, like Camerons Cave, have been artificially irrigated and supplied with leaf litter to try and find additional occurrences of the troglobitic community, without success. Camerons Cave occurs within the Exmouth townsite. It is unprotected and the area around the cave is subject to various proposed developments.

1.2 Extent and location of occurrences

Only a single occurrence of Camerons Cave Troglobitic Community is known. The community occurs within Camerons Cave, which is located within the Exmouth townsite on Lot No. 1388, on the eastern coastal plain of the Cape Range peninsula. Camerons Cave entrance occurs at an altitude of *ca* 13 m. The cave has a maximum depth of 17 m and is approximately 65 m long by up to 34 m wide. The roof of the cave is 5 m thick.

1.3 Critical habitat

Critical habitat is habitat identified as being critical to the survival of a listed threatened species or community. Habitat means the biophysical medium or media: (a) occupied (continuously, periodically or occasionally) by an organism or group of organisms; or (b) once occupied (continuously, periodically or occasionally) by an organism, or group of organisms, and into which organisms of that kind have the potential to be reintroduced (*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)).

The critical habitat for Camerons Cave Troglobitic Community and of Camerons Cave Millipede *Stygiochiropus peculiaris* and Camerons Cave Pseudoscorpion *Hyella* sp. is Camerons Cave, the doline in which the entrance occurs, the water in the cave, the groundwater feeding the water in the cave and its catchment, and the interstices in the limestone adjacent to the cave in which the terrestrial components of the Community live.

1.4 Biology and ecology

Camerons Cave contains four species of Threatened Fauna—*Milyeringa veritas, Draculoides bramstokeri, Hyella* sp. and *Stygiochiropus peculiaris*. *M. veritas* is listed in the vulnerable category of the List of Threatened Species established under section 178 of the Commonwealth EPBC Act. *Hyella* sp. is listed as Critically Endangered and *Milyeringa veritas*, *Draculoides bramstokeri* and *Stygiochiropus peculiaris* are listed as Vulnerable in the ANZECC List of threatened Australian fauna. The three invertebrate taxa are under consideration for listing under the EPBC Act. Of the four threatened species, *Hyella* sp. and *Stygiochiropus peculiaris* are endemic to Camerons Cave.

M. veritas (troglomorphic) and Copepoda are among Camerons Cave's aquatic fauna. Most of the troglobitic species found there are known from nowhere else and therefore likely to be subject to the same level of threat as the cave community itself. These include:

• *Stygiochiropus peculiaris* Shear and Humphreys (Diplopoda: Polydesmida: Paradoxosomatidae Australiosomatinae: Antichiropodini) which is only known from six specimens (2 collected dead) from Camerons Cave. Three other species of the genus, which is endemic to Cape Range (Humphreys and Shear 1993, Shear and Humphreys 1996), occur in Cape Range *sensu stricto*;
• *Hyella* sp. (Pseudoscorpionida: Hyidae) which is only known from the dark zone of Camerons Cave, from 4 female, one adult male and 5 immature specimens (specimens BES 2545, 2546, 2554, 4249, 4148, 4149, 4154, 1154 and 2525). Another species of the genus, which is endemic to Cape Range (Harvey 1993) occurs in Cape Range *sensu stricto*;
• A troglomorphic harvestman (Opilionida: Assamiidae) (specimens BES 2549 and 4189);
• A troglomorphic harvestman *Glennhuntia glennhunti* (Opilionida: Phalangodidae) which is the only known specimen of the family Phalangodidae from Cape Range (specimen BES 2543);
• An undescribed troglomorphic species of cave spider (Hahniidae: Araneae), known from one specimen (specimen BES 1155). A related troglomorphic species is known from caves in Cape Range proper;
• *Phaconeura* sp. nov. (Hemiptera: Meenoplidae), which is troglomorphic (H. Hoch[1] pers. comm.) and very different from all other *Phaconeura* (specimen BES 2544). It is know only from Camerons Cave. Another species of *Phaconeura* occurs in caves in Cape Range proper (Hoch 1993);
• An undescribed troglomorphic species of cave spider (Ctenidae: Araneae) known from three juvenile specimens (specimens BES 2526, 2539 and 2541). Related epigean and troglobitic species are known from Cape Range proper (Harvey *et al*. 1993); and,
• *Trichocyclus* sp. (Pholcidae: Araneae) which is known from three specimens (specimens BES 2021 and 4248).

