Deras (Australia) Pty Ltd

PROPOSED WET-BLUE HIDE TANNERY AT DARKAN

Consultative Environmental Review

KINHILL

675.02(941)
KIN
Copy B

910484/2

Department of Environmental Protection Library

MARCH 1991

LIBRARY
ENVIRONMENTAL PROTECTION AUTHORITY
1 MOUNT STREET PERTH

673.02 (941)
KIN
910484B

DERAS (AUSTRALIA) PTY LTD

PROPOSED WET-BLUE HIDE TANNERY AT DARKAN

CONSULTATIVE ENVIRONMENTAL REVIEW

Prepared by:

Kinhill Engineers Pty Ltd
47 Burswood Road, Victoria Park, WA 6100
Tel: (09) 362 5900; Fax: (09) 362 5627; Telex AA92722

March 1991
PE0114

ISBN 0 949397 46 6
© Deras (Australia) Pty Ltd

CATTLE HIDE TANNERY AT DARKAN
CONSULTATIVE ENVIRONMENTAL REVIEW

The Environmental Protection Authority (EPA) invites persons and organizations to make a submission on this proposal.

The Consultative Environmental Review (CER) for the wet-blue hide tannery at Darkan has been prepared on behalf of Deras (Australia) Pty Ltd in accordance with Western Australian Government procedures. The CER will be available for comment for four weeks, beginning on 20 March 1991 and finishing on 15 April 1991.

Comments from government agencies and from the public will assist the EPA in preparing an assessment report, in which it will make a recommendation to Government.

WHY WRITE A SUBMISSION?

A submission is a way to provide information, express your opinion and put forward your suggested course of action including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received will be acknowledged.

DEVELOPING A SUBMISSION

You may agree or disagree with or comment on, the general issues or specific proposals discussed in the CER. It helps if you give reasons for your conclusions, supported by relevant data.

You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific proposals in the CER:

- clearly state your point of view
- indicate the source of your information or argument if this is applicable
- suggest recommendations, safeguards or alternatives.

POINTS TO KEEP IN MIND

It will be easier to analyse your submission if you keep in mind the following points:

- Attempt to list points so that the issues raised are clear. A summary of your submission is helpful.
- Refer each point to the appropriate section, chapter or recommendation in the CER.
- If you discuss different sections of the CER, keep them distinct and separate, so there is no confusion as to which section you are considering.
- Attach factual information you wish to provide and give details of the source. Make sure your information is accurate.
- Please indicate whether your submission can be quoted, in part or in full, by the EPA in its assessment report.

Copies of the CER can be obtained from Kinhill Engineers, 47 Burswood Road, Victoria Park, Perth, at a cost of $10 plus packaging and postage.

Remember to include:

- name
- address
- date.

The closing date for submissions is 15 April 1991.

Submissions should be addressed to:

The Chairman
Environmental Protection Authority
1 Mount Street
Perth WA 6000

Attention: Mr S. Sadlier

CONTENTS

CONTENTS

SUMMARY

This Consultative Environmental Review (CER) assesses the proposal put forward by Deras (Australia) Pty Ltd (Deras) to establish and operate a 'wet-blue' hide tannery near Darkan, in the Shire of West Arthur, south-west Western Australia.

The Darkan site has advantages over the other sites that were considered in that an adequate and reliable fresh water supply is available, there are no nearby residents likely to be affected by nuisance odours, and both the Shire of West Arthur and local citizens are generally supportive of the development.

The hide preparation and tanning process would be conventional, being exceptional only in the low volume of water required. The hides would be washed, fleshed and dehaired with a lime–sulphide mixture. After deliming and bating, the hides would be pickled and then tanned with a chromium–aluminium mixture.

The separate wastewater streams would be pre-treated as required. All wastewater streams, except the treated pickling and tanning wastewater, would be combined and treated in an anaerobic lagoon; this treated water, combined with the treated pickling and tanning wastewater, would then pass to the facultative and evaporating lagoons for final disposal. During winter, treated dehairing wastewater and bating wastewater would be used as fertilizer. Chrome waste would be removed by a licensed waste disposal operator. Dried salt sludges (predominantly sodium chloride) would be disposed of at a salt lake. Other solid wastes including screenings and anaerobic lagoon sludges would be disposed of by on-site burial or spreading, if a beneficial use could not be found: where possible, waste would be sold to be used in pet food, gelatine and tallow manufacture, and in fertilizers and soil conditioners.

The proposed tannery building and waste disposal facilities would be sited such that they would have minimal impact on the landscape. Deras would maintain all waste disposal areas to the satisfaction of the relevant authorities and monitor their environmental impacts. Waste treatment would be carefully designed and managed to limit production of odours. Similarly, noise and dust would be managed to ensure that the levels were below statutory requirements and did not cause nuisance to nearby residents or the workforce.

Deras is also committed to not adversely affecting the livelihood of the local farmers. In particular, Deras has given informed undertakings not to discharge to surface waters and to control the introduction of pests.

Of the $3 million required to establish the tannery, approximately $2 million would be spent on materials and labour in Western Australia. In addition, the tannery would significantly increase the State's hide processing capacity, thereby increasing export potential and downstream employment opportunities.

Chapter One
INTRODUCTION

1.1 THE PROPOSAL

The proposal assessed in this Consultative Environmental Review (CER) is to establish and operate a 'wet-blue' hide tannery within the Shire of West Arthur. The location of the proposed development, some 14 km north-east of the township of Darkan in south-west Western Australia, is shown in Figure 1.1.

1.2 THE PROPONENT

The proponent, Deras (Australia) Pty Ltd (Deras), is a wholly owned subsidiary of Deraswiss Ltd; an organization whose operations are based on purchasing and processing raw hides and skins for trading purposes. Deraswiss Ltd operates tanneries in Kenya, Nigeria and Zimbabwe with a tannery in the Sudan,under construction.

Asea Brown Boveri of Sweden is subcontracting part of its counter-trade obligation to Deras in order to fulfil requirements that it has assumed as a result of a successful tender to supply heavy electrical equipment for the Northern Suburbs Railway extension in metropolitan Perth.

1.3 BACKGROUND

In 1989 Deras investigated the possibility of establishing a tannery near Boyanup in the Shire of Capel, Western Australia. Works Approval was obtained from the Environmental Protection Authority (EPA). However, the capacity of the plant was restricted by environmental constraints and the limited area available for its operations. Consequently, plans to develop the Boyanup site were abandoned.

Details of the current proposal were referred to the EPA in September 1990 for determination of the appropriate level of assessment. The EPA determined that a CER should be prepared, and issued guidelines for its preparation. These guidelines are provided in Appendix A.

1.4 THE PROJECT

The tannery, which would employ 30-35 people, would process hides to the wet-blue stage. Further upgrading of the leather to a finished product may be instituted once full production of wet-blue leather was achieved. Hides would be purchased predominantly from abattoirs in the South-West, and the majority of products would be sold for further processing within the State.

Deras would commence design, construction and operation of the tannery as soon as practicable, if environmental approval were granted, at an initial rate of 100,000 hides a year; increasing to 220,000 during the first 5 years. Construction is expected to take approximately 5-6 months and would include: a receival yard; a parking area; a process building (including a storage shed, offices and a chemical store); a water reservoir; evaporation lagoons; and wastewater and solid waste treatment facilities and disposal areas. Deras would purchase approximately 65 ha (160 acres) of land to accommodate these facilities.

Before a final decision can be made on this proposal, the State Government's environmental approval process requirements must be met. Key steps in this process are shown in Figure 1.2.

The proposed development is to be subject to review by the public and relevant authorities for 4 weeks. A public information day would be held on site approximately half-way through this period. Written queries received from the public or authorities would be collated by the EPA, and Deras would prepare replies.

The EPA would then assess the project and issue an assessment report to the Minister for the Environment (the Minister) incorporating its recommendations as well as answers to questions. This assessment report would be available to the public: the EPA notices in the press on Saturdays would state when it had been released.

If the project were found to be environmentally acceptable, a period would be allowed for public appeals against the finding. Following this, the Minister would issue Ministerial conditions for the proposal. Normally, these would be similar to the commitments made by Deras, but may include additional requirements. Works Approval consent to allow construction would normally be issued at, or shortly after, this time.

An application has been made to the Shire of West Arthur to have the land rezoned for tannery use only, not for other industries. This would include use for waste treatment and disposal of tannery effluent.

1.5 LEGISLATIVE FRAMEWORK

The construction and operation of the proposed tannery would be in accordance with the legislation described as follows.

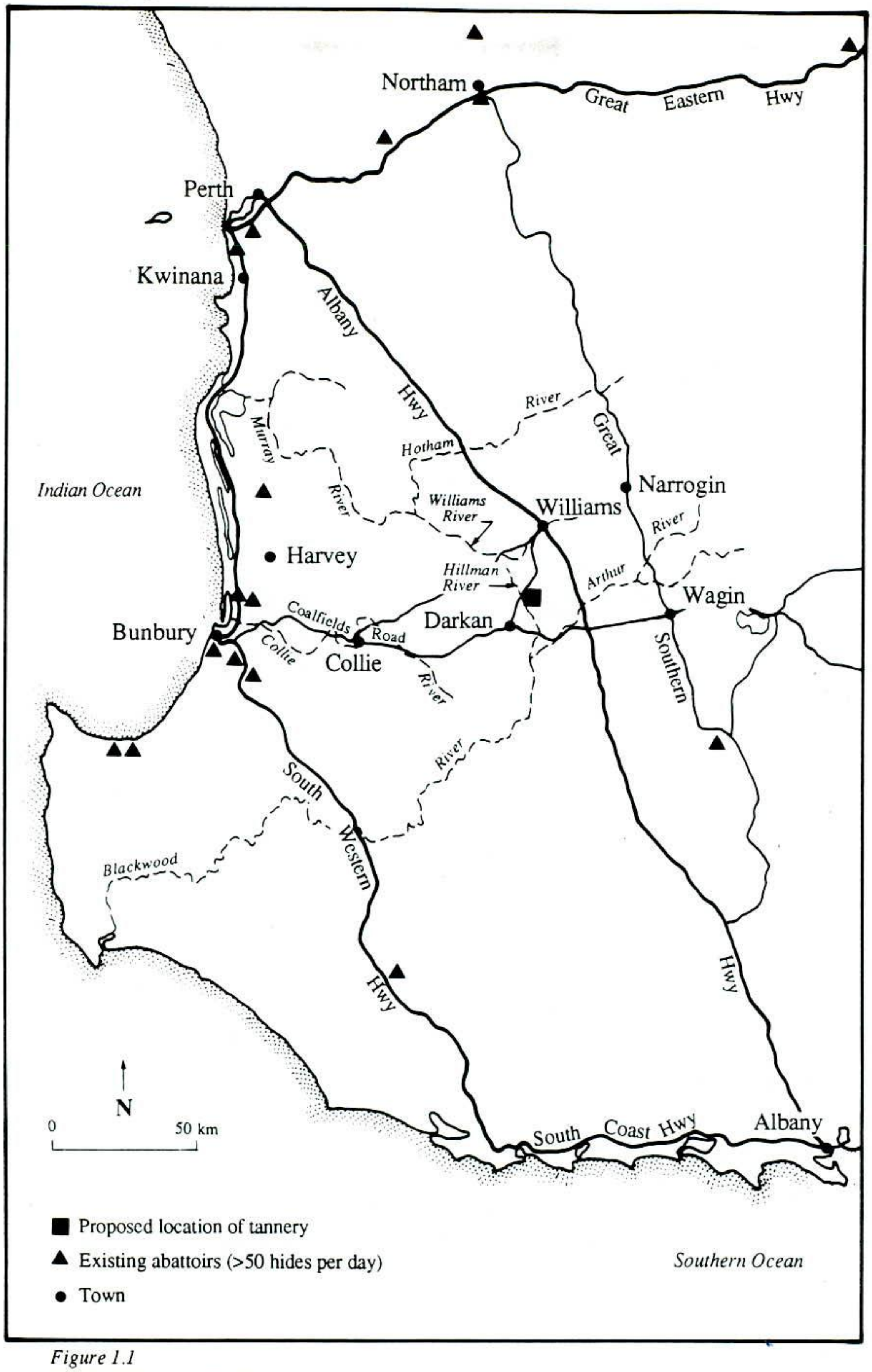


Figure 1.1

REGIONAL MAP

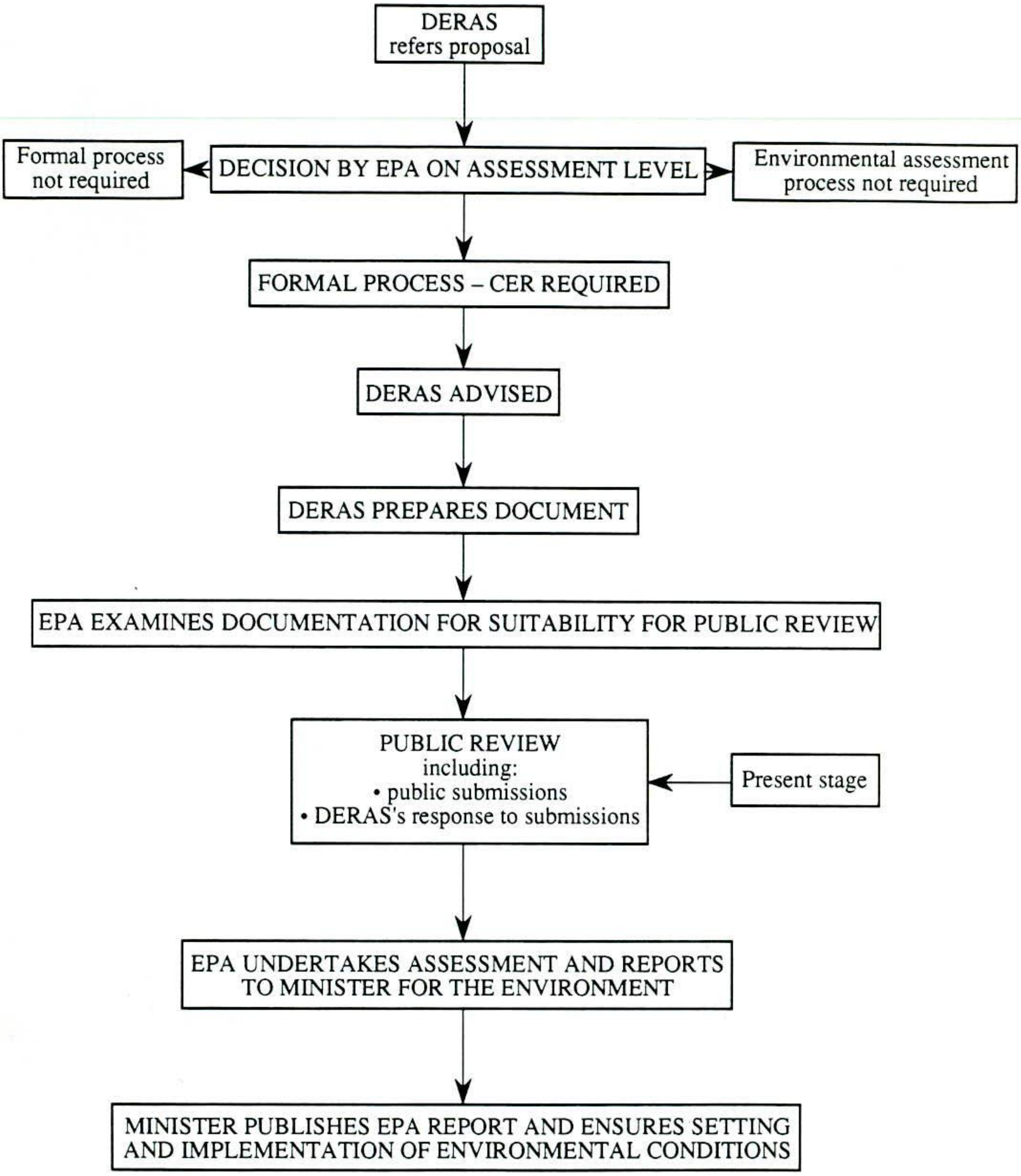


Figure 1.2
ENVIRONMENTAL APPROVAL PROCESS

- The *Environmental Protection Act, 1986*, which is administered by the EPA, requires Deras to prepare a description of the proposed project for evaluation by relevant authorities through the environmental approval process. It also provides for the control, abatement and prevention of discharges into the environment.

- The *Town Planning and Development Act, 1928*, empowers the Shire of West Arthur to control development under the provisions of its Town Planning Scheme and empowers the Department of Planning and Urban Development to control State and regional development.

- The *Occupational Health, Safety and Welfare Act, 1984*, enables the Department of Occupational Health, Safety and Welfare and others to take measures to ensure the good health, safety and welfare of the workforce engaged in construction and operation activities, together with the safety of the general public.

- The *Aboriginal Heritage Act, 1972*, defines Aboriginal sites and provides for the preservation of places and objects customarily used by, or traditionally important to, the Aborigines, as well as prohibiting the concealment, destruction or alteration of any Aboriginal site.

- The *Health Act, 1911*, provides for the preservation of public health and authorizes the Shire of West Arthur to carry out the provisions of the Act and its associated regulations, by-laws and orders. Schedule II of the Health Act defines a large number of industries as 'offensive trades': these include both tanneries and establishments involved in storage of hides.

- The *Agriculture and Related Resources Protection Act, 1976*, in conjunction with the *Agriculture Protection Board Act, 1950*, empowers the Agriculture Protection Board to inspect all hides and take other measures to ensure that declared plants and declared animals are not introduced into the State.

- The *Rights in Water and Irrigation Act, 1914*, establishes that natural waters are vested in the Crown. The Water Authority of Western Australia is the agency that controls waste disposal into waters and extraction of groundwater.

1.6 SCOPE AND STRUCTURE OF THE CER DOCUMENT

The objective of this review document is to provide the public and Government with details of the proposed tannery and an opportunity to make well-informed comments.

This CER presents the following information:

- the need for the proposed project—outlining the benefits that the project could bring to both the local region and the State (Chapter 2);

- the criteria used to assess the respective merits of the nominated sites (Chapter 3);

- a description of the existing physical, biological and social features of the proposed site (Chapter 4);

- the process description (Chapter 5);

- a detailed description of the proposed method for the treatment and disposal of the wastewater and solid waste (Chapter 6);

- an evaluation of the impacts that the project may have on the existing environment during both construction and operational phases, and the proposed programme of environmental management that would be implemented to minimize them (Chapter 7);

- the proposed monitoring programme that would be implemented to monitor the effects of the project on the existing environment (Chapter 8);

- a brief conclusion of the review findings (Chapter 9).

Throughout this document Deras has made a large number of commitments (which are enforceable) to safeguard the environment. These commitments appear in bold type and are compiled in Appendix B for easy reference.

In cases where Deras and the EPA cannot predict the consequences of certain activities, Deras has agreed to prepare 'management plans' detailing how it intends to commission, operate, monitor and evaluate the activities. The management plans would be sent to the EPA for approval and subsequently modified if necessary.

A number of social commitments are also made throughout the text. Although these are not enforceable, they should be seen as part of a genuine desire to justify the confidence that the Shire of West Arthur and the local community have so far shown in Deras.

Local residents have informed Deras and its consultants about their concerns regarding the potential environmental impacts of the project, particularly impacts on agriculture. These concerns are listed in Appendix C and discussed in various sections of the CER.

Deras would adhere to the proposal as assessed by the EPA and would fulfil the commitments listed in Appendix B.

The tannery would be constructed and operated according to the requirements of all relevant government statutes and agencies, and to the satisfaction of the EPA.

Chapter Two

PROJECT BENEFITS

Of the 10 million bovine hides produced annually in Australia, only about 2 million are currently processed; the remainder are exported after preservation. At full production (220,000 hides per annum), the proposed tannery would increase the number of hides processed in Australia by 11%, benefiting the local, State and Commonwealth economies. This production rate is equivalent to approximately one-half of the annual cattle kill in south-west Western Australia.

2.1 SPECIFIC BENEFITS OF IMPLEMENTING THE PROPOSAL

Specific benefits to the abattoir and leather-finishing industries would include:

- availability of processing facilities near the source of hide production;
- availability of a local processor of bovine hides;
- increased availability of wet-blue leather, resulting in employment opportunities from downstream processing.

Benefits to the State and the local community would include:

- a project investment of approximately $3 million, with approximately $2 million of this to be spent on materials and labour in Western Australia;
- increased direct employment opportunities for locals in Darkan and surrounding districts;
- increased indirect employment in the region by creation or expansion of firms providing support services or goods;
- retention and increase of population in the local region due to increased employment opportunities;
- increased likelihood that the local townships would retain existing businesses and government services;

- expansion of the range of secondary industries in Western Australia, both through this project and through the possible future establishment of finished leather production and leather-using industries;
- introduction of large-scale bovine wet-blue tanning technology to the State.

2.2 CONSEQUENCES OF FAILURE TO IMPLEMENT THE PROPOSAL

Western Australia produces approximately 500,000 bovine hides a year, of which approximately 50,000 are tanned locally by Gosh Leather; the balance are exported without being processed, thereby failing to realize their full export potential.

Gosh Leather, the State's only bovine tannery with a wet-blue operation, wishes to expand its leather finishing operations but is unable to do so at its present site. The Company plans to relocate in order to build a major leather retanning, dyeing and finishing tannery, and has made arrangements to have its hides processed through to the wet-blue stage by Deras's tannery, if this were commissioned.

If the tannery were not commissioned, Gosh Leather may be unable to obtain wet-blue hides of sufficient quality to maintain its operations. In this case, it is possible that Gosh Leather would close its existing operations and relocate to Queensland, where it already has a part interest in a finishing tannery. It is also likely that Deras would give up the idea of establishing a tannery in Western Australia, since it would appear that finding a suitable site is extremely costly and difficult. Similarly, other tanners may also be deterred.

The current recession, the fall in the price of wool and uncertain markets for mutton have severely affected the economy of the Shire of West Arthur. Opportunities for employment or establishment of businesses have diminished sharply in recent years. The consequent population loss has led to fears that the school and remaining businesses will close, resulting in further populations losses. The Shire of West Arthur is hopeful this trend can be halted or reversed by the establishment of an industry that would provide steady employment on a different business cycle to that of the wool industry. Failure to implement this proposal would leave the Shire of West Arthur with the task of finding another enterprise willing to locate into the area.

Chapter Three
SITE EVALUATION

3.1 SITE SELECTION CRITERIA

Submissions from shires interested in having a tannery in their region were solicited by the Department of State Development, following abandonment of plans to develop a tannery near Boyanup. The following criteria were used to assess the respective merits of the nominated sites.

3.1.1 DISTANCE TO SOURCE OF SUPPLY AND MARKETS

Potential major suppliers of cattle hides are located in the South-West. A site within reasonable proximity to these suppliers would minimize travelling distances and hence transport costs. Similarly the facility should ideally be within reasonable distance of potential local markets or ports.

3.1.2 WORKFORCE

At full production, the tannery workforce is expected to comprise approximately 30-35 people. To reduce travelling times for workers, the site should ideally be reasonably close to towns that have surplus rental accommodation.

3.1.3 WASTE DISPOSAL

Waste disposal from many agricultural processing industries requires the availability of a considerable area of land. It is sensible to locate such industries in rural areas or smaller towns to reduce costs; this has the added bonus of diversifying the local economy.

3.1.4 ACCEPTANCE BY THE COMMUNITY

Areas where there was poor public acceptance of a tannery were not considered.

3.2 ADVANTAGES OF THE PROPOSED SITE

The proposed site has many features that make it suitable for tannery development:

- a nearby water supply of suitable quantity and quality;
- sufficient land for waste disposal;

- sufficient surrounding rural land to act as a buffer to the nearest residences;
- close to suppliers and potential markets;
- suitable transport routes available;
- labour and rental accommodation available nearby;
- the land is well-drained and above flood levels, with a sufficient area of level land for easy construction of buildings and other facilities;
- a mixture of suitable soils is available for the construction of proposed waste disposal systems;
- the surrounding land does not have a high conservation value: the majority of it has been cleared and farmed for many years;
- both the Shire of West Arthur and local residents are generally supportive of the development.

3.3 ALTERNATIVE SITES

Prospective sites in the Northam and Harvey Shires as well as another in the Shire of West Arthur also met the selection criteria. However, once additional zoning and commercial constraints were considered, the proposed site appeared to be the most suitable.

The disadvantages of the other sites were as follows:

- ***Northam***: The site was small, divided by the railway line, and close to a number of residences.
- ***Harvey***: The site was eliminated because of rumours of poor public acceptance.
- ***West Arthur***: Another site about 3 km north-west of Darkan on the Quindanning Road was considered. This site was just on the border of the Wellington catchment. The major problem was the lack of a water supply. A dam would have been necessary, and water supply prospects in dry years would still have been uncertain.

Chapter Four

EXISTING ENVIRONMENT

The proposed development site (hereafter referred to as the site) is within an area of the Shire of West Arthur that has been cleared for farming. Deras intends to buy approximately 65 ha of land in this area—20 ha of the north-west corner of Crown Grant (CG) 13158 and approximately 45 ha of the south-west corner of CG 12898 (Figure 4.1). The tannery buildings and wastewater treatment lagoons would be located on a ridge that runs along the common boundary of these two pieces of land. This Chapter describes the physical features of the site and the biological and social features of the surrounding areas.

4.1 PHYSICAL ENVIRONMENT

4.1.1 CLIMATE

Darkan has a temperate, mediterranean climate with cool, wet winters and hot, dry summers. Specific data relevant to an understanding of impacts on or from the proposed development are shown in this Section. Where no data exist, climatic conditions at Darkan have been estimated by using data from the closest Bureau of Meteorology stations: Wagin, 75 km to the east; Narrogin, 67 km to the north-east; and Collie, 72 km to the west.

Air temperatures

Average monthly maximum and minimum temperatures at Wagin, Collie and Narrogin are presented in Table 4.1. Because of its location between these towns (Figure 1.1), it is assumed that Darkan has a similar climate, with an average maximum temperature of 31°C in summer and an average minimum temperature of 5°C in winter.

Water temperatures

Water temperatures are known for a reservoir at the Boddington gold mine (Kinhill 1990). Naturally, water temperatures vary with season, location on the reservoir, and depth. Some of these data are shown in Table 4.2. Temperatures of various surface waters near the site were recorded in mid-September 1990. Small streams had daytime temperatures in the 15-18.5°C range.

Table 4.1 **Average monthly air temperatures in the region (°C)**

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Wagin:												
Max.	31	30	28	23	19	16	15	16	18	21	25	29
Min.	14	15	13	10	8	6	6	5	6	7	10	13
Collie:												
Max.	32	31	28	22	19	16	16	16	18	21	25	29
Min.	14	14	12	9	7	6	5	5	6	8	10	13
Narrogin:												
Max.	31	30	27	23	18	15	14	15	18	21	26	29
Min.	14	14	12	10	8	5	5	5	6	7	9	12

Source: Bureau of Meteorology.

Table 4.2 **Water temperatures in Boddington reservoir**

Date	Depth of readings (m)	Depth of water (m)	Temperature (°C)
29 March 1988	0	1.6	22.1
	1.5		21.4
7 July 1988	0	7.5	13.8
	2.0		14.2
11 October 1988	0	10	12.9
	2.0		12.8
7 February 1989	0	8	21.4
	2.0		20.9

– no measurement taken.

Source: Kinhill, 1990.

Rainfall

Rainfall data for Darkan and nearby towns are presented in Table 4.3. The average annual rainfall at Darkan is 564 mm (based on 62 years of records). Rainfall occurs mainly in the winter, with some 81% occurring from May to October.

Figure 4.1
ENVIRONS OF TANNERY SITE

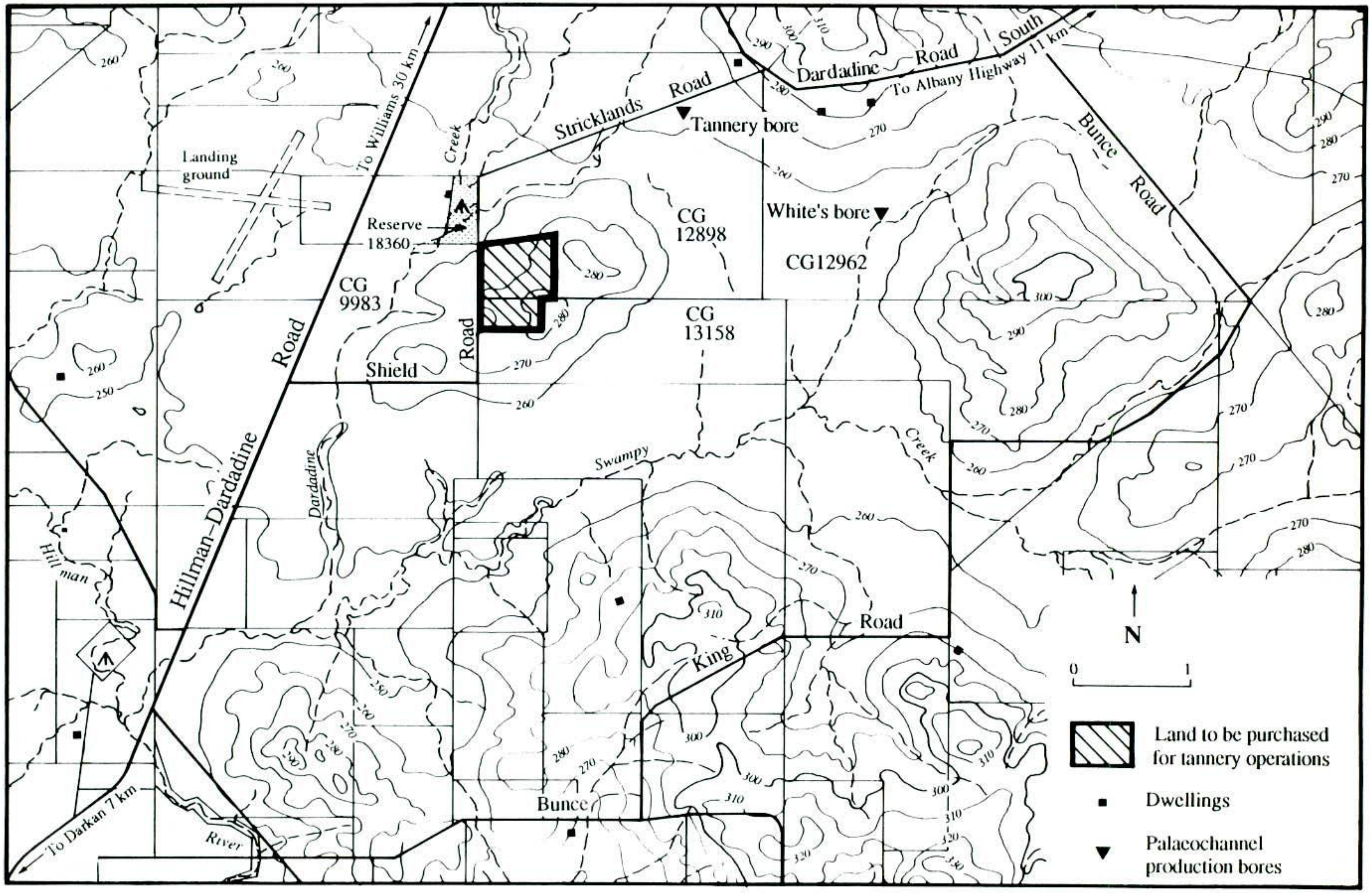


Table 4.3 **Average monthly and annual rainfall totals (mm)**

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Darkan	12	15	17	32	74	106	103	82	54	39	20	10	564
Collie	13	14	25	50	133	193	191	147	103	71	29	16	985
Narrogin	10	16	22	30	64	91	92	70	47	33	14	12	500
Wagin	10	15	21	30	57	77	74	57	42	30	13	12	436
Williams	8	12	18	30	72	103	102	81	53	36	17	13	546

Source: Bureau of Meteorology.

Winter rainfall is regular and consistent, and flooding is uncommon. Flooding in summer (associated with intense storms) has occurred in the region, and water levels along drainage channels have been recorded up to 5 m above normal.

At Narrogin (where the average annual rainfall is 500 mm, and there are an average of 98 wet days per year), the most rain recorded in any one day was 115 mm during a summer storm. The maximum daily rainfall recorded in winter was 81 mm.

Evaporation

The Department of Agriculture (I. Laing, pers. comm., 1990) advises that evaporation rates at Darkan are likely to be 90% of those measured at Narrogin (refer to Table 4.4). On this basis, the annual Class A Pan evaporation at Darkan is estimated to be 1,705 mm.

Table 4.4 **Estimated evaporation at Darkan (mm)**

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	**Total**
Class A pan	283	231	195	113	73	45	46	58	89	129	186	257	**1,705**
Lake	212	173	146	85	55	34	34	44	67	97	140	192	**1,279**
Net water loss from lake	200	158	129	53	−19	−72	−69	−38	13	58	120	182	**715**

Class A Pan from data for Narrogin (Luke, Burke and O'Brien 1988) multiplied by 0.90
Lake data is Class A Pan multiplied by 0.75
Net water loss is lake evaporation minus rainfall.

Wind

Surface wind data for the site are not documented; however, they would be similar to those of Collie and Wagin, which are presented in Figure 4.2. These patterns suggest

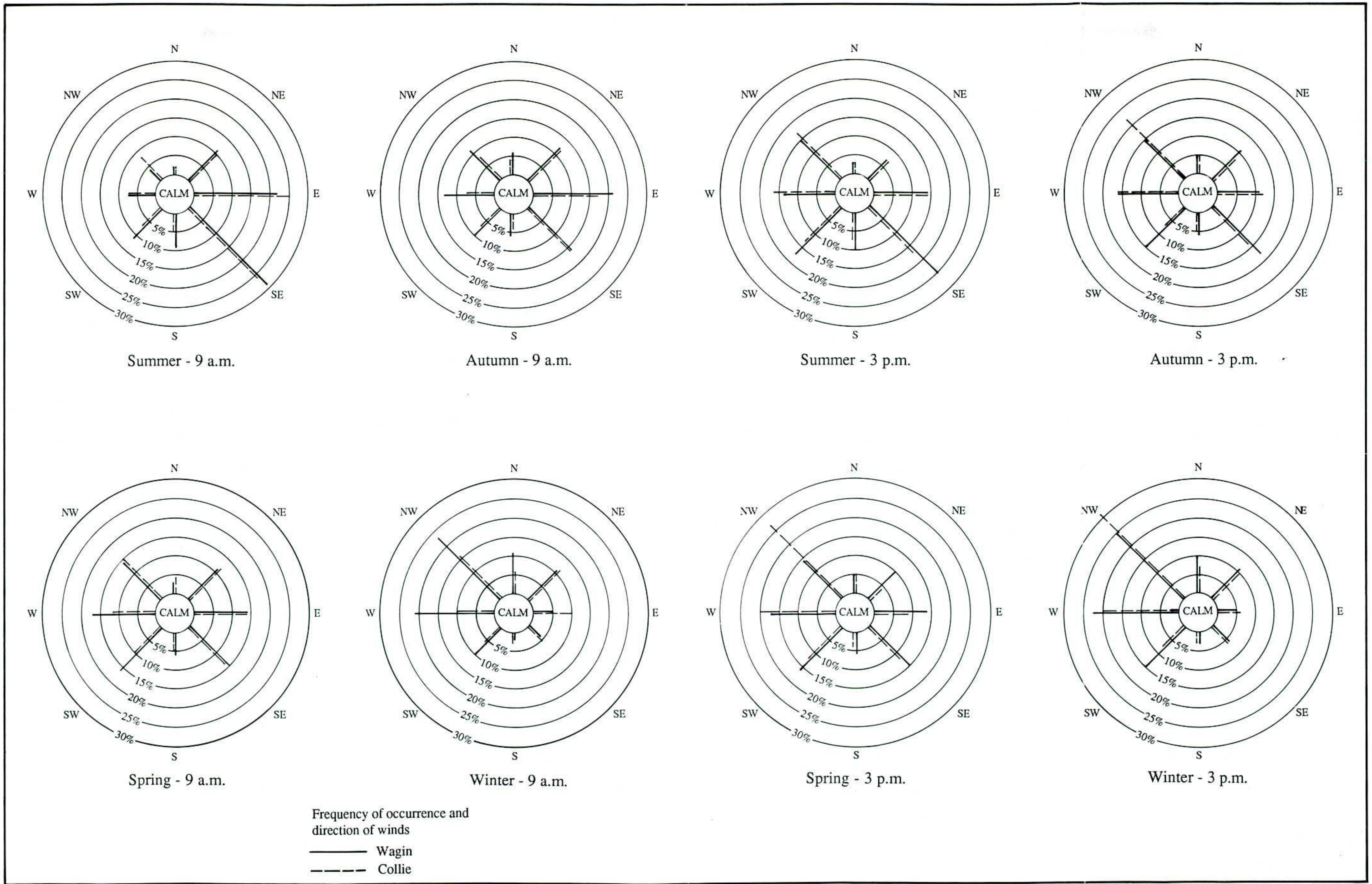


Figure 4.2
SEASONAL WIND ROSES FOR COLLIE AND WAGIN

that the winds in the summer months are generally light to moderate from the south-east in the morning, and from the west to north-west in the afternoon, with occasional strong northerly winds.

The winter winds are generally light and from the north-west in the morning, strengthening to moderate in the afternoon. Westerly gales are associated with the passage of cold fronts.

4.1.2 GEOLOGY AND GEOMORPHOLOGY

The site is located on the Archean Yilgarn Craton. The Yilgarn Craton is a granite, gniess, migmatite and greenstone terrain that forms much of the southern half of the State. The western margin of the craton is the Darling Scarp, which is the eroded margin of the Darling Plateau and the surface expression of the Darling Fault.

The landforms that can be seen today resulted from the dissection of an ancient eroded plain (a peneplain). This peneplain, known as the Great Plateau of Western Australia, was extensively reworked during the Tertiary Age. Further dissection is currently occurring. The result of this activity in the Darkan area is the formation of hills topped with hard laterite (lateritic duricrust), often with a steep fall away, and valleys containing younger laterite zones. This area, which is distinct in appearance from neighbouring areas, is called the Bannister Upland Unit (Beard 1981).

Rivers that originate in this Unit flow to the south-west coast. The river valleys that formed during the Tertiary Age are now full of broad tracts of sand (alluvium and colluvium). A small Tertiary basin (the Dardadine[1] sub-basin) lies to the west of the site. Both this basin and the valleys (palaeochannels) are aquifers, which compose the palaeosystem (ancient structure containing water) referred to later in the document.

The area is unlikely to suffer major earthquake damage. There is a 10% probability of an earthquake of magnitude VI occurring in the area within 50 years (Gaull and Michael-Leiba 1987). Such an earthquake would cause major damage to buildings near the epicentre, but serious damage to well-constructed lagoons is not expected (Goldman et al. 1990).

4.1.3 TOPOGRAPHY

The tannery site is located on the north-west flank of a low ridge between the Dardadine and Swampy Creeks. This ridge is approximately 2.5 km long and 1.5 km wide, and is up to 25 m in elevation above the adjacent flat valley floors. Elevations range from 260-280 m Australian Height Datum in the south-east corner of the site. The land in CG 12898 slopes diagonally (at about 2%) from the south-east to north-west corners. The land in CG 13158 forms a gully sloping westwards. Elevation contours are included in Figure 4.1.

---

[1] *While there are apparently two other spellings for this location—Daradine and Daderdine (Series R712 Sheet 2231-II Edition LAWA)—'Dardadine' is used throughout this review.*

As shown on Figure 4.3, the site drains in three directions. The majority of the land in CG 12898 drains to the north-west, flowing via a depression and an unnamed tributary to the Dardadine Creek. A small area of the central-east portion of the site drains to the east through a saddle, and then to Swampy Creek. The land to be purchased from CG 13158 drains to the west-north-west.

4.1.4 STRATIGRAPHY AND SOILS

The stratigraphy of the area is made up of an upper laterite layer overlying fine-textured kaolinitic clays, which in turn overlie a crystalline granitic basement. The upper laterite layer formed as a result of silica leaching from the upper layers of clay. This laterite has formed a hard crust (lateritic duricrust), which has subsequently been broken and remains primarily on the hilltops.

The clays have developed to a depth of many metres. At the site, the depth of clay over granite is variable: granite outcrops (zero depth) are visible at the surface at the northern part of the site, while clay up to 20 m deep has been found on the ridge between CG 13158 and CG 12898. The fine-textured clay has a very low intrinsic permeability to water. In the field however, this permeability is greatly increased owing to the presence of biopores (old root holes or insect burrows).

The silica leached from the upper layers has formed silicified zones to a depth of a few metres in many areas. This matter, though essentially impermeable, is not continuous. Boulders of this material, excavated during construction of farm dams, can be seen in the area.

The majority of the site is covered with a layer of gravelly, sandy or silty topsoil, which varies in depth between 1 m and more than 8 m; the latter is in the centre of the drainage channel on the northern half of the site. Results of an investigation of surface soil distribution and infiltration rates both on and nearby the proposed site are shown in Figure 4.3 and reported in Appendix D. Water infiltrates into superficial sands and gravels during all but the heaviest rainfall events.

Large quantities of salt are stored in the clay in this region. Published information from an area which is slightly drier than Darkan, 30-50 km north-east of Williams, shows soluble salt levels of up to 1,500 t/ha (Johnston and McArthur 1981). Similar quantities were detected in cores from the Williams River and Bakers Hill areas (Dimmock, Bettenay, and Mulcahy 1974). This quantity is thought to be a minimum estimate of the amount stored at the site (R. George, Dept. of Agriculture, pers. comm., 1990). The majority of the salt is likely to be found deep in the profile.

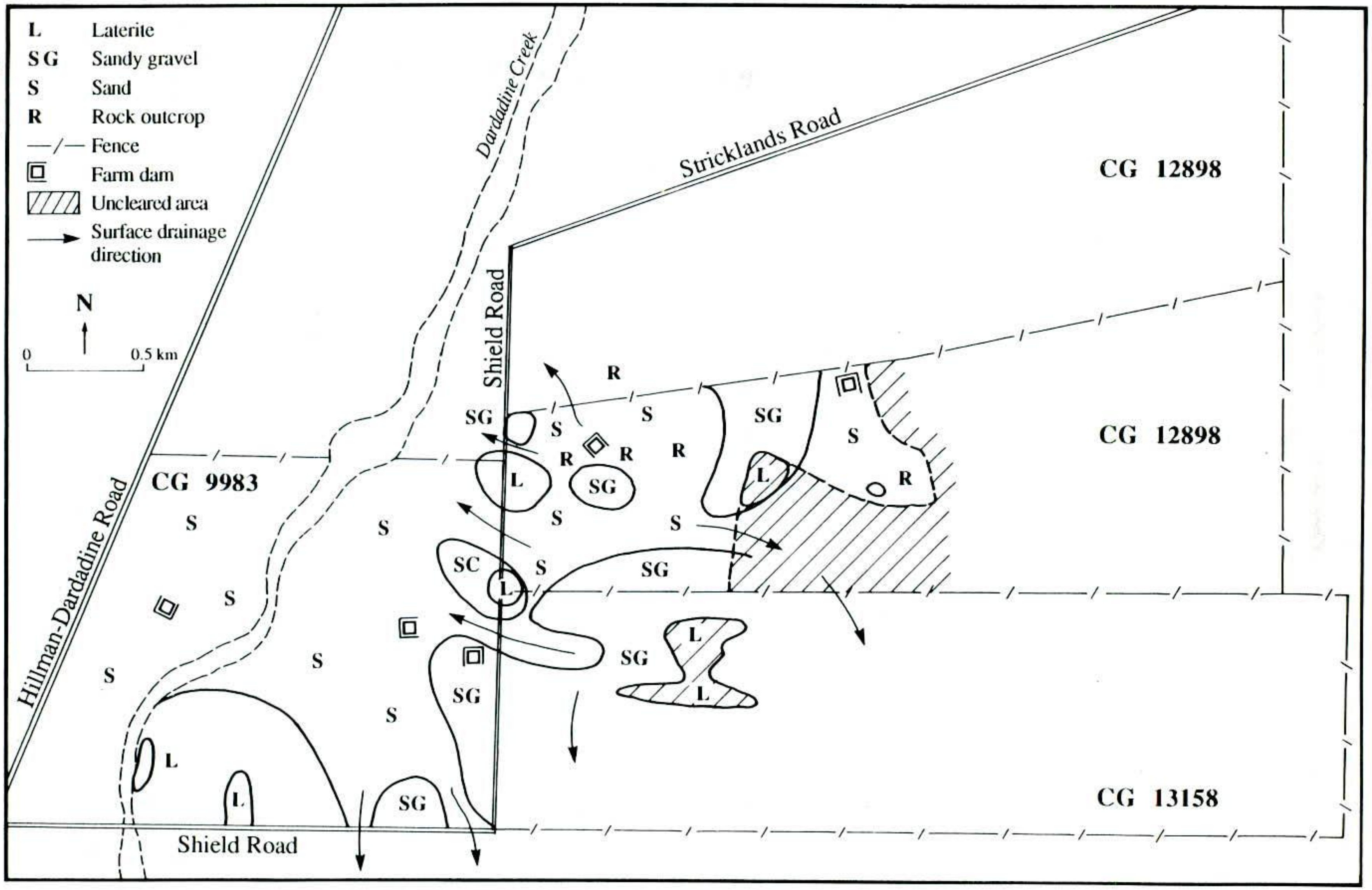
Salt is still being precipitated over the area, mostly in rainfall but also in dry form. In either case, the origin of the salt primarily is from ocean spray. Interpolation into published information (Hingston and Gailitis 1976) suggests that the Darkan area annually receives about 40 kg (of sea-salt) on each hectare.

Figure 4.3

SOIL DISTRIBUTION AND DRAINAGE DIRECTIONS

Source: Rockwater Pty Ltd 1990

Note: Compare Appendix D



4.1.5 HYDROLOGY AND SURFACE WATER QUALITY

The rivers and creeks in the area are seasonal, flowing in clearly incised courses during the winter but drying to brackish pools in early summer. Since the forest was cleared to allow farming, water tables generally have risen. This has mobilized the salt stored lower in the profiles, leading to an increase in surface water salinities.

Calculations of the behaviour of water on the site have been undertaken and are reported in Appendix E. Points pertinent to the present description, from Appendices D and E, are summarized below.

- The infiltration rates of the surface soils are in the range of 12-60 m/day (8.4-42 millimetres per minute). Runoff over the surface of the soil will not occur unless unusual circumstances prevail: the rainfall intensity is greater than the infiltration rate, or the infiltration is lowered by water-repellent coatings on the sand particles or by air trapped in the soil. These situations are only likely to occur during summer. Waterlogging, where the sand layer is saturated with water, is unlikely to occur on this site (although it is possible that a dyke in the extreme north-west corner of the site is impeding drainage).

- During winter, a perched aquifer develops in the sand layer above the clay. The water in this aquifer moves downslope, eventually reaching streams and forming a major part of the streamflow.

- When a perched aquifer is present, rapid infiltration into the clay can occur by preferred paths, notably biopores.

- Maximum water storage is 0.169 m in August, compared to the 0.4 m required to saturate the sand layer.

The site drains to the Dardadine Creek by two drainage lines (Section 4.1.3). The Dardadine Creek is a winter-wet stream with a generally low volumetric flow rate. However, the catchment area upstream of the site is substantial (approximately 300 km^2); as a result, heavy storms can cause a large increase in the quantity of water carried by the Creek. Observations of debris in trees along the embankments of the Creek show that flooding to 2-4 m above the stream bed has occurred. Dardadine Creek joins Swampy Creek 3.5 km downstream from the site, the Hillman River a further kilometre south-west, and eventually reaches the ocean via the Arthur and Blackwood Rivers.

Test drilling, near the site, has shown that the bed of the Dardadine Creek is considerably above the granite basement. A bore sunk near the Creek (Appendix F) was abandoned at 8 m without reaching the granite surface. This means that groundwater flowing above the granite surface does not recharge Dardadine Creek.

Water in Dardadine Creek (adjacent to the site) in mid-September 1990 had an electrical conductivity equivalent to a dissolved salts concentration of approximately 4,800 mg/L.

Another sample taken a month later was more concentrated. At this time, the Hillman River had a salinity of 6,000 mg/L. Analytical results for these later samples are shown in Table 4.5.

Table 4.5 **Surface water quality**

Parameter	Concentration	
	Dardadine Creek near Reserve 18360	Hillman River near 'Glen-Devon' property
pH	7.9	7.6
Electrical conductivity (25°C)	1,080	970
Total dissolved solids (180°C)	6,850	5,950
Sodium	2,000	1,750
Potassium	7.1	4.2
Magnesium	460	465
Calcium	140	175
Chloride	4,350	3,850
Sulphate	170	125
Bicarbonate	185	95
Nitrate	<0.2	<0.2

In mg/L, except conductivity (mS/m) and pH.
Note: Samples collected in October 1990.

These concentrations are tolerable for sheep, although both the salinity and the sum of magnesium and sulphate concentrations are approaching levels that would cause concern (Hart 1974). It is expected that concentrations would increase during the spring and summer.

Farm water supplies are collected predominantly :

- from roofs for potable water supplies;
- in dams, from surface runoff and interflow along the clay–sand interface. Many farmers construct small dykes to channel runoff to the dams. This water is used for stock-watering and non-potable household uses;
- from rivers for stock-watering despite its low quality.

A number of reserves for water and camping are scattered throughout this area. Information collected during preparation of this review shows that water in the reserve immediately to the north-west of the site is no longer potable.

4.1.6 GROUNDWATER

Groundwater resources over much of the Yilgarn Craton are not plentiful, productive, or of high quality. During the course of the groundwater investigations (Appendix G) drilling to the granite produced some groundwater (at the clay–granite interface) but the salinity was rather high: approximately 9,000 mg/L. The surface of the granite basement is usually eroded and water may move downslope relatively rapidly.

The presence of a palaeochannel aquifer, inferred from the volume and quality of water pumped from a bore (Figure 4.1) on Mr G. White's land (CG 12962) and from other information, has been confirmed by recent hydrological testing (Appendix G.2). This particular channel appears to extend at least 20 km from the Albany Highway to a palaeobasin a few kilometres to the west of the site (Figure 4.4). A production bore has been sunk, and testing shows that a yield of up to 500 m^3/day is possible. Mr White's bore is said to have been pumped at a rate of 400 m^3/day for more than a year in an attempt to dewater low-lying land. The tannery would use water from bore DT2P (Figure 4.4). With an estimated length of 20 km, a width of 500 m and a depth of 45 m, the palaeochannel may hold up to 30×10^6 m^3 of fresh water. Potential recharge has been estimated as 1.5×10^6 m^3/a (Appendix G.3): the tannery would require about $6 \times 10^4 m^3/a$.

There is evidence of the existence of other palaeochannels in the area but only a few have been developed for farm water supplies (L. Kevi, Geological Survey of Western Australia, pers. comm., 1990). The presence of pools or marshes in the region (with relatively low salinities) may result from collection of seepage at low-lying points.

The quality of water in the palaeochannel varies, but one sample taken towards the end of the production testing had a dissolved salts concentration of 440 mg/L (Appendix G.2). Samples from the bore on Mr White's property had a dissolved salts concentration in the range of 750-850 mg/L. These concentrations are suitable both for human consumption and for tannery use.

