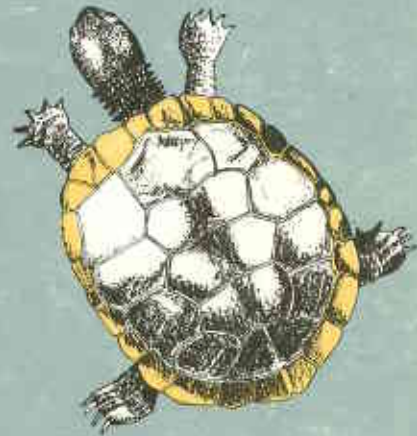
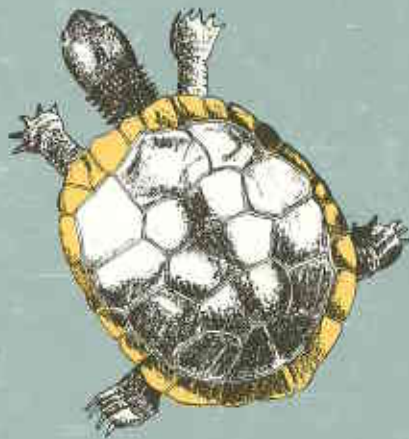
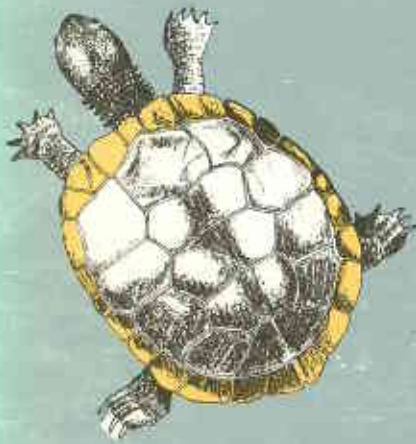


Western Swamp Tortoise Recovery Plan

DUPLICATE

by Andrew A Burbidge and Gerald Kuchling
for the Western Swamp Tortoise Recovery Team



1994

Wildlife Management
Program No 11



Department of Conservation
and Land Management

WESTERN SWAMP TORTOISE
RECOVERY PLAN

by

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FOREWORD

The Western Australian Department of Conservation and Land Management (CALM) publishes Wildlife Management Programs to provide detailed information and management actions for the conservation of threatened or harvested species of flora and fauna. Management Program No. 6 for the Western Swamp Tortoise was published late in 1990 (Burbidge *et al.* 1990) and much of the information and recovery actions are taken from that document. This Recovery Plan provides more detailed descriptions of actions and accurate costing of them.

Recovery Plans delineate, justify and schedule management actions necessary to support the recovery of an endangered or vulnerable species or ecological community. The attainment of objectives and the provision of funds is subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery Plans do not necessarily represent the views nor the official positions of any individuals or agencies represented on the Recovery Team. This Recovery Plan has been approved by the Executive Director, Department of Conservation and Land Management, the National Parks and Nature Conservation Authority and the Minister for the Environment.

Approved Recovery Plans are subject to modification as dictated by new findings, changes in species' status and completion of recovery actions.

This Recovery Plan was prepared in 1992 and was submitted to the Australian Nature Conservation Agency (ANCA) for funding under the National Endangered Species Program. Funds were provided by ANCA in 1992/93 with an indication that it would continue to fund a proportion of the total costs indicated in the Plan in future years.

Information in the Plan is accurate at June 1992, although where it seemed important for a clear reading of the Plan, modifications have been made to provide updated information up to the end of 1993.

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SUMMARY

CURRENT SPECIES STATUS: Threatened species (W.A. Wildlife Conservation Act). Endangered (ANZECC 1991). Endangered (IUCN Amphibia-Reptilia Red Data Book, Groombridge 1982), Priority 1 (Action Plan for Tortoises and Freshwater Turtles, IUCN/SSC 1989). Critical (Draft new IUCN categories). There is only one wild population, of about 30 animals (only 7 adult females known to be alive, 1991) in Ellen Brook Nature Reserve, plus 48 captives, of which only 6 are adult females.

HABITAT REQUIREMENTS AND LIMITING FACTORS: *Pseudemydura umbrina* only inhabits shallow, ephemeral, winter-wet swamps on clay or sand over clay soils with suitable nearby activation refuges. Most original habitat within very small range destroyed by clearing and drainage. Existing protected habitat marginal and affected by increasing aridity and introduced predators.

RECOVERY PLAN OBJECTIVES: To ensure the survival of the Western Swamp Tortoise by creating at least two viable wild populations.

RECOVERY CRITERIA:

1. Increase the number of adult and sub-adult tortoises at Ellen Brook Nature Reserve from about 30 to more than 45.
2. Create a population at Twin Swamps Nature Reserve of at least 40 adult and sub-adult tortoises.
3. Establish and maintain a captive population of at least 50.

ACTIONS NEEDED: A Recovery Team was set up in 1990; at present it comprises members from CALM, Perth Zoo, The University of Western Australia's Zoology Department, Curtin University's School of Biomedical Sciences, World Wide Fund for Nature Australia and the Australian Nature Conservation Agency. It will continue to coordinate the following actions:

1. Management of Ellen Brook Nature Reserve, and wild population
2. Captive breeding
3. Re-introduction to Twin Swamps Nature Reserve
4. Education, publicity and sponsorship.

ESTIMATED COST OF RECOVERY: 1992 prices in \$000s/year

Total cost (TC) and Other (O) Endangered Species Program (ESP)/other external funds required (= TC - CALM/Perth Zoo/WA Water Authority/World Wide Fund for Nature Australia/Bundesverband fur fachgerechten Natur-und Artenschutz contribution):

Actions	(1)		(2)		(3)		(4)		Total	
	TC	O	TC	O	TC	O	TC	O	TC	O
1992/93	36.2	5.0	95.4	22.1	130.8	82.0	3.5	0.0	265.9	109.1
1993/94	43.9	8.6	52.4	22.1	100.3	86.8	3.5	0.0	200.1	117.5
1994/95	62.2	44.3	53.1	22.1	55.7	32.9	3.5	0.0	174.5	99.3
1995/96	12.2	1.0	50.4	22.1	61.2	48.0	3.5	0.0	127.3	71.1
1996/97	12.2	1.0	49.6	22.1	55.2	42.0	3.5	0.0	120.5	65.1
1997/98	12.2	1.0	91.4	63.9	63.2	50.0	3.5	0.0	170.3	114.9
1998/99	12.2	1.0	166.3	138.8	38.9	25.7	3.5	0.0	220.9	165.5
1999/00	19.3	1.0	91.3	63.8	38.7	17.7	3.5	0.0	152.8	82.5
2000/01	11.2	0.0	91.3	63.8	38.9	25.7	3.5	0.0	144.9	89.5
2001/02	11.2	0.0	91.3	63.8	30.9	17.7	3.5	0.0	136.9	81.5
Total	232.8	62.9	832.5	504.6	613.8	428.5	35.0	0.0	1714.1	996.0

BIODIVERSITY BENEFITS: The Western Swamp Tortoise represents the sub-family Pseudemydurinae monotypically and is little changed from fossils discovered in the early Miocene at Riversleigh in Queensland. Ellen Brook and Twin Swamps Nature Reserves protect wetland ecological communities that are now threatened because of clearing for agriculture and urban development. For example, Ellen Brook NR protects a population of the Declared Threatened Plant *Hydrocotyle lemnoides* (Aquatic Pennywort), which is known from only 4 sites and Twin Swamps NR protects *Regelia ciliata* association, a threatened ecological community.

1. INTRODUCTION

1.1 Description and history of species

The Western Swamp Tortoise (*Pseudemydura umbrina* Siebenrock 1901) is a short-necked freshwater tortoise that monotypically represents the sub-family Pseudemydurinae of the side-necked family Chelidae (Gaffney and Meylan 1988). *P. umbrina* is the smallest of the Australian chelids (Burbidge 1967, Burbidge *et al.* 1974). Adult males do not exceed a carapace length of 155 mm or a weight of 550 g. Females are smaller, not growing beyond 135 mm carapace length or a weight of 410 g. Hatchlings have a carapace length of 24-29 mm and weigh between 3.6 and 6.6 g.

The colour of living *P. umbrina* varies with age and swamp type. The shell of hatchlings is grey above and bright cream and black below. The carapace in adults is usually similar in colour to the swamp water and varies from medium yellow-brown in clay swamps to almost black with a maroon tinge in the black coffee-coloured water of the sandy swamps. Plastron colour is variable, from yellow to brown or occasionally black; often there are black spots on a yellow background with black edges to the scutes. The legs are short and covered in scale-like scutes and the feet have well-developed claws. The short neck is covered with horny tubercles and on the top of the head is a large single scute. There are two small barbels.

The Western Swamp Tortoise can be easily distinguished from the only other freshwater tortoise occurring in the south-west of Western Australia by its short neck; the Oblong Tortoise (*Chelodina oblonga*) has a neck that is equal to or longer than the length of its shell.