Other interesting and characteristic species include:
• *Draculoides bramstokeri* Harvey and Humphreys (Schizomida: Hubbardiidae), which is known from one other location in Exmouth and from Barrow Island (Harvey and Humphreys 1995). Several other species in the order Schizomida are known from Cape Range caves both from the coastal plain and the range proper, they are mostly troglomorphic (Harvey *et al.* 1993; M.S. Harvey[2], pers. comm.); and,
• *Trichocyclus* sp. (Pholcidae: Araneae), which is known from only three specimens (specimens BES 2021 and 4248). Other fauna (probably epigean) whose status is unknown include: Isopoda: Oniscoidea: Armadillidae; *Ploiaria* sp.1 (Hemiptera: Reduviidae: Emesinae); ?*Centrogonus* sp. (Hemiptera: Reduviidae: Emesinae); Coleoptera: Trogidae; Blattodea; Collembola; and Calanoida.

Camerons Cave Troglobitic Community relies on particulate and dissolved sources of organic carbon as a primary source of food. This food source is allochthonous, that is, comes in from outside the cave, and is primarily transported by the influx of water. Hence, the intensity, frequency, and periodicity of rainfall will also determine that of their energy recharge (Humphreys in press a). The community is also reliant on the humid conditions in Camerons Cave, which are created through contact with the water table, as well as specific surface conditions.

1.5 Hydrology

The karst terrain precludes surface runoff except after exceptional rainfall. No runoff is likely to occur following a single rainfall event of less than about 25 mm. Such rainfall, and hence minor energy recharge of some caves, occurs on average once every 5.4 months, but with very low predictability. Major flows of water that are sufficient to flood caves deeply, are likely to occur once in 4.7 years (single falls of rain >150 mm). Rainfall events of more than 100 mm occur about once every three years (Humphreys in press b). Owing to the unpredictable climate, there is no seasonality associated with rainfall or energy influx. Caves on the Cape Range peninsula rarely contain drip-water; where it occurs, it is very localised following heavy rain. Hence, the percolation of fine particulate and dissolved organic matter into caves must be extremely restricted or even non-existent.

Camerons Cave reaches the water table. The source of this groundwater is the highly porous, unconfined Cape Range Group aquifer system (the Trealla and Tulki Limestone). Groundwater levels in the area are

[1] Prof. Dr H. Hoch, Institut für Systematische Zoologie, Museum für Naturkunde der Humboldt-Universität, Invalidenstr. 43, 10115 Berlin, Federal Republic of Germany.
[2] Dr Mark Harvey, Western Australian Museum, Perth.

only marginally above sea level, and the general hydrogeological model for oceanic islands has been applied to the groundwater of Cape Range peninsula (following the Ghyben-Herzberg principle). A fresh water lens overlies salt water so that locally a wedge of salt water intrudes under the fresh water contained in the limestone, and a zone of mixing occurs between them, broadening towards the coast. In the Exmouth area, the fresh water-salt water transition is, at *c.* 5 km, described as exceptionally far inland. However, this is to be expected as the greater the transmissivity of the limestone and the more arid the area, the further inland the wedge should penetrate. The inland limit to the saltwater interface in the Exmouth area, appears to be controlled by the presence below the water table of solution cavities and channels (Humphreys in press a).

1.6 Threatening processes

There are a number of existing and potential threats to Camerons Cave Troglobitic Community and its endemic fauna. The severity of threat results from the fact that the community is known only from this single site. The immediate threats are as follows:

- Uncontrolled access to Camerons Cave and its surrounds,
- Modification of the catchment area and surface inflow of water to the cave,
- Pollution, and dumping of rubbish or toxic waste in Camerons Cave, and
- Decline of groundwater quality or levels in the Cape Range Group aquifer.

- **Uncontrolled access to Camerons Cave**

As the cave is located in a residential area of Exmouth Township, it is readily accessible to people and vehicles. Uncontrolled vehicle or heavy machinery activity or building on-site, particularly directly above the cavity, or explosives used too close to the cave, could cause surface subsidence or partial cave collapse.

People entering the subterranean cavity of the cave could also disturb the habitat and fauna if access were uncontrolled.

- **Modification of catchment area hydrology and surface inflow of water and solutes to Camerons Cave**

Urban, rural, industrial, recreational or other forms of development on-site, and in the area around Camerons Cave, are likely to modify the catchment area and, hence, surface water input to the cave, through altering drainage patterns, flow rates and volumes, and water-soil infiltration rates. Changed hydrological conditions, are likely to affect the input of allochthonous food resources, and to impact on the humidity in the cave.

There has been a proposal to site a horse-racing track on or adjacent to the area above the cave, and the general area is subject to boat harbour planning to include marina and canal residential developments.