Results of chemical analysis show that the water in the palaeochannel is suitable for beamhouse and tanyard operations (Table 4.6). The sulphate concentration (52 mg/L) is slightly greater than optimal. The rather low pH (5.35) is presumably a result of a high free carbon dioxide and hydrogen sulphide content (the former is inferred, the latter was detectable by smell). A particularly desirable feature is the low bicarbonate hardness, which is associated with the low pH.

Figure 4.4

INFERRED PALAEOSYSTEM

Source: Rockwater Pty Ltd 1990

Note: Compare Appendix E

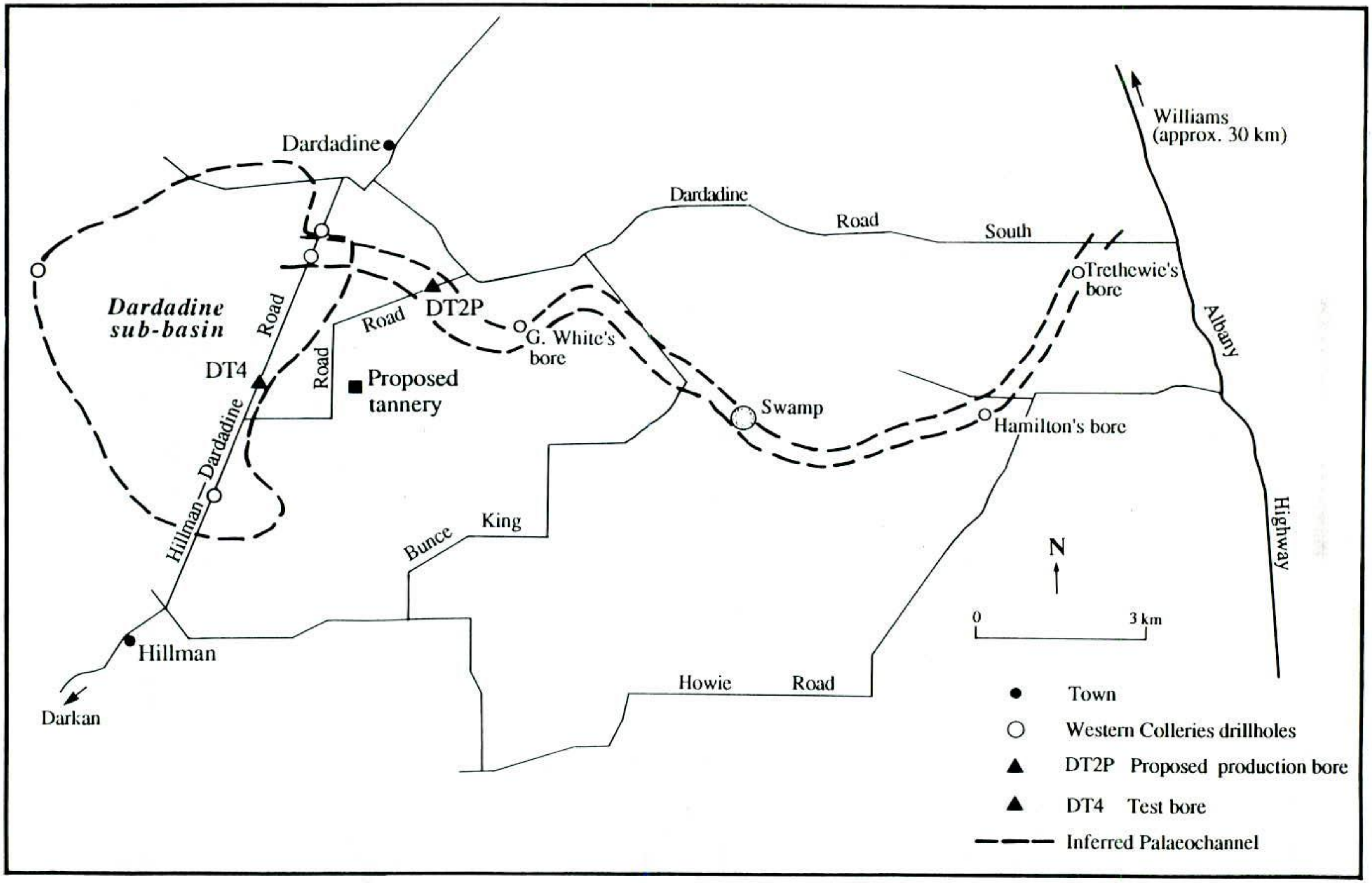


Table 4.6 **Water quality in the palaeochannel**

Parameter	Concentration
pH	5.35
Dissolved solids	444
Sodium	123
Potassium	4
Magnesium	18
Calcium	7
Iron (total)	1.5
Chloride	215
Sulphate	52
Bicarbonate	12
Nitrate	11

In mg/L, except pH.
Note: Dissolved solids estimated from analysis. From conductance, dissolved salts is estimated as 438 mg/L.

The quality of water in the palaeobasin to the west of the site is not known with certainty. Water from a bore north-west of the site formerly used for piggery purposes is said to have been brackish (dissolved salts of 2,000-3,000 mg/L). Bore DT4, which may have intersected the basin, yielded water with a conductivity equivalent to 3,700 mg/L. It is possible that a proportion of the water that recharges the basin around these bores may come from the Dardadine Creek (Appendix F). This may partly explain the greater salinity.

4.2 BIOLOGICAL ENVIRONMENT

4.2.1 VEGETATION

The vegetation in the Darkan area has characteristics of both the jarrah forest and the Wheatbelt (Beard 1981). The main large trees are eucalypts including wandoo *(Eucalyptus wandoo)*, marri *(E. calophylla)*, jarrah *(E. marginata)* and brown mallet *(E. astringens)*. York gums *(E. loxophleba)* and river gums *(E. camaldulensis)* line the creeks. Thickets of jam trees (*Acacia acuminata*) and other acacia species; sheoaks, including *Casuarina fraseriana*; paperbarks including *Melaleuca uncinata*; and other smaller shrubs would have formed the original understorey.

The area has been almost entirely cleared to allow establishment of pasture. Uncleared areas are found only on hilltops, near outcrops and along roadsides. Selective felling of remaining large trees for firewood and elimination of understorey species by grazing has occurred.

The pasture species are mixtures of annual grasses and clover, of which the following are likely to predominate:

- subterranean clover *(Trifolium subterraneum)*
- annual rye grass *(Lolium rigidum)*
- winter grass *(Poa annua)*, and other *Poa* species.

These species die off in late spring/early summer and regenerate each autumn from seeds stored on or in the topsoil. A survey of weed species is to be carried out during the growing season in 1991: in September 1990 the introduced geophyte *Romulea sp.* *(rosea?)* was observed to be widespread on site and on neighbouring properties. Cape weed (*Arctotheca calendula*) is also common, along with other weeds.

4.2.2 FAUNA

There has been no specific survey of the native fauna found in this area. Some of the original fauna found in the wandoo woodlands (Department of Conservation and Land Management 1987) that are still likely to be resident include:

- western grey kangaroo (*Macropus fuliginosus*)
- western brush wallaby (*Macropus irma*)
- common brush-tail possum (*Trichosurus vulpecula*)
- common ringtail possum (*Pseudocheirus peregrinus*)
- short-nosed bandicoot (*Isoodon obesulus*)
- mardo (*Antichinus lavipes*)
- dugite (*Pseudonaja affinis affinis*)
- emu (*Dromaius novaehollandiae*)
- purple-crowned lorikeet (*Glossopsitta porphyrocephala*)
- western rosella (*Platycercus icterotis*)
- Port Lincoln ringneck (*Barnardius zonarius*)
- golden whistler (*Pachycephala pectoralis*)
- grey fantail (*Rhipidura fuliginosa*)
- red wattlebird (*Anthochaera carunculata*)
- brown goshawk (*Accipiter fasciatus*)
- wedge-tailed eagle (*Aquila audax*).

The presence of the western grey kangaroo, western rosella and the rabbit (*Oryctolagus cuniculus*) is apparent in the area. However, the clearing of native vegetation that has taken place is expected to have reduced the population density and diversity of most of the original fauna. Species such as waterfowl, which are indifferent to the particular ecological environment, have populated suitable niches in the altered environment.

A regional survey of the river fauna indicates that various salt-tolerant species are common in the area (Hodgkin 1978). These include koonak (*Cherax plebjus*), shrimp (*Palaemonetes australis*), various native fish and the introduced redfin perch (*Perca fluviatilis*). Various zooplankton, including copepods and a variety of insects, are also found in the upper reaches of the Blackwood River system.

4.3 SOCIAL FEATURES

4.3.1 REGIONAL SETTING

The site lies in the south-west corner of the central-south region of Western Australia. This region extends from the Darling Scarp in the west, to the eastern part of the Wheatbelt. The closest towns to the site are Darkan, 14 km to the south-west, and Williams, 36 km to the north. Both towns have well-established service infrastructures including emergency services, schools and retail outlets. The town of Narrogin, 67 km to the north-east, is the commercial and administrative centre of the central-south region and has a significant manufacturing and service infrastructure. Wagin, 75 km to the east, the second largest town in the central-south region, has agricultural machinery, engineering and stockfeed operations. The town of Collie, 72 km to the west, is a well-established coal mining and power generating centre with a significant service infrastructure (Table 4.7).

Table 4.7 **Regional towns and shires**

	Distance from Perth (km)	No. of residents (1986 census)	Distance from Darkan (km)
Collie	215	9,674	59
Wagin	227	2,206	61
West Arthur	204	1,118	0
Narrogin	193	5,723 (Shire)	72
Williams	161	1,146 (Shire)	41

Source: Department of Regional Development and the North West.

The economy of the central-south region is based on agriculture. In 1986, some 73% of the total land area of the Shire of West Arthur was taken up by farms (Department of Regional Development and the North West 1988). Approximately half of the workforce is directly involved in the agricultural industry, and a large proportion of the remaining workforce supplies goods or services to the agricultural sector.

As in most agriculturally based regional economies, the area has experienced a recession in recent years. There was a 14% decrease in the population of the Shire of West Arthur, between 1981 to 1986 (Department of Regional Development and the North West 1988). Two of the three manufacturing firms in the Shire in 1981 had ceased operating by 1986. The recent closure of the Narrogin–Collie railway reduced the employment opportunities in the district and produced a surplus of rental accommodation. In comparison, the population of Collie, which has a mining-based economy, increased by approximately 3% in the same period.

The proposed tannery would widen the economic base for the district by providing a significant manufacturing operation in the region. Increased employment opportunities would become available to the local community, helping to reduce the population drift from the region and attracting new residents to the Shire.

4.3.2 ZONING AND LAND USE

The proposed tannery site is currently zoned rural under the Shire of West Arthur Town Planning Scheme. An application would be made for rezoning to special use, for tannery operations only. It is likely that most of the site would continue to be farmed under agreements with the present owners.

Nearly all of the land around this site is privately owned. Land is predominantly used for grazing sheep (for wool production), with some grain production. The closest dwelling, which occupies a site used for pig raising, is 1 km north-west of the tannery site (Figure 4.1): this house is not currently occupied. Another group of dwellings to the north-east are over 3 km away, and houses in other directions are even more distant. There are 11 private dwellings within 5 km of the site.

The closest reserve (No. 18360/14066, for water and camping) is approximately 1 km north-west of the site proposed for the tannery buildings. This 14.27 ha reserve is adjacent to the north-west boundary of the land to be purchased, and borders Dardadine Creek and Shield Road (alternatively, Shields Road): it has been severely degraded by grazing of stock. The nearest areas of relatively undisturbed natural vegetation are found in the Hillman Nature Reserve (No. 16904) and at the designated site for the Hillman township. These areas are about 8 km south-west of the site.

A light plane landing strip is located approximately 2 km to the west of the site. This is used by the Hillman Farm Skydivers Inc. Club.

4.3.3 TRANSPORT SERVICES AND ACCESS

The area is well served by roads. The most direct route suitable for public transport from Perth is south along the Albany Highway (route No. 30), north-south along the Williams–Darkan Road and then east along Dardadine Road West. Coalfields Road (route No. 107) is a major transport road to and from Bunbury, to which the Hillman–Dardadine Road connects. Access to the site from the Hillman–Dardadine Road is provided by Shield Road. The Hillman–Dardadine Road is an unsealed well-formed road used for district traffic (40 movements per day) and forms part of the school bus route. Shield Road is not an all-weather road and is used for local traffic only: it would require considerable upgrading in order to be suitable for heavy vehicles.

Deras would continue its discussions with the Shire of West Arthur and the Main Roads Department to ensure that the roads would be suitably upgraded for the increased traffic loads. General goods are mainly transported by a number of private road transport companies. These companies have the vehicles and capacity to transport most goods to and from the tannery and would be used where possible. Deras would do its best to arrange delivery and removal of goods when the school bus was not in operation.

There are regular bus services along the Albany Highway. The Narrogin–Collie railway line, currently disused, passes close to the site parallel and adjacent to the Hillman–Dardadine Road. Bunbury and Kwinana have excellent port facilities for export of products and import of supplies.

4.3.4 ELECTRICITY AND GAS

Electricity would be supplied from the interconnected grid system of the State Energy Commission of Western Australia (SECWA). A three-phased supply would be required for the project. As this is not available near the site, SECWA would extend the transmission line from Darkan to the site. SECWA would submit details of the route of the proposed transmission line to the EPA for separate environmental assessment. A number of farmers who live between Darkan and the site have expressed interest in using power from this line.

Deras would do its best to plan (in conjunction with SECWA) the route of the transmission line so that farmers who wish to use power could connect to it easily, and those who do not wish to have the line on their property would not be inconvenienced.

There is currently no gas reticulation system in the region. If gas were required for heating water, it would be supplied, stored and used in an approved manner. Since only warm water is needed, solar heating supplemented by electrical heating may be adequate. This would be investigated at the design stage of development.

4.3.5 WATER SUPPLY

There is no public water supply near the site. The Great Southern Towns Water Supply Scheme pipeline passes approximately 30 km north of the site. Construction of a spur to the site would be very expensive and is considered undesirable by the Water Authority of Western Australia.

As described in Section 4.1.6, an aquifer in a palaeochannel close to the site has been investigated. These studies have indicated that the aquifer would provide a water supply of adequate volume and quality.

4.3.6 SOCIAL INFRASTRUCTURE

The region offers a wide range of services, including education, health and recreation. The reduction in population in the region has led to many of these services being under-utilized. The extra employment generated both directly and indirectly by the proposed tannery would contribute to the viability of many services, particularly that of the District High School and also community groups at Darkan.

Deras would do its best to employ local construction and operational staff. Similarly, Deras would obtain plant, materials and services from the district or the south-west and central-south regions, where available.

4.3.7 EUROPEAN HERITAGE

The area was originally settled in the 1830s near Williams, as links were established between the settlements on the Swan and Avon Rivers and Albany. Pastoralism and agriculture gradually increased in the region, particularly with the advent of railways in the 1880s. The Darkan area was opened as agricultural land in 1894, and the township of Darkan was gazetted in 1906.

Although there are many sites of natural and human interest throughout the region, no sites near the proposed tannery are on the register of the National Estate.

4.3.8 ABORIGINAL HERITAGE

The Department of Aboriginal Sites of the Western Australian Museum was contacted to establish whether any significant Aboriginal sites were registered in the area. The Department advised that although it had no knowledge of any such sites, the area had not been systematically examined, and it is therefore possible that Aboriginal sites may be present.

Should Aboriginal sites be found during the construction of the tannery, an application under the *Aboriginal Heritage Act, 1972,* would be lodged with the Trustees of the Western Australian Museum to obtain written permission to build on the site.

Chapter Five
PROCESS DESCRIPTION

5.1 WET-BLUE TANNAGE

5.1.1 HIDES AND LEATHER

Cattle hides, like those of most mammals, consist of three layers (BASF, n.d.; Bayer, 1983):

- the epidermis, or outer layer
- the corium, comprising the papillary layer and the reticular layer
- subcutaneous connective tissue.

These are shown in cross-section in Figure 5.1.

The first part of leather production involves the removal of the epidermal and subcutaneous connective tissue. The epidermis and hair are removed by chemical means (sulphiding and liming) and the subcutaneous tissue is removed mechanically (fleshing). An enzymatic treatment (bating) then removes that 1-2% of the corium layer that is elastin, leaving only the fibrous protein, collagen. During these processes, the hide material opens up, which allows penetration of tanning agents. These processes are carried out in what is referred to as a 'beamhouse'.

Once cleaned of all extraneous matter, the corium is tanned: a process that involves adding an agent to the pelt that irreversibly stabilizes the collagen against both putrefaction and further changes in shape or thickness. There are a number of suitable agents available, but the material of choice for this proposal is chrome. A fungicide is added to the tanning solutions if preservation is required before the leather is processed further into finished leather. Excess water is removed by passing the leather through a set of rollers. These operations are carried out in what is referred to as a 'tanyard'.

After this treatment the leather can be stored while damp, in contrast to the raw hide. The chrome turns the leather a light-blue colour. These two features result in the product being described as 'wet-blue'.

Many different types of finished leather can be made from wet-blue products. Production of finished leather at the site may be instituted after full design production of wet-blue is achieved. Such a development would require separate environmental assessment and approval.

5.1.2 NATURE AND VOLUME OF PROCESS

The beamhouse and tanyard processes (and the waste streams they produce) are described in more detail in the following sections. The tanning process (shown schematically in Figure 5.2) has been adopted without alteration from the process sheets of Gosh Leather. Hence, the volumes of water used and the quality of wastewater produced are known accurately. The process described is very conservative in terms of water consumption; many similar operations use two to three times as much water.

All quantities in this description are based on a nominal throughput of 1,000 hides per day. As described elsewhere, initial production would be at a rate of 100,000 per annum, or approximately 400 per day based on a working year of 254 days. On this basis, the capacity of the tannery would be 254,000 hides per annum. All quantities listed are derived on the basis of this maximum; on most days less waste would be produced, and less water and chemicals used. An estimated production of 220,000 hides per annum has been used throughout the document, assuming that the production rate of 1,000 per day would not always be possible because of factors such as non-availability of hides, and maintenance.

The volume of water and weight of chemicals required for a particular batch of hides is calculated as a percentage of the weight of hides or pelts. In this Chapter, an average weight of 22.5 kg per hide has been used to allow estimation of these quantities, and hence the volume of the wastewater. Cattle hides vary in weight between 15-30 kg each (Bayer 1983).

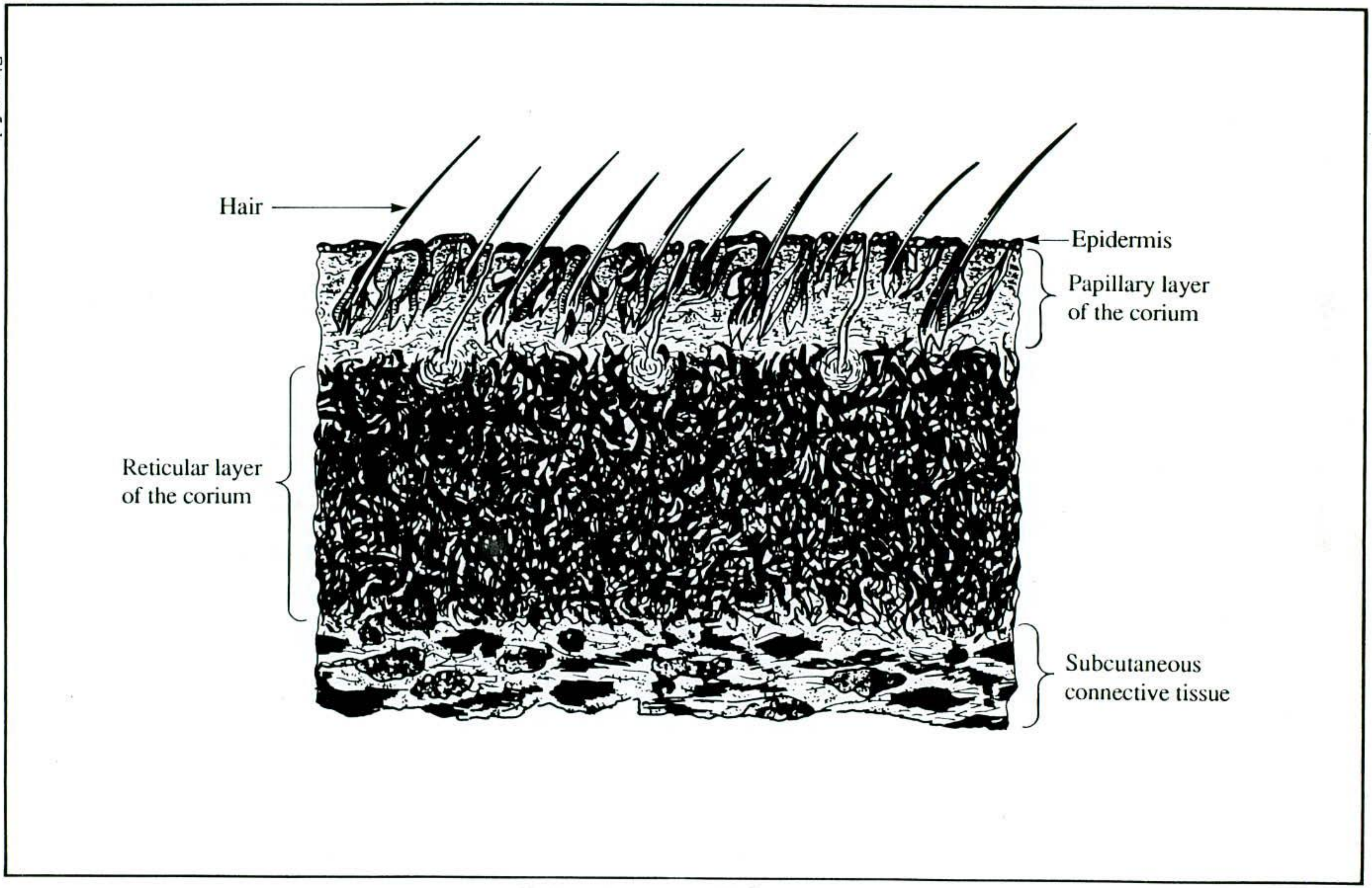
Hides that are not processed immediately require preservation, using either salt or microbiocides, to prevent microbial attack; in Western Australia salt (sodium chloride) is commonly used. There are two major methods of salting hides: brine-curing, which involves soaking the hide in a brine solution and adds about 5 kg of salt to each hide; and salting, whereby hides are coated with salt adding a much greater and variable weight of salt to the hide. These methods of preservation are carried out at abattoirs. To avoid introducing unnecessary salt to the area, Deras would use brine-cured hides rather than salted hides.

5.2 BEAMHOUSE PROCESSES

Beamhouse processes include:

- acceptance and storage of hides
- washing and soaking
- fleshing
- dehairing
- rinsing
- splitting
- deliming
- bating.

Figure 5.1
CROSS-SECTION THROUGH A CATTLE HIDE



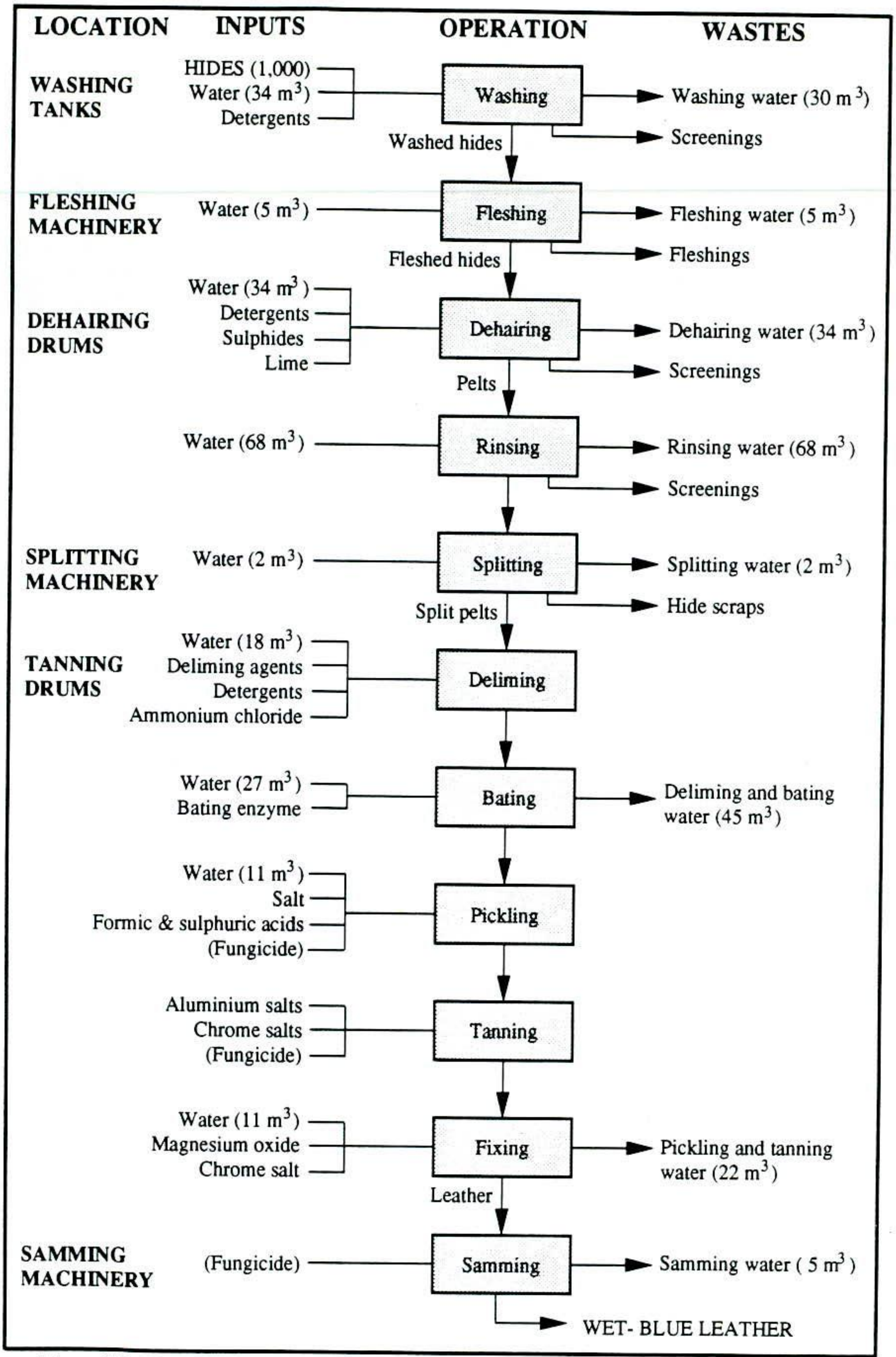


Figure 5.2
TANNING PROCESS SCHEMATIC

In practice, the last two operations would be carried out in the drums used for tanning (Figure 5.2).

5.2.1 STORAGE

To avoid microbial spoilage, green (i.e. fresh) hides would either be used directly or chilled. Chilled hides can be stored in a chiller or refrigerated container for up to a week before processing. Brine-cured hides can be stored in a ventilated room for up to a year before processing. Many smaller abattoirs brine-cure their hides so that they can be stored and accumulated before being transported. This, together with Deras's desire to maintain a stock of hides for use when supply is restricted, means that some brine-cured hides would need to be processed. To allow calculation of wastewater composition in Chapter 6 and Appendix H, it has been assumed that 50% of the hides processed would be brine-cured. This assumption affects the quality of the washing water only.

5.2.2 WASHING AND SOAKING

The hides require washing and soaking to remove dirt, blood, manure and any salt used in preservation. Brine-cured hides require longer soaking times than green or chilled hides, partly to replace water lost during preservation: these times vary depending on the initial condition of the hides. Tanks equipped with slowly rotating paddle stirrers would be used. It is assumed that up to 4 m^3 (or 4 litres per hide) of the washing water would be absorbed by the hides. Washing water is a favourable environment for the growth of putrefying organisms.

The washing water would contain salt, organic matter including grease and dirt from the hide, and additives. These additives would include detergents to aid cleaning, and a bacteriostatic agent if long wash times were required (as with brine-cured hides). The washing water would be passed through a screen to remove solid matter such as hair, grit and seeds.

5.2.3 FLESHING

Fleshing removes the fatty subcutaneous tissues from the flesh side of the skin. This would be performed mechanically using a revolving knife cylinder, which operates as the hide is fed through pressure rollers. A continuous stream of water would lubricate the hide and wash waste solids (fleshings) to a collection box.

The fleshing process would produce approximately 1 kg of solid waste per hide, thereby resulting in daily production of up to one tonne of fleshings (based on the design throughput of 1,000 hides per day). The fleshings from green or chilled hides would be returned to abattoirs for rendering. If fleshings from brine-cured hides were not worth rendering, they would be disposed of with other solid wastes. Fleshing can be carried out after the dehairing step.

5.2.4 DEHAIRING

The hair and epidermis are composed of the fibrous protein—sulphur-rich keratin—which is also the main component of wool and hooves (or nails). This protein is rapidly rendered soluble by alkaline solutions containing the bisulphide ion: lime and a mixture of sodium sulphide and bisulphide would be used in this case. If high bicarbonate water (Section 4.1.6) were used, deposits of calcite would form on and within the hide, lowering product quality.

The washed and fleshed hides would be transferred to a large drum, rotating around a horizontal axis (paddle tanks could also be used). Water, non-ionic detergents, sodium sulphide and bisulphide, and lime would be added, and the mixture allowed to work for 16 hours (overnight). The drum would be rotated slowly for a few minutes each hour. During this time the hide expands, the hair fibres are partly dissolved and loosened from the follicles, the epidermal layer is dissolved and abraded, and skin greases are emulsified or saponified. The friction caused by rotation helps remove the hairs from the skin.

The wastewater would contain the above substances (solid and dissolved lime, bisulphide ions, detergents), thiosulphate formed by oxidation of sulphide, and high concentrations of dissolved and particulate keratin and grease.

5.2.5 RINSING

The liquid contents of the drum would be drained at the end of the dehairing step. The hides would be rinsed thoroughly and continuously with water while the drum was rotated. Rinsing would continue until the water in the drum was 'clean', which normally requires twice as much water as used in the dehairing step. The pH of the hides would still be high, they would have swelled and absorbed lime and sulphide.

The wastewater would contain progressively reduced concentrations of the substances used or produced during dehairing.

5.2.6 SPLITTING

Splitting separates the skin into two layers: the outer 'grain split' is more valuable than the inner 'flesh split'. Only a little water (for lubrication) would be used in this process and the hide scraps produced would be collected in a filter. Splitting need not be carried out, depending on the potential market for the leather. The washed, dehaired, fleshed and (possibly) split hide is called a 'pelt'.

5.3 TANYARD PROCESS

The tanyard process comprises pickling and tanning. The process would be carried out in a single drum similar to that used for dehairing, with chemicals being added and drained in sequence. During this time, the remaining beamhouse processes (deliming and bating) would occur. The hides would then be pickled with acid and salt (pickling). These processes condition the pelts to absorb and retain chromium and aluminium compounds (tanning).

5.3.1 DELIMING

It is important to remove calcium from the pelts to prevent carbonate or sulphate deposits forming, which would spoil the feel of the leather. The pelts would be washed again with water and drained; fresh warm water would then be added to the drum. Ammonium chloride would be used to neutralize the pelts to a pH of 8-9 (the isoelectric point of collagen), and a deliming agent would be added to complex the calcium ions and allow washing from the pelt. Deliming agents are commonly organic acids or similar substances: details of the deliming agent to be used are proprietary to the various manufacturers. Sodium metabisulphite would be added in order to oxidize the sulphide that remains in the hide, since this may cause a hazard to operators during the pickling step. Further additions of non-ionic detergents would be made to ensure the pelt was free from grease. As a consequence of the neutralization, the volume of the pelt would be reduced, helping to expel water and calcium salts from the pelt. This mixture would be allowed to work for 30 minutes.

5.3.2 BATING AND CHILLING

The pH of the water would be checked and adjusted if necessary to a reading of 8.0-8.5. The bating enzyme trypsin (an extract from the pancreas) would be added to hydrolyse the elastin in the pelt, thereby further opening the hide material for the tannage step. After 45 minutes this solution would be drained from the drum, and cool water added to prevent further enzyme action. The deliming and bating waters would contain ammonium salts, and also smaller quantities of organic matter, detergents, and calcium and sodium salts.

5.3.3 PICKLING

The pelt must be acidified to allow efficient penetration of the metal salts used as tanning agents. A mixture of sulphuric acid and formic acid would be used to promote rapid and uniform penetration. Because acidification would itself cause the pelts to swell, the use of a salt solution (approximately 7%) would be necessary in pickle drums. The high ionic strength created by the salt counteracts the tendency to swell and allows the pelt to be tanned in a relatively unstressed condition. A total of 2.5 hours would be required for pickling. A fungicide would usually be added at this stage of the process to allow absorption by the pelt, although this could be delayed until (or supplemented during) the tanning or samming steps.

5.3.4 TANNING

The tanning process would involve tannage with both aluminium and chromium salts, in a ratio of approximately 1:2. Aluminium sulphate and chromium sulphates would be added to the pickling solution. After an hour, more chromium sulphate would be added. Magnesium oxide, sufficient to raise the pH of the solution from 3.1 to 3.9, would be added to fix the chrome and aluminium in the leather. After addition of more water, tanning would be completed by standing the mixture for 8 hours, mixing slowly for a few minutes each hour. The chrome and fungicides are preferentially absorbed from the water into the pelts. Normal processes result in uptake of approximately 70% of the chrome into the pelt to give a 4.4% content of chromium (as Cr_2O_3) in the leather (dry weight). The residual concentration of chromium (as Cr_2O_3) in the water would be about 7 g/L. Pickling and tanning waters would be acidic and would contain high concentrations of chromium salts, sodium chloride, sulphates and moderate concentrations of a fungicide.

5.4 SAMMING AND PACKING

The wet-blue leather would be passed through a series of rollers to remove excess water—an operation known as 'samming' (or 'sammying'). The leather would have a final water content of 20-30%. The water would be combined and treated with the pickling and tanning water.

After inspection and sorting, the hides would be packed flat in crates and covered in plastic sheeting. These crates would be stored in a warehouse on site prior to distribution to finishing tanneries in Western Australia or elsewhere.

5.5 OPERATING TIMES

It is proposed to operate the tannery from Monday to Friday. The majority of the workforce would be required during normal working hours, with maintenance, security and some waste disposal work being required after hours. A number of operations would occur overnight, particularly washing, dehairing and tanning. The times required for the various operations are:

- Washing – 1-2 hours to overnight, depending on the condition of the hides
- Dehairing – 17 hours
- Deliming and bating – 1.5 hours
- Pickling – 2.5 hours
- Tanning – 10.5 hours.

Operations would cease for 2 weeks during the Christmas–New Year period. Observation of statutory holidays outside this period would result in a working year of approximately 254 days.

5.6 PROCESS INPUTS

5.6.1 WATER

The tannery would require about 210 m^3/day of water for hide processing. This represents an average of 210 L of water per hide. Some additional water would be used for a variety of other purposes, including ablutions, tannery washdown, irrigation of dust control and so on. Some recycling of water could occur. Water from the final rinse prior to deliming would be used for the initial washing step, as has been already assumed in estimation of quantities. This process, which uses a relatively small amount of water, combined with the use of evaporation to dispose of the majority of wastewater, would ensure that water consumption was kept to a minimum. However, use of lower quantities than described is considered likely to adversely affect leather quality.

It is proposed to obtain water supplies from a bore to the north-east of the site (Section 3.1.6). This water is of good quality for tannery use. Further investigation of the water quality (chemical and microbiological) would be undertaken before being approved for human consumption: it would require aeration to remove dissolved gases and to reduce its corrosivity, and possibly would require some additional pH correction. These steps would be carried out at a reservoir, which would hold about 3 days supply (600-750 m^3) of water.

5.6.2 CHEMICALS

The chemicals that would be used during operation of the tannery are shown in Table 5.1.

Table 5.1 **Main chemicals used in tannery operation**

Chemical	Quantity used per hide (g)	Annual usage (t)
Lime	500	110
Sodium sulphide and bisulphide	450	100
Ammonium chloride	340	75
Deliming agent (as formulated)	110	25
Sodium metabisulphite	110	25
Bating enzyme	140	30
Salt (sodium chloride)	1,600	350
Sulphuric acid	200	45
Formic acid	55	12
Basic chrome sulphates	1,300	290
Aluminium sulphate	450	99
Magnesium oxide	120	26
Detergents and similar substances (as formulated)	450	100
Fungicide	70	15

Notes: Based on processing of 220,000 hides (5,000 tonnes) per annum; rounded to two significant figures. Weights are 'as used', including water of crystallization or solution.

A chemical store would be built. The store would be bunded to contain spills, and incompatible chemicals would be stored in separate sections. Solid chemicals would probably be delivered in bags. Sulphuric acid, formic acid and detergent concentrates would be delivered in plastic drums and stored in a separate section of the chemical store. The fungicide to be used is still to be decided: possibilities include formulations containing either 2-(thiocyanomethylthio)benzothiazole or a mixture of phenols (not including pentachlorophenol), which are commercially available and widely used for leather preservation. Representative safety data sheets for many of the process chemicals are reproduced in Appendix I.

Additional chemicals may be used for waste treatment. These include manganese sulphate (approximately 10-100 kg/a) as an aeration catalyst; and polyelectrolytes or similar substances (up to 60 kg/a), and lime or magnesium oxide (approximately 5 t/a) to aid chrome precipitation.

5.7 TRANSPORT

Hide import would normally result in 4 truck arrivals and departures per day. However, use of some smaller abattoirs (producing less than 100 hides per day) as sources of hides may result in an increase in the total number of transport events. Chilled hides would be delivered to the tannery in refrigerated trucks. Brine-cured hides would be transported to the site stacked on pallets and wrapped in plastic sheeting. Chemicals would be transported to the site approximately 4 times per week.

The leather products would be packed in plastic-covered crates and trucked from the tannery in bulk. There would be some 10 loads per week. Wherever possible, shipment of products or return of fleshings for rendering would be in trucks that have brought hides or other supplies to the tannery. Estimated movements of transport vehicles are shown in Table 5.2.

Table 5.2 **Main transport movements during operations**

Type	Movements per week
Raw hides	20
Chemicals	4
Wet-blue hides	10

Notes: Based on production of 220,000 hides per annum with no backloading.
Excluding private car or bus operation.

5.8 ALTERNATIVE PROCESS TECHNOLOGIES

Unlike processes described in previous documents (prepared for the Boyanup site) and those used at other tanneries owned by Deras, the processes in this proposal result in a product suitable for finishing at Gosh Leather's tannery. Consequently, no alternative processes were considered.

However, it is almost inevitable that minor changes would be made as part of normal production refining. As the tannery evolves during the initial years of operation a more economic use of materials and recycling of certain water or chemical streams may be developed. Such changes would generally lessen environmental impacts, which, in any case, are small. Some possible changes include:

- use of the Bayer 'Baychrome C' process, which allows the hide to absorb more than 95% of the chrome in the tanning float (Bayer, n.d.). The chrome salts suitable for this process are more expensive to purchase, but the cost may be recoverable against the costs for disposal of waste chrome;

- recycling of all the pickling and tanning waters, after replenishment of substances absorbed by the pelt (Davis and Scroggie 1980). This is not favoured at present because of the risk of lowering the quality of the leather by errors in replenishment;

- increasing the proportion of chilled or green hides used to greater than 50% (the benchmark figure used in this review);

- possible use of ammonium sulphate in the deliming step (as in Deras's tanneries in Africa) to reduce the concentration of chloride in the fertilizer (Section 6.4.3). Use of ammonium chloride in the deliming water and sodium sulphides in the dehairing water results in the fertilizer waste effectively containing sodium chloride (salt).

- use of the CSIRO dehairing process, Sirolime. The major advantage of this process is that it avoids decomposition of hair during the dehairing step. This allows recovery of the hair for use elsewhere, and results in an effluent of reduced organic strength. This has major advantages for urban-based beamhouses, but is of little value for those in rural locations where plenty of land is available for the treatment facilities. In addition, the process is still being developed.

Chapter Six

WASTE TREATMENT AND DISPOSAL

6.1 INTRODUCTION

6.1.1 WASTEWATER

In common with most other industries that process agricultural products, the wastewater from beamhouse operations has a high content of organic substances. These are mostly proteinous matter dissolved from the hide or hair, but also include blood and fat. In addition, the wastewater contains high concentrations of ammonia; sulphide and its oxidation products; and dissolved salts including sodium, chloride, calcium and bicarbonate ions. Some wastewaters contain high concentrations of suspended particles. Wastewater is produced from four sets of individual or combined processes: washing, dehairing and rinsing, deliming and bating, and pickling and tanning. Minor wastewater streams would be handled as follows: samming water would be combined and treated with pickling and tanning water; fleshing water would be combined with washing wastewater; and splitting water would be combined with deliming and bating wastewater.

6.1.2 SOLID WASTES

Solid wastes include:

- hair, possibly highly denatured, which has been screened from the wastewaters
- grease, hair, and proteinous foam skimmed from the aeration and balancing tanks
- sludges separated from the wastewater during pre-treatment and balancing
- scraps of hide, flesh or fat that have been trimmed from the hide
- sludges produced during biological treatment of wastewater
- a salt sludge produced during evaporation.

6.1.3 ODOURS

Odours may originate from several sources in the operation; in particular, the sulphide used in dehairing, or the wastewaters in the treatment and evaporation lagoons.

This Chapter describes the proposed treatment and disposal of wastewater and solid wastes. The proposed method has been designed to minimize environmental impacts at the site and to avoid wasting valuable resources.

6.2 PROPOSED WASTE DISPOSAL

6.2.1 WASTEWATER

The origins of major constituents of the wastewater streams are shown in Table 6.1 and Figure 6.1. Most of the salt would be contained in the washing and the pickling and tanning wastewaters. For this reason, these waste streams would pass to evaporation, following treatment to reduce the biochemical oxygen demand (BOD) and chromium content, respectively. Virtually all the nitrogen and BOD would be contained in the dehairing and rinsing, and deliming and bating wastewaters. Since these constitute three-quarters of the volume of the wastewater it is desirable to treat these two streams by land application in winter, which reduces the area of evaporation required and makes use of the wastewater's fertilizer value. The dissolved salts content of the dehairing wastewater would be greatly reduced during pre-treatment, since gypsum (calcium sulphate) would separate as a sludge.

Table 6.1 **Origins of major wastewater constituents**

Wastewater stream	Volume %	BOD* %	Nitrogen %	Dissolved salts %
Washing	15	7	3	38
Dehairing and rinsing	51	73	58	18
Deliming and bating	23	17	39	15
Pickling and tanning	11	3	0	30

**Biochemical oxygen demand .*

Summer

During summer (late October to early May) wastewater would be disposed of by evaporation. Wastewaters from washing, dehairing and rinsing, and deliming and bating would be combined in a balancing tank, thereby producing a controlled flow of even quality to be treated in an anaerobic lagoon. After anaerobic treatment the wastewater would pass to a facultative lagoon. The water would flow from the facultative lagoon to a series of two evaporation lagoons and then a final drying lagoon. Pre-treated pickling and tanning wastewater would pass directly to the facultative lagoon.

Winter

During winter (late May to early October) precipitation equals or exceeds evaporation, and therefore it would be desirable to reduce the amount of wastewater passing to the evaporation lagoons. The intention would be to maintain, as far as feasible, a constant volume of stored water in the lagoons. The pre-treated dehairing wastewater would be combined with the rinsing, and deliming and bating wastewaters and then used as fertilizer on the site (or, if desired by the owners concerned, on neighbouring farmland).

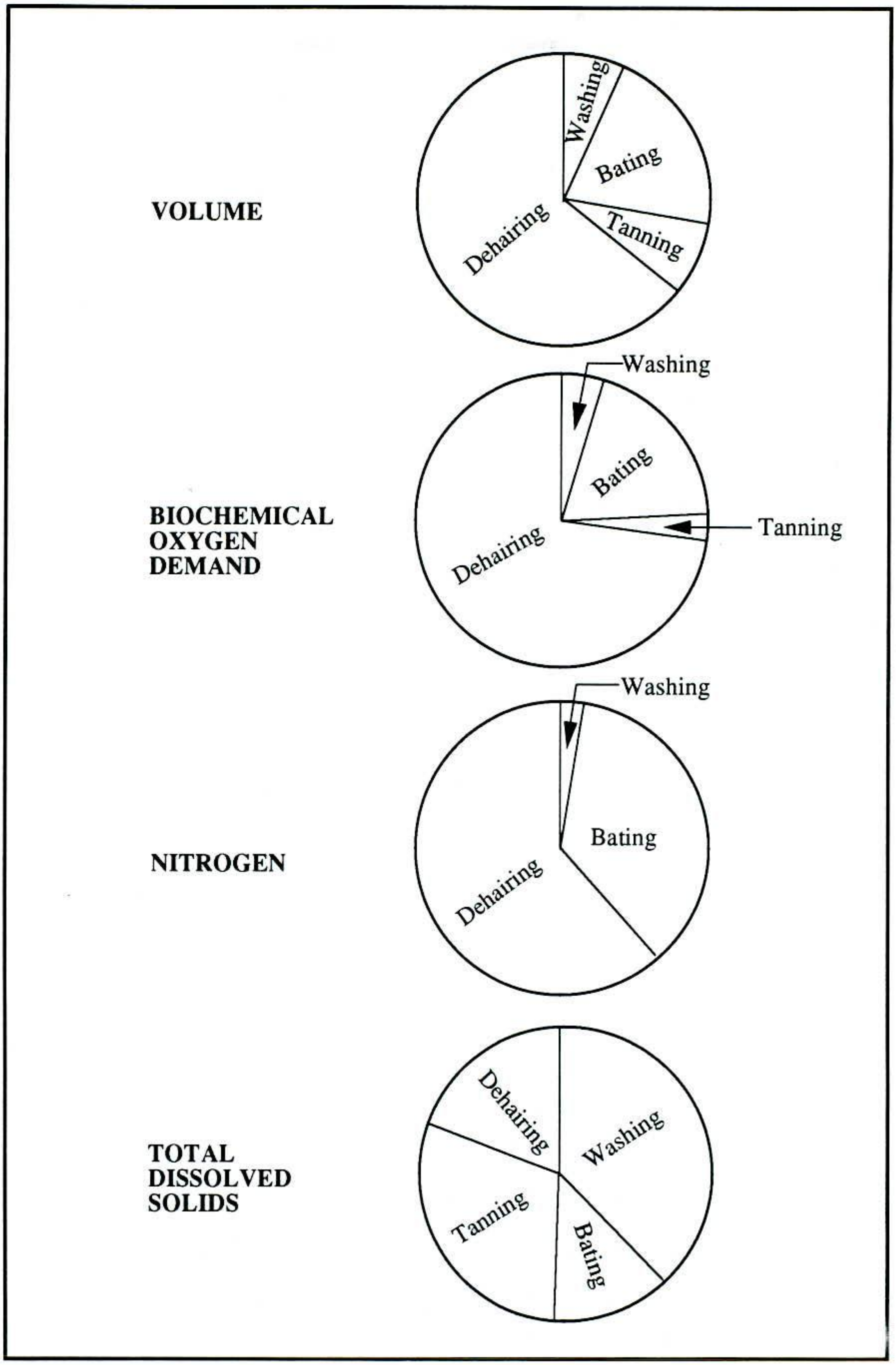


Figure 6.1
WASTEWATER PROPERTIES

This wastewater contains moderate concentrations of salt and high concentrations of nitrogen (Table 6.1). Other wastewater streams, which are saline, would be treated as during the summer. Schematics of the proposed wastewater treatment process during both summer and winter are shown in Figures 6.2 and 6.3 respectively.

Pre-treatment

During pre-treatment, dehairing wastewater would be aerated to oxidize reduced sulphur compounds to sulphate. Sludges, comprising mainly gypsum and partly calcite (calcium carbonate) and unreacted lime, would then settle and be removed. The water would then be treated in the anaerobic lagoon or added to the fertilizer, depending on the season. Chrome would be precipitated from the pickling and tanning waters by neutralization: the resulting chrome sludges would be removed from the site by a licensed waste disposal operator; the treated water would pass directly to the facultative lagoon.

6.2.2 SOLID WASTES

Solid wastes such as fleshings, pre-treatment sludges and screenings would be disposed of daily. Organic sludges from the anaerobic and maturation lagoons would be disposed of every several years. Dried salt from the drying lagoon would also have to be removed periodically. Solid waste disposal is detailed in Sections 6.8 and 6.9. Reasons for the sizing (preliminary in nature) of the various facilities are given in Appendix H.

6.3 PRE-TREATMENT OF WASTEWATER

The dehairing wastewater and the pickling and tanning wastewaters would be pre-treated to facilitate disposal.

6.3.1 PRE-TREATMENT OF DEHAIRING WASTEWATER

The dehairing wastewater results from the removal of hair, epidermal layers and grease from the hides. It has a high pH (because of its lime content), a high concentration of reduced sulphur (partly as bisulphide and partly as thiosulphate) and a high concentration of organic matter (predominantly dissolved and partly suspended). Before the dehairing wastewater can be mixed with deliming and bating wastewaters in the balancing tank, the bisulphide concentration must be greatly reduced to prevent toxic, volatile and odorous hydrogen sulphide gas forming. This wastewater would be treated by aeration, to oxidize reduced sulphur to sulphate; and by standing to allow calcium salts (gypsum, calcite and residual lime) to settle from the water. This operation is carried out at most tanneries, especially those that discharge to sewers. Though it is not essential for this tannery, (since the proposed anaerobic lagoon system could handle raw effluent efficiently), it would still be carried out, demonstrating Deras's commitment to controlling odour generation and also to recovering lime sludges so that they could be used as fertilizer.

