Department of Conservation and Land Management, W.A.

Benger Swamp Nature Reserve

Draft Management Plan

DECEMBER 1986

BENGER SWAMP NATURE RESERVE

DRAFT MANAGEMENT PLAN

DECEMBER 1986

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MANAGEMENT PLAN NO. 7

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ACKNOWLEDGEMENTS

Contributions by the following two groups of people, who provided information on the Swamp and suggestions regarding its future management, are gratefully acknowledged. First, members of the local community - Brian Briney, Neil Campbell, Nat Debiase, Tony Frisina, Barry Fry, Bill Fry, Gess Italiano, Joe Italiano, the late Roy Pinner, Les Robinson, Eric Sedgwick and Ian Offer. Second, officers from the Departments of Mines, Land Administration and Agriculture (Harvey and Perth Offices), the Water Authority of Western Australia, Bush Fires Board (Bunbury), Shire of Harvey and Harvey Agricultural School. The contributions by a number of officers from the Department of Conservation and Land Management are also gratefully acknowledged.

We would also like to acknowledge the work of Chris Simms in preparing the maps and diagrams, Melinda Walker for typing the plan and Sue Patrick for the drawing on the front cover.

PREFACE

The draft management plan for Benger Swamp is based on the best available knowledge and resources. The plan, once approved, will have a five year term.

This management plan is one of a series prepared by the Department of Conservation and Land Management (CALM) for the relevant controlling body (either the National Parks and Nature Conservation Authority or the Lands and Forest Commission, or both), to fulfil the requirements of the Conservation and Land Management Act (1984).

The Act states that:

> 'A management plan for any land shall contain -
> (a) a statement of the policies or guidelines proposed to be followed; and
> (b) a summary of the operations proposed to be undertaken,'
>
> (Section 55(1))
>
> and
>
> '... in particular management plans shall be designed -
> (d) in the case of nature reserves, ... to maintain and restore the natural environment, and to protect, care for, and promote the study of, indigenous flora and fauna'
>
> (Section 56(1))

Completion of each plan involves three stages. First, the plan is published as a draft, and members of the local community (particularly reserve neighbours), government departments, local government authorities, tertiary institutions, conservation groups and the general public are encouraged to submit comments. Second, the draft is reviewed in the light of these comments, and an amended draft and summary of public submissions produced. The amended draft and summary of public submissions are then submitted by the National Parks and Nature Conservation Authority (NPNCA) or the Lands and Forest Commission, or both, to the Minister for Conservation and Land Management for approval. Third, once approved, the plan is published in its final form.

The amended draft and summary of public submissions are also submitted to the Bush Fires Board. Once approved by the Board the management plan consitutes the fire protection plan for the given area.

In all management plans plant species are named according to Green (1985). Birds are named according to Blakers et al. (1984). Mammals are named according to Strahan (1983) and reptiles according to Cogger (1983). All graphs in this plan are based on a 'wetland year', that is, May to April, rather than the calendar year of January to December. This approach has been used to show the close relationship between rainfall and waterbird use.

SUMMARY

NATURE CONSERVATION VALUES

Benger Swamp is an important conservation area for several reasons:

1. It provides a seasonal wetland for a wide range of waterbird species.

2. It is one of only four known breeding sites in south-western Australia for the Freckled Duck.

3. It has the highest number of Australasian Bitterns recorded from any one of the eighteen known sites in south-western Australia.

GENERAL MANAGEMENT OBJECTIVE AND STRATEGY

General Management Objective

The general management objective for Benger Swamp is to protect and enhance the area as waterbird habitat for the present range of species, with special emphasis on the habitat requirements of the Freckled Duck and Australasian Bittern.

General Management Strategy

To achieve this objective manipulative management techniques will be used. This is necessary given the highly altered nature of Benger Swamp, with the area having been used for vegetable growing for the last 70 years. Such management complies with the management objectives for nature reserves given in the Conservation and Land Management Act, namely to 'protect and care for ... indigenous flora and fauna'. This manipulative approach to management is accepted by the International Union for Conservation of Nature and Natural Resources (IUCN) as being the best way, in some instances, of guaranteeing the stability and survival of certain species and ecosystems. Where this approach has been adopted, the IUCN has used the term managed nature reserve.

The above objective and strategy will be achieved by resolution of the following issues and implementation of the following detailed strategies.

MANAGEMENT ISSUES AND STRATEGIES

1. LAND TENURE

Issues

Benger Swamp has a mixture of land tenures, making co-ordinated management difficult. Benger Swamp Nature Reserve and other land purchased by the Government encompasses 87% of the Swamp area. Road and drain reserves cover less than 1%. The remaining 13% is privately owned.

Strategies

1. Continue discussions with landholders regarding the purchase, by CALM, of all remaining privately owned land on the Swamp.

2. Add all land on the Swamp purchased by the Government to the Nature Reserve.

2. WATER LEVELS AND DRAINAGE

Issues

Water levels in the Swamp are artifically controlled. Historically, the Swamp has been drained in December, to hasten its drying by six to eight weeks, so that crops could be grown and harvested before the Swamp flooded in May. The Swamp has been filled via drains opened in early winter which allow run-off from farmland to the north-east to flow into the Swamp.

The date of commencement of drainage has been based on the need to retain water in the Swamp for as long as possible to provide waterbird habitat and the need to have the Swamp dry by mid-January so cropping can commence. It should be noted that if the Swamp was left to dry naturally it would only take an extra six to eight weeks to dry.

Strategies

1. Divide the Swamp into northern and southern compartments, draining the northern compartment so it is dry by mid-January and allowing the southern compartment to dry naturally. Implementation will include consultation with the Benger Swamp Regional Advisory Committee.

   Most of the privately owned land lies in the northern part of the Swamp. Only one block of privately owned land remains in the southern part and purchase of this block is presently being negotiated. Thus, this strategy enables farmers to commence cropping the northern part of the Swamp by mid-January, while retaining water for as long as possible on the southern part.

2. Fill the whole Swamp in June with water to a depth of 0.7 m.

   This is the maximum depth which can be achieved without flooding adjacent low-lying ground. Levels lower than 0.7 m would reduce the extent of the flooded areas on the Swamp.

3. *TYPHA* CONTROL

Issues

If control measures are not taken *Typha* may well spread to cover the entire Swamp, decreasing habitat diversity and making fire control difficult. Frequent fires are a problem at Benger as they kill the stands of *Melaleucas* which fringe the Swamp. Freckled Ducks use these stands for moulting and breeding.

At present, ploughing stands of *Typha* seedlings, and subsequent cultivation of fodder crops by local farmers, is an effective control method.

Strategies

1. Plough and cultivate existing open areas each autumn, in both the northern and southern compartments, under a leasing system.

2. Use firebreaks to divide existing *Typha* stands into blocks and separate from stands of *Melaleucas*.

4. DUCK SHOOTING

Issues

Benger Swamp is an important waterbird feeding and breeding area, particularly for the Freckled Duck, a rare and endangered species. In accordance with this plan, considerable resources will be dedicated to the enhancement of the Swamp as waterbird habitat for the present range of waterbirds, including the Freckled Duck.

In the past, duck shooting on Benger Swamp has resulted in Freckled Ducks being shot.

Strategy

1. Close Benger Swamp to duck shooting.

5. MINING

Issues

Two recent exploration licence applications cover land on the eastern edge of the Swamp.

It is likely that mining in the vicinity of Benger Swamp would adversely affect water supply and quality.

Strategies

1. Establish a 'no mining condition' over Benger Swamp. If this condition is established, exploration or mining may only be carried out with the written consent of the Minister for Minerals and Energy, who must consult with the Minister for Conservation and Land Management. Ministerial consent may be withheld, or given subject to terms and conditions.

2. If mining is approved, develop environmental conditions to ensure that the current values of the Swamp as waterbird habitat are conserved. Conditions will be determined by CALM in consultation with the Department of Mines.

6. LOCAL COMMUNITY INVOLVEMENT

Issues

Successful management of Benger Swamp for waterbird conservation is dependent on the support of landholders on and adjacent to the Swamp.

Strategies

1. Expand the functions and revise the structure of the Benger Swamp Regional Advisory Committee, to provide a forum for discussion of all aspects of management on the Swamp. Changes to this Advisory Committee will be made in consultation with them.

PART A. BENGER SWAMP

1.0 LOCATION AND PHYSICAL FEATURES

1.1 Location and Tenure

Benger Swamp is located on the Swan Coastal Plain, 155 km south of Perth and 25 km north-east of Bunbury, in the Shire of Harvey (Fig. 1). The Swamp is 2 km west of the townsite of Benger, with access from the South Western Highway via Swamp Road.

Benger Swamp originally covered an area of approximately 1 000 ha. Over the last century this area has effectively been reduced, by the construction of a network of drains and levees, to 572 ha.

The present tenure of land on Benger Swamp is 19% nature reserve, 68% land purchased by the Government for addition to the Nature Reserve and 13% privately owned (Fig. 2).

The present area of Benger Swamp Nature Reserve (No. 34811, Class C) is 113 ha (October 1986). Ultimately, the Reserve will encompass all of the existing Swamp, plus a small area of adjacent land, and have a total area of 582 ha (Fig. 1).

System Six recommendation C65 applies to Benger Swamp. The major recommendation is that Benger Swamp, once it is all part of the one reserve, be classified as Class A.

1.2 Surrounding Land Use

Benger Swamp is surrounded by farmland, most of which has been cleared. To the east and south, the rich soil at the base of the Scarp is used for dairy farming. In the summer, this area is irrigated to provide green feed. Farmland to the north and west has poorer soil and is too flat for irrigation. This area is under pasture and is used for cattle grazing.

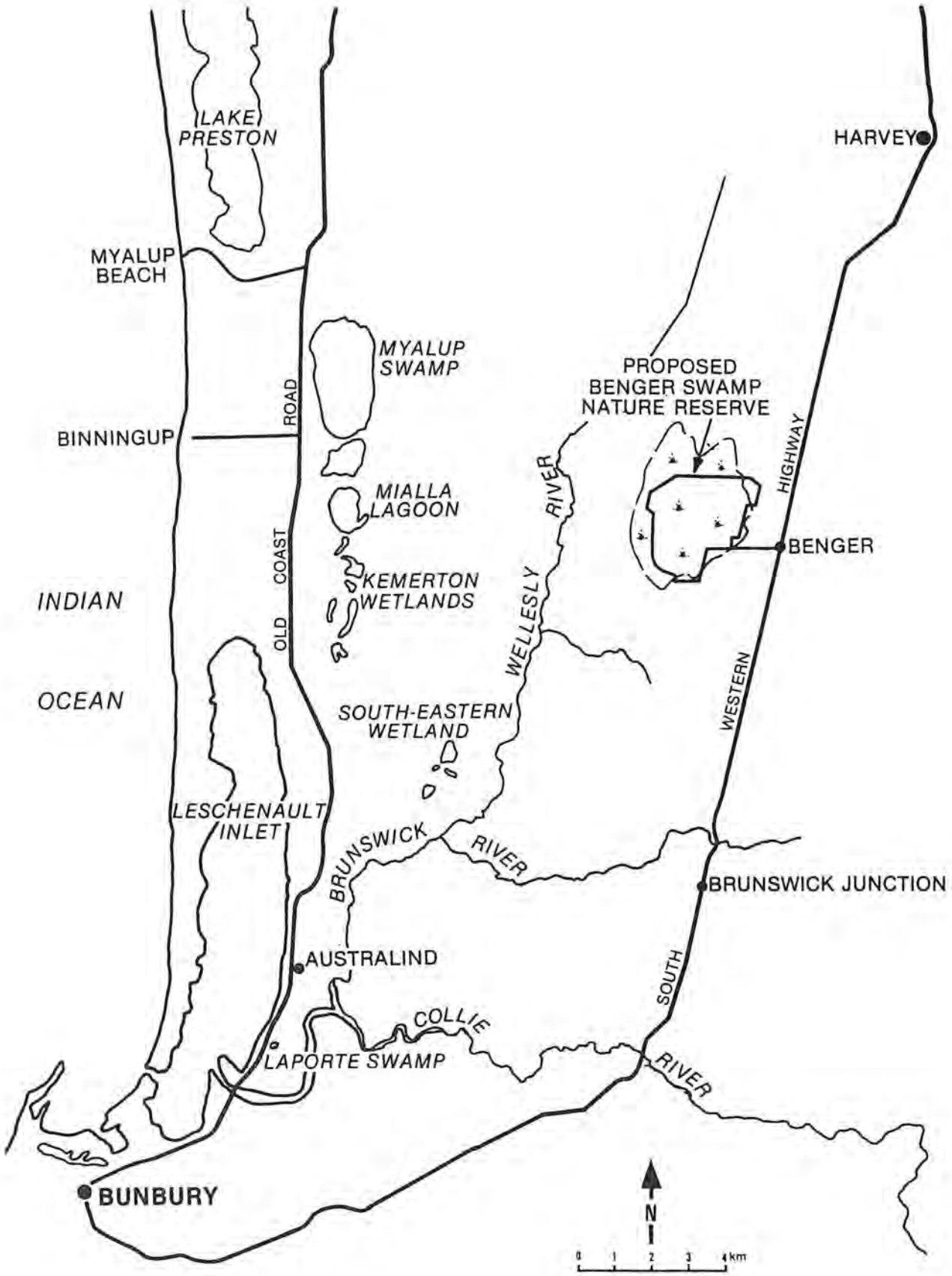

Figure 1. Location of the proposed Benger Swamp Nature Reserve and major regional wetlands.

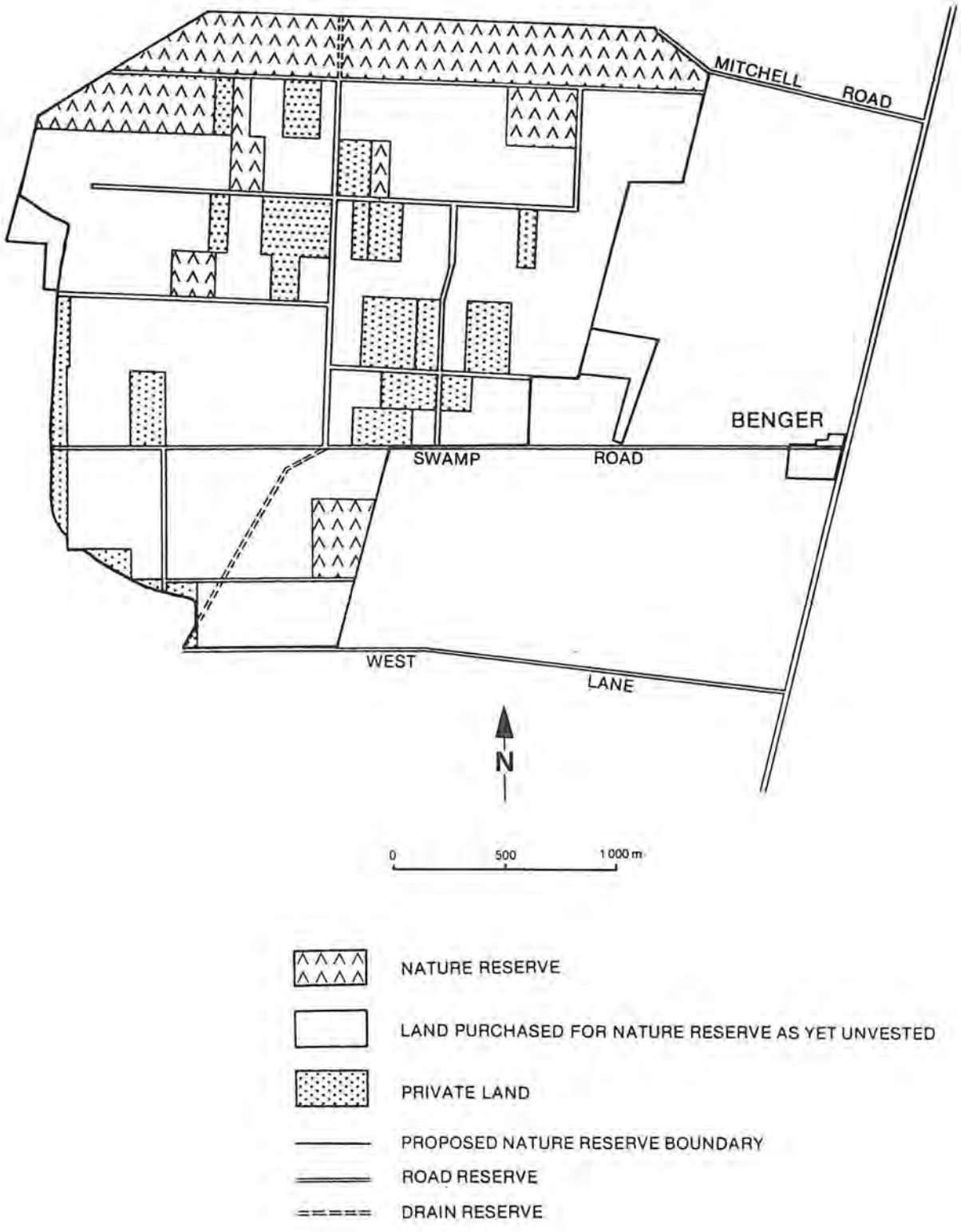

Figure 2. Land tenure of the proposed Benger Swamp Nature Reserve (October 1986).

1.3 Other Wetlands in the Region

Other wetlands in the region include the Leschenault Inlet, Laporte Swamp, the Collie, Brunswick and Wellesley Rivers, Kemerton wetlands, Mialla Lagoon, Myalup Swamp and Lake Preston (Fig. 1). These wetlands provide refuge and breeding habitat for a number of waterbird species. Species present include ones which move freely, in large numbers, between the major wetlands of the region as well as species restricted to just one or two wetlands.

1.4 Implications for Management

1. CALM does not have control over the whole Swamp because some land (13%) is still privately owned.

2. Although 87% of the Swamp has been purchased by the Government, only 19% has been set aside as nature reserve.

2.0 CLIMATE

2.1 General

The Mediterranean climate of the region is characterised by mild, wet winters and hot, dry summers. On average the Benger area receives 1 000 mm of rainfall each year, almost 70% of which falls between May and August. For eight months of the year, that is, September to April, monthly evaporation exceeds rainfall[+] (Fig. 3).

