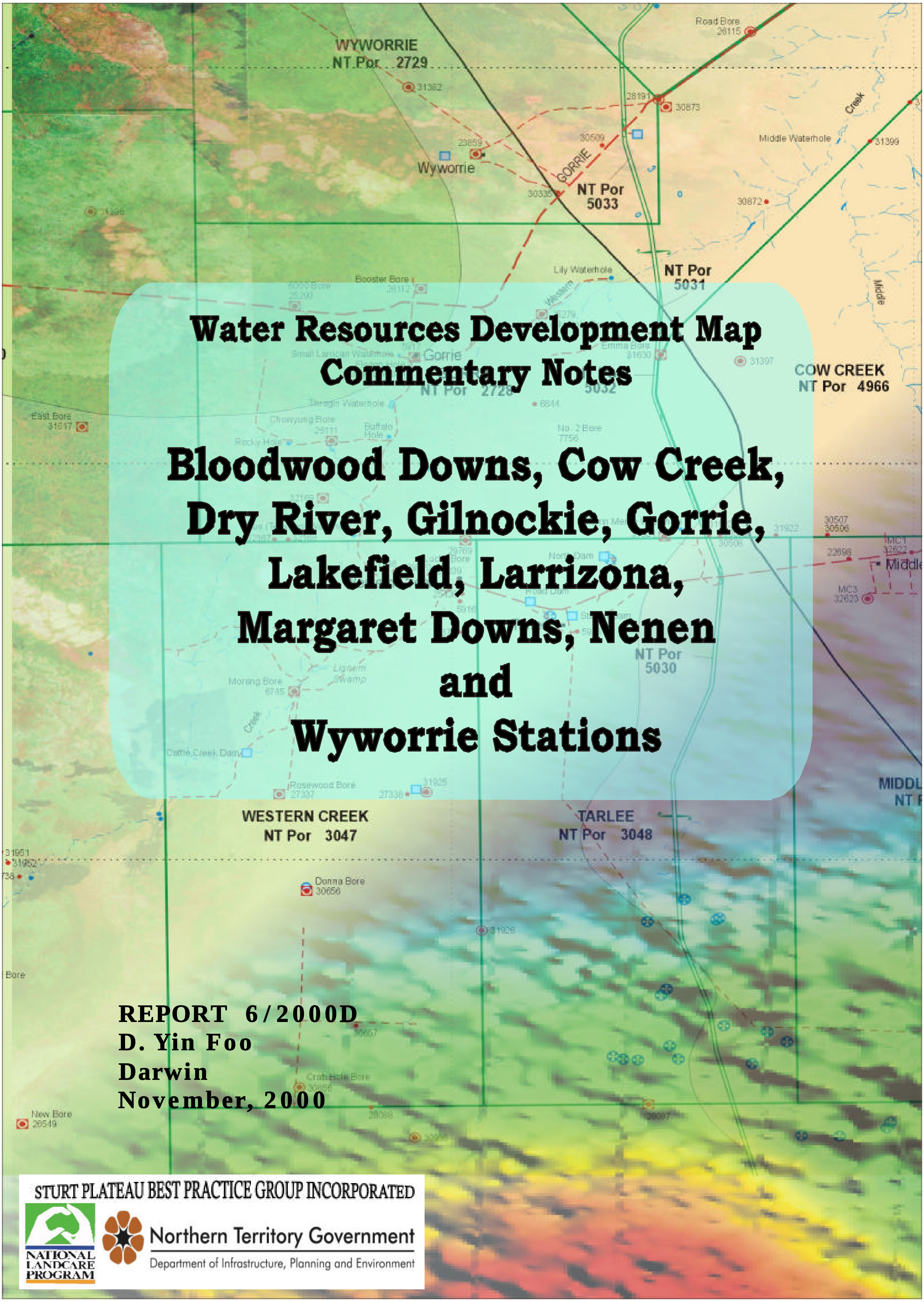

Water Resources Development Map Commentary Notes

Bloodwood Downs, Cow Creek, Dry River, Gilnockie, Gorrie, Lakefield, Larrizona, Margaret Downs, Nenen and Wyworrie Stations

REPORT 6/2000D

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Darwin

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STURT PLATEAU BEST PRACTICE GROUP INCORPORATED

NATIONAL LANDCARE PROGRAM

Northern Territory Government

Department of Infrastructure, Planning and Environment

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LIST OF ABBREVIATIONS

m	-	metre
m^3	-	cubic metre
km	-	kilometre
L/s	-	litres per second
mg/L	-	milligrams per litre
ML	-	megalitre (million litres)
mm	-	millimetre
µS/cm	-	microsiemens per centimetre
pH	-	acidity and alkalinity index
RN	-	Registered Number
TDS	-	total dissolved solids

LIST OF CONVERSIONS

1 mm (millimetre)	=	0.04 inches (4 points)
1 m (metre)	=	3.3 feet
1 km (kilometre)	=	0.6 miles
1 L (litre)	=	0.22 gallons
1 ML (megalitre)	=	220,000 gallons
1 L/s (litre per second)	=	800 gallons per hour

PLATES

SUMMARY

This Water Resources Development map is designed as a guide in determining the most appropriate type of water supply for an area.

Groundwater throughout the Sturt Plateau is mainly exploited from aquifers developed in the fractures and cavities of a limestone formation. The limestone immediately underlies the surface sediments, which may be up to 60m thick. Groundwater availability is influenced by the nature of the underlying basement rock, usually basalt. Within the region covered by this map, the groundwater potential ranges from excellent, particularly in the north-western parts, to poor along the eastern flank where the basalt rises to near surface.

Surface water development options within the map region are also generally good. However, experience with dams elsewhere in the Top End has shown that hazards posed by the wet season need to be considered. An effective dam must resist potential flood damage, have viable capacity and harvest adequate sheet flow from the catchment. On the Sturt Plateau, there are difficulties associated with flat topography and low runoff potential. There is usually sufficient clay in the soil for a viable construction. Evaporation is high and deeper dams with adequate storage to persist through the dry season may not always be an option. In such instances, shallower tanks or dams are still viable and will permit a greater area of pasture to be used for at least the early part of the dry season.

1.0 INTRODUCTION

This map and accompanying notes represent one in a series of four covering the Sturt Plateau region. The intention was to provide station managers with a map tool containing up to date information on water resources. In conjunction with other natural resources maps, planning and management at property scale will be feasible.

The Sturt Plateau Best Practice Group (SPBPG) provided the initiative for this project. The Northern Territory Government and the National Landcare Program took carriage of, and jointly funded this project. The water resources in the Sturt Plateau region, comprising 23 properties and land trust areas, was studied between May 1997 and June 2000.

The Sturt Plateau region covers approximately 30000 km^2 and defines an area which extends between Mataranka in the north and Dunmarra in the south. The eastern boundary is featured by an upland area parallelling the Stuart Highway. It is bounded to the west by the Buntine Highway. Road access is good throughout the region. During the wet season, the main roads are generally accessible by light vehicles, although many station tracks may be impassable.

The availability of stock water is a major influence on stock management. Nearly all of the annual rainfall, which averages about 800mm, occurs in the short hot monsoonal wet season between December and March. Little rainfall is experienced during the remainder of the year. Recharge to groundwater systems occurs at this time. Evaporation rates of water bodies such as dams or waterholes are between 5 and 11 millimetres per day (average about 8 mm per day or 2.8 metres per year). This ensures that water levels in creeks, dams and tanks decline rapidly. Air temperatures are high throughout the year. The average monthly maxima range from about 29 degrees in June to 37 degrees in December. The corresponding average monthly minima are 13 and 24 degrees. Climatic data for Larrimah, at the centre of the Sturt Plateau, are presented in Table 1.

Plate 1 - Dry River road crossing.

In this map sector of the Sturt Plateau, bores currently supply the vast majority of stock water needs with the remainder coming from waterholes. Where bores are used, steel tanks are popular as temporary storages.

Plate 2 – 'KTM Bore' and ground tank at Gorrie Station.

During the wet and the early dry season, most of the surface water that is accessible is used, but as the dry season progresses, these sources become depleted. A few waterholes within the Western Creek system and on the relict black soil plains of the Dry River can persist throughout the year.

TABLE 1 CLIMATIC AVERAGES for LARRIMAH

	Rainfall (mm)	Rain Days	Daily Min. Temp (^{0}C)	Daily Max. Temp (^{0}C)	Daily Evap. (mm)
January	201	15	24.0	35.5	10.4
February	191	15	23.6	34.3	7.9
March	154	11	22.5	33.7	7.5
April	33	3	19.6	33.8	8.6
May	14	1	16.2	31.4	6.1
June	5	1	12.8	29.2	5.0
July	4	1	12.0	29.0	6.0
August	0	0	14.7	32.1	7.2
September	5	1	17.9	34.7	6.9
October	27	3	21.6	37.0	8.6
November	65	7	24.1	37.7	11.4
December	113	10	24.3	36.9	8.3
Total	812	67			

2.0 WATER SUPPLY DEVELOPMENT

The accompanying Water Resources Development Map gives a broad view of the most likely and suitable development option for stock watering. The map classifications are based on a combination of information on groundwater occurrence, soil types and topography. Local conditions, such as soil types can vary considerably, so the maps should not be taken as a definitive guide to cover every situation. Detailed on-ground investigations are recommended when considering specific developments.

For an explanation of the colour codes on the main map, refer to the legend entitled "Water Resources Development Options". Four categories of "preferred options" have been mapped:

OPTION 1 - Where natural waterholes exist, piping from these features is the most appropriate development option. Man made surface water developments are not suitable and the prospect for stock water supplies from groundwater is low.

OPTION 2 - Within this area, surface water developments are viable and the prospect for stock water supplies from groundwater is low.

OPTION 3 - Groundwater is a viable option within this area, and surface water development is not suitable.

OPTION 4 - Water supply development is viable using either groundwater or surface water sources.

Some of the main features of the development map are:

- groundwater availability is good for the majority of the map. In some areas, geophysical information will aid site selection.