Aeration would be carried out (using a metal ion as a catalyst) at the pH at which the wastewater was drained from the drum. Under these circumstances the oxidation reaction

Figure 6.2
WASTEWATER TREATMENT SCHEMATIC (SUMMER)

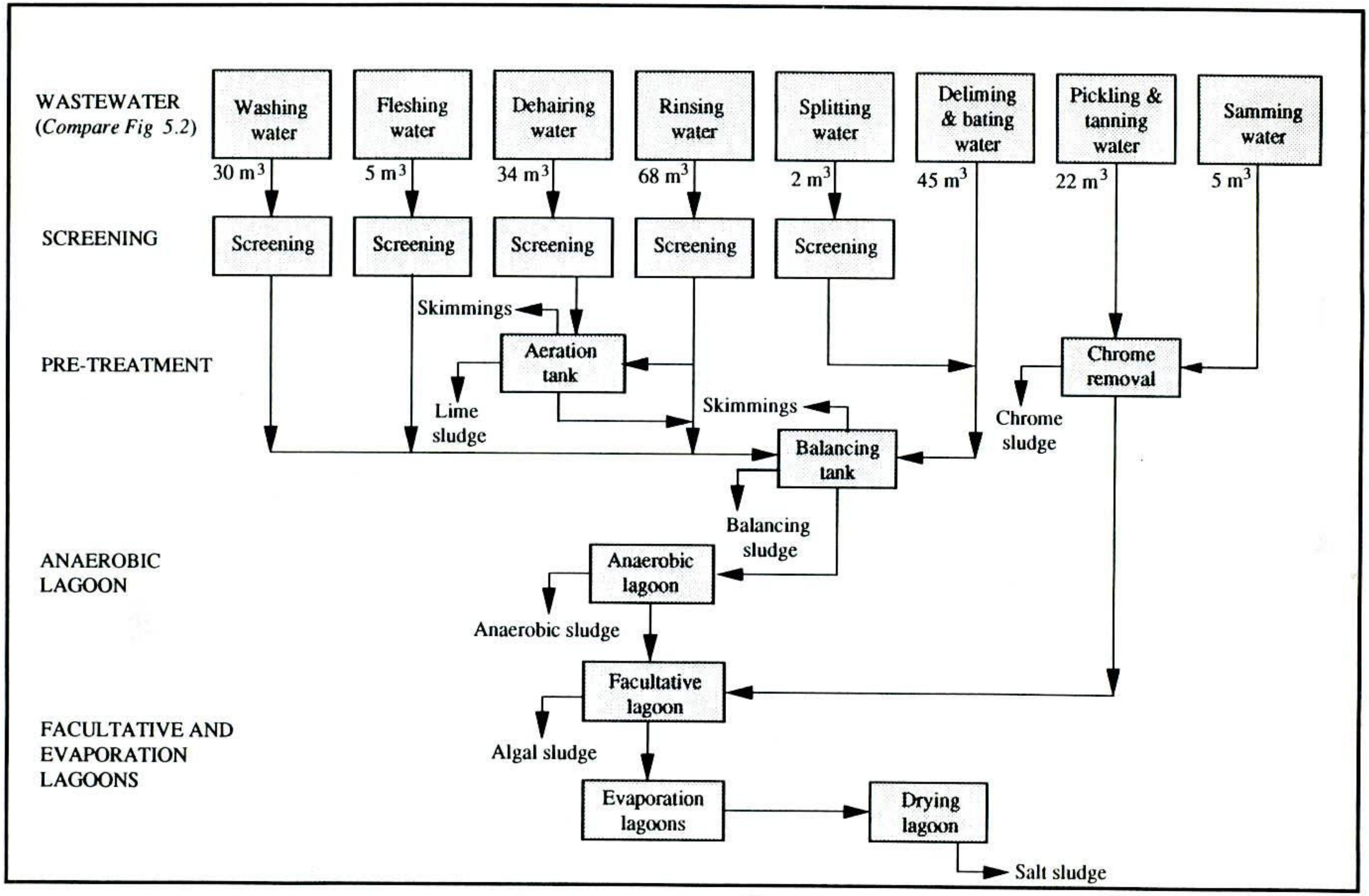
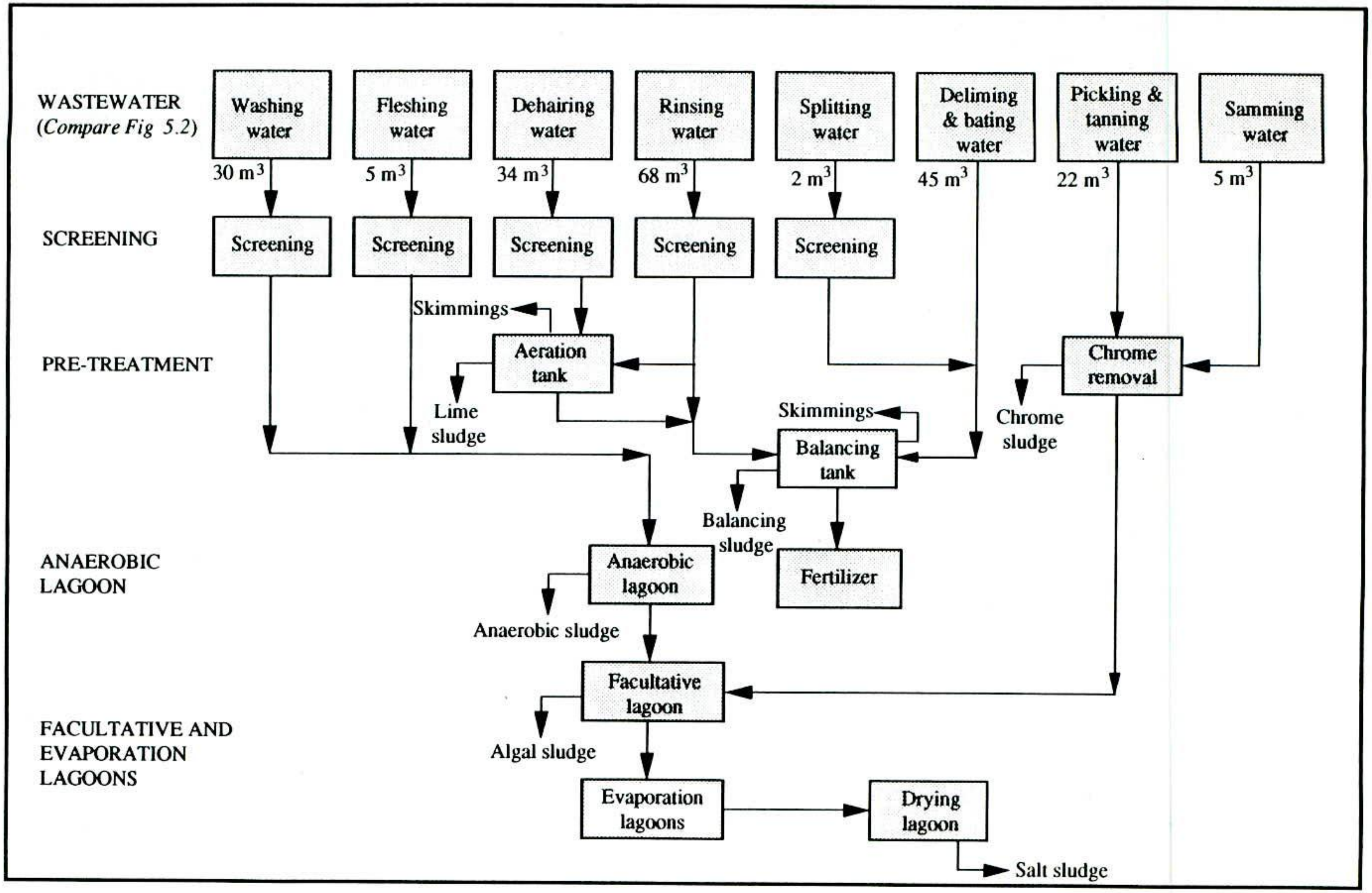


Figure 6.3
WASTEWATER TREATMENT SCHEMATIC (WINTER)



is rapid and the extent of odour generation is negligible. During oxidation, bisulphide and thiosulphate ions are converted to sulphate ions. The lime solids in the water are converted from calcium hydroxide to calcium sulphate and carbonate, which precipitate as a lime sludge. The pH of the wastewater is reduced to mildly alkaline, partly by the absorption of atmospheric carbon dioxide, but mostly as a result of acidity produced when bisulphide is oxidized. Settlement of the wastewater is expected to remove about 90% of the sulphur and 50% of the calcium. Nearly all of the phosphorus is expected to be concentrated in the lime sludges.

Manganese, as manganous sulphate, would be used as the catalyst. Trials would be necessary to determine optimum concentrations of manganese since values between 1-200 mg/L have been reported as being effective (Martin and Rubin 1978). Normally, an aeration period of 3-5 hours is required to oxidize all the reduced sulphur. This process requires about 6 kg of oxygen per 1 kg of sulphur.

The wastewater is prone to produce heavy proteinous foams during aeration; addition of a suppressant would therefore be necessary. Foam suppressants are commonly detergents or similar substances. Any remaining foam, along with a scum containing grease and hair, would be skimmed from the tank as required. This would be disposed of with other solid wastes. A small simultaneous reduction in the BOD of the wastewater is expected, as settlement of lime sludge would assist settlement of suspended organic matter. However, most of the soluble organic matter is expected to remain in solution. The estimated composition of the dehairing wastewater before and after aeration is shown in Table 6.2.

Table 6.2 **Estimated composition of dehairing wastewater**

Parameter	Before aeration	After aeration and settling
pH	12.6	7-9
Suspended matter	30,000	3,000
BOD	19,000	17,000
Sulphur (inorganic)	5,100	500
Nitrogen (total)	5,600	5,000

In mg/L except pH.

6.3.2 PRE-TREATMENT OF PICKLING AND TANNING WASTEWATER

Chrome and aluminium would be removed from the pickling and tanning wastewater by precipitation. Again, this is a very common practice at tanneries and the process is known to produce good results. Precipitation is carried out by:

- pouring off the exhausted waters from the tanning step into a separate tank;
- adding a quantity of a neutralizing agent (sufficient to bring the pH close to and slightly greater than neutral);

- prolonged settling, usually overnight, to allow chromium and aluminium hydroxides to precipitate.

Polyelectrolytes or similar substances could be added to aid coagulation and settlement of the floc, if needed. The chromium and aluminium hydroxide sludge would be removed and stored, and the treated wastewater discharged directly to the facultative lagoon. The residual chrome content is likely to be less than 0.1 mg/L. The recovered chrome would be disposed of off site by a licensed waste disposal operator.

Deras would prepare, before commissioning of the tannery, a management plan for fine-tuning the chrome precipitation system to achieve the above commitment. This would be prepared in collaboration with the EPA.

6.4 BIOLOGICAL WASTEWATER TREATMENT

Following pre-treatment, all the wastewaters would undergo a combination of biological treatments followed by evaporation. Biological treatment uses the natural processes of degradation that occur when organic matter is placed in water or on soil. The degradation is carried out primarily by bacteria, but many other types of micro-organisms are involved. The organic and inorganic matter in the waste is used by the micro-organisims, both as a source of energy and as a source of material for creation of new cells. Since microbial cells are relatively inert to degradation, a stable form of organic matter is created in place of a larger quantity of an unstable form. On soil, this contributes to an increase in soil organic matter, which is generally considered desirable. In lagoons, the cells settle from the water to form a sludge at the bottom. This sludge continues to undergo slow degradation but normally accumulates faster than it is degraded. Therefore lagoons would require removal of sludge every few years, as there is a possibility that odours would develop if too much sludge were present.

Since a large area of lagoons would be needed to evaporate the wastewater, it is logical to use these to provide treatment as well. The wastewater would initially be quite high in BOD so primary biological treatment would be undertaken in an anaerobic lagoon. This would reduce the organic strength of the wastewaters. Subsequent treatment would be in a facultative lagoon, which is designed to be anaerobic on the bottom and aerobic at the surface; and then in shallow, fully aerobic, evaporation lagoons.

The fertilizer water would be treated by aerobic bacteria at the soil surface. Bacteria on the soil have ready access to the oxygen required for respiration. This is in contrast to those bacteria in aerobic or facultative lagoons, which are limited in effectiveness by the low solubility of oxygen in water. The important feature in using soils to treat wastewater is that microbial growth should not be inhibited by lack of moisture. For this and other reasons, this treatment method would be used in winter. Bacterial degradation of the dissolved and suspended protein in the wastewater would result in slow release of nitrogen throughout the growing season, thereby promoting pasture growth. Up to 85% of the water content of the fertilizer would evaporate.

6.4.1 ANAEROBIC LAGOONS

During summer, all wastewater except the pickling and tanning wastewater would be mixed and balanced in a balancing tank and discharged to an anaerobic lagoon for treatment. The lagoon would have a volume of 5,800 m^3 (area: 0.2 ha) and its performance would be monitored carefully over the first years of operation to evaluate the need to expand or duplicate the lagoon. During winter, only the washwater would pass to the anaerobic lagoon.

Sulphate in the wastewater would be reduced to sulphide in the anaerobic lagoon, renewing the potential for odour generation. There are several methods available to deal with this: one is to cover the lagoon to prevent odour emissions. This method is convenient for many situations but is considered likely to result in very poor treatment in the proposed operation. In fact, the waste is not ideal for conventional anaerobic digestion, since in addition to sulphur, it has a very high concentration of dissolved salts and ammonia, each of which can be inhibitory to anaerobic, especially methanogenic bacteria (Speece and Parkin 1983). The concentrations of ammonia and sulphide would increase during digestion since the majority of the organic matter is degraded keratin, a protein rich in nitrogen and sulphur.

The concentration of sulphide in the lagoon would be controlled by allowing sulphur bacteria to grow. For this to happen, a long residence time must be provided, and the lagoon must not be covered because sulphur bacteria, being photosynthetic, require light. (Pfennig 1989). Normally, the purple varieties of sulphur bacteria grow and colour the water pink to red (Wenke and Vogt 1981.) These bacteria convert sulphide to sulphate (and elemental sulphur) and so maintain low concentrations of sulphide in the lagoon. This allows sulphate-reducing bacteria to oxidize the organic matter in the wastewater, at the same time producing sulphide. As a result, organic matter is oxidized as a part of the sulphur cycle (van Lotringen and Gerrish 1978).

Sulphur bacteria are rather slow growing and are normally encountered only during summer and autumn, when high water temperatures increase their growth rate sufficiently to allow them to populate lagoons not designed to accommodate them. During this time they maintain low sulphide concentrations in the lagoons. This improved reliability and performance in warmer weather fits very conveniently with the proposal to spread the less-saline wastewater streams on pasture in winter, since this would reduce both the hydraulic and organic loadings to the anaerobic lagoon during the colder periods.

If, despite this, odour problems were to develop, small aerators would be used to maintain aerobic conditions in the surface water. This type of operation has been called an aerobic/anaerobic stratified lagoon (Schultz, Jones and Barnes 1987). The aerators would be operated until the purple sulphur bacteria populations had increased and they were again capable of controlling sulphide concentrations.

Sludge would gradually accumulate in the anaerobic lagoon. Most of the lime would be removed in pre-treatment; some of the remainder may precipitate in the lagoon. Organic solids (mostly bacterial cells) would also accumulate, but because of the very low loading rates the lagoons would only require sludge removal after long intervals of 5 or more years.

6.4.2 FACULTATIVE LAGOON

Evaporation of wastewater and aerobic treatment would be carried out in three lagoons, each with an area of 1.3 ha. The first—the facultative lagoon—would be deeper than the two evaporation lagoons, and would function both as a treatment lagoon and also as an initial evaporation lagoon.

Facultative lagoons are the most common form of waste treatment lagoon. They are commonly 1.5-2.0 m deep and are loaded so that the sludge and water close to the bottom are anaerobic, whereas algal photosynthesis and diffusion of oxygen from the atmosphere maintain aerobic conditions at the surface. Thermal stratification may develop and contribute to the stability of the lagoon ecology.

The loading (see Appendix H) should be fairly conservative for a high-sulphate wastewater, but facultative lagoons are highly adaptable and can accept quite long periods of overloading without causing problems especially in warmer weather.

This facultative lagoon would contribute substantially to wastewater evaporation. At full capacity, over 9,000 m^3 of the 38,000 m^3 of annual hydraulic load would evaporate. The lagoon would require a full year to fill, even if it were to receive all the wastewater produced from processing 100,000 hides. The steady-state salinity is expected to be approximately 40,000-45,000 mg/L.

6.4.3 USE OF WASTEWATER AS FERTILIZER

During winter, when precipitation is greater than evaporation, the volume of wastewater passing to the lagoon system would be minimized by using it as fertilizer. Initially, Deras would use this on its own land, and then neighbouring farmers could use it if they so desired.

Minimizing the volume of water passing to the lagoons would also minimize the area needed for the evaporation lagoons; thereby reducing the cost of construction and reducing the area through which seepage of saline water could occur. It is also advantageous to maintain as constant a level of water as possible because keeping the clay liners moist helps prevent drying and cracking, thereby preserving watertightness. Finally, using wastewater as a fertilizer makes use the of nitrogen and other fertilizer values of the wastewater.

During winter, wastewater would be treated and disposed of as follows (Figure 6.3):

- Washing wastewater: Normally, this would contain significant concentrations of salt from preserved hides. It would be discharged directly to the anaerobic lagoon (by-passing the balancing tank), and would eventually pass to the evaporation lagoons.

- Dehairing wastewater: This would be aerated as normal. The resulting wastewater would be mixed in the balancing tank with rinsing wastewater, and deliming and bating wastewater and then used as fertilizer.

- Deliming and bating wastewater: This would be combined with the pre-treated dehairing and rinsing wastewaters for use as fertilizer, as described above.

- Pickling and tanning wastewater: This would continue to be pre-treated to remove chrome and then would be discharged to the facultative lagoon, as in summer.

Composition

The estimated composition of the fertilizer water is shown in Table 6.3.

Table 6.3 **Estimated composition of fertilizer water**

Components	Concentration
pH	8-8.5
Dissolved salts	11,000
BOD	6,000
Ammonia (as N)	780
TKN* (as N)	2,100
Calcium	450
Sodium	3,500
Sulphate (as S)	1,200
Chloride	3,000
Volume (m^3/day) (220,000 hides per annum)	147

In mg/L, except pH and volume.

**TKN= total Kjeldahl nitrogen (nitrogen in organic form plus that in ammonia).*

The fertilizer water would contain useful concentrations of nitrogen, sulphur and calcium. The nitrogen would occur as approximately one-third ammonia and two-thirds organic (proteinous) nitrogen. As mentioned previously, the fertilizer water would contain both sodium ions (from the dehairing wastewater) and chloride ions (from the deliming wastewater): that is, approximately 5,000 mg/L of salt. These concentrations are tolerable and their impact is discussed in Section 7.1 and Appendix E. However, Deras is aware that it would be advantageous to replace ammonium chloride with ammonium sulphate in the deliming process, and would investigate this, as discussed in Section 5.8.

The current value of ammonium sulphate fertilizer is $205/t. On this basis, the nitrogen content of the fertilizer-water is worth approximately $630/day. Over the 5-month fertilization period (winter) this amounts to an equivalent value of $95,000. The cost of irrigation systems to apply the fertilizer is expected to be a comparable figure, yielding a pay-back period of about one year (it is recognized that yield increases may not be in this proportion).

Method of application

Initially, only 67 m^3 of fertilizer would be produced each working day. This would increase over the first 5 years to 147 m^3/day. The composition would remain the same. Deras would conduct trials on its own land and monitor soil salinity and pasture production during the first year or two of operation to determine the effects of applying this fertilizer.

A management plan would be prepared, in collaboration with the EPA, describing how the trials would be conducted and assessed. This plan would consider the area of application, the effect on pasture, and the movements of salts and nitrates outside the fertilized zone.

The fertilizer water would be distributed over 30 ha of cleared land on the northern part of the site (Figure 6.4) during winter, using a small travelling irrigator. Each section of the land would be fertilized 5 times during winter. The travelling irrigator would be designed to apply approximately 6 mm during each pass at a rate of around 3 mm/h.

If the results of these trials were successful, farmers would be encouraged to make use of this wastewater as a fertilizer. There is enough nitrogen in the fertilizer water to supply the requirements of at least 140 ha of pasture. One farmer has already indicated an interest in using the entire amount of fertilizer water. However, if farmers did not take advantage of this fertilizer water, the system installed by Deras would be capable of disposing of the wastewater output at full production. This would be achieved by applying 54 mm of fertilizer in five passes.

As discussed in Section 7 and Appendix E this amount would not saturate the 1 m deep sands at the surface of the area to be fertilized. However, it would increase the salinity of the perched water (at the bottom of the root zone) to around the maximum tolerable for some pasture species, and could result in salinization of the soil in any areas with shallow topsoil or poor drainage.

The Shire of West Arthur has agreed to promote the use of this resource among farmers near the tannery site, and to request the Department of Agriculture to assist with the initial trials (Appendix J).

6.5 EVAPORATION LAGOONS

Evaporation is considered a suitable method of disposing of the majority of the wastewater because:

- the annual evaporation rate is considerably in excess of the annual rainfall;
- hot, dry summers combined with the generally windy conditions facilitate evaporation, particularly final evaporation;

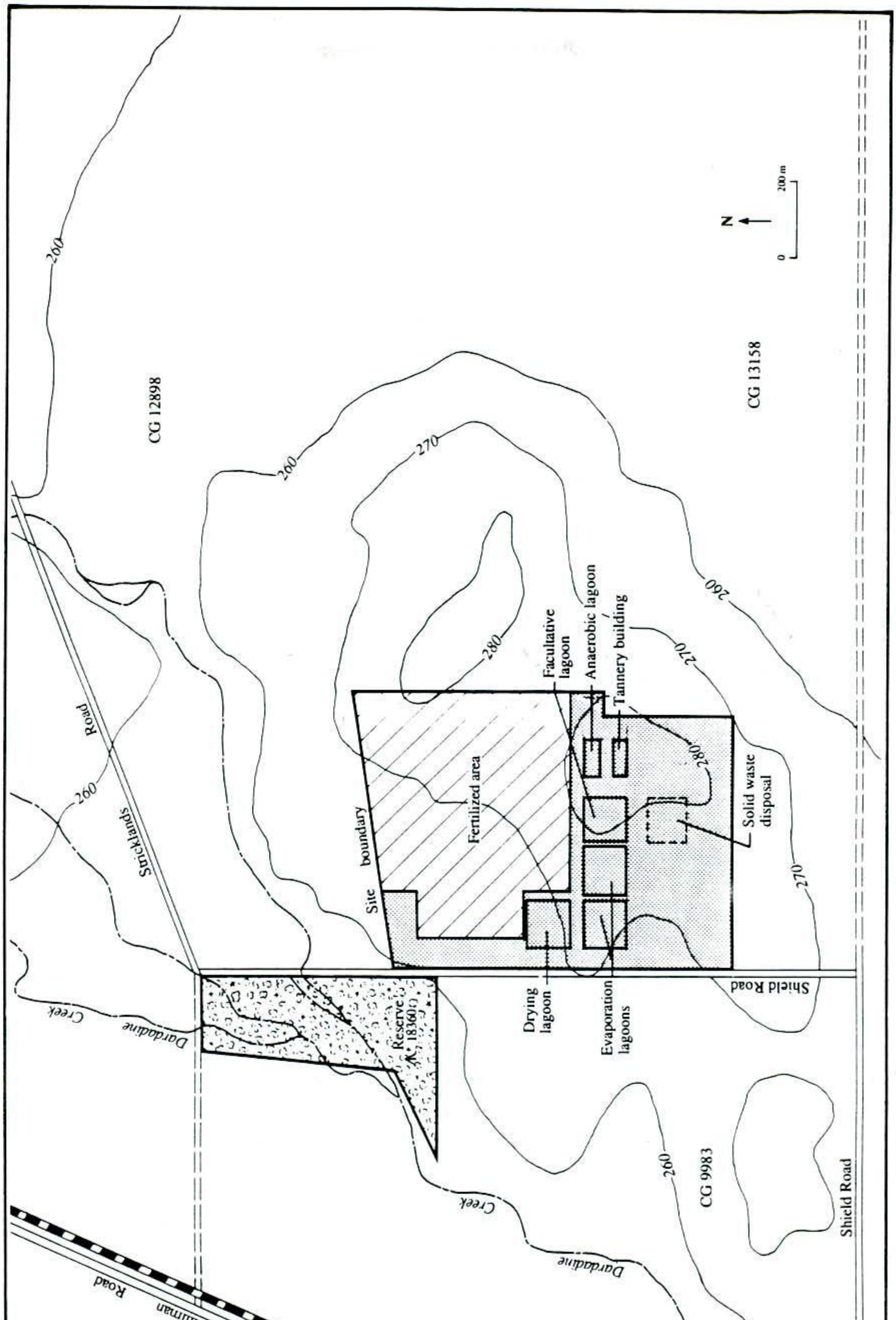


Figure 6.4
LAYOUT OF WASTE TREATMENT FACILITIES

- the topography is suitable for lagoon construction and operation;
- the clay on site is suitable for constructing a lagoon liner of low permeability;
- no additional fresh water would be required;
- tanneries in the US and Africa have used evaporation successfully to dispose of wastewaters (Rowswell, Cooper, and Shuttleworth 1985). It has also been used in Western Australia for disposal of domestic wastewater. Hence, there is sufficient knowledge available to enable the ponds to be constructed, maintained and operated in a safe and efficient manner.
- the resulting sludges can be disposed of without harmful effects on the surrounding environment.

The major potential problem with evaporation is odour production. In the proposed tannery, because the wastewater would undergo a two-stage biological treatment (anaerobic and facultative) before passing to the evaporation lagoons, odour generation is expected to be minimal. In the South African tannery, where untreated wastes were disposed to a series of evaporation lagoons, odours came from only the first one or two lagoons (Rowswell, Cooper and Shuttleworth 1985). This suggests that properly treated wastes would not produce odours during evaporation. Nevertheless, because of the high sulphate concentration (both in the process chemicals and in the water supply) there is a possibility that sulphate would be reduced to volatile odorous sulphur compounds. Therefore, the objectives of the pre-treatment and biological treatment would be to:

- remove most of the sulphur from the wastewater streams;
- reduce the concentration of organic matter in the wastewater streams;
- preserve inorganic nitrogen as much as possible, so that nitrate would be present in the evaporation lagoons to act as a redox buffer.

Other factors to be considered in the design of the evaporation system are variation in water quantity, a reduced evaporation rate due to humid weather, and increased volumes due to heavy rainfalls. A freeboard of 0.6 m would be provided to cope with these factors.

Some 2.6 ha of evaporation lagoons, in addition to other lagoons, would be required to contain and to evaporate the treated wastewater. Deras would investigate the most appropriate way of handling the brines produced. One possibility is that each year, a volume of water (containing an amount of salt equivalent to that entering the lagoon system in the previous year) would be drawn off into a drying lagoon alongside the evaporation lagoons and allowed to evaporate to solid salts.

6.6 WASTEWATER TREATMENT LAGOONS

Preliminary design criteria for the wastewater treatment lagoons are detailed in Appendix H. This section discusses lagoon location, construction and watertightness.

6.6.1 LOCATIONS OF LAGOONS

The lagoons would be located on the ridge between CC 13158 and CC 12898. This location has a number of advantages:

- a downhill gradient to the west, allowing wastewater to flow from one lagoon to another (reducing the need for pumping);
- presence of a considerable depth of very impermeable clay (10-20 m);
- a reduced danger of flooding from overland flow during heavy storms (since the lagoons would be constructed on a ridge, runoff would flow away from them;
- the elevation of the site removes any possibility of flooding, as a result of the Dardadine Creek overflowing;
- the sand cover is thin in this location, so less earthmoving is required.

6.6.2 CONSTRUCTION OF LAGOONS

Construction of the lagoons would involve the removal of the trees along the ridge; removal and storage of topsoil; removal of the remainder of the sand and gravel; and finally using the available clays to build the lagoon liners and embankments.

To ensure the lagoon liners were watertight, they would be worked, watered and compacted such that a layer of at least 300 mm had a density corresponding to a hydraulic conductivity less than 10^{-9} m/s. Laboratory tests on the clays show that this can be achieved (Appendix F). Normal on-site quality control procedures would be used to control the work (Pierce, Sallfors, and Peterson 1986). The compacted clay liners and embankments would be lined with sand to prevent erosion and drying out, as well as allowing easy removal of sludge, should this become necessary.

The lagoons would be approximately square to maximize the use of available space. This would promote mixing of incoming and resident wastewater. The lagoons would be constructed with standard embankment slopes, widths and freeboard.

6.6.3 WATERTIGHTNESS OF LAGOONS

If the actual hydraulic conductivity of the clay in the lagoon liners were 10^{-9} m/s (Appendix F), the seepage through a liner of 300 mm thickness under 1 m of water would be 100 mm/a. Leakage from a 1 ha lagoon would be 1,000 m^3/a; this would be proportionate to the depth of water.

The permeability of the lagoons would decrease with time, owing to a reduction in the hydraulic conductivity of the surface layers of the liner (Bouwer 1978). The surface layer of the lagoons would not be disturbed during operation, resulting in an accumulation of debris on the base of the lagoon and an accumulation of bacterial slimes over the clay surface (Bernhard and Kirchgessner 1987). This natural blinding is expected to reduce permeability to even lower levels. There is also an element of 'filter-clogging': particles moving about in the water eventually settling in and clogging the larger holes. The proposed operation of the lagoon system is expected to reduce the need for scraping the liner to remove the sludge. By not disturbing the liner, the low permeability of the lagoon would be maintained.

If no blinding were to occur, the rate of leakage would simply be dependent on the properties of the clay. It is shown in Appendix E that this rate would be 1,000 m^3/a—three times greater than the estimated rate of drainage into the clay beneath the pasture at Darkan.

Biopores, which transport water and salt downwards from the perched water table in natural soil profiles, would not conduct water through the unsaturated zone beneath the lagoons because the tops would be sealed. Therefore, water and salts would move from the evaporation lagoon down through the soil.

It is shown in Appendix E that it would take approximately 15 years before the underlying water table would start to rise. The increase in the salinity would be propagated downwards at a lower velocity and it would take about 60 years for the increase in salinity to reach the groundwater.

Deras would build a fully integrated wastewater treatment and disposal system, which would be designed and installed by a recognized water/wastewater treatment contractor to the satisfaction of the EPA. The system would be operated and monitored by Deras to the satisfaction of the EPA.

Prior to construction of the wastewater treatment lagoons, Deras would supply details of their exact location and design to the EPA for approval.

Prior to commissioning the plant, evaporative lagoons would be constructed to dispose of treated wastewater and would be operated subsequently to the satisfaction of the EPA.

In the event of treatment or holding lagoon leakage causing an environmental impact, as defined by the EPA, Deras would take immediate action to stop the leakage so that the environmental impact was rectified to the satisfaction of the EPA.

All wastewater treatment lagoons would be constructed to have at least 0.6 m freeboard so as to be able to cope with a 'once in thirty year storm event'.

Deras would ensure that the water level in the wastewater treatment lagoons was maintained to the satisfaction of the EPA.

Deras would take immediate remedial action should failure of the wastewater treatment system occur and would carry out such action to the satisfaction of the EPA.

In order to cope with equipment failure, Deras would keep sufficient spares for immediate repair of the aerators, the electrical system and other key elements of the system, and would advise the EPA. In the event of major failure Deras would take steps to construct holding lagoons, to the satisfaction of the EPA and relevant authorities, as quickly as possible.

Deras would ensure that stormwater runoff from areas adjacent to the lagoons did not, at any time, enter the wastewater treatment lagoon system.

If, due to some unforeseen circumstances, the disposal of treated wastewater by irrigation did not meet the EPA's requirements, Deras would take action to hold that wastewater until it met EPA's standards for irrigation, and this action would be carried out to the satisfaction of the EPA.

Deras would ensure that any treated wastewater would only be irrigated on to the site if it complied with EPA requirements.

Deras would rectify immediately any unforeseen problems resulting from disposal of wastewater.

Before Deras irrigated wastewater on to its property, or any other property, it would provide the EPA with a chemical analysis of the treated water and have it approved for irrigation by the EPA. Additionally, Deras would have the area of land to be irrigated approved by the EPA prior to commissioning the plant.

6.7 WASTEWATER DISPOSAL ALTERNATIVES

Alternative options for wastewater disposal considered include: year-round irrigation on to pasture (rather than just winter irrigation) and evaporation of all the wastewater (rather than approximately two-thirds of it).

The advantage of the year-round irrigation option is that the fertilizer value of the combined wastewater would be utilized throughout the entire year. The disadvantages of the year-round irrigation option include:

- all of the water and salt in the effluent would be discharged on to the ground on the site (rather than evaporating most of it). This would result in an increase in regional groundwater and a rise in salt levels;

- a substantial volume (1,000 m^3/day or more) of fresh water would be required throughout the year to dilute the effluent to a concentration that could be tolerated by the pasture;

- a very large quantity of water would have to drain below the root zone of the plants to maintain a salt balance and this would have an impact on the regional water table.

Evaporation of all of the wastewater has no obvious advantage over the proposed system: rather, it has the following disadvantages:

- a greater evaporation area (approximately 6.5 ha) would be required, resulting in a greater lagoon area and, consequently, a greater volume of saline water leaking into the soil beneath the site;

- there would be a risk of odour generation from the anaerobic lagoon in spring;

- the cost of constructing these larger lagoons would result in the project being only marginally viable.

- the fertilizer value of the wastewater would be wasted.

6.8 SOLID WASTE DISPOSAL

The following eight types of solid waste would be produced during the tanning process (refer to Figure 6.5):

- screenings, approximately 1-3 t/day;

- fleshings, predominantly fat, approximately 1 t/day (50% solids);

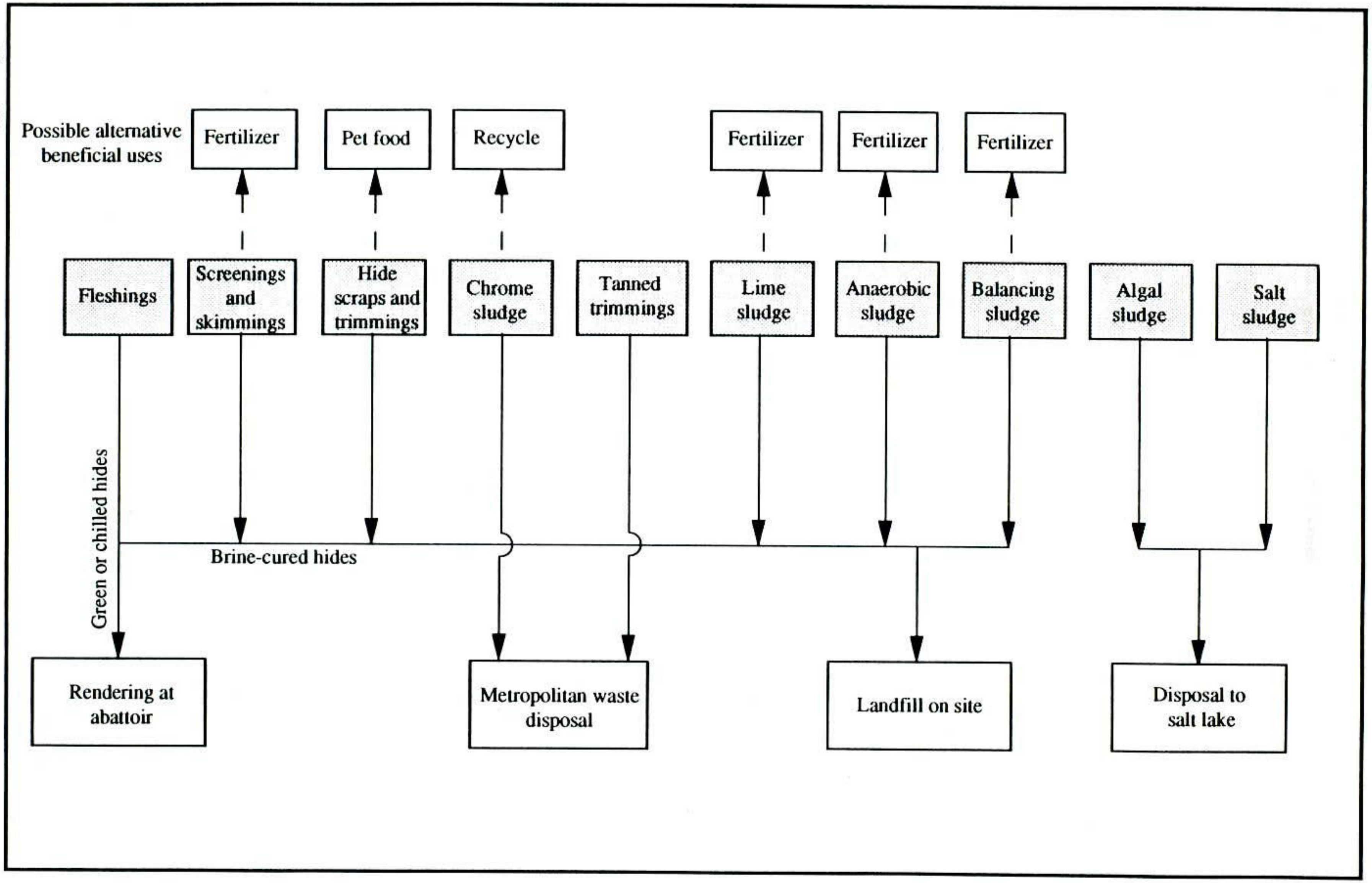
- miscellaneous sludges such as grease, hair and foam skimmed from the aeration tank and sludges separated from the balancing tanks;

- lime sludge from the pre-treatment of dehairing water, approximately 2 t/day (50% solids);

- chrome sludge from the pre-treatment of pickling and tanning wastewater;

- trimmings, which are imperfect hide pieces removed during inspection. A small proportion of these would contain chrome, having been removed during final inspection. The amount would vary with the quality of the hides used but is expected to average about 1 t/day;

Figure 6.5
SOLID WASTE DISPOSAL



- wastewater treatment sludges from desludging the anaerobic lagoons. This is expected to be necessary only every 5-10 years;
- salt sludges, which would accumulate at a rate of 800-1,200 t/a (90% solids).

In addition, various chemical containers, plastic wrappings and domestic solid waste would require disposal. The first six of the listed wastes would be produced daily.

6.8.1 SCREENINGS

Hair and hide scraps would be separated from the wastewater streams by screening and collected in hoppers alongside the screens. These would be disposed of by burial. These wastes are also suitable as fertilizer, containing high concentrations of nitrogen and sulphur, and would best be used by ploughing into crop land during summer. However, weed seeds carried in this solid waste are still likely to be viable so precautions would need to be taken to kill the resulting weeds.

6.8.2 FLESHINGS

Fleshings from green or chilled hides have a commercial value as they are suitable for rendering to recover tallow; where possible these would be returned to the abattoirs. Fleshings from salted hides, or if prompt return for rendering were not possible, would be disposed of by burial.

6.8.3 MISCELLANEOUS SLUDGES

Miscellaneous sludges, including the grease, hair and foam skimmed from the aeration tank and sludges separated from the balancing tank, could be used as fertilizer or buried.

6.8.4 LIME SLUDGE

After the pre-treated dehairing wastewater had been discharged to the balancing tank, the sludge would be removed and disposed of by burial or by spreading over the land. Lime sludge would consist predominantly of gypsum, with minor amounts of unreacted lime, calcite, phosphate, magnesium and manganese, and solid organic matter such as hair and grease. This waste would not be discharged to land suitable for construction of evaporation lagoons, as it might affect the ability of the clays to form a low permeability barrier. It would be used for fertilizer on Deras's land at suitable times and could also be used by farmers.

6.8.5 CHROME SLUDGE

Chrome sludge produced during pre-treatment of pickling and tanning wastewaters would be drained from the precipitation tank and allowed to drain. Drainage water would then pass to the facultative lagoon. Once a sufficient amount of sludge had accumulated, it would be removed by a licensed waste disposal operator. Approximately 200 kg/day (dry weight) of sludge is expected.

6.8.6 TRIMMINGS

Trimmings that had not been chrome-tanned may be used for gelatine manufacture or as an additive in pet food or animal feeds. Trimmings from the tanning industry are used for manufacturing much of the world's gelatine. Markets for these would be explored with the various manufacturers. There have been press reports of plans to establish a gelatine manufacturing plant in Western Australia. If markets could not be found, the trimmings would be disposed of by burial.

All chrome-tanned trimmings would be disposed of by removal along with chrome sludges. Only small quantities would be produced. Satisfactory methods to remove chrome from leather have been sought without success for many years, so recovery of the protein for food value is not possible. One possible option for reuse of chrome-tanned trimmings is in the production of leather board, a product similar to particle board; but it is unlikely that a suitable market could be located.

6.8.7 WASTEWATER TREATMENT SLUDGE

The sludges produced in the anaerobic lagoons would be buried on site.

6.8.8 SALT SLUDGE

The dried salt sludge would contain mainly sodium chloride, as well as sodium sulphate, sodium nitrate, sodium carbonate and other minor inorganic constituents. It would also contain algal and other microbial cells. The exact composition cannot be predicted with any confidence. The final disposal of this salt would be investigated after a better estimate of its composition became available, which would be when the first evaporation lagoon was filled. This is not expected to occur until after many months of operation (depending on the climate in the months after start-up). Waste salt would not be produced until some years of operation had elapsed, allowing adequate time for selection of a disposal method or site (in collaboration with the EPA). Some disposal options, in order of preference, include:

- disposal to a salt-lake. The salt would be evaporated as fully as possible, loaded on to trucks and disposed into a suitable salt lake to the east of the site;

- recovery for reuse in the pickling water. If the composition were predominantly sodium chloride and sulphate, it may be possible to reuse up to half of the waste salts to maintain the ionic strength of the pickling waters. In this case, it would be unnecessary to evaporate the brine to dryness;

- burial on site, after evaporation to dryness, in a clay vault contoured to shed rainfall. This is the method used to dispose of saline wastes from potash mining in Saskatchewan (Ritcey 1989) and may be used to hold salt temporarily if the previous options were being reviewed.

Deras is committed to the removal of evaporated salt sludges from the area to the satisfaction of the EPA.

Deras would prepare a management plan, within two years of tannery commissioning, describing how and where salt sludges would be produced, transported and disposed. This plan would be prepared in collaboration with, and to the satisfaction of, the EPA.

6.9 BURIAL OF SOLID WASTE

Waste would be buried in trenches in accordance with the principles of the Model Health By-Laws: no deeper than 1.8 m and covered each day with a layer of earth at least 0.23 m deep.

These requirements are designed to promote reasonably prompt decomposition while preventing generation of odours and deterring scavengers. The completed trench would be compacted, covered with topsoil and, if necessary, sown to pasture. Sites would be chosen so that the waste was buried into clay rather than sand.

It is expected that the organic wastes (largely protein or grease) would decompose quickly. The Shire of West Arthur has agreed to assist Deras in managing solid waste disposal, and would advise on management of the disposal area and inspect the technique used (refer to Appendix J).

6.10 ALTERNATIVES FOR SOLID WASTE DISPOSAL

Most solids and sludges could be disposed of at a municipal or shire tip in the region. This is not favoured for the following reasons:

- The current tip has a limited life and the Shire does not wish to reduce this (Appendix J).
- Deras would not be able to use the wastes to improve the fertility and soil quality of its own land.
- Traffic movements and transport costs would increase.

Another alternative for disposing of some solid waste would be to mix the screenings, trimmings, miscellaneous sludge, lime sludge, and anaerobic lagoon sludge with cereal straw to make a good quality compost for horticultural use.

Chapter Seven
ENVIRONMENTAL IMPACTS AND MANAGEMENT

7.1 IMPACTS ON WATER

7.1.1 IMPACTS ON GROUNDWATER

General

Groundwater beneath the site is expected to be of low quality. Clearing the forest for farming over the past 15 years would have reduced the interception and evapotranspiration of rainfall. The consequent increase in groundwater levels would have resulted in redissolution of salt. Where this groundwater is approaching the surface, salinization of soil and increased salt loads in streams are likely to result. Therefore, further increases in regional groundwater levels should be avoided.

Additional water would be applied to the soil (and contribute to groundwater) in three ways:

- leakage from the various lagoons, caused by the permeability of the clay liners;
- disposal of water as fertilizer over Deras's land (and possibly neighbouring properties);
- disposal of stormwater to infiltration sumps.

The volume of water removed from the palaeochannel each year would be at least 50,000 m^3. This would be replaced each year by recharge from rainfall. Of the 50,000 m^3 of water, approximately 16,000 m^3 would be applied to the land surface as fertilizer, and up to 5,000 m^3 may leak through the liners of the lagoons. Some of the water associated with fertilizer application is expected to be lost through evaporation or transpiration, because of the low application rate. The remainder of the water would be evaporated in the treatment and evaporation lagoons.

Leakage from the lagoons

The quantity of water leaking from the lagoons is difficult to estimate since the actual hydraulic conductivity of the liner is likely to be different from that estimated during laboratory testing.

Leakage from the two evaporation lagoons, the facultative lagoon and the anaerobic lagoon would be in proportion to the depth of the water above the liner. The estimated volumes of water leaking from each lagoon have been estimated, and are shown in Table 7.1. The estimated volume of water leaked to the profile beneath the lagoons is about 5,750 m^3/a. This is about three times the drainage occurring at present. Root channels beneath the liners would not conduct water, since the tops would be sealed by the liner, and so water would move downwards through the clay as a uniform front. Since the rapid recharge of groundwater through root channels would be prevented, the water table below the lagoons would drop initially. After 15 years the water leaked from the lagoons would reach the groundwater table and water levels would rise.

The quality of leaked water is dependent on the salinity in the individual lagoons, which has been estimated based on typical weather conditions and operation. A worst-case scenario has been made of the leakage that would occur based on estimates of the lagoon salinities and leakage volumes shown in Table 7.1.

Table 7.1 **Estimated water and salt loads to profile**

Lagoon	Dissolved salts (mg/L)	Annual leakage	
		Volume of water (m^3)	Mass of salt (t)
Anaerobic lagoon	32,000	600	19
Facultative lagoon	43,000	1,950	84
First evaporation lagoon	67,000	1,300	87
Second evaporation lagoon	175,000	1,300	228
Total		**5,750**	**418**

Information shown in this table has been estimated assuming the clays have the hydraulic conductivity described in Appendix F. The quantities of leaked water and salt derived from these estimates are likely to be considerably greater than would occur in practice. The following factors would contribute to a decrease in leakage:

- blinding has been ignored. The lagoon bases would nevertheless seal up over a period of 1-3 years after commissioning;
- during the initial years of operation, the salinity of water in the lagoons would be less than that estimated in Table 7.1. It would require more than 5 years for the lagoons to accumulate the quantity of salt shown. During this time, blinding would occur;

- during the initial years of operation, less lagoon area would be involved, because lagoons would be constructed as needed. For example, the final evaporation lagoon would be required after 12-18 months of operation, and the second after 3-4 years;

- as shown in Section 5.1.2, total waste volumes are likely to be overstated by 15%.

Overall, it is considered that actual steady state leakage, both of water and salt, would be less than half of that shown in Table 7.1.

The estimated volume of water leaked in the worst-case scenario would produce about a 100 mm/a increase in the recharge to the groundwater. When native vegetation is cleared and replaced by crops or pastures, the increase in recharge is 25-50 mm/a (Richard George, pers. comm., 1991). The increase in recharge from the four lagoons (with a total area of 4 ha) is therefore equivalent to the impact of clearing approximately 12 ha of native vegetation.

An estimated 6,000 t of salt is currently stored in the soils underneath the lagoons. While an additional 418 t of salt of predicted to leak from the lagoons, this represents a relatively insignificant addition to the estimated 45 million tonnes of salt already stored in the soils on the upstream catchment of Dardadine Creek. Therefore, only a minimal effect on the salinity of Dardadine Creek would occur, as described in Appendix E.

Leakage would be monitored by observation of water levels in 8 bores, 1 bore down to the granite to the west and 7 shallow bores into the clay north and south of the lagoons, as described in Chapter 8. This would allow remedial action if observed increases in water levels were greater than expected. If necessary, Deras would establish recovery bores and return leaked water and salt to the evaporation lagoons.

Fertilizer water

In this section, it has been assumed that all the fertilizer water would be irrigated on to the 30 ha of land set aside for this purpose. There would be sufficient nitrogen to fertilize up to 200 ha of pasture at a rate of 180 kg/ha—at which leaching does not occur (Starr and DeRoo 1981).

In the first year of operation, 7,300 m^3 of of fertilizer water would be produced. At full production, about 16,000 m^3 would be produced. As mentioned previously, Deras intends to promote the use of the wastewater among neighbouring farmers.

This wastewater would be used to fertilize 30 ha of the tannery site (Figure 6.4). Based on the hydrological analysis reported in Appendix E, this would result in a 5 mm/a increase in recharge at a salinity of 7,600 mg/L. The salinity of the drainage water would be of the same order as the 9,000 mg/L salinity of the water in the clay sediments or weathered granite as measured in bore DT4 (Appendix G.2). The increase in recharge is equivalent to that caused by clearing 4 ha of land and the salinity of the drainage water would not adversely affect the regional groundwater.

The wastewater would have a total nitrogen content of 2,100 mg/L. The loading of nitrogen during the winter of the first year would be 577 kg/ha. Approximately one-third of this nitrogen is ammonia. Of this, approximately 60 kg would be lost by volatilization. The pasture is expected to uptake 100-200 kg. A large portion of the remaining 300-400 kg is expected to be gradually converted to nitrate and to be subsequently denitrified by the reaction with organic matter in the waste.

There is still likely to be some nitrate seepage downwards into the regional groundwater. However, even if half the applied nitrogen were to reach Dardadine Creek, the nitrogen content of the water in the Creek would be increased by less than 1 mg/L. Therefore, even in this most pessimistic scenario, the impact on the Creek water would be insignificant.

The wastewater used as fertilizer has a BOD of 6,000 mg/L. The application of 75 m^3/day of wastewater would therefore result in an average daily BOD loading of 15 kg/ha for the 30 ha of pasture. This is only half of the normal loading adopted by the Water Authority of Western Australia for the design of land disposal systems for dairy wastes. On the basis of this information no adverse environmental impacts are expected from the proposed BOD loading.

7.1.2 COMBINED IMPACT ON GROUNDWATER

The impact of the leakage from the evaporation lagoons and the application of wastewater as fertilizer over 30 ha of the site has been analysed in some depth by hydrological consultants (Appendix E). From this and other analyses it is concluded that:

- The effects of the increase in recharge due to leakage from the lagoons would be relatively insignificant: it would be 15 years before the leakage caused any impact on the level of the regional groundwater and 60 years before the salinity of groundwater was affected.

- Disposal of 8,000 m^3/a (half of the ultimate production) of the fertilizer water on 30 ha of the site would only increase the existing recharge by 14% and would have a minimal effect on the regional groundwater and its salinity.

7.1.3 SURFACE WATER QUALITY

Deras has agreed with a number of farmers, whose properties border the Dardadine Creek or Hillman River, who believe that discharge to this surface water may affect their ability to use this water for stock. Therefore, all wastewater would be either spread very thinly as fertilizer at significant distances from the Creek or evaporated in lagoons.

The impact of the proposed system of waste disposal on surface water quality has also been analysed (Appendix E). From this and other analyses it is concluded:

- It would take about 60 years for leakage from the evaporation ponds to cause an increase in salinity in the regional groundwater under the ponds, and a further 8 years before the increase in salinity had any effect on the flow in Dardadine Creek.

- It would be about 5 years before any increase in salinity in the regional groundwater (caused by spreading the wastewater as fertilizer on the site) reached Dardadine Creek.

- If all of the salts from the fertilized area and the evaporation pond leakage were to reach Dardadine Creek, the increase in average salinity of the water flowing in the Creek would be 48 mg/L. This represents only a 1% increase in the salinity of 4,850 mg/L measured in September 1990 when the salinity of the streamflow would be expected to be near the lowest level for the year.

- This increase in salinity in Dardadine Creek would cause the average salinity of the Hillman River to increase by 25 mg/L. This represents only a 1% increase in the average salinity of 2,500 mg/L recorded by the Water Authority of Western Australia. The water would remain suitable for stock and for careful irrigation of salt-tolerant plants.

- The nitrogen applied as fertilizer would not result in pollution of Dardadine Creek: if as much as 50% of the nitrogen were to reach Dardadine Creek, the nitrogen content of the water in the Creek would only be increased by around 1 mg/L.

Should a failure in the wastewater system occur, Deras would take immediate remedial action to ensure contaminated water did not reach the Creek. The risk of earthquake damage has been considered in Section 4.1.2, and can be discounted. The lagoon walls would be inspected regularly for signs of erosion or damage, and timely remedial action taken if any were observed.