2.2 Implications for Management

1. During the hot, dry summers the rush *Typha* , which covers much of the Swamp, dries out providing high levels of combustible fuel.

[+] data from Wokalup Agricultural Research Station, 9 km north of Benger.

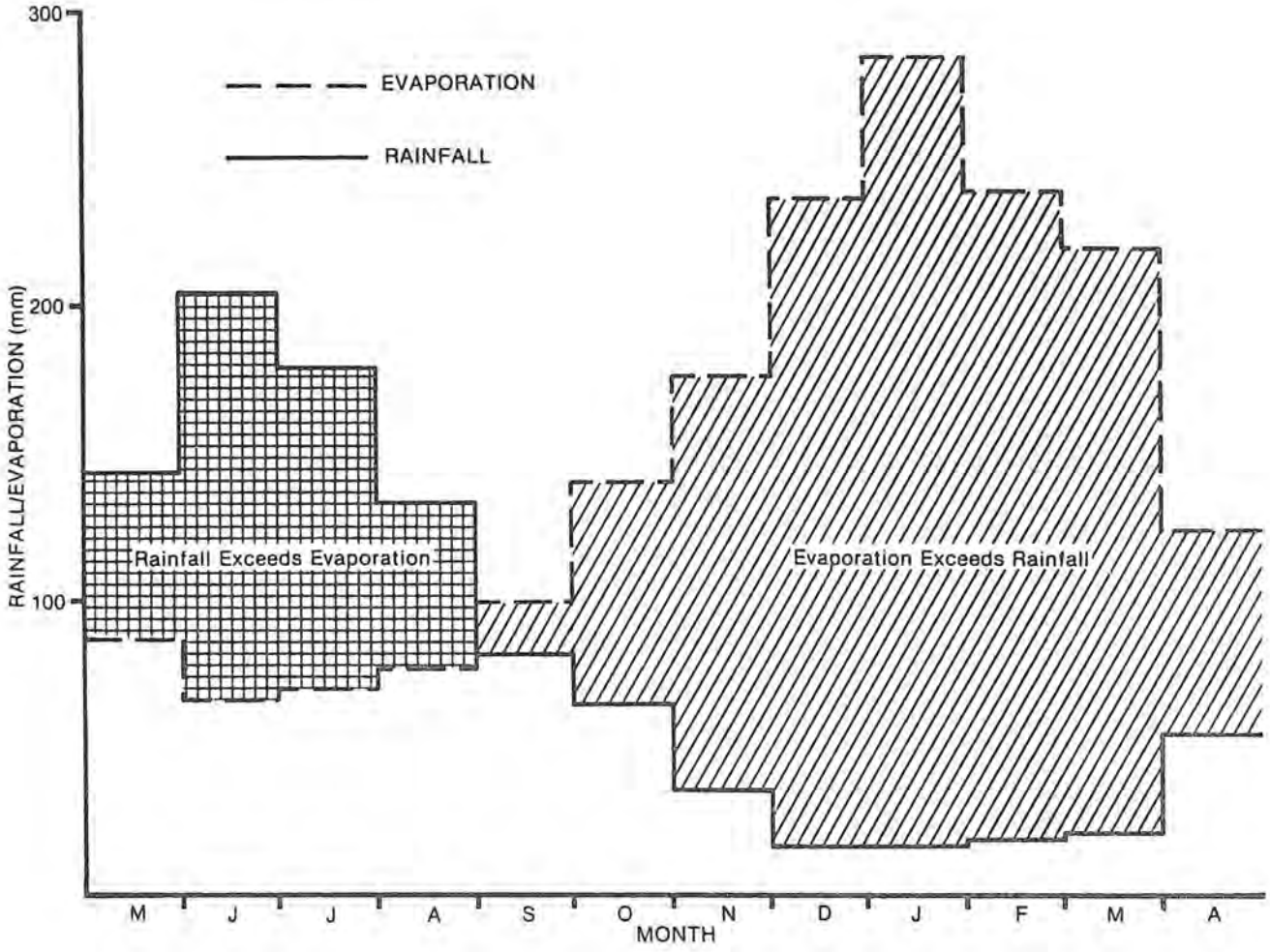

Figure 3. Monthly rainfall and evaporation. (Source: Wokalup Agricultural Research Station, 9 km north of Benger, 1986.)

3.0 GEOLOGY, GEOMORPHOLOGY AND SOILS

3.1 Geology, Geomorphology and Soils

The Swamp lies within the Pinjarra Plain (MacArthur and Bettanay 1960), which is part of the Swan Coastal Plain. The Pinjarra Plain is composed of a series of alluvial soils forming a band, up to seven kilometres wide, stretching from the Darling Scarp to the Wellesley River. The Swamp is situated in an oval-shaped depression in the Plain.

A feature of the landscape is a series of low-lying ridges or lunettes which have formed to the west of the Swamp. These have resulted from wind erosion of the dry Swamp surface during summer.

Soils consist of friable, dark-grey loams overlying low permeability clays.

3.2 Mining

Two recent exploration licence applications in the Benger area cover land on the eastern edge of the Swamp. The companies involved are Westralian Sands and Bedrock Mining.

Discussions are currently underway, between CALM and the Department of Mines, to establish a 'no mining condition' over Benger Swamp. If this condition is established, exploration or mining may only be carried out with the written consent of the Minister for Minerals and Energy, who must consult with the Minister for Conservation and Land Management prior to any decisions being made (Sections 23 and 24, Mining Act 1978). Ministerial consent may be withheld, or given subject to conditions and terms.

3.3 Implications for Management

1. The exploration licence holders may seek Government approval to conduct mineral exploration in the Benger area.

2. If mining is approved in the Benger area, environmental conditions will need to be developed by CALM in consultation with the Department of Mines.

4.0 HISTORY

4.1 Aboriginal Occupation

It is likely that Aborigines used the Benger area, although no Aboriginal sites have been recorded on or adjacent to the Swamp.

4.2 Nomenclature

The area was originally known to European settlers as Mornington, and the Swamp referred to as the Flats of the Mornington. Benger was derived from the local Aboriginal name for Benger Swamp which has been given as Bengerup, meaning place of water (de Jong 1958) and Beenja, meaning big water (South Western Times, 21 November 1968).

4.3 European Exploration and Ownership

The first European to explore the Benger area was Governor Stirling, in April 1836. He was closely followed by Shenton and Wells who, in December 1837, passed to the east of the Swamp.

In 1830, prior to exploration, 42 000 ha of land including Benger Swamp had been granted to Lautor. Similarly to other settlers of the time, however, he could not claim full title until he had carried out improvements to the land. As few improvements had been made by 1837 Stirling was able to claim 16 200 ha of the grant (known as Wellington Location (1) and including Benger Swamp). In the late 1830s the West Australian Company was established. Both Lautor and Stirling recognised the opportunity to capitalize on the situation and sold their land to the Company.

The first land title under the Transfer of Land Act of 1884 shows the owners of 889 ha of Benger Swamp as Leake, Harper and Paterson. This title covered most of the Swamp (Fig. 4a). The land changed ownership several times in subsequent years and by the 1890s was owned by Wellard.

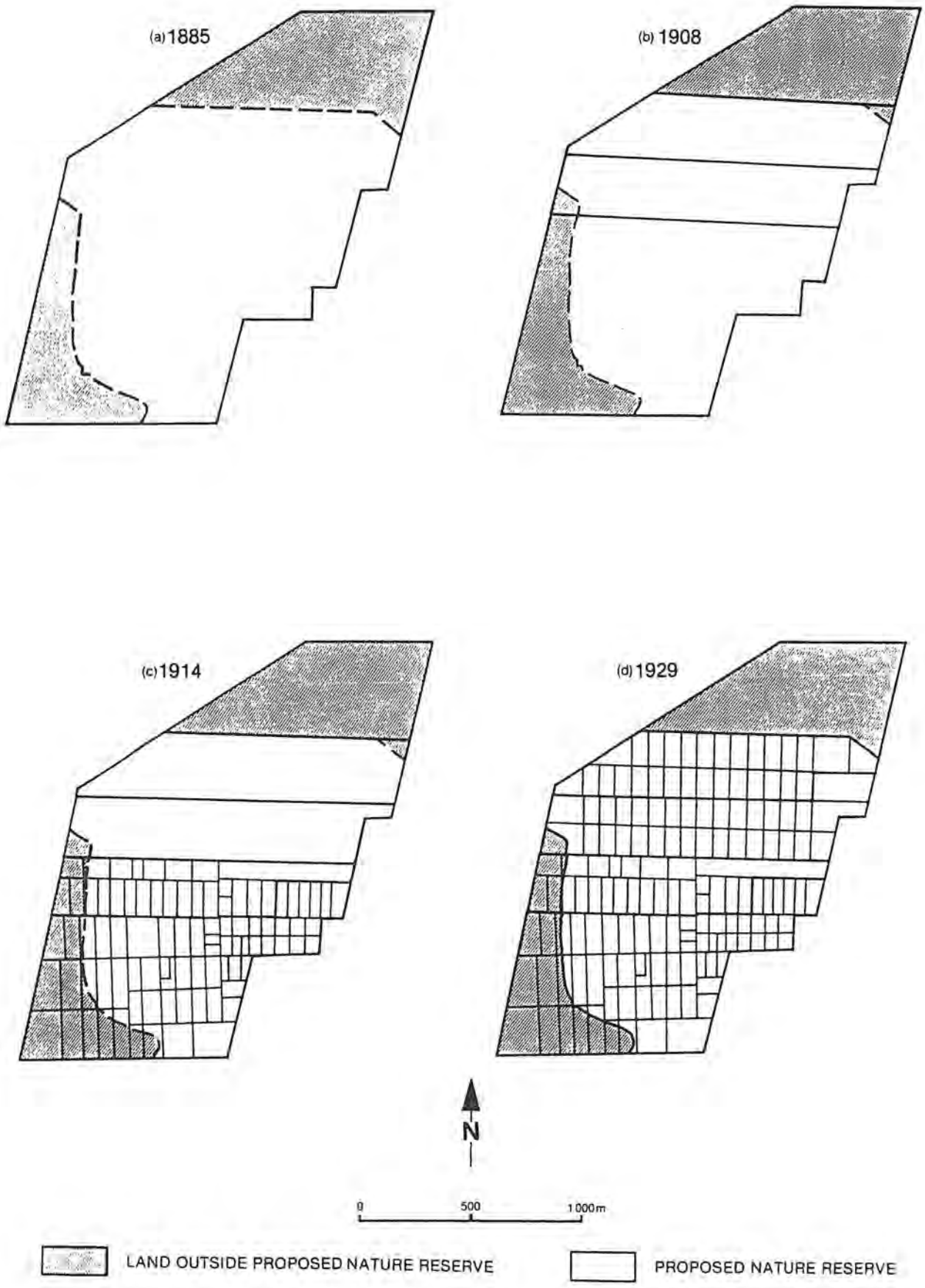

Figure 4. Subdivision of Benger Swamp, 1885-1986. The proposed Nature Reserve boundary has been super-imposed.

4.4 Subdivision and Agricultural Development

Wellard has been credited as being the first person to use the Swamp for agriculture. In the late 1890s, he grazed cattle on the Swamp over the summer months (de Jong 1958). The early 1900s saw the first potato crops grown and harvested. In 1908 Wellard divided the title into four lots (Fig. 4b) and sold the northern three of these to Mitchell. As well as growing potatoes Mitchell experimented with subterranean clover and water couch. These grew well and the clover proved to be a valuable pasture crop. The water couch, however, became a pest to potato growers in later years.

Wellard died in 1909 and the 430 ha southern block was passed to Richardson and Lowe, who divided it into 90 lots in 1914 (Fig. 4c). In 1929 Mitchell subdivided the northern part into 62 lots (Fig. 4d). Following subdivision most of the lots, which averaged 2-4 ha, were sold to potato growers. As well as potatoes other vegetable crops such as peas, beans and maize were grown. An area of some 200 ha was cropped over the years 1920 to 1960. Fertilisers and insecticides, such as DDT, were applied to the crops over this period.

By the late 1960s, potato growing on the Swamp was becoming uneconomic. Yields averaging around 8 tons per acre (20 tonnes per ha) at Benger contrasted with yields of about 15 tons per acre (38 tonnes per ha) in the Manjimup district (South Western Times, 2 May 1972). Lack of water in summer was the main reason for low yields. An irrigation scheme proposed in 1929 was abandoned because of difficulties in getting water to the Swamp. Further irrigation proposals were all considered impractical until 1962, when a new channel was completed to supply the area with water from Wellington Dam.

In 1964, the Public Works Department was approached by the Benger Drainage Board regarding summer irrigation of potato crops on the Swamp. Trials involving the Department of Agriculture, Public Works Department and several potato growers were conducted during the years 1965 to 1967. Although irrigation increased potato yields they were still lower than

those of other potato-growing areas. During the trials, groundwater and surface soil salinities were extensively monitored. Increased salinity, as a direct result of irrigation, was identified as a potential problem.

By 1968, the area cropped had fallen from an annual average of 200 ha to 122 ha. Crops consisted of fodder (42%), potatoes (57%) and other vegetables (1%).

4.5 Establishment of the Nature Reserve

During 1970, the Department of Fisheries and Fauna considered purchasing the Swamp for gazettal as a nature reserve. The Department had long recognised the value of Benger Swamp for waterbirds as a result of considerable data collected by Honorary Game Warden, Reg Taylor. A number of individuals and organisations also recognised the Swamp's value to waterbirds and also urged the establishment of a nature reserve.

Proposals to drain and irrigate the Swamp continued. In 1971 levee banks and drains were constructed in the northern and western parts of the Swamp, effectively reducing the area of the Swamp by 300 ha to its present area of approximately 570 ha.

By 1972, the area under potatoes had dropped to 24 ha (South West Times, 2 May 1972). The future of Benger Swamp for agriculture appeared uncertain. In mid-1973 an area of 56 ha was offered for sale and was purchased by the Department of Fisheries and Fauna. A further 80 ha of land became available and was purchased in the same year. Additional land sales to the Department followed quickly.

The Department of Fisheries and Fauna, and subsequently the Department of Fisheries and Wildlife and then CALM, continued to purchase land as it became available.

The following land on the Swamp remains freehold (Fig. 2 - private land):

Wellington Location (1):-
Plan 4847 - Lots 41 west, 42 east
4599 - Lots 5 east, 7, 8, 9 east, 10, 14 east, 25
3467 - Lots 5 west, 14 part, 26, 27, 28
3466 - Lots 56, 57, 65, 66, 68, 69, 71, 71 west, 80, 83 part, 88 part, 111 part, 112 part, 113 part, 114 part.

4.6 Implications for Management

1. A long history of intensive agricultural use has resulted in an area vastly different from the original natural system. Manipulative management will be necessary to enhance its nature conservation values.

5.0 HYDROLOGY

5.1 General

Water enters the Swamp either as rain falling directly onto the Swamp or as run-on from its catchment. Water is lost through evaporation, transpiration and drainage. Studies by CALM, the Geological Survey section of the Department of Mines, and the Department of Agriculture indicate that Benger Swamp is a lens of relatively fresh water overlying a saline water table. Movement between the two water bodies is limited by a clay layer of low permeability.

5.2 Surface Drainage

In the early 1900s, Benger Swamp was a swampy flat covering 1 000 ha. The Mornington River flowed from the Scarp via the Swamp into the Wellesley River.

Recognition of the Swamp's value for potato growing resulted in a need to control surface water. Water had to be drained from the Swamp early in summer so planting could commence and flooding controlled until

harvesting was complete. The first drains, constructed in the 1910s, carried water from the southern end of the Swamp (Fig. 5); however, flooding still occurred after heavy rains. In the 1920s a replacement drain was constructed around the eastern and southern edges.

In the 1970s two levees and associated drains were built. The first of these drained land to the north of the Swamp. The second was constructed north/south along the slight rise between Benger Swamp and a small swamp to the west (Fig. 5). This enabled land to the north and west of the Swamp to be farmed in winter.

Benger Swamp is now bounded by banks and drains to the north and south and a levee to the west (Fig. 5). To the east, and north of Swamp Road, Benger Main Drain lies 500 m to the east of the Swamp, while south of Swamp Road it forms the eastern boundary of the proposed Reserve. Thus water flow into and out of the Swamp is now completely dependent on artificial control.

Internally, the Swamp has one main north/south drain (Fig. 5). The Swamp has been filled and drained using checks. A check is a concrete frame, with boards slotting into it creating a barrier across the drain. The checks are opened or closed by addition or removal of the boards.

5.3 Groundwater

In the Benger area there is a net groundwater flow, albeit very slow, westwards from the Scarp towards the Wellesley River (Geological Survey, pers. comm., 1986). This slow flow rate is a function of lack of relief as well as the almost impermeable clay soils. In the dunes on the western edge of Benger Swamp there is a small fresh water recharge which flows both east and west. There are no known groundwater seepages on the Swamp itself (Geological Survey, pers. comm., 1986).

The Swamp reaches its maximum water depth of 0.7-0.8 m in July. By December the water table is beginning to fall, by February it has fallen to 0.7 m below the surface of Benger Swamp and by May it is 1.5 m below the surface. In June the water table begins to rise again, to 0.7 m below the surface, and by July the Swamp has flooded.