The first Western Swamp Tortoise known to science was sent to the Vienna Museum in 1839 by the Austrian J.A. Ludwig Preiss, who collected in Western Australia from 1839 to 1841. It is not known where this specimen was collected - it was simply labelled "New Holland". The specimen remained in the Museum undescribed until 1901 when it was named by Siebenrock, a well-known herpetologist of his day. Siebenrock provided further details and comments on the species in 1907. No further specimens were collected until 1953 when two were found near Warbrook, only 30 km north-east of the centre of the city of Perth. These were described as a new species, *Emydura inspectata*, by Glauert (1954), but this was shown to be a synonym of *P. umbrina* by Ernest Williams (1958) of Harvard University.

A relict species, apparently little changed since the Miocene, *P. umbrina* is the only member of its genus and has no close relatives among other members of the Chelidae (Burbidge 1967; Burbidge *et al.* 1974; Gaffney 1977). *P. umbrina* is so different from other members of the family that a separate sub-family, the Pseudemydurinae, has been proposed for it (Gaffney 1977, Gaffney and Meylan 1988). The only fossil records of *Pseudemydura* are a portion of a skull and a pygal bone from the early Miocene Riversleigh deposits of north-west Queensland, which show only slight differences from modern specimens (Gaffney *et al.* 1989, Archer *et al.* 1991).

1.2 Distribution and abundance

Western Swamp Tortoises have been recorded only from scattered localities in a narrow (3 to 5 km wide) strip of the Swan Coastal Plain with largely alluvial soils, roughly parallel with the Darling Scarp, running from Perth Airport at Guildford to near Pearce Royal Australian Air Force Base at Bullsbrook. Anecdotal information (Burbidge 1967, 1981) suggests that their stronghold was the clay soils of the Swan Valley, the first part of Western Australia developed for agriculture. Almost all this land is now cleared and either urbanised or used for intensive agriculture or the extraction of clay for brick and tile manufacture.

During the 1960s to 1980s there were two significant populations; one in each of Twin Swamps and Ellen Brook Nature Reserves, which were created to protect its habitat in 1962. By 1985 the population at Twin Swamps was effectively extinct.

Mark and recapture studies have been carried out since 1963. Three estimates of population size are available: known to be alive (KTBA) and two calculated from mark and recapture data using the Jolly method (Jolly 1965, Seber 1982, Krebs 1989) and the Manley and Parr method (Manley and Parr 1968).

KTBA data under-estimate the size of Western Swamp Tortoise populations, particularly in recent years, since only a small proportion of tortoises are usually captured in any one year. For these reasons KTBA population estimates are usually considered to be reasonably reliable only for periods five years or more before the last sample, since most animals are captured within a five year period. The Jolly method has not provided as reliable estimates as the Manley and Parr method, since it does not take account of the known dates of hatching and only the Manley and Parr estimates are presented in Table 1. Although mathematical estimates are unreliable because of small population size and low recapture rates they are included in Table 1 because they confirm the general trends revealed by the KTBA data.

Table 1.
Population data - Ellen Brook Nature Reserve and
Twin Swamps Nature Reserve.

ELLEN BROOK NATURE RESERVE				TWIN SWAMPS NATURE RESERVE			
Year	No Captured	KTBA [#]	M&P estimate	Year	No Captured	KTBA [#]	M&P estimate
1963	4	26	-	1963	1	55	-
1964	9	27	63	1964	4	76	292
1965	3	23	63	1965	9	97	273
1966	4	21	27	1966	65	101	125
1967	2	20	38	1967	25	75	150
1968	5	20	24	1968	17	62	68
1969	1	19	19	1969	8	61	93
1970	3	21	-	1970	26	59	71
1971	0	20	-	1971	27	52	72
1972	6	21	24	1972	15	40	57
1973	0	23	-	1973	13	34	59
1974	2	24	46	1974	8	28	88
1975	3	23	33	1975	8	23	32
1976	9	22	26	1976	4	20	25
1977	3	21	21	1977	9	19	24
1978	8	22	30	1978	9	17	45
1979	4	21	21	1979	6	10	18
1980	8	23	28	1980	2	6	6
1981	8	25	27	1981	3	6	8
1982	10	27	34	1982	3	6	6
1983	5	28	63	1983	4	6	7
1984	10	33	87	1984	3	5	9
1985	7	30	47	1985	1	3	0
1986	2	28	28	1986	0	2	0
1987	6	29	34	1987	0	2	0
1988	5	31	70	1988	0	2	0
1989	17	30	35	1989	0	2	0
1990	12	26	36	1990	2	2	0
1991	21	21	-	1991	0	0	0

- can not be calculated from available data

[#] KTBA known to be alive

M&P Manley and Parr (1968) method

The data suggest that the population at Twin Swamps Nature Reserve has dropped from a high of over 100 in the mid-1960s, to about 50 in the early 1970s, to near extinction by 1985. The population at Twin Swamps must now be considered to be extinct. At Ellen Brook Nature Reserve numbers have never been as high as at Twin Swamps Nature Reserve. The KTBA data suggest that numbers have remained fairly static at around 20 to 30.

1.3 Habitat

P. umbrina inhabits shallow, ephemeral, winter-wet swamps on clay or sand over clay soils with nearby suitable aestivation refuges.

1.4 Life history and ecological relationships

Perth has a Mediterranean climate with cool, wet winters and hot, dry summers. The mean annual rainfall is about 800 mm. After the swamps fill in June or July the tortoises can be found in water, feeding when water temperatures are high enough ($>14^{\circ}\text{C}$). They are carnivorous, eating only living food such as insect larvae, small crustaceans and small tadpoles. As the swamps warm in spring and swamp life becomes plentiful, the tortoises' food intake increases and fat supplies are laid down for the forthcoming summer. When the swamps are nearly dry and water temperatures rise above 28°C , usually in November, the tortoises leave the water to aestivate during the summer and autumn. Aestivation refuges vary with the soil type: at Ellen Brook Nature Reserve they are naturally-occurring holes in the gilgai clay, while at Twin Swamps Nature Reserve most aestivated under *Banksia* leaf litter or fallen branches, but a few find holes in the ground dug by other animals or left by a rotting tree root.

P. umbrina is not territorial and individuals do not appear to have a fixed home range, using all suitable habitat in the nature reserves. At Twin Swamps Nature Reserve movements of up to 500 m have been recorded in two weeks. At Ellen Brook Nature Reserve the area of suitable habitat is much smaller and most movements are correspondingly shorter (Burbidge 1981); however, one animal was recorded moving 450 m in 24 hours. Twin Swamps animals have been found up to 600 m outside the nature reserve boundary, especially in dry years, suggesting that there may have been movements between swamps some distance apart before habitats in the area were fragmented by clearing (Kuchling unpublished).

Females lay three to five hard-shelled eggs of *ca* 35 x 20 mm in an underground nest in November or early December (Burbidge 1981). Only one clutch per year is produced; in most other Australian chelids multiple clutching is the norm. Hatching is triggered by lowering incubation temperature and hatchlings emerge the following winter, about 180 days after laying. Growth in juveniles is slow and varies considerably from year to year as well as within age-classes. Consequently, age to sexual maturity (which occurs in females at about 112 mm carapace length, Kuchling and Bradshaw 1993) varies from animal to animal and depends on seasonal conditions - the lower the annual rainfall the shorter the swamp life and the slower the growth. Age to sexual maturity at Twin Swamps Nature Reserve has varied from 6.5 to 14 years, with a mean of about 11 years while at Ellen Brook Nature Reserve the mean is probably around 15 years (Burbidge 1981).

There are few data relating to sex determination in Australian chelid tortoises, but available data from both laboratory and field studies indicate that sex is genetically-determined rather than being determined by incubation temperature (Thompson 1988, Palmer-Allen and Beynon 1990). Histological examination of Western Swamp Tortoise hatchlings from the captive colony that died in 1989 also suggests that sex is genetically determined (Kuchling unpublished).

Longevity is unknown, but captive animals estimated to be at least 20 years old in the late 1950s are still producing eggs. An adult female captured at Ellen Brook Nature Reserve in 1963 (carapace length 122 mm) was recaptured in 1990 (carapace length 135 mm) with oviducal eggs.

Predation by introduced carnivores, especially the European Red Fox, has been shown to be a significant conservation concern in Australia in recent years (Kinnear *et al.* 1988). There is only a little direct evidence that introduced predators have a significant effect on the tortoises (Burbidge 1967). However, there is now much circumstantial evidence that predators, particularly the fox, kill Western Swamp Tortoises. They may also destroy eggs, as has been documented for other Australian tortoises (Clay 1981, Thompson 1983). Foxes were abundant in both nature reserves and there is no other explanation for the rapid decline in numbers at Twin Swamps Nature Reserve. Tortoises are thought to be more prone to predation at Twin Swamps Nature Reserve, where aestivation refuges are mostly on the surface. At Ellen Brook Nature Reserve, where aestivation occurs underground, the species is better protected, but the very small population size means that even occasional predation can have a significant effect.