7.1.4 MANAGEMENT OF STORMWATER AND FLOODING

Stormwater runoff from roof and site drainage would be disposed of separately from the wastewater treatment system. Runoff would be collected in open gully drains and directed to sumps for disposal by evaporation and/or infiltration through the ground.

Interceptor drains and bunds would be constructed around the solid waste disposal areas where required, to prevent erosion and possible contamination of the runoff waters. These drains would be designed to return stormwater to the natural drainage system.

The wastewater treatment system would be designed to consider the effects of wet years and would incorporate adequate safety factors to contain extreme rainfall events. The lagoons would be sized to maintain a minimum freeboard of 0.6 m to prevent overtopping by wave action. The location of the lagoons on a ridge would reduce the possibility of flooding, both from rainfall and from flooding of the local streams.

7.2 ECOLOGY

The tannery would not have a major effect on the ecology of the area. Potential areas of impact include breeding of mosquitoes and spreading of weeds and diseases.

7.2.1 FAUNA AND FLORA

The development would create several hectares of permanent open water, with a potential for breeding mosquitoes and attracting waterfowl such as ducks.

Mosquitoes breed throughout the year in waters of varying salinities. Some are known to be capable of breeding in facultative lagoons: these include the complex *Anopheles annulipes*, *Culex fatigans*, *C. annulirostris* and *C. molestus*. The *A. annulipes* rarely attacks man, but the *Culex* species are common and attack both man and birds. Mosquitoes known to carry (and possibly to transmit) Ross River Virus include *Aedes vigilax*, *A. camptorhynchus* and *C. annulirostris*. The first two are not known to be lagoon breeders, preferring tidal salt marshes, but the other is known to breed in poorly maintained lagoons.

Little is known about the ability of these species to breed in water of the quality expected in the facultative lagoon. The salinity of this water is expected to vary between 30,000-60,000 mg/L, depending on the season; it may be as low as or lower than seawater (32,600 mg/L) during winter. Breeding may occur during this time.

Normally, predators in the water (dragonfly larvae, etc) keep mosquitoes under control, except where the mosquito larvae can shelter among emergent macrophytes or similar objects. Good lagoon maintenance includes prevention of macrophyte growth. It is expected that macrophytes would not be able to grow in any of the proposed lagoons owing to the high salinity; but it is not known whether mosquitoes or their predators would be able to flourish (T. Wright, Department of Health, pers. comm., 1990). Mosquito larvae can be controlled by spraying with chemicals: the approved insecticide, Abate, would be used if and as required.

A large variety of waterfowl, including ducks, are likely to visit or be resident in the area. Ducks are regarded as a nuisance by some farmers because they affect dam water quality and eat grain crops. The high salinity of the water in the lagoons, the absence of food organisms in the water or sediment, and the absence of shelter near the lagoons is expected to discourage waterfowl. The majority of native vegetation around the site has been cleared. There would be only limited additional removal of natural vegetation (and associated habitats): those trees along the ridge on which the lagoons would be built, and other trees likely to interfere with evaporation.

7.2.2 WEED AND PEST CONTROL

There is the potential for diseases and weed seeds to be introduced into the area via unprocessed hides or vehicles: this risk is considered small. All hides would be purchased from accredited abattoirs as required by the *Agriculture and Related Resources Protection Act, 1976*. All hides imported into the State would be inspected by the Agriculture Protection Board to ensure declared noxious species were not introduced on either the hides or the vehicles.

The majority of hides are expected to come from animals raised and slaughtered within 250 km of the site, so most of the associated weeds, pests or diseases would have already had an opportunity to establish in the area. Animal diseases tend to be carried in the live animal, not on hides; so the risk of animal diseases being introduced is small. Transport vehicles would not pass through areas of dieback-infected forest or any locations subject to quarantine restrictions.

Weed seeds and disease organisms would be removed from the hides during the first two steps of processing (washing and dehairing). Washing water would be treated and evaporated rather than being used as fertilizer. Organisms in the dehairing wastewater are expected to be eliminated by the severe conditions of the dehairing process. The subsequent physical–chemical treatment of the dehairing water would remove most of the large suspended particles such as seeds; these would settle into the lime sludge or float into the skimmings of hair and foam. The treated wastewater is expected to be free of weed seeds and diseases.

Deras would regularly inspect its land for weed growth, and promptly remove any weeds that were found. All waste disposal areas would be maintained to the satisfaction of the Health Department of Western Australia and the Shire of West Arthur.

Fungal spores (e.g. ring worm) may be carried on the green hides, or in the dirt and mud on hides and trucks. *Phytophthora* species, which cause dieback disease, are widespread in the South-West. Since the tannery site is located some distance from existing vegetation, the presence of jarrah dieback at the site cannot be determined. However, *P. citricola*—the only *Phytophthora* species known to affect pasture—may be introduced. Pasture thus affected has been successfully treated at various locations within the South-West (B. Shearer, Department of Conservation and Land Management, pers. comm., 1991).

Deras would control insects and weeds around the wastewater treatment system (including the lagoons and any sludge drying facilities or temporary stock holding areas) to the satisfaction of the EPA.

7.3 ODOUR

Prompt burial of the solid waste would prevent odour generation. Odours may be generated during desludging of the anaerobic lagoons. Unfortunately, little can be done about this. However, it is likely that desludging would need to be carried out only every 5 or more years. Even if odours were produced, it is unlikely that they would cause any significant nuisance. The nearest residents are 3 km away, and to the north-west. Winds in this direction occur only about 8-12% of the time (Section 4.1.1). Deras would consult residents before desludging, and attempt to select an occasion when the strength and direction of the winds were favourable for minimizing odour nuisance.

The most likely source of persistent odour generation would be the wastewater treatment lagoons, particularly the evaporation lagoons. These would be designed and operated to reduce the likelihood of odour generation: a large amount of organic matter would be removed from the wastewater (using both physical/chemical and biological means), and some sulphur would be removed where feasible. The presence of nitrate in the wastewater would help maintain oxic conditions in the evaporation lagoons, thereby helping to prevent generation of odours.

If, despite these precautions, odour problems were to occur, the problem may be managed or eliminated by one or more of the following:

- immediate addition of sodium nitrate to restore oxic conditions in the water;
- operation of surface aerators, or use of other methods, to increase the access of oxygen to the water;
- draining and desludging of the lagoon in question.

7.4 CHEMICALS

Most of the chemicals used in the beamhouse and tanyard processes or for waste pre-treatment do not present any environmental or occupational health concerns. Local residents have questioned the effects and fate of the chromium, manganese and fungicides used in the processes. This is addressed below.

7.4.1 CHROMIUM

Chromium salts are used in the tanning process and appear in the pickling and tanning wastewater. This wastewater would be drained from the tanning drums, then neutralized and settled. The sludge would be drained on a drying bed and the solids disposed of by a licensed waste disposal operator. Drainage from the precipitation tank and the drying bed would be sent directly to the facultative lagoon.

Two oxidation states of chromium are relatively stable at the pH and Eh found in natural environments: chromium (III) and chromium (VI). Only chromium (III), would be used in the tannery. A recent review of the chemistry, toxicology and pharmacokinetics of chromium compounds re-emphasized the fact that no known human health effects (except those caused by a dietary deficiency of chromium, traces of which are essential for good health) have resulted from use or ingestion of chromium (III) compounds (Golden and Karch 1989).

Chromium (VI) compounds, however, have been implicated (by several epidemiological studies) in the incidence of lung cancers in persons employed in the chromate-manufacturing industry. Chromium (VI) is thought not to be carcinogenic after oral ingestion or dermal exposure. Conversion of chromium (III) to chromium (VI) under the conditions of use or proposed disposal is not favoured thermodynamically, because of the presence of reducing agents (particularly organic matter) and the great insolubility of chromium (III) compounds under neutral or mildly alkaline conditions.

7.4.2 MANGANESE

Manganese would be used as an aeration catalyst to speed up oxidation of sulphide during the pre-treatment of dehairing wastewater. The optimum concentration would be determined by experimentation, and may be as low as 1 mg/L (Martin and Rubin 1978). This manganese would be disposed of predominantly in the lime sludges (Section 6.8.4). Manganese is a common constituent of soils and of groundwater. Manganese in soil water, released as a result of acidification of soil or during sterilization of horticultural soils with steam, can be toxic to plants`(phytotoxic). Plants can also suffer manganese deficiencies: in the Wheatbelt, manganese is added to soils as an essential trace element.

There is a possibility that burying residues from aeration would increase manganese concentrations in the soil, if the higher concentrations of manganese described in Section 6.3.1 were required. However, this is not considered likely to result in phytotoxicity because the lime sludges would be alkaline and contain considerable residual alkalinity, which would maintain the manganese in an insoluble form. In addition, these sludges would generally be buried at depth (Section 6.9).

However, to prevent any possibility of phytotoxic effects, Deras would undertake to regulate disposal of solid waste in accordance with guidelines from the New South Wales Department of Agriculture and Fisheries (Awad, Ross and Lawrie 1989), which give loadings and rates for metals (in sewage sludge) applied to soils.

7.4.3 FUNGICIDES

Residual fungicides that are not absorbed by the hides or degraded during pre-treatment would pass (with the pickling and tanning wastewaters and samming wastewater) to the facultative lagoon.

The active ingredients in the fungicide formulations are likely to be either a mixture of phenols or an organic sulphur-nitrogen compound. Both are reputed to be readily degradable in biological treatment. In addition, the sulphur-nitrogen compound is known to degrade chemically by hydrolysis and also photochemically (by the action of light) (Appendix H). Consequently, fungicides would pose no threat to human, animal or pasture health: they would be contained entirely within the treatment and evaporation system and degraded very quickly.

7.5 VISIBILITY AND APPEARANCE

The buildings would be situated 1.8 km from the Hillman–Dardadine Road. Because of the topography of the land and the location of trees, the tannery buildings and waste treatment and disposal facilities would not be clearly visible from this main public road, or from neighbouring dwellings. The facilities are expected to consist of a large shed-like building with a number of tanks and lagoons nearby. Trees would not be planted or retained close to the treatment and evaporation lagoons because this would impede wind movement and hence reduce re-aeration and evaporation rates. Deras would consider planting trees in the north-west corner of the site (or to lease this area for others to plant), if this area were to become waterlogged.

Three months before commissioning the plant, Deras would submit a landscaping plan (tree planting) to the EPA for approval, to ensure the amenity of the area was retained

7.6 NOISE

Tanneries do not generate much noise. The topography of the site and the distances from neighbouring dwellings would result in no noise impact on residents. Transport operations are likely to produce some brief and low-level noise, which would be detectable by a few residents. Waste treatment facilities would generate some low-level noise: the blowers supplying air to the aeration tanks would generate some noise during the morning and, if aerators were used on treatment ponds, these would generate some additional noise probably throughout the entire day.

7.7 DUST

The risk of dust generation would be greatest during the construction period. All construction work would be performed in accordance with the Dust Control Guidelines (EPA 1990). These require dust concentrations, as measured at the site boundary, to be limited to 1,000 mg/L. Deras would do its best to meet this figure, although cyclonic winds or other phenomena beyond its control may result in greater dust generation through loss of soil from its land.

Appropriate measures would be taken to prevent dust from being generated by vehicles at the site: roadways and parking lots would be sealed or otherwise maintained. Clearing would be limited to the minimum necessary for construction and efficient operation of the tannery and waste treatment and disposal facilities. Cleared surfaces would be restored and sown to pasture (or covered with stored topsoil) as soon as practicable.

Deras would ensure that dust, odour and noise would be controlled at all times to the satisfaction of the EPA. All machinery with a potential to cause nuisance noise levels would be enclosed to ensure that noise levels were satisfactory to the EPA.

7.8 TRAFFIC

As indicated in Section 4.7, there would be approximately 34 truck movements per week associated with the transportation of hides and chemicals. Workers and visitors to the tannery would make up to 60 vehicle journeys per day, if there were no sharing of vehicles or if no bus transport were developed. There are currently 38-40 traffic movements per day along the Hillman–Dardadine road (Shire of West Arthur, pers. comm., 1991).

Traffic levels may be high during the construction period. A workforce of 30-35 people and a construction period of around 20 weeks are envisaged. About 60 traffic movements per day is expected during this period, together with vehicle use on site.

The Shire of West Arthur has agreed both to upgrade Shield Road and to complete a planned extension of this road to pass near the site. Since public roads would be used, all traffic would be bound by government regulations, particularly in relation to quarantine, safety and transport of hazardous goods.

No unique transport problems are expected to be generated by the tannery project. A likely benefit is that the increase in traffic movements along the Hillman–Dardadine Road could justify an application to the Main Roads Department for funding to assist with sealing. Deras would endeavour to assist the Shire of West Arthur with an application for such funding.

7.9 FIRE

The tannery would be located in an area with a potential for grass fires in the summer. Tanneries introduce negligible fire risks; however, there would be some additional risk (as a result of careless disposal of cigarettes or similar incidents) associated with the increase in population. If propane gas were to be used for water heating, it would be handled, stored and used in an approved manner. Flammable solvents are not required in the tannery processes, so only minimal quantities are likely to be used.

To further minimize fire risk, Deras would:

- consult the Western Australian Bush Fires Board, the Shire of West Arthur and the local volunteer fire brigade to determine suitable management strategies and emergency procedures;
- provide fire hydrants and extinguishers to the satisfaction of the Western Australian Fire Brigade and in accordance with Government requirements;
- maintain suitable fire breaks around the tannery buildings and the borders of the land to be purchased;
- impose a ban on smoking outside the buildings in summer.

7.10 RESPONSIBILITIES TO NEIGHBOURS

As a neighbouring landowner, Deras would assume the following responsibilities:

- prevent the stock grazing on its land from straying on to roads or neighbouring properties by maintaining stock-grids, gates and fences;

- maintain the health of these grazing animals (although Deras would not own or manage them), and inspect the animals for lice, footrot and similar conditions:

- keep pastures weeded to the standard considered acceptable in the area and, in particular, inspect for introduced weeds. The presence of any declared plants would be brought to attention of the Agriculture Protection Board;

- exercise care in the use of herbicides;

- assist in the control of rabbits;

- promptly notify owners of animals straying on to Deras's land;

- avoid contaminating dam water stored on the site or other properties, or creek water.

7.11 AIRFIELD

The landing ground used by the Hillman Farm Skydivers Inc. Club is approximately 2 km north-west of the site. The Civil Aviation Authority places restrictions on constructing high buildings in the direct line of runways and on night lighting near airfields under its jurisdiction. Although the airfield near the site is not controlled by this Authority, Deras would not construct buildings in the direct line of the runways. The tannery buildings, which are likely to be a maximum of 10 m high, may be lighted at night for security purposes: this would not affect the runways seeing as they are not used at night.

Deras would modify its pollution control operations, if it could not meet its licence conditions, so that environmental impacts were reduced to a level acceptable to the EPA.

Deras would be responsible for decommissioning the plant and rehabilitating the site and environs to the satisfaction of the EPA.

Deras would, at least six months prior to decommissioning, prepare a decommissioning and rehabilitation plan to the satisfaction of the EPA.

Deras would not transfer ownership, control or management of the project, without consulting the EPA and the Minister for the Environment.

Chapter Eight
MONITORING

Proper operation of any waste treatment and disposal system requires regular monitoring to ensure that proper treatment is being achieved and to enable the prediction or detection of malfunction. The general principles of monitoring are set out below; a detailed programme would be submitted to the EPA for approval before plant commissioning.

8.1 INSPECTION AND MAINTENANCE

Deras's responsibilities would include:

- maintaining the surrounds of the wastewater treatment lagoons: trimming grass cover; maintaining fences; noting bank degradation (to allow remedial action); and documenting the lagoon ecology;

- inspecting and maintaining solid waste disposal practices to prevent odours and unsightly conditions, and to deter scavenging by birds, rodents and other animals;

- inspecting its land regularly to allow early detection of weed growth, pasture loss, dust creation, waterlogging, or other problems;

- maintaining the physical and mechanical operability of the waste treatment system;

- observing the behaviour of fauna, from mosquitoes to mammals.

Careful attention to these and similar details is considered to be the most important part of environmental monitoring and management.

8.2 MONITORING OF WASTEWATER TREATMENT

The quality of the wastewater would be monitored at each major location in the treatment system. Measurement of parameters such as pH, BOD, dissolved salts, suspended solids (using visual or microscopic observation), major ions, chromium and nutrient species would indicate whether the wastewater facilities needed expanding. Because of the long detention time in the lagoons, only occasional (monthly) sampling frequencies would be necessary.

8.3 MONITORING OF THE WIDER ENVIRONMENT

8.3.1 SURFACE WATER AND GROUNDWATER QUALITY

Two observation bores would be established: on the west end of the line of evaporation lagoons and close to Shield Road in the north-west corner of the site. These would be used to monitor groundwater levels and occasionally to provide water samples for analysis of salinity. If unusually large increases were recorded, further investigation would be undertaken to establish whether the lagoons were leaking. In this case, a bore may be established on the land to the west (CG 9983), in co-operation with the landowner, to detect any change in salinity or unexpected increases in water levels at this point. The background rate of rise of the regional groundwater levels would be monitored at a third bore situated well away from the development.

In addition, 12 shallow bores would be established to monitor the quality of water in the perched water that develops during winter. These would be located as shown in Figure 8.1. Bores close to lagoons are intended to detect possible leakage through the sides of the lagoons. Bores near the solid waste disposal area and those in the north-west corner of the site are intended to detect possible movement of nitrogen and salts (in seepage water) to neighbouring properties.

Deras has agreed to monitor water quality in the Dardadine Creek, even though the tannery is not likely to affect the quality of water in this Creek. Since nitrogen and dissolved salts are the only pollutants likely to reach the Creek, the concentration of nitrate and the electrical conductivity would be recorded regularly.

A trench would be constructed in the gully draining the south-west corner of the site. Water collected there, from runoff or seepage, would be analysed regularly for a full range of parameters. The water quality in the dam (on CG 9983) close to Shield Road would also be monitored.

8.3.2 WATER SUPPLY

Monitoring of the palaeochannel aquifer would be carried out as recommended in Appendix G.3. This would require weekly monitoring of water levels in the production bores and nearby observation bores, and monthly monitoring of the levels in distant observation bores. In addition, pH, temperature, electrical conductivity and nitrate measurements would be made on water from the bore. This programme would be reviewed after one year.

8.3.3 OTHER ISSUES

Monitoring of odour, noise or chemical parameters (such as ambient hydrogen sulphide concentration) would be undertaken only if warranted (i.e. if perceptible to tannery employees or nearby residents.

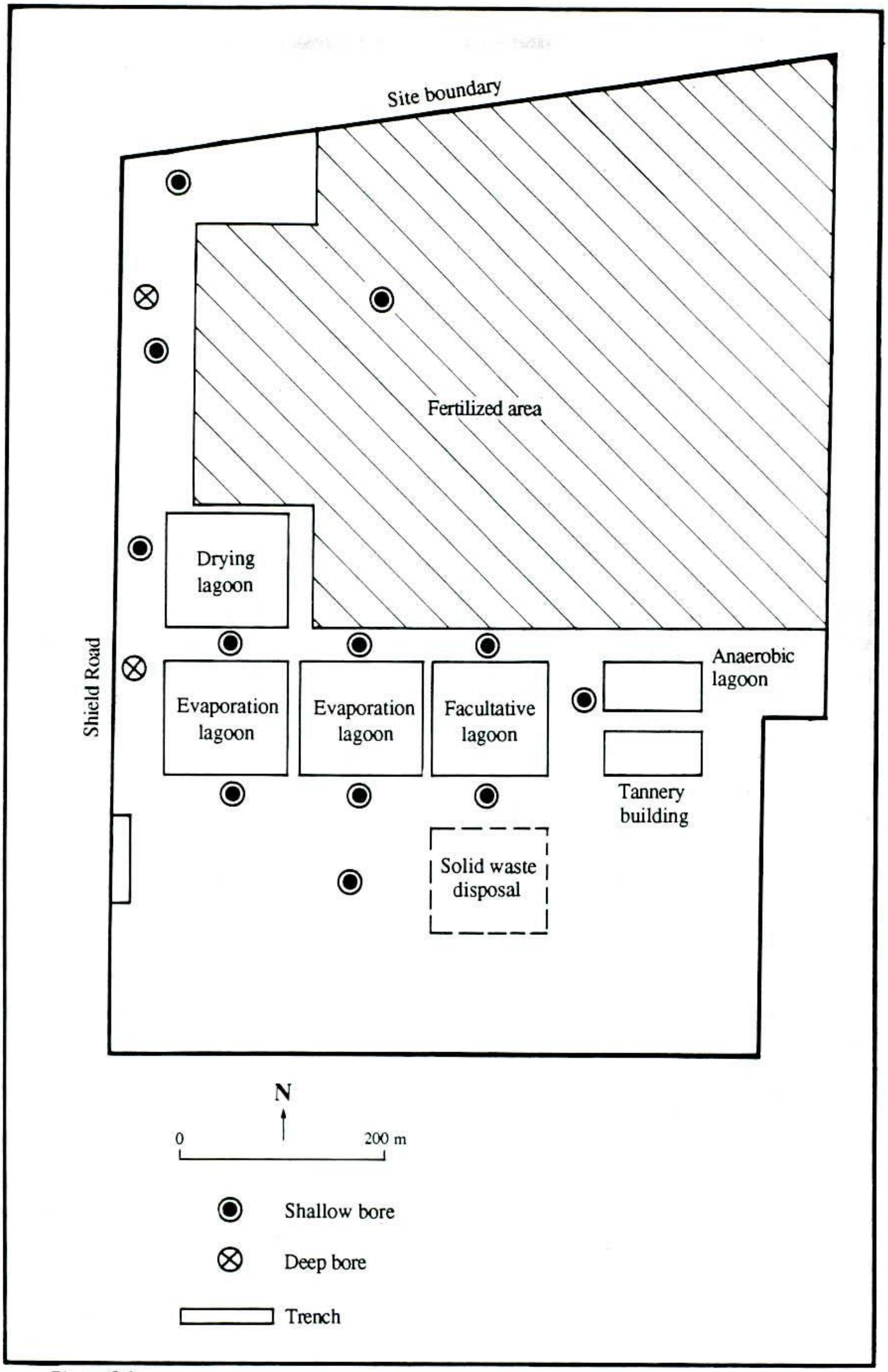


Figure 8.1
LOCATION OF MONITORING BORES

Prior to construction, Deras would submit and subsequently implement a monitoring programme to the satisfaction of the EPA.

The monitoring programme would include:

- **initial baseline sampling period to determine the status quo;**
- **parameters to be measured;**
- **sampling sites and times;**
- **reporting times to the EPA;**
- **a commitment to modify the environmental management programme, if necessary, to reduce the impact of pollution to the satisfaction of the EPA.**

All samples taken in the monitoring programme would be analysed in a laboratory acceptable to the EPA. In the event that the monitoring programme indicated an adverse environmental impact was occurring or developing, Deras would alter the tannery operation or introduce additional environmental management controls as necessary, to reduce the impact to a level acceptable by the EPA.

8.3.4 SOCIAL

Deras would consult local residents, the Shire of West Arthur and relevant government authorities to ensure that adverse social impacts were minimized. These consultations would be documented and available for inspection.

It is proposed to carry out a study of the socio-economic effects of the establishment of the tannery on the Shire of West Arthur and surrounding areas. Because the tannery would be the only development in the area for some distance, the study would give a clear measure of the tannery's impacts, which would be valuable for planning a similar development.

Ongoing consultations and a policy to use local resources where available would help detect and predict social or economic impacts.

Chapter Nine

CONCLUSIONS

Development of a tannery as described in this review would have a number of advantages. The leather industry would benefit from the establishment of a secure source of supply of wet-blue leather, and the abattoirs would find a market for half of the hides they produce.

The community of Darkan and neighbouring towns and shires would benefit both directly and indirectly from the economic activity generated. The tannery would employ 30-35 people in a wide variety of roles. Most employees could be obtained from the Darkan area, although a number of positions require experience and skills not likely to be found locally. The tannery would require transport services, and a wide range of support services from skilled tradespersons, equipment suppliers, and construction contractors.

The effects of the tannery on the physical environmental would be very small. The tannery would produce no noise, there would be only a limited area from which dust could be generated, and precautions to prevent fires would be taken. Considerable care to limit the production of odours has been taken during design of the waste-treatment facilities.

Solid wastes would be removed from the site for further processing into valuable by-products, if possible, and otherwise buried in an approved manner. These buried wastes would breakdown very quickly; most could be used as soil conditioners or fertilizers.

Wastewater would receive extensive treatment before evaporation. Salt produced by evaporation would be removed from the area for disposal. Non-saline wastewater would be used as fertilizer, and would be available to neighbouring farmers.

Some degree of additional increase in regional groundwater levels would result from irrigation of the fertilizer and from leakage from the lagoons. The effects of this would be small, equivalent to clearing a few hectares of land. Water leaking from the evaporation lagoons would carry salt into the soil profile, and there would be some salt in the fertilizer water. Even if all this salt were to pass to the Dardadine Creek, it would increase the salinity by only 1%.

An extensive monitoring programme would provide information to enable management of the environmental effects. If parts of the waste disposal system were not performing as well as expected, they would be modified to eliminate the defects.

REFERENCES

Awad, A.S., A.D. Ross, and R.A. Lawrie. 1989. *Guidelines for the use of sewage sludge on agricultural land.* New South Wales: Department of Agriculture and Fisheries.

BASF (n.d.) *Pocket book for the leather technologist.* 2nd Ed. Ludwigshafen, Germany: BASF AG.

Bayer (n.d.) Baychrome C process. Technical advice bulletin. Leverkusen, Germany: Bayer AG

Bayer. 1983. *Tanning, dyeing, finishing.* 4th Ed. Leverkusen, Germany: Bayer AG.

Beard, J.S. 1981. Vegetation survey of Western Australia. The vegetation of the Swan area. Nedlands: University of Western Australia Press.

Bernhard, C., and N. Kirchgessner. 1987. A civil engineer's point of view on water tightness and clogging of waste stabilization ponds. Water Science and Technology, 19:365-367.

Bouwer, H. 1978. *Groundwater Hydrology.* New York: McGraw-Hill.

Davis, M.H., and J.G. Scroggie. 1980. Theory and practice of direct chrome liquor recycling. Das Leder. 31:1-8.

Department of Conservation and Land Management. 1987. Draft management plan central forest region. Western Australia: Department of Conservation and Land Management.

Department of Regional Development and the North West. 1988. Central south regional profile. Western Australia: Department of Regional Development and the North West.

Dimmock, G.M., E. Bettenay, and M.J. Mulcahy. 1974. Salt content of lateritic profiles in the Darling Range, Western Australia. Aust. J. Soil. Res., 12:63-69.

Environmental Protection Authority. 1990. *Dust control guidelines. Guidelines for the assessment and control of dust and airborne material for land development sites.* Perth, Western Australia.

Gaull, B.A., and M.O. Michael-Leiba. 1987. Probabilistic earthquake risk maps of southwestern Western Australia. BMR Journal of Australian Geology and Geophysics. 10:145-151.

GHD-Dwyer. 1985. Report on a study of oxidation pond performance and design. Report no. WRB 121. Western Australia: Public Works Department.

Golden, R.J., and N.J. Karch. 1989. Assessment of a waste site contaminated with chromium. In *The risk assessment of environmental hazards. A textbook of case studies*. D.J. Paustenbach, ed., 577-598. New York: Wiley.

Goldman, L.J., L.I. Greenfield, A.S. Damle, G.L. Truesbury, C.M. Northeim, and R.S. Truesdale. 1990. *Clay liners for waste management facilities. Design, construction and evaluation*. New Jersey: Noyes Data Corporation.

Hart, B.T. 1974. A compilation of Australian water quality criteria. Technical paper no. 7. Canberra: Australian Water Resources Council.

Hingston, F.J., and V. Gailitis. 1976. The geographic variation of salt precipitated over Western Australia. Aust. J. Soil Res., 14:319-35.

Hodgkin, E.P. 1978. An environmental study of the Blackwood River Estuary, WA 1974-75. Report No. 1. Perth: Department of Conservation and Environment.

Irving-Bell, R., and P. Liehne (revised A. Blair). 1978. A means of identifying the common mosquitoes of the Perth metropolitan area. Bulletin No. 42. Perth, Western Australia. Department of Conservation and Environment.

Johnston, C.D., and W.M. McArthur. 1981. Sub-surface salinity in relation to weathering depth and landform in the eastern part of the Murray River catchment area, Western Australia. Land Resources Management Technical Paper no. 10. CSIRO.

Kinhill Engineers Pty Ltd. 1990. Report on the water supply reservoir water quality. Report for Worsley Alumina Pty Ltd. Boddington gold mine. Perth: Kinhill Engineers Pty Ltd.

Luke, G.J., K.L. Burke, and T.M. O'Brien. 1988. Evaporation data for Western Australia. Technical Report 65. Perth: WA Department of Agriculture.

Martin, J.L., and A.J. Rubin. 1978. Removal of sulphides by catalytic oxygenation in alkaline media. In *Proceedings of the 33rd Purdue industrial waste conference*, ed J.M. Bell, 814-822. Lafayette, Indiana: Ann Arbour Science.

McFarlane, P.N., and H. Melcer. 1978. Evaluation of parameters for the design of anaerobic lagoons treating fellmongery (unhairing) wastewater. In *Proceedings of the 33rd Purdue industrial waste conference*, ed. J.M. Bell, 479-486. Lafayette, Indiana: Ann Arbour Science.

Pierce, J.J., G. Sallfors, and E. Peterson. 1986. Clay liner construction and quality control. J. Environ. Eng. ASCE. 112:13-24.

Petrovic, A.M. 1990. The fate of nitrogenous fertilizers applied to turfgrass. J. Environ. Qual. 19:1-14.

Pfennig, N. 1989. Ecology of phototrophic purple and green sulphur bacteria. In *Autotrophic bacteria*, eds H.G. Schegel and B. Bowien, FEMS Symposium 42. Gottingen: Science Tech/Springer Verlag.

Ritcey, G.M. 1989. *Tailings management. Problems and solutions in the mining industry*. Amsterdam: Elsevier.

Rowswell, R.A., D.R. Cooper, and S.G. Shuttleworth. 1985. Evaporation ponds: a solution for tannery effluent disposal. J. Soc. Leath. Technol. Chem., 69:123-129.

Schultz, T.J., T. Jones, and D. Barnes. 1987. Aerobic/anaerobic stratified lagoon for the treatment and storage of high strength wastewater. Technical papers of the 12th Federal convention. Adelaide: Australian Water and Wastewater Association.

Speece, R.E., and G.F. Parkin. 1983. The response of methane bacteria to toxicity. In *Proceedings of the third international symposium on anaerobic digestion*. 23-35. Boston, Mass: Third International Symposium on Anaerobic Digestion.

Starr, J.L., and H.C. DeRoo. 1981. The fate of nitrogen applied to turfgrass. Crop Sci. 21:531-536.

Steel, E.W., and T.J. McGhee. 1979. *Water Supply and Sewerage*. 5th Ed. New York: McGraw-Hill.

van Lotringen, T.J.M., and J.B. Gerrish. 1978. H_2S removal by purple sulphur bacteria in swine waste lagoons. In *Proceedings of the 33rd Purdue Industrial Waste Conference*, ed. J.M. Bell, p440-448. Lafayette, Indiana: Ann Arbour Science.

Wenke, T.L., and J.C. Vogt. 1981. Temporal changes in a pink feedlot lagoon. Applied and Environmental Microbiology 41: 381-385.

GLOSSARY

acidogenic (bacteria)	bacteria which produce simple organic substances, particularly fatty acids, from polymeric organic matter
aeration	introduction of air into a liquid
aerobic	living or active only in the presence of oxygen
alluvium	sediment which has been deposited from flowing water
anaerobic	living or active only in the absence of dissolved oxygen
anaerobic lagoon	a lagoon designed and operated so that the concentration of dissolved oxygen is always essentially zero
aquifer	layer of rock or soil able to hold or transmit a useful quality of water
archaeological	of ancient times
autotrophic	organisms which produce their own organic constituents from inorganic compounds, obtaining energy from sunlight or oxidation processes
bacteriostatic	a substance which inhibits growth of bacteria
beamhouse	the part of a tannery in which hides are cleaned and freed of hair
BOD	biochemical oxygen demand - an indication of the amount of oxygen needed to oxidize the organic matter in a water sample by biological means
bovine	of cattle

brackish	water with a lower salt concentration than seawater, but still a substantial concentration (normally 500-30,000 parts per million of sodium chloride)
cadastral	showing the extent and ownership of land
coagulation	the coalescing of colloidal or very finely divided suspended matter into larger particles
collagen	fibrous proteins abundant in the skin of animals
colluvium	a deposit formed by soil motion downslope
corium	the major part of the skin of vertebrates
craton	a continental block that has been stable over a long period of geological time
dissolved salts	salts (ionic components) dissolved in water, usually expressed in milligrams per litre and estimated from the electrical conductivity
duricrust	hard, rock-like materials
emulsion	a suspension of very fine particles in a fluid: for example, milk is an emulsion of fat in water
enzyme	an organic catalyst (often proteinous and very specific in action) that controls the rate of a chemical reaction, often one involving metabolism or growth
epidermis	the outer layer of cells of an animal or a plant
ethnographic	of a race of man: particularly of sites for which Aboriginal comment is or has been available. Mythological sites, past camping places and sources of supplies are examples of ethnographic sites
facultative lagoon	a wastewater treatment lagoon deep enough to allow anaerobic conditions to develop at the bottom
floc	the result of flocculation
flocculation	formation of fine precipitations into larger particles
freeboard	distance between the designed maximum water level and the top of an embankment

geomorphology	the relationship between the earth's surface and physical features and geological structures underneath
geophyte	an herbaceous plant possessing subterranean perennating parts (bulbs, corms, etc.)
gniess	a metamorphic rock of course grain size characterized by mineral banding
granite	a coarsely crystalline acid igneous rock containing quartz and feldspars
hydraulic conductivity	(or coefficient of permeability) the volume of water per unit time flowing through a unit cross-section of ground
hydrolysis	decomposition of organic compounds by interaction with water
isoelectric point	the pH at which the net electrical charge on a protein (in context, the hide protein collagen) is zero
kaolinitic clay	a clay consisting of aluminium silicate formed by the weathering of feldspars in rocks
keratin	a sulphur-containing protein of variable constitution that forms epidermal products such as nails, hooves, hair and the outermost layer of skin
laterite	an earthy, granular or concretionary mass, chiefly iron and aluminium oxides and hydroxides
macrophyte	large aquatic plants
methanogenic (bacteria)	bacteria which produce methane as a by-product of their metabolism
microbiocide	a substance that kills microbes
migmatite	a rock with both igneous and metamorphic characteristics
neutralization	the addition of acid to alkali (or vice versa) until neither in is excess and the solution is neutral (i.e. at pH 7)
oxidation	the reaction of a substance with oxygen

palaeo-	a prefix meaning ancient. Palaeochannels are ancient rivers, palaeobasins are ancient lakes, etc.
particulate	not dissolved
peneplain	land worn down by erosion almost to a level plain
perched aquifer	an aquifer containing perched water
perched water	water temporarily stored above the water table, such as occurs when an impermeable lens or layer of material above the main water table causes the ground above it to become saturated with water
permeable	allowing passage of fluids (normally, at a useful rate)
pH	a measure of the acidity of a solution: a pH less than 7 indicates acidity, and one above 7 alkalinity
photosynthetic	the synthesis of organic compounds by living cells using energy from light
polyelectrolytes	synthetic polymers that are used to cause coagulation of colloidal suspensions
potable	water of drinkable quality
proteinous	of proteins. Proteins, are polymers of amino acids and form an important part of the food chain
redox buffer	oxidation–reduction buffer. In context, nitrate would prevent development of reducing conditions and hence odours, for as long as it remains in the lagoon water
rendering	to recover tallow from fatty tissue
salinization	becoming salty
samming	the process of pressing excess water from recently tanned leather
saponified	the hydrolysis of esters into acids and alcohols
siliceous	material composed mainly of silica ($Si0_2$) particles
silicified	rocks or soil cemented by deposited silica

stratigraphy	description of the layers of rocks and soils of the earth's crust
subcutaneous	under the skin
tanyard	the part of a tannery where the tanning process itself is carried out
volatilization	passing from a condensed state to a gaseous state
wet-blue hides	hides which have been cleaned and have undergone preliminary tanning with chrome salts

ABBREVIATIONS

GENERAL ABBREVIATIONS AND ACRONYMS

BOD	biochemical oxygen demand
CER	Consultative Environmental Review
CG	Crown Grant
COD	chemical oxygen demand
Deras	Deras (Australia) Pty Ltd
EPA	Environmental Protection Authority
SECWA	State Energy Commission of Western Australia
TDS	total dissolved salts
TKN	total Kjeldahl nitrogen

MEASUREMENTS

g	gram
g/L	gram(s) per litre
ha	hectare (one hectare = 10,000 m^2 ~ 2.471 acres)
kg/a	kilogram(s) per annum
kg/day	kilogram(s) per day
kg/ha	kilogram(s) per hectare
km	kilometre
km^2	square kilometre(s)
L	litre
m	metre
m^3	cubic metre (= 1,000 litres)
m^3/a	cubic metre(s) per annum
m^3/day	cubic metre(s) per day
mg/L	milligram(s) per litre
m/s	metre(s) per second
mm/a	millimetre(s) per annum
mS/m	milliSiemens per metre
t	tonne (= 1,000 kg)
t/a	tonne(s) per annum
t/day	tonne(s) per day

Appendix A

ENVIRONMENTAL PROTECTION AUTHORITY GUIDELINES

GUIDELINES FOR THE CONSULTATIVE ENVIRONMENTAL REVIEW ON THE PROPOSED TANNERY - 10 KM NORTH-EAST OF DARKAN

These guidelines have been prepared by the Environmental Protection Authority to assist in identifying issues that should be addressed within the Consultative Environmental Review (CER). They are not intended to be exhaustive and the proponent may consider that other issues should also be included in the document.

The CER is intended to be a brief document: its purpose should be explained, and the contents should be concise and accurate as well as being readily understood. Specialist information and technical description should be included where it assists in the understanding of the proposal. It may be appropriate to include ancillary or lengthy information in technical appendices.

Where specific information has been requested by a Government Department or the Local Authority, this should be included in the document.

1. Summary

The CER should contain a brief summary of:

- salient features of the proposal;
- alternatives considered;
- the receiving environment and analysis of potential impacts and their significance;
- environmental monitoring and management programmes, safeguards and commitments; and
- conclusions.

2. Introduction

The CER should include an explanation of the following:

- identification of proponent and responsible authorities;
- relevant statutory requirements and approvals;
- background and objectives of the proposal;
- brief details of, and timing of the proposal; and
- scope, purpose and structure of the CER.

3. Need for the proposal

The CER should examine the justification for the proposal. Broad costs and benefits of the proposal at local and regional levels could also be discussed. The consequences of not implementing the proposal should be outlined.

4. Evaluation of alternative sites

A discussion of alternative sites and scales (sizes) of the proposal should be provided. Given the existing salt problems in soils, groundwater and rivers in WA, and the potential environmental problems associated with evaporation ponds, a rationale, on environmental grounds, should be presented to show why the proposed site is most suitable for the proposal. Additionally, as the effluent will need considerable treatment before any disposal, it is important to point out what characteristics favour this site over others considered. Social considerations in the evaluation of alternative sites should also be discussed.

5. Description of proposal

The document should provide descriptions of the important elements of the proposal, specifically:

- location, including cadastral information;
- overall concept of proposal, including any changes or additions in the foreseeable future;
- operational procedures of the tannery;
- amounts, quality and source of water to be used in each part of the process;

- a description of the quantity and types of chemicals to be used, together with methods of storage and handling;
- proposed method of solid and liquid waste disposal;
- safeguards to cope with any floods and pond leakage;
- noise and air quality buffer zones around the area;
- site layout, access and road development;
- infrastructure and auxiliary services (power, water, sewerage and drainage);
- development schedule;
- project lifetime; and
- anticipated ultimate capacity of tannery.

6. Existing environment

This chapter should provide an overall description of environmental systems likely to be affected by the proposed tannery (both within and beyond the immediate project area). At the end of this section the various elements should be brought together, describing the way in which they interact as a system and their potential interaction with the proposal. Descriptions using newly acquired date should include some detail on the methodology and sampling intensity relative to spatial variation.

Specific items to be addressed are:

- regional setting of the project area;
- physical environment, including climate (wind, rainfall, temperature, inversions); geology, geomorphology, soil types; hydrology (including quality of groundwater, water courses, dams, catchments); salinity levels and salt distribution in the soil profile;
- biological environment, including a general vegetation map of the area; the occurrence of any restricted or endangered species of flora and fauna; assessment of conservation values; occurrences of plant diseases or harmful fungi;
- human environment, including the location of nearby existing and proposed residences; relevant planning issues; historical, archaeological and ethnographic sites; background air quality and noise levels; land use patterns of the surrounding area; existing transport services infrastructure; landscape values.

7. Effluent treatment and disposal methods

The CER should indicate the sources of effluent from the tannery and discuss the proposed treatment and disposal methods. It is very important to describe in detail the proposed effluent treatment and disposal methods to be used. Before treatment, the effluent will contain chromium, high BOD, salt and sulphides, and so a clear rationale should be provided for choosing the method of containment and treatment presented. Additionally, a rationale should be presented explaining why the final quality of the treated effluent would be suitable for the proposed method of disposal.

To this end the CER should include:

- a description of the nature of the waste and effluent of each effluent stream, including volume and composition, especially with respect to salt, chrome and other metals; sulphides; BOD; pH; phenols; fats, oils and greases; total nitrogen and phosphorus; organic solvents; pathogens and weeds;
- a description of the treatment of the waste and effluent, including the design basis used to determine the size of each component of the treatment process and the rationale for selection of the particular treatment process;
- a review of alternative tanning processes and effluent disposal methods leading to the rationale for the selected option;
- a description of the method of disposal of waste and effluent, including the volume, frequency of disposal, location of disposal and composition of effluent at final treatment;

- an indication of the manner and extent to which waste and effluent will be either recycled or utilised by other industries;
- an outline of any backup treatment and disposal system;
- disposal of solid waste off-site including screen solids, pond sludge and salt buildup in the treatment pond system; and
- potential impacts on surrounding landowners and communities, including employment and other socio-economic considerations at both construction and operational stages.

8. Site and effluent impacts and management

Having described the treatment and disposal of effluent, it is important to identify potential impacts on the environment, including implications to surrounding land users, owners and communities and the effluent receiving environment if spillage or pond leakage occurs.

The CER should also indicate approaches that will be adopted to ameliorate and manage the identified impacts. Contingency plans for managing events such as fires, and floods should be outlined.

Issues that should be addressed include:

- impact of all effluents on the receiving environment;
- procedures to be adopted in the event of plant or effluent disposal system breakdown;
- procedures used to ensure that the effluent treatment system operates efficiently and effectively;
- methods of ensuring that other potential environmental and social problems, such as noise and traffic, are minimised and managed;
- procedures to be adopted to deal with any odour problems, especially from the wastewater treatment system;
- consideration of related site management, such as stormwater disposal etc;
- effects of climatic factors on waste and effluent disposal methods;
- any changes to the salinity, availability or other characteristics which might affect the beneficial use of ground and river waters, particularly that used by other landowners;
- creation of unsanitary conditions associated with rodent, mosquito or fly-breeding nuisances;
- spreading of animal diseases and weeds;
- programme for long-term effluent disposal, taking account of replacement of effluent treatment components and need for treatment of these components;
- procedures to be adopted in the event of pollution being detected in groundwater, drains, creeks or rivers;
- methods of ensuring that other potential problems, such as visual factors, are minimised and overcome;
- procedures to be adopted to detect and deal with any under-pond leakage;
- procedures to be adopted to prevent soil erosion during periods of high rainfall;
- a management plan for the disposal of solid wastes should be presented indicating location and method of disposal; and
- restrictions on and potential land use for the site following decommissioning of the tannery.

9. Monitoring

The effluent treatment and disposal system will require monitoring to ensure that it is operating efficiently and does not leak. The specification of any monitoring system should be given and responsibility for the operation of that system should be assigned.

10. Public consultation

The public consultation activities that occurred during the planning of the proposal and preparation of the report should be described. This should outline the activities, the objectives of the activities and the groups or individuals involved. A summary of concerns raised should be documented along with how each of these concerns has been addressed.

11. Conclusion

12. Guidelines

A copy of these guidelines should be included in the document.

13. References

All references should be listed.

14. Appendices

Where detailed technical or supporting documentation is required, this should be placed in appendices.

15. Commitments

It is very important for the proponent to adequately address all relevant environmental and social issues so that the public can understand the implications of the proposal. In order for the public to be assured that the proponent understands these environmental and social implications, the proponent is advised to make commitments on all aspects of the proposal which have the potential for an environmental or social impact. Such commitments are common to many proposals. The EPA will give guidance on how to prepare such commitments if requested to by the proponent.

Where an environmental or social problem has the potential to occur the proponent should cover this potential problem with a commitment to rectify it. Where appropriate, the commitment should include:

- what is the nature of the work;
- who will do the work;
- when the work will be carried out; and
- to whose satisfaction the work will be carried out to, and if relevant, where will the work be carried out.

Appendix B

SUMMARY OF COMMITMENTS

Appendix B

SUMMARY OF COMMITMENTS

GENERAL COMMITMENTS

1 Deras would adhere to the proposal as assessed by the EPA and would fulfil the commitments made below.

2 The tannery would be constructed and operated according to the requirements of all relevant Government statutes and agencies, and to the satisfaction of the EPA.

WASTEWATER MANAGEMENT COMMITMENTS

3* Deras would build a fully integrated wastewater treatment and disposal system, which would be designed and installed by a recognized water/wastewater treatment contractor to the satisfaction of the EPA. The system would be operated and monitored by Deras to the satisfaction of the EPA.

4 Prior to construction of the wastewater treatment lagoons, Deras would supply details of their exact location and design to the EPA for approval.

5* Prior to commissioning the plant, evaporative lagoons would be constructed to dispose of treated wastewater and would be operated subsequently to the satisfaction of the EPA.

6* In the event of treatment or holding lagoon leakage causing an environmental impact, as defined by the EPA, Deras would take immediate action to stop the leakage so that the environmental impact was rectified to the satisfaction of the EPA.

7 All wastewater treatment lagoons would be constructed to have at least 0.6 m freeboard so as to be able to cope with a 'once in thirty year storm event'.

8* Deras would ensure that the water level in the wastewater treatment lagoons was maintained to the satisfaction of the EPA.

9* Deras would take immediate remedial action should failure of the wastewater treatment system occur and would carry out such action to the satisfaction of the EPA.

10* In order to cope with equipment failure, Deras would keep sufficient spares for immediate repair of the aerators, the electrical system and other key elements of the system, and would advise the EPA. In the event of major failure Deras would take steps to construct holding lagoons, to the satisfaction of the EPA and relevant authorities, as quickly as possible.

11 Deras would ensure that stormwater runoff from areas adjacent to the lagoons did not, at any time, enter the wastewater treatment lagoon system.

12* If, due to some unforeseen circumstances, the disposal of treated wastewater by irrigation did not meet the EPA's requirements, Deras would take action to hold that wastewater until it met EPA's standards for irrigation, and this action would be carried out to the satisfaction of the EPA.

13 Deras would ensure that any treated wastewater would only be irrigated on to the site if it complied with EPA requirements.

14 Deras would rectify immediately any unforeseen problems resulting from disposal of wastewater.

15* Before Deras irrigated wastewater on to its property, or any other property, it would provide the EPA with a chemical analysis of the treated water and have it approved for irrigation by the EPA. Additionally, Deras would have the area of land to be irrigated approved by the EPA prior to commissioning the plant.

MONITORING

16* Prior to construction, Deras would submit and subsequently implement a monitoring programme to the satisfaction of the EPA.

The monitoring programme would include:

- initial baseline sampling period to determine the status quo;
- parameters to be measured;
- sampling sites and times;
- reporting times to the EPA;
- a commitment to modify the environmental management programme, if necessary, to reduce the impact of pollution to the satisfaction of the EPA.

17* All samples taken in the monitoring programme would be analysed in a laboratory acceptable to the EPA. In the event that the monitoring programme indicated an adverse environmental impact was occurring or developing, Deras would alter the tannery operation or introduce additional environmental management controls as necessary, to reduce the impact to a level acceptable by the EPA.

SOLID WASTE

18 Deras would dispose of all solid wastes in a manner satisfactory to the EPA, and would obtain the approval of the EPA for the method of and location for solid waste disposal prior to commissioning the plant.

DUST, ODOUR AND NOISE

19* Deras would ensure that dust, odour and noise would be controlled at all times to the satisfaction of the EPA.

20 All machinery with a potential to cause nuisance noise levels would be enclosed to ensure that noise levels were satisfactory to the EPA.

OTHER COMMITMENTS

21 Deras would control insects and weeds around the wastewater treatment system (including the lagoons and any sludge drying facilities or temporary stock holding areas) to the satisfaction of the EPA.

22 Three months before commissioning the plant, Deras would submit a landscaping plan (tree planting) to the EPA for approval, to ensure the amenity of the area was retained.

23* Deras would modify its pollution control operations, if it could not meet its licence conditions, so that environmental impacts were reduced to a level acceptable to the EPA.

24 Deras would be responsible for decommissioning the plant and rehabilitating the site and environs to the satisfaction of the EPA.

25 Deras would, at least six months prior to decommissioning, prepare a decommissioning and rehabilitation plan to the satisfaction of the EPA.

26 Deras would not transfer ownership, control or management of the project, without consulting the EPA and the Minister for the Environment.

*Note: * denotes those commitments that can be administered under part 5 of the* Environmental Protection Act, 1986. *The remainder can be implemented using Ministerial Conditions.*

Appendix C
PUBLIC CONSULTATION

Appendix C
PUBLIC CONSULTATION

The public participation and consultation programme was an important component of this CER. The programme involved:

- discussions with the West Arthur Shire Council and officials
- open public meetings with the local community
- opportunities for Deras to address public concerns and questions
- informing the public about any modifications to the original proposal
- discussions with various government and non-government bodies.

At the meetings with the Council the proposal was outlined and issues such as road upgrading and land rezoning were raised. Open public meetings were held at the beginning of the environmental review period in October and again towards the end of the review period, to ensure that issues of concern were addressed in the CER.

The following issues were raised by local residents:

- the amount and composition of the salt sludge and methods used to dispose of it;

- the capacity of the lagoons to accommodate summer storms;

- lagoon desludging operations;

- the impermeability of clay lagoon liners;

- possible contamination of farm dams by overland drainage;

- the potential for odour generation;

- the effects of chrome on human and animal health;

- possible chrome recycling processes;

- the effects of using fungicides in the tanning processes;

- possible changes to the quality or volume of water in Dardadine Creek and the Hillman River;

- the use of trees in assisting with waste disposal, notably increasing transpiration;

- introduction of weeds or pests by the waste disposal methods;
- the effect of 'greenhouse' warming on the operations;
- the potential uses of tannery wastes, particularly as fertilizers;
- the impact of additional traffic, particularly on the Hillman–Dardadine Road;
- the alignment of the transmitter line easements for power supply;
- monitoring;
- visual impact;
- the environmental assessment process;
- operating licence requirements;
- the government's authority to enforce environmental protection conditions;
- the benefits to the local community (especially to the school) resulting from an increase in population.

