SURFACE WATER RESOURCES
WILDMAN RIVER STATION

(INTERIM REPORT for WATER DIVISION PROJECT NUMBER 2026)

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SURFACE WATER RESOURCES: WILDMAN RIVER STATION

ABSTRACT

Investigations have commenced to determine the nature and extent of surface water availability for a cashew nut plantation on Wildman River Station.

In addition to outlining the overall project background and objectives, this interim report presents the findings of the surface water investigation to date (June 1984).

01:REP3
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CONCLUSION

Based on observations made in April, May and June 1984, the Twin Sisters Lagoons will probably meet the water requirement of the 30 hectare pilot plantation (Section 7.0).

The seasonal reliability of this supply has not, as yet, been assessed.

RECOMMENDATIONS

It is recommended that, for the next stage of this study, Water Division:

1. Proceed with the proposed monitoring network to provide information for a water balance study (Section 1.2 Objective 2).

2. Assess the seasonal reliability of the Twin Sisters Lagoons meeting the plantation water demand (Section 8.4).

3. Reconsider the proposal to establish a stream gauging station and/or flow control structure on Cattle Creek adjacent to the plantation (Section 5.1).

4. Investigate the feasibility of diverting Swim Creek into the lagoon system (Section 5.2).

Further, it is recommended that Water Division:

5. Commence the groundwater investigation (Water Division Project Number 2021) in the vicinity of the Twin Sisters Lagoons (Section 6.2).
1.0 INTRODUCTION

1.1 Background

Commonwealth Sugar Refineries (CSR) are examining the viability of large scale cashew nut production in the coastal regions of the Northern Territory.

A site in the north-eastern corner of Wildman River Station has been chosen for a pilot cashew plantation of 30 hectares (Figure 1.1). Development of this site, adjacent to the Twin Sisters Lagoons, commenced in May 1984.

It has been estimated (Reference 5) that the fully developed pilot plantation (30 ha) will require 350 ML of water per year.

1.2 Objectives

The objectives for the surface water component of this project are:

1. To assess surface water resources suitable for, and in proximity to, a proposed cashew nut plantation in the north-eastern corner of Wildman River Station.

2. To establish a monitoring network designed to provide information for a water balance study.

1.3 Project Documentation

This interim report addresses Objective 1 and specifically summarises projected maximum and existing (June 1984) reserves of water in the major lagoon at the Twin Sisters.

Achievement of objective 2 will culminate in a final report programmed for completion in March 1985.

The concurrent groundwater investigations (Water Division Project Number 2021) and any subsequent water resource investigations will be reported separately.
2.0 GEOGRAPHY: WILDMAN RIVER STATION

2.1 Location

Wildman River Station (12°43'S, 131°49'E) lies centrally in the coastal Adelaide-Alligator region of the Northern Territory. The station has an area of over 500 sq km and is about 110 km (by air) ESE from Darwin (Figure 1.1).

2.2 Climate

The rainfall of the area is strongly seasonal. It is negligible between April and October, builds up steeply to a high monthly average (270 mm) November to March then drops off more sharply than it rises. The peak monthly rainfall, about 330 mm, is expected in January or February.

Temperatures, on the other hand, are relatively even. They are highest in November. On a fortnightly basis the mean maximum varies by 4.8°C (35.9° to 31.1°). Similarly the mean minimum varies by 9.0°C (24.3° to 15.3°) (Reference 2).

Evaporation is highest toward the end of the Dry Season (October); approximately 230 mm per month (Class A pan value).

High humidity during the summer Wet results in oppressive conditions.

2.3 Land System

Wildman River Station is broadly classified as Koolpinyah surface and more specifically Undulating Upland Terrain (Slopes 5%) (Reference 3). The pilot plantation, centred on the Twin Sisters Lagoons, is concentrated on the land system Queue (Reference 2).
Soils are of the Killuppa family; typically deep, well drained, sandy red earths. Their very low water holding capacity of 73 mm/m (Reference 1) is indicative of a 'droughty' soil. Also their sandy non-cohesive nature makes them vulnerable to erosion once the land is totally cleared of ground cover.

Vegetation consists of tall open forest. Where fires have not extended in recent seasons there is a healthy understorey of grass, shrubs and litter.
3.0 CATCHMENT DESCRIPTION

3.1 Landforms

The Queue land system is characterised by level terrain up to 3 km wide, slopes less than 3.5% and relief to 6 m. The level terrain is evidenced by lowland adjacent to nearby creeks. A ground profile linking Cattle Creek with the major lagoon is plotted in Figure 3.1.