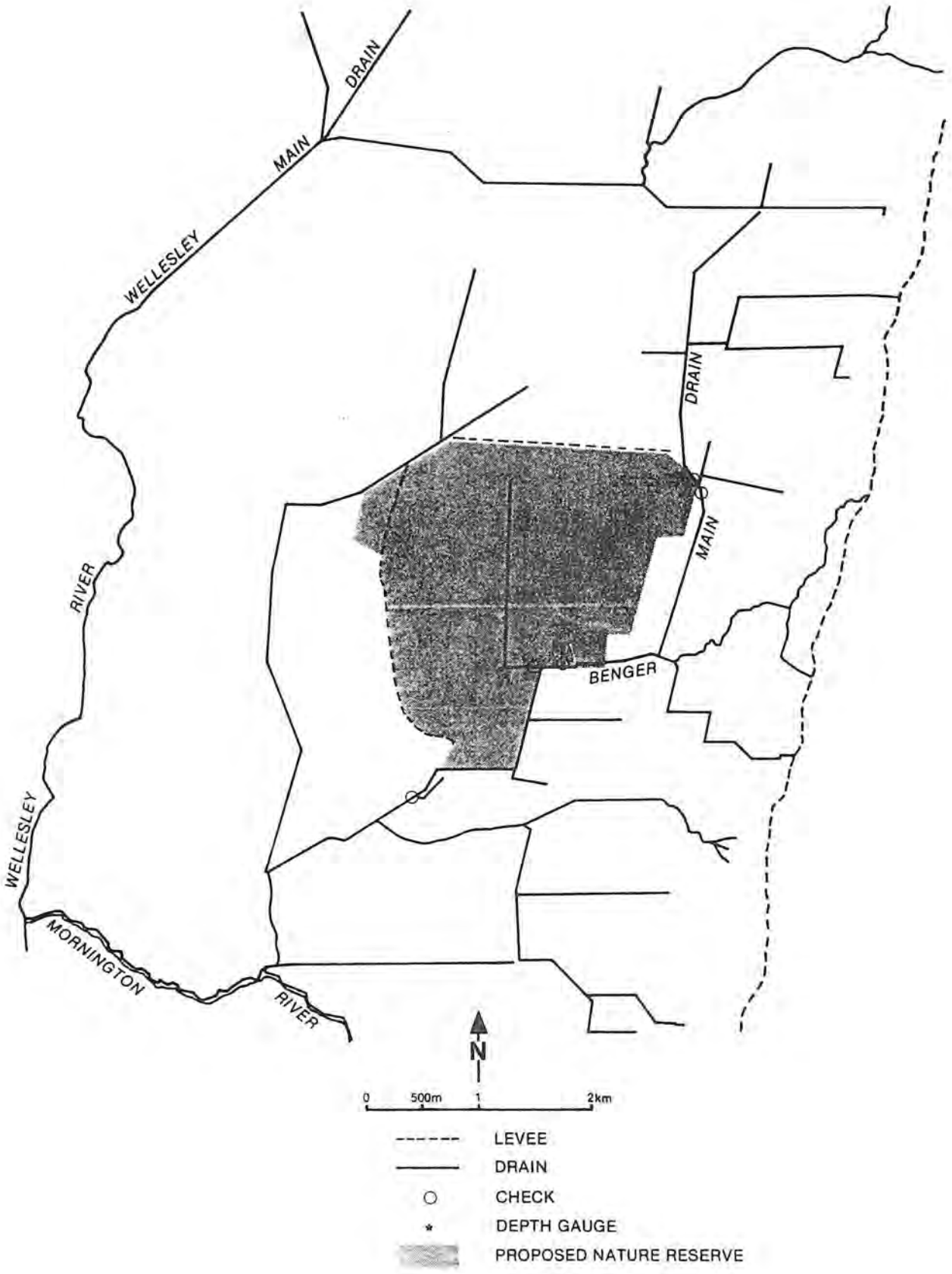

Figure 5. Benger regional drainage, 1986.

5.4 Water Levels, Flooding and Drainage

5.4.1 *Water Levels*

Water levels in the Swamp range from approximately 0.8 m deep in winter to dry in late summer (Fig. 6).

Few historic accounts of water levels in the Swamp have been kept and it appears that the few references that do exist were made when levels were unusually low. In the 1930s, for example, the Benger Drainage Board twice recorded water 0.35 m deep in the second week of December and in December 1964 the Honorary Warden recorded a level of 0.45 m. From recollections by locals and records of levels kept in more recent years it is likely that levels were generally held around 0.8 m in winter. In recent years the Swamp Road checks have been closed when the water level in the Swamp has been approximately 0.7 m. This water level has been achieved by allowing excess water to flow over the checks.

A water level of 1 m could be held in the Swamp, but it is likely that any heavy rainfall would cause the banks adjacent to the checks to wash away. In addition, levels of 1 m or greater would lead to flooding of the privately owned land on the western and eastern (north of Swamp Road) boundaries of the Swamp. Negotiations are currently underway to purchase the land on the western boundary which will solve this problem, if in the longer term it becomes desirable to retain water at a depth of 1 m or greater. Flooding of the eastern area could be prevented by constructing a levee and drain along this edge of the Swamp.

5.4.2 *Flooding*

The water flooding onto the Swamp originates from farmland to the east (Fig. 7). The controlled filling of the Swamp has generally commenced in June. Historically, this was done by closing the main check on the Benger Main Drain to the south of the Swamp and back-filling the drain so that water flowed through the two checks adjacent to Swamp Road (Fig. 7). In 1985, the flooding procedure was changed by the construction of a drain on the north-east corner of the Swamp allowing water to run directly from Benger Main Drain onto the Swamp. The two Swamp Road checks were kept closed (Fig. 8).

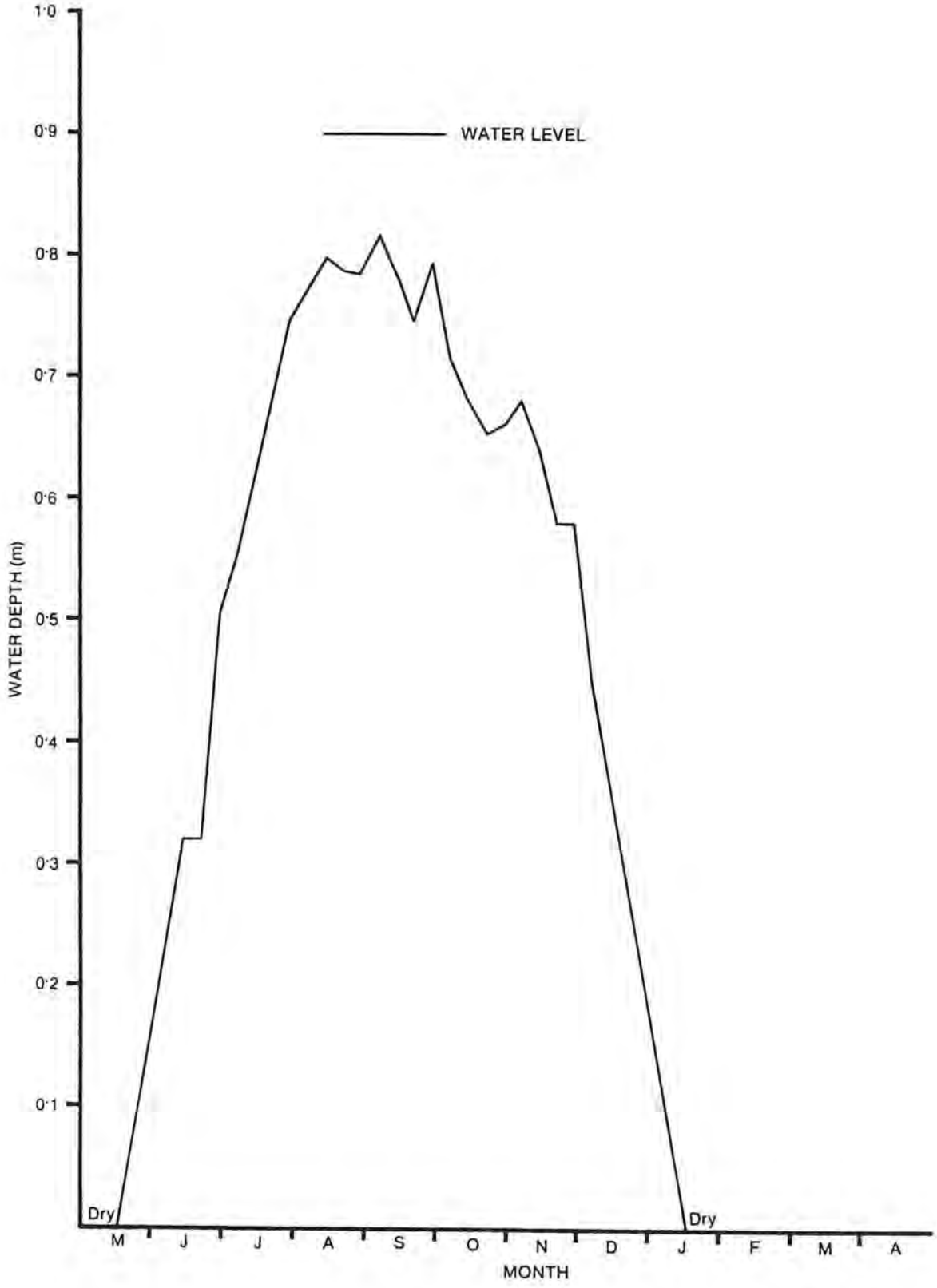

Figure 6. Monthly water levels for Benger Swamp (mean 1980-1985). (Source: Water Authority of Western Australia, 1986.)

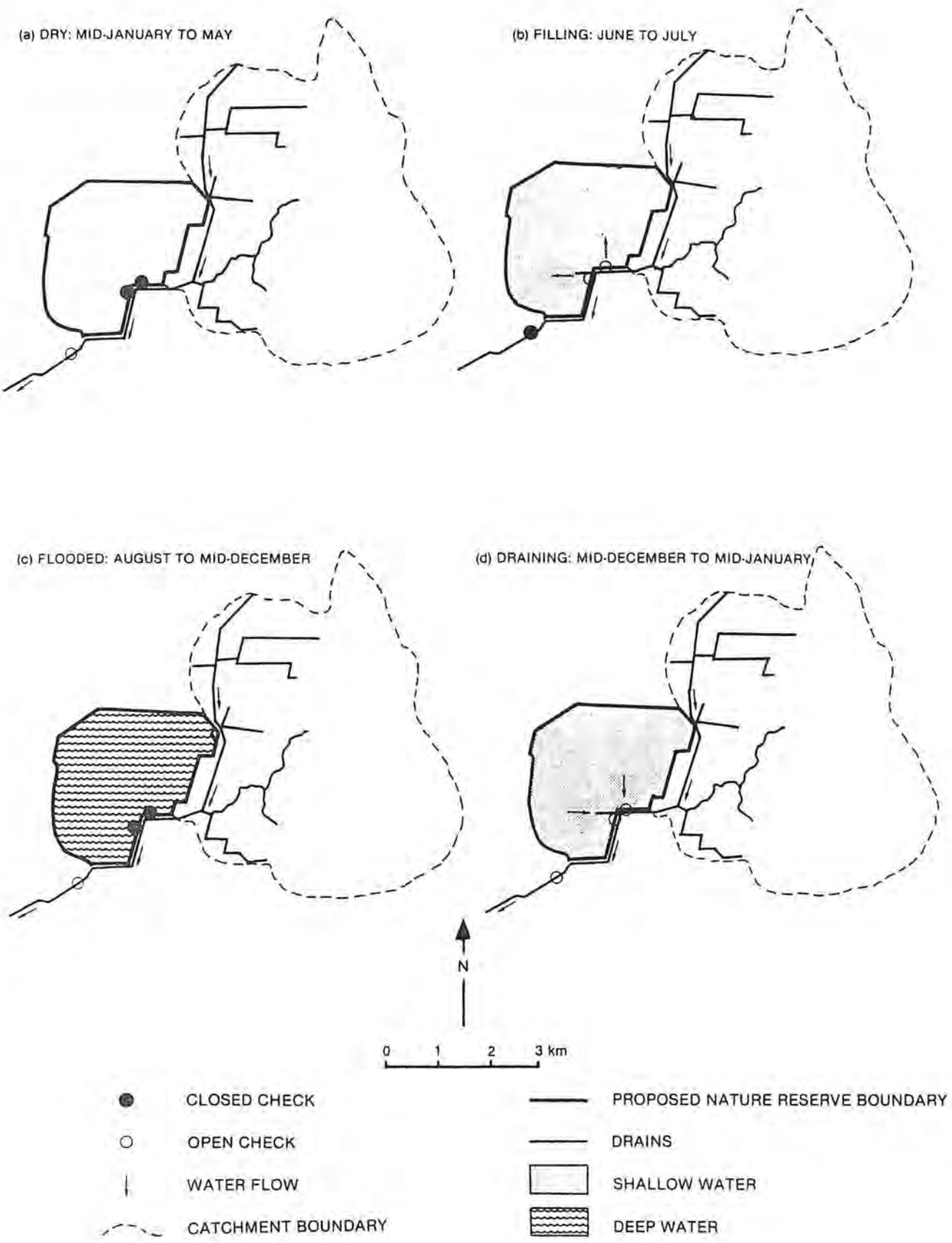

Figure 7. Control of water levels on Benger Swamp, 1930-1984.

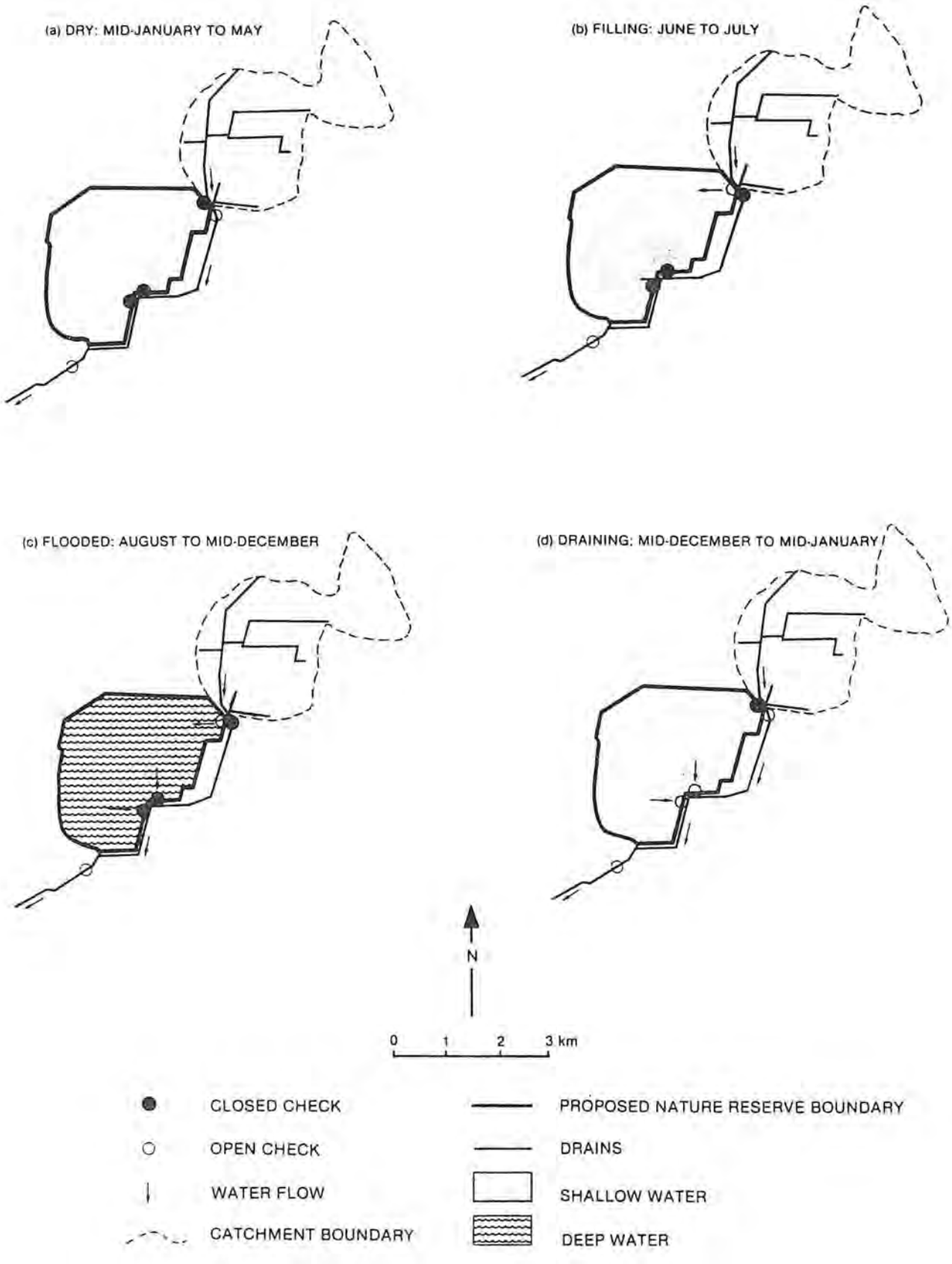

Figure 8. Control of water levels on Benger Swamp, 1985.

The new flooding procedure has had several ramifications. First, the external catchment for the Swamp has been reduced from 2 100 ha to approximately 620 ha (compare Fig.s 7 and 8). Partly as a result of this, water in the Swamp took approximately four weeks (or 57%) longer to reach 0.7 m in depth than in the previous 5 years. Second, silt now collects in the *Melaleucas* where the drain ends, whereas previously it flowed onto the Swamp. Third, the new drain passes through a salt seep at the edge of the Swamp. In June 1985 the salinity of the water lying in the drain was 12 000 ppm, however once the water was flowing the salinity level fell to 800 ppm.

During years when the Harvey Weir is overflowing by late July it is possible to redirect overflow from the Harvey Diversion Drain into Benger Swamp. This has been done in some years.

5.4.3 *Drainage*

The timing of drainage has varied considerably over the past 60 years; however, over the past 13 years the checks have generally been opened in mid-December. This regime has resulted in the Swamp being dry by the second week of January.

No systematic method has been used to calculate the best date for opening the two Swamp Road checks so as to ensure that the Swamp is dry by mid-January. As part of an effort to develop a more systematic approach to drainage the Department of Fisheries and Wildlife installed three depth gauges in 1983 to monitor the rate of fall in water level.

Data collected over the past three years indicate that opening the checks when the water level is greater than 0.4 m appears to have a considerable effect on the rate of drying (with a rate of fall up to 0.02 m per day). Once the level is below 0.4 m however, the rate of fall is about 0.01 m per day which is approximately equal to the evaporation rate (App. 1). Drainage is very inefficient at low levels because the water ponds on low areas of the Swamp and in the internal drain.