1.5 Reasons for threatened status

The Western Swamp Tortoise has been declared as 'rare or likely to become extinct' under Section 14(2)(ba) of the Western Australian Wildlife Conservation Act 1950 and is classified as threatened by CALM. It is listed as endangered on the Official List of Australian Endangered Vertebrates (Burbidge and Jenkins 1984, ANPWS 1991), is listed as 'Endangered' in the IUCN Amphibia-Reptilia Red Data Book (Groombridge 1982), is on Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) and has been given a priority rating of '1' in the Action Plan for Tortoises and Freshwater Turtles (IUCN/SSC 1989). Under the draft IUCN categories of Critical, Endangered and Vulnerable (Mace and Lande 1991, Mace *et al.* 1992), *P. umbrina* clearly meets the category 'Critical', having a total effective population of less than 50 and having a greater than 50% decline in numbers in the last generation. The effective population size for *P. umbrina* at present is about 30. 'Critical' equates to a 50% probability of extinction within two generations (the generation time of the Western Swamp Tortoise is about 20 to 25 years).

There are a number of compounding reasons for the current critically endangered status of the Western Swamp Tortoise:

- (i) a very small geographic range, most of which has been converted to agricultural, industrial or urban use
- (ii) protection of habitat solely in two small nature reserves that include only marginal habitat
- (iii) a specialised biology that includes dependence on a rare habitat, a wholly carnivorous diet, low fecundity and slow growth rates, mitigated to some extent by great longevity
- (iv) increasing aridity, a factor compounded by the marginal nature of the remaining habitat and which could become worse if the climate becomes more arid; and
- (v) the presence of exotic predators, particularly the European Red Fox.

1.5.1 Geographic range and habitat

Because of the rediscovery of the Western Swamp Tortoise within the Perth metropolitan area as late as 1953, little is known of its pre-European geographic range. There are no indications, however, that it had a range in the recent past significantly different from its recent one, i.e. an area of about 100-150 km². Within this very small range the species is restricted to winter-wet ephemeral swamps with suitable aestivating refuges nearby. Western Swamp Tortoises do not occur in the many permanent swamps or lakes on the Swan Coastal Plain, so presumably they cannot survive in this habitat. Most of the original range of the Western Swamp Tortoise has been greatly modified in the past 160 years. What we know now of breeding and hatchling survival in the two nature reserves suggests that the habitat in them must be considered as only marginal. Additionally, both reserves, especially Ellen Brook Nature Reserve, are small. It is likely that some animals are lost when they move outside the reserves and are exposed to unsuitable habitat and increased predation.

1.5.2 Biology

P. umbrina is the smallest Australian chelid. It is also the only species in which the female is smaller than the male. Another indication of the significant differences of Western Swamp Tortoises from other tortoises and turtles is that they are the only known species in the world that digs the nest chamber with the front feet (Kuchling, in press). Egg size is similar to other species in the family and, accordingly, it has very low fecundity: females produce a maximum of one clutch of three to five eggs per annum. This compares unfavourably with other Australian chelids, e.g. the Oblong Tortoise *Chelodina oblonga*, which can produce two or three clutches per year each of 8-15 eggs (Burbidge 1967, Clay 1981, Kuchling 1989). Only live food is eaten; other species eat a greater variety of food including carrion and vegetable matter. Growth is slow, food being available for only a short time each year, and sexual maturity is not usually reached until 10-15 years or more.

1.5.3 Effects of drought

Aestivating tortoises desiccate during the summer. Measurements of desiccation rates of radio transmitter-equipped animals at Twin Swamps Nature Reserve have shown that hatchlings must achieve a body weight of about 25 g in their first six months in order to survive the following summer (Burbidge 1967, 1981). This is not achievable in years of below average rainfall because the swamps retain water for only a short time. Furthermore, there is evidence that females are not able to produce eggs in low rainfall years; thus two successive years of average or above average rainfall are required for effective recruitment to take place at Twin Swamps. Since the mid-1960s Perth has had many years of below average rainfall. This has undoubtedly affected the abundance of the Western Swamp Tortoise.

1.5.4 Exotic predators

As discussed above, the European Red Fox was abundant in both nature reserves and predated *P. umbrina*.

1.6 Existing conservation measures

1.6.1 Creation of nature reserves

Following the interest generated by the rediscovery of a presumed extinct species so close to Perth, the Government of the day, aided by a public appeal for funds, created two Class A (within the meaning of the Western Australian Land Act; ie. can not be cancelled, reduced in area or used for any other purpose unless by Act of Parliament) nature reserves that protected much of its remaining habitat. These are Ellen Brook Nature Reserve of 65 ha, located two kilometres north of Upper Swan, and Twin Swamps Nature Reserve of 155 ha, located about 5 km north-north-west of Ellen Brook Nature Reserve. Both reserves are vested in the National Parks and Nature Conservation Authority and managed by the Western Australian Department of Conservation and Land Management.

1.6.2 Extension of nature reserves

Land was purchased and added to Twin Swamps Nature Reserve in 1965. Negotiations to add land to Ellen Brook Nature Reserve have proceeded since 1990. An area of 5.9 ha immediately south of the reserve was purchased in December 1991 and negotiations are proceeding to add land in two lots to the west of the reserve.

1.6.3 Ecological studies

Studies on *P. umbrina* commenced shortly after it was rediscovered. Initially, Dr David Ride, then Director of the Western Australian Museum, coordinated field searches and kept a captive colony at his home. (This colony was transferred to Perth Zoo in 1964.) Then, in 1963, Professor A.R. Main of the University of Western Australia initiated and supervised a project by several Zoology Honours Degree students, one of whom was the senior author (Lucas 1963). In 1964 the senior author commenced his Ph.D. studies with Professor Main on *P. umbrina* and, for comparison, two other southern Western

Australian long-necked tortoises, *Chelodina oblonga* and *C. steindachneri*. In 1968 the senior author started work as a Research Scientist with the Western Australian Government and has conducted and coordinated less intensive studies of *P. umbrina* since, with research studies becoming more intensive through the 1980s as it became clear that the species was declining in numbers. Results of these studies can be found in Burbidge 1967, 1981, 1984, 1987a, 1987b and Burbidge and Friend 1988. Ecological studies re-commenced in 1991 when Kuchling radio-tracked animals on Ellen Brook Nature Reserve and located nests in the wild for the first time. Four nests were equipped with data loggers that measure temperature at three depths as well as soil moisture.

1.6.4 Management of nature reserves

The management of Ellen Brook and Twin Swamps Nature Reserves is the responsibility of the Department of Conservation and Land Management and the reserves have been managed since their declaration.

Management has included general protection, the monitoring of water quantity and quality, fire management, predator management and work to mitigate deleterious effects from surrounding land.

1.6.4.1 Water quantity and quality

The Department of Conservation and Land Management has maintained water depth records at two depth gauges at Ellen Brook Nature Reserve and four gauges at Twin Swamps Nature Reserve and has had water samples taken from immediately adjacent to each gauge analysed by the W.A. Chemistry Centre annually since 1972. Data are held on a Departmental file and in a micro-computer data base, copies of which are stored in a fire-proof safe. At Ellen Brook Nature Reserve water levels are not greatly affected by drought and the swamps contain water from June to November during most years. Water quality at Ellen Brook Nature Reserve is excellent and there is no evidence of pollution entering the swamps on the reserve. At Twin Swamps Nature Reserve the swamps are greatly affected by drought. Only in high rainfall years do they contain water for long enough to enable females to produce eggs and hatchling Western Swamp Tortoises to feed sufficiently to survive the summer aestivation period. Water quality varies between swamps. Some areas receive run-off from surrounding land and have relatively high levels of phosphates and nitrogen; others have excellent quality water. There is no evidence that suggests that Western Swamp Tortoises have been affected by changing water quality.

1.6.4.2 Predator control

Fox control has been carried out on both nature reserves sporadically since 1979, but the technique available at that time (laying of strychnine baits in meat crackle) proved to be inadequate. Predator control was stepped up at Ellen Brook Nature Reserve in 1988 by the Department of Conservation and Land Management using new fox control techniques (regular laying of Compound 1080 in fresh meat or fowl egg baits) developed by Dr Jack Kinnear and colleagues from the Department of Conservation and Land Management (Kinnear *et al.* 1988).

However, two significant problems arose with respect to control by the use of poison baits. Much of Ellen Brook Nature Reserve is under water for up to six months of the year. The use of Compound 1080 under such conditions can be ineffective, because it is highly soluble in water. The tortoises are most likely to be eaten by foxes during the wet months when they are not aestivating. Also the reserves are small and re-invasion of them by foxes from surrounding land is rapid.

It was considered that these problems could be largely solved by the construction of a fox-proof fence. In 1989 the Department of Conservation and Land Management applied for and received \$24 000 (50% of the funds required for the construction of a fence) from the then Australian National Parks and Wildlife Service (now Australian Nature Conservation Agency) under their Endangered Species Program. The other half of the cost was met by the Department of Conservation and Land Management. Construction commenced late in 1989, but was delayed because of unseasonable heavy rains during the 1989/90 summer. The fence was completed in December 1990.

Regular patrols of the fence are maintained by Department of Conservation and Land Management's Swan Region staff. Although the fence is termed 'fox-proof', experience shows that foxes are capable of finding any weak links in a fence so regular poisoning inside the fence will be carried out as necessary to kill any foxes that are able to negotiate it.

The fence also prevents emigration or immigration of Western Swamp Tortoises from or to the reserve.