- **Pollution and/or dumping of rubbish or toxic waste in Camerons Cave**

Camerons Cave and the troglobitic community could be threatened by contamination from nutrients, toxic substances, or other waste, originating from point or diffuse sources. The thin soil cover, typical of karst areas, provides little filtration of percolating fluids making such areas prone to contamination. In addition, the open conduit hydrological systems permit the rapid and distant spread of any contaminants (nutrients or toxins) introduced to the system. As the flushing of groundwater in the arid Cape Range area is exceptionally low, the residence time of contaminants would be long (Humphreys et al. 1999). The introduction of energy, via nutrients entering subterranean systems, changes the energy balance and enhances the competitive abilities of epigean organisms, allowing them to displace hypogean organisms that are adapted to a low energy environment (Humphreys *et al*. 1999a). Hence, these ecosystems are sensitive to pollution.

The risk of waste dumping and pollution will increase if access to the site and urban, rural, industrial or recreational development in the immediate area is not controlled.

- **Decline in groundwater levels and quality in the Cape Range Group aquifer**

Changes to groundwater levels and quality in the Exmouth Groundwater Subarea, have the potential to affect the stygofauna of the Cape Range peninsula, including that of Camerons Cave. Altered groundwater hydrology within Camerons Cave could result in loss or modification of habitat for aquatic taxa, and could impact on humidity levels important to troglobitic fauna.

Groundwater is naturally discharged from the aquifer by flow to the ocean, by several springs along the coast (including submarine springs), and by evapotranspiration from vegetation on the coastal plain. It is also discharged by abstraction from the well or borefield. Groundwater is the major water resource for Cape Range peninsula and is currently utilised to meet the public water requirements of the town of Exmouth plus private, tourist and industrial uses. This water resource is limited and is already heavily utilised in the Exmouth area.

The Groundwater Allocation Plan for the Exmouth Groundwater Subarea (Water and Rivers Commission, 1999) split the North West Cape into five subareas to facilitate management. Exmouth Central Subarea, which includes Camerons Cave, was created south of the town of Exmouth and predominantly covers the public water supply borefield. Water use in this area is close to 90% allocated, when compared to the sustainable yield of the aquifer (sustainable yield is total throughflow minus water reserved for protection of the aquifer and the environmental). The Commission has an adaptive management approach to groundwater allocation and a water level and quality monitoring program is in place to ensure that sufficient water has been reserved for protection of the aquifer and environment.

It is not known what water level and water quality values should be maintained on the Cape Range peninsula to protect the majority of the stygofauna, as the effect of changes in water levels and quality have not been completely studied for subterranean fauna. However, the Water and Rivers Commission utilised the precautionary principal in the setting of environmental water provisions in the Exmouth Groundwater Subarea, proposing that water levels and water quality be maintained at their present levels (Water and Rivers Commission 1999). Currently, groundwater resources are over-allocated in the Exmouth Town Subarea (Water and Rivers Commission 1999, 2000).

There is currently little pollution of the groundwater of the Cape Range peninsula, either from point sources (e.g. petrol tanks) or diffuse sources (e.g. fertilisers).

1.7 Guide for decision-makers

Section 1.6 provides details of current and possible future threats. Developments in the region of Camerons Cave require assessment. No developments should be approved unless the proponents can demonstrate that they will have no significant impact on the cave and its faunal communities. Impacts on the aquifer, either leading to its depletion or pollution, would be expected to have a significant impact on the threatened ecological community. Developments downstream as well as upstream of Camerons Cave need assessment, as downstream (eastward) changes may lead to an inflow of salt water.

1.8 Conservation status

Camerons Cave Troglobitic Community meets the following criteria for critically endangered communities (from English and Blyth 1997):

B (i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 5 years)

B (ii) current distribution is limited and very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes.

Stygiochiropus peculiaris and *Hyella* sp. meet criteria for Critically Endangered under IUCN (1994) Red List Criterion B1+2c. Under Criterion B1+2c, the extent of occurrence is less than 100 km^2 or the area of occupancy is less than 10 km^2, the species is known from a single location and a continuing decline in area,

extent or quality of habitat is inferred or projected. Both species are listed as threatened fauna under the *Wildlife Conservation Act 1950* and are ranked as Critically Endangered.

1.9 Strategy for recovery

Two strategies will be implemented:

- To identify management requirements and influence the management of Camerons Cave, and its catchment, to maintain the natural biological and non-biological attributes of the site.

- To conduct appropriate research into the ecology of Camerons Cave Troglobitic Community in order to develop further understanding about the management actions required to maintain or improve the condition of the community and its habitat.

2. RECOVERY OBJECTIVE AND CRITERIA

2.1 Objective

To maintain or improve the overall condition of the community and its endemic fauna and reduce the level of threat to its survival towards downgrading it from Critically Endangered to Endangered.