If the Swamp was left to dry naturally it would take six to eight weeks longer to dry, given an evaporation rate of at least 0.01 m per day and a depth in early December of 0.7 m or less.

5.5 Water Quality

5.5.1 *Nutrients*

Although no data are available on the nutrient status of Benger Swamp, it is assumed that the sediments at least are richer in nutrients than they were 100 years ago. It is estimated that 12 000 tonnes of superphosphate have been applied directly to the dry Swamp bed over the last 40 years. Nutrients would also have entered the Swamp, over at least the last 70 years, in run-off from the farmland to the east and north.

While nutrients are essential to support the plants and animals of aquatic systems, excessive levels of nutrients may lead to undesirably high levels of plant biomass. Excessive water nutrient levels frequently promote blooms of large algae or small blue-green algae, or both. Blooms of either can collapse and rot releasing foul-smelling toxic gas. Some blue-green algae are also known to be toxic if ingested by humans, waterfowl and livestock.

Perhaps the most undesirable impact of algal blooms is oxygen depletion of the water. This is brought about either by respiration (that is, when a significant proportion of the plants cease photosynthesis) or by the high oxygen demands of rotting plant matter. Although some organisms are capable of reducing their metabolism to cope with oxygen depletion, species which need more oxygen to survive may disappear from wetlands in which algal blooms are frequent and intense. These changes may also lead to the death of aquatic plants and invertebrates, both of which are important foods for waterbirds.

5.5.2 *Salinity*

Groundwater salinities of 2 000-4 000 ppm were recorded under the Swamp in 1982/83 by the Geological Survey section of the Department of Mines (pers. comm., 1986). The Department of Agriculture recorded somewhat

lower salinities of 900 ppm over the years 1974-1980 (pers. comm., 1986). Salinities of 10 000 ppm were recorded several kilometres to the east of the Swamp where the land is irrigated with saline water from the Wellington Dam.

Between July and December of 1985 salinity measurements (by Doug Watkins) of water from the Swamp indicated levels of 200-400 ppm. This reinforces the suggestion that the Swamp is a lens of fresh water overlying a saline water table.

5.6 Control Agencies

The Benger Drainage Board regulated water levels in Benger Swamp between 1918 and 1985.

In 1985, the responsibilities of the Benger Drainage Board were transferred to the Water Authority of Western Australia. The Benger Swamp Regional Advisory Committee was established to advise the Water Authority on water level management. The Committee is chaired by a member of the Water Authority and includes representatives from local farmers, the Shire of Harvey, Department of Agriculture and CALM. The Committee ensures that local farmers, who collectively still own 13% of the Swamp, have a direct input into water management decisions.

5.7 Implications for Management

1. Human impacts on the catchment have produced an artificial water regime with artificial regulation of water supply and level. Thus, ongoing manipulative management is necessary.

2. The reduced catchment may affect water levels in the Swamp. Further investigations are required.

3. The two checks on Benger Main Drain adjacent to Swamp Road limit the water depth to a maximum of 1 m. However, at depths greater than 0.7-0.8 m flooding of adjacent privately owned land occurs. Thus, 0.7 m is the maximum water depth that can be retained at present.

4. Data from the depth gauging stations accumulated over the past three years could be used to determine the optimum drainage date in future years.

5. Farmland in the catchment is a potential source of nutrients and salts which enter the Swamp in the run-off. This source should be a primary consideration in any water quality studies.

6. Little is known about the water quality. Investigations are required.

7. The Benger Swamp Regional Advisory Committee provides advice to the Water Authority on water management on the Swamp. Therefore, management must involve consultation with this Committee.

6.0 VEGETATION

6.1 Historic Perspective

The vegetation of Benger Swamp has changed substantially over the past 100 years. When Stirling and Shenton passed by the Swamp in the 1830s they described it as a vast marsh and swampy plain. Stirling recorded it as 2 miles long and Shenton, as 3 miles long (Staples 1979). The West Australian Company Register of Sales of Land described the Swamp as follows:

> The area is covered with water during some months in the year - there is no timber on it, the vegetation being a dwarf sort of ti-tree scrub with sparse coarse pastorage during the summer months.
>
> (de Jong 1958)

Surveys conducted in the area during the years 1897, 1898, 1902, 1912 and 1913 also contain notes on vegetation. They describe the area and its vegetation variously as bulrush swamp, dense scrub, scrubby swamp, scattered ti-tree in clusters, ti-tree, swampy ti-tree with no large timber, rich potato swamp land covered with tall bulrushes, low rushes and bulrushes, light scrub on sand banks, open scrub and dog wood.

It appears that before European settlement, the vegetation probably consisted of *Melaleuca* stands and rushes in the lower lying areas, with wattles and light scrub on the higher sandy areas.

Most of the changes have resulted from clearing for agriculture and frequent fires. The major vegetation component removed for potato growing was the rush species, *Baumea*. The stands grew on the lowest ground and were easy to clear. Some *Melaleuca* stands were also removed. Fire, associated with clearing areas for agriculture, also led to loss of *Melaleucas*.

During the 1940s, the rush *Typha orientalis* invaded potato growing areas on the Swamp. By 1958, *Typha* was one of the main vegetation types present on the Swamp (de Jong 1958); by 1974 it covered 200 ha and by 1985, 300 ha (Fig. 9).

6.2 Present Vegetation

The present vegetation on the proposed Nature Reserve can be divided into five communities - *Melaleuca* forest and shrubland, *Typha* sedgeland, *Baumea* sedgeland, grasslands and aquatic communities. The extent of each is shown in Figure 10.

6.2.1 *Melaleuca Forest and Shrubland*

Melaleucas cover approximately 20% of the proposed Nature Reserve, occurring mainly on the eastern and northern edges. Four species occur - *Melaleuca rhaphiophylla, M. viminea, M. laterita* and *M. scabra*. *M. rhaphiophylla* occurs as a dense low forest to 10 m. *M. viminea* and *M. laterita* are both shrub species,with height and density of the stands being dependent on age. *M. scabra* occurs as a shrub to 2 m, mostly as a dense thicket in the north-west corner of the Swamp.

6.2.2 *Typha Sedgeland*

Stands of *Typha orientalis* cover approximately 50% of the proposed Nature Reserve. Several botanists suggest that this species was introduced around the time of European settlement in Western Australia

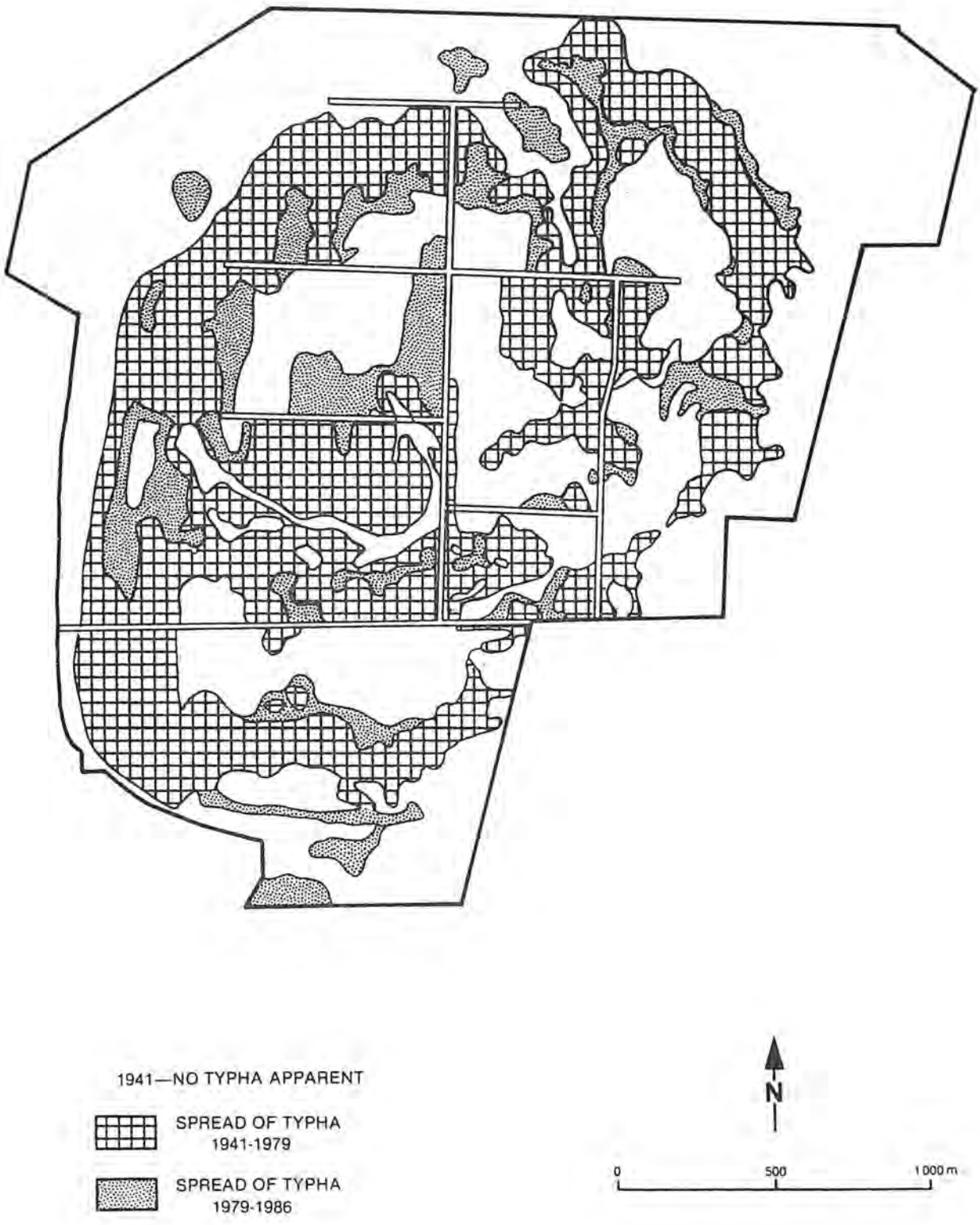

Figure 9. Spread of *Typha* across Benger Swamp, 1941-1986.

Figure 10. Vegetation of the proposed Benger Swamp Nature Reserve, 1986.

(N. Marchant, pers. comm., 1984; Green 1985). It appears to be an aggressive coloniser of wetlands with muddy substrates, especially following disturbance, and occurs on most wetlands on the Swan Coastal Plain.

The other species found in Western Australia, *Typha domingensis*, is native to the south-west. Probably because of competition from *Typha orientalis* it is now only found at a few locations on the Swan Coastal Plain.

Typha colonises areas by two methods - seedling establishment and rhizomal growth. Seedling establishment is the fastest. The species has the potential, under favourable conditions, to convert an open area of tens of hectares into a closed stand of *Typha* in only a few years. In early summer seedlings appear on areas of bare mud following germination under water. Very few seedlings have been observed in mature *Typha* stands or in areas of thick grass. Large beds of seedlings occur where the ground has been cultivated in the previous season and in areas where the grass cover has been burnt. Spread by rhizomal growth has been slower, although continuous, with stands at Benger spreading at a rate of 1 m to 2 m per year along non-cultivated edges and 2 m to 3 m per year along cultivated edges.

It is possible that *Typha* plays an important role in buffering systems from the effects of high nutrient levels. *Typha* has been shown to be capable of extracting nutrients from water (Davis and Van Der Valk 1983) and has been used for purifying waste water.

6.2.3 *Baumea Sedgeland*

Baumea articulata occupies approximately 1% of the proposed Nature Reserve. The largest stands occur in the north-west corner of the Swamp. Some smaller, isolated stands are also present along the northern boundary. *Baumea* has not recolonized any areas used for cropping. *Typha* is invading *Baumea* stands in some areas, mainly along cattle pads and following fire.

6.2.4 *Grasslands*

Grasslands occupy approximately 29% of the proposed Nature Reserve. There are two types of grasslands - one on low-lying flooded areas (20%), the other on higher ground (9%).

Couch grass *(Cynodon dactylon)* and water couch *(Paspalum distichum)* dominate the flooded areas. Couch grass dies back as the Swamp floods, then reshoots during summer. In contrast, most of the water couch continues to grow during the flooded months. It forms a dense mat which enables the plant to hold its leaves out of the water. These dense mats tend to choke open water and restrict the movement of waterbirds.

On higher ground other introduced annual grass species occur.

6.2.5 *Aquatic Communities*

Those parts of the Swamp supporting aquatic communities over winter and spring are shown as 'open water in winter/spring' in Figure 10. No surveys have been carried out on the aquatic flora of Benger Swamp. This vegetation type is particularly important as it provides a source of food, either directly or indirectly, for most of the waterbirds using the Swamp. It is also an important indicator of water quality.

6.3 Implications for Management

1. Only 21% of the proposed Nature Reserve retains its original vegetation. It is highly unlikely that the original vegetation could ever be restored. Furthermore, no detailed information is available regarding the original vegetation.

2. *Typha* covers 50% of the Swamp and is spreading, effectively reducing the area of open water and correspondingly decreasing habitat diversity. *Typha* is also invading the *Melaleuca* and *Baumea* stands. Active management is necessary to control the *Typha*.

3. The *Melaleuca* and *Baumea* stands have been degraded by frequent fires. Fire control measures are necessary to protect these stands.

4. The *Melaleuca/Baumea* stand in the north-west corner of the Nature Reserve is the only area where these communities have not been invaded by *Typha*. Management should ensure that *Typha* continues to be excluded from this area.

5. Where the water couch grows thickly it causes problems for waterfowl because it chokes areas of open water. Control of water couch may be necessary.

6. Further surveys are needed to document the flora, particularly the aquatic flora, of the proposed Nature Reserve.

7.0 FAUNA

7.1 General

Annual water level changes significantly affect the extent of use of the Swamp by fauna. Some vertebrates, such as frogs and tortoises, become inactive during the dry period while more mobile vertebrates, such as waterbirds, move to more favourable locations. Other vertebrates, such as reptiles and the songbirds, remain all year in the fringing vegetation. Aquatic invertebrates remain dormant during the Swamp's dry phase with activity triggered by the return of water.

Waterbird use of the Swamp has been reasonably well documented and is discussed below.

7.2 Waterbirds

Surveys of waterbirds at the Swamp have been carried out by Reg Taylor (Honorary Warden) from 1957 to 1969, Eric Sedgwick from 1967 to 1986 (Sedgwick 1973, 1978; Sedgwick and McNee 1984) and the Royal Australasian Ornithologist's Union (RAOU) as part of the Waterbird Usage Study (Jaensch, in prep.).

During the 1950s Taylor regularly observed 2 000 - 3 000 ducks on the Swamp. The RAOU observed over 3 000 birds in November 1982 and 4 300 in December 1985, with a total of 50 waterbird species, including 12

breeding species, noted. Based on these numbers Benger Swamp was ranked, by the RAOU, as one of the 10 most important wetland nature reserves in the south-west.

Waterbird numbers on the Swamp and on other wetlands in the south-west vary as migratory species come and go, with water level changes and with the time of year (Fig. 11). Sedgwick and McNee (1984) divided the annual water level changes on the Swamp into five phases: dry, flooding, deep water, falling water levels and drying out.

During the dry period, mid-January to June, only a few waterbirds use the Swamp, feeding in the grasslands. Numbers dramatically increase within a few days if the Swamp is flooded by summer rains.

Winter rains flood the Swamp during June/July and waterbirds move in rapidly to utilise food resources such as crop remnants and invertebrates. Species include the Australian Grebe, White-faced Heron, Sacred Ibis, Pacific Black Duck, Grey Teal, Australasian Shoveler, Hardhead and Black-winged Stilt. At the end of this period most of these species leave the Swamp. Other species, which arrive during this period, such as the Black Swan, Marsh Harrier, Purple Swamphen, Spotless Crake and Little Grassbird, stay until the Swamp dries out.

August, September and to some extent October are the lean deep-water months. The water level rises to approximately 0.8 m and falls to around 0.6 m by the end of October. During this period numbers of the Blue-billed Duck are greatest, followed by Musk Ducks. These species are diving ducks, feeding on animal and plant life on the bottom of the Swamp.

When water levels fall in late October and November waterbird numbers triple. Species such as the Australian Pelican, Little Pied Cormorant, White-faced Heron, Great Egret, Australian Shelduck, Eurasian Coot, Wood Sandpiper and Clamorous Reed-warbler arrive. Numbers of Sacred Ibis, Pacific Black Duck, Grey Teal, Australasian Shoveler and Hardhead increase as water levels drop.