1.6.4.3 Fire

Fire has limited effects on Western Swamp Tortoises at Ellen Brook Nature Reserve because aestivation sites are underground. At Twin Swamps Nature Reserve fire is thought to have some detrimental effects on Western Swamp Tortoises because aestivation sites are often in leaf litter or under fallen branches. The Department of Conservation and Land Management's fire procedures at present are:

- (i) to meet its responsibilities under the Bush Fires Act by maintaining a perimeter and internal fire break
- (ii) to continue to classify the reserves as "Red Action" areas requiring priority response from Departmental fire-fighting forces when a fire is reported
- (iii) to fight any fires on or threatening the nature reserves, including providing assistance to neighbours and the local Bush Fire Brigade where possible
- (iv) at Ellen Brook Nature Reserve, once a fire has entered the main part of the tortoise habitat to allow it to burn to the other side so fire-control machinery does not damage the gilgai aestivating tunnels; and
- (v) at Twin Swamps Nature Reserve, to allow fire-fighting machinery off constructed fire-breaks only with the permission of the Regional Ecologist or a senior Research Scientist.

1.6.4.4 Effects of adjacent land use

There have been several proposals to mine clay from private land near Ellen Brook Nature Reserve and these have been the subject of assessment by the Environmental Protection Authority. In 1988 and 1989 a study of the possible effects of clay mining near the reserve was conducted by Bowman Bishaw Gorham (1989) on behalf of Bristle Clay Tiles, International Brick and Tile Holdings Ltd (now part of the Metro Brick Group), Prestige Brick Company Pty Ltd, Midland Brick Company Pty Ltd and the Main Roads Department. The main conclusions of the study were:

- (i). Clay mining in the vicinity of Ellen Brook Nature Reserve would have no adverse impact on the quantity or quality of water in the tortoise swamps
- (ii). Tortoise habitat in the immediate locality of Ellen Brook Nature Reserve had been reduced in size by at least 70% prior to its declaration in 1962 due to land clearing and drainage. In addition, the surface water catchment for the swamps had been severely restricted due to drainage modifications and the construction of Great Northern Highway on the eastern boundary of the reserve
- (iii). The tortoise swamps now have only a small catchment area, limited to narrow segments on their northern and eastern margins. To the east, runoff from a 150m section of the Great Northern Highway discharges directly into the swamps; pollution from the Highway is therefore a possible problem

- (iv). The catchment of the drain near the southern boundary of Ellen Brook Nature Reserve comprises land to the south-west, south, south-east and east and includes seven existing or proposed clay quarries and the road train marshalling yard to the south. The drain acts as a through-flow channel to Ellen Brook and does not discharge water into the main tortoise swamps. The water quality in the drain during the study period, while inferior to that in the swamps, was still reasonable

CALM and the Department of Zoology, The University of Western Australia, in submissions to the EPA, recommended that:

1. A no-mining buffer be applied to limit the edge of excavations to at least 100 m from Ellen Brook Nature Reserve and the areas currently being purchased for addition to it.
2. The proponents be required to provide a new drain along the southern boundary of Lot 14 to replace the "nature reserve" drain, which should be closed and filled in.
3. The proponents be required to contribute to the provision of new tortoise habitat.

In late 1991 and early 1992 the EPA released its recommendations for the mining of three areas by Midland Brick and Metro Brick. The 100 m buffer was applied and the companies were required to consult with CALM during the preparation of a regional development, drainage and rehabilitation strategy for the Upper Swan locality. Metro Brick, who wish to mine clay to the south-east of the reserve, were required to divert all drainage waters from the eastern side of Great Northern Highway from entering the tortoise habitat area at Ellen Brook Nature Reserve within two years of the approval of the proposal and the other companies were required to prevent any drainage waters entering swamp tortoise habitat. The companies have also committed themselves to contributing towards the cost of relocating the 'nature reserve' drain (see 3.1.2) and Midland Brick has offered to help with rehabilitation of land being added to Ellen Brook Nature Reserve. The Minister for the Environment approved the developments, subject to conditions as recommended by the EPA.

In 1993, the EPA decided to prepare an Environmental Protection Policy for land adjacent to the tortoise reserves. The Policy is aimed at implementing Recommendation M17.1 of the System Six Report (DCE 1983) that "ways and means of providing protective buffers around Reserves A27620 and A27621 be sought through planning procedures...".

1.6.5 Captive breeding

At Perth Zoo captive breeding was attempted in a low key, non-interventionist way from 1964, when Western Swamp Tortoises were first kept, until 1979 (Spence *et al.* 1979). Success was, however, very low with only four animals still being alive from the 26 that hatched between 1966 and 1977.

In 1979, the three remaining adult females from the Zoo population were transferred to the Western Australian Wildlife Research Centre for more intensive husbandry and the use of interventionist techniques in obtaining and incubating eggs. During the first year three eggs were obtained by oxytocin inducement and incubated artificially. Two hatchlings were obtained, but one died in its first year and the other in its second. In 1980, 14 eggs were produced and artificially incubated; six of these hatched, but the hatchlings did not survive for more than a few months. This work did, however, show that eggs could still be produced by the captives and demonstrated that the hatching of *P. umbrina* eggs is triggered by a drop in incubation temperatures; if the incubation temperature is maintained most embryos develop to hatchling size but do not hatch and eventually die. This adaptation presumably prevents hatchlings emerging before winter.

No further eggs were produced by the captive animals until 1987.

In 1987 Dr G. Kuchling arrived at The University of Western Australia from Austria to work with Professor S.D. Bradshaw on the hormonal control of reproduction in the Oblong Tortoise *Chelodina oblonga*. Later he asked the Department of Conservation and Land Management if he could help with captive breeding in *P. umbrina*, a suggestion that was welcomed. The development of techniques for the examination of the female reproductive tract using ultra-sound scanners (in collaboration with Dr

Bruno Colomb) was a breakthrough, enabling measurements to be made of egg follicle development for the first time (Kuchling 1989). Previously it was not known whether eggs were being developed until ovulation had taken place and the shell had been laid down. Even then, palpation in Western Swamp Tortoises is difficult because of the small leg openings between the carapace and plastron, and the only certain method of counting eggs was via the use of radiography.

In 1987 seven eggs were obtained from two captive females. These eggs were incubated artificially, but none hatched, the embryos dying at an early stage of development. The reasons for this are not clear: recent research suggests that the most likely explanation is poor quality eggs due to inadequate nutrition of the females that produced them.

Also in 1987 the Department of Conservation and Land Management and the Zoology Department of The University of Western Australia developed a budget for a two and a half year captive breeding project and sought and obtained funds from the World Wide Fund for Nature Australia, the Australian National Parks and Wildlife Service, the Western Australian Nature Conservation and National Parks Trust Account and the Western Australian Department of Conservation and Land Management. The project was carried out by Dr Kuchling, now a Research Fellow at Zoology Department, The University of Western Australia, utilising tortoises kept at Perth Zoo and at the Department of Conservation and Land Management's Wildlife Research Centre. Perth Zoo and the Department of Conservation and Land Management have supported the project with staff and with additional funds and The University of Western Australia has provided facilities and financial administration. Perth Zoo has obtained external sponsorship for the construction of new facilities for the captive tortoises and hatchlings, husbandry was greatly improved (Kuchling and DeJose 1989) and the captive colony was increased by addition of tortoises captured outside Ellen Brook and Twin Swamps Nature Reserves. The project was supervised and coordinated by the Western Swamp Tortoise Captive Breeding Project Management Committee of Dr Andrew Burbidge (Conservation and Land Management, chair). Mr John DeJose and Mr Darryl Miller (Perth Zoo) and Professor Don Bradshaw and Dr Gerald Kuchling (Zoology Department, The University of Western Australia).

This project has been successful and the results are shown in Table 2. The captive breeding project team was a finalist for the 1990 IBM Australia Conservation Award. In mid-1991 responsibility for the project was transferred to Perth Zoo, with Dr Kuchling continuing to provide advice and help.

Table 2.
Results of captive breeding project, 1987-1992

	Number laying	Viable eggs laid	Number hatched	Number alive May 1992
1987/88	2	7	0	-
1988/89	3	12	11	5
1989/90	5	13	11	11
1990/91	6	18	16	16
1991/92	6	15	12	12

In May 1992, the captive colony consisted of 9 adult males, 6 adult females and 46 sub-adults and hatchlings.

1.6.6 Genetic management

P. umbrina is in a severe genetic bottleneck with only approximately 30 animals of breeding age for the whole species. In this situation loss of genetic variability can be a serious constraint for the long-term survival and future evolutionary potential of a species. Conservation actions have to take this into account and genetic management of the species is necessary in order not to lose its genetic diversity. Another potential problem for small populations is inbreeding and its possible consequence of depression of fertility and viability of the population.

Several aspects have to be considered when choosing management options for preserving genetic diversity of the small population of *P. umbrina*. Evaluations in other species show that when animals are bred in captivity to re-establish wild populations, the methods of randomly selecting breeding pairs, choosing the best breeders, or managing mating pairs by allozyme data result in substantially reduced genetic diversity of the re-introduced population. Genetic management based on pedigree analysis (equalizing founder contribution, or maximizing founder genome equivalents, or maximizing allelic diversity) produces more genetically diverse release populations (Haig *et al.* 1990).