2.2 Criteria

2.2.1 Criteria for success

1. Camerons Cave, and an appropriate buffer zone around it, declared a Class A nature reserve vested in the Conservation Commission of Western Australia (CCWA).

2. Appropriate land use controls being put in place for land considered to be in or above the catchment affecting the groundwater or surface inflows to Camerons cave

3. The continuing existence of *Hyella* sp. and *Stygiochiropus peculiaris* within Camerons Cave.

4. The identification of existing and potential threatening processes affecting the troglobitic community and Camerons Cave habitat, and instigation of actions to ameliorate or reduce them.

2.2.2 Criteria for failure

Failing to detect *Hyella* sp. and *Stygiochiropus peculiaris*, or failing to ameliorate major threats to the habitat.

3. RECOVERY ACTIONS AND COSTS

3.1 Existing recovery actions

3.1.1 Establishment of a Recovery Team

The North West Cape Karst Management Advisory Committee (NWCKMAC) has been established to provide advice to CALM, and to other agencies and groups upon request, regarding the biological values of karst systems on Cape Range peninsula, and the management of those values. The committee functions as the recovery team for listed threatened species and ecological communities on Cape Range peninsula, and proposes to meet 2 or 3 times per year. Core membership includes representatives from: CALM (Pilbara Region, Exmouth District, WA Threatened Species and Communities Unit), the WA Speleological Group (Exmouth), the Shire of Exmouth, WA Museum, the Water and Rivers Commission, and the Department of Defence.

Responsibility: CALM (WATSCU and Exmouth District)
Cost: $20,000 (CALM's contribution for travel and accommodation over 3 years, plus time contributed by Committee members) (costs shared with IRP for North West Cape Remipede Community)
Completion Date: First meeting June 1999

3.1.2 Liaison with authorities and land users regarding land uses and threatening processes that may adversely impact on Camerons Cave and the troglobitic community

Camerons Cave and the proposed conservation reserve around it, lie within the Exmouth townsite. Several developments are pending in the area near the reserve, including subdivision of land, a boat harbour residential development and relocation of the racecourse. The Department of Land Administration (DOLA) has been advised of the occurrence of Camerons Cave Troglobitic Community, and liaison between DOLA and the NWCKMAC (through CALM) has been established. DOLA has plotted the location of the cave on their preliminary subdivision design plans.

Liaison with numerous other appropriate authorities and land users has been established through the NWCKMAC (refer 3.1.1). Additional bodies not represented on NWCKMAC, that have interests or responsibilities in karst area management, or in managing exploitation of resources on the Cape Range peninsula include the Department of Environmental Protection (DEP) and the Environmental Protection Authority (EPA); the Water Corporation (groundwater abstraction and monitoring), the Department of Minerals and Energy (limestone mining); the Gascoyne Development Commission (local social and economic development); the Gascoyne Coast Planning Coordinating Committee, Technical Advisory Group (GCPTAG) (two members of the NWKCMAC are also members of GCPTAG); the Coastal Zone Council; and, tourism operators (adventure caving etc). The majority of these bodies have been advised of the formation of the NWCKMAC and its aims.

Responsibility: CALM (WATSCU and Exmouth District) in liaison with the NWCKMAC
Cost: Nil
Completion Date: Ongoing

3.1.3 Construction of an appropriate gate on the cave entrance

In the 1998/99 funding year, a Bankwest *Landscope* Conservation Visa Card grant of $1000 was obtained to replace an old gate previously installed by the Shire of Exmouth. The new gate was installed in 1999. Works were overseen by a member of the WA Speleological Group in liaison with CALM (Exmouth District) staff. The replacement gate is lockable and inconspicuous. It consists of a galvanised, steel gate or lid in a frame concreted to the rock entrance to the cave. The lid is 2200 mm below ground level and in the centre of a depression. During the works, a large pile of gravel previously deposited near the entrance of the cave was removed.

Responsibility: CALM (WATSCU and Exmouth District) in liaison with the NWCKMAC

Cost: $1,000
Completion Date: 1999

3.2 Additional recovery actions

3.2.1 Survey further likely areas for additional occurrences of Camerons Cave Troglobitic Community, within the known distribution of elements of the community

Additional occurrences of the Camerons Cave Troglobitic Community (or new stygofauna community types) may occur in other caves or sinkholes in north-western Australia. While considerable sampling of cave and groundwater habitats has occurred on the Cape Range peninsula and adjacent areas, investigation into the extent of the karst stygofauna should be continued, with examination of further sites within the extent of the north-western Australian karst fauna (Cape Range peninsula, Barrow Island, Robe and Fortescue alluvial aquifers). Any new-found occurrences of Camerons Cave Troglobitic Community should be subject to cooperative management actions as listed in this IRP.