- most areas are suitable for surface water development. The construction of drainage-line excavated tanks are preferred due to the flat nature of the landscape.

- the area on the eastern fringe of the map is featured by a high basalt basement. Man-made development options are not preferred due to sandy soils, shallow rock and poor groundwater prospects.

- the north-western corner of the map features a deepening of the limestone basin. While there is a potential for individual high yielding bores, there is also a deep water table (> 100m) which is due to increased land elevation.

3.0 GROUNDWATER

Groundwater prospects across the area have been assessed using information on geology, ground and airborne geophysical surveys and from existing boreholes. Assessment of this data has enabled a more detailed side map entitled the Groundwater Resources Map, to be produced. 'The Thickness of Limestone Below the Water Table' and 'The Depth to Water Table' side maps should be used as guides to minimum bore depths and indicative pumping depths and are applicable to areas within the limestone basin.

Technical information on bores in the area is held on the Natural Resources Division's files and is available on request. Chemical analyses of groundwaters from all bores and guideline limits for common uses are listed in Appendix 2 and Appendix 3 respectively.

Plate 3 - Karstic weathering.

Within the study area, the vast majority of bores exploit an extensive aquifer system within the limestone formation. This system is termed karstic - a term which describes a landscape resulting from dissolution and weathering of limestone, and usually noted for cavern development. An aquifer thus formed comprises a myriad of interconnected cavities and fractures developed within the horizon of the host rock, which allows movement of groundwater through it. Successful bores intersect submerged cavities, voids and fractures in the formation.

Three categories, representing 'expected or likely bore yields', ranging from less than 0.5 L/s (poor success rate) to more than 5 L/s (high success rate), are referred on the Groundwater Resources side map. For stock watering, bores yielding above 0.5L/s are generally regarded as successful.

Consider a typical case of a paddock holding 1000 head of cattle (each consuming 50 litres per day). Adequate stock watering is represented by a pumping regime yielding a minimum of 0.5 L/s continuously. This equates to a bore yielding 1 L/s to run two days out of four. A bore yielding more than 2 L/s to top up storages intermittently would provide a good safe margin.

The expected yield is based on knowledge of the type of aquifer, and in some cases, the submergence characteristics. For example, consider a limestone aquifer. Where the aquifer submergence is greater than 20m, a bore intersecting a cavity or fractured rock will likely yield in excess of 5L/s. Where the submergence is less than 20m, but more than 5m, a yield of between 0.5 and 5L/s may be expected. In an area where the submergence is less than 5m, the likelihood of intersecting a cavity or fracturing in the formation within this interval, is low. Therefore it is considered as a poor prospect because there is a high risk of failure.

Water quality from all aquifers across this region of the Sturt Plateau is suitable for stock. Appendix 2 tabulates the available water analyses from all bores in the area. Higher, although still acceptable salinity, is noted from bores intersecting basalt aquifers.

The three zones shown on the groundwater map are now described:

3.1 Areas of Poor Likelihood of Success

On this map, there are two areas where the basalt basement is known to subcrop above the water level (see Cross Sections). There are low prospects for groundwater in the basalt as occurrences depend on fractures in the rock. The fractures are difficult to locate as they are generally masked by a cover of other sediments. Bores intersecting the weathered surface of the basalt occasionally yield about 0.3 L/s. Bores intersecting fractures in the rock may yield 1 to 2 L/s.

The use of geophysics currently presents the most cost-effective option in locating a viable aquifer within the basalt. An appropriately designed investigation should aim to locate fractures, which can then be targeted with drilling. Costs will mainly depend on the technique used.

27 bores have been drilled on Larrizona, Lakefield, Cow Creek, Gorrie, Wyworrie, Gilnockie, Bloodwood Downs and Margaret Downs specifically to investigate groundwater in the basalt. These have met with a total of seven successes. This includes three bores drilled through the basalt into an underlying aquifer.

Aquifers developed in basalt are usually isolated and independent and hence water qualities from different bores vary considerably. However, within the map area, they are usually of satisfactory water quality for stock and hardness levels bear a general similarity to the limestone waters. That is, hard to very hard and scale forming.

Where high salinities are observed (TDS greater than 4000mg/L), it is usually due to the presence of sodium chloride (NaCl). The TDS from such bores should be monitored for increases with testing at six monthly intervals if the bore is in regular operation.

Within this map area, three bores have drilled through the basalt. A sandstone aquifer was intersected at all three locations. These bores indicate that there is considerable variation in thickness of the basalt (between 100 and 200m) and water quality ranged from good to saline. With this limited information, the extent of the resource, its recharge mode, water quality variations and resource sustainability cannot be adequately assessed.

Drilling rig access is considered an important factor in categorising the area's prospectivity. Areas with such limitations include the outcropping limestone pinnacles in the north-western corner of the map, and the sandy and rocky areas in the vicinity of Middle Creek.

3.2 Areas of Moderate Likelihood of Success

Plate 4 - Drilling on the Sturt Plateau.

Aquifers within this zone are part of the regional limestone basin which underlies the majority of the map (refer cross sections on the map). Bore yields can be expected to range from 0.5 L/s to more than 5 L/s. Variation in success and yield from bores within this category can be attributed to at least four factors.

Firstly, natural variations in the properties of the rock and in the development of dissolution features of the limestone leads to variations in groundwater yields. Also, where cavities or fractures exist, they need to be intersected by a borehole – usually 200mm in diameter before a successful yield is obtained.

Secondly, bore yields also depend on the aquifer's submergence characteristics. This term describes the location of the aquifer in relation to the water table. Submergence will vary with the undulations of the ground surface and by virtue of the random nature of aquifer occurrence within the limestone.

Bore construction, and the drillers' skill may also influence bore yields. Drilling in the limestone environment of the Sturt Plateau is difficult. Cavities usually exist above the water table as well as below it, and these can determine how drilling progresses and the outcome of the hole. The driller's assessment of the strata, the depth to the aquifer and the possible yield from the bore depends on uphole returns of drilled cuttings and intersected water. Where cavities exist, and the returns are 'lost' into them, this data becomes ambiguous. The bore is eventually constructed based on the drillers' perception of the available data and sometimes his experience. Although a potential for error is recognised here, in most cases, bores producing at stock supply rates have a good tolerance level for errors in judgement, and many have been successfully constructed.

Plate 5 -Dry River Stock Route 'No. 5 bore' with ground tank, Margaret Downs.

Another significant reason for the variability in bore success rates across the Sturt Plateau is the presence of a structural features within the basalt basement, affecting the groundwater system in the southern portion of the map. It is relevant to the north-eastern quadrant of Gilnockie and the southern parts of Margaret Downs, Gorrie and Larrizona. The feature is a system of parallel ridges and troughs trending north-west / south-east. The higher ridges intersect or approach the water table in the majority of cases. This affects groundwater conditions and creates corridors which are non-prospective for groundwater.

The use of airborne geophysics has enabled these features to be mapped (Reference 1). Where these features are prominent, bore site selection can be critical. It is important that the troughs be targeted to intersect an adequate thickness of limestone and optimise aquifer submergence. A map showing these basement features is considered an essential tool in bore site selection within the affected areas, and is available from the Natural Resources Division upon request.

Groundwater quality from the limestone across this map area is considered suitable for stock. A measure of salinity, known as the total dissolved solids (TDS), is considered the primary indicator of water quality. The desirable limit for human consumption is 500mg/L, although up to 1500mg/L is acceptable. Cattle will tolerate TDS up to 10000mg/L (Refer Appendix 3). Typically, the TDS in limestone aquifers of this area are less than 500mg/L.

The water is, however, hard to very hard (total hardness over 200mg/L) and scale forming. Measures can be taken to minimise the occurrence of scale development on elements of the reticulation. These include control of thermal variation of the reticulated water and limiting the aeration of the water.

3.3 Areas of High Likelihood of Success

Mapping of these zones is based on areas where aquifer submergence exceeds 20m. This occurs where the basalt basement deepens. There is a high likelihood of success for stock bores with yields in excess of 5 L/s.

Within the map region, the primary area of potential high yield is featured in the vicinity of Dry River, Nenen and the surrounding margins. Refer to the Groundwater Resources side map. Here, the limestone formation begins to descend towards the basin's regional centre, considered to be north of the King River crossing on the Victoria Highway, where it is in excess of 500m (refer Cross-Section D-E).

Plate 6 – 'East Bore' at Larrizona Station.

In the north of Dry River Station, the country becomes more elevated, and as a consequence, the water table deepens to over 100m (refer Depth to Water Table Map). Limestone is intersected at about 100m, and therefore, bores will be in excess of 100m in depth. The key to a successful bore in this area is to persist with drilling while still in limestone.

The northern part of Lakefield is another area where there is a deepening of limestone. Here, the limestone extends to depth as a result of geological faulting of the formation (refer Cross-Section A-B). This fault is regionally extensive and has been tracked from north of the Nenen/Manbulloo boundary to the south as far as the Buchanan Highway, and approximately aligns with Birdum Creek. The vertical displacement associated with the fault in the vicinity of Lakefield is in the order of 200m.

It is important to note that although the aquifer in this area may produce high yielding bores, there is currently a low level of information available on which to assess the sustainability of the resource. Issues of resource sustainability, environmental impact and allocation need to be addressed in these areas if large scale water usage (eg. horticulture) is considered.

4.0 SURFACE WATER

Few man made surface water storage constructions exist on the Sturt Plateau. The flat topography, low runoff potential of the area and high evaporation rates may make excavated tank and dam construction unattractive as primary water source options. However, regardless of the difficulties that these factors pose, surface water development options do exist for most areas and formal and purposeful design will provide these options. Even if preferred as secondary options, shallow tanks or dams need to be considered and are encouraged to permit a greater area of pasture to be used for at least the early part of the dry season.

Two major river systems drain this map area - the Dry River and Western Creek systems. The Western Creek system drains to Elsey Creek in the north-east of the Sturt Plateau. For the most part, the land is described as broad, flat to gently undulating plains and is typical of the Sturt Plateau. Of particular note is the lack of well-defined drainage paths across much of the country.

Plate 7 -Dry River stream gauging station near the Nenen/Manbulloo boundary.