The most important rule is: the less time (in generations) a species spends in captivity and the sooner re-introductions start, the better for its genetic situation. The severe genetic bottleneck of *P. umbrina* may be relatively recent (in generation times; there would have been about six generations since non-Aboriginal settlement). Because of the longevity of *P. umbrina* (> 50 years) many individuals of the critically small world population (less than 50 individuals without the captive bred hatchlings of the last four years) are still survivors from a time when the population was larger (e.g. about 200 animals 25 years ago). The captive breeding stock still consists overwhelmingly of wild-caught individuals (Table 3). A continuation of the present captive breeding success should lead to a rapid population expansion. The use of F1 offspring to re-establish populations in the wild will reduce any potentially detrimental genetic drift during the time the species has to be bred in captivity.

Table 3.
Origin of captive stock of *P. umbrina* at May 1992

	males	females	juveniles
Wild caught in 1959, locality unknown	3	2	-
Captive bred between 1966 and 1977, parents unknown	4	1	-
Twin Swamps population, collected 1980-90	2	1	1
Animals from private land, collected 1988-90	-	2	1
Captive bred between 1988 and 1992	-	-	44
Total	9	6	46

There are 44 surviving captive-bred hatchlings from 1989-1992. Eight of these are the offspring of three females from Ellen Brook Nature Reserve and an unknown number of males. Between 1989 and 1991 three males from Ellen Brook Nature Reserve were used for matings with the captive females. It is unknown which males sired the hatchlings, but it is clear that the founder population of the future captive breeding project is very small.

In the past all captive females were kept together with some of the males in a random mating situation. Since 1988 males and females have been kept in separate enclosures and individually introduced to each other for mating purposes in a rotation scheme so that every female mates with a different male in consecutive years and all captive adults have the potential to contribute their genes. This is an attempt to equalise founder contributions as much as possible without, however, diminishing the breeding output of the best breeding females. As long as the world population is at such a low level, this cannot be justified and the breeding output has to be maximised. A complication for genetic management is the ability of females to store sperm over several years (Kuchling *et al.* 1992).

It would be helpful for the genetic management of the species to assess the genetic variability of the captives as well as of the last wild population. The reconstruction of patrilineages for captive-bred animals would be a further helpful tool to assess the genetic contribution of males (which may be obscured by the ability of females to store sperm). Since 1988 chromosome banding, plasma enzyme gel electrophoresis and DNA fingerprinting have been carried out, but only DNA fingerprinting was

able to detect limited variability between individuals. All captive and some wild adults have been bled for fingerprinting. A constraint is the necessity to sample living tissues (blood) from tortoises which are so small, rare, endangered and difficult to breed. During 1991, the allantoic sacs of the captive bred hatchlings were collected and provided enough DNA for fingerprinting (Groth *et al.* in press).

In order to establish a useful genetic data base, all of the available wild animals of sufficient size for sampling have to be DNA fingerprinted over the next few years as well as all captive-bred hatchlings. During 1990 and 1991 all adult, captive *P. umbrina* and 10 hatchlings have been DNA fingerprinted by the School of Biomedical Sciences, Curtin University of Technology. The costs for this study were met with the prize money of the IBM Australia Conservation Award (\$1 000) and with a grant from the Endangered Species Program, ANPWS (\$2 000).

1.6.7 Management Program and Recovery Team

A management program has been developed (Burbidge *et al.* 1990) and was launched by the World President of World Wide Fund for Nature, Prince Philip, in November 1990. Its aim is to ensure that the Western Swamp Tortoise persists by creating at least two viable populations in the wild. The Management Program provided for the establishment of a Recovery Team and this first met in December 1990. It currently meets every three to six months. Membership includes staff from the Department of Conservation and Land Management, the Zoology Department of The University of Western Australia, the School of Biomedical Sciences of Curtin University of Technology, Perth Zoo, the Australian Nature Conservation Agency and World Wide Fund for Nature Australia.

The Recovery Team will report annually on the implementation of the Plan to CALM's Corporate Executive and funding agencies.

1.7 Strategy for Recovery

This Recovery Plan will run for a term of ten years from 1992/93 to 2001/02 inclusive. Six primary strategies will be pursued during this period and are presented below. These strategies will be implemented concurrently:

- (i) prepare and implement Management Guidelines for Ellen Brook Nature Reserve. Manage Ellen Brook Nature Reserve to maintain the existing suitable habitat and construct new habitat in the present reserve and in areas currently being added to it
- (ii) monitor the tortoise population on Ellen Brook Nature Reserve
- (iii) continue with the captive breeding project to produce tortoises for re-introduction to Twin Swamps Nature Reserve
- (iv) prepare and implement Management Guidelines for Twin Swamps Nature Reserve
- (v) re-introduce tortoises to Twin Swamps Nature Reserve when sufficient numbers of partly grown tortoises (> 2 years old) have been produced by the captive breeding project and when the habitat has been upgraded by the construction of a fox-proof fence and pumping into the swamps from groundwater; and
- (vi) continue to disseminate educational and publicity material about the Western Swamp tortoise and continue to raise funds for its conservation

2. RECOVERY OBJECTIVE AND CRITERIA

2.1 Objective

Because of the species' low fecundity, slow growth rates and long time to sexual maturity it will not be possible to achieve uplisting from Endangered (old IUCN categories) or Critical (new IUCN categories) within the 10 year time frame of this Recovery Plan. The objective of this Recovery Plan is, therefore, to decrease the chance of extinction of the Western Swamp Tortoise by creating at least two wild populations and doubling the total number of individuals.

2.2 Criteria

The criteria for successfully achieving the objective are:

1. An increase through reproduction in the wild in the number of adult and sub-adult (> 2 years old) tortoises at Ellen Brook Nature Reserve from about 30 to more than 45.
2. The creation of a population from captive-bred animals at Twin Swamps Nature Reserve of more than 40 adult and sub-adult (> 2 years old) tortoises.
3. The establishment and maintenance of a captive population of at least 50.

3. RECOVERY ACTIONS

The Western Swamp Tortoise Recovery Team described in 1.6.7 above will continue to meet regularly to coordinate the implementation of this Recovery Plan and will report annually to CALM's Corporate Executive. The recovery actions presented below have been costed at 1992 prices. Unless otherwise stated CALM contributions include salaries. Figures are shown by calendar year but are actually for the relevant financial year. Thus, figures shown for 1993 are for the financial year 1992/93.

3.1 Management of Ellen Brook Nature Reserve and Wild Population

3.1.1 Management of fire, predators etc.

Patrols and maintenance of the fox-proof fence and boundary fences will continue. Fire management will continue as laid down in 1.6.4.3 above. Rabbit control and fox control within the fenced area will take place as required.

Responsibility: CALM Swan Region, Perth District.

<i>Cost:</i>	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
CALM	6000	10000	6000	6200	6200	6200	6200	13300	6200	6200
ESP/other	-	-	-	-	-	-	-	-	-	-
Total Cost	6000	10000	6000	6200	6200	6200	6200	13300	6200	6200

3.1.2 Removal of the 'nature reserve drain'

A drain runs from the Great Northern Highway through the southern part of Ellen Brook Nature Reserve to join a natural drainage line that flows into Ellen Brook. This drain accepts water from Great Northern Highway and from adjacent private property (see 1.6.4.4). At some times of the year it is likely to be a physical barrier to the movement of tortoises within the reserve, because of its steep sides or because of the rapid flow of water. Conditions imposed on clay mining companies by the Environmental Protection Authority include the development of a regional drainage plan by 1994 and

the diversion of water from the drain (see 1.6.4). CALM will participate in the development and implementation of the plan and ensure that it includes the closure and filling of the drain, and the construction of an alternative drain to remove excess water from land adjacent to the nature reserve. At least the easternmost 100 m of the drain in the nature reserve will need to be filled in; the use of a light tractor wheeled machine will be necessary.

Responsibility: CALM Swan Region, Perth District.

Cost:	92/93	93/94	94/95
CALM	\$500	900	1900
ESP/other	-	-	-
Total Cost	\$500	900	1900

3.1.3 Rehabilitation of purchased land and creation of additional habitat on existing nature reserve

Land recently purchased and being purchased for addition to Ellen Brook Nature Reserve, while retaining some native vegetation, is only marginally suitable for the Western Swamp Tortoise, because the remaining swamps are small and shallow and there are no aestivating tunnels (leaf litter is also largely absent and is considered to be unsuitable aestivating habitat on this soil type). Some land within Ellen Brook Nature Reserve is also largely unsuitable because standing water is too shallow. CALM has already purchased the western half of Lot 14, immediately south on the existing reserve boundary (Now identified as Class A Reserve 42126), but the extent of remaining land to be added to the reserve is at present unknown because negotiations are still underway.

Rehabilitation of Reserve 42126 and that part of Ellen Brook Nature Reserve south and south-west of the nature reserve drain and natural drainage channel will commence immediately and rehabilitation of additional areas will proceed when they have been purchased.