As a priority, the area in the vicinity of Camerons Cave should be sampled for threatened fauna in order to try to extend the geographic ranges of taxa. Some data could be gathered by the WA Speleological Group, in liaison with the North West Cape Karst Management Advisory Committee. For example, the installation of fauna traps in a small sinkhole to the south of Camerons Cave (near the proposed racecourse) has been identified by the NWCKMAC as a required action, and is to be carried out by the WA Speleological Group (Speleological Research Group). Ideally, some holes should be drilled for sampling. With the cooperation of landholders, sampling of private water bores that are not in use could also be conducted. Bores on Department of Defence land may also be suitable for sampling.

Responsibility: WA Museum in liaison with NWCKMAC
Cost: $10,000
Completion date: Ongoing

3.2.2 Examine and report on hydrology, geology, and drainage around Camerons Cave, and make recommendations as to management and reservation requirements

In the 1999/2000 funding year, a Natural Heritage Trust (NHT) grant was sought to support the 'North West Cape Endangered Cave Communities – Recovery Actions' project. This project includes both the Cape Range Remipede Community at Bundera Sinkhole, and Camerons Cave Troglobitic Community. The NHT grant contributes $19,000 to the overall budget of $35,000. The project encompasses employing a consultant to examine and report on the hydrology, geology, and drainage around Camerons Cave, and to make recommendations as to appropriate reservation and other management steps required to safeguard the troglobitic community. In addition, the short term actions such as signage and fencing of an appropriate reserve at Camerons Cave will be implemented under the project (refer to 3.2.3). Work is to commence in 2001.

The determination of surface levels and watersheds is a priority action. This work has commenced with the completion of a contour survey map for the Camerons Cave area, at a scale of 1:1000. Surveys of the below-ground extent of the cave have been completed by the WA Speleological Society.

Responsibility: CALM (WATSCU and Exmouth District) and the NWCKMAC
Cost: $4,000
Completion Date: 2001

3.2.3 Carry out management actions such as signage and fencing of an appropriate reserve at Camerons Cave

Under the 'North West Cape Endangered Cave Communities Recovery Actions' project, part funded by NHT in the 1999/2000 funding year, a consultant will be employed to examine and report on the hydrology, geology and drainage around Camerons Cave, and to make recommendations as to appropriate reservation and other management steps required to safeguard the troglobitic community (refer to 3.2.2). In addition, the

short term actions associated with recommended management will be implemented under the project. For example, actions may include signage and fencing of an appropriate reserve around Camerons Cave. Another priority action will be the development of an interpretation plan for the cave and the troglobitic community. Work is to commence in 2001. In 2000, the NWCKMAC discussed signage and fencing and decided that signs were unnecessary at present (and may draw attention to the site). Fencing will be further considered given that a reserve has been delineated and is soon to be declared (see 3.2.4).

Responsibility: CALM (Exmouth District and WATSCU) in liaison with the NWCKMAC
Cost: To be determined
Completion Date: 2001

3.2.4 CALM seek to acquire Camerons Cave and an appropriate buffer zone, for addition to the reserve system

The NWCKMAC has concluded negotiations with the Shire of Exmouth to have Camerons Cave and an appropriate buffer zone around it declared a Class A nature reserve vested in the CCWA. CALM will now ask DOLA to carry out the reservation. CALM, with NWCKMAC advice, will be responsible for implementing control of threatening processes, and for seeking planning arrangements to minimise threatening processes originating outside the reserve.

Boundaries have been agreed and the reserve area encompasses, at the surface, the full extent of the underground area of the cave. The buffer area around the cave is sufficient for maintenance of the catchment area and surface conditions affecting the humidity of the cave and allochthonous food resource input for the troglobitic community. Due to the risk of surface subsidence, the driving of vehicles and heavy machinery over the ground surface above the cave will be prohibited.

Responsibility: CALM (Park Policy and Tourism Section and Exmouth District)
Cost: To be determined
Completion date: 2001

3.2.5 Continue to liaise with authorities and land users regarding land uses and threatening processes that may adversely impact on Camerons Cave and the troglobitic community

Liaison with other authorities and land users regarding land uses and threatening processes that may adversely impact on Camerons Cave and the troglobitic community, has been established (refer to recovery action 3.1.2) and should be continued on an ongoing basis (refer to recovery action 3.2.6).

Responsibility: CALM (Exmouth District and WATSCU) and the NWCKMAC
Cost: Nil
Completion date: Ongoing.