Flow records exist for both the Dry River and Elsey Creek. These records are indicative of the general runoff characteristics over the Sturt Plateau where only a small percentage of rainfall (less than 10%) eventually contributes to sheet flows over the catchment. Flow only occurs during the wet season after the catchment has been adequately wet or following significant rainfall events. Initial wetting of the catchment may account for up to 40% of the total seasonal rainfall each year. See map side graphs for Dry River flow and indicative regional rainfall data.

Typically, the drainage systems on the Sturt Plateau deplete to form isolated pools in the rivers, and waterholes on the relict channel (black soil) areas of the flood plain. The majority of these are dry by about August or September.

The region's suitability for surface water development has been assessed by broadly adapting the land systems classifications and supplementing this information with field testing. The Land Systems Classifications (Reference 2), which integrate factors including topography, soil and vegetation types provide an approximation to relative runoff characteristics. Field investigation at a number of localities has allowed assessment of site suitability in terms of depth and clay content and enabled comment on the water retention characteristics of various soils. The results are presented as the Surface Water Resources Map, one of the side maps accompanying the Water Resources Development Map. However, it should be noted that the broad scale of this map is primarily for planning purposes and does not preclude the need for site specific investigations.

4.1 Surface Water Storage Types

By its nature, monsoonal rainfall in the Top End gives rise to discrete, sometimes significant flow events in local drainage systems. Dam construction types, which are sympathetic to this regime but enable effective and adequate harvest of surface water, are limited. As well, the general lack of defined drainage courses on the Sturt Plateau further limit options.

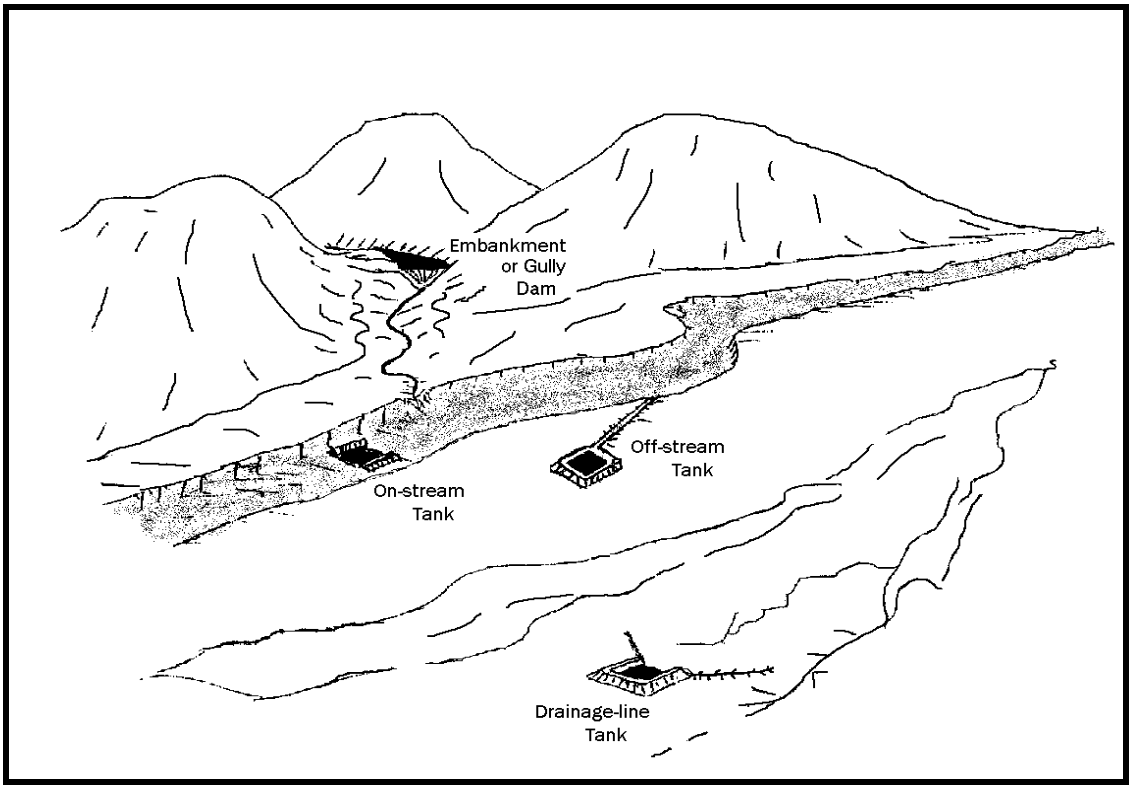

Figure 1 Types of Tanks and Dams

Three types of excavated tanks are suitable for the generally flat to gently sloping plains of this map region. They are on-stream tanks, off-stream tanks, and drainage-line tanks (see Figure 1). An on-stream tank is one which is constructed in a well defined stream channel. Off-stream tanks are constructed away from the main channel but are connected to it by an excavated inlet channel. The third type, the drainage-line tank is the preferred option and is one which is sited along a broad poorly defined watercourse.

The on-stream excavated tank requires a high standard of design and construction and is prone to erosion and silting because of its location in a fast flowing main stream channel. The off-stream design (see Figure 2) reduces these problems by using a man-made channel to divert water from the stream to the tank. This is an improvement on the on-stream design, but has excessive excavation costs because to take advantage of short duration stream flows, the tank level must be below that of the natural stream bed.

The drainage-line tank or hillside storage is constructed in flat to moderately sloping areas where there are no clearly defined incised creeks. This type of construction is considered the most suited to the environment of this area. The tank itself is of the same design as the off-stream one, but without an inlet channel (see Figure 3). Sheet flow on the plains, with its low silt load, may be harvested. Catch drains or wing walls directing flow towards the dam may be used to enhance interception capacity.

Some common problems experienced with excavated tanks include the following:

- inadequate spilltail channels do not direct water away from bunding
- erosion of wing walls
- silting of catch drains

Regular maintenance is required before the wet season to correct these problems.

Another type of dam, the gully or embankment dam, is suited for undulating to hilly country and consists of an embankment built across a drainage line. It should be noted that structural failures are high amongst gully dams, as they require a high standard of design, construction and management. Within the map region, low hilly country is only predominant in the north-western part of Dry River Station. As such, this type of construction may not be economically feasible due to the nature and permeability of the gravelly lateritic soils.

Construction of gully dams involves potential high costs in dealing with the foundations and mitigation of flood flows with diversion through an adequate by-wash or spillway. It is recommended that appropriate planning and design be undertaken, particularly for construction on rock foundations.

The "Earth Movers Training Course" booklets 9 and 10 (Reference 3), provides an excellent background guide to dam building and design. However, it is important that the information be considered in conjunction with local knowledge as many of the dam types in the booklets are only applicable to the less extreme conditions experienced in southern climates.

4.2 Selection of Sites for Excavated Tanks

The availability of runoff and depth of impermeable soil are usually the determining factors in site selection for excavated tank construction. Conditions appear to be favourable across the major part of the map area as it comprises gently undulating plains to low hills. The soil appears to have adequate clay content and sufficient depth.

Plate 8 - Soil sampling with a small auger rig.

In areas mapped with cracking clay (black) soils, such as the relict drainage paths of Western Creek and the Dry River, the clay may extend to depths of about two metres in most places and will be suitable for excavated tanks. However it should be noted that this is unlikely to be sufficient depth to be economical, and hence underlying soil conditions should also be investigated to confirm viability.

A drainage-line tank is best suited to this country where there is flat or gently sloping ground. Excavation will be minimised where the tank site has some slope, say about 1:100, to allow bunds constructed from excavated material to add to the storage volume of the tank. Drainage-line tanks may also be feasible in areas immediately adjacent to the low hilly country on rippable laterite horizons if there is sufficient depth of clayey soils.

A few areas have been mapped indicating where ferricrete is predominant on the surface. This rock, in its 'in-situ' form is highly permeable and would appear to be non-prospective as a foundation for shallow dam or tank construction. However, Avago and Hidden Valley have conducted informal trials in such areas using small holding dams, and report that success has been achieved over a short period of time, simply by allowing animals to 'work' the soil in the base. After the soil is 'pugged in', a seal is effected. A number of landholders, through personal communication, report a similar result is commonly noted in sinkholes, where once freely draining 'holes' are 'pugged' when animals are allowed access into them.

Areas mapped with variable soils are minor, but they may also be suitable for excavated tanks. In these areas, there is a likelihood of encountering dispersive or sandy profiles, or high permeability zones and these should be avoided. Remedial work such as installing a clay or plastic liner brings added expense but would be necessary.

4.3 Design and Construction of Excavated Tanks

In this section, empirical calculations are used for example purposes only. However, the examples serve to demonstrate typical dimensions which may be encountered on the Sturt Plateau.

The design dimensions for an excavated tank are determined by the number of stock in the paddock to be watered. This is often governed by the carrying capacity of the country and grazing radius. On the Sturt Plateau, this would be typically between 400 and 800 head. Based on a consumption of 50 litres per head per day, the corresponding water requirement is between 6 ML and 12 ML for the 9 month period from April through to December. With a depth of about 4m, which is the minimum preferred for good reliability and 1:3 batters, the larger tank would measure approximately 70m square at the top.

Following from this example, a storage of 12 ML (if neglecting evaporation and leakage losses) as a drainage-line dam would need a minimum catchment area of about 1 km^2 for the typical environment. This figure assumes an average annual rainfall of 700mm, a runoff threshold of 60% of rainfall and a runoff coefficient of 5%. For tank sizes of larger or smaller storage capacity, the required catchment area would need to be varied correspondingly to capture the required amount of runoff.

The proposed design is indicated in Figure 3 and is relatively simple. Excavated soil can be dumped to waste or used to build a bund on three sides of the tank. Bund and wing walls will increase the storage capacity of a drainage-line tank where there is a moderate slope on the natural ground surface. The excavated volume in this example is large for the proposed design dimensions (approximately 10,000 m^3) so construction costs will be high (usually in the order of $\$1/m^3$). The cost will also be influenced by ground conditions. Tank construction is described in more detail in Appendix 5.