These issues are addressed throughout the CER.

Appendix D

SURFACE SOIL DISTRIBUTION INVESTIGATIONS

Rockwater
PROPRIETARY LIMITED
94 ROKEBY ROAD, SUBIACO, WESTERN AUSTRALIA 6008
P.O. BOX 237, SUBIACO, WESTERN AUSTRALIA 6008
TELEPHONE (09) 382 4922
INTERNATIONAL 619 382 4922
FACSIMILE (09) 381 3264

KINHILL ENGINEERS LTD

DARKAN TANNERY SITE

WASTE WATER DISPOSAL

OCTOBER 1990

1. INTRODUCTION

Kinhill Engineers Ltd is investigating the feasibility of a tannery which would be constructed for Deras Ltd at a site about 15 km north-east of Darkan. Waste water from the tannery would be disposed of by spray irrigation.

Rockwater Pty Ltd was engaged by Kinhill to investigate the hydrological feasibility of waste disposal by irrigation in either of two areas to the north (part of CG 12898) or west (CG 9983) of the tannery site. It was proposed that the investigation should:

(i) identify the major soil types in each of the possible disposal areas, and estimate their depths;

(ii) measure infiltration rates into each of the major soil types;

(iii) estimate natural water balances and the capacity for waste water disposal;

(iv) report on the above, noting the possibility of any water movement into significant aquifers or streams.

Rockwater was subsequently asked to extend the soil mapping to include the area of the proposed tannery, (part of CG 13158) where water may be stored in lagoons.

A hydrogeological assessment of the proposed tannery site has been provided by Rockwater (1990).

2. METHODOLOGY

With the permission of Mr John King and the daughter of Mr David Smith, soils were assessed by driving along lines about 200 m apart in each of the areas, except for the east side of CG 9983 which was under crop. In this area, an assessment was made by driving around the perimeter of the crop, and the internal pattern was estimated from the topography and a sketch provided by Kinhill.

Soil profiles were investigated by augering and digging at selected sites, and by noting the material exposed in the roots of fallen trees, and in the walls of farm dams.

The basis of interpretation of the soil distribution and soil types was CSIRO mapping of experimental catchments about 30 km to the west, which has been described in detail by Bettenay et al (1980).

Infiltration rates were measured using 300 mm diameter stainless steel rings which were driven at least 100 mm into the ground. A falling head method was used, and water depths were measured using an inclined scale to provide an amplification of x5.

3. SOIL DISTRIBUTION

The soil distribution in the three areas (CG 9983 and parts of CG 12898 and CG 13158) is shown in Figure 1. Because of the gradational nature of the surface soils, the boundaries between soil types are diffuse and only approximated by the lines drawn in Figure 1.

Soils in the southern area of CG 12898, the north-west of CG 13158, and the east of CG 9983 are typical of the lateritic profiles developed over deeply weathered granitic rocks of the Darling Range. Granitic basement rocks are exposed at a number of locations within CG 12898. The higher lands in CG 12898 and CG 13158 consist of coarse to blocky lateritic duricrust which has been left uncleared. Downslope of these areas, the surface soils are sandy gravels which grade into sands over most of the slopes and valleys, as reported by Bettenay et al (1980).

It can be expected that the lateritic profiles which cover much of the areas of CG 9983 east of Dardadine Gully, the north-east corner of CG 13158, and the south-west corner of CG 12898 consist of up to 20 m or more of weathered granite. The lateritic profiles thin out in the northern section of CG 12898 where granitic rocks outcrop at a number of locations, but experience elsewhere suggests that there may be significant depths of weathered rock between the outcrops.

4. SOIL TESTS

4.1 SITE 1

This site was in the south-west corner of CG 9983 (see Fig. 1).

An auger hole to 0.7 m depth revealed the following:

0 - 0.3 m	Grey fine sand; moist
0.3 - 0.4 m	Yellow-orange silty clay; mottled
0.4 - 0.7 m	Yellow-orange silty clay; dry; dense.

The nature and depth of the surface soils in the area west of Dardadine Gully was confirmed by examination of material around the roots of several fallen trees.

Infiltration rates were measured at two locations, about 7 m apart. The results of these tests are shown in Figure 2.

Cumulative infiltration is the total volume of water entering unit area of the soil surface in a given time after the surface is flooded. In the two tests, the cumulative infiltration in 36 minutes of flooding was 22 and 17 mm respectively. Most of the difference was in the early-time infiltration behaviour.

The longer-term infiltration curves approach straight lines. According to infiltration theory (Philip, 1969) the slope of these lines is approximately equal to the hydraulic conductivity (K) of the saturated soil. From Figure 2,

$$K_1 = 7.4 \times 10^{-6} \text{ m/s}$$
$$K_2 = 8.8 \times 10^{-6} \text{ m/s.}$$

These values are below the average for clean sands.

The infiltration curves show no evidence of any restriction of infiltration by the underlying clay. Given the depth of the clay, it would be expected that the surface sands would be saturated by the infiltration of about 90 mm of water. Thereafter, the infiltration rate would be expected to be reduced considerably by the underlying clay, and additional rainfall or irrigation would flow over the ground surface into Dardadine Gully.

4.2 SITE 2

This site was close to the edge of the wheat crop near the south-east corner of CG 9983 (see Fig. 1). The soil type was confirmed as sandy gravel to 0.3 m when the infiltration ring was dug out at the end of the test.

The results of the infiltration test are shown in Figure 2. In only 9 minutes, the cumulative infiltration at this site was 33 mm. The hydraulic conductivity of this soil, based on the 6 to 9-minute infiltration data was:

$$K = 4.4 \times 10^{-5} \text{ m/s.}$$

This value is typical for a sandy gravel soil. The soil profile would be expected to become less permeable with depth, and consequently the infiltration rate would be expected to decrease after the infiltration of about 100 mm of water.

4.3 SITE 3

This site was close to the edge of the wheat crop near Dardadine Gully in the north-central part of CG 9983 (see Fig. 1). The soil type was confirmed as sand to 0.3 m when the infiltration ring was dug out at the end of the test.

Results of the infiltration test are shown in Figure 2. In 20 minutes, the cumulative infiltration was 38 mm. Based on the 16 to 20-minute infiltration data, the hydraulic conductivity of the soil was:

$$K = 2.4 \times 10^{-5} \text{ m/s.}$$

This value is slightly below the average for clean sands, or above the average for silty sand.

The depth of sand at this site is not known, but an infiltration capacity of at least 100 mm before any significant reduction of infiltration rate, could be expected.

4.4 SITE 4

This site was in CG 12898, about 200 m north and 100 m east of the south-west corner of the block (see Fig. 1). The soil profile at this site was examined by hand-auger with the following result:

0 - 0.5 m	Grey sand; medium; dry
0.5 - 1.0 m	Yellow sand; fine; moist
1.0 - 1.5 m	Yellow sand with some gravel; water at 1.5 m.

Results of the infiltration test at this site are shown in Figure 3. Note that the time scales differ in Figures 2 and 3.

In 4 minutes, the total infiltration at this site exceeded 45 mm. Based on the 2 to 3-minute infiltration data, the hydraulic conductivity of the soil at this site was:

$$K = 7 \times 10^{-4} \text{ m/s.}$$

This is slightly above the average for clean sands. The depth of sand at this site is such that the soil could accept about 400 mm of water before saturation.

4.5 SITE 5

This site was along the southern boundary of CG 12898, and about 200 m from the south-west corner of the block (see Fig. 1). The soil was confirmed as sand to 0.15 m, then sandy-gravel to 0.3 m.

Results of the infiltration test at this site are shown in Figure 3. More than 38 mm of water was infiltrated in 4 minutes. Based on the 3 to 4-minute infiltration data, the hydraulic conductivity of the soil at this site was:

$$K = 1.4 \times 10^{-4} \text{ m/s.}$$

This value is about the average for clean sands.

The presence of gravels in the 0.15 to 0.3 m depth interval suggests that pallid zone clays may reduce infiltration rates at this site after some time. A conservative estimate of the quantity of infiltration which would be accepted before the infiltration rate decreased significantly is 150 mm.

5. WATER BALANCE

Average monthly rainfall and tank evaporation data for Darkan were obtained from the Bureau of Meteorology and maps prepared by the Bureau respectively. These data were used to compute average monthly and yearly water balances for non-irrigated and irrigated land, given in Tables 1 and 2.

Water balance calculations assume that:

(i) runoff from the soils is negligible;

(ii) in the non-irrigated area, water storage in the plant root zone is zero at the end of summer (end of February);

(iii) maximum water storage before drainage from the root zone is 100 mm (this corresponds to a rooting depth of 1 m and plant-available water of 0.1 on a volumetric basis);

(iv) when the water storage at the end of the previous month is non-zero, the evaporation rate is 0.75 times the tank evaporation rate, or the water storage, whichever is the smaller;

TABLE 1

NON-IRRIGATED WATER BALANCE

(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	12	15	17	32	74	106	103	82	54	39	20	10	564
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0
Evaporation	12	15	17	32	53	38	30	45	68	90	55	10	465
Incr Moist Store	0	0	0	0	21	68	11	0	-14	-51	-35	0	0
Drainage	0	0	0	0	0	0	62	37	0	0	0	0	99
Moist Store *	0	0	0	0	21	89	100	100	86	35	0	0	-
Tank Evap	260	210	170	100	70	50	40	60	90	120	180	250	1600

* storage at the end of the month.

TABLE 2

IRRIGATED WATER BALANCE

(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	12	15	17	32	74	106	103	82	54	39	20	10	564
Irrigation	183	143	111	43	0	0	0	0	14	51	115	178	838
Evaporation	195	158	128	75	52	38	30	45	68	90	135	188	1202
Incr. Moist. Store	0	0	0	0	0	0	0	0	0	0	0	0	0
Drainage	0	0	0	0	22	68	73	37	0	0	0	0	200
Moist Store *	100	100	100	100	100	100	100	100	100	100	100	100	-
Tank Evap.	260	210	170	100	70	50	40	60	90	120	180	250	1600

* Storage at the end of the month

(v) when the water storage at the end of the previous month is zero, the evaporation rate is equal to the rainfall, or 0.75 times the tank evaporation rate, whichever is the smaller;

(vi) in the irrigated area, water storage in the plant root zone is maintained as close as practicable to the maximum to maximise evaporation;

(vii) some drainage from the irrigation area is necessary to prevent excessive salinity of the root zone.

Table 1 may be considered as the water balance of a wheat crop. Water storage in the root zone of pasture would be less, because of a smaller rooting depth, and it would be greater beneath deep-rooted native vegetation. Therefore the water balances for these other plant covers would be slightly different from that in Table 1.

Table 2 shows that each year a total of 838 mm of water could be used as irrigation without causing any runoff under average rainfall and evaporation conditions. Total drainage would be 200 mm, or double that under non-irrigated conditions (see Table 1). The leaching fraction (drainage divided by rainfall plus irrigation) would be about 0.14 so that the salinity of the drainage water would be about 7 times greater than the average of the irrigation and rain, assuming no precipitation or dissolution of salts in the soil.

Irrigation applications in excess of those shown in Table 2 would result in greater drainage to underlying aquifers, or in runoff from the soil surface.

6. EFFECTS OF DISPOSAL BY IRRIGATION

6.1 EFFECTS ON SOILS

The soils in CG 12898 and to the east of Dardadine Gully in CG 9983 are well-drained, and with the excess of rainfall over evaporation in winter months there would be only a limited accumulation of salts in the root zone under irrigated conditions. However, greater drainage through the soils under irrigation would result in rising water tables, and the possibility of soil salinity in some areas of shallow water table. This could be prevented by construction of a ditch or tile drainage system.

In the western section of CG 9983, drainage is restricted by a layer of silty clay. A system of ditch drains would probably be essential to prevent salinity if this area was irrigated with saline waste water.

Salinity would have no adverse effect on the hydraulic conductivity or structure of the sandy soils. However, a high sodium adsorption ration (SAR) in the waste water may reduce the hydraulic conductivity of the pallid zone clays which underlie the sands and gravels of the lateritic soil profiles.

The nature of the clays beneath the western section of CG 9983 is not known. It is likely that they would be more reactive than the pallid zones, and therefore disposal of saline wastewater in this area could cause these subsoils to become even less permeable.

6.2 EFFECT ON AQUIFERS

Aquifers in pallid zone clays sometimes yield small quantities of water which is suitable for stock. However, no bores or wells are known in the south-west of CG 12898, the north-west of CG 13158, or CG 9983. Bores and wells in surrounding areas are shown in Rockwater (1990).

The groundwater resources in the south-west of CG 12898 and in CG 9983 east of Dardadine Gully are likely to be minor and probably saline. On the basis of existing information, it is considered to be unlikely that waste water disposal in these areas would have a detrimental effect on any significant aquifers.

It is possible that the area of CG 9983 west of Dardadine Gully forms part of a small Tertiary basin. Waste water disposal in this area could affect a significant groundwater resource. The nature of aquifers in this area, and the extent to which they may be recharged through the silty-clay subsoil, requires further investigation.

6.3 SURFACE WATER RESOURCES

Some of the saline waste waters disposed of in CG 12898 or CG 9983 would eventually find their way to Dardadine Gully, either as runoff or seepage from the irrigation areas.

Dardidine Gully is a tributary of the Hillman, Arthur and Blackwood rivers.

According to information provided to Kinhill by the Water Authority of WA, the average salinity (total soluble salts - TSS) of the Hillman River is 2501 mg/L and the salt discharge is 0.088 kg/m^2yr from the catchment of area 555 km^2, or a total of about 4.9×10^7 kg/yr. It is understood that the quantity of salt in the waste water disposal would be about 200 tonnes/yr, or 2×10^5 kg/yr, and ultimately a proportion of this would reach the Hillman River via Dardadine Gully.

In comparison with the present salt load of the Hillman River, the additional discharge would not be detectable. The discharge of saline effluent would ultimately cause a small increase of salinity of seepages along Dardadine Gully, where it crosses CG 9983. In September 1990, the salinity of the stream in this area was 4850 mg/L, which is probably about the lowest value for the year. It is likely that this stream is unsuitable for stock in summer (it is fenced off from the pasture on the western side of CG 9983), and a small local increase of salinity would not be harmful to users or to the environment.

Several farm dams on CG 12898 and CG 9983 are within or downslope of possible irrigation areas. These dams capture surface runoff which would be likely to become more saline as a result of the disposal of saline waste water. It may be necessary to construct small earth banks to divert any saline runoff, and this may reduce the inflow of water to the dams.

7. CONCLUSIONS AND RECOMMENDATIONS

The surface soils in the south-west corner of CG 12898, the north-west corner of CG 13158, and the area of CG 9983 east of Dardadine Gully are typical of those developed by lateritisation after in situ deep weathering of granitic rocks in the Darling Range. They consist of blocky duricrust in the higher areas flanked by sandy gravels and extensive areas of grey sand of medium texture. Granitic rocks outcrop on CG 12898, downslope of the area examined.

The hydraulic conductivity of the sands and sandy gravels are normal for their texture, ranging from about 1.4×10^{-4} to 7×10^{-4} m/s. The soils exhibit high infiltration rates, with estimated capacities of 100 to 400 mm of water before any significant reduction of the rate.

Soils to the west of Dardadine Gully in CG 9983 consist of fine sands which overlie dense silty clay at a depth of about 0.3 m. Infiltration rates and hydraulic conductivities of the sands are low for their texture ($K \sim 8 \times 10^{-6}$ m/s). It is estimated that the infiltration rate into this soil would be reduced by the silty clay after infiltration of about 90 mm of water.

Monthly water balances for non-irrigated and irrigated land under average weather conditions for Darkan have been estimated. There is a capacity for disposing of about 838 mm/yr of waste water by irrigation, with a leaching fraction of about 0.14. Winter rainfall will ensure drainage of at least 100 mm of water beyond the root zone each year.

Disposal of saline water by irrigation would probably reduce the hydraulic conductivity of the subsoil clays, particularly those in the western section of CG 9983.

There are no bores or wells in the south-west of CG 12898, the north-west of CG 13158, or CG 9938. Therefore disposal of saline waste water would not affect any existing groundwater supplies in these areas. It is unlikely that there are any useful groundwater resources in the south-west of CG 12898, the north-west of CG 13158, or east of Dardadine Gully on CG 9983. There is a possibility of useful aquifers in the western section of CG 9983, but these may be protected by the shallow silty clay encountered in this area.

It may be necessary to construct earth banks to divert saline runoff and protect farm dams in CG 12898 and CG 9983, downslope of irrigation areas.

Ultimately a proportion of any saline effluent would be discharged to Dardidine Gully and the Hillman River. At the catchment scale, the effect of the saline effluent would not be detectable. At the local level, the salinity of water in Dardidine Gully would be increased, possibly by a measurable amount, but this stream is already saline.

On the basis of this investigation, the south-west corner of CG 12898 or the eastern section of CG 9983 would be suitable for disposal of waste water by irrigation.

It is recommended that, as part of the water supply investigation, a hole should be drilled in CG 9983 west of Dardadine Gully. This hole should be geophysically logged to determine the thickness of the silty clay layer which may protect the aquifer in the area.

DATED: 4 OCTOBER 1990 ROCKWATER PTY LTD

A. J. PECK
PRINCIPAL HYDROLOGIST

REFERENCES

Bettenay, E., Russell, W.G.R., Hudson, D.R., Gilkes, R.J. and Edmiston, R.J. (1980). A description of experimental catchments in the Collie area, Western Australia. CSIRO Div. of Land Resour. Management, Tech. Paper No. 7.

Philip, J.R. (1969). Theory of infiltration. Adv. in Hydrosci. 5, 215-296.

Rockwater, (1990). Preliminary groundwater investigation, proposed tannery site at Dardadine. Unpub. rpt. to Kinhill Engineers Ltd, September 1990.

Client : KINHILL ENGINEERS LTD.
Project : DARKAN TANNERY
Date : October 1990
Drg. No. 108-2/90/2-1

ROCKWATER PTY LTD

SITE PLAN & SOIL DISTRIBUTION

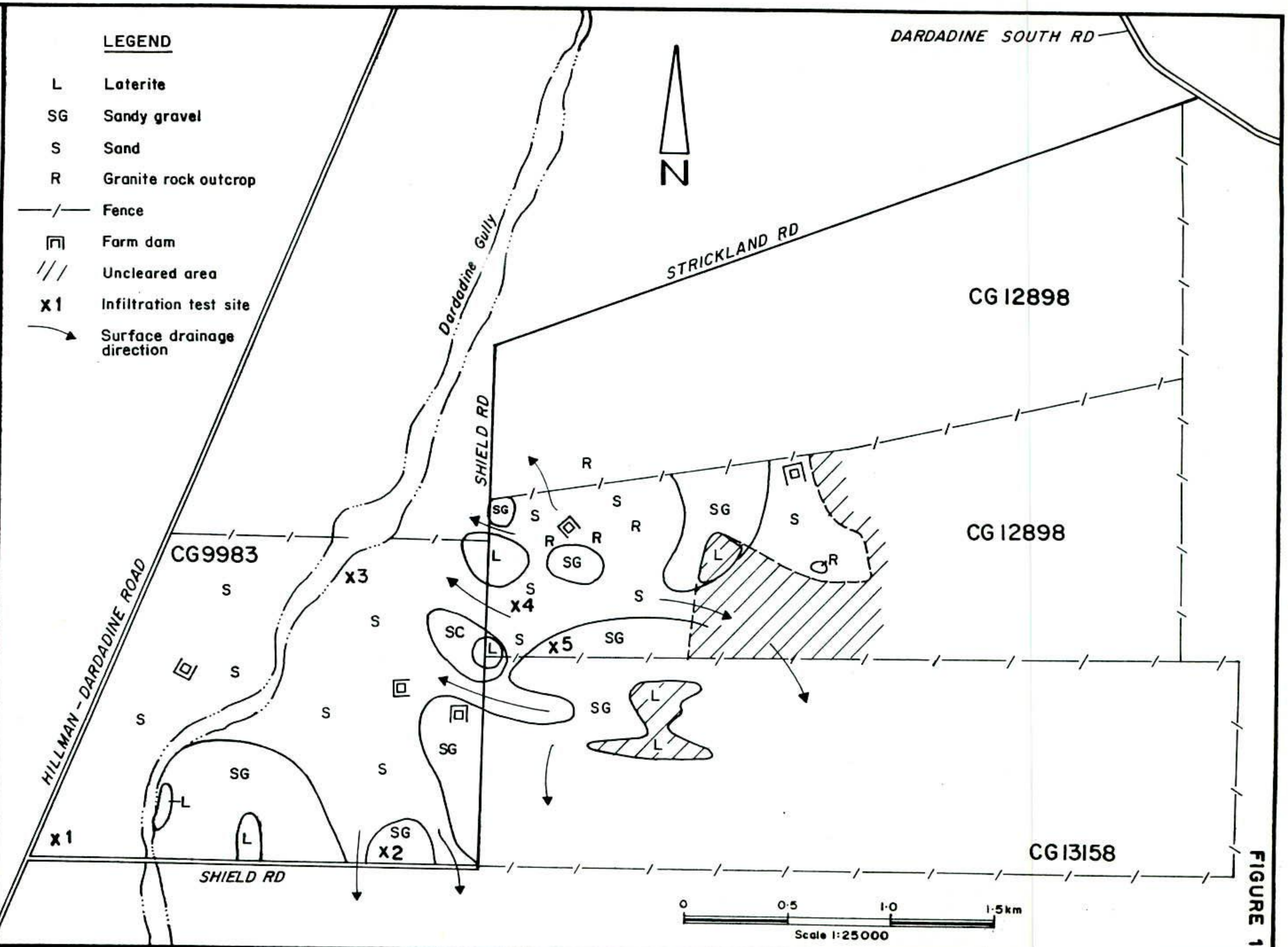


FIGURE 1

Appendix E

WATER AND SALT MOVEMENT

Rockwater
PROPRIETARY LIMITED
94 ROKEBY ROAD, SUBIACO, WESTERN AUSTRALIA 6008.
P.O. BOX 237, SUBIACO, WESTERN AUSTRALIA 6008.
TELEPHONE: (09) 382 4922
INTERNATIONAL: 619 382 4922
FACSIMILE: (09) 381 3264

KINHILL ENGINEERS PTY LTD

PROPOSED DARKAN TANNERY

WATER AND SALT MOVEMENT

FEBRUARY 1991

108.2/91/1
GW PROP/7

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

KINHILL ENGINEERS PTY LTD

PROPOSED DARKAN TANNERY

WATER AND SALT MOVEMENT

FEBRUARY 1991

1. INTRODUCTION

Kinhill Engineers Pty Ltd is acting for Deras Australia Pty Ltd in relation to a proposed tannery at a site on Shield Road, about 15 km north-east of Darkan, W.A.

During winter, some of the wastewater from the tannery (salinity about 11,000 mg/L) will be sprayed over an area of about 30 ha as shown in Figure 1. Disposal is proposed to consist of an application of up to 11 mm of water once each month. In addition to sodium chloride, sodium sulphate and ammonium chloride, the waste-water will have a BOD of about 6,000 mg/L due to the presence of grease, protein and detergents. The waste-water will provide a useful source of nitrogen for crop or pasture production. Up to 75% of the waste-water could be taken from the site by local farmers, and used as fertilizer.

Throughout the summer, all of the wastewater will be directed to evaporation ponds for disposal. These ponds will cover an area of about 3 ha, and contain water with salinities of 60,000, 130,000 and 200,000 mg/L.

Rockwater Pty Ltd was engaged to report on the water and salt balance of the area which is fertilised by waste-water disposal, the movement of water and salt which leaks from the evaporation ponds, and the movement of water and salts from the site towards regional drainage lines.

2. HYDROLOGICAL BACKGROUND

The hydrology of small catchments in the Darling Range has been studied in areas about 20 km west of Darkan and described in a series of papers (Peck and Williamson, 1987). The surface soils are typically lateritic and gravelly sands with high infiltration capacities. These soils extend to depths of 0.1 to perhaps 3 m, and overlie deeply weathered clays. The basement rocks are granites and gneiss usually at depths of about 20 m, but occasionally outcropping.

A perched aquifer develops above the clay in winter, and makes a major contribution to streamflow. Water moves downwards from the perched aquifer in root channels and other preferred paths (Johnston et al, 1983). There is evidence that water moves upwards within the clay matrix at some depths, from a permanent aquifer in the most recently weathered basement rocks (Peck, Johnston and Williamson, 1981).

There are large quantities of salts of oceanic composition within the clay matrix. These are essentially immobile in the unsaturated zone above the permanent water table, but can be mobilised by upwards movement of the water table due to increased groundwater recharge.

3. PREVIOUS WORK

Rockwater has reported on characteristics of soils on the site, and the hydrogeology of the project area.

Infiltration rates of the surface soils (gravelly sands and sands) range from 1.4 x 10^{-4} to 7 x 10^{-4} m/s (12 to 60 m/d) (Rockwater, 1990a).

The surface soils range in thickness between 0.3 and 3.9 m, and overlie clays and silts of 0.7 to 2.2 m thickness, and a layer of partly silicified clay.

Hydraulic conductivities of compacted samples of the shallow clays and silts ranged from 1.1 x 10^{-10} to 4.5 x 10^{-9} m/s (9.9 x 10^{-6} to 3.9 x 10^{-4} m/d). Four holes were drilled through pallid zone clays (weathered granite) to 20 m depth without encountering basement rocks. Two other holes encountered weathered granite at depths of 13 and 18 m, and granite is exposed to the north and north-east of the site. One hole near Dardadine Creek encountered fresh water in sands at a depth of 5 to 8 m in an alluvial sequence (Rockwater, 1990b).

Fresh groundwater has been found in a valley about 2 km north-east of the site of the proposed tannery. A paleodrainage aquifer is inferred with a width of about 500 m and a length of at least 20 km. This is inferred to extend into a small Tertiary basin to the west of the tannery site (Rockwater, 1990c). Dardadine Creek is probably the south-eastern boundary of this basin.

The locations of bores and wells in the area are shown in Rockwater (1990c). The nearest bore is on the west bank of Dardadine Creek and about 2.5 km north-west of the proposed evaporation ponds.

4. WATER AND SALT BALANCES

4.1 WATER BALANCES

Monthly soil water balances were computed for several situations, as described below. The water balances are driven by average monthly rainfall data for Darkan, and average monthly Class A pan evaporation rates estimated as 90% of those measured by the WA Department of Agriculture at Narrogin.

Details of the methods and assumptions used in calculating the water balances are provided in Appendix 1.

4.1.1 Farm Land at Darkan

Table 1 is the computed water balance for non-irrigated crop or pasture on flat land at Darkan. There is no waste-water disposal or net inflow of groundwater. Maximum storage is 169 mm, in August, so the 1 m deep soil profile is never saturated. Storage exceeds 100 mm in the period July to September, and parts of June and October. Total drainage into the clays during the year is 34 mm, or about 6% of rainfall. This is considered to be a reasonable representation of normal soil water conditions at Darkan.

TABLE 1
Water Balance of Crop or Pasture on a Plane Surface
(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	12	15	17	32	74	106	103	82	54	39	20	10	564
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0
Disposal	0	0	0	0	0	0	0	0	0	0	0	0	0
Run In	0	0	0	0	0	0	0	0	0	0	0	0	0
Evaporation	12	15	17	32	58	36	37	46	71	103	79	23	530
Drainage	0	0	0	0	0	0	8	10	10	6	0	0	34
Storage Incr	0	0	0	0	16	70	58	26	-27	-70	-59	-13	0
Storage	0	0	0	0	16	86	144	169	142	72	13	0	
Tank Evap	283	231	195	113	73	45	46	58	89	129	186	257	1705

4.1.2 Effect of Waste-Water Disposal

Table 2 is the computed water balance for crop or pasture on flat land with the addition of 5 mm of waste-water in May and October, and 11 mm in the months of June to September (a total of 54 mm in the year). This simulates the maximum rate of disposal of waste-water. Maximum storage increases by 36 mm to 205 mm, or just over 50% of the amount needed to saturate a 1 m deep soil profile. Total drainage for the year increases by 8 mm to 42 mm. Eighty five percent of the waste-water is lost by evaporation, and the remainder becomes additional drainage into the underlying clays.

TABLE 2
Water Balance of Crop or Pasture on a Plane Surface
With Waste-Water Disposal
(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	12	15	17	32	74	106	103	82	54	39	20	10	564
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0
Disposal	0	0	0	0	5	11	11	11	11	5	0	0	54
Run In	0	0	0	0	0	0	0	0	0	0	0	0	0
Evaporation	12	15	17	32	58	36	37	46	71	103	120	28	576
Drainage	0	0	0	0	0	0	10	10	10	10	2	0	42
Storage Incr	0	0	0	0	21	81	67	37	−16	−69	−102	−18	0
Storage	0	0	0	0	21	102	169	205	189	120	18	0	
Tank Evap	283	231	195	113	73	45	46	58	89	129	186	257	1705

4.1.3 Reduced Rate of Waste-Water Disposal

Table 3 is the computed water balance for a reduced rate of application of waste-water. This simulates the situation when 75% of the waste-water is sold to other farmers for fertiliser. In this case, total drainage for the year is just 3 mm greater than it is without waste-water disposal, and 83% of the waste-water is lost by evaporation.

TABLE 3
Water Balance of Crop or Pasture on a Plane Surface
Reduced Rate of Waste-Water Disposal
(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	12	15	17	32	74	106	103	82	54	39	20	10	564
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0
Disposal	0	0	0	0	1	4	4	4	4	1	0	0	18
Run In	0	0	0	0	0	0	0	0	0	0	0	0	0
Evaporation	12	15	17	32	58	36	37	46	71	103	106	10	544
Drainage	0	0	0	0	0	0	9	10	10	8	0	0	37
Storage Incr	0	0	0	0	17	74	61	29	−23	−71	−86	0	0
Storage	0	0	0	0	17	91	152	181	157	87	0	0	
Tank Evap	283	231	195	113	73	45	46	58	89	129	186	257	1705

4.1.4 Water Balance in a Valley

Table 4 shows the effects of net groundwater inflow, which is expected in the floor of a valley. In this simulation, there is a net run-in of 158 mm of water in the year, in addition to direct rainfall and the disposal of waste-water at the higher rate (54 mm/yr). The net inflow of groundwater could be increased by any impediment to groundwater outflow, or two-dimensional convergence of the groundwater flow in plan view. Groundwater inflow causes maximum storage to increase by 75 mm to 280 mm (compare Tables 2 and 4) or 70% of the capacity of a 1 m deep soil profile. Drainage also increases by 8 mm to 50 mm.

TABLE 4
Water Balance of Crop or Pasture in a Long Valley
With Waste-Water Disposal
(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	12	15	17	32	74	106	103	82	54	39	20	10	564
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0
Disposal	0	0	0	0	5	11	11	11	11	5	0	0	54
Run In	0	0	0	0	0	1	30	30	30	30	30	7	158
Evaporation	12	15	17	32	58	36	37	46	71	103	149	149	726
Drainage	0	0	0	0	0	0	10	10	10	10	10	0	50
Storage Incr	0	0	0	0	21	82	97	67	14	-39	-109	-132	0
Storage	0	0	0	0	21	103	200	266	280	241	132	0	
Tank Evap	283	231	195	113	73	45	46	58	89	129	186	257	1705

4.1.5 Reduced Drainage in a Valley

If drainage was reduced by saturation of the underlying clays, or by lower hydraulic conductivity of the underlying strata, the maximum storage would increase to 310 mm (Table 5). Then a soil profile of 0.78 m depth would be fully saturated with water at the end of September, and above average rainfall at that time would result in surface runoff. Drainage may be impeded by the silicified clay layer encountered in some drillholes (Rockwater, 1990b).

TABLE 5
Water Balance of Crop or Pasture in a Long Valley
With Waste-Water Disposal
No Drainage
(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	12	15	17	32	74	106	103	82	54	39	20	10	564
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0
Disposal	0	0	0	0	5	11	11	11	11	5	0	0	54
Run In	0	0	0	0	0	1	30	30	30	30	30	14	165
Evaporation	13	15	17	32	58	36	37	46	71	103	149	206	783
Drainage	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage Incr	−1	0	0	0	21	82	107	77	24	−29	−99	−182	0
Storage	0	0	0	0	21	103	210	286	310	281	182	1	
Tank Evap	283	231	195	113	73	45	46	58	89	129	186	257	1705

4.1.6 Reduced Soil Depth

The depth of the surface sands affects both the capacity to store water and the amount of storage at which a perched water table develops and drainage begins. Although drilling on the site has shown an average depth of gravelly sand of more than 1 m, it is possible that the surface soils are shallower in some lower areas. The water balance of an 0.5 m deep surface soil was computed for the crop or pasture on flat land with the high rate of waste-water disposal (Table 6). Results show that maximum storage would be 199 mm, and therefore the profile would be saturated at the end of August under average rainfall and evaporation conditions. Because the perched water table develops earlier, drainage increases by 10 mm to 52 mm/yr (compare Tables 2 and 6).

TABLE 6
Water Balance of Crop or Pasture on a Plane Surface
With Waste-Water Disposal
Reduced Soil Depth
(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	12	15	17	32	74	106	103	82	54	39	20	10	564
Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0
Disposal	0	0	0	0	5	11	11	11	11	5	0	0	54
Run In	0	0	0	0	0	0	0	0	0	0	0	0	0
Evaporation	12	15	17	32	58	36	37	46	71	103	120	18	566
Drainage	0	0	0	0	0	6	10	10	10	10	6	0	52
Storage Incr	0	0	0	0	21	75	67	37	−16	−69	−106	−8	0
Storage	0	0	0	0	21	96	163	199	183	114	8	0	
Tank Evap	283	231	195	113	73	45	46	58	89	129	186	257	1705

4.1.7 Supplementary Irrigation

A small amount of irrigation could be used to reduce the salinity of the surface soil. Table 7 shows the computed water balance for an addition of 50 mm of water in May. Irrigation increases drainage by 10 mm to 52 mm/yr (compare Tables 7 and 2). Irrigation would be less beneficial at any other time, according to this model.

TABLE 7
Water Balance of Crop or Pasture on a Plane Surface
With Waste-Water Disposal and Irrigation
(mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	12	15	17	32	74	106	103	82	54	39	20	10	564
Irrigation	0	0	0	0	50	0	0	0	0	0	0	0	50
Disposal	0	0	0	0	5	11	11	11	11	5	0	0	54
Run In	0	0	0	0	0	0	0	0	0	0	0	0	0
Evaporation	12	15	17	32	58	36	37	46	71	103	120	68	616
Drainage	0	0	0	0	0	6	10	10	10	10	6	0	52
Storage Incr	0	0	0	0	71	75	67	37	−16	−69	−106	−58	0
Storage	0	0	0	0	71	146	213	249	233	164	58	0	
Tank Evap	283	231	195	113	73	45	46	58	89	129	186	257	1705

4.2 SALT BALANCE

Application of up to 54 mm/yr of waste-water with a salinity of about 11,000 mg/L will provide a salt load to the soil of about

$$54 \times 10^{-3} \times 11,000 \times 10^{-3} = 0.59 \text{ kg/m}^2 \text{ yr.}$$

The salt input in rainfall can be neglected as it is estimated to be less than 1% of that in the waste-water.

Assuming the salt to be uniformly spread through a 1 m deep layer of soil with a density of 1,600 kg/m^3, after 1 year without any drainage of saline water, the average soil salinity would be about

$$0.59/(1 \times 1600) = 0.00037$$
$$= 0.037\%.$$

Under these conditions, neither the surface soil nor the sub-soil would be described as saline, and plant growth would not be affected. However, without any loss of salt in drainage to the underlying clays, or by runoff, the surface soil would become saline in about 3 years, and the sub-soil in about 8

Drainage into the underlying clays is expected to be about 42 mm/yr with the higher rate of waste-water disposal and no irrigation (Table 2). Therefore, a salt balance would be maintained by a flow-weighted salinity in the drainage water of about

$$(54/42) \times 11,000 = 14,100 \text{ mg/L}.$$

If the waste-water disposal was reduced by a factor 4 by selling the fertilizing waste-water to other farmers, the drainage would fall to about 37 mm/yr (Table 3), and the flow-weighted average salinity would be about

$$(14/37) \times 11,000 = 4,000 \text{ mg/L}.$$

The salinity of drainage water could also be reduced by using irrigation to increase drainage, as discussed above.

The salinity of soil water will vary considerably during the year, due to dilution by rainfall in the Autumn and early Winter, and concentration by evapotranspiration in the Spring.

In any part of the waste-water disposal area where natural drainage was impeded and/or net groundwater inflow was exaggerated by the topography and the aquifer properties, the perched water table is likely to lose water by direct evaporation. Soil salinity is likely to develop in these areas, due to the concentration of salt in a layer of about 0.1 m thickness of surface soil.

5. LEAKAGE FROM EVAPORATION PONDS

Silty and clayey sub-soils will be compacted to seal the evaporation ponds. Assuming that there is a depth of 1 m of water in each pond, and the compacted layer is 0.3 m thick with a hydraulic conductivity of 8×10^{-5} m/day (the average reported by Rockwater, 1990b), the rate of leakage will be about

$$(1/0.3) \times 8 \times 10^{-5} = 2.7 \times 10^{-4} \text{ m/d}$$
$$= 100 \text{ mm/yr}.$$

This is three times greater than the estimated rate of drainage into the clays beneath crop or pasture under a plane surface at Darkan (Table 1).

Although the compacted clay layer will be saturated with water through essentially its total thickness, the underlying clays will remain slightly unsaturated above the aquifer which probably exists in the clay and recently weathered basement rock.

Root channels, which are important in transporting water and salt downwards from the perched water table in natural soil profiles, will not conduct water through the unsaturated zone. Therefore, water and salts will move downwards from the evaporation ponds through the soil matrix.

The first effect of constructing the evaporation ponds is expected to be a drop of water table beneath them, because rapid recharge through the root channels will stop. Subsequently the water table will rise, because the rate of leakage from the ponds will be about three times the present rate. An estimate of the extent of the water table rise beneath the ponds would require a more detailed study.

The initial volumetric water content of the underlying clay matrix is expected to be about 0.3 (Johnston and McArthur, 1981), and this will increase to about 0.4 immediately below the evaporation ponds. Therefore, the velocity of the wetting front in the clay will be about

$$100/(0.4-0.3) = 1000 \text{ mm/yr.}$$

Assuming the water table to be initially at a depth of 15 m, it will take about 15 years before there is any effect of leakage on the underlying water table.

The velocity at which the increase of salinity is propagated downwards, due to leakage from the ponds, will be even less. Neglecting solute diffusion and dispersion, the solute front will move at a rate of about

$$100/0.4 = 250 \text{ mm/yr.}$$

Therefore it will take about 60 years for the increase of salinity to reach a depth of 15 m.

6. REGIONAL EFFECTS ON WATER AND SOILS

6.1 SURFACE WATER

The principal surface water resource in the area of the proposed tannery is Dardadine Creek. This is a tributary of the Hillman, Arthur and Blackwood Rivers. Streamflow in Dardadine Creek is not gauged or regularly sampled.

In September 1990, the salinity of water in Dardadine Creek was measured as 4850 mg/L at the Shield Road crossing and in the reserve near Strickland Road. At that time of the year, stream salinities are expected to be relatively low.

The total discharge of salt in the 30 ha waste-water disposal area is estimated to be:

$$54 \times 10^{-3} \times 30 \times 10^{4} \times 11{,}000 \times 10^{-3} = 1.8 \times 10^{5} \text{ kg/yr.}$$

The total leakage of salt from the 3 ha of evaporation ponds is estimated to be:

$$100 \times 10^{-3} \times 3 \times 10^{4} \times 130,000 \times 10^{-3} = 3.9 \times 10^{5} \text{ kg/yr.}$$

The area of the catchment of Dardadine Creek above the proposed tannery site is estimated to be 300 km^2 and the runoff to total 40 mm/yr (advice from the Water Authority of WA). Therefore the streamflow is about

$$300 \times 10^{6} \times 40 \times 10^{-3} = 1.2 \times 10^{7} \text{ m}^3\text{/yr.}$$

If all of the salts from the waste-water disposal area and the evaporation pond leakage reached Dardadine Creek, the increase of average salinity would be

$$(1.8 \times 10^{5} + 3.9 \times 10^{5}) \times 10^{3}/1.2 \times 10^{7} = 48 \text{ mg/L.}$$

That is, the increase of average salinity would be about 1% of the lowest salinity in Dardadine Creek.

According to the Water Authority of WA, the average salinity (total soluble salts - TSS) of the Hillman River is 2,500 mg/L, and the salt load is about 4.9×10^{7} kg/yr.

If all of the salts reached the Hillman River, the increase of the salt load in the river would be about 1%, and the average salinity would increase by about 25 mg/L. The water would remain suitable for use by stock, and for careful irrigation of salt-tolerant plants.

6.2 GROUNDWATER

Both leakage from the evaporation ponds, and drainage of soil water beneath the waste-water disposal area will eventually result in plumes of saline water developing in the groundwater beneath these facilities.

It has been argued above that it will take more than 50 years for saline water to reach the aquifer beneath the evaporation ponds. These are at least 800 m from Dardadine Creek. The hydraulic gradient to Dardadine Gully is about 0.03 and the hydraulic conductivity of the deeper aquifer is probably about 0.5 m/d. Therefore the average rate of water movement to the gully will be about

$$0.5 \times 0.03 = 0.015 \text{ m/d}$$
$$= 5.5 \text{ m/yr}$$

The velocity of the front of the saline plume is always greater than the rate of water movement, because of the presence of solids, and most of the water and solute is carried in a small fraction of the pore space. Assuming an effective porosity of 0.05, the velocity of movement of the front of the saline plume in this aquifer would be about

$$5.5/0.05 = 110 \text{ m/yr.}$$

Therefore it would take about 8 years for the increase of salinity in the aquifer beneath the evaporation ponds to result in a saline plume extending as far as Dardadine Creek.

These calculations are based on assumed values of aquifer properties, and consequently they can provide only a rough guide to the rate of movement of the salt plume.

The total time for saline leakage from the evaporation ponds to travel to the area of Dardadine Creek is estimated to be about 70 years.

The waste-water disposal area is closer to Dardadine Creek, and saline water draining from the surface soils is expected to move quickly to the deeper aquifer through root channels and other large pores. Therefore the total time for salt to move through the deeper aquifer from the surface soils in the irrigation area to the area of Dardadine Creek is estimated to be about 5 years.

6.3 SOILS

Within the irrigated area, surface soil is likely to become saline in any area where drainage to underlying strata is impeded, as noted in section 4.2 above. Any saline area is expected to be water-saturated during part of the year, and additional rainfall under these conditions will cause runoff. The natural direction of surface drainage from the irrigated area is north-west to Dardadine Creek. Soils along this drainage line are expected to become saline from the irrigated area to Dardadine Creek, unless the runoff is captured in a dam.

7. SUMMARY AND CONCLUSIONS

A tannery is proposed off Shield Road, about 15 km north-east of Darkan.

Waste water from the tannery will be sprayed over an area of 30 ha at a rate of about 54 mm/yr, or less depending on sales of the liquor which will contain ammonium chloride in the roughly 11,000 mg/L of total soluble salts. More saline water will be held in evaporation ponds with compacted clay liners.

Drainage to the deeper aquifer beneath the spray irrigation area is expected to increase from about 34 to about 42 mm/yr, assuming no sales of the waste-water. The salinity of this drainage water will average about 14,100 mg/L, varying through the winter to a maximum in late Spring.

In valleys which gain water and salt by lateral flow in the perched aquifer, irrigation will increase maximum storage in the surface soils.

Areas which are prone to winter saturation of the surface soils without irrigation, will tend to increase when irrigated. If there are areas where there is inadequate drainage to underlying strata, the soils will become saline and plant growth will be reduced.

Leakage to the deeper aquifer from the evaporation ponds will be at a rate about three times greater than present recharge. Water and salt movement downwards from the ponds will be restricted to the soil matrix. It will take about 15 years for the water table in the deeper aquifer to begin to increase after leakage commences, and about 60 years before the salinity of water in the aquifer begins to increase.

Spray irrigation and leakage of saline water from the tannery will have no significant effect on the salinity of streamflow in Dardadine Creek and the Hillman River, or of groundwater in the palaeodrainage aquifer and the Tertiary basin in the valley north of the tannery.

If soils become saline in the valley of the irrigation area, any runoff from from soils would increase soil salinity down the valley towards Dardadine Creek.

DATED: 26 FEBRUARY 1991

ROCKWATER PTY LTD

A. J. PECK
PRINCIPAL HYDROLOGIST

REFERENCES

Johnston and McArthur (1981). Subsurface salinity in relation to weathering depth and landform in the eastern part of the Murray River catchment area, Western Australia. CSIRO Land Resour. Manage. Tech Paper No. 10.

Johnston, Hurle, Hudson and Height (1983). Water movement through preferred paths in lateritic profiles of the Darling Plateau, Western Australia. CSIRO Groundwater Res. Tech. Paper No. 1.

Peck, Johnston and Williamson (1981). Analyses of solute distributions in deeply weathered soils. Agric. Water Manage 4:83-102.

Peck and Williamson (1987). Hydrology and Salinity in the Collie River Basin, Western Australia (eds). Special Issue, J. Hydrol. 94:1-198.

Rockwater (1990a). Darkan Tannery Site Waste Water Disposal. Unpub. Rpt. to Kinhill Engineers Pty Ltd., October 1990.

Rockwater (1990b). Proposed Tannery Site at Dardadine: Results of Soil Stratigraphy and Hydraulic Conductivity Testing. Unpub. Rpt. to Kinhill Engineers Pty Ltd., December 1990.

Rockwater (1990c). Proposed Tannery Site at Dardadine: Results of Groundwater Investigations. Unpub. Rpt. to Kinhill Engineers Pty Ltd, November 1990.

APPENDIX 1

DETAILS OF WATER BALANCE CALCULATIONS

1. The soil profile is assumed to consist of two layers which may be described as sand over clay. The water balance of the sand layer is computed.

2. The sand layer is 1 m thick with a porosity of 0.4. A perched water table develops in the sand when its average volumetric water content is 0.1 (storage of 100 mm of water). If the storage reaches 400 mm, the sand is saturated and runoff occurs, otherwise the infiltration capacity of the sand is assumed to be greater than the rainfall intensity.

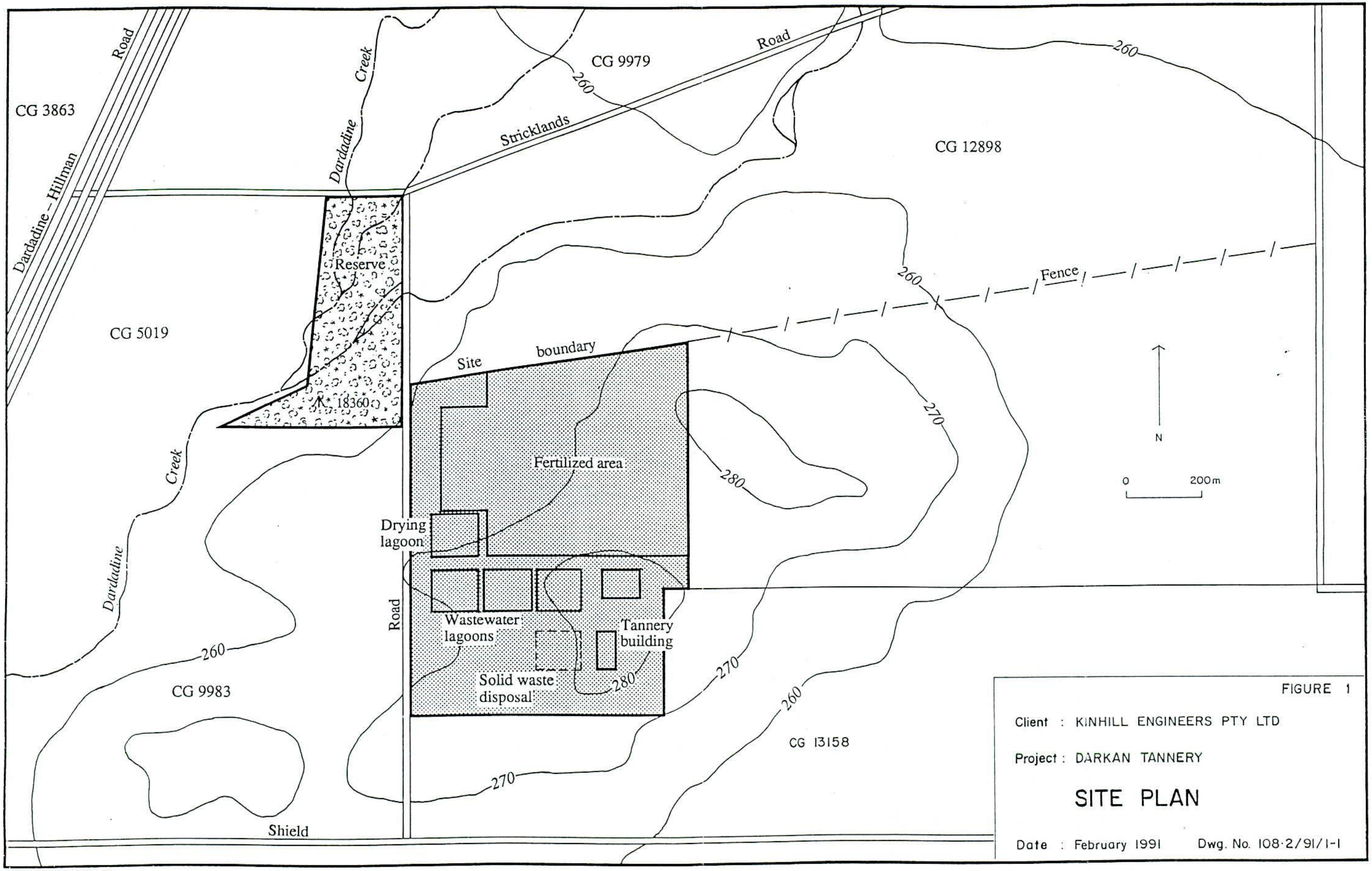
3. Before a perched water table develops, the rate of drainage into the underlying clay layer is negligible (<0.5 mm/month).

4. After a perched water table develops, water moves downwards in root channels and the clay matrix at a constant rate of drainage of 10 mm/month. When a perched water table develops during a month (storage changes from <100 mm to >100 mm, or vice versa), the drainage is scaled in proportion to the storage in excess of 100 mm.

5. In a valley situation, there is an accretion of water by lateral flow in the perched aquifer from each side of the valley. The rate of accretion is taken to be 30 mm/month when the perched aquifer exists (storage >100 mm). This corresponds to the situation in a long valley where the slope of the water table changes from +1% to -1% over a distance of 100 m, and the aquifer transmissivity is 0.5 m^2/d.

6. Evapotranspiration takes place at 80% of the pan evaporation rate, so long as there is water in storage. When there is no water in storage, evapotranspiration equals the sum of rainfall, any irrigation, and any net inflow of groundwater.

7. Soil water storage cannot become negative. The storage can be considered as that in excess of the permanent wilting capacity of the soil.