3.2 Streams

Two small streams flow adjacent to the Twin Sisters study area; Cattle and Swim Creeks to the east and west respectively (Figure 3.2). They flow approximately northward from their source less than 10 km to the south.

Streamflow has not been measured in the vicinity of the pilot plantation.

Cattle Creek, less than 10 m wide and 1.5 m deep, will have its peak flows attenuated by an area of lowland immediately upstream. Similarly Swim Creek extends into a number of low lying areas suggesting poor horizontal drainage and small main channel bed slopes to the west of the study area.

3.3 Major Lagoon

The major lagoon lies between Cattle and Swim Creeks (Figure 3.2). When full, it will extend nearly 3 km and have a maximum width and depth of 700 m and 3.8 m respectively. It has a maximum storage potential of 2490 ML (Section 4.2). This value can be rounded up to 2500 ML without loss of accuracy.
FIG 3.2
3.4 Soil Water

The level sandy soil encourages high rates of rainfall infiltration particularly where good ground cover exists (see also Section 5.4).

The fate of the substantial amount of infiltrated water expected in the sandy soil is of interest. Studies are underway to enhance our knowledge of this potential water resource.
4.0 LAGOON CAPACITY SURVEY

4.1 Methodology

4.1.1 Physical

A series of benchmarks were installed linking the Twin Sisters lagoons with Cattle Creek (Figure 4.1.1(a)). They were also extended along the eastern side of the major lagoon. This framework will enable free water levels at points across the entire study area to be readily related to one arbitrary datum (TBM 1 = 100.000 m).

Eight sections across the major lagoon were measured (Figures 4.1.1(b)-(j)). Each cross-section extended at least into the tree line (above the high water mark). They were located in plan by a series of intersecting bearings and fixed in elevation by the common water level and/or a nearby benchmark.

Water samples were collected for complete analysis.

4.1.2 Analytical

Two methods were used (one a check calculation) to determine the water level/volume relationship (Figure 4.1.2).

(i) Simpson's Rule:

\[ V = \frac{L}{3} \left( A_1 + 4A_2 + 2A_3 + \ldots + 2A_{n-2} + 4A_{n-1} + A_n \right) \]

where \( A_1, A_2, \ldots A_n \) are successive cross-section areas.

\( L = \) distance between sections.
FIG 4.1.1(a)

ALL LEVELS BASED ON ASSUMED DATUM T.B.M. 1 = 100.000
ALL BEARINGS MAGNETIC

WILDMAN RIVER STATION
FIG 4.1.1(b)
FIG 4.1.2

WATER LEVEL/STORAGE VOLUME
MAJOR LAGOON, TWIN SISTERS

<table>
<thead>
<tr>
<th>W.L.(m)</th>
<th>VOLUME (ML)</th>
</tr>
</thead>
<tbody>
<tr>
<td>95.5</td>
<td>0</td>
</tr>
<tr>
<td>96.0</td>
<td>20</td>
</tr>
<tr>
<td>96.5</td>
<td>170</td>
</tr>
<tr>
<td>97.0</td>
<td>450</td>
</tr>
<tr>
<td>97.5</td>
<td>790</td>
</tr>
<tr>
<td>98.0</td>
<td>1160</td>
</tr>
<tr>
<td>98.5</td>
<td>1560</td>
</tr>
<tr>
<td>99.0</td>
<td>2010</td>
</tr>
<tr>
<td>99.5</td>
<td>2490</td>
</tr>
</tbody>
</table>
FIGURES 4.1.1 (c) to (j)

(major lagoon cross-sections)

ARE CONTAINED IN APPENDIX A
(ii) Trapezoidal Rule:
\[ V = (L) \left( \frac{A_1 + A_n + A_2 + A_3 + \ldots + A_{n-1}}{2} \right) \]

4.2 Results

<table>
<thead>
<tr>
<th>Water Level (m)</th>
<th>Volume (ML)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Simp.</td>
</tr>
<tr>
<td>95.5</td>
<td>0</td>
</tr>
<tr>
<td>96.0</td>
<td>20</td>
</tr>
<tr>
<td>96.5</td>
<td>170</td>
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<td>97.0</td>
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<td>98.5</td>
<td>1560</td>
</tr>
<tr>
<td>99.0</td>
<td>2010</td>
</tr>
<tr>
<td>99.5</td>
<td>2490</td>
</tr>
</tbody>
</table>

Capacities quoted and future calculations performed will be based on the lower, more conservative, volumes given by Simpsons Rule.
5.0 POTENTIAL WATER SOURCES TO SUPPLEMENT LAGOON SUPPLIES

5.1 Cattle Creek

Initially a gauging station consisting of streamflow recorder and/or flow control structure was proposed for Cattle Creek adjacent to the plantation. Data from this station was to be used to examine the feasibility of pumping water from Cattle Creek onto the plantation and/or into the lagoons.