An off-stream tank shown in Figure 2 is similar and with 12ML capacity. However, its ‘filling’ capability is controlled by the elevation of the inlet channel in relation to the creek bed and the nature and frequency of flow in the creek. The hydrology of the creek would therefore need to be examined to enable a viable tank to be designed.

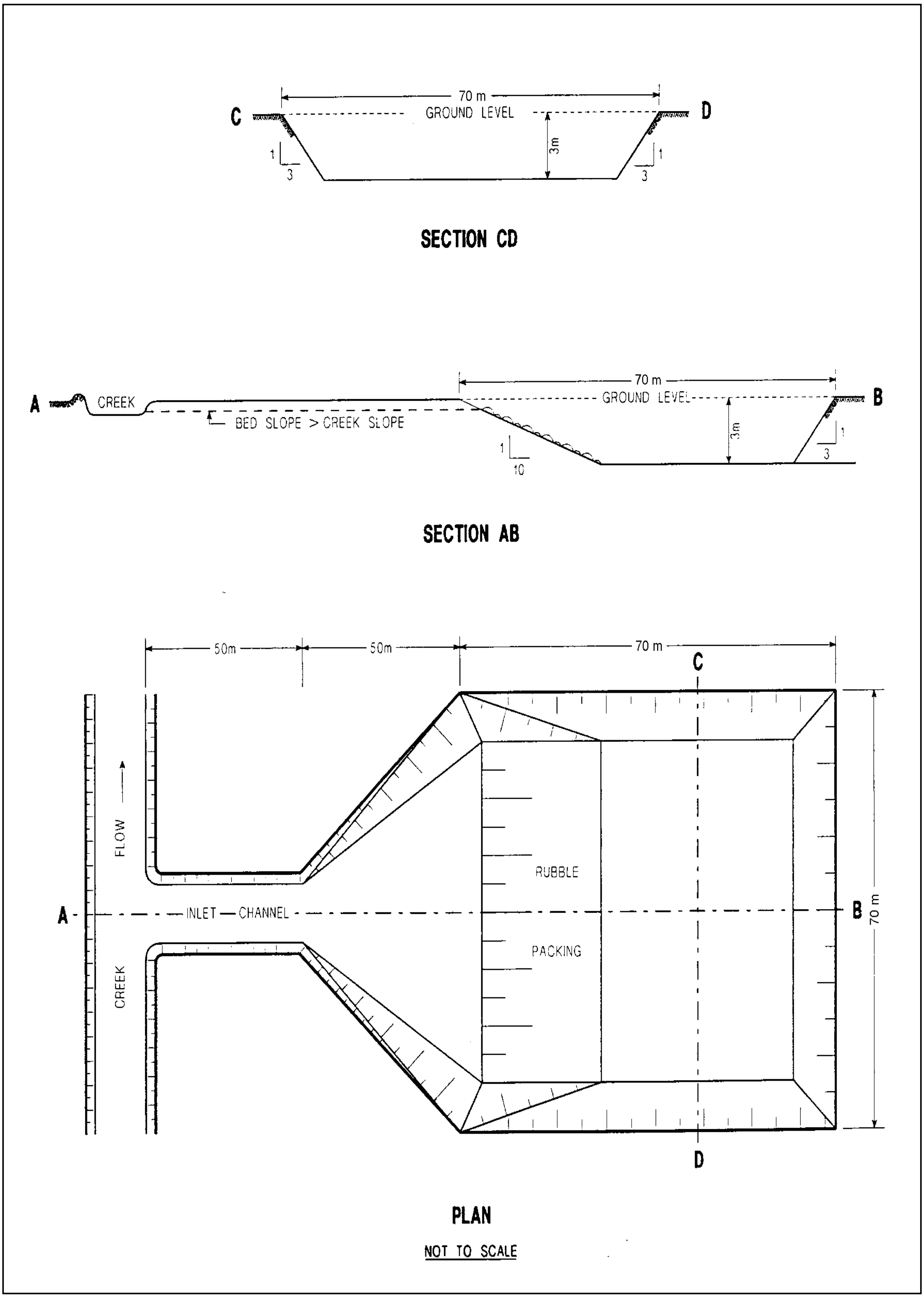

Figure 2 Typical Off-Stream Excavated Tank

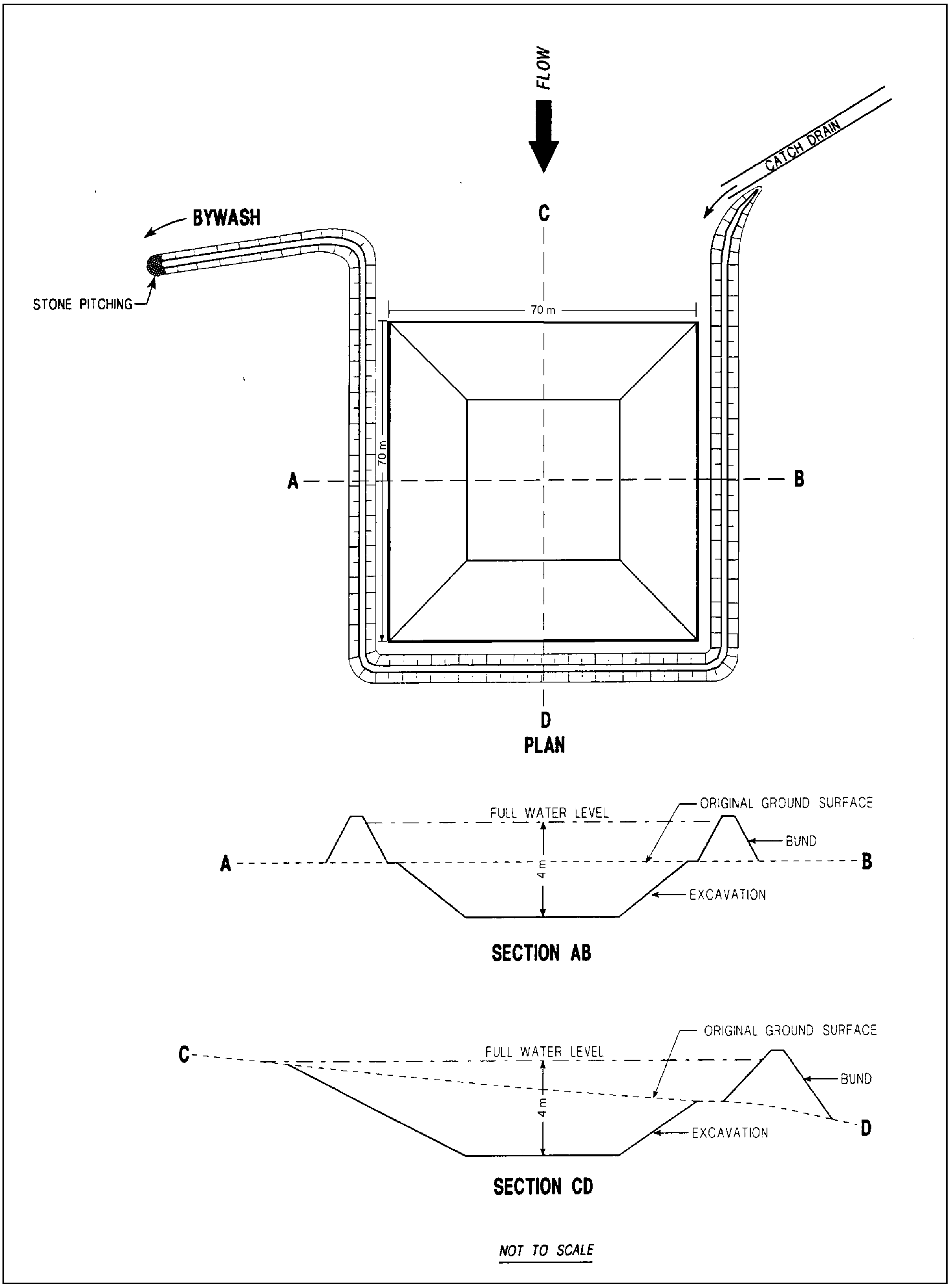

Figure 3 Typical Drainage Line Excavated Tank

4.4 Waterholes

In the dry season, natural waterholes are found in depressions in streambeds and in the black soil areas of relict floodplains. Most are shallow and become dry a few months after the end of the wet season. The available capacity of such waterholes may be increased by excavation of the base (Appendix 5), but only where clay or a rippable and impermeable rock underlies the site. The storage capacity of a well confined waterhole with high banks could be increased by construction of a bund at its downstream end. The bund would need to be designed and constructed to withstand flood flows.

Examples of waterholes in the study area exist mainly on the present day and ancient Dry River channels and adjacent floodplains. The relict Dry River watercourse runs from Gilnockie through Larrizona and north to Dry River Station. Most of these waterholes do not persist through the dry season.

Plate 9 - Chowyung Waterhole

In contrast, many large, deep waterholes on the Western Creek system have formed within its current path and mostly perennial. On Gorrie, the waterholes appear to have been influenced by the development of large sinkholes.

4.5 Piping of Surface Water

Surface water may be piped from borrow pits into turkey nests and this practice is effective as an alternative low cost option where possible. The use of turkey nests is a good option as losses to evaporation can be minimised. 50mm polythene pipe, buried where possible, can be used to pipe water to about four kilometres in flat country. The distance can be increased by using larger diameter pipes and higher capacity pumps. It is desirable to bury polythene pipe to protect it from physical damage (eg. grass fires or stock trampling) and because its strength is reduced if subjected to elevated daytime temperatures.

Piping is a recommended option for a large portion of Cow Creek where the basalt basement is shallow or the veneer of surface soil is sandy. Water may exist in shallow natural waterholes immediately following the wet season and their exploitation should be considered.

4.6 Supply of Stock Water from Tanks

Turkey nests are required as a balancing reservoir between the tank and stock watering troughs. Dimensions for turkey nests providing three days water for various stocking rates are given in Appendix 5. The basic equipment to transfer water from an excavated storage tank to a turkey nest is a pump, with a choice of three energy sources - diesel, wind or solar. The initial cost of a windmill or solar powered pump is high but running costs are low. The low cost and availability of a relatively cheap diesel motor and centrifugal pump makes diesel the preferred option even though running costs are high. The advantages are mobility and ease of maintenance.