3.2.6 Ensure land use planning and development control processes effectively safeguard against potentially adverse impacts of development on Camerons Cave and the troglobitic community

Camerons Cave lies on unallocated Crown Land, held by DOLA, and several developments are pending, including subdivision of land, a boat harbour residential development and relocation of the racecourse.

Operations or developments that have potential to cause pollution, or to impact on the hydrology of Camerons Cave ecosystem, should undergo environmental impact assessment. All developments on the Cape Range peninsula should be referred to the Environmental Protection Authority for assessment and should comply with both the Groundwater Allocation Plan for the Exmouth Groundwater Subarea (drafted by the Water and Rivers Commission Policy and Planning Division), and the Exmouth – Learmonth (North West Cape) Structure Plan (drafted by the Western Australian Planning Commission in conjunction with the Gascoyne Development Commission). The Gascoyne Coast Planning Coordinating Committee, Technical Advisory Group (GCPTAG) has been given the task of implementing the recommendations of the report on Karst management considerations for the Cape Range Karst Province, Western Australia, prepared for the Western Australian Department of Environmental Protection.

These plans provide the framework for State and local government decision making on development proposals, and will provide a level of certainty to the local community in terms of the type and scale of developments. Consequently, all development proposals, including all those that require groundwater, substrate, or waste disposal, will need to comply with the concepts within the structure plan. CALM, in liaison with the NWCKMAC, is currently investigating the potential for modifying the existing structure plan for the Exmouth area, considering that the area over and around Camerons Cave is currently marked for low intensity urban development.

Responsibility: CALM (Exmouth District and WATSCU) and the Environmental Protection Authority (EPA), in liaison with the NWKCMAC
Cost: nil
Completion date: Ongoing

3.2.7 Monitor Camerons Cave Troglobitic Community and respond to results of monitoring as appropriate

The NWCKMAC has identified the development of a monitoring plan for the fauna and physical environment of Camerons Cave as a priority action towards the conservation of the troglobitic community.

As a minimum monitoring requirement for the troglobitic community, the presence of *Hyella* sp. and *Stygiochiropus peculiaris* within Camerons Cave should be confirmed by bait sampling every two years. Ideally, the species composition and abundance of all dominant taxa within the community should be monitored.

The principal investigations of the fauna along the Cape Range peninsula were undertaken by the Western Australian Museum and associated researchers (Adams and Humphreys 1993; Bruce and Humphreys 1993; Danielopol *et al*. 2000; Humphreys 1993a, 1993b, 1994, 1999a, 1999b; 1999c, in press a, in press b, submitted; Humphreys and Adams 1991; Humphreys and Feinberg 1995; Humphreys *et al*. 1999; Jaume and Humphreys in press; Jaume *et al.* submitted; Karanovic *et al*. submitted; Pesce *et al*. 1996a, 1996b; Poore and Humphreys 1992; and Yager and Humphreys 1996). Further investigations into the karst environment and the subterranean fauna have been undertaken by the Water Corporation as part of the Consultative Environmental Review (Muir 1995), and in consultation with the Department of Environmental Protection (Hamilton-Smith *et al*. 1998).

The WA Speleological Group, Speleological Research Group, may be able to undertake some monitoring activities.

Responsibility: CALM (Exmouth District and WATSCU) in liaison with the NWCKMAC
Cost: To be determined
Completion Date: Monitoring program to commence as soon as possible, then ongoing

3.2.8 Monitor water quality and levels in Camerons Cave, and surface input of water-borne food sources, to establish long term trends

The current level of understanding of the Camerons Cave ecosystem and its ability to sustain subterranean fauna is elementary. There is a lack of basic data on groundwater movement, and on the effects of episodic rainfall on surface input of nutrients and water (Humphreys 1999). Information on these issues would permit ongoing assessment of the condition of Camerons Cave as a habitat, and provide insight into required strategies for managing the hydrology, and other important non-biological and biological processes.

The NWCKMAC has identified the development of a monitoring plan for the physical environment of Camerons Cave as a priority action for conservation management. It has been suggested that monitoring of water levels in the cave could be done by bore, with down-hole instrumentation, or by establishing instruments within the cave. Appropriate methodologies are under consideration and will proceed using equipment belonging to the Water and Rivers Commission.

Responsibility: CALM (Exmouth District and WATSCU) and Water and Rivers Commission, in liaison with the NWCKMAC
Cost: To be determined
Completion date: Monitoring program to commence as soon as possible, then ongoing

3.2.9 Liaise with stakeholders to continue to monitor and manage groundwater quality and levels for the Cape Range peninsula.

The NWCKMAC will continue liaison with the Water and Rivers Commission and other stakeholders that monitor, assess, and manage groundwater quality and levels for the Cape Range Group aquifer.