Drains will be filled, swamps deepened, native vegetation planted and weeds controlled. It is proposed to involve volunteers in the labour-intensive parts of this project and clay mining companies in the area have offered earth-moving machinery. Action will be taken to ensure that these operations will not affect the declared threatened plant *Hydrocotyle lemnoides*, which occurs on Ellen Brook Nature Reserve. Should any impact be unavoidable, the approval of the Minister for the Environment will be sought.

Responsibility: CALM Swan Region (Perth District) and Science & Information Division, UWA Zoology Department.

Cost:	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00
CALM	-	-	-	-	-	-	-	-
ESP/other	5000	5000	2500	1000	1000	1000	1000	1000
Total Cost	5000	5000	2500	1000	1000	1000	1000	1000

3.1.4 Extension of fox-proof fence

The fox-proof fence will be extended to include the land currently being added to Ellen Brook Nature Reserve. The additional length required will be about 1.2 km. (Actual length will not be known until land purchases / swaps are finalised.) The date of construction has been set for 1995/96, so as not to be in the same years as the costs of construction of the fox-proof fence at Twin Swamps Nature Reserve (see below).

Responsibility: CALM Swan Region, Perth District.

Cost:	94/95
CALM	-
ESP/other	40000
Total Cost	40000

3.1.5 Population monitoring

Regular patrols of both nature reserves will continue. During 1992 and 1993 most monitoring activities will be concentrated on the population at Ellen Brook Nature Reserve. With the start of translocations to Twin Swamps Nature Reserve (proposed for 1994) released animals will be intensively monitored, but this aspect is dealt with under 3.3.3. By 1994 the rehabilitated habitat on purchased land will be included within the fenced area of Ellen Brook Nature Reserve (see 3.1.3). The intensive level of monitoring has to continue for another three years in order to evaluate the usefulness of the new areas, particularly concerning aestivation and nesting sites.

Responsibility: CALM Science & Information Division and UWA Zoology Department.

Cost:	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
CALM	13500	13500	7500	5000	5000	5000	5000	5000	5000	5000
WWFA	10000	10000	2500							
ESP/other	-	3600	1800	-	-	-	-	-	-	-
BNA*	900	900	-	-	-	-	-	-	-	-
Total Cost	24400	28000	11800	5000	5000	5000	5000	5000	5000	5000

3.1.6 Interim Guidelines for Necessary Operations

Management of a nature reserve and its associated flora and fauna is as laid down in the Conservation and Land Management Act 1984 (CALM Act). Ordinarily, management is undertaken in accordance with a management plan which has undergone statutory planning requirements, including public consultation. However, there are many land management operations that need to be undertaken in the absence of a management plan which are necessary for the preservation or protection of persons, property, land, flora or fauna, or for the preparation of a management plan. These operations are defined in the CALM Act as 'necessary operations' and they can be carried out when there is no management plan in force.

The works proposed in this Recovery Plan are considered to be necessary for the preservation of the Western Swamp Tortoise and are necessary operations. A full Management Plan is not, therefore, required. CALM will update the existing "Interim Guidelines for Necessary Operations" for Ellen Brook Nature Reserve and seek approval of the guidelines by the Director of Nature Conservation and the National Parks and Nature Conservation Authority.

Responsibility: CALM Swan Region (Perth District) and appropriate Recovery Team members.

Cost:	92/93
CALM	300
ESP/other	-
Total Cost	300

* Bundesverband für fachgerechten Natur- und Artenschutz (Germany)

3.2 CAPTIVE BREEDING

The extremely small size of the population and its continued decline in the wild means that captive breeding is essential if the species is not to become extinct. Responsibility for captive breeding passed from the Western Swamp Tortoise Captive Breeding Project Management Committee to Perth Zoo in July 1991, but the tortoises remain the property of the Department of Conservation and Land Management. The Captive Breeding Program will operate to meet, to the greatest extent practicable, the objectives laid down in the IUCN Policy Statement on Captive Breeding (IUCN 1987a). The selection of mating pairs will be guided by results of continuing studies on genotypes of the captives.

The World Wide Fund for Nature Australia and the Department of Conservation and Land Management have provided funds to enable Dr Kuchling's contract with the University of Western Australia to be extended until 1994 on a half-time basis. Technical advice on captive breeding will continue to be provided by Dr Kuchling for the next three years. Perth Zoo proposes to employ an experienced, professionally-trained zoologist to supervise captive breeding of Western Swamp Tortoises and other endangered species, as part of its program to develop the Byford Endangered Species Centre. The zoologist's salary is included in this Plan from 1998/99, even though the Swamp Tortoise will be only part of his/her duties; the costs will be reviewed if money can be raised from projects on other threatened species.

As part of its plans to develop the Byford Endangered Species Centre, Perth Zoo plans to transfer the captive colony there in 1998/99. By that time the current facilities for the Western Swamp Tortoise will need replacement and expansion and the present site is too small. The full costs of this move are included in this Plan; however, some may be absorbed by the Zoo through Government or sponsorship funding. The costs associated with the move to Byford will be reviewed by the Recovery Team at a later date, when Perth Zoo's plans are more advanced. Also, the Byford Centre, which is located in the Darling Range, has a climate somewhat different from the nature reserves at Upper Swan and Perth Zoo, being cooler during winter and spring, the time of greatest activity of *P. umbrina*; this has not yet been discussed by the Recovery Team.

Captive breeding is required largely to provide healthy tortoises for translocation to the wild. The number of tortoises in the captive population will fluctuate depending on breeding and rearing success and the needs of the translocation project. Translocating four year old sub-adults with a minimum weight of 100 g will require a captive population of up to 65 sub-adults to be maintained.

Responsibility: Perth Zoo with advice from UWA Zoology Department.

Cost:	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
Perth Zoo	73300	30300	31000	28300	27500	27500	27500	27500	27500	27500
ESI/other	22100	22100	22100	22100	22100	63900	138800	63800	63800	63800
Total Cost	95400	52400	52400	50400	49600	91300	166300	91300	91300	91300

3.3 Re-introduction to Twin Swamps Nature Reserve

3.3.1 Construction of fox-proof fence

The construction of a fox-proof fence is essential before tortoises can be translocated to Twin Swamps Nature Reserve. The fence will be built to the same general design as the one already constructed at Ellen Brook Nature Reserve. It will be approximately 4.7 km long. Cheaper fence designs have been used elsewhere in Australia, but the risk associated with constructing a less secure fence is considered unacceptable for this critically endangered species.

Responsibility: CALM Swan Region.

Cost:	92/93	93/94
CALM	-	-
ESP/other	73500	73500
Total Cost	73500	73500

3.3.2 Pumping groundwater to maintain swamps and monitoring of food in swamps

Swamps at Twin Swamps Nature Reserve are greatly affected by drought. Only in average to high rainfall years do the swamps contain water for long enough to enable Western Swamp Tortoises to feed sufficiently to survive the summer aestivation period and breed successfully.

Hydrological studies of the area have been conducted by the Western Australian Water Authority with advice from the Geological Survey of Western Australia. These studies suggest that it is feasible to pump from groundwater to maintain swamp life in years of average to below average rainfall. In 1992/93 a bore will be drilled near the north-western corner of the reserve, where the best quality water and electricity are both available, and pipelines will take the water to selected swamps. Initially it is proposed to pump into North-west and East Swamps, commencing in the winter of 1993 or 1994, with North-east and South-east Swamps being used as controls.

The water to be used will be as low in dissolved salts as possible, to prevent a build up of salts and possible effects on the aquatic species that the tortoises depend on for food. However, the best quality water available in the area has about 300 mg/L total dissolved salts, whereas rainfall has only about 20 to 30 mg/L.

The desirable period of swamp life is from early June to the end of November, with at least 20 cm and preferably 30 cm depth from late June to early to mid-November. It is proposed to add water only when rainfall does not provide sufficient water naturally. North-west Swamp overflows at about 20 cm depth; thus depths of 30 cm are not achievable. At East Swamp, however, depths of well above 30 cm have been reached naturally, but only very infrequently over the past two decades.

It would be desirable for sufficient water to be available from pumping to flush North West Swamp occasionally, although this should occur often enough naturally to prevent salt build up. East Swamp has no natural overflow and, if salts build up there, some artificial means of flushing may be needed.

Studies on the effects of groundwater pumping will be necessary to find out whether there is any increase in dissolved salts and to ensure that any increase does not have any deleterious impact on the tortoises' food. Analysis of water samples from the swamps will continue, with costs being absorbed by CALM. Collections of invertebrates from the swamps commenced in 1991, and the samples have been sorted and identified, with financial support from the W.A. Water Authority. A sampling program for invertebrates has been designed and will be implemented. Funds are required to pay for the sorting and identification of the samples. Sampling will be carried out every year for the first three years after pumping commences, and thereafter every second year.

The Western Australian Water Authority has made a commitment (subject to final budget approval) to construct the bore and install the pump and pipelines. They have also made a tentative commitment to maintain the pump. Electricity costs are needed from other sources, while CALM will provide staff time (costed under monitoring).

Responsibility: CALM Swan Region and Science & Information Division, WA Water Authority (WAWA).