ROCKWATER PTY LTD

Appendix F

STRATIGRAPHY AND GEOTECHNICAL INVESTIGATIONS

Rockwater
PROPRIETARY LIMITED

94 ROKEBY ROAD, SUBIACO, WESTERN AUSTRALIA 6008
P O BOX 237, SUBIACO, WESTERN AUSTRALIA 6008
TELEPHONE: (09) 382 4922
INTERNATIONAL: 619 382 4922
FACSIMILE: (09) 381 3264

KINHILL ENGINEERS PTY LTD

PROPOSED TANNERY SITE AT DARDADINE RESULTS OF SOIL STRATIGRAPHY AND HYDRAULIC CONDUCTIVITY TESTING

DECEMBER 1990

108.2/90/4

TABLE OF CONTENTS

KINHILL ENGINEERS PTY LTD

PROPOSED TANNERY SITE AT DARDADINE
RESULTS OF SOIL STRATIGRAPHY AND HYDRAULIC CONDUCTIVITY TESTING

DECEMBER 1990

1. INTRODUCTION

A tannery for processing cattle skins is proposed near Dardadine, approximately 15 km north-east of Darkan. It is currently proposed that waste water would be pumped into ponds for disposal by evaporation with periodic removal of solids. An area measuring approximately 200 x 200 m is required for this option.

Following an earlier examination of the distribution of soil types in the area, prospective sites for evaporation ponds were chosen east of Shield Road on properties CG 13158 to the south, and CG 12898 to the north. Exploratory holes were drilled to ascertain the depths to clay and underlying basement rock. Samples of the uppermost clays were taken for testing to determine their hydraulic conductivities.

2. PREVIOUS WORK

The soils in the area of the proposed tannery site were investigated and reported by Rockwater Pty Ltd in November 1990 (Report 108.2/90/3). It was concluded from this work, that the soils in the south-western corner of CG 12898 and the north-west corner of CG 13158 are typical of those developed by lateritisation, after deep in-situ weathering of granitic rocks in the Darling Range. The surface soils found in the prospective area consist of a blocky duricrust in the higher areas, flanked by deposits of sandy gravels and medium grained grey sands. Some deposits of an underlying silty clay were located and tested at a site to the west of Dardadine Gully. Infiltration rates of the surface soils (sandy gravels and sands) ranged from 1.4×10^{-4} to 7×10^{-4} m/s.

There are no bores or wells in the south-west corner of CG 12898 nor the north-west corner of CG 13158, which could be affected by disposal of saline waste water. It is unlikely that there are any useful groundwater resources in this immediate area, but a paleochannel yielding a reaonable supply of fresh water has been delineated about 2300 m to the north-east.

3. FIELD INVESTIGATION

The field investigation took place in two stages. In Stage 1, five holes were drilled to determine the nature of materials to a depth of 20 m, or to basement rock if this was encountered first. In Stage 2, eight holes were drilled to determine the depth of clay, and one was continued to basement rock.

Drilling was carried out by Austvac Drilling on the 12 November and 2 December 1990, using a modified Edson 2000 drilling rig, with the reverse circulation, air-core drilling method.

All but one of the drilling sites was chosen to delineate an area of about 200 x 200 m of reasonably flat ground which could be used for construction of evaporation ponds. In Stage 2, one hole was drilled next to Dardadine Gully to determine the nature of any hydraulic connection between groundwater and the surface water flow.

Cuttings from the drillholes were collected at 1 metre depth intervals and geologically logged on site. These logs are presented in Appendix I. Samples of the uppermost clayey soils were taken for hydraulic conductivity tests (Section 4). On completion of all of the deeper holes, they were backfilled to between 4.5 and 6.5 metres depth using clay drill cuttings. Twenty five kilograms of bentonite clay pellets were then poured into each hole to ensure a secure hydraulic seal should the hole be located beneath an evaporation pond. Finally the holes were backfilled to the surface using the remaining drill cuttings.

Lithological descriptions for each drillhole are presented in Appendix I. The soil stratigraphy in the area which could be used for evaporation ponds can be summarised by the following:

1) Surface sands and gravels. The thickness ranged between 0.3 m (hole 2) and 3.9 m (hole 12). The upper portion tends to be a grey, medium to fine grained sand in a pisolitic iron-laterite gravel matrix. The lower parts tend to be an orange, slightly silty gravelly sand.

2) Shallow silt/clay. These were encountered at depths ranging between 0.3 and 1.5 m. The thickness of this unit ranged from 0.7 m (hole 2) to 2.25 m (hole 1). Holes 1 and 2 intersected a layer of sandy silt overlying the shallow clays. The shallow clays are variable in colour. In the main, they tend to be reddish-brown, yellow-brown or white. These clays were sampled for hydraulic conductivity tests.

3) Hard, partly silicified clays. This lithology was intersected by drillholes 1 to 5 and 9. It consists of white or light brown hard clay which in patches is very hard and partly silicified. Cored sections revealed fractures oriented between 60° to sub-vertical. Some are planar whilst others are rough and irregular. All those observed, however, appear to be closed and tight. The thickness of this unit ranged between 1.0 m (hole 4) and 2.0 m (holes 2 and 3).

4) Completely weathered granite - clay. These "pallid zone" clays represent the final weathered product of granitic rocks. They were intersected by all of the deeper drillholes. The thickness of this unit ranged between 9.5 m (hole 4) and 17 m (hole 2). Generally these clays are cream or white throughout the upper half. At depth they become red-brown and/or various shades of orange. In the main, they are slightly moist, with increasing moisture at depth (14 to 17 m). In holes 1 and 4, there were some fragments of highly weathered granite below 14 m and 11 m respectively.

5) Granite rock. Slightly weathered granite rock was intersected by holes 4 and 9 at depths of 13 and 18 m respectively. The rock prevented drilling to greater depths. Some orange iron-oxide staining was present, but no free water or wet samples were returned.

The stratigraphy of one hole drilled near Dardadine Gully was quite different and is probably an alluvial sequence. The salinity of water bailed from this hole was measured in the field as 750 mg/L.

4. HYDRAULIC CONDUCTIVITY TESTING

Samples of the shallow clays from eight sites were used to measure hydraulic conductivities in laboratory tests. The samples were taken from depths between 1.0 and 4.0 m. Details of the depth intervals sampled are given in Table 1 below. All samples are interpreted to be clays from completely weathered granite.

The samples were firstly wetted by mixing with about 10% by weight of water, in order to bring the moisture content up to a level that approximated the plastic limit, or optimum water content for compaction. The samples were then compacted in a 38 mm ID mould, using a 1.1 kg weight with 25 mm diameter ramming face, dropped from a height of 450 mm. The samples were compacted in several layers using about 20 blows of the compaction tool on each layer. The samples were set up under a hydraulic gradient of about 20, and left for 2 days to ensure that they were saturated with water.

Falling head tests were then conducted over a period of about 1 day. Calculated values of hydraulic conductivity for each sample are given in Table 1 below.

TABLE 1

RESULTS OF HYDRAULIC CONDUCTIVITY TESTING

SITE NUMBER	SAMPLED DEPTH INTERVAL (m)	HYDRAULIC CONDUCTIVITY (m/s)	(m/d)
1	2.0 - 4.0	4.5×10^{-9}	3.9×10^{-4}
2	2.5 - 4.0	1.5×10^{-9}	1.3×10^{-4}
3	1.5 - 2.5	3.2×10^{-10}	2.7×10^{-5}
4	1.0 - 2.5	2.9×10^{-10}	2.4×10^{-5}
5	1.5 - 3.0	2.6×10^{-10}	2.2×10^{-5}
9	1.0 - 2.0	1.1×10^{-10}	9.9×10^{-6}
10	1.4 - 4.0	2.5×10^{-10}	2.2×10^{-5}
11	2.0 - 3.0	5.6×10^{-10}	4.8×10^{-5}
	AVERAGE:	9.7×10^{-10}	8.4×10^{-5}

5. SUMMARY

Twelve holes were drilled on 2 properties (CG 13158 and CG 12898) which are possible locations for the proposed tannery near Darkan. These holes were placed in the area of possible sites for evaporation ponds, which would be used for disposal of the tannery's saline effluent. The holes intersected between 0.3 and 3.9 m of sands and gravels overlying shallow clays and silts that were between 0.7 and 2.25 m thick. Beneath the shallow clays is a layer of hard clay which is partly silicified in patches. This layer ranged between 1.0 and 2.0 m thick.

Four of the holes continued through pallid zone clays (weathered granite) to 20 m depth without encountering basement rocks. Two holes encountered weathered granite at depths of 13 and 18 m respectively.

One hole was drilled to a depth of 8 m in alluvial sands and silts near the present course of Dardadine Gully. This hole encountered fresh water in sands at a depth of 5 to 8 m total depth. As the water level is below that of surface water in Dardadine Gully, the aquifer is probably recharged by stream flow.

Hydraulic conductivities of samples of the shallow clays from eight sites were measured in the laboratory. After compaction, the hydraulic conductivities ranged from 1.1×10^{-10} to 4.5×10^{-9} m/s (9.9×10^{-6} to 3.9×10^{-4} m/d).

It is concluded that the shallow clays could be compacted to produce evaporation ponds with very low leakage rates.

DATED: 12 DECEMBER 1990 ROCKWATER PTY LTD

R WALLIS
HYDROGEOLOGIST

A J PECK
PRINCIPAL HYDROLOGIST

APPENDIX I

BORE LITHOLOGY

HOLE 1

LITHOLOGY:
(m)

0 - 1.5	SAND	- Very gravelly. Gravel - Iron oxide laterite <30 mm diameter, iron oxide stained, orange-brown, sub rounded to angular (pisolitic) ~40%; Sand, fine-coarse, light brown, light grey-brown, slightly silty, poorly sorted, angular-sub angular quartz, dry
1.5 - 2.0	SILT	- Clayey & Sandy. Yellow, orange-yellow slightly moist; sand fine-coarse, angular quartz
2.0 - 19	CLAY	- Silty, some sand, reddish-brown 2.0 - 2.5 m. White, rare orange below 2.5 m; moist, 5% sand, fine-coarse, quartz, angular to sub-angular; rare pisolites (irregular - rounded). <30 mm across -Below 3.75 m, bands of semi-silicified completely weathered granite, hard, some red & reddish-brown streaks -Below 5 m, clay as for 2.5 m -Below 6.5 m, white only -Below 12.5 m, colour change to orange-yellow with some white -17-19 m, very rare chips of highly weathered granite, medium grained, orange, iron oxide stained.
19 - 20	GRANITE /CLAY	- Orange, clayey matrix, iron oxide stained, ~20 - 30% granite fragments, highly weathered

HOLE 2

LITHOLOGY:
(m)

0 - 0.3	SAND	- Grey, medium to fine grained, slightly organic, dry
0.3 - 1.0	SILT/SAND	- Orange, orange-brown, slightly clayey in parts, very poorly sorted, slightly moist
1.0 - 20	CLAY	- White, some orange iron oxide staining, hard, slightly to moderately silicified (completely weathered granite). Rare speckles <1 mm diameter - relict mica. Some tight sub-vert, irregular fractures - rare iron and manganese oxide staining/coatings in parts. Some softer bands below 2.5 m - Below 3 m, yellow & pinkish brown - Below 3.5m, cream & white, rare slightly cemented patches (harder) - Below 6 m, no hard patches, slightly moist (6.0 - 7.5 m) some yellow-orange - Below 12m, yellow, orange, rare white - Below 14m, bright orange, darker with depth, moist, rare small chips of orange/red-brown limonite (hard)

HOLE 3

LITHOLOGY:
(m)

0.0 - 1.5	GRAVEL/SAND	- ~50% gravel, pisolitic iron-oxide laterite, <30 mm diameter, irregular to sub-rounded. ~50% sand, grey-brown, grey fine to coarse, some silt, very poorly sorted quartz.
1.5 - 2.5	CLAY/SILT	- Orange-brown, pinkish-red, ~5% sand
2.5 - 4.5	CLAY	- White/orange/some red-brown, hard, silicified in patches (very hard) (completely weathered granite), some irregular sub vertical fractures in core fragments returned
4.5 - 20.0	CLAY	- White, some yellow, rare red, some moderately hard patches, slightly moist, completely weathered granite. - Below 11.5 m, red-brown/red-orange - Below 14.5 m, yellow-brown, white, rare red - Below 16 m, bright orange - Below 17.5, m orange/yellow/khaki/white slightly silty, moist

HOLE 4

LITHOLOGY:
(m)

0.0 - 0.5 GRAVEL	- Sandy. Pisolitic iron-oxide laterite, <10 mm diameter, orange, orange-brown; sand, grey, medium to fine grained, quartz, poorly sorted
0.5 - 1.0 SAND	- Gravelly silty, brown, light brown; sand, fine to coarse, quartz/laterite; very poorly sorted, gravel as above
1.0 - 2.5 CLAY	- Red/white, rare sand (quartz, fine to coarse grained), silty, completely weathered granite
2.5 - 3.5 CLAY	- White, some red and orange, hard, silicified in patches
3.5 - 11 CLAY	- Yellow/light brown/white/orange, slightly moist to dry - Below 9 m, white only, completely weathered granite
11 - 13 GRANITE /CLAY	- Moderately to highly weathered clayey matrix, (silty clay), with common grains of quartz (clear/white, angular) and orange iron oxide stained, medium grained. Matrix white/orange/light orange/brown

HOLE 5

LITHOLOGY:
(m)

0.0 - 0.5	GRAVEL	- Sandy; gravel, red-brown, orange iron-oxide laterite, pisolitic <40 mm diameter, angular to rounded, spherical to irregular. Sand grey, medium to fine quartz, poorly sorted
0.5 - 1.5	SAND/GRAVEL	- (~50/50) Orange, orange-brown. Gravel as above, sand fine to coarse, slightly silty, moist
1.5 - 3.0	CLAY	- Red, red-brown, white, mottled, slightly silty, dry to slightly moist, completely weathered granite. - Below 2.5 m, mainly white, rare coarse sand, white/clear, angular quartz
3.0 -4.75	CLAY	- White, some red/orange, hard to very hard, silicified in parts, completely weathered granite
4.75- 20	CLAY	- White/cream, slightly moist, rare medium to coarse quartz sand - angular. Completely weathered granite rare silt - Below 6 m, very pale greenish white - Below 8 m, no sand present - Below 9.5 m, light orange-brown - Below 10.5 m, as for 6 m with rare sand and silt - Below 17 m, moderately sandy, moist - Below 18 m, as for 10.5 m

HOLE 6

LITHOLOGY:
(m)

0 - 1.0	SAND	- Grey/grey-brown, fine to coarse poorly sorted, some silt, slightly micaceous slightly moist, quartz, some organic fragments
1.0 - 2.0	CLAY	- Silty, some fine to coarse sand (quartz), orange-brown/ /light brown, moist
2.0 - 2.5	CLAY	- Red/pale red/rare light grey, silty, some fine to coarse sand, moist
2.5 - 2.8	SILT/CLAY	- Fine to coarse, sandy, grey-brown/khaki, moist, very moist with depth
2.8 - 3.0	CLAY	- Slightly silty, pink, rare white, dry to slightly moist

HOLE 7

LITHOLOGY:
(m)

0 - 1.3	SAND	- Fine to coarse, moderately sorted, buff/light brown rare pisolites (Fe oxide) <10 mm diameter, orange below 1 m, dry to slightly moist
1.3 - 2.1	SILT	- Clayey to fine sandy (quartz), dry to slightly moist
2.1 - 3.0	CLAY	- Very silty, some fine sand, slightly moist
3.0 - 4.3	CLAY	- Pink/white rare orange, silty, some fine sand, moist, below 4.0 m becomes sandy fine to very coarse quartz, angular to sub-angular
4.3 - 4.6	CLAY	- White, silty, rare fine to medium sand, moist

HOLE 8

LITHOLOGY:
(m)

0 - 0.5	SAND	- Light grey, fine to coarse, moderately to poorly sorted quartz, slightly moist
0.5 - 2.8	SILT	- Orange/orange brown rare white, clayey and sandy, slightly moist, sand quartz sub-round to angular, rare clasts Fe oxide, medium to angular <30 mm diameter
2.8 - 3.3	SAND	- White, silty, fine to coarse grained quartz, angular to sub-angular
3.3 - 5.2	SILT	- Brown/white/orange, clayey & sandy, sandier in layers, moist, sand fine to coarse, angular to sub-round
5.2 - 8.0	SILT/CLAY	- Red/red-brown/white, sandy fine quartz, moist to wet, rare Fe oxide clasts <40 mm diameter (moderate hard to hard dark red to brown), medium to sub-angular to rare, wet below 7 m

HOLE 9

LITHOLOGY:
(m)

0.0 - 0.5	SAND/GRAVEL	- Sand fine to coarse, quartz, some silt, grey brown/grey, dry, gravel Fe laterite medium to angular, spherical to irregular <30 mm diameter
0.5 - 1.0	SAND	- Silty, yellow/yellow-brown, quartz/Fe laterite fine to coarse, dry, rare medium to fine gravel - Fe laterite
1.0 - 2.5	CLAY	- Red-brown/red/brown, slightly silty, dry rare fine to coarse sand
2.5 - 3.5	CLAY	- Moderately cemented/partly silicified in patches moderately hard, some medium to coarse quartz sand, dry
3.5 - 15	CLAY	- White/cream, dry, rare silt, rare medium to coarse sand above 5 m Below 4.5 m, light orange brown rare pink-white Below 5 m, pink/white Below 7 m, white/light orange brown Below 8 m, white/light yellow brown Below 9 m, white Below 10 m, white/light yellow brown Below 11 m, rare chips of granite, yellow brown
15 - 16	GRANITE	- Orange/orange brown/yellow-brown, common quartz fragments <5 mm diameter, angular rare white relict feldspar
16 - 18	GRANITE	- Brown/orange brown, coarse grained quartz/feldspar, some Fe oxide staining

HOLE 10

LITHOLOGY:
(m)

0 - 0.5	SAND	- Grey, yellow-brown, silty, fine to coarse, dry
0.5 - 1.0	SAND/GRAVEL /WOOD	- Sand as above, gravel ~40% fine to coarse, rounded to sub rounded, spherical to sub-spherical, dry, wood ~10% fibres and root chunks
1.0 - 1.4	CLAY/ROOTS	- Clay grey/dark grey/orange, odorous to organic slightly moist, roots ~10%
1.4 - 2.0	CLAY	- Red/red-brown/rare white, slightly moist, slightly silty
2.0 - 4.0	CLAY	- White/rare pink and light red, dry to slightly moist

HOLE 11

LITHOLOGY:
(m)

0 - 1.5	GRAVEL	- Orange/orange-brown, sandy, fine to coarse, rounded to sub-round, Fe laterite, pisolitic, ~10-15% fine to coarse, quartz/laterite sand, slightly moist
1.5 - 2.0	SILT	- Red-brown/rare white/orange/orange brown, clayey, dry, rare medium to coarse sand
2.0 - 6.0	CLAY	- Slightly silty, white/red/red brown, rare orange, dry, rare Fe oxide clasts <15 mm diameter

HOLE 12

LITHOLOGY:
(m)

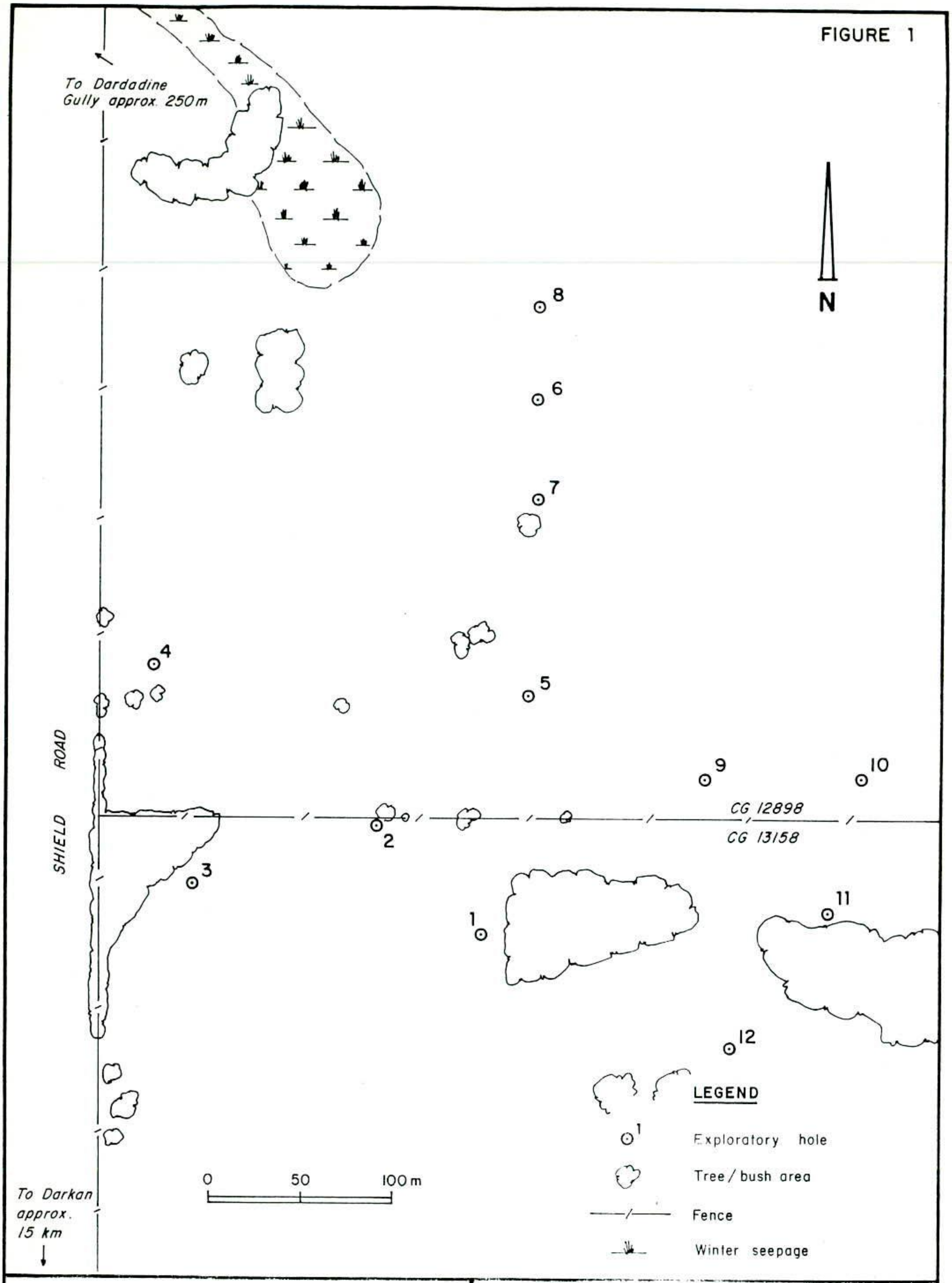
0 - 0.5	GRAVEL	- Sandy, gravel fine to very coarse, Fe laterite, round to angular, irregular-spherical, sand ~50%, light brown, fine to coarse, mainly quartz, rare silt
0.5 - 1.0	SAND	- Fine to coarse, quartz, light brown/grey brown, rare Fe laterite, round to angular, <2 mm diameter
1.0 - 3.9	SAND/GRAVEL	- Sand as above, gravel fine to coarse, Fe laterite, rare boulders of duricrust-hard (cemented Fe oxide fine to coarse grained) vuggy dry
3.9 - 5.0	SILT/CLAY	- Silty, some fine to medium sand, slightly moist
5.0 - 6.0	CLAY	- White, some fine to coarse quartz sand, angular (~5-10%)

DARDADINE GULLY

LITHOLOGY:
(m)

0 - 0.8	SAND	- Grey/grey-brown, fine, moderately sorted, slightly moist, quartz, angular to sub-angular
0.8 - 1.5	SAND	- Silty, brown/orange brown/grey brown, fine to coarse, poorly sorted
1.5 - 3.5	SILT	- Orange/orange-brown/brown, clayey and sandy, sand medium to fine, below 2.5 m white
3.5 - 3.8	SAND	- Red-brown, cemented Fe oxide, hard, silty, medium to fine grained
3.8 - 4.5	SILT	- As for 1.5 m
4.5 - 5.0	CLAY	- Grey/light grey, slightly moist to dry
5.0 - 8.0	SAND	- Grey/grey brown, medium to fine grained quartz, rare silt, moderately sorted, angular to sub-rounded, well sorted, wet - sloppy samples

FIGURE 1



Client KINHILL ENGINEERS PTY LTD

Project DARKAN TANNERY - SOILS STRATIGRAPHY INVESTIGATION

Date December 1990 Job No 108·2/90/4-1

APPROXIMATE LOCATIONS OF BOREHOLES

ROCKWATER PTY LTD

Appendix G

HYDROLOGICAL INVESTIGATIONS

Appendix G.1
PRELIMINARY INVESTIGATIONS

Rockwater
PROPRIETARY LIMITED
94 ROKEBY ROAD, SUBIACO, WESTERN AUSTRALIA 6008
P.O. BOX 237, SUBIACO, WESTERN AUSTRALIA 6008
TELEPHONE (09) 382 4922
INTERNATIONAL 619 382 4922
FACSIMILE (09) 381 3264

KINHILL ENGINEERS PTY LTD

PROPOSED TANNERY SITE AT DARDADINE: PRELIMINARY GROUNDWATER INVESTIGATION

SEPTEMBER 1990

108.2|90|1
R21 GW

Rockwater
PROPRIETARY LIMITED
94 ROKEBY ROAD, SUBIACO, WESTERN AUSTRALIA 6008
P.O. BOX 237, SUBIACO, WESTERN AUSTRALIA 6008
TELEPHONE (09) 382 4922
INTERNATIONAL 619 382 4922
FACSIMILE (09) 381 3264

KINHILL ENGINEERS PTY LTD

PROPOSED TANNERY SITE AT DARDADINE: PRELIMINARY GROUNDWATER INVESTIGATION

SEPTEMBER 1990

1. INTRODUCTION

A tannery for processing cattle skins is proposed near Dardadine, approximately 12 km north-east of Darkan (Fig. 1). If the tannery is constructed, a water supply of about 250 cu m/day will be needed for processing the skins, and up to 500 cu m/day will be needed to mix with waste-water prior to disposal by irrigation.

A bore on the property of Mr G. White may be available to provide part of the water supply. It was pumped previously to lower groundwater-levels in a water-logged area, and is reported to have yielded about 350 cu m/day of fresh water for one year with only very local depression of the water table.

The Water Authority of Western Australia has indicated that the basin containing fresh water must be defined, and the long term water yield confirmed before they will allow the project to proceed. This report presents an initial assessment of the groundwater resources, based on a review of existing information and a reconnaissance of the area.

2. GEOLOGICAL SETTING

The tannery site is situated on the Yilgarn Block, where crystalline granitic rocks of Archaean age crop out, or are generally close to the surface. It is east of the Collie Basin, which contains sediments of mainly Permian to Tertiary age.

The presence of about 30 m thickness of sand in the bore on G. Whites property (B1, in Fig. 1) suggests that the bore may be in a basin or palaeodrainage of Tertiary age, similar to that which has been defined along the Beaufort River near Bokal.

3. PREVIOUS WORK

Magnetic and resistivity traverses, and test drilling, were carried out over part of G. Whites property (West, 1986) as part of an investigation to remedy land salinisation and water-logging.

The drilling, and possibly the resistivity survey results, indicate the presence of a palaeochannel of 30 m (or more) depth, containing fresh groundwater. They show there is about 5 m of clayey material overlying mainly fine to medium sands. The much higher salinity of water intersected in the piezometers 1 km west of the production bore (Table 1) suggests that the strata in that location may have a higher clay content.

Western Collieries have carried out gravity surveying and some drilling, in a Tertiary sedimentary basin which is believed to be situated west of Hillman-Dardadine Road. Results of these studies will be obtained in the near future.

4. HYDROGEOLOGY

The tannery site is in an area of moderately low rainfall, which averages about 550 mm per year. Since land was cleared for farming, the water table has risen, causing some problems with water logging and mobilisation of salts which had previously been stored in the soil.

As a result, groundwater-fed streams and creeks in the area are generally brackish or saline, and the salinity is expected to increase during summer months when there is no contribution to streamflow from surface runoff.

Measurements of stream salinity on 18-19 September 1990 indicated that water in Dardadine Gully, immediately west of the proposed tannery site, was saline with a salinity of 4,850 mg/1 TSS (Table 1). The water quality was similar downstream of the confluence between Dardadine Gully and Swampy Creek (Fig. 1). Stream salinity generally decreases up-catchment: the water was brackish in the upper reaches of Swampy Creek (1,700 - 2,000 mg/1 TSS).

Fresh groundwater discharges under artesian heads from bore B1, piezometers and the abandoned well on G. Whites property, and from soaks that have been dug in the valley upstream of the bore and along the northern end of Bunce King Road (Fig. 1). Some of these soaks, and others on the property of A. Bunce east of the road, are reported to yield fresh water throughout the summer months.

There is a freshwater lake/wetland 4 km east-south-east of bore B1. Tertiary fossils (Mollusca) found on the eastern-edge of the lake suggest the presence of an ancient river channel or sedimentary basin.

It is reported that a borehole drilled for G. King (B2, Fig. 1) intersected good supplies of fresh water. The hole was not cased and has since caved in.

Based on the above observations, air-photograph interpretation and topographic contours, it is likely that a sand-filled Tertiary palaeochannel extends north-eastwards up the valley containing Bore B1, turns to the south-east along Bunce King Road, underlies the two small lakes, and then continues to the east and north-east. Further upstream, the palaeochannel may cut the Dardadine south road 10 km east of the intersection with Bunce King Road. It is reported that Mr M. Trethewie has a fresh water bore yielding a good supply in that area.

West of bore B1, the palaeochannel probably either follows Swampy Creek to the south-west, or crosses Stricklands Road, or both, flowing into the Hillman-Dardadine sub-basin, a small Tertiary sedimentary basin that has been defined by Western Collieries.

5. CONCLUSIONS

The bore on G. Whites property at Dardadine probably intersects sand that was deposited along a palaeochannel (ancient river) during the Tertiary period. This palaeochannel could extend at least as far as the intersection of Dardadine South Road and the Albany Highway, and west into a postulated Tertiary sedimentary basin extending westward beyond the Hillman-Dardadine Road.

There are good prospects for constructing a production bore within 1 to 2 kilometres of the tannery site.

DATED: 28 SEPTEMBER 1990

ROCKWATER PTY LTD

P. H. WHARTON
PRINCIPAL HYDROGEOLOGIST

REFERENCE

West, S.M. (1986). Salinity study report and recommendations, G.E. White and Co., Darkan (unpublished).

TABLE 1

SALINITY MEASUREMENTS, 18-19/9/90 (by conductivity)

DATE	SITE (Fig 1)	STREAMFLOW	COND. micros/cm	$T^{o}C$	TSS mg/1	REMARKS
18/9/90	1	<0.5 1/sec	1,920	18.5	1,250	Small trib. to Dardadine G.
"	2	est. 45 1/sec	6,500	16	4,850	Dardadine Gully, in Reserve
"	3	100 1/sec	6,500	16	4,850	Dardadine Gully, Shields Rd
"	4	-	1,000	16.5	650	Culvert east of G. Whites house
"	5	-	3,000	15	2,200	Bunce King Rd culvert
"	6	-	2,500	18.5	1,700	Creek adj. Abd well
19/9/90	7	est. 100-200 1/sec	5,900	12	4,800	Northern bridge, Hillman-Dardakine Rd
18/9/90	Piezometers (P2)	-	660	18.5	400	Flowing, ~50 m NE of old well (Abd)
"	Desalinisation Bore (B1)	~30 cu m/d	1,330	19	840	Flow from bore. SO_2 smell
"	Piezometers (P1)	v. small	11,900	14	9,700	1 km west of B1. Flowing piezometer sampled (deep)
19/9/90	Well (soak) (W1)	-	490	13	330	Property of Bob & Terry Bunce

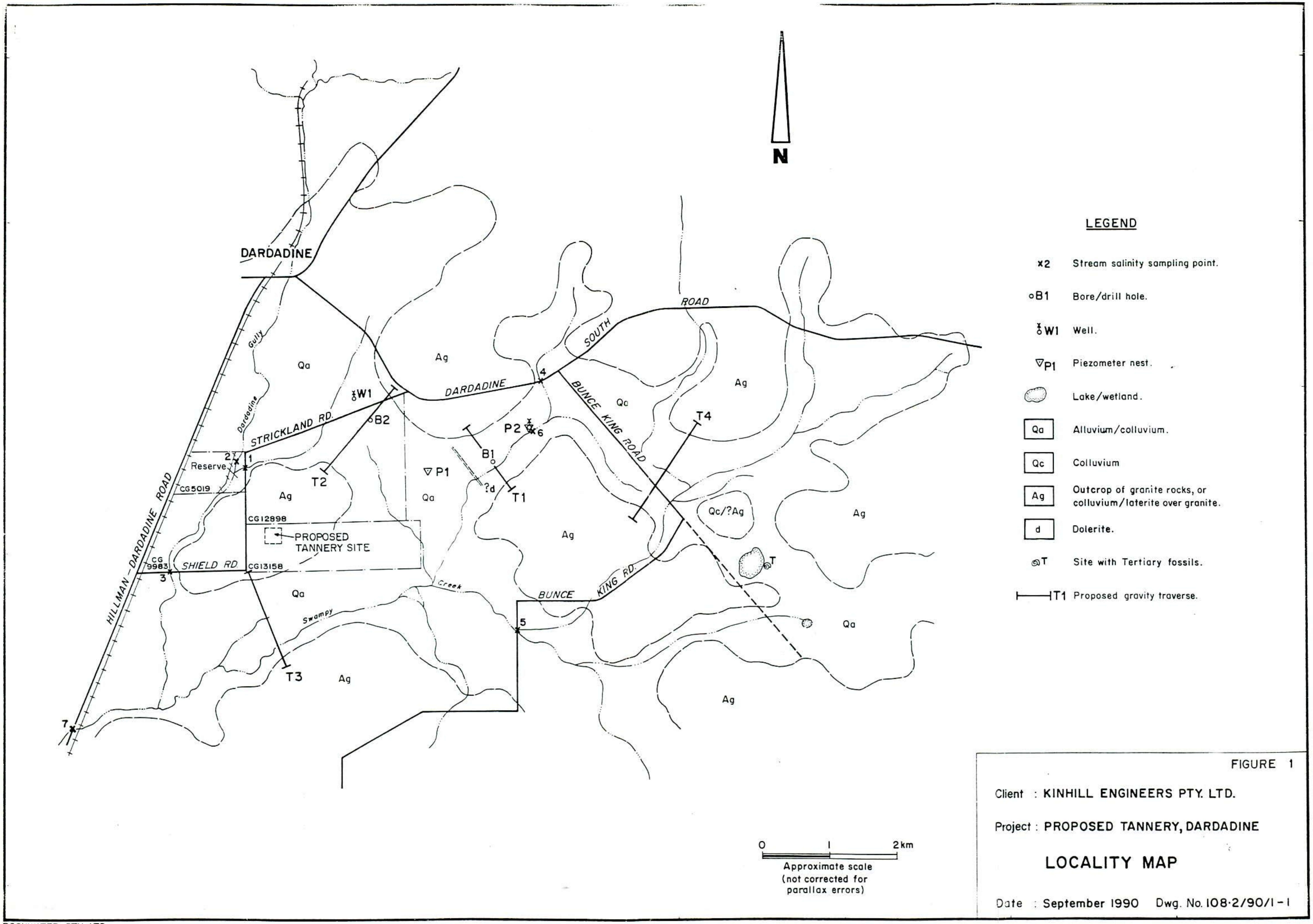


FIGURE 1

Client : KINHILL ENGINEERS PTY. LTD.

Project : PROPOSED TANNERY, DARDADINE

LOCALITY MAP

Date : September 1990 Dwg. No. 108-2/90/1-1

ROCKWATER PTY LTD

Appendix G.2
RESULTS OF GROUNDWATER INVESTIGATIONS

Rockwater
PROPRIETARY LIMITED
94 ROKEBY ROAD, SUBIACO, WESTERN AUSTRALIA 6008
P.O. BOX 237, SUBIACO, WESTERN AUSTRALIA 6008
TELEPHONE (09) 382 4922
INTERNATIONAL 619 382 4922
FACSIMILE (09) 381 3264

KINHILL ENGINEERS PTY LTD

PROPOSED TANNERY SITE AT DARDADINE
RESULTS OF GROUNDWATER INVESTIGATIONS

NOVEMBER 1990

108.2/90/3
R23/GW

TABLE OF CONTENTS

KINHILL ENGINEERS PTY LTD

PROPOSED TANNERY SITE AT DARDADINE

RESULTS OF GROUNDWATER INVESTIGATIONS

NOVEMBER 1990

1. INTRODUCTION

A tannery for processing cattle skins is proposed near Dardadine, approximately 12 km north-east of Darkan (Figs. 1, 2). If the tannery is constructed, a water supply of about 250 cu m/day will be needed for processing the skins. Options for waste disposal include evaporation ponds and disposal by irrigation. Substantial quantities of water would be needed, in addition to the supply for processing, to mix with waste-water if the irrigation option was adopted.

The Water Authority of Western Australia has indicated that they will require the extent of the water source that will be used for the project to be defined before giving their approval for the project to proceed. This report presents the results of the groundwater investigation and testing, and follows an earlier report (Rockwater, September 1990) on the preliminary desk study and site reconnaissance.

2. SETTING, AND PREVIOUS WORK

The tannery site is situated on the Yilgarn Block, where crystalline granite of Archaean age crops out, or is generally close to ground surface. It is east of the Collie Basin, which contains sediments of mainly Permian to Tertiary age.

Western Collieries Limited has defined a small Tertiary basin, the Dardadine Sub-Basin, in an area west of the site (Fig. 1). It was delineated by gravity surveying, and limited drilling near the margins of the basin.

Recently, the Geological Survey of Western Australia has been carrying out a regional gravity survey in the area. Preliminary results were made available for this study.

Magnetic and resistivity traverses, and test drilling, were carried out over part of G. White's property (West, 1986) as part of an investigation to remedy land salinisation and water-logging. The drilling results indicated the presence of at least 30 m thickness of sand containing fresh groundwater. A bore (B1, Fig. 2) was pumped for about one year at 350 cu m/day with only very local depression of the water-table.

Bores with large yields of fresh water have been reported on the properties of M. Threthewie and R. D. Hamilton (Fig. 1), east of G. White's property.

Rainfall in the area averages about 570 mm per year. Potential evaporation averages about 1,600 mm/year.

3. INVESTIGATION PROGRAMME

Exploratory bores (DT1 - DT3) were drilled on a transect on G. King's property, about 2 km west of G. White's bore, and on D. South's property (TD4) west of the tannery site (Fig. 2). A test-production bore, DT2P, was constructed at site DT2, and test-pumped.

The drilling and testing were carried out by Mega Drilling Pty Ltd in conjunction with Western Irrigation. Bores were drilled using a modified Rucker rotary rig, and air-rotary and mud-rotary methods.

Natural gamma logs were run in the holes using an SIE T450 down-hole logging unit, to distinguish between clay and sand beds, and to provide an indication of clay content in the sand beds.

Details of bore construction, lithology and the gamma ray logs are presented in Composite Bore Logs (Figs. 3 to 6). Geological descriptions of cuttings samples are presented in Appendix I. Results of the drilling and testing are discussed below.

3.1 DRILLING RESULTS

Bores DT1 to DT3 were drilled on a transect along Stricklands Road to explore for an extension to the palaeodrainage intersected by G. White's bore. They were drilled to depths of 20 m (DT1), 45 m (DT2) and 28 m (DT3). All except DT2 intersected granite (moderately weathered) at total depth. Bedrock was not intersected in DT2. A geological cross-section through the bores is presented in Figure 7.

DT1 and DT2 intersected mainly coarse to very coarse sand and granules to depths of 20 m and 23+ m respectively, infilling a palaeodrainage. DT3 (28 m depth) and DT4 (22.5 m depth) intersected mainly sandy or slightly sandy clays which are probably derived from in-situ weathering of granite. Moderately weathered granite was intersected in both holes at total depth.

3.2 BORE CONSTRUCTION

Test-production bore DT2P was drilled to 30 m depth, 30.1 m south of DT2, using mud-rotary methods. It was reamed at 222 mm diameter to 24 m, and completed with a production string consisting of 155 mm Class 9 UPVC casing from +1 - 13 m (slotted 7 m - 13 m), and in-line continuous slot 152 mm stainless-steel screens from 13 m to 22 m depth. Slot aperture of the screens was 0.5 mm, and of the casing, 1 mm.

The production string was packed with 1.5 - 3.0 mm graded sand/gravel, and developed by displacing the drilling mud with clean water, treatment with "Well-Clean", followed by airlifting and surging until clear, silt-free water was obtained. The borehead was completed with 200 mm steel casing and a lockable cap, and a surrounding concrete block.

DT1, DT2, and DT4 were completed as observation bores by installing slotted 50 mm Class 9 UPVC pipe in the 114 mm drill-holes. Graded sand/gravel was used to stabilise the annulus of each bore, and the bores were developed until the salinity had stabilised and a true water sample was collected for salinity measurement (by electrical conductivity). Steel pipe (152 mm diameter) and flush-fitting caps were installed at the boreheads to protect the UPVC pipe.

Details of bore construction are shown in Figures 3 to 6.

3.3 PUMPING TESTS

3.3.1 Method

Bore DT2P was test-pumped to determine the capacity of the bore and the response of the aquifer to pumping. Initially, a four-stage step-rate test was carried out at 60 minute steps of 670, 750, 990 and 1730 cu m/day. This test is mainly designed to select a suitable rate for the constant rate test, and the results are not included in this report.

The main constant rate test was run at a rate of 1350 cu m/day for 48-hours. The water was pumped via layflat hose into the drain alongside Stricklands Road, but the high flow rate and low gradient of the drain caused the water to back-up in the drain, and there was minor flooding in the paddock near the test-bore. However, there was no evidence in the test results of re-circulation.

Drawdowns were monitored regularly in the test-production bore and observation bores DT1 and DT2, and occasionally in Bunce's soak (W1 in Fig. 2), 260 m to the north, and in two piezometers on G. White's property (P1 in Fig. 2), 1300 m to the south-east.

3.3.2 Results

Figures 8 to 10

Drawdowns measured in DT1, DT2 and DT2P are plotted against time on a semi-logarithmic scale in Figures 8 and 9. Maximum drawdowns were as follows:

DT2P (pumped bore)	6.08 m
DT2 (observation bore)	3.40 m
DT1 (observation bore)	0.24 m
G. White's piezometers	0.02 m
Bunce's soak	Nil

In an ideal aquifer, drawdown versus time follows a straight line trend when plotted on semi-logarithmic scale. During this test, drawdowns in DT2P, DT2 and DT1 followed downward curving trends, and at the test rate, the water level in the pumped bore would have reached the pump-inlet after about 8 days. The data for DT2P, plotted on a square root of time scale (Fig. 10), follow a straight line, showing that the flow is one-dimensional, ie, along the drainage. There is little flow to the bore from the margins of the palaeodrainage, for example, from the direction of DT1.

DT2, 30 m north of the pumped bore, showed a very similar response to DT2P, reflecting the high along-channel transmissivity. There were only small drawdowns 300 m across-channel in DT1, and 1300 m along the channel in G. White's piezometers. Measurements at both sites were affected by diurnal fluctuations.

The one dimensional nature of flow to DT2P reduces the effective transmissivity from about 1200 cu m/d/m initially, to about 70 cu m/d/m by the end of the test. The storage coefficient (early time) is 6×10^{-4} typical of a confined aquifer. With extended periods of pumping, gravity drainage should occur, decreasing the rate of drawdown.

The long term capacity of DT2P will be substantially lower than the test rate, probably about 500 cu m/day on a continuous basis. The actual rate will depend on rates of recharge and gravity drainage. Soils overlying the main aquifer are very sandy, and water airlifted from the bore during development infiltrated into the ground within a short period, showing that a high rate of recharge and an unconfined response to pumping are likely.

It is recommended that the bore be equipped with a pump capable of yielding up to 750 cu m/day (if such a rate is needed), with a pump setting of 18 m below ground level. If additional water supplies are required, bores should be spaced at least one kilometre apart, along the palaeodrainage.

4. WATER QUALITY

The salinity of water intersected during the exploratory drilling is as follows, determined from field conductivity and temperature measurements:

DT1	605 mg/L TSS
DT2	610 - 670 mg/L TSS
DT3	9,000 mg/L TSS
DT4	3,700 mg/L TSS

These values show there is fresh water in the palaeodrainage (DT1, DT2), and saline water in the clayey sediments or weathered granite that border the palaeodrainage (DT3) and the Dardadine Sub-Basin (DT4).

Field measurements of salinity were also made during development and testing of DT2P (Fig. 11). These show some variability during bore development and the early part of the constant rate test, followed by a decrease in salinity, and then a small but gradual increase over the final 24 hours. The salinity could continue to increase with long-term pumping, or stabilise at some value above 450 mg/1 TDS.

Samples were taken near the beginning and at the end of the constant rate pumping test, and analysed for salinity and pH. The final sample was also analysed for major ions. Results of the chemical analyses are presented in Table 1.

TABLE 1
RESULTS OF CHEMICAL ANALYSES, BORE DT2P

	2.5 Hours	End of Test (48 hours)
	mg/L	
Ca		7
Mg		18
Na		123
K		4
Fe (sol)		0.70
Fe (tot)		1.45
HCO_3		12
SO_4		52
C1		215
NO_3		11
TDS (calc)	534	438
pH	5.65	5.35

These show an overall decline in salinity during the pumping test, and an increase in acidity. The pH is low, 5.35, indicating that the water is quite acidic. Hydrogen sulphide was released from the water on exposure to air, and so the acidity probably results from solution of hydrogen sulphide in the water.

5. EXTENT OF THE PALAEODRAINAGE

A Tertiary palaeodrainage is inferred to extend from at least Albany Highway to the east, to the Dardadine sub-basin in the west, as shown in Figure 1. Its course has been drawn to include known high-yielding fresh water bores, areas of "sand seams" and permanent freshwater soaks, a Tertiary fossil locality, and areas of low topography.

The sequence of sands intersected in Western Collieries drillhole R215 is similar to that in DT2P, and so R215 may also have intersected the palaeodrainage (or the Tertiary sub-basin into which it drains).

Recent regional gravity data provided by the Geological Survey of Western Australia show low Bouguer anomalies along a zone which includes DT2P and R215, but suggest that there may be another tributary or channel extending to the south-east from DT2P, as well as to the east through G. White's bore.

The palaeodrainage could be at least 20 km long, about 500 m wide and at least 45 m deep (at DT2P). With this size it could contain up to 30×10^6 (or more) cubic metres of fresh water in storage.

Groundwater in clayey material bordering the palaeodrainage is saline.

6. CONCLUSIONS

Drilling and testing near the Dardadine tannery site has confirmed the presence of a substantial palaeodrainage aquifer that is inferred to extend over a length of at least 20 kilometres, a width of about 500 metres, and a depth of at least 45 metres.

The paleodrainage contains fresh groundwater (approx. 450 mg/L TSS at bore DT2P), and could contain up to 30×10^6 cu m of water in storage. Where tested, it is overlain by sandy soils which readily allow the infiltration of rainfall or runoff.

The drainage is inferred to extend into a small Tertiary basin that has been defined west of the Tannery site, but the nature of this basin is uncertain. The palaeodrainage could possibly extend through, and west of the basin.

Bore DT2P is capable of yielding about 500 cu m/day of fresh water in the long-term, with the actual yield dependent on rates of recharge. If additional water supplies are required, bores would need to be widely spaced along the palaeodrainage (at least one kilometre apart), or possibly in the Dardadine Sub-Basin. The extent of aquifers and groundwater quality in the Sub-Basin have not been tested.

DATED: 19 NOVEMBER 1990

ROCKWATER PTY LTD

P. H. WHARTON

PRINCIPAL HYDROGEOLOGIST

REFERENCES

Rockwater, September 1990, Proposed tannery site at Dardadine: preliminary groundwater investigation. Unpub. report to Kinhill Engineers Pty Ltd.

West, SM, 1986, Salinity study report and recommendations, G.E. White and Co., Darkan (unpublished).

APPENDIX I: GEOLOGICAL LOGS

DT1 GEOLOGICAL LOG

Depth (m)		Description
0 - 4	SAND;	brown, very slightly clayey, poorly sorted fine to very coarse and granules, subangular - subrounded. Rare laterite. 2 - 4 m, predominantly fine to coarse.
4 - 6	SAND;	light-brown, slightly clayey, very poorly sorted, very fine to very coarse sand and gravel up to 5 mm. Angular to subrounded, with minor iron-stained grains and rare pebbles of granite.
6 - 8	SAND;	as for 2 - 4 mm, but minor iron-staining, and a band of pale grey, slightly silty CLAY.
8 - 10	SAND;	orange-brown, slightly clayey, moderately sorted, medium to very coarse, sub angular - subrounded, iron-stained quartz. Rare fine dark heavy minerals and very rare weathered granite fragments.
10 - 12	SAND;	light brown, very slightly clayey, moderately sorted mostly coarse to very coarse, sub angular - subrounded white and clear quartz. Common heavy minerals.
12 - 15	SAND;	pale brown-grey, clayey to very clayey, poorly sorted, mostly fine to coarse, subrounded quartz. Abundant (~5%) heavy minerals. Soft off-white interstitial clay.
16	SAND;	pale brown-grey, slightly clayey, moderately sorted, fine to very coarse (mostly coarse to very coarse), mostly subrounded, with common heavy minerals.
17 - 20	SAND;	pale grey or pale brown, slightly to moderately clayey, poorly sorted fine to very coarse, sub angular to subrounded quartz and 5 - 10% heavy minerals. 19 - 20 m, very poorly sorted; quartz up to 5 mm. Common heavy minerals, and biotite and/or manganese stains on quartz grains. Minor deeply weathered granite chips.
20	GRANITE;	hard (no samples) - possibly a boulder.

DT2 GEOLOGICAL LOG

Depth (m)		Description
0 - 1	CLAY;	grey, with abundant orange-brown SAND; poorly sorted, fine to very coarse, slightly clayey. Subangular - subrounded quartz, commonly iron-stained. Rare granules.
1 - 4	SAND;	orange-brown, minor grey, clayey. Quartz grains as above. Layers of grey, plastic CLAY 3 - 4 m depth.
4 - 6	CLAY;	pale grey, as above, and SAND; light grey, slightly clayey, poorly sorted fine to very coarse and granules. Quartz mostly angular - sub angular with minor iron-staining.
6 - 7.5	CLAY;	light brown-grey, slightly clayey, well sorted very fine to fine with approx. 5% heavy minerals.
10 - 16	SAND;	light grey or brown grey, slightly clayey, poorly sorted fine to very coarse and granules, sub angular - subrounded. Thin CLAY band at base. 10 - 14 m, approx 5% heavy minerals 10 - 12 m, predominantly fine to medium sand 14 - 16 m, " coarse sand to 5 mm gravel
17	SAND;	light grey, poorly to moderately sorted, fine to very coarse, trace of clay, minor heavy minerals
18 - 26	SAND;	light grey, moderately sorted very coarse to 5 mm gravel, sub angular - sub rounded. Minor fines and light brown clay. Rare heavy minerals, except 3 - 5% 24 - 26 m. 22 - 24 m, well sorted coarse sand to granules 24 - 26 m, mainly medium to very coarse, and minor lignite.
26 - 38	SAND;	light grey, slightly clayey, poorly sorted fine to very coarse and granules, rare fine gravel. Minor soft brown clay and heavy minerals. 34 - 36 m, moderately sorted, mainly very coarse to granules
38 - 42	SAND;	grey, clayey, poorly to moderately sorted, fine to coarse (minor very coarse and granules). Minor to rare heavy minerals.
45 T.D.	GRANULES/GRAVEL;	grey, slightly clayey, sub angular - subrounded, well sorted mainly 2 mm - 3 mm quartz. Rare heavy minerals, chips of weathered granite and iron-stained quartz.