Ground reconnaissance has revealed only a short period of surface water flow at Cattle Creek after the Wet Season. For example, despite above average rainfall during the 1983/84 Wet Season, Cattle Creek bed was dry by June 1984.

Cattle Creek is an intermittent stream because the water table is above the stream bed, sustaining baseflow, for as little as two months after the Wet Season. Other factors inhibiting the flow period are the small catchment above the study area and evaporation.

In this light of limited flow capacity (Section 3.2) and duration it appears that the initial proposal to establish a gauging station on Cattle Creek should be reconsidered.

5.2 Swim Creek

The concept of lagoon 'top-up' by diverting stream flow into the lagoon system appears reasonable in which case Swim Creek offers greater potential (physically) than Cattle Creek.

Preliminary calculations indicate sufficient runoff from the Swim Creek catchment to ensure maximum lagoon water reserves at the beginning of each Dry Season.
To realise this scheme a stream gauging station and weir will need to be established on Swim Creek to verify flows. Ground slopes must be surveyed and a cost/benefit analysis should be performed to prove the viability of the scheme.

5.3 Dam Construction

The level terrain, lack of streamflow record, and high evaporation and seepage losses are not favourable for damming either Cattle or Swim Creeks.

The major lagoon overflow section (northwestern corner) could be raised by up to 0.5 m to increase the storage capacity. Further investigation will be required to finalise details should this option be selected.

5.4 Soil Water

The expected substantial volume of infiltrated water may remain within the sands encompassing the lagoon and offer a practical supplementary water source. It may, on the other hand, drain through the permeable soils away from the developing plantation.

A better understanding of the behaviour of this potential water source will be achieved by regular piezometric observations planned as part of the water monitoring program.
6.0 COMPARISON: TWIN SISTERS VS OTHER LAGOONS

6.1 Physically Similar Lagoons

A brief comparison was made between the Twin Sisters and two physically similar lagoons; Knuckey and McMinns, references 7 and 8 respectively (Figure 6.1 (a)).

As well as being of a similar size the three lagoons have the following similarities:
climate, topography, land system, vegetation, soils and underlying geology.

It could reasonably be deduced that the Twin Sisters may have formed in a manner similar to Knuckey and McMinns Lagoons; namely by the solution and collapsed of underlying rock (Figure 6.1 (b), from Reference 9).

In addition a first approximation might be to transpose the known seasonal water level fluctuations in Knuckey and McMinns Lagoons to the unknown behaviour of water levels in the Twin Sisters Lagoons. The assumptions made in this approximation will be better quantified following drilling at the Twin Sisters in late 1984.

6.2 Known Lagoon Behaviour

(i) Knuckey and McMinns Lagoons

Water level recession curves for Knuckey Lagoon are given at figure 6.2 (adapted from Reference 6). The water line recedes steadily for six months, from March, at a rate of approximately:

Knuckey Lagoon: 400 mm per month
McMinns Lagoon: 600 mm per month
KNUCKEY AND McMINNS LAGOONS
LOCALITY PLAN

FIG 6.1(a)
(A) FORMATION OF SUBSIDENCE DOLINES

20-60 metres (approx) STRONG VERTICAL DRAINAGE SOLUTION

DOLINE 40-200 metres

CONTINUED SOLUTION COLLAPSE

COLLAPSE BRECCIA

(B) FORMATION OF PERENNIAL LAGOONS

CONTINUED INTERNAL DRAINAGE

VERTICAL GROUNDWATER MOVEMENT

20-50 metres (approx)

PERENNIAL LAGOON

LATERSITIC CLAY

COLLAPSE BRECCIA

INFILLING WITH LATERITIC CLAY

FORMATION OF SUBSIDENCE DOLINES AND PERENNIAL LAGOONS
(diagrammatic)
A corresponding recession at the Twin Sisters Lagoon would seriously deplete water reserves.

(ii) Twin Sisters Lagoons

Preliminary observations (April to June 1984) at the Twin Sisters indicates a relatively low average recession of 145 mm per month. This rate is lower than the expected loss to evaporation alone and suggests:

(a) a piezometric gradient rising from the lagoon i.e. water held in the adjacent sands is draining into the lagoons.

(b) seepage through the lagoon bed is not substantial.

Clearly the period of observation has not been long enough to confidently predict lagoon water level behaviour. Similarly it is too early to make a statement on the seasonal reliability of the lagoons in satisfying the plantation water requirements.