Plate 10 - 'New Bore' at Gilnockie Station with a turkey nest in the background.

5.0 RECOMMENDATIONS

- The water resources development map should be used during the conceptual planning stage to determine the type of water supply most appropriate to the development of a specific area on the property. In areas where a number of options are available, economics will normally determine the final development type selected.
- Groundwater is available over much of the region.
- In situations where surface water flows and soil types are suitable, excavated tanks away from clearly defined drainages, and sited to harvest sheet flow are an alternative to bores.
- The provision of reliable water supplies with a maximum grazing radius of six kilometres should be a priority, in order to reduce potential for over-grazing and ultimately soil erosion.
- Advice should be sought from geotechnical engineering consultants when considering the construction of larger excavated tanks.

Specific recommendations are considered under three headings: distribution, groundwater, and surface water.

5.1 Water Supply Distribution

Over-grazing will severely reduce ground cover and eventually, initiate soil erosion. A major adverse effect is the degradation of pasture quality by allowing non-beneficial species and weeds to become dominant. Apart from the number of cattle present, the distribution of watering points is a major factor affecting grazing pressure. A rule of thumb commonly adopted for planning the location of watering points is that they should be located so that cattle can graze the whole paddock without having to walk more than six kilometres for water. Where possible, tanks or bores should be located to give a maximum spacing of twelve kilometres between watering points. Otherwise the water can be piped to steel tanks / turkey nests or directly to troughs in appropriate locations. The piping of water away from supplies sited in the corners of paddocks may decrease the grazing pressure by keeping the cattle spread over a greater area. Figure 4 is an example layout showing the potential increase in the size of the grazing area due to improved water reticulation from a bore or tank.

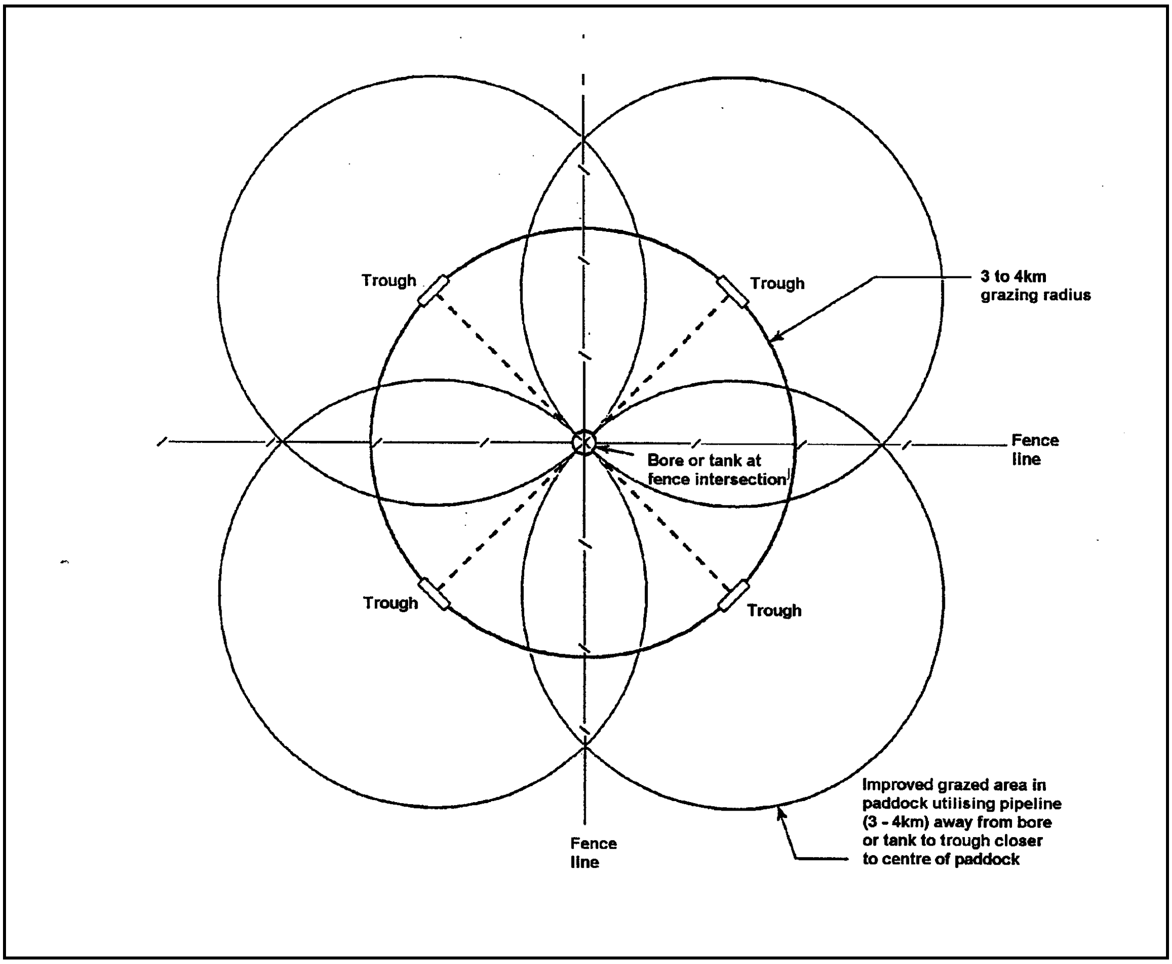

Figure 4 Sketch showing increased size of grazing area due to improved water reticulation from bore or tank

5.2 Groundwater

The prospect for obtaining a groundwater supply in the map area is generally good. Adequate stock water supplies may be obtained from aquifers in the limestone formation underlying most of the region. Such areas are indicated on the 'Groundwater Resources' side map. 'The Depth to Water Table' and 'Thickness of Limestone Below the Water Table' side maps should be used as a guides to minimum and maximum bore depths and indicative pumping depths.

Bore siting is critical in some areas. The basement variations described in Section 3.2 will affect groundwater prospects in parts of Gilnockie, Margaret Downs, Larrizona and Gorrie. The Natural Resources Division may assist in further defining target areas using available aeromagnetic mapping, however, ground geophysics may be needed to optimise the specific siting of bores.

In areas where groundwater prospects are mapped as poor, water supplies are usually only available in basalt aquifers. If groundwater options are to be pursued in these areas, geophysical or other aids should be utilised to locate specific targets for drilling.

5.3 Surface Water

The 'Surface Water Resources' side map accompanying the main map provides an indication of the potential for dam and excavated tank construction over the area. However, this is based on broad scale mapping and intended for planning purposes only. Site specific investigations will need to be conducted to ascertain the viability of particular sites.

Drainage-line and off-stream type excavated tanks are recommended for this area. These construction types are less susceptible to washout during seasonal flooding, and more effective in harvesting the low runoff available from the catchments on the Sturt Plateau.

Generally, the sub-soils are suitable for dam construction. Where clayey soils are shallow or there is underlying shallow rock, small capacity excavated tanks should still be considered. The supply may not be sustained throughout the year, however, a greater spread of grazing will possible for the initial part of the dry season.

6.0 ACKNOWLEDGMENTS

The author would like to thank the managers, families and staff of all stations involved for their time, assistance and fruitful discussions during the study.

The work of Anthony Knapton contributed largely to the outcomes of this project. His assessment and analysis of the geophysical components, particularly airborne magnetics, laid the cornerstone for the current understanding of the basement structure.

Technical advice and guidance from Peter Jolly and Gary Humphreys throughout the survey has been much appreciated.

Acknowledgment and thanks is also extended to Paul Schober who assisted in the geophysical and ground surveys, Jeff Fong of the GIS unit who drafted the maps and figures for the report, and the drilling and bore testing crews of the Technical Services Group.

7.0 REFERENCES

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2. Day, K.J., Sivertsen, D.P. and Torlach, D.A., “Land Resources of the Sturt Plateau, Northern Territory – A Reconnaissance Land System Survey”, Land Conservation Unit, Conservation Commission of the Northern Territory, Darwin (1985).

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8.0 GLOSSARY

AMG EASTING	The east-west coordinates of the bore in metres from the grid's origin. It refers to the grid lines on the map.
AMG NORTHING	The north-south coordinates of the bore in metres from the grid's origin. It refers to the grid lines on the map.
AQUIFER	A body of rock that is sufficiently permeable to transmit groundwater and to yield economically significant quantities to bores and springs.
BATTER	Slope expressed as a ratio of horizontal to vertical distance.
BERM	Flat area between excavated area of tank and bund.
BORE	Lined hole constructed with a drilling rig and which is used to extract groundwater.
BORE DIAMETER	The minimum internal bore diameter in millimetres
BORE REGISTERED NUMBER (RN)	A number assigned by the Natural Resources Division to each registered bore.
BUND	Bank constructed of compacted fill used to contain water.
CASING	Tubing used to line boreholes. The length of casing in the hole is expressed in metres and its internal diameter in millimetres.
DEMAND	The volumetric flow rate required for stock watering therefore the rate at which water would be supplied if available.
DEPTH DRILLED	The total depth of the bore in metres below ground level.
DISSOLUTION	The process where rock has been dissolved by water and the component parts are carried in solution.
GROUNDWATER	Water contained in rock below the water table.
KARSTIC	Term which denotes the characteristic scenery of a limestone region.