Cost:	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
CALM	-	-	-	-	-	-	-	-	-	-
WAWA	35000									
ESP/other	8500	9000	9000	1000	9000	1000	9000	1000	9000	1000
Total Cost	43500	9000	9000	1000	9000	1000	9000	1000	9000	1000

3.3.3 Translocation

The Management Program provides for translocation of captive-bred tortoises to Twin Swamps Nature Reserve. Twin Swamps Nature Reserve appears to have offered good habitat during periods of average to above average rainfall (e.g. the mid-1960s) when the tortoises reproduced successfully and grew much faster than those at Ellen Brook and should do so again once swamp life is lengthened and exotic predators are controlled.

The timing of translocations and the number of tortoises released will be dependent on the continued success of captive breeding and will be decided by the Western Swamp Tortoise Recovery Team. It is likely that translocations can commence in winter 1994. Translocations will need to take place over several years. Translocated tortoises will be equipped with radio-transmitters to monitor their survival and reproductive success in the wild. Radio-tracking and monitoring of translocated tortoises will be labour intensive over the first five years of the project and will continue at a lower level for the remainder of the term of this plan.

Translocations will be guided by the IUCN Position Statement on Translocation of Living Organisms (IUCN 1987b) and will be subject to approval pursuant to the CALM Translocation Policy.

Responsibility: UWA Zoology Department and CALM Science & Information Division.

Cost:	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
CALM	3300	3300	6600	5000	5000	5000	5000	5000	5000	5000
WWFA	5000	5000	5000							
ESP/other	-	4300	23900	39000	41000	16700	16700	16700	16700	16700
Total Cost	8300	12600	35500	44000	46000	46000	21700	21700	21700	21700

3.3.4 Interim Guidelines for Necessary Operations

Management of a nature reserve and its associated flora and fauna is as laid down in the Conservation and Land Management Act 1984 (CALM Act). Ordinarily, management is undertaken in accordance with a management plan which has undergone statutory planning requirements, including public consultation. However, there are many land management operations that need to be undertaken in the absence of a management plan which are necessary for the preservation or protection of persons, property, land, flora or fauna, or for the preparation of a management plan. These operations are defined in the CALM Act as 'necessary operations' and they can be carried out when there is no management plan in force.

The works proposed in this Recovery Plan are considered to be necessary for the preservation of the Western Swamp Tortoise and are necessary operations. A full Management Plan is not, therefore, required. CALM will update the existing "Interim Guidelines for Necessary Operations" for Twin Swamps Nature Reserve and seek approval of the guidelines by the Director of Nature Conservation and the National Parks and Nature Conservation Authority.

Responsibility: CALM Swan Region (Perth District) and appropriate Recovery Team members.

Cost:	92/93
CALM	300
ESP/other	
Total Cost	300

3.3.5 Management of fire, predators etc.

Active, ongoing management is required for Twin Swamps Nature Reserve. Management needs to ensure that sufficient leaf litter for tortoise aestivation is present in some of the reserve at all times. The creation of artificial aestivating tunnels will be investigated. Before the production of the Management Plan, management will be guided by normal reserve management procedures and by the Recovery Team. Fox and rabbit control will be implemented within the fenced area as required.

Responsibility: CALM Swan Region.

Cost:	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
CALM	3200	5200	11200	8200	8200	8200	8200	16000	8200	8200
ESP/other	-	-	-	-	-	-	-	-	-	-
Total Cost	3200	5200	11200	8200	8200	8300	8200	16000	8200	8200

3.4 Education, Publicity and Sponsorship

3.4.1 Education and publicity

The Recovery Plan described here is expensive in terms of both staff and finance and the support of the public is essential if the Western Swamp Tortoise is to be conserved.

The Department of Conservation and Land Management and Perth Zoo, in cooperation with other relevant organizations, will coordinate a public education program on the Western Swamp Tortoise and on the measures being undertaken to prevent its extinction.

Responsibility: CALM Corporate Relations Division, Perth Zoo, The University of Western Australia.

Cost:	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
CALM	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Perth Zoo	500	500	500	500	500	500	500	500	500	500
ESP/other	-	-	-	-	-	-	-	-	-	-
Total Cost	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500

3.4.2 Sponsorships

In recent years the amount of money raised by sponsorships and public appeals has been a feature of the research into and management of the Western Swamp Tortoise. Since 1988, in addition to the provision of funds and staff-time from the Department of Conservation and Land Management and Perth Zoo, money, equipment, substantial discounts on purchases or direct assistance have come from:

World Wide Fund for Nature Australia
Endangered Species Program, Australian Nature Conservation Agency
WA Nature Conservation and National Parks Trust Account
Bundesverband für fachgerechten Natur-und Artenschutz (Germany)
British Chelonia Society
Western Australian Water Authority
Aherns Pty Ltd
East-West Veterinary Supplies
Kailis Brothers
Minerva Airconditioning
Unidata Australia Pty Ltd
Zoology Department, The University of Western Australia
School of Biomedical Sciences, Curtin University of Technology

Because of its high public profile the Western Swamp Tortoise Recovery Plan lends itself to further sponsorships and other methods of fund-raising.

Responsibility: CALM (external funding officer) and the Recovery Team.

<i>Cost:</i>	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CALM	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
ESP/other	-	-	-	-	-	-	-	-	-	-
Total Cost	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

4. IMPLEMENTATION SCHEDULE

Task	Priority	Feasibility	Responsible party	Funding	Cost estimate (\$000s/year, 1992 dollars)										Total	
					92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02		
3.1 MANAGEMENT OF ELLEN BROOK NATURE RESERVE AND WILD POPULATION*																
3.1.1 Management of fire, predators	1	100%	CALM Perth	a	6.0	10.0	6.0	6.2	6.2	6.2	6.2	6.2	13.3	6.2	6.2	72.5
3.1.2 Removal of drain	2	75%	CALM Perth	a	0.5	0.9	1.9									3.3
3.1.3 Rehabilitation of land	2	75%	CALM Perth/ CALM SID	f	5.0	5.0	2.5	1.0	1.0	1.0	1.0	1.0	1.0			17.5
3.1.4 Extension - fox fence	1	100%	CALM Perth	f		40.0										40.0
3.1.5 Population monitoring	1	100%	CALM SID/ UWA Zoology	a	13.5	13.5	7.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	69.5
3.1.6 Interim management guidelines	3	100%	CALM Perth	a	0.3	10.0	2.5									22.5
				d	0.9	0.9										1.8
				f	-	3.6	1.8									5.4
				a	0.3											0.3
3.2 CAPTIVE BREEDING																
	1	100%	Perth Zoo	b	73.3	30.3	31.0	28.3	27.5	27.5	27.5	27.5	27.5	27.5	27.5	327.9
				f	22.1	22.1	22.1	22.1	22.1	63.9	138.8	63.8	63.8	63.8	63.8	504.6
3.3 RE-INTRODUCTION TO TWIN SWAMPS																
3.3.1 Construction of fox fence	1	100%	CALM Perth	f	73.5	73.5										147.0
3.3.2 Pumping groundwater into swamps	1	100%	CALM Perth/ CALM SID/ WAWA	e	8.5	9.0	9.0	9.0	1.0	9.0	9.0	9.0	1.0	9.0	1.0	65.5
				a	3.3	3.3	6.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	35.0
				f	4.3	4.3	23.9	39.0	41.0	41.0	16.7	16.7	16.7	16.7	16.7	48.2
				c	5.0	5.0	5.0									15.0
3.3.3 Translocation	1	50%	UWA Zool/ CALM SID	f	0.3	5.2	11.2	8.2	8.2	8.2	8.2	8.2	16.0	8.2	8.2	86.8
3.3.4 Interim management guidelines	3	100%	CALM Perth	a	0.3											0.3
3.3.5 Management of fire, predators	1	100%	CALM Perth	a	5.2	5.2										10.4
3.4 EDUCATION, PUBLICITY, SPONSORSHIP																
3.4.1 Education and publicity	1	100%	CALM CR Div Perth Zoo	a	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0
				b	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5.0
3.4.2 Sponsorships	1	50%	CALM/ Recovery Team	a	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	20.0
ANNUAL COST OF WESTERN SWAMP TORTOISE RECOVERY																
			CALM		32.1	35.9	36.2	27.4	27.4	27.4	27.4	27.4	42.3	27.4	27.4	310.9
			Perth Zoo		73.8	30.8	31.5	28.8	28.0	28.0	28.0	28.0	28.0	28.0	28.0	332.9
			Sponsors/donations		50.9	15.9	7.5									74.3
			ESP/other funds required		109.1	117.5	99.3	71.1	65.1	114.9	165.5	82.5	82.5	89.5	81.5	996.0
			Total Cost		265.9	200.1	174.5	127.3	120.5	170.3	220.9	144.9	132.8	144.9	136.9	1714.1

* a CALM

SID Science and Information Division

b Perth Zoo

c World Wide Fund for Nature

d Bundesverband für fachgerechten Natur- und Artenschutz (Germany)

e Western Australian Water Authority

f ESP (National Endangered Species Program)/other funds required

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GLOSSARY

aestivation, dormancy during the summer.

ANCA, Australian Nature Conservation Agency, the Commonwealth Government body responsible for wildlife conservation.

carapace, the upper part of the shell of tortoises and turtles.

CALM, the Western Australian Department of Conservation and Land Management.