DT2P GEOLOGICAL LOG

Depth (m)	Description
0 - 4	SAND; brown, some CLAY; brown, soft. Moderately sorted fine to coarse quartz, mostly iron-stained.
4 - 6	AS ABOVE; but fine to very coarse sand (many grains clear), and moderately consolidated white-brown clay.
6 - 8	SAND; light brown, very slightly clayey, well sorted, very coarse to granules. Sub angular with common iron-staining. Minor red-brown consolidated clay.
8 - 14	SAND; pale brown or brown-grey, very slightly clayey, moderately sorted mostly coarse to very coarse (range fine to granules), angular - sub rounded. Rare to minor heavy minerals.
14 - 22	SAND/GRANULES; pale grey, sub angular, well sorted, mostly very coarse sand to 2 mm granules, but up to 3 mm 14 - 16 m. Very slightly clayey 18 - 22 m, with minor fines. Rare to common heavy minerals.
22 - 28	SAND; brown-grey, slightly clayey, becoming clayey from 23 m. Moderately sorted mostly coarse to very coarse sand (range fine sand to granules). Clay is soft, brown, with common chips of COAL (with common woody texture). Very clayey at base.
28 - 30 T.D.	CLAY; light grey and light brown, sandy, soft. Sand as above. Common black COAL chips.

DT3 GEOLOGICAL LOG

Depth (m)	Description
0 - 2	CLAY; orange-brown, minor red, slightly sandy and silty. Consolidated at base.
2 - 6	CLAY; pale grey, red-brown (ferruginised, consolidated), minor green-grey 2 - 4 m, sandy (fine to very coarse)
6 - 8	CLAY; white, slightly sandy (fine to very coarse, sub angular - sub rounded quartz. Rare ferruginised clay lumps.
8 - 22	CLAY; white, some yellow-brown, minor red-brown and brown. Slightly sandy (as above), soft.
22 - 24	CLAY; (as above), with GRANULES; brown, well sorted angular - sub angular quartz and rare ferruginised, very deeply weathered granite.
24 - 28	CLAY; brown, soft, minor granules as above. Soft.
28	GRANITE; mottled brown and white, moderately weathered.

(Note: Entire sequence may be a granite weathering profile, with "gritty layer" 22 - 24 m).

DT4 GEOLOGICAL LOG

Depth (m)		Description
0 - 2	CLAY;	orange-brown and light grey, slightly sandy (fine to coarse quartz). Moderately consolidated.
2 - 4	SAND;	brown, very coarse to granules, angular to sub rounded, with abundant CLAY (as above).
4 - 6	CLAY;	as for 0 - 2 m, but with some soft, plastic clay. Minor fine to very coarse quartz grains.
6 - 10	CLAY;	red-brown, orange-brown and light grey, minor white and olive. Slightly sandy in part (fine to very coarse grained). Moderately consolidated.
10 - 14	CLAY;	white, some red-brown, very slightly sandy, soft.
14 - 16	CLAY;	as above, with some SAND; fine to very coarse and granules, angular to subrounded, with minor red-brown ferruginised/ silicified clay chips.
16 - 22.5	CLAY;	yellow, white, red-brown and brown, soft. Slightly sandy, with fine to very coarse and granules of angular quartz. Rarely up to 5 mm. Common iron-stained grains 20 - 22.5 m.
22.5	GRANITE;	brown, moderately to deeply weathered, hard.

MAP SHOWING INFERRED TERTIARY PALEODRAINAGE

Client : KINHILL ENGINEERS PTY. LTD.

Project : PROPOSED TANNERY, DARDADINE

Date : November 1990 Drg. No. 108-2/90/3-1

ROCKWATER PTY LTD

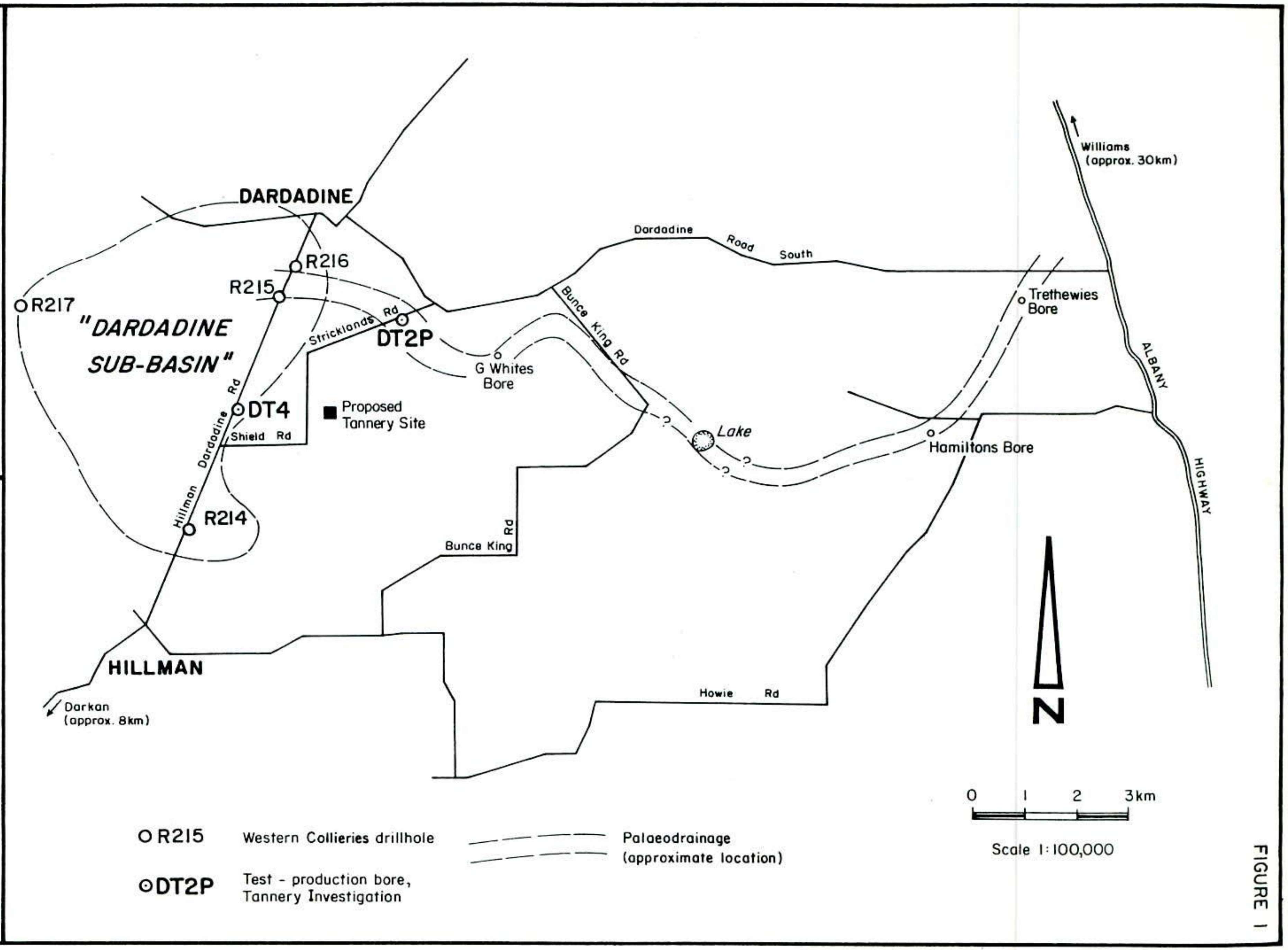


FIGURE 1

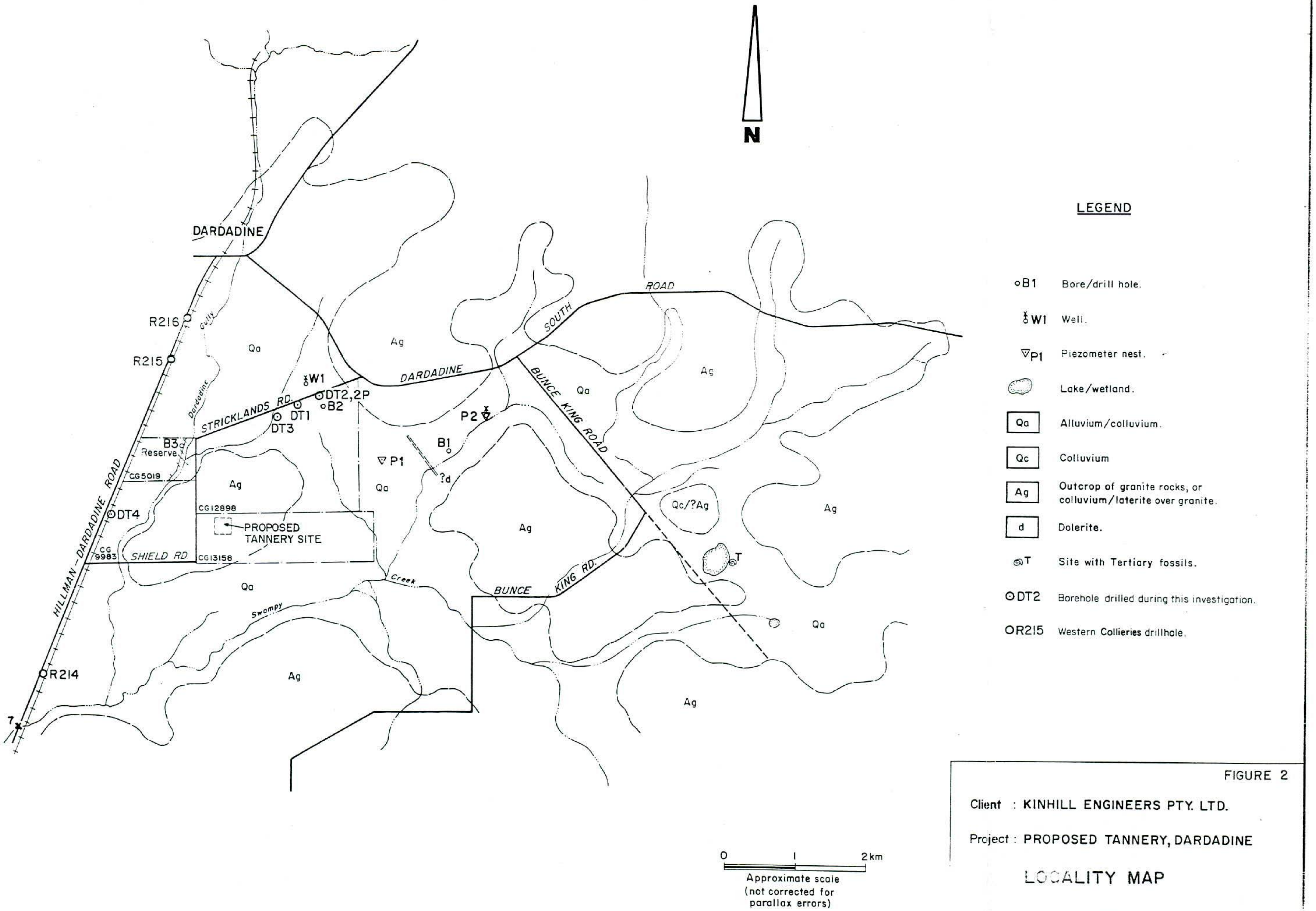


FIGURE 2

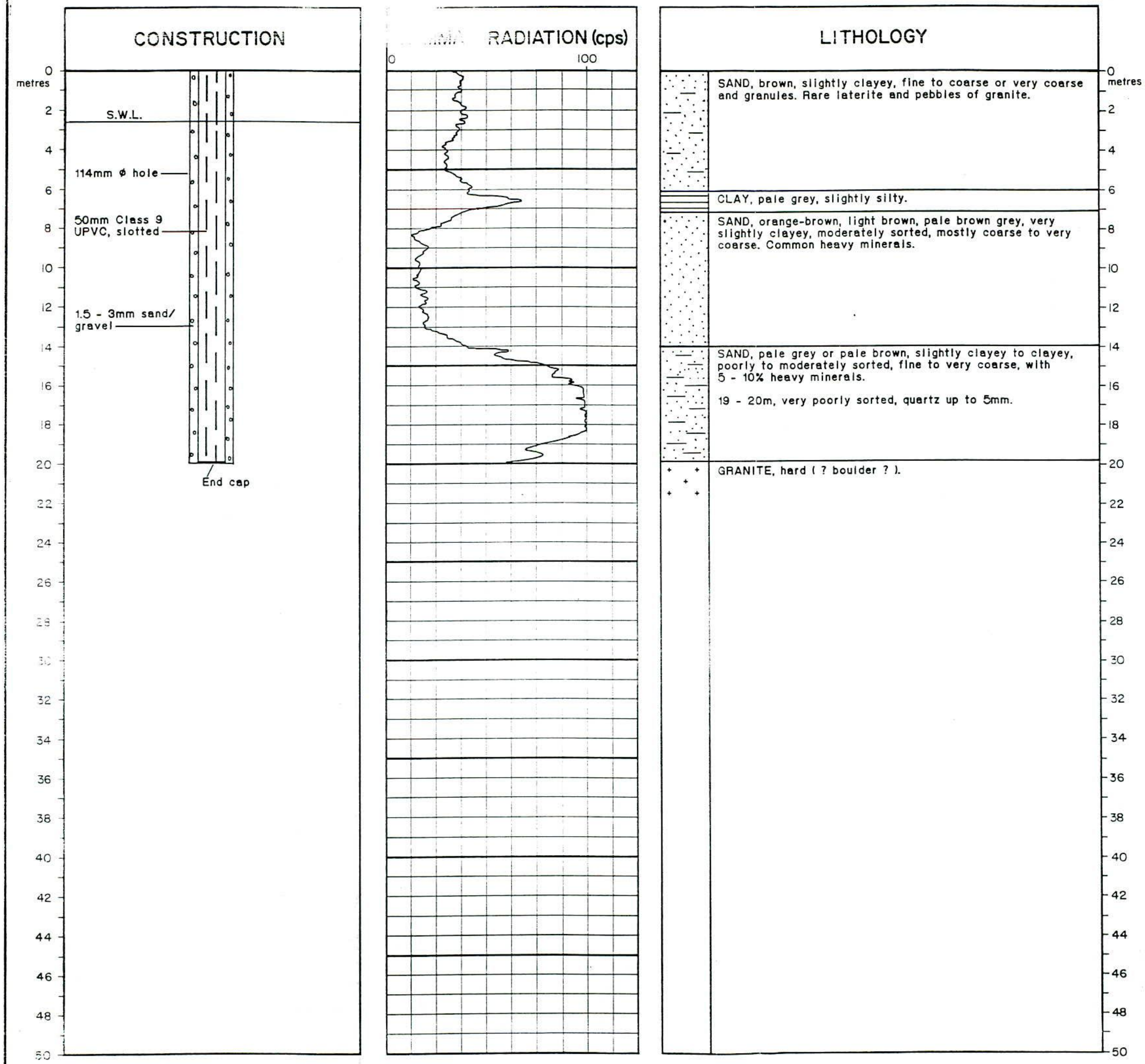
Client : KINHILL ENGINEERS PTY. LTD.

Project : PROPOSED TANNERY, DARDADINE

LOCALITY MAP

1990 Dwg 08-2/90/3-2

FIGURE 3



KINHILL ENGINEERS PTY. LTD.

PROPOSED TANNERY, DARDADINE.

COMPOSITE BORE LOG DT1

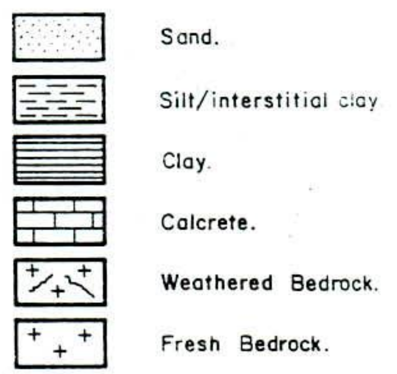
BORE DATA

Location : See Figures 1 & 2
Reduced Level of Collar : Not determined
Static Water Level below Collar : 2·92m
Depth Drilled : 20m
Date Completed : 21·10·90
Status : Observation bore
Height of collar rel. ground : 0·8m

GEOPHYSICAL DATA

Date Run : 21·10·90
Logger : SIE T450
Casing : 50 mm UPVC
Hole Size : 114mm
Fluid Type : Mud
γ T.C. : 2
Recorded by : P.H.W.

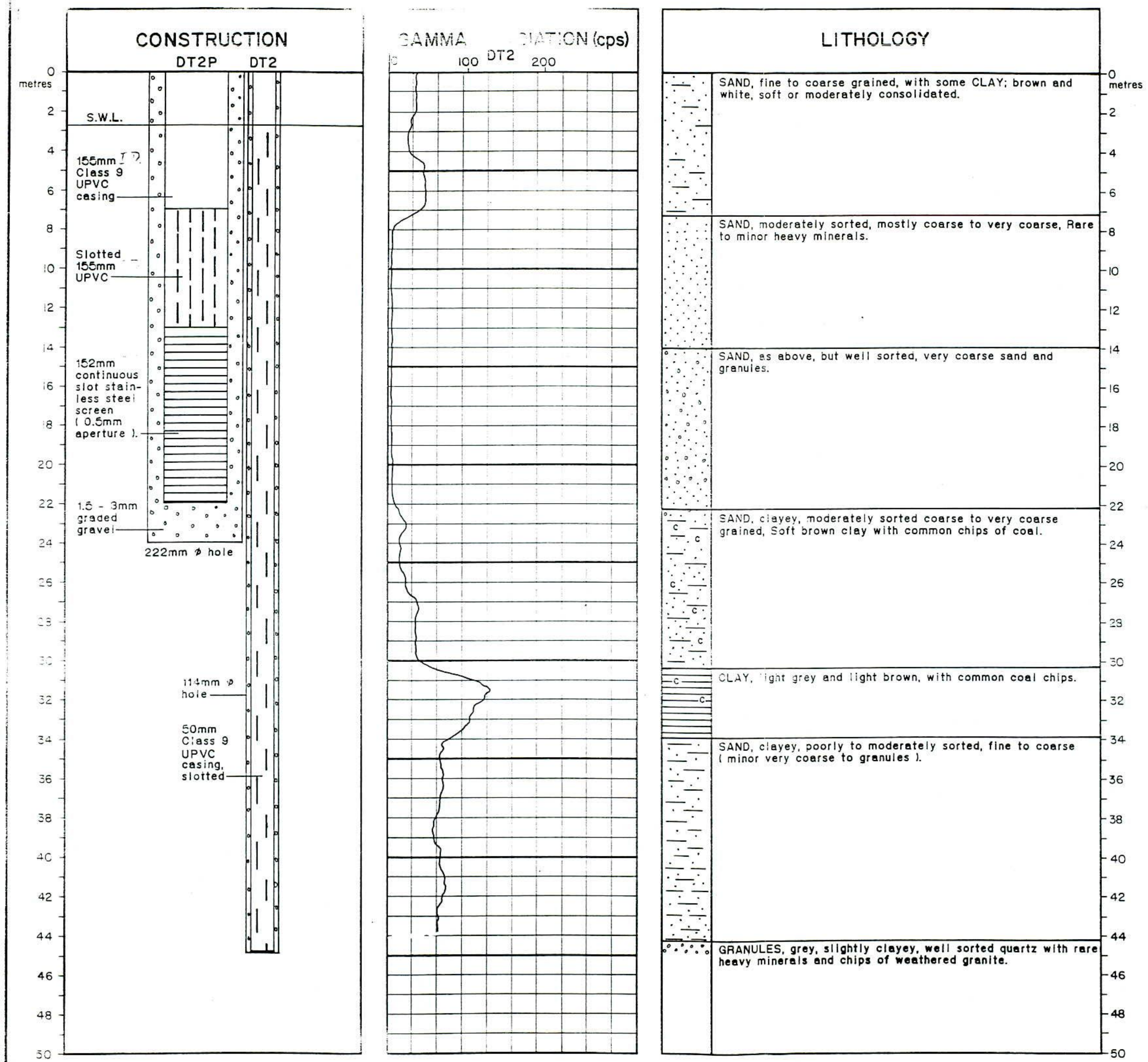
GEOLOGICAL REFERENCE



November 1990

108·2/90/3–3

FIGURE 4



KINHILL ENGINEERS PTY. LTD.

PROPOSED TANNERY, DARDADINE.

COMPOSITE BORE LOG DT2, 2P

BORE DATA	DT2	DT2P
Location :	– See Figures 1 & 2 –	
Reduced Level of Collar :	– Not determined –	
Static Water Level below Collar :	2·71m	3·05m
Depth Drilled :	45m	24m
Date Completed :	23·10·90	25·10·90
Status :	Observation bore.	Production bore.
Height of collar rel. ground :	0·84m	0·25m

GEOPHYSICAL DATA		
Date Run :	22·10·90	25·10·90
Logger :	– SIE T450 –	
Casing :	50mmUPVC	Nil
Hole Size :	114mm	152mm
Fluid Type :	Mud	Mud
γ T.C. :	2	2
Recorded by :	P.H.W.	P.H.W.

GEOLOGICAL REFERENCE

- Sand.
- Silt/interstitial clay.
- Clay.
- Calcrete.
- Weathered Bedrock.
- Fresh Bedrock.

November 1990

108·2/90/3-4

ROCKWATER PTY LTD.

FIGURE 5

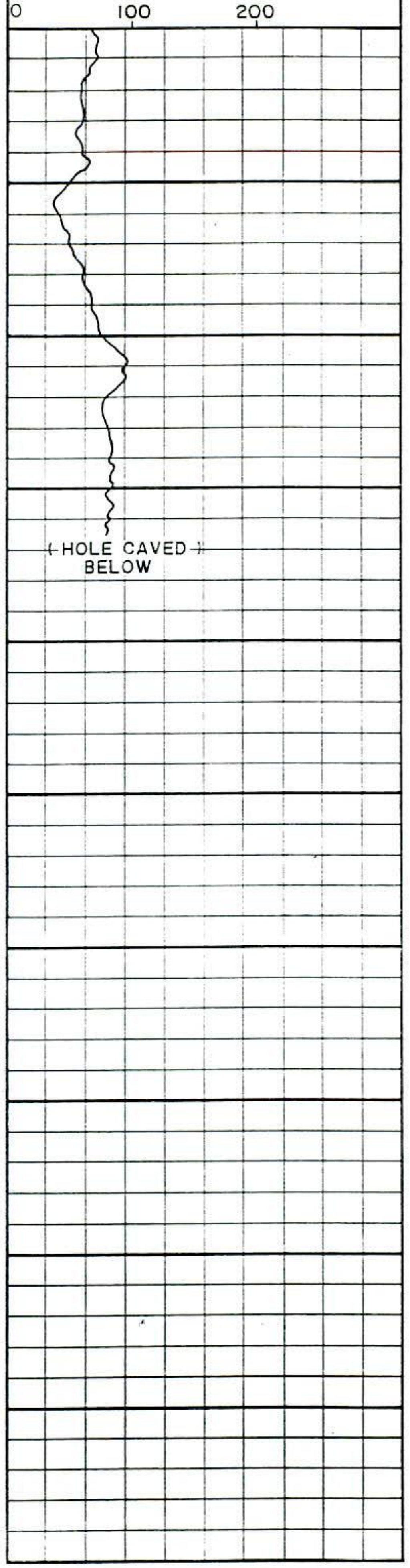
CONSTRUCTION

S.W.L.

114mm ø hole

Hole abandoned uncased.

GAMMA RADIATION (cps)



LITHOLOGY

CLAY, orange-brown, minor red, slightly sandy.

CLAY, sandy, as above, but with pale grey and green-grey.

CLAY, pale grey, red-brown, minor white.

CLAY, white, slightly sandy, (fine to very coarse quartz).

CLAY, white, some yellow-brown, minor red-brown and brown, slightly sandy, soft.

GRANULES, brown, slightly clayey, with minor clay as above, Well sorted, angular to subangular, 2mm quartz.

CLAY, brown, soft, minor granules as above.

GRANITE, moderately weathered, hard.

KINHILL ENGINEERS PTY. LTD.

PROPOSED TANNERY, DARDADINE.

COMPOSITE BORE LOG DT3

BORE DATA

Location : See Figures 1 & 2
Reduced Level of Collar : Not determined
Static Water Level below Collar : 2·10m bgl
Depth Drilled : 28m
Date Completed : 23·10·90
Status : Exploration hole, abandoned
Height of collar rel. ground : –

GEOPHYSICAL DATA

Date Run : 23·10·90
Logger : SIE T450
Casing : Nil
Hole Size : 114mm
Fluid Type : Water
γ T.C. : 2
Recorded by : P.H.W.

GEOLOGICAL REFERENCE

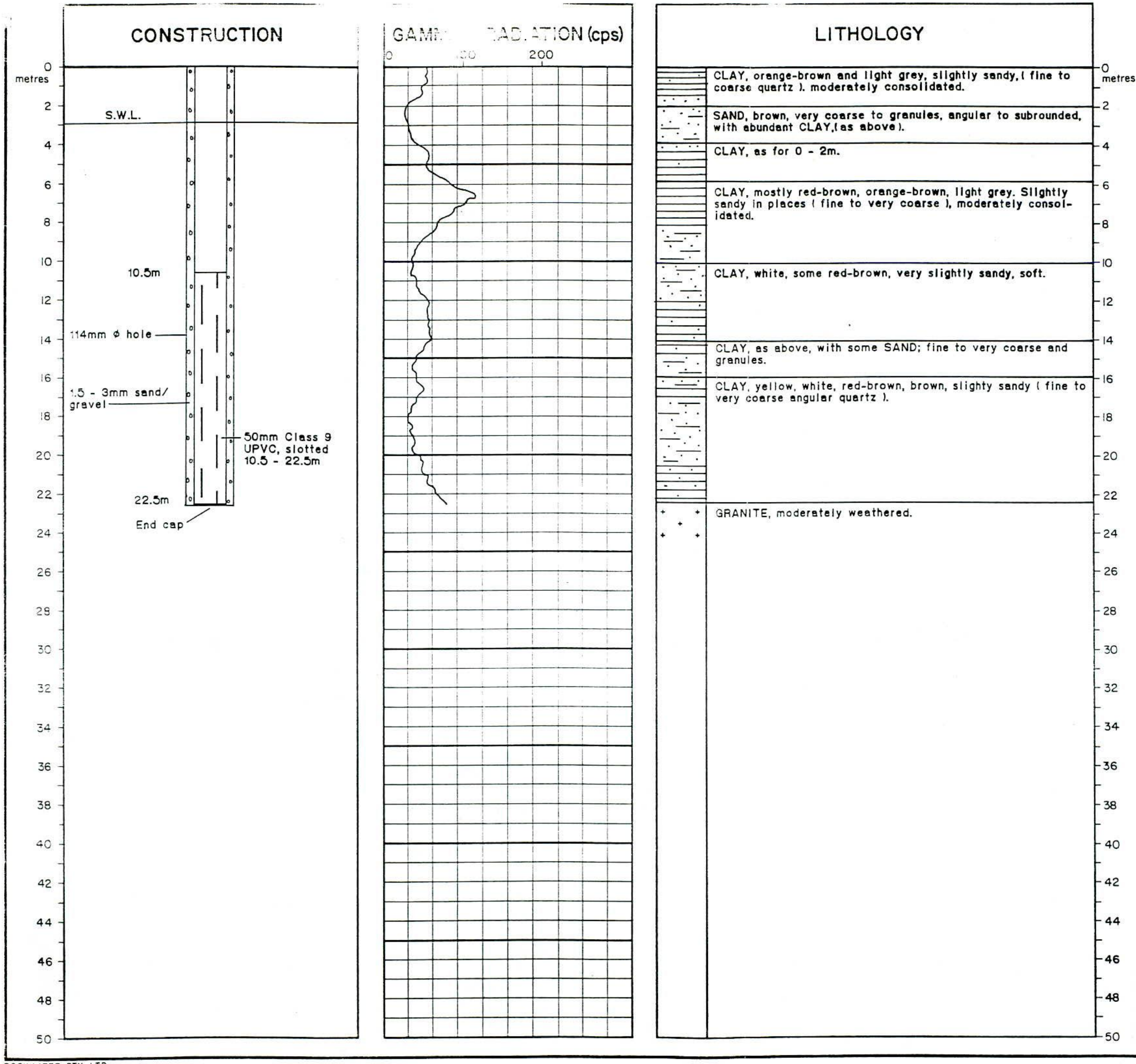
Sand.
Silt/interstitial clay.
Clay.
Calcrete.
Weathered Bedrock.
Fresh Bedrock.

November 1990

108·2/90/3–5

ROCKWATER PTY. LTD.

URE 6



KINHILL ENGINEERS PTY. LTD.

PROPOSED TANNERY, DARDADINE.

COMPOSITE BORE LOG
DT4

BORE DATA

Location : See Figures 1 & 2
Reduced Level of Collar : Not determined
Static Water Level below Collar : 3·45m
Depth Drilled : 22·5m
Date Completed : 29·10·90
Status : Observation bore
Height of collar rel. ground : 0·74m

GEOPHYSICAL DATA

Date Run : 29·10·90
Logger : SIE T450
Casing : 50mm UPVC
Hole Size : 114mm
Fluid Type : Mud
γ T.C. : 2
Recorded by : P.H.W.

GEOLOGICAL REFERENCE

Sand.
Silt/interstitial clay.
Clay.
Calcrete.
Weathered Bedrock.
Fresh Bedrock.

November 1990 108·2/90/3-6

ROCKWATER PTY. LTD.

ROCKWATER PTY LTD

Client : KINHILL ENGINEERS PTY. LTD.

Project : PROPOSED TANNERY, DARDADINE

Date : November 1990   Drg. No. 108·2/90/3-7

GEOLOGICAL CROSS-SECTION

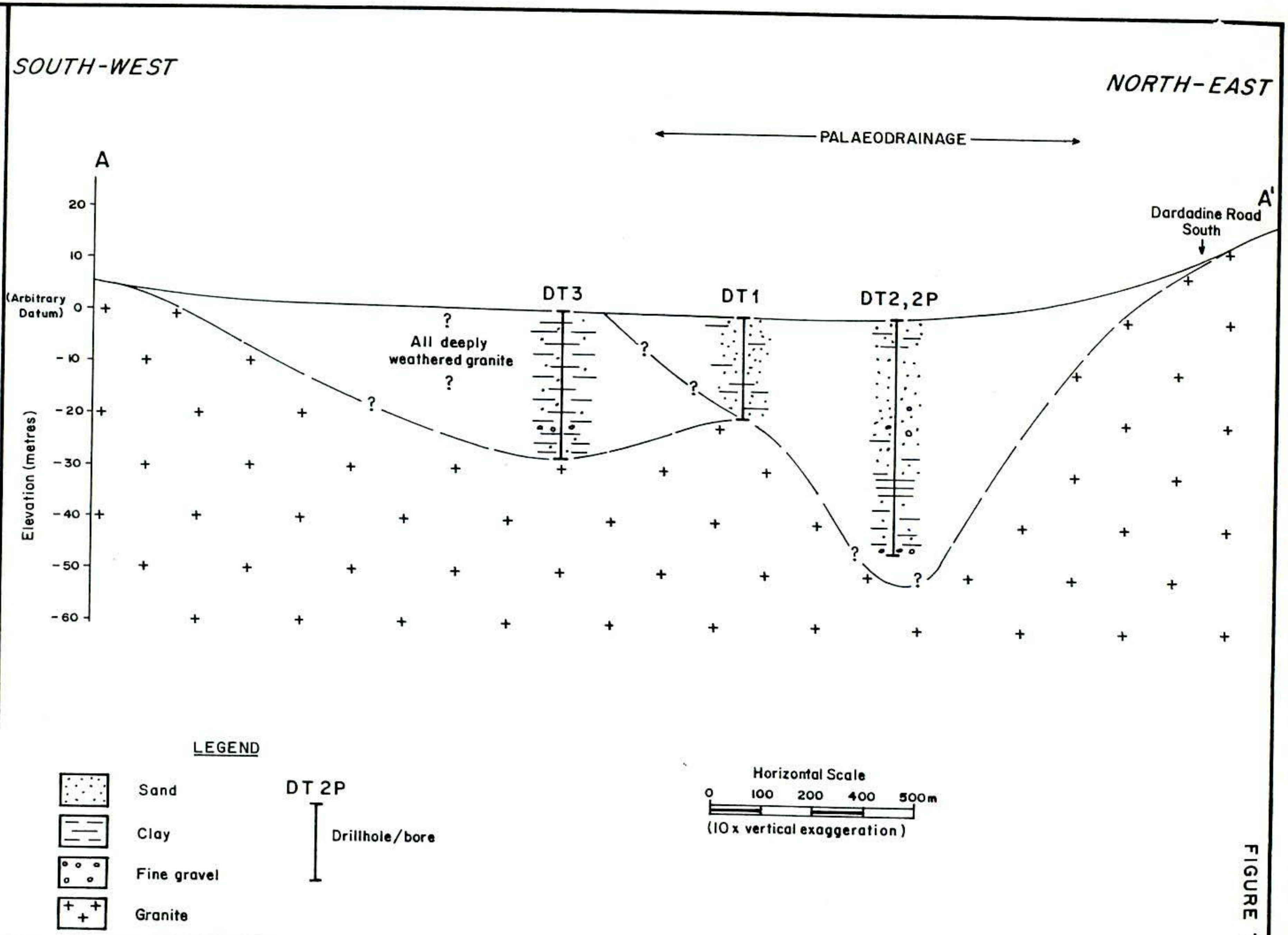
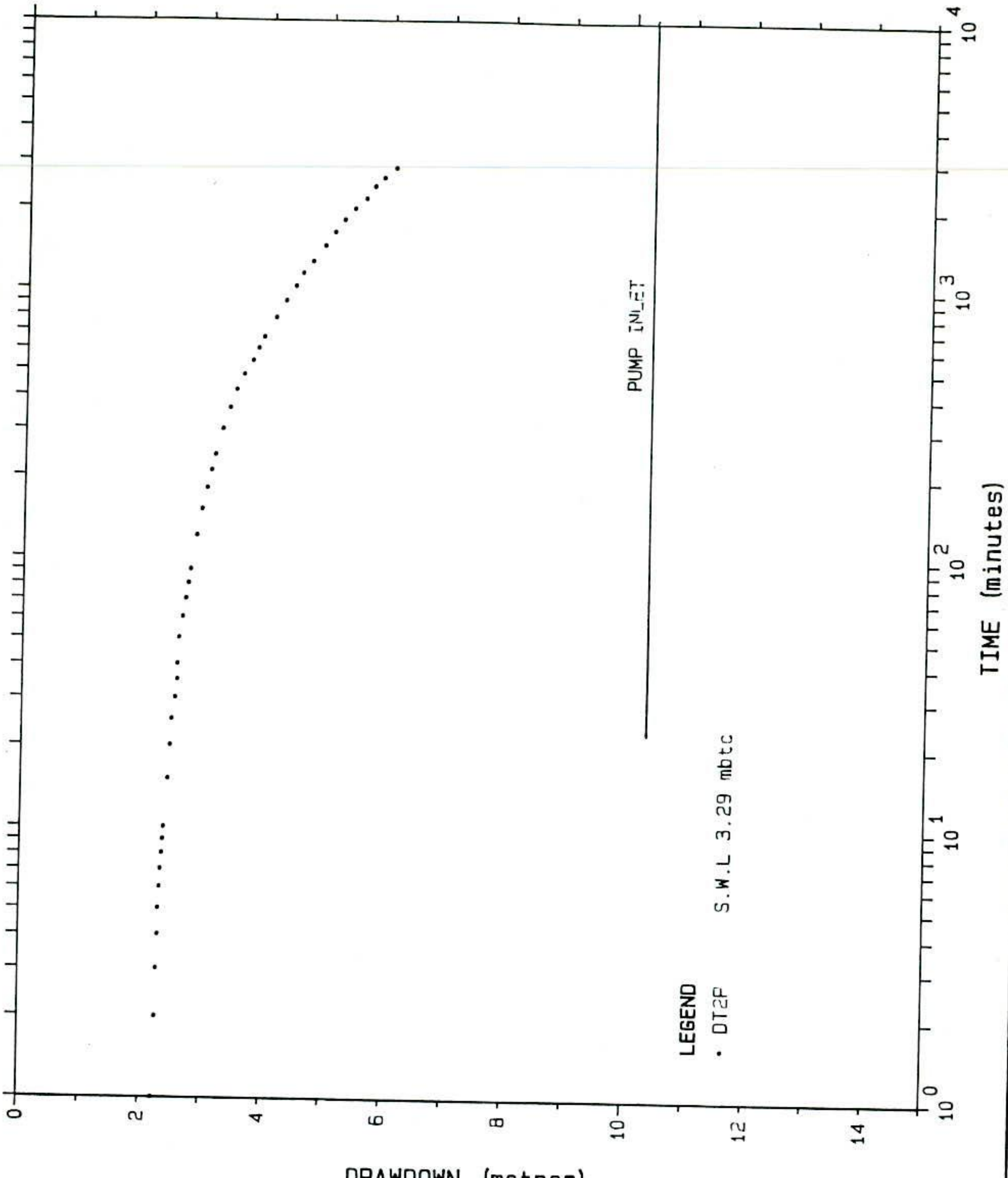


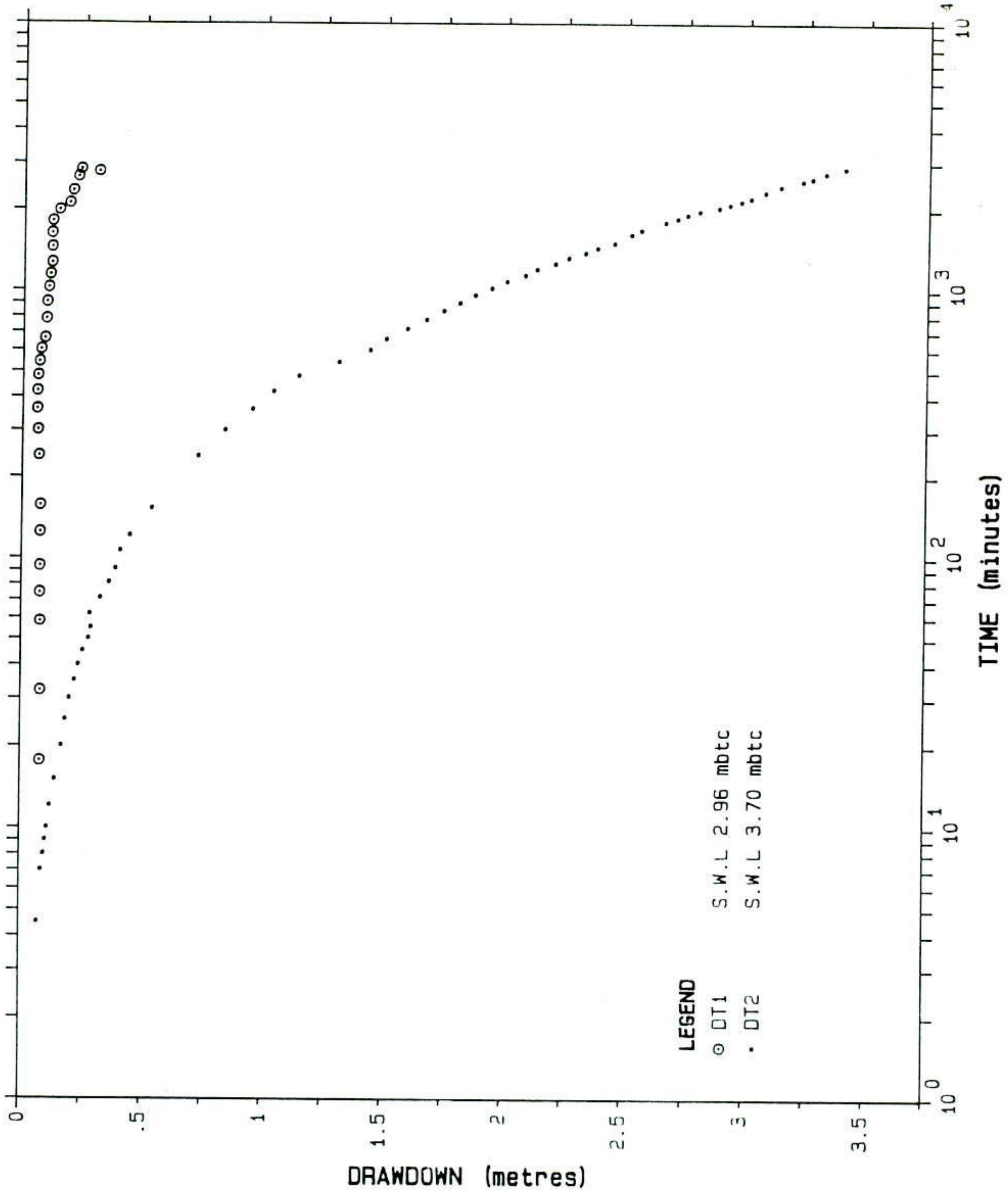
FIGURE 7

Figure 8



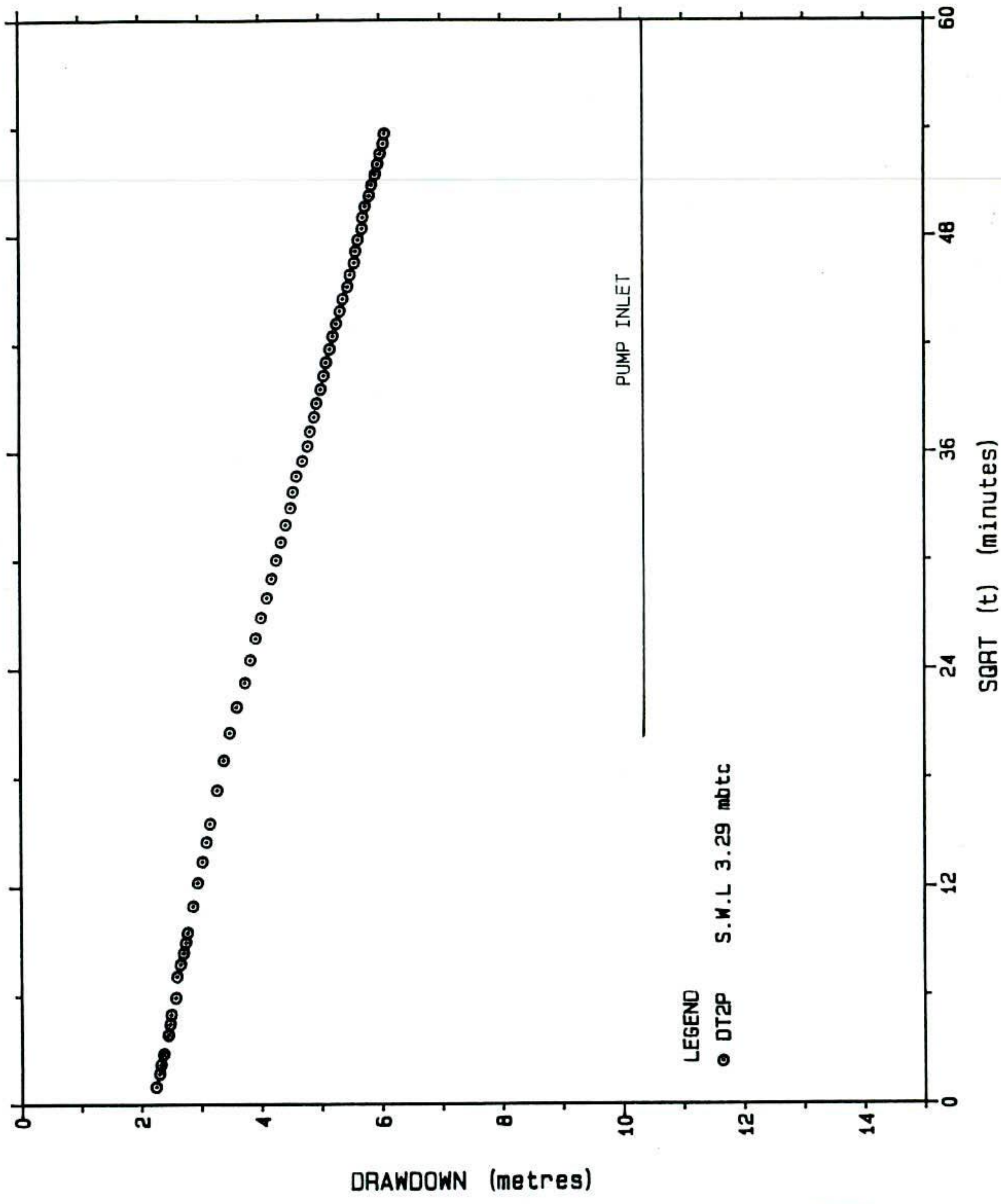
Client : KINHILL ENGINEERS PTY LTD	BORE DT2P CONSTANT RATE PUMPING TEST
Project : DARDADINE TANNERY INVESTIGATION	DRAWDOWN IN PUMPED BORE
Date : NOVEMBER 1990	Pumping Rate of DT2P 1350 m^3/day
Dwg. No.: 108.2/90/3-8	Commenced test on 27/10/90

Figure 9



Client : KINHILL ENGINEERS PTY LTD	BORE DT2P CONSTANT RATE PUMPING TEST
Project : DARDADINE TANNERY INVESTIGATION	DRAWDOWN IN OBSERVATION BORES
Date : NOVEMBER 1990	Pumping Rate of DT2P 1350 m^3/day
Dwg. No.: 108.2/90/3-9	Commenced test on 27/10/90

Figure 10



Client : KINHILL ENGINEERS PTY LTD	BORE DT2P CONSTANT RATE PUMPING TEST
Project : DARDADINE TANNERY INVESTIGATION	DRAWDOWN IN PUMPED BORE
Date : NOVEMBER 1990	SQUARE ROOT OF TIME PLOT
Dwg. No.: 108.2/90/3-10	Pumping Rate of DT2P 1350 m^3/day

Client : KINHILL ENGINEERS PTY. LTD.

Project : PROPOSED TANNERY, DARDADINE

Date : October 1990

Drg. No. 108.2/90/3-11

OCKWATER PTY LTD

VARIATION IN WATER SALINITY (Mg/L TSS) DURING DT2P DEVELOPMENT & PUMPING TESTS

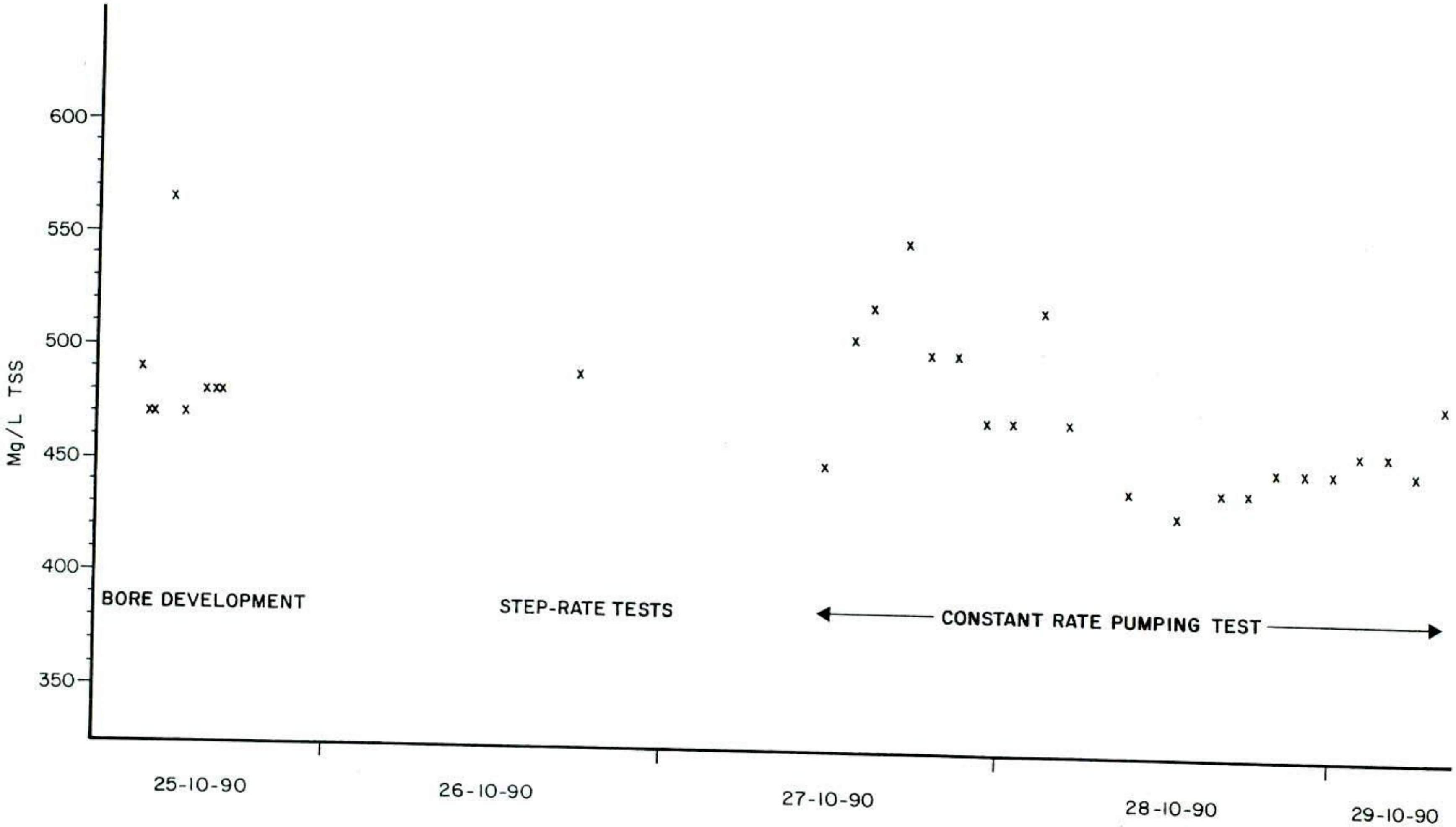


FIGURE 11

Appendix G.3

ADDENDUM

Rockwater
PROPRIETARY LIMITED
94 ROKEBY ROAD, SUBIACO, WESTERN AUSTRALIA 6008
P O BOX 237, SUBIACO, WESTERN AUSTRALIA 6008
TELEPHONE (09) 382 4922
INTERNATIONAL: 619 382 4922
FACSIMILE (09) 381 3264

KINHILL ENGINEERS PTY LTD

PROPOSED TANNERY SITE AT DARDADINE
RESULTS OF GROUNDWATER INVESTIGATION
ADDENDUM

NOVEMBER 1990

1. INTRODUCTION

The Water Authority of Western Australia have requested the following additional information on the palaeodrainage aquifer which would be utilised for the tannery water supply:

(i) An estimate of potential recharge to the palaeodrainage.