OFF-STREAM TANK	Excavated tank built near creeks and connected to the creek by a channel to tap the creek flow.
ON-STREAM TANK	Excavated tank built in the bed of a well defined stream.
PERENNIAL	Lasting throughout the year, or through many years.
PUMPING RATE	The recommended pumping rate in litres per second.
PUMP SETTING	The recommended depth below ground level at which the pump intake should be set.
SLOTS	The apertures located in the casing adjacent to the aquifer. An interval over which they exist is usually expressed between depths in metres below ground level.
SPILLWAY	A structure designed to overflow excess water out of a dam.
SPILL TAIL CHANNEL	A channel built downstream of the spillway to direct excess water back into the creek.
STANDING WATER LEVEL (SWL)	The level below the ground surface to which groundwater will rise in a bore or well.
STORAGE CAPACITY	The volume of water that can be stored in a tank up to its full supply level.
TOTAL DISSOLVED SOLIDS (TDS)	A measure of water salinity based on the quantity of solids left after evaporation of a litre of the sample.
WATER TABLE	The surface resulting when the standing water levels in adjacent bores in the same aquifer are connected.
WATER STRUCK	The depth in metres below ground level at which the main water bearing zone was encountered.
YIELD	The amount of water obtained in litres per second by airlifting usually during drilling of the hole.

APPENDIX 1

BORE TEST REPORTS

Test reports for bores within the region are included in this Appendix. Further details of the bore tests and other bore information is available from the Natural Resources Division in Darwin.

1. General Recommendations for Finishing, Operating and Protecting Groundwater Bores.

Attention to the following points will prolong the life of the bore supply and help prevent pollution of the groundwater resources.

a. Construct a concrete apron around the borehead to prevent surface flow and any spillage from entering the bore.

b. Seal the space between casing and pump equipment to prevent entry of small animals, insects, dirt and pollutants.

c. Maintain pumping equipment in good order to prevent pollution. Avoid spillage of fuel and oil on the ground around the bore.

d. Keep stock away from the bore head. Discourage domestic activity at the bore and store fertiliser and other chemicals at least 50 metres distant.

e. Pumping the bore at higher than recommended rates may cause sand intrusion and lead to instability or pump problems. Seek advice from this office or other qualified source.

f. When bore is not equipped or no longer required it should be securely capped. If the bore is to be abandoned, the casing may need to be removed, the bore backfilled and cement plugs placed.
NB. This requires the services of a registered driller

Please ensure that the BORE IDENTIFICATION TAG is retained securely at all times. The registered bore number, RN, is the Natural Resources Division's only reference to the scientific and engineering data on this bore and hence important to this Division’s records for advice to bore owners.

NATURAL RESOURCES DIVISION
TEST REPORT - RN 6845

Bore Location: Margaret Downs Station
Map: DRY RIVER 1:100,000 Sheet: 5367
Grid Reference: 206967 - 8293173

Client : Margaret Downs Station
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 6 L/s **Pump Setting: 65 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 6845**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 91.40 m Completion date: 20.10.69
Standing Water Level: 54.17 m on 4.6.98
Construction Details:

Test Date: 5.6.98
Test Rate: up to 6.7 L/s
Test Duration: 4 hours

Interval	Description
0.0 - 85.34 m	**156 mm ID steel casing**
85.34 - 91.40 m	**156 mm ID steel casing, oxy cut slots**

Notes:
1. Top of casing when tested was 0.20 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 156 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 156 mm.

****

COMMENTS:

1. The above recommendations are based on a step drawdown test up to 6.7 L/s for 4 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

****

WATER ANALYSIS: 0731 9/7/98#3 Lab Register 736

Prepared by: P Rees
9.9.98

Checked by: B Thatcher
9.9.98

NATURAL RESOURCES DIVISION
TEST REPORT - RN 24612

Bore Location: Dry River Station
Map: DRY RIVER 1:100,000 Sheet: 5367
Grid Reference: 190800 - 8313200

Client: Dry River Station
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 40 L/s **Pump Setting: 80 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 24612**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 103 m Completion date: 24.5.86
Standing Water Level: 59.29 m on 18.6.86
Construction Details:

Test Date: 19.6.86
Test Rate: up to 50 L/s
Test Duration: 6 hours

Interval	Description
0 - 87.00 m	**203 mm ID steel casing**
87 - 92.65 m	**203 mm ID steel casing, 9 mm slots**
92.65 - 103 m	**open hole**

Notes:
1. Top of casing when tested was 0.71 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 203 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 203 mm.

****

COMMENTS:

1. The above recommendations are based on an extended step drawdown test up to 50 L/s for 6 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Discharge was clean and clear throughout testing.

****

WATER ANALYSIS: 86/87/0111

Prepared by: D Hill 9.9.98

Checked by: B Thatcher 8.11.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 26116

Bore Location: Margaret Downs Station
Map: DRY RIVER 1:100,000 Sheet 5367
Grid Reference: 202278 - 8294031

Client: Margaret Downs Station
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 12 L/s **Pump Setting: 65 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 26116**

Water Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 89.0 m Completion date: 5.10.88
Standing Water Level: 55.53 m on 2.6.98
Construction Details:

Test Date: 3.6.98
Test Rate: 13 L/s
Test Duration: 6 hours

Interval	Description
0.0 - 8.0 m	**200 mm ID PVC casing**
0.0 - 71.0 m	**156 mm ID steel casing**
71.0 - 89.0 m	**156 mm ID steel casing, oxy cut slots**

Notes:
1. Top of casing when tested was 0.47 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 156 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 156 mm.

****

COMMENTS:

1. The above recommendations are based on a constant discharge test at 13 L/s for 6 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

****

WATER ANALYSIS: 0731 9/7/98 # 2

Prepared by: P Rees
9.9.98

Checked by: B Thatcher
9.9.98

NATURAL RESOURCES DIVISION
TEST REPORT - RN 27794

Bore Location: Lakefield Station
Map: ELSEY 1:100,000 Sheet: 5467
Grid Reference: 277250 - 8312700

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 10 L/s **Pump Setting: 35m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 27794**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 75.0 m Completion date: 29.6.91
Standing Water Level: 27.55 m on 22.11.97
Construction Details:

Test Date: 24.11.97
Test Rate: up to 17 L/s
Test Duration: 400 mins

Interval	Description
0 - 6.5 m	**203 mm ID steel casing**
0 - 69.0 m	**154 mm ID steel casing**
69 - 75.0 m	**154 mm ID steel casing, oxy slotted**

Notes: 1. Top of casing when tested was 0.30 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 154 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 154 mm.

****

COMMENTS:

1. The above recommendations are based on an extended step drawdown test up to 17 L/s for 6.6 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. Discharge was clean with a few fine grains throughout the duration of testing.

****

WATER ANALYSIS: 993

Prepared by: D Hill
8.11.99

Checked by: B Thatcher
8.11.99

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30660

Bore Location: Gorrie Station — Client: Natural Resources
Map: ELSEY 1:100,000 Sheet: 5467 — Purpose: Stock
Grid Reference: 276076 - 8310272

****

RECOMMENDATIONS: Pumping Rate: 5 L/s — **Pump Setting: 39 m**
For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 30660** Palmerston NT 0831

****

Bore Data:
Finished depth: 53.0 m Completion date: 18.4.96 — Test Date: 23.8.96
Standing Water Level: 28.71 m on 22.8.96 — Test Rate: 5 L/s
Construction Details: — Test Duration: 5 hours

Interval	Description
0.00 - 5.8 m	**208 mm ID PVC casing**
0.00 - 40.0 m	**152 mm ID steel casing**
40.0 - 46.5 m	**152 mm ID steel casing, 3 mm slots**
46.5 - 53.0 m	**152 mm ID steel casing**

Notes: 1. Top of casing when tested was 0.45 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:
1. The above recommendations are based on a constant rate test at 5 L/s for 5 hours and assume that hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped
3. Further advice can be obtained from Natural Resources Darwin.

****

WATER ANALYSIS: 1738
Prepared by: D Low 2.9.96 — Checked by: B Thatcher 2.9.96

NATURAL RESOURCES DIVISION
TEST REPORT - RN 30873

Bore Location: Gorrie Station
Map: ELSEY 1:100,000 Sheet: 5466
Grid Reference: 261606 - 8297821

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 1 L/s **Pump Setting: 46 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 30873**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 60.0 m Completion date: 14.8.96
Standing Water Level: 24.65 m on 26.8.96
Construction Details:

Test Date: 26.8.96
Test Rate: up to 4 L/s
Test Duration: 17.5 hours

Interval	Description
0.00 - 5.8 m	**208 mm ID PVC casing**
0.00 - 48.0 m	**147 mm ID PVC casing**
48.0 - 60.0 m	**147 mm ID PVC casing, 3 mm slots**

Notes: 1. Top of casing when tested was 0.25 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 147 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 147 mm.

****

COMMENTS:

1. The above recommendations are based on a constant rate test at 2 L/s for 17.5 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped

4. Further advice can be obtained from Natural Resources Darwin.

****

WATER ANALYSIS: 1704

Prepared by: D Low 2.9.96

Checked by: B Thatcher 2.9.96

Northern Territory Government — Lands Planning Environment

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31108

Bore Location: Dry River Station
Map: DRY RIVER 1:100,000 Sheet: 5367
Grid Reference: 196954 - 8320688

Client: Dry River Station
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 12 L/s **Pump Setting: 120 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31108**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 154.60 m Completion date: 31.7.97
Standing Water Level: 92.14 m on 13.6.98
Construction Details:

Test Date: 15.6.98
Test Rate: up to 12 L/s
Test Duration: 5 hours

Interval	Description
0.0 - 5.70 m	**203 mm ID steel casing**
0.0 - 126.0 m	**156 mm ID steel casing**
126.0 - 128.0 m	**156 mm ID steel casing, 5mm slots**
128.0 - 130.0 m	**156 mm ID steel casing**
130.0 - 154.6 m	**203 mm open hole**

Notes:
1. Top of casing when tested was 0.40 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 156 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 156 mm.

****

COMMENTS:
1. The above recommendations are based on a step drawdown test up to 12 L/s for 5 hours and assume that hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
3. This bore is suspended with an annular ring.

****

WATER ANALYSIS: 0731 9/7/98 #7 Lab Register 740

Prepared by: P Rees
9.9.98

Checked by: B Thatcher
9.9.98

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31381

Bore Location: Nenen Station
Map: DRY RIVER 1:100,000 Sheet 5367
Grid Reference: 231463 - 8319669

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 10 L/s **Pump Setting: 60 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31381**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 67.7 m Completion date: 30.9.97
Standing Water Level: 56.16 m on 11.6.98
Construction Details:

Test Date: 12.6.98
Test Rate: 10 L/s
Test Duration: 3 hours

Interval	Description
0.00 - 5.50 m	**203 mm ID steel casing**
0.00 - 61.30 m	**156 mm ID steel casing**
61.30 - 67.30 m	**143 mm ID steel casing, 5 mm slots**

Notes: 1. Top of casing when tested was 0.57 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 143 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 154 mm.