The proposed water level monitoring program will provide insight into these uncertainties.
OUTLET CEASE TO FLOW (30.8 M)

DARWIN EAST-HYDROLOGY  KNUCKEY LAGOONS WATER LEVEL RECESSION CURVES
7.0 PLANTATION WATER DEMAND

Hurle (Reference 5) estimates that the maximum water requirement of the 30 hectare pilot cashew farm will be 350 ML per year. This figure was derived from maximum water deficits calculated from monthly rainfall and pan evaporation data. Similarly he estimates the maximum monthly rate of farm water use to be about 60 ML.

These water requirements were scaled up (Reference 5) from the 30 hectare pilot farm to the expected fully developed plantation of 5000 hectares. The resulting water demand:

- maximum annual = 60 000 ML
- maximum monthly = 10 000 ML

Hurle (Reference 5) suggests that "the potential irrigation requirement of 60 megalitres/month per 30 hectares may be a considerable over-estimate of the true requirement."

The water level monitoring program will assist in quantifying the cashew trees' water usage during the pilot study.
8.0 SUMMARY OF RESULTS

8.1 Capacity Survey

Table 8.1

<table>
<thead>
<tr>
<th>Observation</th>
<th>Water Level (m)</th>
<th>Volume (ML)</th>
<th>% Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected Max.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>99.5</td>
<td>2490</td>
<td>100</td>
</tr>
<tr>
<td>5 April 1984</td>
<td>98.96</td>
<td>2000</td>
<td>80</td>
</tr>
<tr>
<td>24 May 1984</td>
<td>98.76</td>
<td>1775</td>
<td>71</td>
</tr>
<tr>
<td>20 June 1984</td>
<td>98.59</td>
<td>1625</td>
<td>65</td>
</tr>
</tbody>
</table>

8.2 Supplementary Water Potential

Supplementary water resources near the lagoons are being investigated:

(i) Cattle Creek: Poor potential for irrigation during the dry season.

(ii) Swim Creek: Good potential for diversion and lagoon 'top-up'. Further investigation required.

(iii) Dam Construction: Neither stream offers a practical dam site. A levee bank, at the lagoon overflow point, may raise the maximum water level attainable in the main lagoon by up to 0.5 m. Further investigation required.

(iv) Soil Water: Unknown at this stage.

(v) Groundwater: Subject of a separate study.
8.3 Projected Plantation Demand (Reference 5)

(i) 30 hectare pilot farm:
    maximum annual requirement = 350 ML
    maximum monthly requirement = 60 ML

(ii) 5000 hectare plantation:
    maximum annual requirement = 60 000 ML
    maximum monthly requirement = 10 000 ML

8.4 Resource Reliability

A statement on the reliability of the Twin Sisters Lagoons in meeting the water requirement of the pilot cashew farm cannot be made at this early stage in the investigation.
9.0 REFERENCES


2. CSIRO : "Lands of the Adelaide - Alligator Area, Northern Territory"; Land Research Series No 25, Melbourne 1969


7. TRANSPORT AND WORKS : "Knuckey Lagoon"; G S File No 815243
8. TRANSPORT AND WORKS, DEPARTMENT OF
   "McMinns Lagoon at Lilys Lane"; G S File No 815008

VERTICAL EXAGGERATION = 40
ASSUMED ARBITRARY DATUM = 100.000 m

TWIN SISTERS LAGOONS
CROSS-SECTION 1
TWIN SISTERS LAGOONS
CROSS-SECTION 2
VERTICAL EXAGGERATION = 40
ASSUMED ARBITRARY DATUM = 100.000 m
TWIN SISTERS LAGOONS
CROSS-SECTION 3

VERTICAL EXAGGERATION = 40
ASSUMED ARBITRARY DATUM = 100.000 m
VERTICAL EXAGGERATION = 40
ASSUMED ARBITRARY DATUM = 100.000 m

FIG 4.1.1(f)
TWIN SISTERS LAGOONS
CROSS-SECTION 4
TWIN SISTERS LAGOONS
CROSS-SECTION 5

VERTICAL EXAGGERATION = 40
ASSUMED ARBITRARY DATUM = 100.000m
TWIN SISTERS LAGOONS
CROSS-SECTION 6

VERTICAL EXAGGERATION = 40
ASSUMED ARBITRARY DATUM = 100.000 m
TWIN SISTERS LAGOONS
CROSS-SECTION 7

VERTICAL EXAGGERATION = 40
ASSUMED ARBITRARY DATUM = 100.000m
VERTICAL EXAGGERATION = 40
ASSUMED ARBITRARY DATUM = 100.000 m

TWIN SISTERS LAGOONS
CROSS-SECTION 8