(ii) A prediction of aquifer behaviour at the planned extraction rate of 240 cu m/d for 5 days each week.

(iii) A suggested monitoring programme.

This addendum addresses these points.

2. POTENTIAL RECHARGE

The palaeodrainage that would be pumped for the tannery water supply is inferred to extend over a length of at least 20 km, and a width of 500 m. It is overlain by generally sandy soils, which readily allow the infiltration of water.

At present, potential recharge is being rejected, as in some areas (for example, near G White's bore) hydraulic heads are above ground level. Also, water discharges from the palaeodrainage to permanent soaks along the drainage lines.

With lower groundwater levels when the palaeodrainage is pumped, there would be recharge, both from direct infiltration of rainfall, and runoff from the surrounding granitic hills. As a conservative estimate of potential recharge, it is assumed that 10 percent of rainfall on the area of the palaeodrainage would infiltrate to the aquifer.

Therefore, potential recharge = 0.1 x 0.57 m x 20,000 m x 500 m
= 570,000 cu m/year
= 1560 cu m/day average

With the additional infiltration of runoff water from the whole catchment of the palaeodrainage, potential recharge is estimated to be about 1.5×10^6 cu m/year.

3. EFFECTS OF PUMPING

The planned rate of extraction from bore DT2P is 250 cu m/day for 5 days per week (179 cu m/day average). This is low in comparison to the pumping test rate of 1350 cu m/day, the estimated capacity of 500 cu m/day, and past extraction from G. White's bore (350 cu m/day). It is reported that G White's bore, which intersects the same palaeodrainage as DT2P, yielded at that rate for one year with only very local depression of the water table. Water levels have since recovered to the original (artesian) levels.

3.1 AQUIFER MODELLING

A simple numerical groundwater model was established to simulate pumping from the palaeodrainage aquifer. A variable finite-difference grid was set up to represent the palaeodrainage, covering a width of 450 m. and extending about 2,000 m upstream and downstream from bore DT2P.

Hydraulic conductivities were adjusted until simulation of the DT2P pumping test gave calculated drawdowns that were within 0.25 m of those measured in DT2, and within 0.1 m of those measured in DT1 during the pumping test.

Adopted model parameters are as follows:

hydraulic conductivity along columns (parallel to palaeodrainage) = 40 m/d
hydraulic conductivity along rows (perpendicular to palaeodrainage) = 2 m/d
storage coefficient = 0.005
average recharge rate = 1.6×10^{-4} m/day

The model was then run to predict drawdowns around the bore after 365 days at 179 cu m/day average. The results suggest that there will be drawdowns of about 0.5 m within 25 m of the bore, decreasing to less than 0.1 m at a distance of about 700 m along-channel from the bore, and 150 m across-channel.

Long-term drawdowns in the palaeodrainage are expected to be of the same order.

4. RECOMMENDED MONITORING PROGRAMME

It is recommended that water levels be monitored weekly for the first year of operation in bores DT2P, DT2 and DT1. Also, monthly measurement of electrical conductivity, temperature and pH should be made of water pumped from DT2P.

Monthly water level measurements should be made in Bunce's soak, and in the two piezometers on G White's property, approximately 1300 m south-east of DT2P.

The monitoring data should be assessed after the first year, and the programme modified if necessary.

5. CONCLUSIONS

Permanent seepage from soaks, and high hydraulic heads indicate that potential recharge to the palaeodrainage aquifer is being rejected. A conservative estimate of potential recharge to the palaeodrainage is 570,000 cu m/year (1560 cu m/day), but it is likely that potential recharge, including infiltration of runoff, is at least 1.5×10^6 cu m/year.

The effects of pumping DT2P at an average rate of 250 cu m/day for 5 days each week will be small and localised. G White's bore, which is in the same aquifer, was pumped for 350 cu m/day for one year with only local depression of the water table. Numerical modelling of the proposed pumping indicates that drawdowns exceeding 0.1 m will only extend up to 700 m along-channel from the bore, and about 150 m across-channel.

It is recommended that water levels be monitored weekly for the first year of operation, in bores DT2P, DT2 and DT1, and monthly in Bunce's Soak and in two piezometers 1.3 km south-east of DT2P. Also, monthly measurements of electrical conductivity, temperature and pH should be made of water pumped from DT2P. The data should then be assessed, and the programme modified if necessary.

DATED: 30 NOVEMBER 1990

ROCKWATER PTY LTD

P H WHARTON
PRINCIPAL HYDROGEOLOGIST

Appendix H
PRELIMINARY DESIGN OF FACILITIES

Appendix H
PRELIMINARY DESIGN OF FACILITIES

The expected concentrations of the combined wastewater streams are shown in Table H.1.

Table H.1 **Estimated concentrations and loads of wastewater constituents**

Source	Volume (m^3)	BOD	TKN	COD
Washing water[1]	35	2,000 (70)	300 (11)	7,000 (245)
Dehairing and rinsing	105	6,200 (651)	1,800 (189)	17,500 (1,800)
Deliming and bating[2]	47	3,400 (160)	2,600 (122)	7,250 (340)
Pickling and tanning[3]	27	1,000 (27)	50 (1)	–

In mg/L

1 includes fleshing water

2 includes splitting water

3 includes samming water

Note: Loads of BOD, COD (chemical oxygen demand) and nitrogen, in units of kilograms per operating day, are shown in brackets.

ANAEROBIC LAGOON

The information in McFarlane and Melcer 1978 (on laboratory trials of the treatment of synthetic unhairing water using a bacterial consortium dominated by *Thiocapsa roseopersicina)* is used. For a temperature of 17.5°C, which is expected to be the lowest at which the lagoon will receive full loading, organic removal constants averaged 0.2 day^{-1}. For a feed COD concentration of 13,000 and a desired effluent COD of 1,700 mg/L the detention time required would be:

$$t = \frac{13\ 000-1\ 700}{0.2\ (1\ 700-400)}$$

$$= 43 \text{ days}$$

assuming a non-degradable COD of 400 mg/L in the wastewaters. This corresponds to a volume of 5,800 m^3, allowing for 5 days' wastewater production per week.

The effluent BOD is expected to be 625 mg/L. This results in a loading of 83 kg/day—7 days per week—to the facultative lagoon.

FACULTATIVE LAGOON

Experience with facultative lagoons treating sewage either in northern areas of Western Australia (where evaporation rates are high and water is rather saline), or where high sulphate water is being treated suggests that conventional loading rates should be reduced by a factor of about 30% (GHD–Dwyer 1985). For the latitude of Darkan, this corresponds to an areal BOD loading of 73.5 kg BOD/ha/day.

The lagoon would have an area of 1.3 ha, and would receive wastewater only on 5 days per week. Therefore, an acceptable working day loading is 134 kg BOD. The pickling and tanning wastewater would provide a load of 25 kg BOD per day. The anaerobic lagoon would provide a load of 83 kg per day during summer. During winter, the BOD load from the anaerobic lagoon is expected to be less than 15 kg per day.

By any standards, the lagoon is loaded lightly. This would allow nitrification of ammonia to proceed, yielding nitrate as a redox buffer for the evaporation lagoons.

EVAPORATION AREA

Evaporation lagoons are designed on a mass-balance basis. The mass balance for this proposal is:

Rainfall gain + wastewater volume

= Evaporative loss + leakage + volume removed for disposal.

Therefore, if the evaporative area required is designated by A, 6,000 m^3 annually is removed for drying and disposal, and other factors are as in Sections 3.1.1 and 6.5 then:

$$0.564.A + 37{,}340 = A.1.279 + 5{,}750 + 6{,}000$$

$$A = \frac{25\ 590}{0.715}$$

$$= 3.6 \text{ ha}$$

An area of 4.1 ha has been quoted, to allow for uncertainties in the actual evaporation rates at the site.

The concentration of salt in the second evaporation lagoon is at about the level at which the activity, and hence the evaporation rate, of water is measurably reduced. If evaporation rates were substantially greater than estimated (Table 4.4), salt could be allowed to accummulate in this lagoon to a higher concentration than shown in Table 7.1.

Appendix I
CHEMICAL SAFETY DATA SHEETS

PRODUCT NAME BAL BAYMOL A

EMERGENCY TEL. NO.: 008 033 111

COMPANY ADDRESS: BAYER AUSTRALIA LTD
47 WILSON ST.
BOTANY NSW 2019
PH. (02) 666-9641

1.01 Chemical Characterisation:

Preparation of alkyl polyglycol ether and alkyl aryl polyglycol ethers contains 3-Methyl-3-Methoxy Butanol.

1.09 Form: Liquid

1.10 Colour: Yellow

1.11 Odour:

1.12 Change in physical state:

Solidifying point: -4'C
Boiling point: From 82'C

1.13 Density: 1.0 g/cm(3)

1.14 Vapour Pressure: <100 mbar at 50'C

1.15 Viscosity: 130-140 mPa.s at 20'C

1.16 Solubility in water: miscible

1.17 pH value: 6.0-7.5 at 10 g/l water

1.18 Flash point: 71'C

1.19 Ignition temperature: 440'C

1.20 Explosive limits:

1.22 Further information:

2.01 Information on toxicity:

Acute oral toxicity (LD50): above 5000 mg/kg (tested in rats) *
Skin irritation: non-irritant (OECD re-evaluated) (tested on rabbits) *
Eye irritation: non-irritant (OECD re-evaluated) (tested on rabbit eyes)*

PRODUCT NAME BAL BAYMOL A

* Test results of a similarly composed product.

2.02 Regulations:

Labelling according to the Dangerous goods (prescribed list) of the Dangerous Goods Act 1986 (Victoria).

2.03 First aid: Skin: cleansing with plenty of water
Eyes: rinse with copious amounts of water, seek medic advice.

3.01 Technical Protective measures: Keep container tightly closed, in a well-ventiloged place and remove sources of ignition.

3.0_ Personal protective equipment:

3.03 Industrial hygiene: Avoid contact with the skin and inhaling aerosols and vapours.

3.04 Protection against fire and explosion:

Pay attention to solvent.

3.05 Classification under the Transportation of Dangerous Goods Code:

Not dangerous cargo.

4.01 After spillage/leakage/gas leakage:

Remove sources of ignition. Use sufficient ventilation or wear a respirator. Take up with absorbent material and fill into a closable container.

4.02 Disposal:

May be incinerated if local official regulations are observed.

4.03 Thermal decomposition:

4.04 Hazardous decomposition products:

4.05 Hazardous reactions:

4.06 Extinguishing media:

PRODUCT NAME BAL BAYMOL A

Water mist. foam. dry powder. CO(2)

4.07 Further information:

4.08 Information on ecological effects:
Biological elimination: 50-100% *
Method: Analysis Method: BIAS
Fish toxicity: LC0 1-10 mg/l *
Test species: Leuciscus idus Duration of test: 48 h
Inhibition of activity of waste water bacteria: No inhibitory effects at 1000 mg/l *
Test organism: Pseudomonas fluorescens
Test procedure: Growth inhibition test modified according to G. Bringmann.
* Test results of a similarly composed product.

Hazard class: (WGK): 2 - impairment of water quality

5. FURTHER INFORMATION

The product contains less than 0.003% ethylene oxide.

The data given here is based on current knowledge and experience. The purpose of this Safety Data Sheet is to describe the products in terms of their safety requirements. The data does not signify any warranty with regard to the products properties.

Bayer

DIN Safety Data Sheet

Business Group: Inorganic Chemicals

003763/03

Date of issue: August 26, 1988

Commercial product name Baychrom F

1.1 Chemical characterisation: basic chromium(III)-sulphate, format masked
1.2 Form: powdery
1.3 Colour: green
1.4 Odour: odourless

2. Physical and safety data

tested in accordance with

2.1 Change in physical state:
- Melting point: not applicable
- Boiling point: not applicable

2.2 Density:
- Bulk density: approx. 800 kg/m³ at 20 °C

2.3 Vapour pressure: not applicable
2.4 Viscosity: not applicable
2.5 Solubility in water: approx. 1200 g/l at 20 °C
2.6 pH value: 4 at 50 g/l water at 20 °C
2.7 Flash point: not applicable
2.8 Ignition temperature: not applicable
2.9 Explosive limits: not applicable
2.10 Thermal decomposition: Decomposition begins at 300 °C.
2.11 Hazardous decomposition products: No hazardous decomposition products observed.
2.12 Hazardous reactions: No hazardous reactions observed.
2.13 Further information:

3. Transport

GGVSee/IMDG Code:	UN No.:	MFAG:	EmS:
GGVE/GGVS: Class	No.	RID/ADR: Class	No.
ADNR: Class	No. Cat	ICAO/IATA-DGR: NOT RESTR.	

Other information:
Not dangerous cargo. Irritating to the eyes. Keep separated from foodstuffs.

4. Regulations

No labelling is required in accordance with the Federal German Regulation on Dangerous Substances (GefStoffV) dated August 26, 1986 and corresponding EEC directives.
When handling observe the usual precautionary measures for chemicals.
MAK value (fine dust): 6 mg/m³.

5. Protective measures, storage and handling

5.1 Technical protective measures: Keep container dry.

5.2 Personal protective equipment: Eye protection: goggles
Hand protection: of rubber
Respiratory protection: Dust-protection mask if there is a risk of dust formation.

5.3 Industrial hygiene: Do not breathe dust.
Avoid contact with eyes.

5.4 Protection against fire and explosion: No special measures required.

(to be continued)

Commercial product name Baychrom F

5. Protective measures, storage and handling (Continuation)

5.5 Disposal: May be transported to an approved landfill in closed container provided local regulations are observed. Address manufacturer. Disposal of emptied containers: Transport to approved incinerator.

6. Measures in case of accidents and fires

6.1 After spillage/leakage/gas leakage: Take up avoiding formation of dust.

6.2 Extinguishing media: No restriction.

6.3 First aid: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
After contact with skin, wash immediately with plenty of water and soap.
Should the product be swallowed seek medical advice.

6.4 Further information:

7. Information on toxicity

Acute toxicity:
LD_{50} oral, rat: approx. 5000 mg/kg
Rabbit eyes: slightly irritant
Rabbit skin (24 h): non-irritant
(Tests at the Institute for Toxicology of Bayer AG)

8. Information on ecological effects

Acute bacterial toxicity:
No harmful effect on Pseudomonas fluorescens: at 500 mg/l
Acute Fish toxicity:
Golden orfe (Leuciscus idus) LC_0: 1000 mg/l (48 h)
(Tests carried out in the biological laboratories of the Environmental Protection Department)
Hazard class (WGK): 1 - slightly hazardous to water
(own classification)
WGK = Classification in accordance with the West German Water Resources Act
Do not allow to escape into waters, wastewater or soil.

9. Further information

The data given here is based on current knowledge and experience. The purpose of this Safety Data Sheet is to describe the products in terms of their safety requirements. The data does not signify any warranty with regard to the products' properties.

Commercial product name Chromosal B & BS.

1.1 Chemical characterisation: Basic chromium(III)-sulfate and sodium sulfate
1.2 Form: powdery
1.3 Colour: green
1.4 Odour: odourless

2. Physical and safety data — tested in accordance with

2.1 Change in physical state:

Melting point:	not applicable
Boiling point:	not applicable

2.2 Density:

Bulk density:	approx. 1000 kg/m³ at 20 °C
2.3 Vapour pressure:	not applicable
2.4 Viscosity:	not applicable
2.5 Solubility in water:	2300 g/l
2.6 pH value:	approx. 2.6 at 50 g/l water at 20 °C
2.7 Flash point:	not applicable
2.8 Ignition temperature:	not applicable
2.9 Explosive limits:	not applicable
2.10 Thermal decomposition:	Decomposition begins at > 1200 °C.
2.11 Hazardous decomposition products:	No hazardous decomposition products observed.
2.12 Hazardous reactions:	No hazardous reactions observed.
2.13 Further information:	

3. Transport

GGVSee/IMDG Code: UN No.: MFAG: EmS:
GGVE/GGVS: Class No. RID/ADR: Class No.
ADNR: Class No. Cat ICAO/IATA-DGR: NOT RESTR.
Other information:
Not dangerous cargo. Keep separated from foodstuffs.

4. Regulations

No labelling is required in accordance with the Federal German Regulation on Dangerous Substances (GefStoffV) dated August 26. 1986 and corresponding EEC directives.
When handling observe the usual precautionary measures for chemicals.
MAK value (fine dust): 6 mg/m³

5. Protective measures, storage and handling

5.1 Technical protective measures: Keep container dry.

5.2 Personal protective equipment: Eye protection: goggles
Hand protection: of rubber
Respiratory protection: Dust-protection mask if there is a risk of dust formation.

5.3 Industrial hygiene: Do not breathe dust.
Avoid contact with eyes.

5.4 Protection against fire and explosion: No special measures required.

(to be continued)

Commercial product name Chromosal B

5. Protective measures, storage and handling (Continuation)

5.5 Disposal: May be transported to an approved landfill in closed container provided local regulations are observed. Address manufacturer. Disposal of emptied containers: Transport to approved incinerator.

6. Measures in case of accidents and fires

6.1 After spillage/leakage/gas leakage: Take up avoiding formation of dust.

6.2 Extinguishing media: No restriction.

6.3 First aid: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. After contact with skin, wash immediately with plenty of water and soap. Should the product be swallowed seek medical advice.

6.4 Further information:

7. Information on toxicity

Acute toxicity:
LD_{50} oral, rat: 3530 mg/kg
Rabbit eyes: non-irritant
Rabbit skin (24 h): non-irritant
(Tests at the Institute for Toxicology of Bayer AG)

8. Information on ecological effects

Acute bacterial toxicity:
No harmful effect on Pseudomonas fluorescens: at 1000 mg/l
Fish toxicity:
No harmful effect on Leuciscus idus at 500 mg/l (96 h)
(Tests carried out in the biological laboratories of the Environmental Protection Department)

Hazard class (WGK): 1 - slightly hazardous to water
(own classification)
WGK = Classification in accordance with the West German Water Resources Act
Do not allow to escape into waters, wastewater or soil.

9. Further information

The data given here is based on current knowledge and experience. The purpose of this Safety Data Sheet is to describe the products in terms of their safety requirements. The data does not signify any warranty with regard to the products' properties.

DIN Safety Data Sheet

013157/04

Date of issue: April 27, 1990

Company Bayer AG, OC-P Umweltschutz und Arbeitssicherheit
5090 Leverkusen 1, Telephone: (0214) 307078
In case of emergency: (0214) 303030 (Werkfeuerwehr Bayer Leverkusen)

Commercial product name Preventol CR
(formerly Preventol TP OC 3038)

1.1 Chemical characterisation:
preparation containing 2-(Thiocyano-methylthio)-benzothiazole
CAS No.: 021564-17-0
1.2 Form: liquid
1.3 Colour: brown, clear
1.4 Odour: weak odour

2. Physical and safety data

		tested in accordance with
2.1 Change in physical state:		
Solidifying point:	approx. -28 °C	
2.2 Density:	approx. 1.2 g/ml at 20 °C	
2.3 Vapour pressure:	approx. 2 mbar at 20 °C	
2.4 Viscosity:	approx. 90 sec. flow time at 20 °C (corresponding 414 mm^2/s at 20 °C)	DIN 53211
2.5 Solubility in water:	miscible	
2.6 pH value:	approx. 5 at 1 g/l water	
2.7 Flash point:	approx. 166 °C	DIN 51758
2.8 Ignition temperature:	approx. 380 °C	DIN 51794
2.9 Explosive limits:		
2.10 Thermal decomposition:		
2.11 Hazardous decomposition products:		
2.12 Hazardous reactions:		
2.13 Further information:	Incompatibility with strong acids and alcalis	

3. Transport

GGVSee/IMDG Code:	UN No.:		MFAG:	EmS:
GGVE/GGVS: Class	No.		RID/ADR: Class	No.
ADNR: Class	No.	Cat	ICAO/IATA-DGR: NOT RESTR.	

Other information:
Not dangerous cargo. Irritating to skin and eyes. Pungent smelling. Keep dry. Avoid temperatures below -20 °C. Keep away from foodstuffs, acids and bases (lyes).

4. Regulations

Labelling according to Appendix I, No. 1 (definition principle) of the Federal German Regulation on Dangerous Substances (GefStoffV) dated August 26, 1986 and the corresponding EEC directives:
Symbol: Xn, hazard description: harmful
Contains 2-[(thiocyanatomethyl)-thio]-benzothiazole.

R 22: Harmful if swallowed.
R 36/38: Irritating to eyes and skin.
S 26: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S 36: Wear suitable protective clothing.

Not subject to the German Federal Regulation on Flammable Liquids (VbF).

Commercial product name Preventol CR
(formerly Preventol TP OC 3038)

5. Protective measures, storage and handling

5.1 Technical protective measures:
Store in original container.

5.2 Personal protective equipment:
Eye protection: goggles
Hand protection: rubber gloves

5.3 Industrial hygiene:
Take off immediately all contaminated clothing.

5.4 Protection against fire and explosion:
Precautions should generally be taken against electrostatic charges according to the equipment used and the way the product is handled and packaged.

5.5 Disposal:
Constantly observing local regulations, for example by controlled incineration. Soiled, empty containers are to be treated in the same way as the contents. When contaminated empty containers are passed on, the recipient has to be informed of possible risks.

6. Measures in case of accidents and fires

6.1 After spillage/leakage/gas leakage:
Remove mechanically; take up remainders with absorbent material. Fill into labelled, sealable containers.

6.2 Extinguishing media:
All extinguishing materials are suitable.

6.3 First aid:
After contact with skin, wash immediately with plenty of water and soap. Contamination of the eyes must be treated by thorough irrigation with water, with the eyelids held open. A doctor (or eye specialist) should be consulted immediately.

6.4 Further information:
In case of fire, possible formation of sulfur dioxide and nitrogen oxides.

7. Information on toxicity

Acute toxicity:
LD_{50} oral, rat: 1163 mg/kg ♂
LD_{50} oral, rat: 729 mg/kg ♀

Irritation of the skin/rabbit (exposure 4 h): moderately to severely irritant Irritation of the eyes/rabbit: severely irritant

Special properties/effects:
In susceptible people sensitization is possible.

8. Information on ecological effects

Biological degradability:
No BOD was detectable under the strict conditions of the closed bottle test. This result does not exclude the possibility that the product may be degradated in the environment.

Behaviour in waste water treatment plants:
In a model waste water treatment plant (Sapromat) the degradation activity is not impaired at concentrations of approx. 5 mg/l.

(to be continued)

Commercial product name Preventol CR
(formerly Preventol TP OC 3038)

8. Information on ecological effects (Continuation)

Acute bacterial toxicity:
Respiration inhibition test with activated sludge. EC_{50} 2.5 mg/l
(OECD 209 = ISO DP 8192)

Acute fish toxicity:
LC_0 on Leuciscus idus: 0.5 mg/l. Duration of test: 48 h.
LC_0 on Brachydanio rerio: 0.24 mg/l. Duration of test: 96 h.

Hazard class (WGK): 2 - impairment of water quality
(own classification)
WGK = Classification in accordance with the West German Water Resources Act

9. Further information

The recommendations given in the leaflet of the "Berufsgenossenschaft der chemischen Industrie" (Employers' Liability Insurance Association for the German Chemical Industry) "Umgang mit gesundheitsgefährlichen Stoffen" (M 050) should be followed.

The data given here is based on current knowledge and experience. The purpose of this Safety Data Sheet is to describe the products in terms of their safety requirements. The data does not signify any warranty with regard to the products' properties.

Business Group: Organic Chemicals

011448/03

Date of issue: November 30, 1988

Commercial product name Preventol WB

1.1 Chemical characterisation:
preparation containing
4-chloro-3-methylphenol, sodium salt — CAS No.: 015733-22-9
2-phenylphenol, sodium salt — CAS No.: 000132-27-4
1,2-propandiol — CAS No.: 000057-55-6

1.2 Form: liquid

1.3 Colour: yellowish brown

1.4 Odour: slightly phenolic

2. Physical and safety data

		tested in accordance with
2.1 Change in physical state:		
Solidifying point:	approx. -28 °C	
Initial boiling point:	approx. 97 °C	
2.2 Density:	1,20 to 1,25 g/cm³ at 20 °C	
2.3 Vapour pressure:	approx. 96 mbar at 20 °C	
2.4 Viscosity:	approx. 24 sec. flow time at 20 °C	DIN 53211
2.5 Solubility in water:	miscible	
2.6 pH value:	approx. 10,5 at 1 g/l water at 20 °C	
2.7 Flash point:	not below 100 °C	DIN 51758
2.8 Ignition temperature:	not below 500 °C	DIN 51794
2.9 Explosive limits:		
2.10 Thermal decomposition:		
2.11 Hazardous decomposition products:		
2.12 Hazardous reactions:		
2.13 Further information:		

3. Transport

GGVSee/IMDG-Code: 8 UN-No.: 1719 MFAG: 705 EmS: 8 06
GGVE/GGVS: Class 8 No. 42B RID/ADR: Class 8 No. 42B
ADNR: Class 8 No. 32 Cat. ICAO/IATA-DGR: 8. 1719 II
Other information: ALKALINE CRESOL SOLUTION (CONTAINS SODIUM HYDROXIDE SOL.)
Corrosive. Keep separated from foodstuffs.

4. Regulations

Labelling according to Appendix I, No. 1 (definition principle) of the Federal German Regulation on Dangerous Substances (GefStoffV) dated August 26, 1986 and the corresponding EEC directives:
Symbol: C, hazard description: corrosive
Contains 4-chloro-3-methylphenol, sodium salt, 2-phenylphenol, sodium salt.
R 22: Harmful if swallowed.
R 35: Causes severe burns.
S 26: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S 28: After contact with skin, wash immediately with plenty of water and soap.
S 37/39: Wear suitable gloves and eye/face protection.

VbF (Federal German Regulation on Flammable Liquids): Class NEIN

5. Protective measures, storage and handling

5.1 Technical protective measures:
Store tightly sealed in original container.

(to be continued)

Commercial product name Preventol WB

5. Protective measures, storage and handling (Continuation)

5.2 Personal protective equipment:
Eye protection: closely fitting goggles
Hand protection: Protective gloves (of PVC or rubber) are recommended.
Other protective equipment: Wear protective clothing.

5.3 Industrial hygiene:
Take off immediately all contaminated clothing.

5.4 Protection against fire and explosion:
Take precautionary measures against static discharges.

5.5 Disposal:
Constantly observing local regulations, for example by controlled incineration. Soiled, empty containers are to be treated in the same way as the contents. When contaminated empty containers are passed on, the recipient has to be informed of possible risks.

6. Measures in case of accidents and fires

6.1 After spillage/leakage/gas leakage:
Dam up with absorbing material, e.g. sand. Take up mechanically, fill into labelled, closable containers.

6.2 Extinguishing media:
All extinguishing materials are suitable.

6.3 First aid:
Wash skin immediately with plenty of water and soap. Contamination of the eyes must be treated by thorough irrigation with water, with the eyelids held open. A doctor (or eye specialist) should be consulted immediately.

6.4 Further information:
Possible formation of hydrogen halide in case of fire.

7. Information on toxicity

Acute toxicity:
LD_{50} oral, rat: approx. 2670 mg/kg ♂
LD_{50} oral, rat: approx. 2000 mg/kg ♀
LD_{50} dermal, rat: approx. 2045 mg/kg

Irritation of the skin/rabbit (exposure 24 h): corrosive
Irritation of the eyes/rabbit: corrosive

8. Information on ecological effects

For the active constituents of the formulation, 4-chloro-3-methylphenol and 2-phenylphenol or, as the case may be, their sodium salts can be said:

Eliminability from water:

degradation	evaluation	method of test	method of analysis
above 80 %	good degradability	closed bottle test	BOD-determination

Behaviour in waste water treatment plants:
In a model waste water treatment plant (Ascomat) the degradation activity is not impaired at concentrations of 100 mg/l.
In a model waste water treatment plant the product is entirely eliminated from the waste water after 3,5 days (O. PAULI, G. FRANKE: Gesundheitswesen und Desinfektion 63 (1971) 150).

(to be continued)

Commercial product name Preventol WB

8. **Information on ecological effects** (Continuation)

Acute bacterial toxicity:
Oxygen consumption test by Robra: No harmfull effects on Pseudomonas putida at 125 mg/l.

Acute fish toxicity:
LC_{50} on Leuciscus idus: 0.5 to 5 mg/l. Duration of test: 48 h.

4-chloro-3-methylphenol:
Hazard class (WGK): 2 - impairment of water quality
WGK = Classification in accordance with the West German Water Resources Act

9. **Further information**

The recommendations given in the leaflet of the "Berufsgenossenschaft der chemischen Industrie" (Employers' Liability Insurance Association for the German Chemical Industry) entitled "Reizende Stoffe - Ätzende Stoffe" (M 004) should be followed.

The data given here is based on current knowledge and experience. The purpose of this Safety Data Sheet is to describe the products in terms of their safety requirements. The data does not signify any warranty with regard to the products' properties.

THE ENVIRONMENTAL IMPACTS AND BEHAVIOUR OF TCMTB

John E.H. Ward, PhD
Head, Toxicology Unit
Waste Management Program
Ministry of Environment
810 Blanshard Street
Victoria, British Columbia
V8V 1X5

1.0 INTRODUCTION

Large volumes of chlorophenol compounds are currently used in Canada to preserve and protect wood from attack by various pests. Concerns about acute aquatic toxicity, about occupational impacts, and about hazardous impurities in chlorophenols are among the reasons for rising dissatisfaction with their use. In British Columbia, the formation of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDDs and PCDFs) during the low temperature combustion of chlorophenols and chlorophenol-containing wastes has become a major issue.

The search for alternative chemicals has now intensified. Leading contenders to replace the antisapstain agent sodium tetrachlorophenate are pesticides which contain the active ingredient 2-(thiocyanomethylthio)benzothiazole (TCMTB).

The purpose of this paper is to review the environmental properties of TCMTB, Busan 1030 and Busan 30WB. TCMTB is the active ingredient in Busan 1030 and Busan 30WB, which are antisapstain products produced by Buckman Laboratories for the wood protection industry.

Busan 1030 and 30WB appear to be effective antisapstain agents, and a critical evaluation of their toxicological andenvironmental impacts has been assisted by Buckman Laboratory's cooperation in providing access to full research reports created for various regulatory agencies. However, there is little information published in the scientific, technical and medical literature on these products, so this paper is been based almost solely on information received directly from Buckman Laboratories.

2.0 HISTORICAL BACKGROUND

The commercial use of TCMTB apparently had its origins in with Buckman Laboratories, Inc., of Memphis, Tennessee[1]. In the late 1940's this company became involved in the search for solutions to the problem of breaks in paper on high speed paper machines due to the formation of microbiological slime. The company first developed the microbiocide BSM-11, a product containing mercuric acetate and trichlorophenol, which seemed to find acceptance in the paper making industry.

However, in view of the potential for adverse health and environmental impacts from the use of mercury compounds, Buckman Laboratories developed a line of organosulphur compounds which also proved to be effective slime control agents. Alone, or inconjunction with other active ingredients, TCMTB is now found in a variety of Buckman products.

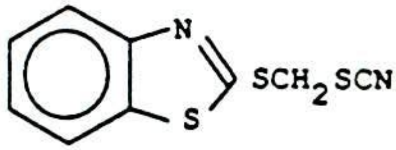
Busan 1030[2] is a Buckman product, which is organic solvent based, and contains 30% TCMTB as the active ingredient. Under license with Buckman Laboratories, several companies

In B.C. have made 30% TCMTB formulations available for this purpose under the brand names Woodblok 30[3], Diachem Woodstar[4], Mitrol[5], Woodsheath 11 T-230 Clear[5], and Concentrate B30 T1090 Liquid Microbiocide[5]. Busan 1030 is recommended for a host of other applications including the control of microorganisms in cooling water systems, wooden cooling towers, water-thinned cutting fluids, crude and refined oils, drilling fluids, and paints[6,7]. A water-based formulation containing 30% TCMTB, called Busan 30WB has recently been introduced for antisapstain use.

TCMTB was first registered in Canada as a seed treatment in Co-op Co-San Liquid Seed Treatment, which contained 30% active ingredient[8]. The registered uses included control of stinking smut or bunt of wheat, and other seed and soil-borne seed diseases[9]. By 1977 it was also registered as an agent to resist mold and sapstain on freshly cut lumber. Busan 1030 and Busan 30WB are now also registered pesticides with Agriculture Canada[2,10].

3.0 PROPERTIES

The structural formula of TCMTB is shown below:



It is a viscous reddish liquid and is insoluble in water, but soluble in organic solvents such as acetone, dimethylformamide, cyclohexanone, benzene and xylene[8]. It has a specific gravity of 1.38[8], a boiling point greater than 120°C[8] and a vapour pressure of 3.6×10^{-6} torr[11]. The supplier normally mixes TCMTB with solvents to form a concentrate. Emulsifiers or surfactants may be added to the concentrate to improve the stability of emulsions formed when the concentrate is diluted with water[3].

TCMTB is sold commercially as 80% technical material under the trade name "TCMTB" by Buckman Laboratories, which is the sole manufacturer of the material[3,12]. The patented preparation involves a reaction of 2-mercaptobenzothiazole and chloromethylthiocyanate[3], but confidential data obtained from Buckman Laboratories indicates another preparative method may now be used.

Busan 1030 is a dark brown liquid with a specific gravity of 1.08, a flash point of 50°C and a slight odor[13]. It is miscible with water. Normally diluted to a 0.5 - 1% solution, it may be applied to freshly cut lumber through spray or dipping systems.

Busan 30WB is a milky white liquid containing 30% TCMTB. Like Busan 1030, various surfactants and emulsifiers are used to keep the TCMTB in suspension. It is diluted and used in the same manner as is Busan 1030.

4.0 ENVIRONMENTAL SOURCES, DISTRIBUTION AND BEHAVIOUR

TCMTB is unlikely a naturally occurring material, so its sources are expected all to be man-made. These would include spills and other unintentional discharges, permitted discharges from commercial facilities using the substance, as well as certain materials such as leather, wood, paper, paint and seeds. No reports of measurements of environmental levels of TCMTB were located.

The environmental behaviour of TCMTB has been investigated in a variety of experiments. Recently, a series detailed reports addressing the environmental behaviour of TCMTB was completed in 1987[14-20]. These studies were designed to meet the requirements of the Pesticide Assessment Guidelines of the United States Environmental Protection Agency, and are summarized below. All studies failed to find significant levels of volatile TCMTB degradation products.

4.1 Aqueous Hydrolysis

The first study[14] considered the hydrolysis of carbon-14 labeled TCMTB in 10 ppm aqueous solutions buffered to pH 5, 7 and 9. The solutions were kept in the dark and analyzed by thin-layer chromatography at specified time intervals ranging from 0-35 days for pH 5 and 7 samples, and from 0-122 hours for pH 9 samples.

At pH 5, TCMTB was stable, but at pH 7, it slowly degraded, with 8% being reported hydrolyzed after 35 days. At pH 9, the hydrolysis was much more rapid, with the half life being calculated at 81 hours. Several hydrolytic products at this pH were observed, representing 43% and 18% of the TCMTB after 122 hours. The hydrolysis products were not conclusively identified, but likely include 2-mercaptobenzothiazole and 2,2'-(dithiobis)benzothiazole.

4.2 Artificial and Natural Sunlight Degradation on Soil

One study by A & L Agricultural Laboratories of Memphis, Tennessee[20], indicates sandy loam treated with TCMTB at a ratio of 3.6 g TCMTB/gram of soil had only 1.5% of the TCMTB remaining after two months. On the other hand, Southern Yellow Pine sawdust treated with 18 times its mass of TCMTB left a residue of 81% TCMTB after two months. Neither the conditions for these experiments, nor the characteristics of the degradation products were reported.

The fate of carbon-14 labeled TCMTB on soil was studied by spiking Fox sandy loam soil in petri dishes and following its behaviour in darkness, under continuous artificial sunlight using two Chroma 50 lamps, and natural sunlight[16]. The samples were maintained at 25 °C.

Assuming first order kinetics, the half lives were calculated as follows:

	T 1/2 Artificial Sunlight	T 1/2 Natural Sunlight
Experimental	388 hours	23 hours
Control	917 hours	662 hours

From the table above, it is evident that thermal degradation occurred in the control samples, and that this is enhanced by both types of radiation. No degradation products were identified. In the absence of other evidence, the extreme differences in half-lives for the two experimental conditions suggests that the artificial sunlight does not match the natural sunlight very well.

4.3 Artificial Sunlight Degradation in Aqueous Solution

The photodegradation of carbon-14 labeled TCMTB[15] was followed by the irradiation of 10 ppm solutions of TCMTB in sterilized sodium acetate pH 5 buffer at 25 °C. Chroma 50 lamps, which were said to have spectral distributions similar to that of natural sunlight, were used as the radiation source. The degradation appeared to follow first-order kinetics, with a half-life of 3.8 hours. After 8 hours, 28% of the TCMTB remained. No degradation was noted in control samples, which were wrapped in metal foil, but otherwise subjected to the same experimental conditions. The major byproduct was tentatively identified as 2-mercaptobenzothiazole.

4.4 Aerobic Aquatic Metabolism

An experiment using carbon-14 labeled TCMTB studied the aquatic metabolism in lake sediment and water[17]. The lake sediment, collected from Lake Mendota in Wisconsin, had 96% sand, 3% silt, 3% clay, and 1% organic matter, with a pH of 7. The lake water had a pH of 8 to 8.5. Spiked samples were incubated at 26 °C, and followed up to 31 days.

The level of TCMTB fell from 88% at day 0 to 1% at day 14, with a calculated half-life of 2.8 days. While six different byproducts were observed, only two were tentatively identified. 2-mercaptobenzothiazole was thought to increase from 1.4% at day 1 to 10% at day 4 and then decreased to 1% by day 31. Another product, tentatively identified as 2,2-dithiobisbenzothiazole increased from 4% at day 1 to a maximum at day 14, and then declined to nondetectable levels at day 31.

It is interesting to compare the half-life of 81 hours determined from the aqueous hydrolysis study above at pH 9, with the half-life in the sediment and water, which is about 67 hours. Since the rate of hydrolysis is less at lower pH values, and since the pH of the sediment and water is slightly less than 9, one might expect a water/sediment half-life above 81 hours to result solely from non-biological degradation mechanisms. Since the experimental result is less that 81 hours, biological degradation mechanisms may be in operation.

4.5 Absorption on Agricultural Soils

In this experiment[18], four agricultural soils, Plainsfield sand, Plano silt loam, Fox sandy loam, and Kewaunee clay loam were each equilibrated with aqueous solutions of carbon-14 labeled TCMTB of 0.5, 1, 5, and 10 ppm at 25 °C for 2 hours. While all the soils adsorbed the TCMTB to some extent, the equilibrium constants varied from 1.9 for the Plainsfield sand, which is low in organic matter, to to 38.4 for the Kewaunee clay loam. The potential for leaching seems greatest for the Plainsfield sand.

4.6 Mobility on Soils

The mobility of carbon-14 labeled TCMTB on four soils was studied[19] by coating glass plates with thin layers of soil, spotting the plate with TCMTB, and then allowing water to migrate up the plates. Consideration of the distance the spots moved suggested that TCMTB should be classified, using USEPA mobility classes, as "mobile" in the Plainsfield sand and as having "low mobility" in the Mississippi silt loam, Fox sandy loam, and Hagerstown clay loam.

The mobility of soil-aged TCMTB residues has also been investigated[20]. In this experiment, Dickenson sandy loam was fortified with carbon-14 labeled TCMTB and incubated at 25°C for 32 days under aerobic conditions. A sample of the aged soil was subjected to thin-layer chromatography, being eluted by water. The soil-aged TCMTB residues were revealed to be more mobile than nonsoil-aged TCMTB residues. The soil-aged residues were classed as "mobile", while the non-soil aged residues were labeled "low mobility".

5.0 ENVIRONMENTAL TOXICOLOGY

5.1 Aquatic Species Tests on Technical Grade and Pure TCMTB

48 hour LC50: (80% TCMTB	daphnia -	850 ppm[21]
96 hour LC50: 99% TCMTB	rainbow trout -	0.050 ppm[22]
		0.052 ppm[22]
		0.047 ppm[22]
	Chinook Salmon -	0.026 ppm[23]
		0.025 ppm[23]

5.2 Aquatic Species Tests on Busan 1030 and Busan 30WB

Environment Canada[24] has carried out a number of fish bioassays on Busan 1030 and Busan 30WB. The values reported below must be multiplied by 0.3 to obtain the aquatic toxicities based on the concentrations of the active ingredient:

96 hour LC50 (Busan 1030):	rainbow trout	- 0.13 ppm (3 tests).
	chinook salmon	- 0.05 ppm.
		- 0.06 ppm.
96 hour LC50 (Busan 30WB):	rainbow trout:	- 0.15 ppm.
		- 0.18 ppm

Recently the lowest 96 hour LC50 value from the chinook salmon test, 0.05 ppm was used as the basis for proposing a TCMTB stormwater runoff standard for discharges from wood protection storage areas[25].

6.0 FURTHER STUDIES

Further studies on the environmental fate of TCMTB are presently underway, sponsored by Buckman Laboratories and the National Water Research Institute in Burlington, Ontario.

7.0 REFERENCES

1. Buckman Laboratories: Buckman Laboratories (corporate brochure, undated).

2. Buckman Laboratories. Busan 1030, Bulletin No. D37CAN, June 15, 1985.

3. B.C. Research. Division of Environment and Health and Forest Industry Health Research Program. Wood Products Manufacturing Sector Subcommittee. Sapstain Control Chemicals: Copper-8, TCMTB and MBT. A Review of Properties, Uses and Health Hazards. Vancouver, B.C.: B.C. Research, April, 1984.

4. Diachem Industries. Diachem Woodstat, Technical Data. Lumber Anti-stain Biocide (undated).

5. B.C. Research. Industrial Chemistry Division. Occupational Health Group and Forest Industry. Industrial Health Research Program. Anti-sapstain chemicals: Properties, uses, and health hazards of Busan 1030 and Busan 30 WB, Vancouver, B.C.: B.C. Research, July, 1987.

6. Buckman Laboratories. Product Data. Busan 1030, Bulletin C52W, April 10, 1982.

7. Buckman Laboratories. Busan 1030. A New Microbiocide for the Paint Industry (catalogue number an date not provided).

8. Canada Department of Agriculture. Plant Products Division. Production and Marketing Branch. Control Products Section. Memorandum: "Re: Registration of New Pesticide 2-(thiocyanomethylthio)benzothiazole", March 14, 1972.

9. Canada. Agriculture Canada. Compendium of Registered Uses of Pesticides in Canada, December, 1977.

10. Buckman Laboratories of Canada, Ltd. Busan 30WB product label, Canada Pest Control Products Act registration No. 19965, January, 1987.

11. Buckman Laboratories. Personal Communication, June 1, 1988.

12. Buckman Laboratories. TCMTB, Toxicity Profile, TP-TCMTB-W, October 26, 1981.

13. Buckman Laboratories. Material Safety Data Sheet. Busan 1030, April 7, 1986.

14. Hazelton Laboratories America, Inc., Obrist JJ. Hydrolysis of TCMTB in Buffered Aqueous Solutions, Memphis, TN: Buckman Laboratories, Inc., October 9, 1987.

15. Hazelton Laboratories America, Inc., Saxena AM. Artificial sunlight photodegradation of TCMTB in a buffered aqueous solution, Memphis, TN: Buckman Laboratories, October 29, 1987.

16. Hazelton Laboratories America, Inc., Rustum AM. Artificial and natural sunlight photodegradation of TCMTB on soil, Memphis, TN: Buckman Laboratories, October 29, 1987.

17. Hazelton Laboratories America, Inc., Saxena AM. Aerobic aquatic metabolism of TCMTB, Memphis, TN: Buckman Laboratories, October 12, 1987.

18. Hazelton Laboratories America, Inc., Saxena AM. The adsorption and desorption of TCMTB on representative agricultural soils, Memphis, TN: Buckman Laboratories, May 13, 1987.

19. Hazelton Laboratories America, Inc., Lesheski MJ. Determination of the mobility of TCMTB in selected soils by soil thin layer chromatography, Memphis, TN: Buckman Laboratories.

20. Hazelton Laboratories America, Inc., Obrist JJ. Determination of the mobility of soil-aged TCMTB residues by soil thin layer chromatography, Memphis, TN: Buckman Laboratories, April 2, 1987.

21. Buckman Laboratories. Busan 1030, Toxicity Profile, TP-1030W, October 15, 1984.

22. Canada. Environment Canada. Conservation and Protection. Pacific and Yukon Region. Liu S. Personal Communication, February 24, 1988.

23. Canada. Environment Canada. Conservation and Protection. Pacific and Yukon Region. Liu S. Personal Communication, March 3, 1988.

24. Canada. Environment Canada. Liu S. Personal Communication, July, 1987.

25. Canada. Environment Canada and British Columbia. Ministry of Environment and Parks. News Release. Chlorophenate control strategy announced, September 15, 1987.

BUCKMAN LABORATORIES

Products for the Leather Industry

D27U

Busan® 30WB
For Microorganism Control in Tanneries

Busan 30WB is an effective and economical microbicide for preventing fungal attack of skins and hides during tannery processing and subsequent storage. It is specifically recommended for use in chrome tanning to prevent leather damage and consequent losses caused by microorganisms. Busan 30WB is a water-based emulsion microbicide that contains no hazardous solvents. It is specifically formulated to eliminate storage and application limitations occasionally associated with nonaqueous liquid products.

PRODUCT CHARACTERISTICS

Active ingredient:	
2-(Thiocyanomethylthio)benzothiazole	30%
Inert ingredients	70%
Density at 25 °C (77 °F)	1.11 g/mL
Approximate weight per U.S. gallon	9.25 lb
Approximate volume per kilogram	900 mL
Approximate volume per pound	410 mL
pH (100 ppm in distilled water)	5-6

METHODS OF APPLICATION

Because of the moist condition and acid pH of the stock, chrome-tanned stock held "in the blue" readily molds and may become discolored. Severe mold growth at this stage will usually cause permanently discolored areas that influence subsequent finishing operations and reduce the value of the leather. Treatment with Busan 30WB, however, is expected to help eliminate mold growth on chrome-tanned stock when used along with good sanitation procedures.

Busan 30WB should be applied as a dispersion in water. Satisfactory dispersions using one(1) part Busan 30WB and three(3) parts water can be prepared with proper addition sequence and sufficient agitation. Busan 30WB should be added to the water as opposed to the water being added to Busan 30WB. Higher dilutions such as one(1) part Busan 30WB to 19 or more parts of water are preferred where such dilutions can be conveniently used in the tanning process. Dispersions of Busan 30WB in water remain stable for only a short period of time. It is thus recommended that such dispersions be prepared immediately prior to their addition to the tanning process.

Busan 30WB is adsorbed on the hide and therefore dispersions of Busan 30WB in water must be added in a manner to ensure maximum uniform distribution over the entire skin or hide. The preferred points of addition are to the pickling liquor or chrome-tanning liquor. When added to the pickling liquor, it is very important that the additions be made following neutralization of any residual lime or alkaline salts with the acid pickling liquor. Under no circumstances should Busan 30WB be added to solutions or hides when the pH is above 8.0.

Under some circumstances it may be advantageous to make split additions of the Busan 30WB dispersion with approximately one-half added to the pickling liquor and the remainder to the tanning liquor.

An alternate addition procedure would be to add approximately one-half of the required amount of Busan 30WB dispersion to the tanning drum or vat as the initial tanning liquor charge is made. The remainder of the dispersion can then be added directly to the drum or vat with vigorous mixing just after mid-point of the tanning cycle has been completed.

Suggested treatment rates are 0.25 to 2.0 kg of Busan 30WB per metric tonne (0.25 lb to 2.0 lb per 1000 lb) of white stock weight. Treatment rates will vary depending on factors such as relative fat content of the skins or hides, thickness or density of the stock, subsequent washing, neutralizing, chemical fixing agents, and the degree of preservation required for specific storage conditions. The higher treatment rates are required where the skins or hides have high fat content; where the hides are unusually thick or dense; and where final post-tanning operations such as washing, neutralizing, and chemical fixing would contribute to the extraction of Busan 30WB from the hides.

When long term preservation of splits of whole hides is required, it is suggested that a supplemental surface application of the Busan 30WB be made to all surfaces. This can be done by a vat or drum soak or a roll/wringer application procedure. The important factor is uniform distribution of the Busan 30WB dispersion onto the top and bottom surfaces of each split.

The exact procedure for adding Busan 30WB and contact time needed to provide maximum protection of hides from microbial attacks will vary from one tannery to another. The most effective program should be developed specifically for each location.

PACKAGING AND HANDLING

Busan 30WB is a liquid emulsion. Inventory control is important with emulsion products. Oldest inventory should be used first and in-plant storage of Busan 30WB kept to a minimum. After extended periods of storage, or if a clear fluid appears on the top of the emulsion, the products should be thoroughly mixed or agitated before using.

Busan 30WB can be handled and stored in stainless steel, aluminum, polyethylene, polypropylene, glass, and fiberglass-reinforced polyester equipment. In the concentrated form Busan 30WB can have an adverse effect on rubber, poly(vinyl chloride), acrylics and certain other plastics.

Improper handling of this product can be injurious to workers. Observe all safety precautions shown on the label and in the Material Safety Data Sheet.

Recommendations given in this bulletin are based on tests believed to be reliable. However, the use of the product is beyond the control of Buckman Laboratories, and no guarantee, expressed or implied, is made as to the effects of such or the results to be obtained if not used in accordance with directions or established safe practice. The buyer must assume all responsibility, including injury or damage, resulting from misuse of the product as such, or in combination with other materials. This bulletin is not to be taken as a license to operate under or recommendation to infringe any patent.

Printed in U.S.A. (5/15/88)
(Replaces 2/15/88)

Buckman Laboratories in Argentina, Australia, Belgium, Brazil, Canada, Japan, Mexico, Monaco, South Africa, Spain, United Kingdom, U.S.A., and West Germany

LIBRARY
ENVIRONMENTAL PROTECTION AUTHORITY
1 MOUNT STREET PERTH

Appendix J
CORRESPONDENCE

Shire of West Arthur

Our Reference 6.5.1

Your Reference

Enquiries to kto:tph

Burrowes Street,
DARKAN, W.A. 6392
~~Telephone: (097) 36 1003~~
(097) 36 1 7
Facsimile: (097) 36 1201

26th February 1991

Mr E Heales
Kinhill Engineers
47 Burswood Road
VICTORIA PARK WA 6100

Dear Eric,

RE: PROPOSED TANNERY - MANAGEMENT PLANS

SOLID WASTE DISPOSAL: Our Council believes that the best option for disposal would be for Deras to operate a land fill site on their own land, with Council overseeing and regularly inspecting the operations.

The use of Councils own refuse site would severely restrict the useful operating life of the site, as it now caters for all of Darkan townsite and surrounding rural properties.

LIQUID FERTILISER WASTE DISPOSAL: Council believes that they could be of assistance to Deras in encouraging local farmers to use the surplus waste for pasture enhancement. As well as Council becoming involved we feel that the Agriculture Department would be willing to conduct field trials using the waste to demonstrate its qualities to farmers in the district.

If you require any further information please contact the undersigned at this office.

Yours faithfully,

K. T. O'Connor
SHIRE CLERK.