****

COMMENTS:

1. The above recommendations are based on a constant discharge test at 10 L/s for 3 hours and assume that hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

****

WATER ANALYSIS: 0731 09.07.98 # 6 Lab Register 739

Prepared by: P Rees
9.9.98

Checked by: B Thatcher
9.9.98

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31382

Bore Location : Wyworrie Station
Map: ELSEY 1:100,000 Sheet: 5467
Grid Reference: 247662 - 8298771

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 2 L/s **Pump Setting: 70 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31382**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 80.6 m Completion date : 1.10.97
Standing Water Level: 57.7 m on 25.11.97
Construction Details:

Test Date: 25.11.97
Test Rate: up to 6 L/s
Test Duration: 4 hours

Interval	Description
0 - 5.5 m	**203 mm ID steel casing**
0 - 73.4 m	**155 mm ID steel casing**
73.4 - 79.9 m	**155 mm ID steel casing, 5mm slots**
79.9 - 80.6 m	**149 mm open sump**

Notes: 1. Top of casing when tested was 0.7 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 149 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 155 mm.

****

COMMENTS:

1. The above recommendations are based on an extended step drawdown test up to 6 L/s for 3 hours and assume that hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
3. Discharge was clean with a few fines throughout testing.

****

WATER ANALYSIS: 994

Prepared by: D Hill
8.11.99

Checked by: B Thatcher
8.11.99

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31393

Bore Location: Gilnockie Station
Map: BIRRIMBA 1:100,000 Sheet: 5388
Grid Reference: 191988 - 8258540

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 1 L/s **Pump Setting: 84 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31393**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 91.8 m Completion date: 22.7.98
Standing Water Level: 46.3 m on 22.9.99
Construction Details:

Test Date: 24.9.99
Test Rate: 1.2 L/s
Test Duration: 24 hours

Interval	Description
0 - 85.3 m	**155 mm ID steel casing**
85.3 - 90.8 m	**155 mm ID steel casing, 4 mm slots**
90.8 – 91.8 m	**155 mm ID steel sump**

Notes:
1. Top of casing when tested was 0.7 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 155 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 155 mm.

****

COMMENTS:

1. The above recommendations are based on a constant rate test at 1.2 L/s for 24 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

****

WATER ANALYSIS: 1052

Prepared by: D Hill
29.9.99

Checked by: B Thatcher
29.9.99

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31394

Bore Location: Margaret Downs Station
Map: BIRRIMBA 1:100,000 Sheet: 5366
Grid Reference: 203140 - 8282550

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 1.5 L/s **Pump Setting: 65 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31394**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 85.3 m Completion date: 23.7.98
Standing Water Level: 54.33 m on 23.7.98
Construction Details:

Test Date: 9.7.98
Test Rate: up to 10 L/s
Test Duration: 8.7 hours

Interval	Description
0.0 - 5.50 m	**203 mm ID steel casing**
0.0 - 70.10 m	**154 mm ID steel casing**
70.10 - 85.30 m	**150 mm ID open hole**

Notes: 1. Top of casing when tested was 0.48 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 150 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 154 mm.

****

COMMENTS:

1. The above recommendations are based on a multi rate test to 10 L/s for 8 hours and assume that hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
3. Note: The attached water quality analysis indicates a high, though acceptable level of NaCl for stock watering. It is recommended that if the bore is regularly used, then water quality sampling at six monthly intervals should be undertaken.

****

WATER ANALYSIS: 1026

Prepared by: P Rees
3.9.98

Checked by: B Thatcher
3.9.98

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31396

Bore Location: Larrizona Station
Map: DRY RIVER 1:100,000 Sheet: 5367
Grid Reference: 305 - 910

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 6 L/s **Pump Setting: 60 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31396**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 91.3 m Completion date: 28.7.98
Standing Water Level: 54.65 m on 2.10.98
Construction Details:

Test Date: 3.10.98
Test Rate: up to 6 L/s
Test Duration: 8 hours

Interval	Description
0.0 - 5.5 m	**202 mm ID steel casing**
0.0 - 68.5 m	**155 mm ID steel casing**
68.5 - 91.3 m	**open hole**

Notes: 1. Top of casing when tested was 0.60 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 150 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 155 mm.

****

COMMENTS:

1. The above recommendations are based on a multi-rate test rate up to 6 L/s for 8 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped

3. This bore is capable of higher yields. For further advice contact Natural Resources.

****

WATER ANALYSIS: 1305

Prepared by: D Low
5.1.99

Checked by: B Thatcher
5.1.99

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31397

Bore Location: Cow Creek Station
Map: WESTERN CREEK 1:100,000 Sheet: 5466
Grid Reference: 265640 - 8281460

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 1.5 L/s **Pump Setting: 60 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31397**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 229.1 m Completion date: 3.8.98
Standing Water Level: 36.65 m on 1.10.98
Construction Details:

Test Date: 1.10.98
Test Rate: up to 4 L/s
Test Duration: 6.7 hours

Interval	Description
0.00 - 5.50 m	**203 mm ID steel casing**
0.00 - 61.80 m	**152 mm ID steel casing**
61.80 - 229.10 m	**open hole**

Notes: 1. Top of casing when tested was 0.65 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 150 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a multi-rate test up to 4 L/s for 6.7 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

3. A water analysis should be undertaken six monthly if this bore is operated regularly.

****

WATER ANALYSIS: Lab Report No. 1304

Prepared by: D Low
26.11.98

Checked by: B Thatcher
26.11.98

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31617

Bore Location: Larrizona Station
Map: BIRRIMBA 1:100,000 Sheet: 5366
Grid Reference: 229995 - 8277330

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 3 L/s **Pump Setting: 65 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31617**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 84.0 m Completion date: 14.10.97
Standing Water Level: 57.96 m on 9.6.98
Construction Details:

Test Date: 10.6.98
Test Rate: up to 6 L/s
Test Duration: 10 hours

Interval	Description
0.00 - 6.00 m	**208 mm ID PVC casing**
0.00 - 71.00 m	**152 mm ID steel casing**
71.0 - 77.50 m	**152 mm ID steel casing, 3 mm slots**
77.5 - 84.00 m	**152 mm ID steel casing**

Notes:
1. Top of casing when tested was 0.3 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a multi-rate test up to 10 L/s for 10 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

****

WATER ANALYSIS: 0731 9/7/98 #5

Prepared by: P Rees
9.9.98

Checked by: B Thatcher
9.9.98

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31618

Bore Location: Larrizona Station
Map: BIRRIMBA 1:100,000 Sheet: 5366
Grid Reference: 218137 - 8276884

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 0.5 L/s **Pump Setting: 65 m**

For alternative pumping rates or settings contact: Natural Resources Goyder Centre
General recommendations are on reverse side. 25 Chung Wah Terrace
In all correspondence please quote **RN 31618** Palmerston NT 0831

****

Bore Data:

Finished depth: 78.0 m Completion date: 15.10.97
Standing Water Level: 53.80 m on 8.6.98
Construction Details:

Test Date: 8.6.98
Test Rate: up to 0.5 L/s
Test Duration: 2 hours

Interval	Description
0.00 - 6.00 m	**208 mm ID PVC casing**
0.00 - 65.00 m	**152 mm ID steel casing**
65.00 - 78.00 m	**152 mm ID steel casing, oxy slots**

Notes: 1. Top of casing when tested was 0.30 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a step drawdown test up to 0.5 L/s for 4 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.

****

WATER ANALYSIS: 0731 9/7/98 # 4

Prepared by: P Rees
9.9.98

Checked by: B Thatcher
9.9.98

LANDS PLANNING ENVIRONMENT
Northern Territory Government

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31630

Bore Location: Gorrie Station
Map: WESTERN CREEK 1:100,000 Sheet: 5466
Grid Reference: 261327 - 8281857

Client: Mike Harding
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 2 L/s **Pump Setting: 55 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31630**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 94.0 m Completion date: 18.8.97
Standing Water Level: 47.05 m on 26.11.97
Construction Details:

Test Date: 27.11.97
Test Rate: up to 4 L/s
Test Duration: 7 hours

Interval	Description
0.0 - 6.0 m	**208 mm ID PVC casing**
0.0 - 81.0 m	**152 mm ID steel casing**
81.0 - 94.0 m	**152 mm ID steel casing, 3 mm oxy slots**

Notes: 1. Top of casing when tested was 0.40 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a multi-rate test rate up to 4 L/s for 7 hours and assume that hydrological conditions remain constant.

2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped

****

WATER ANALYSIS: 1088

Prepared by: D Low
6.1.99

Checked by: B Thatcher
6.1.99

NATURAL RESOURCES DIVISION
TEST REPORT - RN 31924

Bore Location: Gorrie Station
Map: WESTERN CREEK 1:100,000 Sheet: 5466
Grid Reference: 261524 - 8270415

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate: 0.8 L/s **Pump Setting: 50 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 31924**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 77.09 m Completion date: 11.8.98
Standing Water Level: 45.75 m on 4.9.99
Construction Details:

Test Date: 6.9.99
Test Rate: up to 1 L/s
Test Duration: 18.3 hours

Interval	Description
0.0 - 5.70 m	**203 mm ID steel casing**
0.0 - 50.17 m	**152 mm ID steel casing**
50.17 - 54.00 m	**open hole**

Notes: 1. Top of casing when tested was 0.59 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

****

COMMENTS:

1. The above recommendations are based on a multi-rate test rate up to 1 L/s for 5 hours and assume that hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
3. This bore was reconstructed and retested in 1999.
4. The casing is suspended with an annular ring.