The Water and Rivers Commission manages groundwater resource utilisation and conservation in Western Australian. On the Cape Range peninsula, the licensing of all bores and wells is compulsory. Groundwater licensing administration is the responsibility of the Water and Rivers Commission's Gascoyne District Office, located in Carnarvon. The Groundwater Allocation Plan for the Exmouth Groundwater Subarea (Cape Range peninsula) has been developed to establish policies and principles for the sustainable allocation of groundwater resources. It provides direction for the district office in the issuing of groundwater licenses, with further specialist advice on groundwater matters available from the Water and River's Commission's Allocation's Branch.

As mentioned in section 1.6, Cameron's Cave is located in the Exmouth Central Subarea, where water use is close to 90% allocated. The management of wells or bores in the area involves limiting the quantity of water abstracted from the aquifer, and the physical area in which pumping occurs in order to maintain water levels and restrict saline upconing (Water and Rivers Commission 1999).

The Exmouth Subarea Allocation Plan (1999) stated that additional work was required to estimate the Ecological Water Requirements and Environmental Water Provisions for the subterranean fauna of the Cape Range Group aquifer. In particular, there is a requirement for further monitoring which includes the establishment of baseline data to help in the identification of acceptable environmental change (Waters and Rivers Commission 1999).

The Water Corporation is the major user of groundwater from the Cape Range Group aquifer, providing public water supply of 1029 ML per annum. The Exmouth Water Resource Operation Management Strategy (1998) details the operational agreement between the Water and Rivers Commission and the Water Corporation, outlining how the Water Corporation will conduct its extraction operations under license from the Commission. The strategy includes commitments by the Water Corporation to implement a regular stygofauna and aquifer monitoring program, and that pumping be done in a manner that maintains appropriate water salinity levels at each bore.

The objectives of the Water Corporation's Cape Range peninsula/Exmouth borefield monitoring program are to:

- accurately measure water level variation with time to determine the influence on water levels of water abstraction, tides and recharge events;
- accurately measure salinity variation with time to determine the influence of water abstraction on the thickness of the freshwater lens;
- characterise the patterns of variation in major ions and pH with time.

The monitoring protocol entails sampling 32 water level bores monthly, salinity sampling 29 production bores monthly, sampling the salinity profile of two stygofauna monitoring bores annually, sampling salinity of two sets of Salt Water Interface Monitoring bores annually, and sampling EC, pH and major ions from all production bores annually (Water Corporation 1998).

In liaison with the NWCKMAC, the Water and Rivers Commission will consider the establishment of monitoring bores adjacent to Camerons Cave.

The Environmental Protection Authority (1999) have provided further guiding principals for water management to protect the ecological values of the Cape Range Province, in Position Statement No.1 for the Environmental Protection of Cape Range Province.

Responsibility: Water and Rivers Commission and Water Corporation in liaison with the NWCKMAC
Cost: Included in 3.1.1
Completion date: Ongoing

3.2.10 Report on success of management strategies for Camerons Cave and the troglobitic community

The NWCKMAC will prepare annual reports for CALM's Corporate Executive. In 2003, a review of this IRP will be conducted and a decision made as to whether the community still meets criteria for Critically Endangered. Preparation of a full recovery plan will be undertaken if it does.

Responsibility: CALM (Exmouth District and WATSCU) and the NWCKMAC Recovery Team
Cost: included in 3.1.1
Completion date: Ongoing