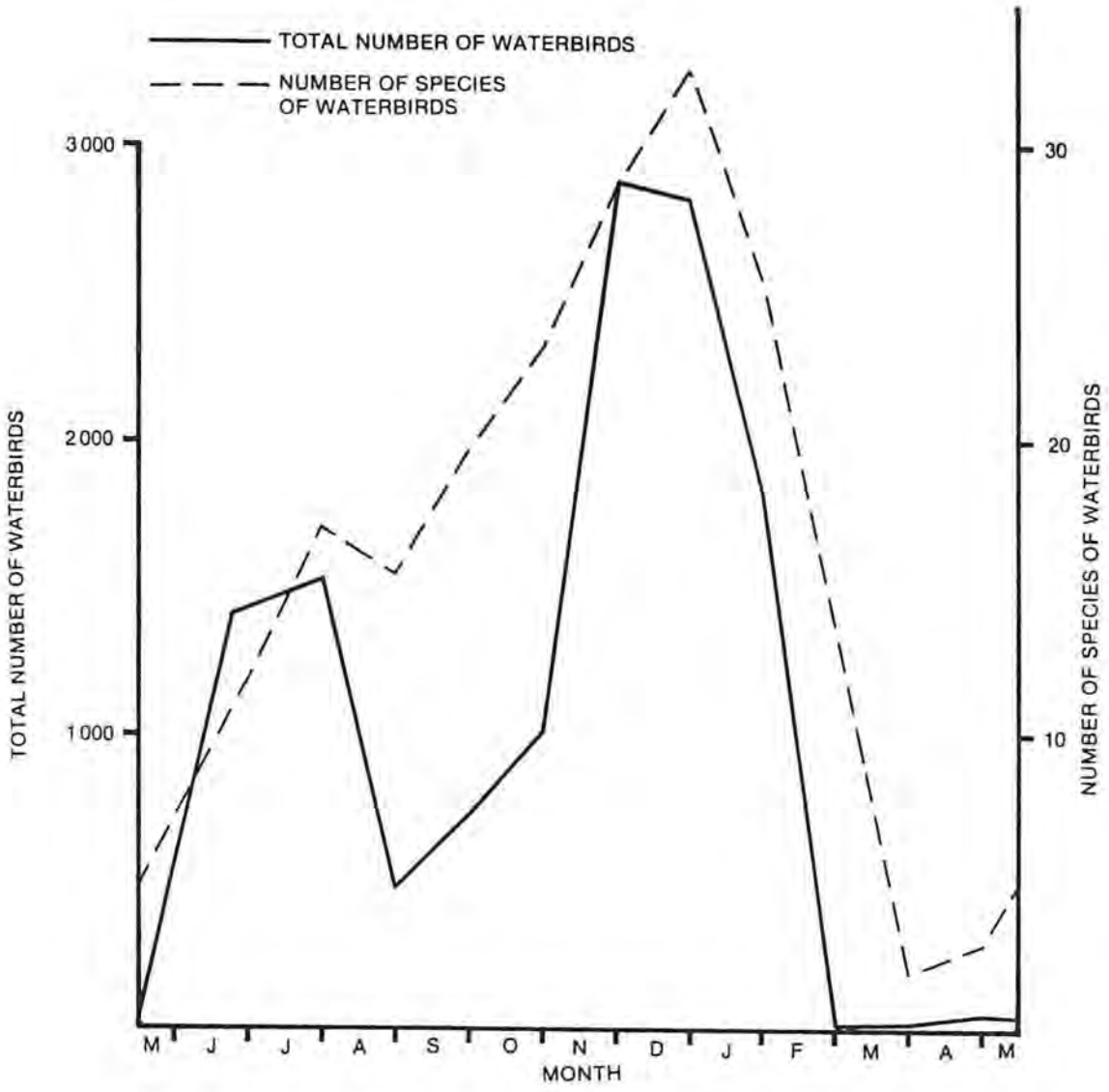

Figure 11. Monthly changes in waterbird populations at Benger Swamp. (Source: Jaensch, in prep.)

December and January are the drying-out months and further birds arrive including the Hoary-headed Grebe, Little Black Cormorant, Pacific Heron, Rufous Night Heron, Yellow-billed Spoonbill, Pink-eared Duck, Black-winged Stilt, Banded Stilt, Greenshank and Sharp-tailed Sandpiper.

7.3 Waterbirds of Special Importance

7.3.1 *Freckled Duck*

The Freckled Duck is gazetted as 'rare, or otherwise in need of special protection' under the Wildlife Conservation Act (1950). This species is also fully protected in other Australian states.

Benger Swamp has long been a focal point for conservationists and waterbird enthusiasts alike because of the presence of the Freckled Duck. Reg Taylor studied its nesting, from 1957 to 1969, making an important contribution to knowledge of this species (Frith 1982). He noted flocks of 30 in September 1959 and 100 in September 1962.

During the Waterbird Usage Study Freckled Ducks were recorded on the Swamp on three occasions; 13 in December 1981, 2 in December 1982 and a breeding record in November 1983. During the spring of 1985 one bird was sighted. It is probable that Freckled Ducks regularly use the area for moulting (R. Jaensch, pers. comm., 1986).

It appears that Freckled Ducks are now not as common at Benger as they were in the late 1950s and early 1960s. Possible reasons for this are: lack of suitable feeding areas due to the spread of *Typha* on the Swamp; frequency of fire in the *Melaleuca* stands decreasing the available nesting and refuge habitat; and the pressures of duck shooting.

7.3.2 *Australasian Bittern*

Eight birds of this secretive species were observed at the Swamp during the Waterbird Usage Study. The birds were observed on 18 other Reserves, but highest numbers were recorded at Benger Swamp. No breeding was observed, although finding their nests is particularly difficult as

the birds construct them in thick reed stands. The suitability of Benger Swamp as a breeding ground may be limited by the Swamp drying in January, rather than retaining water into late summer (R. Jaensch, pers. comm., 1986).

7.4 Other Birds

In addition to waterbirds the area supports a number of other birds. These inhabit the *Melaleucas*, rushes and grasslands in greatest numbers during summer and autumn. However, a number of species utilise the fringing vegetation throughout the year.

7.4.1 *Southern Emu-Wren*

Sightings of this species were made on the Swamp by Taylor in 1962 and RAOU members in 1982 (Milhinch and Milhinch 1982). In Western Australia, this species occurs in areas of dense vegetation along the south coast, in isolated pockets on the Swan Coastal Plain, on the Darling Scarp and at Denham (Blakers et al. 1984). The sightings at Benger Swamp are the only known recent records between Bunbury and Perth.

7.4.2 *Birds of Prey*

During the summer months, the grasslands on the Swamp become a valuable feeding area for birds of prey. Up to 20 Nankeen Kestrels, 5 Brown Falcons and 4 Black-shouldered Kites have been recorded at one time.

7.4.3 *Chestnut-breasted Mannikin*

During late autumn in 1983 and 1984 a flock of Chestnut-breasted Mannikins was sighted on the Swamp. This species, considered introduced in south-western Australia, generally only occurs in northern and eastern Australia (Blakers et al. 1984). At least one population now occurs in Perth, as there have been reports of flocks at Herdsman and Bibra Lakes. Presumably these populations established after escaping from aviaries.

As the Benger population has not been sighted recently it seems likely that it has died out.

7.5 Importance of Vegetation to Birds

The aquatic vegetation provides a food source, both directly and indirectly, for many of the waterbirds using Benger Swamp.

Melaleuca rhaphiophylla forests are used for nesting by the Little Pied Cormorant, Freckled Duck, Pacific Black Duck, Coot, Black Swan, White-faced Heron, Pink-eared Duck, Purple Swamphen and songbird species. There is also evidence to suggest that the *Melaleucas* are used as refuge areas by the Freckled Duck during moulting.

Baumea and *Typha* stands provide nesting areas for crakes, the Purple Swamphen, Clamorous Reed-warbler and Little Grassbird. *Typha* is also important as a food source for ducks and the Black Swan (Frith et al. 1969).

Typha stands of different ages are used by waterbirds in various ways. Old dense stands are most suitable for nesting, whereas young stands are valuable as feeding areas. In 1983, 1984 and 1985 flocks of up to 200 Sacred Ibis were seen feeding in areas of *Typha* that had been burnt less than 12 months previously.

Grassland areas, particularly those adjacent to water, are used by some species of waterfowl for feeding and breeding. In the summer these areas provide habitat for Brown Quail and Richards Pipit.

Fodder crops are also used by birds. In late May large numbers of Red-capped Parrots, Port Lincoln Ringnecks, Elegant Parrots and Western Rosellas feed on the fodder seed-heads. In July 1985 two Black Swan nests made of stems from fodder crops were found.

7.6 Other Fauna

No detailed fauna surveys, apart from waterbird surveys, have been conducted on the Swamp.

7.6.1 *Reptiles and Amphibians*

An obvious reptile species at the Swamp is the tiger snake *(Notechis scutatus)*. During summer on a warm day more than 10 snakes were seen by Doug Watkins during a 2 hour walk along the roads.

7.6.2 *Mammals*

The only native mammals seen in recent years are western grey kangaroos *(Macropus fuliginosus)* and water rats *(Hydromys chrysogaster)*, although bats have been seen flying over the Swamp and there are historic records of the western brush wallabies *(Macropus irma)* occurring at the Swamp.

Introduced mammals such as foxes, cats, house mice and rats are common. Foxes have been observed killing waterbirds on several occasions. Occasionally, cattle and horses escape onto the Swamp.

7.7 Implications for Management

1. Continued monitoring of waterbird use will be necessary to assess management effectiveness.

2. As waterbird use changes with changing water levels, it is important to cater for the range of waterbirds by providing a range of water levels during the year.

3. The variety of waterbirds using the Swamp have very different habitat requirements. Thus, it is essential to maintain the present diversity of habitats.

4. Special consideration should be given to managing the Swamp to accommodate the needs of the Freckled Duck and Australasian Bittern.

5. Stands of recently burnt *Typha* are required as they provide valuable feeding areas for some species of waterbirds.

7. Visitors to the Swamp will need to be aware of the high numbers of tiger snakes.

8. Foxes are common in the area and have been observed killing waterbirds. The control of foxes on the Swamp may be necessary.

8.0 DUCK SHOOTING

8.1 General

Between 1959 and 1966 Benger Swamp was a popular location for duck shooters on the opening day of the season, with the number of shooters varying between 145 and 220. Since then its popularity has declined (Fig. 12a), with an average of only 18 shooters over the years 1981-1985. Over the years 1960-1963, 2 661 ducks were shot on opening days, compared with only 138 in the period 1981-1985 (Fig. 12b).

Changes to the dates of the duck shooting season have contributed to this decline in popularity. During the 1950s and 1960s the duck shooting season opened before Christmas when the Swamp had approximately 200 ha of open water. Since 1978, if a duck season is declared, the season does not open until the second weekend in January. The Swamp is generally dry by this time and shooting opportunities are limited.

8.2 Freckled Ducks

At Benger Swamp the Freckled Duck has at times been a casualty of duck shooting. The numbers of Freckled Ducks known to have been shot on the Swamp during the period 1958 to 1971 are:

Year	Number
1959	1
1960	2
1965	3+
1970	10
1971	1
Total	17+

After the 1970 season, to give the species greater protection, night shooting was prohibited and an area of the Swamp where Freckled Ducks were known to breed was closed. No data are available after 1971.

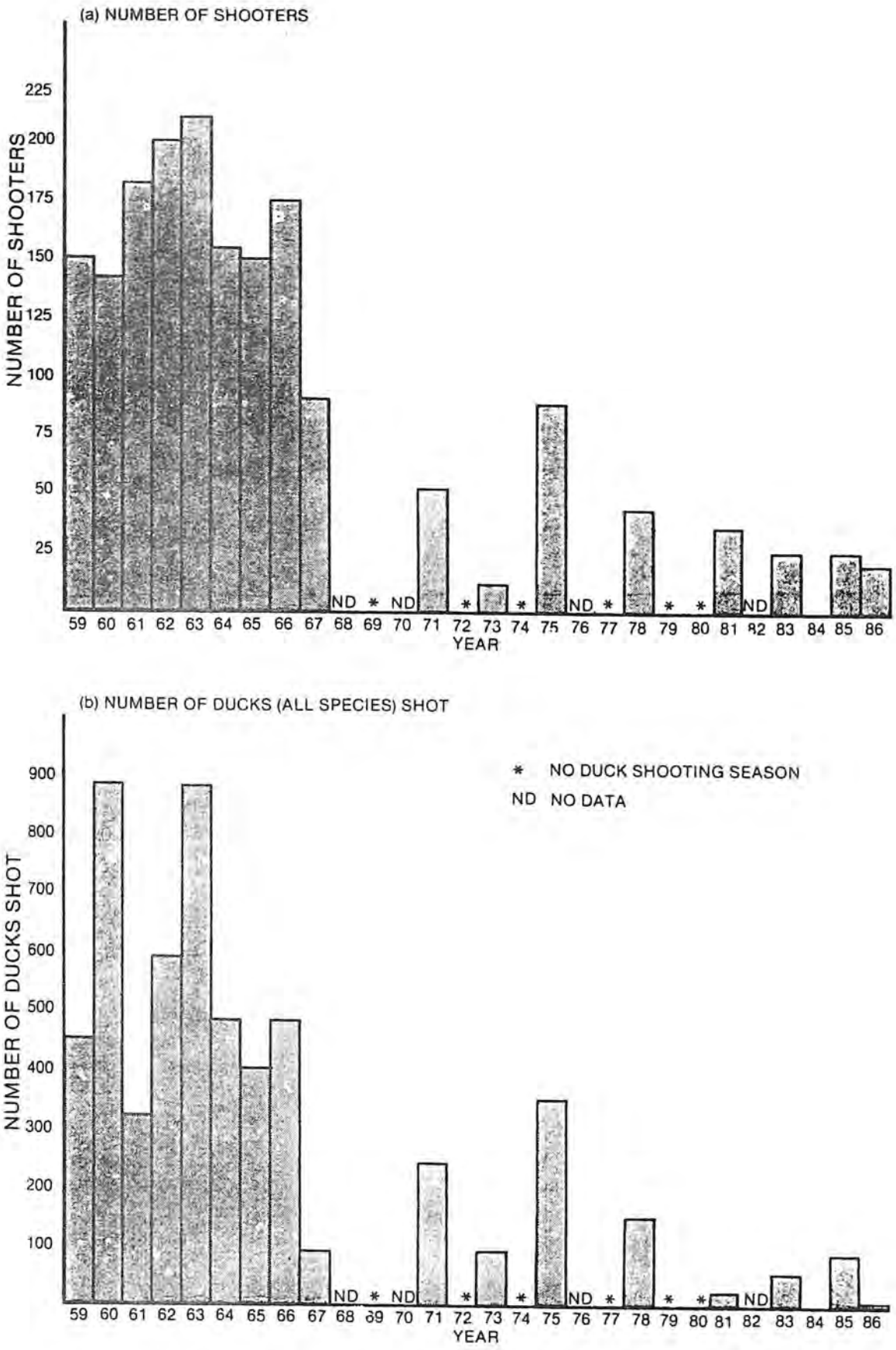

Figure 12. Duck shooting on Benger Swamp on Open Day, 1959-1986.

8.3 Implications for Management

1. As considerable resources will be dedicated to the protection and enhancement of the Swamp for waterbirds, including the Freckled Duck, the area should be closed to duck shooting.

2. Benger Swamp is no longer an important wetland for duck shooting because there is no water in the Swamp, and therefore few ducks, by the time the season opens.

9.0 FIRE

9.1 General

The Benger district has few problems with wildfires as the area is dominated by green, irrigated pasture. The Swamp, however, is a major fire concern.

During the past four years six wildfires have occurred on the Swamp (Fig. 13). Three of the wildfires started as fuel reduction burns and the other three were lit by arsonists. Two spread to neighbouring farmland damaging fences and pasture. These fires have burnt 80% of the *Melaleuca* and 83% of the *Typha* communities and 45% of the pasture on higher ground (Table 1).

Table 1. Areas of vegetation burnt in wildfires, 1983-1986 (ha).

	'83 May	'84 March	'84 April	'85 March	'86 April	'86 June	Totals (excluding areas burnt twice)	% of vegetation type
Melaleucas	1	35	23	34	5	20	117	95
Typha	55	31	28	46	65	34	214	75
Pasture	5	8	-	-	5	-	13	25
Total	61	74	51	80	75	54	344	

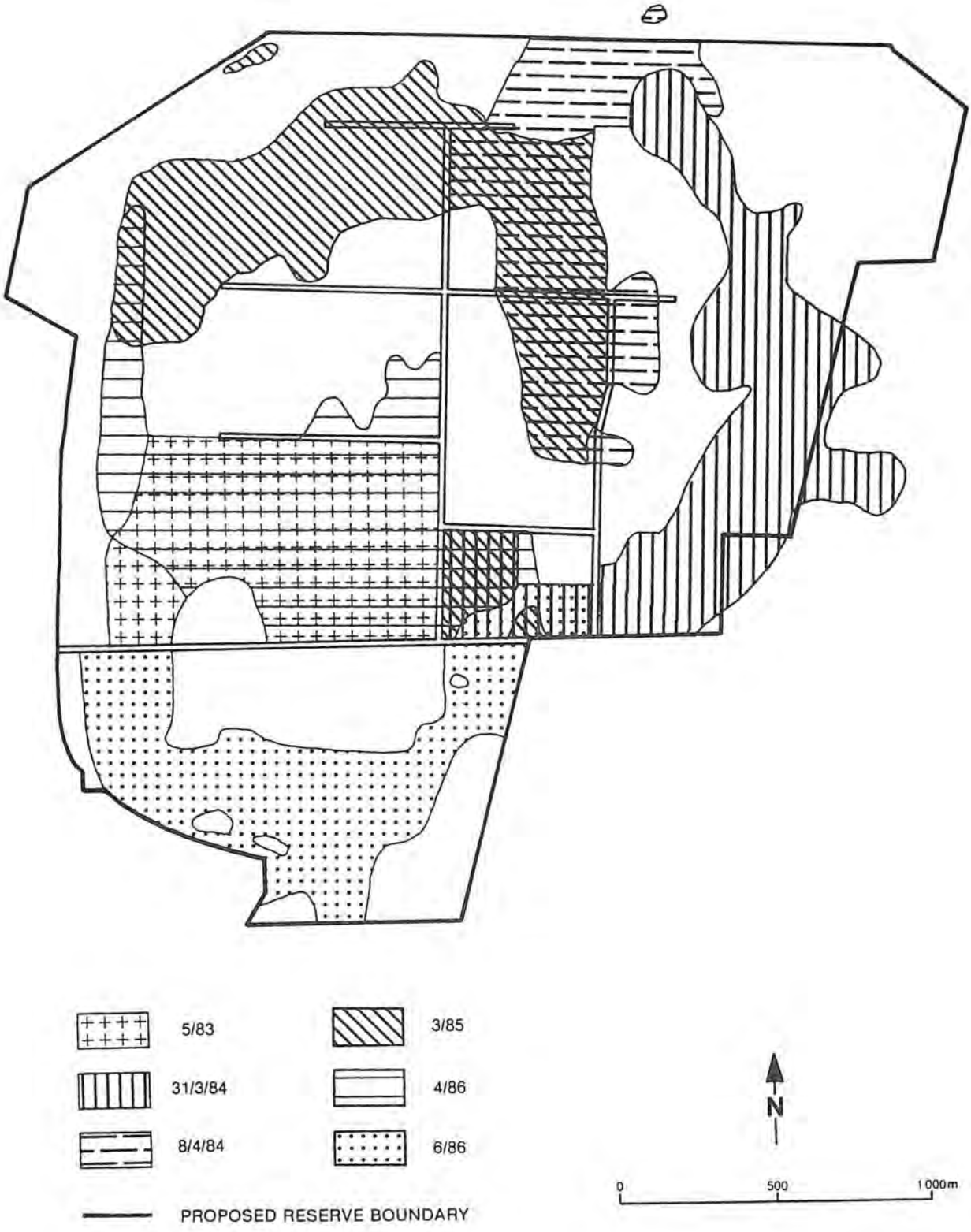

Figure 13. Wildfires on Benger Swamp, 1983-1986.