Chelidae, the family of pleurodiran Testudines to which the Western Swamp Tortoise belongs.

chelid, a member of the Chelidae.

Cryptodira, the sub-order of Testudines containing the hidden-necked families: families where most species (but not marine turtles) are able to withdraw their necks into the shell by bending the neck in a vertical plane.

fecundity, the capacity to produce young.

gilgai, a clay soil containing natural hollows.

Gondwanan, originating in Gwondana, the southern "super-continent" that split up to form Australia, Antarctica, South America, Africa, Madagascar, New Zealand and India. Australia remained joined to Antarctica until between 45 and 38 million years ago.

husbandry (of animals), careful management.

Miocene, a geological epoch lasting from about 4.5 to 24.6 million years ago.

palpation, examination by the sense of touch

plastron, the under part of the shell of tortoises and turtles.

Pleurodira, the sub-order of Testudines containing the side-necked families: families where species are unable to withdraw their necks into the shell but are able to gain some protection for the head by bending the neck in a horizontal plane (side-ways) between the carapace and plastron.

pygal, a bone forming part of the carapace of a testudinid.

radiography, the production of images on a photographic plate using X-rays or other rays

taxonomy, study of the classification of organisms according to their similarities and differences.

Testudines, the order of Reptiles to which tortoises and turtles belong

testudinid, a tortoise or turtle.

translocation, moving an organism from one place to another.

UWA, The University of Western Australia.

vernacular name, the common name for a plant or animal.

WWF, The World Wide Fund for Nature (formerly the World Wildlife Fund).

APPENDIX I

DETAILS OF COSTINGS

Section 3.1.1 Ellen Brook Nature Reserve - management of fire, predators, etc.

The existing farm-type stock fence on the boundary of the Nature Reserve was retained after the fox-proof fence was constructed. It needs replacement every several years and this is staged because different parts of it are in various states of repair. Rabbits occur within the fox-proof fence and will require annual control unless eradication is achieved.

Item	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
Firebreaks	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Weed control	1000	1000	1000	1200	1200	1200	1200	1200	1200	1200
Reserve/fence inspections	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Fox control	500	500	500	500	500	500	500	500	500	500
Rabbit control	500	500	500	500	500	500	500	500	500	500
Replace farm fence	-	4000	-	-	-	-	-	7100	-	-
Farm fence maintenance	500	500	500	500	500	500	500	500	500	500
Fox fence maintenance	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
TOTAL	6000	10000	6000	6200	6200	6200	6200	13300	6200	6200

Section 3.1.5 Population monitoring

Number of days of field-work in nature reserves

1992/93 and 1993/94:

December - April: 3 days per month	15
May: 3 days per week	12
June - September: 1 day per week	17
October / November: every day	61

days of field work per year: 105

Vehicle costs: 40c/km, 94 km per day of field work = \$ 37.60 per day = \$ 3948 per year.

In 1994/95 the field work will be combined with the monitoring of the translocated animals at Twin Swamps Nature Reserve. Although the same number of days will still be required, 50% of the vehicle costs are shown under 3.3.3. Later, work will be done by CALM staff. CALM staff costs are 36 trips of 75 km at \$0.33 per km per year: \$900, plus vehicle overheads \$800.

Radio-transmitters (females):

10 transmitters (@ \$400 per transmitter) were purchased during 1991 and will be used, but have to be re-battered and maintained every year: \$160 per transmitter (40 % of purchase costs) = \$ 1600 per year.

Salaries:

2/3 of the costs of a 0.5 research scientist in 1992/93 and 1993/94: \$20140 per year. 1/3 of the costs of a 0.5 research scientist in 1994/95: \$10070. CALM staff costs equivalent to four weeks per year: \$3300.

Section 3.2 Captive breeding

Major costs associated with the transfer of the captive colony to Perth Zoo's new Endangered Species Centre at Byford in 1998 may be able to be absorbed by the Zoo if sufficient funds are made available by Government or provided through public appeals or by sponsors.

PERTH ZOO CONTRIBUTIONS

Item	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
<i>Staffing Costs</i>										
Salary (keeper 0.7 FTE)	18500	18500	18500	18500	18500	18500	18500	18500	18500	18500
Leave loading	250	250	250	250	250	250	250	250	250	250
Payroll tax	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Superannuation	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Sub-Total	22050	22050	22050	22050	22050	22050	22050	22050	22050	22050
<i>Operational Costs</i>										
Hatchling food	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Adult/sub-adult food	250	325	340	340	340	340	340	340	340	340
Veterinary services	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Veterinary supplies	700	700	700	700	700	700	700	700	700	700
DNA finger- printing	600	750	1300	1550	750	750	750	750	750	750
Identification implementation	150	0	110	160	120	150	150	150	150	150
Sub-Total	\$5200	\$5275	\$5950	\$6250	\$5410	\$5440	\$5440	\$5440	\$5440	\$5440
<i>Capital Costs</i>										
Existing hatchery	8000									
Existing enclosure	35000									
Aestivation ponds	650	650	650							
Hatchling ponds	1000	1000	1000							
Enclosure extensions	1000	1000	1000							
Adult/sub-adult	350	350	350							
Sub-Total	46000	3000	3000							
ZOO TOTAL	73250	30325	31000	28300	27460	27490	27490	27490	27490	27490

ESP/OTHER FUNDS REQUIRED

Item	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
Staffing Costs										
Salary (Keeper 0.7 FTE)	18500	18500	18500	18500	18500	18500	18500	18500	18500	18500
Salary (Zoologist)						35000	35000	35000	35000	35000
Leave loading	250	250	250	250	250	725	725	725	725	725
Payroll tax	1100	1100	1100	1100	1100	3200	3200	3200	3200	3200
Superannuation	2200	2200	2200	2200	2200	6400	6400	6400	6400	6400
Sub Total	22050	22050	22050	22050	22050	63825	63825	63825	63825	63825
CAPITAL COSTS										
Construction and fitting out tortoise facility at Byford							75000			
Sub Total							75000			
ESP TOTAL	\$22050	\$22050	\$22050	\$22050	\$22050	\$63825	\$138825	\$63825	\$63825	\$63825
GRAND TOTAL	\$95300	\$52375	\$52375	\$50350	\$49510	\$91315	\$166315	\$91315	\$91315	\$91315

Section 3.3.3 Translocation.

Radio transmitters: The radio transmitters must be as light as possible and have a long battery life. Because of the weight limit the batteries may have to be changed twice a year. It is anticipated that 1993 and 1994 will be trial years with only 5 transmitters needed per year and that in 1995 and 1996 about 20 animals with transmitters will be released per year. From then on, 10 animals per year may be released, but the final numbers depend on the PVA simulations and the success of captive breeding. Transmitter costs are calculated to be \$350 per transmitter when purchased and \$200 per year for maintenance. Since larger batteries can be used when animals grow bigger, maintenance costs come down slightly for older animals.

DNA fingerprinting: Only the fingerprinting costs for the first 30 animals to be released are calculated, because most of the older captive-bred animals have not been fingerprinted after hatching, via allantoic membranes. Fingerprinting of the remaining animals to be released is shown under 3.2, because they will have been fingerprinted as hatchlings.

Vehicle costs: 1994/95: 50% of 94 km per day for 105 days per year (see 3.1.5 for details): \$ 1974. 1995/96-1997/98: 94 km per day for 105 days per year: \$3984. 1998/99-2001/02: 94 km per day for 50 days per year: \$1880 per year.

Salary:

1992/93-1993/94: 1/3 of 0.5 research scientist:	\$10070
1994/95: 2/3 of 0.5 research scientist:	\$20140
1995/96-1997/98: 0.5 research scientist:	\$30200
1998/99-2001/02: 1/2 of 0.5 research scientist:	\$15100

Section 3.3.5 Twin Swamps Nature Reserve - management of fire, predators, etc.

The existing farm-type stock boundary fence will be retained after construction of the fox-proof fence and requires replacing in 2000. Western Grey Kangaroos are abundant at Twin Swamps and some will be confined after construction of the fox-proof fence. Control will probably be necessary to prevent numbers building up to levels that cause degradation of vegetation. Rabbits will also be trapped within the fence and will require annual control. Weed control costs will rise after construction of the fox-proof fence, because control will be necessary at and adjacent to the base of the fence.

Item	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02
Firebreaks	950	950	950	950	950	950	950	950	950	950
Weed control	750	750	1750	1750	1750	1750	1750	1750	1750	1750
Reserve/fence inspections	-	-	1500	1500	1500	1500	1500	1500	1500	1500
Fox control	-	-	2000	1000	1000	1000	1000	1000	1000	1000
Rabbit control	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Kangaroo management	-	-	500	500	500	500	500	500	500	500
Replace farm fence	-	-	-	-	-	-	-	7800	-	-
Farm fence maintenance	500	500	500	500	500	500	500	500	500	500
Fox fence maintenance	-	-	1000	1000	1000	1000	1000	1000	1000	1000
Rehabilitation	-	-	-	-	-	-	-	-	-	-
fence line erosion	-	2000	2000	-	-	-	-	-	-	-
TOTAL	5200	5200	11200	8200	8200	8200	8200	16000	8200	8200