Table 1: Summary of recovery actions

Recovery Action	Responsibility	Completion date
Existing recovery actions		
1. Establish recovery team	CALM (WATSCU and Exmouth District)	June 1999
2. Liaison with other authorities and land users regarding land uses and threatening processes that may adversely impact on Camerons Cave and the troglobitic community	CALM (Exmouth District and WATSCU) in liaison with the NWCKMAC	Ongoing
3. Construction of an appropriate gate at Camerons Cave entrance	CALM (Exmouth District and WATSCU) in liaison with the NWCKMAC	1999
Additional recovery actions		
4. Survey further likely areas for additional occurrences of the Camerons Cave Troglobitic Community within the known distribution of elements of the community	WA Museum in liaison with NWCKMAC	Ongoing
5. Examine and report on hydrology, geology, and drainage around Camerons Cave, and make recommendations as to appropriate reservation and other management steps to safeguard the troglobitic community.	CALM (WATSCU and Exmouth District) and the NWCKMAC	2001
6. Carry out management actions such as signage and fencing of an appropriate reserve at Camerons Cave.	CALM (Exmouth District and WATSCU) and the NWCKMAC	2001
7. Seek to acquire Camerons Cave for addition to the reserve system	CALM (Park Policy and Tourism Section and Exmouth District)	2001
8. Continue to liaise with other authorities and land users regarding land uses and threatening processes that may adversely impact on Camerons Cave and the troglobitic community	CALM (Exmouth District and WATSCU) and the NWCKMAC	Ongoing
9. Ensure land use planning and development control processes effectively safeguard against potentially adverse impacts of development on Camerons Cave and the troglobitic Community	CALM (Exmouth District and WATSCU) and the Environmental Protection Authority (EPA), in liaison with the NWKCMAC	Ongoing
10. Monitor Camerons Cave Troglobitic Community and respond to results of monitoring as appropriate	CALM (Exmouth District and WATSCU) in liaison with the NWCKMAC	Initiate as soon as possible, then ongoing
11. Monitor water quality and levels in Camerons Cave to establish long term trends	CALM (Exmouth District and WATSCU) and Water and Rivers Commission in liaison with the NWCKMAC	Initiate as soon as possible, then ongoing
12. Liaise with stakeholders to continue to monitor and manage groundwater quality and levels for the Cape Range peninsula.	Water and Rivers Commission and Water Corporation, in liaison with the NWCKMAC	Ongoing
13. Report on success of management strategies for Camerons Cave and the troglobitic community.	CALM (Exmouth District and WATSCU) and the NWCKMAC Recovery Team	End of third year

3.3 Costs

Table 2: Summary of costs for each recovery action

Recovery Action	2001	2002	2003
Existing recovery actions			
1. Establish recovery team	$10,000	$12,000	$8,000
2. Liaison with authorities and land users regarding land uses and threatening processes that may adversely impact on Camerons Cave and the troglobitic community	included in 3.1.1	included in 3.1.1	included in 3.1.1
3. Construction of an appropriate gate at Camerons Cave entrance	$1,000 completed 1999	nil	nil
Additional recovery actions			
4. Survey further likely areas for additional occurrences of the Camerons Cave Troglobitic Community within the known distribution of elements of the community	$3,000	$3,000	$4,000
5. Examine and report on hydrology, geology, and drainage around Camerons Cave, and make recommendations as to appropriate reservation and other management steps to safeguard the troglobitic community.	$4,000	nil	nil
6. Carry out management actions such as signage and fencing of an appropriate reserve at Camerons Cave.	$13,750	nil	nil
7. Seek to acquire Camerons Cave for addition to the reserve system	To be determined	To be determined	To be determined
8. Continue to liaise with authorities and land users regarding land uses and threatening processes that may adversely impact on Camerons Cave and the troglobitic community	Included in 3.1.1	Included in 3.1.1	Included in 3.1.1
9. Ensure land use planning and development control processes effectively safeguard against potentially adverse impacts of development on Camerons Cave and the troglobitic Community	Included in 3.1.1	Included in 3.1.1	Included in 3.1.1
10. Monitor Camerons Cave Troglobitic Community and respond to results of monitoring as appropriate	To be determined	To be determined	To be determined
11. Monitor water quality and levels in Camerons Cave to establish long term trends	To be determined	To be determined	To be determined
12. Liaise with stakeholders to continue to monitor and manage groundwater quality and levels for the Cape Range peninsula.	Included in 3.1.1	Included in 3.1.1	Included in 3.1.1
13. Report on success of management strategies for Camerons Cave and the troglobitic community.	Included in 3.1.1	Included in 3.1.1	Included in 3.1.1
Total	**over $31,750**	**over $15,000**	**over $12,000**

Summary of costs over three years:
In excess of $58,750. Additional costs to be determined.

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GLOSSARY

Allochthonous: originating from outside and transported into a system or area.

Doline: a shallow depression, either funnel- or saucer-shaped, and having its floor covered by cultivated soil, formed by solution in mountain karst.

Epigean: living or growing at or above the soil surface.

Evapotranspiration: the combined effect of transpiration by plants and direct evaporation.

Gondwana: The southern supercontinent formed by the break up of Pangaea in the Mesozoic era.

Halocline: A salinity discontinuity; a zone of marked salinity gradient.

Hypogean: living or germinating underground.

Karst: Irregular limestone strata permeated by streams, typically with sinks, caves and other subterranean passages.

Laurasia: The northern supercontinent formed by the break up of Pangaea in the Mesozoic era.

Mesozoic: The geological time period occurring from about 240 million to 67 million years ago.

Pangaea: The single supercontinent comprising the present continental land masses joined together, which formed about 240 million years BP and began to break up about 150 million years BP.

Troglofauna: a fauna comprising troglobites.

Troglobite: obligate subterranean species inhabiting air-filled voids. The term troglobite is sometimes used generally to encompass all hypogean fauna.