9.2 Vegetation and Fire

The following communities (described in 6.2 Present Vegetation) each have a different response to fire.

9.2.1 *Typha*

Typha becomes highly flammable in the late summer/autumn when the Swamp is dry. If a fire occurs, damage to the stands is minimal as most plants are dormant at this time of year. *Typha* regenerates vigorously after fire reaching high fuel levels within 12 to 18 months of being burnt.

9.2.2 *Melaleucas*

Unlike *Typha, Melaleuca* species are particularly sensitive to fire. At Benger the *Typha* fuels fires which penetrate the *Melaleuca* stands, open the canopy and enable the *Typha* to invade further. Over the past four years 95% of the *Melaleuca* stands have been burnt and, unless the frequency of fires is reduced, the remaining 5% is likely to be lost. Frequent fires also kill regenerating plants.

9.2.3 *Baumea*

In late summer/autumn this rush species will burn, but generally only once a wildfire has become well established.

9.2.4 *Grassland*

Couch presents no fire problem as it remains green throughout the year. Other annual grasses, unless regularly grazed or mown, are a fire risk during the summer months.

9.3 Implications for Management

1. The frequency of wildfires indicates that there is little appreciation of the strong likelihood that fuel reduction burns may

escape and become wildfires. The associated risks should be brought to the attention of all people involved in fuel reduction burning.

2. Frequent fires highlight the need to:
   (a) ensure that the Swamp has adequate fire protection
   (b) make information available on the damaging effects of fire on the Swamp.

3. *Typha* stands provide high levels of combustible fuels in summer, making wildfire control difficult.

4. Fuel reduction burning of *Typha* stands achieves little for fire control, as the stands can only be burnt in late autumn and by the next summer again carry high loads of combustible fuels. This information is of prime importance in any formulation of fire protection measures.

5. The damage from wildfires will be minimised and they will be easier to control if they can be prevented from burning into the *Melaleucas*.

6. Ungrazed winter/spring pasture produces high fuel levels in summer and autumn making wildfire control difficult. Fuel reduction measures are necessary.

7. Wildfires on the Swamp pose a threat to adjacent landholders, necessitating the development of strict protection measures.

10.0 PAST USE AND MANAGEMENT

10.1 Agricultural Use

10.1.1 *General*

No cropping statistics are available for the Swamp for the decade prior to 1983, although it is likely that 20 to 25 ha were cropped each year. Since 1983, 5 ha of vegetables and 12 ha of fodder crops have been grown

each year on privately owned land. This represents only 3% of the Swamp area. The areas used for agriculture over the 1985/86 summer are shown in Figure 14. In addition to cropping on private land, local farmers have used land controlled by CALM by agreement. These areas were formerly used for potato growing and were either bare or covered with short grass during summer and autumn.

This agricultural use has provided a method of controlling the spread of *Typha* across the open areas of the Swamp at no cost to CALM.

10.1.2 *Vegetable Cropping*

Both commercial and non-commercial growers use the Swamp. Over the three years 1982-1985 the number of vegetable growers has varied between four and six and the area cropped between seven and eight hectares. A wide variety of vegetables are planted for domestic consumption; involving ploughing and seeding in January and harvesting in May. Insecticides are generally required to control pests.

10.1.3 *Fodder Cropping*

Fodder crops are grown on the Swamp by local farmers to feed to dairy cattle during autumn. Fodder crops grown include millet, sudax/sorghum and sweet sorghum. Fertilisers are generally used.

There is support within the local community for the continuation of fodder cropping on the Swamp. The reasons for this are twofold:

(a) using the Swamp for fodder cropping is economic because there are no irrigation costs (these can account for 30% of the cost of growing a fodder crop, Department of Agriculture, Harvey, pers. comm., 1986)

(b) there is a genuine feeling that summer/autumn cultivation of the Swamp is fundamental to preventing *Typha* from covering the whole Swamp.

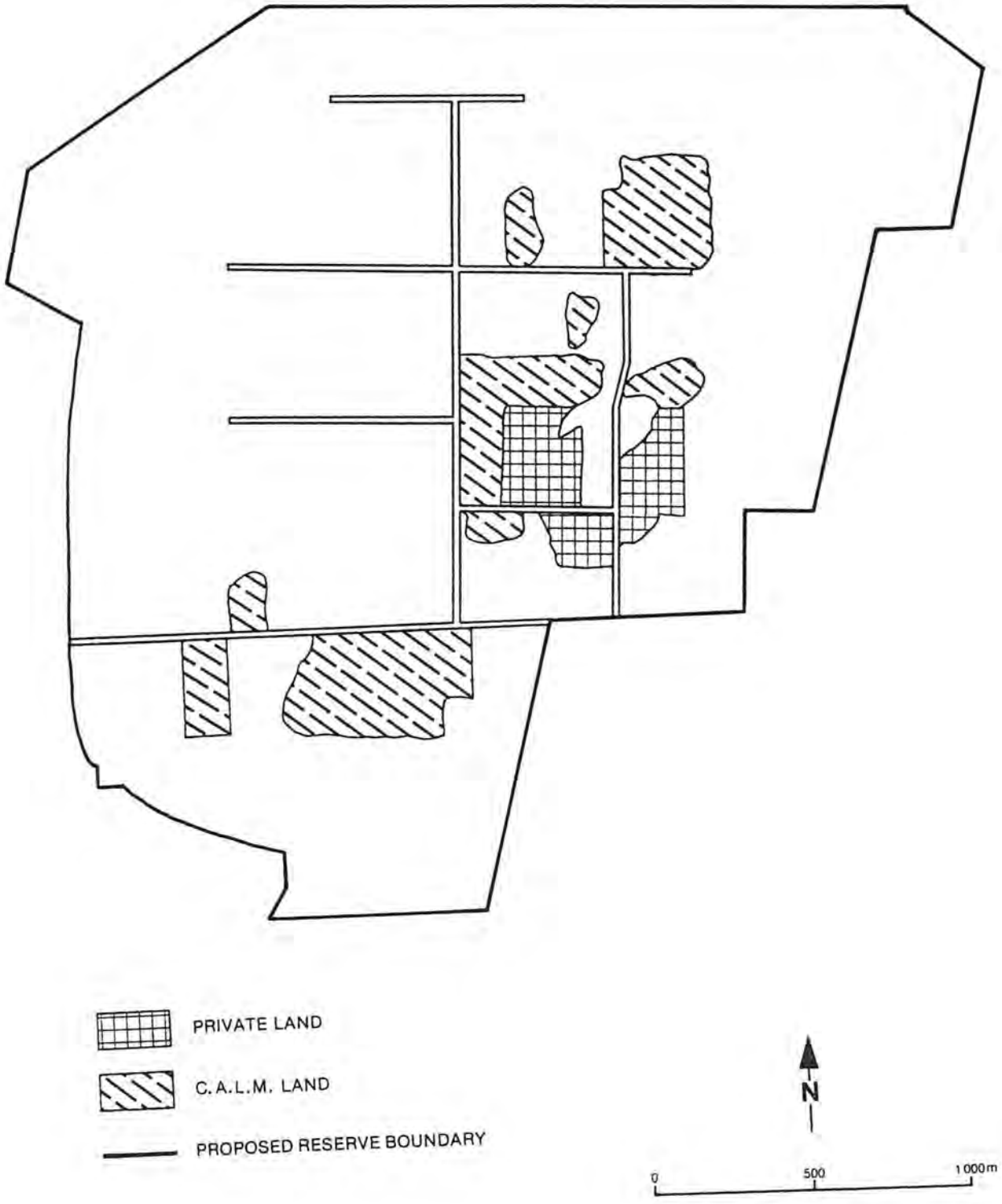

Figure 14. Agricultural use of Benger Swamp, 1985/86.

10.1.4 *Grazing*

In the past cattle have grazed the northern part of the Swamp. This could have affected the vegetation patterns as some species, such as *Baumea*, if trampled by cattle, are subsequently susceptible to invasion by *Typha*.

Grazing no longer occurs on the Swamp.

10.2 Departmental Management

Due to a lack of resources, little active management was carried out by the Department of Fisheries and Wildlife (now CALM) prior to 1982. The only exceptions were active management of duck shooting, both in and out of the duck shooting season, by wildlife research officers and wildlife officers, and regular patrols of the area by wildlife officers.

10.2.1 *Appointment of a Consultant*

In 1982 a consultant was employed from December to May for three years to:

(a) examine agricultural use
(b) monitor vegetation
(c) monitor waterbird use
(d) develop management strategies
(e) liaise with the local community.

The consultancy has formed the basis for the preparation of this management plan.

10.2.2 *Management Works*

Over the years 1982-1985 the following management works were carried out:

1. Construction of firebreaks

In 1983 a perimeter firebreak, which has since been annually maintained, was constructed on top of the levee banks to the south, west and north

of the Swamp (Fig. 5). The verges of formed roads within the Swamp have been slashed annually to improve their function as internal firebreaks.

2. Firefighting

Wildfires occurring on the Swamp have been attended by CALM firefighting staff.

3. *Typha* control trials

A number of trials have been conducted on *Typha* stands and seedlings to assess the success of different control techniques. Techniques have included:

(a) Spraying mature plants with herbicide

Problems were experienced with applying the herbicide at the most effective time (mid-December), as the Swamp was still covered by approximately 0.45 m of water. Reservations also exist about the broad-scale use of chemicals on nature reserves because of the effects such applications may have on non-target species.

(b) Cutting mature *Typha* plants under water

This method has been successfully used in other parts of Australia (Wilson 1977) and was used to a limited extent by potato growers at Benger in earlier years. A mechanical method of cutting under water is required because of the large areas involved. A light, shallow draft boat, with a reciprocating cutter mounted on the front, has been constructed by CALM. Field trials are being conducted.

(c) Ploughing and cultivation of areas invaded by mature plants and seedlings

Over the past two years trials have been conducted to assess the effectiveness of cultivation as a control measure for mature stands and seedlings. Mature stands have been burnt and then deep ploughed. Stand densities have been reduced by up to 80% in one year, however, the method requires further refinement. Ploughing and cultivating areas invaded by seedlings has proved to be a highly effective technique for controlling *Typha* spread.

10.3 Illegal Activities

10.3.1 *Stick Cutting*

Cutting of *Melaleuca viminea* and *M. laterita* for sticks, both for sale and private use, has been a considerable problem. This activity causes extensive damage to the *Melaleuca* stands and facilitates invasion by *Typha*. To date there have been two prosecutions for stick cutting on Benger Swamp.

10.3.2 *Rubbish Dumping*

This has not been a major problem, although over the years sheep and cattle carcasses, and domestic and garden rubbish have been dumped on the Swamp.

10.3.3 *Illegal Duck Shooting*

In the past Freckled Ducks have been shot and duck shooting has occurred outside the duck shooting season on Benger Swamp. Both activities are illegal.

10.4 Implications for Management

1. Some landowners still grow crops on privately owned land on the Swamp. This activity must be considered when determining water level strategies.

2. Part of the Swamp must be dry by mid-January for commercial vegetable crops to have sufficient growing time. This will necessitate drainage of those parts of the Swamp still used for vegetable growing.

3. Local farmers are growing crops on CALM land. Development of a leasing system is essential, if use of the Swamp by farmers is to be equitable.

4. A number of *Typha* control techniques have been tested at Benger Swamp. Of these, cultivation appears to be the most successful.

5. Illegal activities are having a detrimental effect on the Reserve. Continued management is essential.

PART B. MANAGEMENT OBJECTIVES

1.0 MANAGEMENT OBJECTIVES FOR NATURE RESERVES

The management objective for nature reserves is...

> 'to maintain and restore the natural environment, and to protect, care for, and promote the study of, indigenous flora and fauna'
> (Section 56(1d), Conservation and Land Management Act, 1984)

2.0 MANAGEMENT OBJECTIVE FOR BENGER SWAMP

The general management objective for Benger Swamp is to protect and enhance the area as waterbird habitat for the present range of species, with special emphasis on the habitat requirements of the Freckled Duck and Australasian Bittern.

3.0 ACHIEVEMENT OF OBJECTIVES

To achieve this objective manipulative management techniques will be used. This is necessary given the highly altered nature of Benger Swamp, with the area having been used for vegetable growing for the last 70 years. Such management complies with the management objectives for nature reserves given in the CALM Act, namely to 'protect and care for ... indigenous flora and fauna'. This manipulative approach to management is accepted by the International Union for Conservation of Nature and Natural Resources (IUCN) as being the best way, in some instances, of guaranteeing the stability and survival of certain species and ecosystems. Where this approach has been adopted, the IUCN has used the term managed nature reserve.

Active management is required in the following areas:

1. Land acquisition
2. Reserve classification
3. Mining
4. Water levels, flooding and drainage
5. Water quality
6. *Typha*

7. *Melaleucas*
8. Duck shooting
9. Fire
10. Weeds and pests
11. Public use and environmental education
12. Community involvement in management
13. Research

The detailed management objectives and strategies for each of these areas are given in Part C. Plan for Management.

PART C. PLAN FOR MANAGEMENT

1.0 LAND ACQUISITION

1.1 Objective

1. To rationalise management of Benger Swamp by ensuring that as much of the Swamp as possible is added to the Nature Reserve, so the Swamp can be managed as an integrated unit.

1.2 Rationale

Having one body responsible for the management of the Swamp means that resources can be efficiently allocated to management of the total Swamp environment. Management responsibility is best formally allocated, in this instance by inclusion of the entire Swamp in Reserve C34811 (Benger Swamp Nature Reserve) with vesting in the NPNCA.

1.3 Management Strategies

1. Discussions with landholders on the Swamp regarding the addition of their land to the Nature Reserve will continue. These additions will be based on direct purchase and land swaps. All land obtained by CALM will be added to Reserve C34811 and vested in the NPNCA.

2. Addition to the Nature Reserve of drain reserves and road reserves on the Swamp (where they are no longer required for access to private land) will be sought.

2.0 RESERVE CLASSIFICATION

2.1 Objective

1. To ensure that Benger Swamp is afforded the highest possible protection, given its importance for wetland and waterbird conservation.

2.2 Rationale

Benger Swamp Nature Reserve is currently a Class C Reserve (Land Act 1933), which means that its purpose can be changed by the Minister for

Lands. Its long-term protection would be more assured if it was made Class A, meaning that its purpose could only be changed with the consent of both Houses of Parliament.

2.3 Management Strategy

1. A change in the classification of Benger Swamp Nature Reserve, from Class C to Class A, will be sought. All land subsequently added will assume the status of the Nature Reserve at that time.

3.0 MINING

3.1 Objective

1. To ensure that the conservation values of Benger Swamp are not affected by mining proposals.

3.2 Rationale

It is likely that any form of mineral exploration or mining on Benger Swamp or in the Swamp's catchment would adversely affect the value of the area as a waterbird habitat. This effect would be primarily through changes to water supply and water quality and secondarily through general increases in levels of activity in the area.

3.3 Management Strategies

1. Discussions are underway, between CALM and the Department of Mines to establish a 'no mining condition' over Benger Swamp. (Refer to Part A, 3.2 Mining, for a discussion of 'no mining conditions'.) These discussions will continue.

2. If exploration or mining is approved in the Benger area, environmental conditions guiding these activities will be developed so that the current values of the Swamp, as waterbird habitat, are conserved. These conditions will be determined by CALM in consultation with the Department of Mines.

4.0 WATER LEVELS, FLOODING AND DRAINAGE

4.1 Objectives

1. To provide an annual pattern of flooding and drying to cater for the range of waterbirds using the Swamp.

2. To take account of the effects of water level control on private land use.

4.2 Rationale

The conservation value of Benger Swamp lies in its capacity to provide for large numbers and a range of species of waterbirds. This is due, at least in part, to the annual cycle of changing water levels. Given that the cycle is important, management could cater for more waterbirds in two ways - either by applying the cycle to a larger area or by lengthening the period of time over which the Swamp has water in it.

Applying the cycle to a larger area is not possible because the area that can be flooded is limited by levee banks. The area of open water used by waterbirds, within the existing boundaries, could be increased by reducing the area of *Typha* (Part C, 6.0 *Typha*). However, this would adversely affect those waterbirds which rely on the *Typha* stands as an important component of their habitat.

Extending the cycle is possible. This could be achieved by flooding earlier, providing deeper water in winter, draining later or a combination of these measures. All courses of action, if implemented at present, would adversely affect farmers growing vegetables on private land on the Swamp. Unless all privately owned land is purchased extending the cycle will be difficult.

Land use conflicts could be overcome by dividing the Swamp into two sections. This could be achieved by raising the height of the bank adjacent to the southern section of the internal drain and incorporating a simple check structure (Fig. 15). This would allow water to be held on the southern compartment, while allowing drainage of the northern compartment.

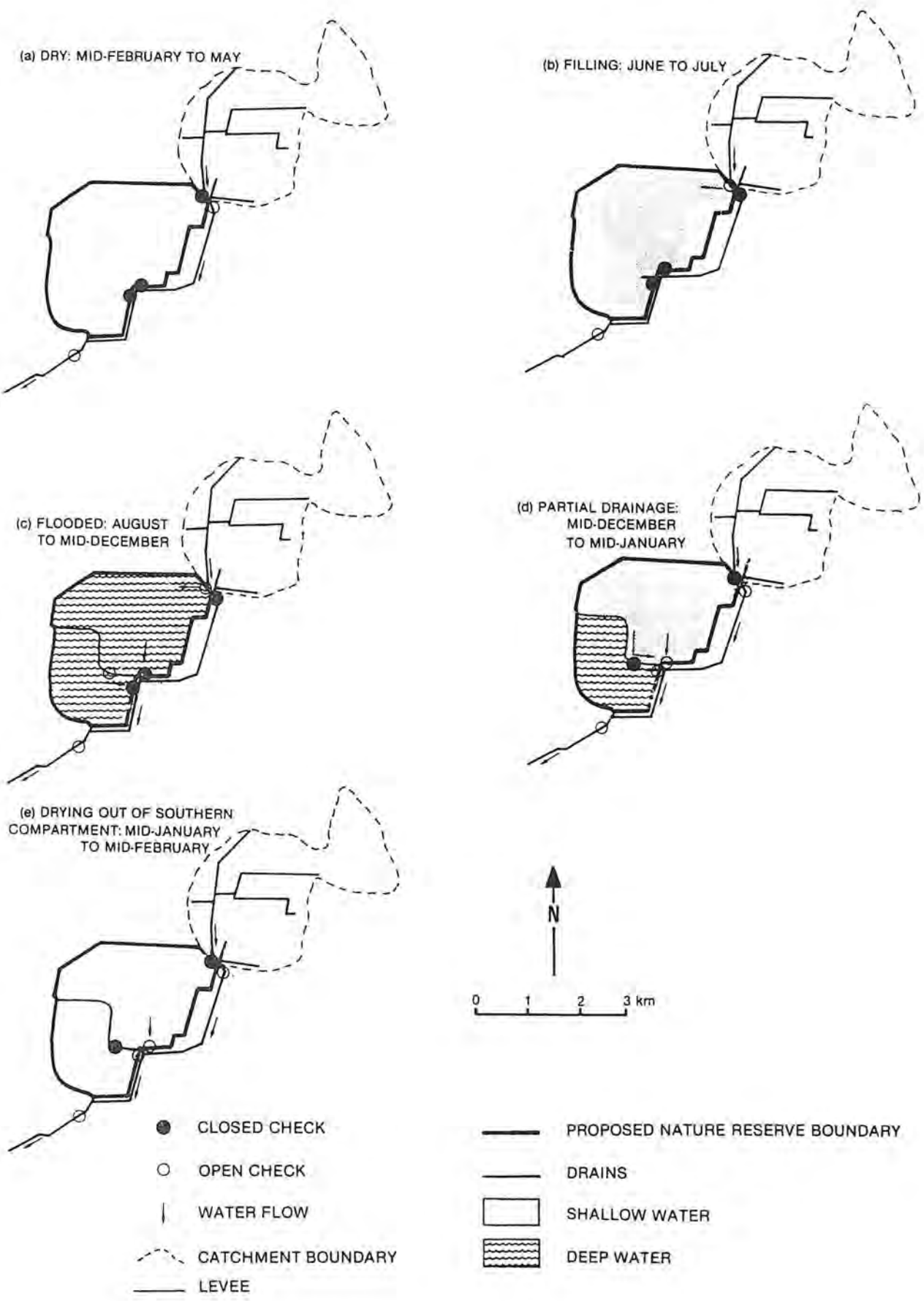

Figure 15. Proposed management of water levels on Benger Swamp.

One block of privately owned land remains in the southern compartment. Therefore, allowing the southern compartment to dry naturally will be dependent on purchase of this block by CALM or agreement by the landholder. Based on the rate of drying over the past three years water could be expected to remain in the southern compartment until mid-February.

The water level in the northern compartment would be managed in consultation with private landowners.

4.3 Management Strategies

1. Management of water levels, flooding and drainage will involve consultation with the Benger Swamp Regional Advisory Committee.

2. The Water Authority will be advised to direct water from the Swamp's catchment area to the Swamp in the first week of June.

3. The Water Authority will be advised to maintain the Swamp Road checks during the months July to November so that a water level of approximately 0.7 m is retained in the Swamp.

4. The Swamp will be divided into two compartments (Fig. 15) by raising the height of the bank adjacent to the southern section of the internal drain. A check structure will be incorporated in this bank.

5. Prior to division of the Swamp traditional drainage practices will continue, the aim being to have the Swamp dry by mid-January. The drainage date will be calculated using Table 2 in Appendix 1.

6. Following division of the Swamp, the southern compartment will be allowed to dry naturally, subject to agreement by the relevant landholder or purchase of their block by CALM.

7. Following division of the Swamp, the Water Authority will be advised to open the Swamp Road checks to enable drainage of the northern compartment so it is dry by mid-January. For as long as

part of the Swamp is privately owned, implementation of this strategy will involve discussions with the Benger Swamp Regional Advisory Committee regarding the desirability of such a timetable. Table 2 in Appendix 1 will be used to assist in the determination of the date for commencement of drainage.

8. Internal drains will be maintained in co-operation with the Water Authority.

9. CALM will liaise with the Water Authority if it becomes necessary to construct additional drains.

4.4 Investigations Required

The following investigations will be based on close liaison between CALM and the Water Authority.

1. Water levels will be monitored fortnightly.

2. The optimum filling and drainage patterns, in terms of systems of drains and timing of actions, will be determined. As part of this determination the current filling regime is being evaluated and the option of installing self-closing pipes leading from Benger Drain into the Swamp adjacent to Swamp Road is being considered.

3. The feasibility and desirability of a number of different water regimes for the Swamp will be investigated.

4. Studies will be conducted into the effects of dividing the Swamp on waterbird use, vegetation, water quality and groundwater. Changes in salinity will receive particular attention.

5. The drainage rate of the northern compartment will be monitored so the date for commencement of drainage can be accurately determined.

6. An improved understanding of the relationship between groundwater and surface water in the Swamp will be developed so that optimum water levels and management strategies can be determined.

5.0 WATER QUALITY

5.1 Objective

1. To maintain water quality so that the Swamp remains healthy and continues to support a diverse biota.

5.2 Rationale

The maintenance of a productive, stable food chain in the Swamp is considered desirable if the Swamp is to continue to support high numbers and a wide range of waterbirds. The key to productivity and stability in this system is water quality.

Successful management of water quality must be based on an understanding of the sources and processing of nutrients within, and of the effects of various levels of salinity on, a given system. Little is known about these processes and effects within Benger Swamp.

5.3 Management Strategies

1. *Typha* stands will be retained on at least 30% of the Swamp, because of their possible importance in nutrient buffering (Part A, 6.2 Present Vegetation), as well as their importance as fauna habitat.

2. Consultation with relevant landholders regarding catchment management will be carried out if investigations indicate that it is necessary.

5.4 Investigations Required

1. Water quality will be monitored by CALM in co-operation with the Water Authority. These data will be used to guide management practices.

2. The salinity of the wetland and the underlying groundwater will be monitored by CALM in co-operation with the Water Authority and the Department of Agriculture.

3. Soil testing will be undertaken by the Department of Agriculture to determine optimum fertiliser application rates if water quality investigations indicate that it is needed. These data will be used to encourage farmers to minimise the quantities of fertiliser applied to crops on the Swamp.

6.0 *TYPHA*

6.1 Objectives

1. To manage *Typha* to cater for the needs of the range of waterbirds using the Swamp.

2. To manage *Typha* to limit its spread, with regard for the effect that this action may have on water quality.

3. To manage *Typha* to minimise the effect of wildfires on *Melaleuca* stands.

6.2 Rationale

The most pressing short term management concern at Benger Swamp is the spread of *Typha*. Currently, 50% of the Swamp is covered by *Typha* and it is likely to spread and cover the remaining 20% of open water/grassland if control measures are not implemented.

At present, ploughing and subsequent cultivation of open areas of the Swamp appears to be the most effective and economic method of controlling the spread of *Typha*. There are two possible approaches to cultivation - either employing contractors or leasing parts of the Swamp to local farmers. Leasing parts of the Swamp to local farmers, for fodder cropping, creates few costs for CALM and provides a small return to local farmers who undertake the work.

Fodder crops have a growing season of less than eight weeks and do not require irrigation or the application of insecticides. It is anticipated that they could be planted as late as mid-February. Thus, fodder cropping should still be possible on the southern compartment. Up

to 150 ha of the Swamp could be used, ensuring that at least 25% of the Swamp remained free of *Typha*. This would ensure the retention of a diversity of habitats.

Commercial vegetable cropping is less desirable as it requires a longer growing season, necessitating draining the Swamp in mid-December.

6.3 Management Strategies

1. Existing open areas will be ploughed and cultivated each autumn to prevent *Typha* becoming established.

2. Cultivation will be based on a leasing system. Up to 150 ha of the Swamp will be available to local farmers to grow fodder crops during the months January to May. No more than 20 ha will be available to any farmer. This area limitation is to ensure that production is not undertaken on a commercial basis, as the aim of this system is to provide additional summer fodder for local farmers. Leasing conditions are given in Appendix 2.

3. To aid in fire control, large *Typha* stands will be separated by clear earth firebreaks 6-8 m in width (Fig. 16).

4. *Typha* cutting will be permitted where it is compatible with the above strategies.

6.4 Investigations Required

1. New methods of controlling the spread of *Typha* will continue to be tested. All control methods will be monitored so their effectiveness can be determined.

2. Trials will be conducted to determine if fodder crops can be successfully grown if planting is delayed until late February.

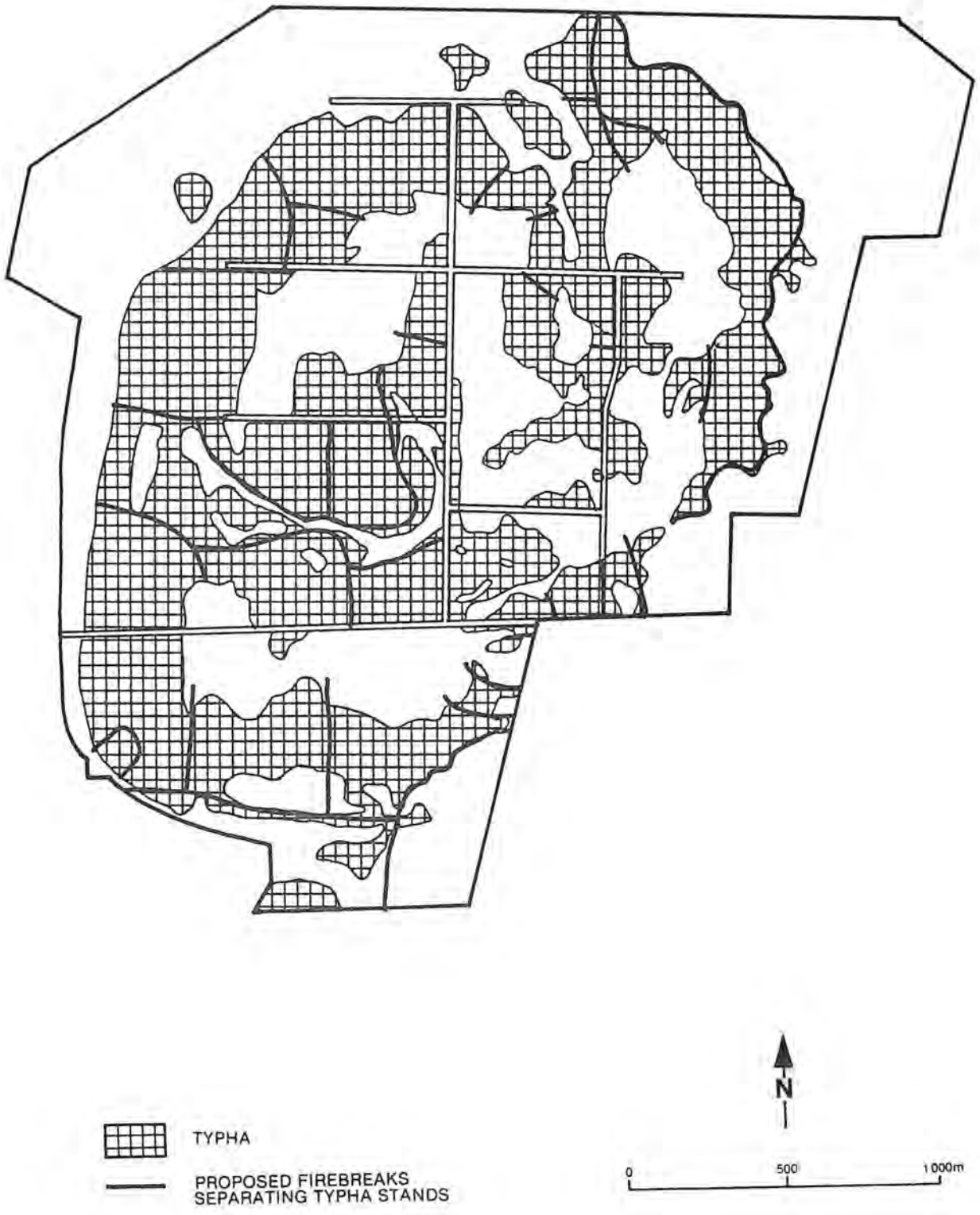

Figure 16. Proposed management of *Typha* stands on Benger Swamp.

7.0 *MELALEUCAS*

7.1 Objective

1. To ensure that adequate areas of *Melaleuca* forest and shrubland are provided, for use by waterbirds (and particularly Freckled Ducks) as refuge and nesting sites.

7.2 Rationale

The area covered by *Melaleucas* has been greatly reduced by frequent fires. This reduction has resulted from mature plants, as well as regenerating plants and seedlings, being killed by fire. Therefore, some form of artifical replacement is necessary.

7.3 Management Strategy

1. Replanting with *Melaleuca* species known to occur on the Swamp will be undertaken, subject to the limitations of resources. The assistance of volunteers will be sought.

8.0 DUCK SHOOTING

8.1 Objective

To ensure that the use of Benger Swamp reflects its importance for waterbird conservation.

8.2 Rationale

Benger Swamp is an important waterbird feeding and breeding area particularly for the Freckled Duck; a rare and endangered species. In accordance with this plan, considerable resources will be dedicated to the enhancement of the Swamp as waterbird habitat for the present range of waterbirds, including the Freckled Duck.

In the past, duck shooting on Benger Swamp has resulted in Freckled Ducks being shot.

8.3 Management Strategy

1. Benger Swamp will be closed to duck shooting.

9.0 FIRE

9.1 Objectives

1. To protect fire-sensitive habitats, particularly the *Melaleuca* forest and shrubland.

2. To manage *Typha* stands to provide a diversity of habitats and to limit the spread of wildfires.

9.2 Rationale

Frequent fires on the Swamp are adversely affecting the conservation values of the area as well as leading to an increase in the levels of combustible fuels. This adverse effect is mainly through a reduction in the area covered by *Melaleucas* and an increase in the area covered by *Typha*. Combustible fuel levels are increasing as frequent fires have facilitated the spread of *Typha* and grasses, both of which exhibit rapid rates of fuel accumulation.

9.3 Management Strategies

1. Fire-fighting units from CALM will attend wildfires on or threatening Benger Swamp. Fire crews will also attend prescribed burns adjoining the Swamp, provided the crews are not already committed elsewhere. Because of the time taken for units to get from Harvey to Benger, the responsibility for first attack will lie with local brigades. Upon arrival at the fire, CALM will assume control.

2. Any wildfires which occur on the Swamp will be contained to the smallest possible area by direct attack or by back burning from established firebreaks or low fuel zones (for example, irrigated pasture), taking into consideration the likely threats to life and property.

3. Preventing wildfires from entering *Melaleuca* stands (and if this is not possible, containing the wildfire to the smallest possible area) will be of highest priority in any fire suppression activities on the Swamp.

4. Existing perimeter firebreaks will be regularly maintained.

5. Clear earth firebreaks, 6-8 m in width and separating large stands of *Typha* and stands of *Typha* and *Melaleucas*, will be constructed and regularly maintained.

6. Three blocks of *Typha* near the centre of the Swamp will be burnt in autumn on a 3 year rotation to provide waterbird feeding areas.

7. No other fuel reduction burning will be undertaken during the term of this plan because of the capacity of *Typha* stands to attain hazard levels after one year and the detrimental effects of frequent fires on *Melaleuca* stands.

8. Areas of pasture on the north-eastern and western edges of the Swamp which are currently the subject of negotiations to purchase will, once CALM is responsible for their management, be leased for grazing over summer and autumn to minimise fuel accumulation.

9. All landholders on the Swamp, adjacent landholders and the Benger Post Office will be advised in December of each year of procedures for contacting CALM in the event of fire on or adjoining the Swamp.

10. CALM will take the necessary steps to become a Notifiable Authority with respect to Benger Swamp Nature Reserve. Responsibilities concerning Notifiable Authorities are described in the Bush Fires Regulations (1954).

10.0 WEEDS AND PESTS

10.1 Objectives

1. To manage grasslands to prevent them from choking areas of open water.

2. To control exotic plants that threaten the conservation values of Benger Swamp.

3. To minimise predation of native fauna by foxes.

4. To prevent domestic livestock from grazing on the Swamp, the only exception being the areas of summer pasture which will be leased for grazing as a fire control measure.

10.2 Rationale

Benger Swamp carries extensive grasslands over the summer months. Although these grasslands add to the variety of habitats at Benger water couch can, if left unmanaged, choke areas of open water. Similarly, the establishment of exotic shrubs and trees can eventually reduce available habitat.

In the past cattle have trampled *Baumea* stands and invasion by *Typha* has followed. Therefore, it is important to exclude stock from those parts of the Swamp still carrying native vegetation.

10.3 Management Strategies

1. If water couch begins to choke areas of open water control measures will be instigated.

2. Any non-native shrub or tree species which become established on the Swamp will be removed. Other non-native plants will be controlled if they pose a threat to the Swamp's conservation values.

3. Fox numbers will be opportunistically controlled.

4. Adjacent landholders will remain responsible for the maintenance of stock-proof fences where their land adjoins the Swamp.

11.0 PUBLIC USE AND ENVIRONMENTAL EDUCATION

11.1 Objectives

1. To provide opportunities for the local community and general public to enjoy and appreciate the conservation values of Benger Swamp.

2. To ensure that public use of the area is compatible with its nature conservation values.

11.2 Rationale

Benger Swamp, with its areas of open water, is ideally suited for waterbird watching. The management strategies below aim to enhance this value.

11.3 Management Strategies

1. Swamp Road will be raised so that it provides access, for birdwatching in winter, to the southern section of the Swamp.

2. A small car park and turn-around area will be provided at the junction of Swamp Road and Typha Road. Interpretive material will be provided there. This material will include a warning regarding the high numbers of tiger snakes on the Swamp.

3. CALM will approach the Shire of Harvey regarding closure of most of the internal roads for the period the Swamp is flooded. This will increase public safety, while decreasing damage to roads and disturbance to fauna.

4. Guided nature walks will be held to provide an opportunity for the public to learn about the flora and fauna of the Swamp.

5. Roads will be named to enable the public and management staff to find their way around the Swamp (Fig. 17).

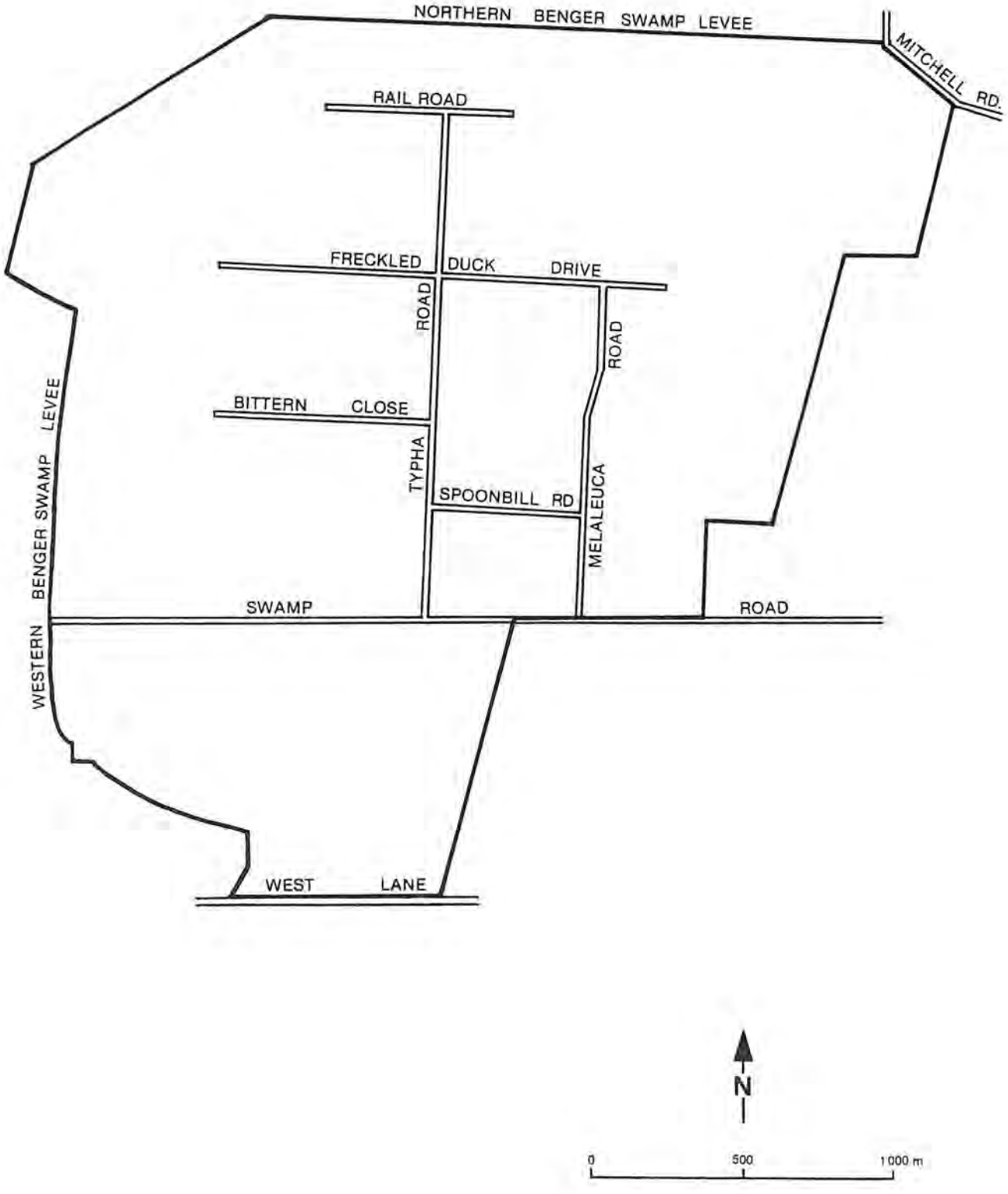

Figure 17. Proposed road and levee names on Benger Swamp.

6. Wildlife officers will continue to visit Benger Swamp immediately before, during and after the duck shooting season, as well as continuing to include Benger Swamp in their routine enforcement patrols.

12.0 COMMUNITY INVOLVEMENT IN MANAGEMENT

12.1 Objectives

1. To actively involve the local community in the management of Benger Swamp for waterbird conservation.

2. To ensure that the local community, Water Authority and other interested individuals and organisations remain well-informed regarding management practices on Benger Swamp.

12.2 Rationale

Given that 13% of the Swamp is privately owned and adjacent landholders live in close proximity to the Swamp, successful management is dependent on the support of the local community. As the Water Authority is responsible for water management State-wide, successful management of Benger Swamp is particularly dependent on continuing close liaison with, and support from, that Authority.

12.3 Management Strategies

1. It is desirable that the functions of the Benger Swamp Regional Advisory Committee are expanded and the structure revised, to provide a forum for discussion of all aspects of management on the Swamp. Any changes to this Advisory Committee should be made in consultation with them.

2. Information on current management practices on Benger Swamp will be readily available.

3. Landowners whose land adjoins Benger Swamp will be encouraged to manage their land in sympathy with the management objectives given in this plan, particularly in relation to exercising their

privileges under the open season notice covering damage to property by the Australian Shelduck (Mountain Duck).

13.0 RESEARCH

13.1 Objective

1. To obtain information on the resources of Benger Swamp and on the processes affecting and influencing these resources.

13.2 Management Strategies

1. Strategies for research into water levels and quality and *Typha* are given earlier in this plan in the relevant Investigations Required sections (Part C, 4.4, 5.4, and 6.4).

2. The RAOU, as part of the on-going South-west Waterbird Project and with funding provided by CALM, will continue to regularly monitor waterbird species and numbers at Benger Swamp. The Freckled Duck will continue to receive particular attention.

3. If funding and staff are available, the terrestrial and aquatic flora of Benger Swamp will be surveyed, and its importance to particular waterbird species determined.

PART D. IMPLEMENTATION AND REVIEW

1.0 IMPLEMENTATION

CALM is responsible for the implementation of this management plan. Primary responsibility rests with the Harvey District Office of CALM. Implementation of a number of the strategies given in the plan is dependent on close liaison between CALM and other government departments or groups, particularly the Water Authority and the Benger Swamp Regional Advisory Committee. The necessary liaison will be established and maintained at a district, regional and State level.

Plan implementation will depend on continuing liaison, not only with other government departments and groups, but also with landholders on the Swamp and adjacent landholders. Continued attention to the resolution of land tenure and *Typha* control trials, as well as the continuing development of public awareness of the conservation values of Benger Swamp, are also vital to the success of the plan.

The rate and level at which strategies are implemented will be dependent on the resources and funds available. Yearly works programs for Benger Swamp will be developed by the CALM Harvey District Office based on this management plan.

Management Records

The Harvey District Office will maintain accurate and up-to-date records of all management activities undertaken on Benger Swamp. These records will include current inventories of the flora and fauna.

2.0 REVIEW

Two levels of review are envisaged.

1. Annual

Prior to the preparation of the annual works program for the Swamp a brief review of plan implementation over the preceding financial year will be prepared. The review will identify which strategies have been implemented and to what degree, and any new information which may affect management.

2. Final

The plan will be reviewed during the final year of its term. This review will identify: the extent to which objectives have been achieved and strategies implemented; reasons for lack of achievement or implementation; and a summary of information which may affect future management. Another management plan will be prepared before this plan expires.

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APPENDICES

APPENDIX 1. DRAINAGE OF BENGER SWAMP

Introduction

The date at which drainage of Benger Swamp commences has been a source of controversy since the Department of Fisheries and Wildlife started purchasing land on the Swamp in 1974. Private landowners have wanted to continue traditional use of the land necessitating commencing drainage, by opening the Swamp Road checks, in December to hasten drying of the Swamp. The Department of Fisheries and Wildlife and subsequently CALM, on the other hand, has sought to delay drainage as long as possible, aiming to maximise waterbird usage of the area by keeping water on the Swamp longer.

As this plan proposes to continue the traditional drainage regime for the northern compartment (and on the whole Swamp until the area is divided) there is a need to develop a method for determining the exact date on which drainage should commence. This date will be influenced by the needs of the private landholders to have part of the Swamp dry enough by mid-January to allow the planting of vegetable crops, and by the nature conservation objectives to leave water on the Swamp for as long as possible. Thus, management must aim to have the Swamp dry by mid-January, while leaving the commencement of drainage as late as possible.

Water is removed from the Swamp by two processes: drainage and evaporation. When the water is deep and water (head) pressure is high, drainage will be the dominant process. When the water is shallow and the head pressure is low, drainage slows and evaporation becomes the dominant process. Measurements were necessary to determine the relative importance of these two factors in the drying process.

Drainage

To determine the effect of removal of the checks on rate of drying, rates of fall in water levels two weeks before and two weeks after opening the check, were monitored over the three years 1983-85 (Fig. 1a). Three depth gauges in different parts of the Swamp were used to record the different rates of drainage across the Swamp. Depths below 25 cm were not recorded as at this

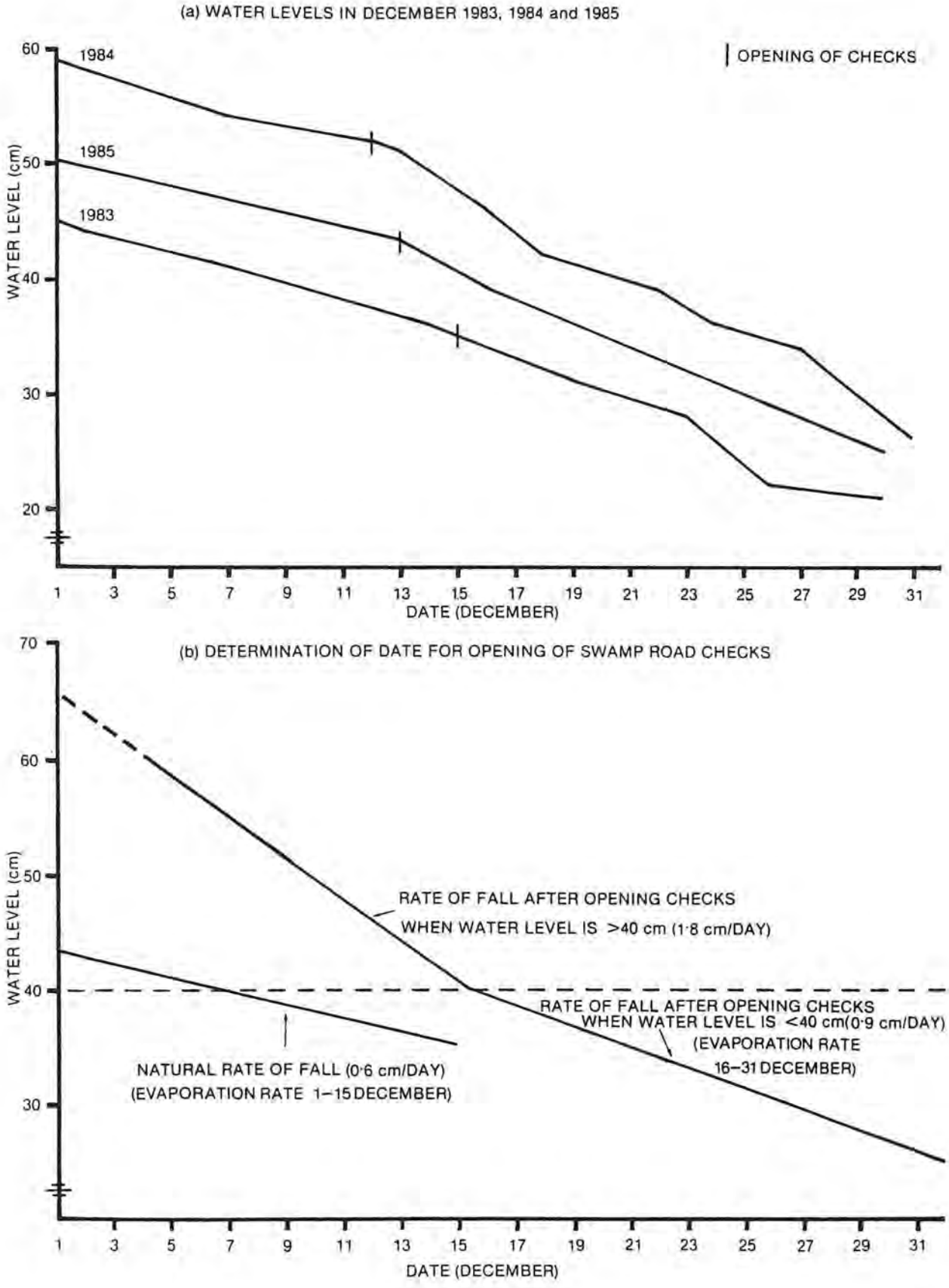

Figure 1. Determination of opening date for Swamp Road checks.

depth of water and lower the gauges read zero, with the remaining water lying in shallow, widely separated pools. The water levels shown in Figure 1a are the mean levels for the three depth gauges.

The slope of the plots in Figure 1a can be used to calculate the rate of fall in water level before and after opening the checks. Calculated rates of fall are shown in Table 1.

Table 1. Rate of fall in water levels on Benger Swamp (cm/day).

Period	Rate of fall of water level 1983	1984	1985	Mean
1 Dec. - opening	0.71	0.64	0.58	0.64
Level at time of opening (cm)	36	52	42	43
Opening - 40 cm	-	1.71	2.00	1.82
40 - 25 cm	0.95	0.75	0.97	0.89

Evaporation

Evaporation rates measured at the Wokalup Agricultural Research Station (9 km north of Benger) over December 1983/January 1984 were:

1 - 15 December = 0.6 cm/day
16 - 31 December = 0.9 cm/day
1 - 15 January = 0.9 cm/day

The Drying Process

RATES OF FALL

The following points summarise the various influences on the rate at which the Swamp dries:

1. the rate of fall in water level in the Swamp, before the Swamp Road checks are opened, is 0.6 cm/day (evaporation rate 1-15 December)

2. the rate of fall in water level after opening the checks is 1.8 cm/day (combination of evaporation and drainage), until the level reaches 40 cm
3. the rate of fall after opening of the Swamp Road checks, when the level is between 40 cm and 25 cm, is 0.9 cm/day (evaporation rate 16-31 December)
4. a level of 25 cm on January 1 will result in the Swamp being dry by mid-January.

These interpretations are represented graphically in Figure 1b.

CALCULATION OF OPENING DATE

Given the above, the checks should be opened so as to achieve a level of 25 cm on 1 January.

The following calculations, which are derived from Figure 1b, can be used to determine the approximate opening date for the Swamp Road checks.

1. Water level greater than 60 cm - no data available.

2. Water level 60-49 cm, use the following equation -

$$\text{Date} = \frac{\text{y intercept of 1.8 rate - water level on 1 December (cm)}}{\text{1.8 rate - 0.6 rate}}$$

$$\text{Date} = \frac{66 - \text{water level on 1 December (cm)}}{1.2}$$

For example, if the water level is 60 cm on 1 December -

$$\text{Date} = \frac{66 - 60}{1.2} = \frac{6}{1.2} = 5$$

Therefore, given a water depth of 60 cm on 1 December, the Swamp Road checks should be opened on 5 December to ensure that the Swamp is dry by mid-January.

3. Water level less than 49 cm - allow to dry naturally.

The above three calculations were used to formulate Table 2.

Table 2. Date of opening of Swamp Road checks

Water Level on December 1 (cm)	Opening Date (December)
>60	To be Determined
60	5
59	6
58	7
57	8
56	8
55	9
54	10
53	11
52	12
51	13
50	13
49	14
<49	No opening necessary

CONCLUSION

By measuring the water level on 1 December and referring to Table 2 the opening date for the Benger Swamp checks can be readily determined. This will allow drainage to be delayed for as long as possible, thereby maximising waterbird usage, while at the same time ensuring that the Swamp is dry by mid-January.

APPENDIX 2. ISSUE OF LEASES ON BENGER SWAMP

1. Leases over sections of Benger Swamp will be issued to local farmers, and agricultural institutions such as the Harvey Agricultural Senior High School, for the purpose of growing fodder crops.

2. The leases will be issued annually for the period 1 January to 31 May.

3. The maximum size of each lease will be 20 ha.

4. The price of each lease will be $5 per ha per year.

5. The allocation of leases will be the responsibility of the CALM Harvey District Manager. Priorities for allocation of leases will be as follows:

   1st Priority

   Farmers who currently use the Swamp and either (a) do not own land on the Swamp or (b) own and fully utilize land on the Swamp. Farmers who own but do not fully utilize land on the Swamp will not be issued with a lease.

   2nd Priority

   Other local farmers who wish to use the Swamp, using criterion (a) above.

6. The following conditions will apply to each lease:

   a. no crops other than fodder crops will be grown without the specific approval in writing of the CALM Harvey District Manager
   b. no insecticides or herbicides will be used without the specific approval in writing of the CALM Harvey District Manager
   c. no fires will be lit without the specific approval in writing of the CALM Harvey District Manager
   d. no rubbish dumping
   e. no grazing
   f. the land must be cultivated by 30 April each year.