****

WATER ANALYSIS: 1302 & 1058

Prepared by: D Low
6.1.99

Checked by: B Thatcher
6.1.99

NATURAL RESOURCES DIVISION
TEST REPORT - RN 32162

Bore Location: Larrizona Station
Map: BIRRIMBA 1:100,000 Sheet: 5388
Grid Reference: 222443 – 8277054

Client: Natural Resources
Purpose: Stock

****

RECOMMENDATIONS: Pumping Rate 0.8 L/s **Pump Setting: 68 m**

For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote **RN 32162**

Natural Resources Goyder Centre
25 Chung Wah Terrace
Palmerston NT 0831

****

Bore Data:

Finished depth: 93.0 m Completion date: 14.7.99
Standing Water Level: 57.03 m on 7.9.99
Construction Details:

Test Date: 8.9.99
Test Rate: up to 1 L/s
Test Duration: 25 hours

Interval	Description
0 - 5.5 m	**200 mm ID PVC casing**
0 - 69 m	**148 mm ID PVC casing**
69 - 75 m	**148 mm ID PVC casing, 3mm slots**
75 - 81 m	**148 mm ID PVC casing**
81 - 87 m	**148 mm ID PVC casing, 3mm slots**
87 - 93 m	**148 mm ID PVC casing**

Notes: 1. Top of casing when tested was 0.4 m above ground.
2. All depths are measured from natural ground level.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 148 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 148 mm.

****

COMMENTS:

1. The above recommendations are based on a multi-rate test up to 1 L/s for 25 hours and assume that hydrological conditions remain constant.
2. This bore should not be pumped more than 16 hours per day at recommended rate
3. Provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
4. The total depth of this bore was 91.42 metres from ground level prior to testing.

****

WATER ANALYSIS: 1059

Prepared by: D Hill
29.9.99

Checked by: B Thatcher
24 .11.99

APPENDIX 2

CHEMICAL ANALYSES OF GROUNDWATERS

The following table lists chemical analyses of bores sampled in this area of the Sturt Plateau. See Appendix 3 for quality guideline limits for stock and domestic consumption.

Table 2 Water Quality Data - Limestone Aquifers

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
903	26-07-67	588	7.8	312	190	308	340	46	10		46		0.6	8	1		0.1		
903	01-07-69	550	7.6	317	386	300	290	76	10		27		1	9	2	0.1	0.1		
904	26-07-67	1086	7.8	96	59	155	663	6	305		34		3.2	200	1	0.9	0.3		
904	01-07-69	1050	7.55	108	132	106	640	30	294		5		3	195	3	1	0.4		
905	26-07-67	303	10.1	124	76	4	254	1	22		1		0.3	90	1	0.5	0.1		
905	01-07-69	310	10	132			240	1	20		1		1	95	14	0.6	0.1		
906	26-07-67	471	7.88	234	143	202	311	5.5	14		45		2.8	30	2		0.2		
906	01-07-69	470	7.45	258	315	226	340	60	12		16		3	32	2	0.2	0.2		
6845	21-01-70	445	8	228	278	240	340	82	12		11		4	7	23	0.1	0.7		
6845	01-10-70	360	8.6	202	227	167	210	11	8		34		4	12	9	0.2	3.8		2.5L/s, 90m
6845	05-06-98	677	6.4	365	445	355.5	400	134	9	15	5	1	2	4	15	0.1	2	26	
21784	27-09-82	280	7.2	148	181	146	150	42	4	8	10		3	1	5	0.1		12	4L/s, 58m,airlift
21784	21-11-97	312	6.6	168	205	150.1	172	42	2	3	11	1	2	1	8	0.2	0.2	15	4L/s, 58m, pumped
22101	30-06-83	750	7.5	300	366	335	440	89	38	63	29	3	6	38	56	1.3	1	24	8L/s, 90m,airlift
22101	02-05-86	855	7.2	413	504	445	495	124	30	48	33	1	3	22	30	0.1	0.1	36	Homestead tap sample
22101	20-06-86	825	7.6	413	503	416	520	122	34	56	27	1	3	22	29	0.2	1.2	33	12.2L/s, 74m, pumped
23859	26-06-85	770	6.8	420	512	419	480	130	12	20	23	1	2	11	13	0.2	0.2	55	1.2L/s, 54m, pumped
24612	24-05-86	650	8	200	250	210	400	20	60	100	40	1	5	50	45	0.1	0.3	50	20L/s, 103m,airlift
24612	19-06-86	1060	7.1	483	589	494	675	135	28	44	38	1	4	49	51	0.2	0.8	46	40L/s, 85m, pumped
24783	10-08-86	630	7.6	266	325	269	370	50	20	31	35		7	23	54	0.3	6.3	21	2L/s, 105m,airlift
24784	24-09-86	805	7.9	442	539	434	490	116	8	13	35	1	3	9	16	0.3	0.2	43	5L/s, 65m,airlift
24784	03-06-98	872	6.4	496	605	483.3	517	131	7	12	38	1	3	9	18	0.1	0.1	42	pumped as equipped, approx 3L/s

Table 2 Water Quality Data - Limestone Aquifers (continued)

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
24785	12-08-86	645	7.7	294	358	273	365	45	8	13	39	1	6	30	60	0.3	15	17	0.5L/s, 150m,airlift
25279	31-08-87	610	7.3	308	376	317	385	94	13	21	20	1	2	5	13	0.2		40	3L/s, 62m,airlift
25290	29-08-87	495	7.6	267	326	249	310	55	10	18	27	2	3	8	9	0.2	1.3	40	7L/s, 80m,airlift
26053	17-09-88	525	8.2	205	250	56	350	16	22	36	4	1	2	96	40	1.2		47	0.4L/s, 103m,airlift
26113	23-09-88	520	8.2	259	316	242	332	28	20	33	42		2	24	12	0.3	14.3		7L/s, 66m
26115	10-10-88	355	7.6	177	216	127	250	21	8	13	18	1	6	32	9	0.5	16.7	64	7L/s, 46m,airlift
26115	28-11-97	197	6	95	116	89.4	187	21	8	13	9	1	3.7	15	5	0.2	0.4	67	1L/s, 15m, pumped
26116	05-10-88	325	7.9	168	205	161	205	48	2	3	10	2	3	5	7	0.2	6.6	20	9L/s, 89m,airlift
26116	05-10-88	445	7.6	225	275	217	275	54	11	18	20	1	3	9	9	0.2		43	9.5L/s, 89m,airlift
26116	21-08-97	628	6.8	335	408	204	360	75	4	7	4	1	3	4	15	0.1	0.2	21	pumped as equipped, approx 7L/s
26116	03-06-98	778	6.36	434	529	411.8	465	127	13	21	23	1	2	10	17	0.1	0.1	39	13L/s, 70m, pumped
26265	19-09-88	405	7.8	160	195	160			36	59									2L/s, 36m,airlift
26549	06-07-89	545	7.9	263	321	270	340	47	8	13	37	1	5	10	34	0.3	6	40	5L/s, 91m,airlift
26549	26-06-94	912	7.7	492	600	604	532	138	11	18	63	1	5	11	43	0.3	11.2	42	
26553	03-07-89	515	7.6	269	328	259	315	48	11	18	34	1	4	10	9	0.3		38	4.5L/s, 105m,airlift
27124	11-11-90	940	7.6	326	398	342	580	58	82	135	48	1	7	71	67	0.2	0.2	51	airlift
28190	07-08-92	880	7.5	285	348	342	500	89	117	193	29	1	4	56	15	0.2		35	2L/s, 68m,airlift
30865	11-07-96	500	7.3	281	343	255	290	51	5	8	31	1	2	7	11	0.2	4.3	38	airlift

Table 2 Water Quality Data - Limestone Aquifers (continued)

Bore RN	Sample Date	Conductivity (uS/cm)	PH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
30866	12-07-96	639	7.6	299	364	279	378	51	29	48	37	1	3	26	30	0.2	4.5	53	airlift
31108	31-07-97	741	6.9	343	418.8	341.1	403	61	31	51	46	1	5	27	33	0.4		40	8L/s, 155m,airlift
31108	15-06-98	903	6.7	445	543	449.7	536	111	24	40	42	1	3	25	36	0.1	0.8	47	12L/s, 100m, pumped
31381	12-06-98	1198	6.8	485	591	505.7	713	117	86	142	52	1	7	72	16	0.2	0.6	48	10L/s, 60m, pumped
31382	03-10-97	638	7.6	316	385	271.2	383	56	15	25	32	1	2	28	23	0.1	0.4	54	2L/s, 70m,airlift
31382	25-11-97	812	6.8	420	512	331.2	515	80	18	30	32	1	2	24	40	1.2	0.2	60	2L/s, 64m, pumped
31391	03-12-97	587	6.5	247	302	252.4	331	37	30	49	39	1	6	26	42	0.5	1.1	36	2.6L/s, 244m,airlift
31391	15-08-98	826	7.9	424	517	402.4	489	97	27	44	39	1	4	21	30	0.3	0.5	40	
31396	28-07-98	562	6.3	302	368	269	341	60	4	7	29	1	3	6	8	0.1		34	6L/s, 91.3m,airlift
31396	03-10-98	742	7.3	410	500	378.9	395	104	11	18	29	1	3	8	23	0.2	0.4	36	6L/s, 69m, pumped
31617	14-10-97	372	6.6	224	273	209.1	257	41	6	10	26	1	3	8	15	0.2		30	4L/s, 84m,airlift
31617	09-06-98	806	6.7	441	538	428	474	122	13	21	30	1	3	10	18	0.2	0.1	35	3L/s, 70m, pumped
31924	13-08-98	605	8	208	253	259.4	369	48	66	109	34	1	3	21	32	0.2		43	Seepage, 77m,airlift
31924	29-09-98	883	7.3	490	598	457.2	511	114	18	30	42	1	3	11	27	0.2	0.5	52	1L/s, 52m,airlift
31924	07-09-99	884	7.3	526	597	485	526	122	14	23	44	1	3	11	20	0.2		50	1L/s, 51m, pumped
32162	09-09-99	907	7.3	313	382	332	584	87	111	183	28	1	4	59	12	0.4	0.1	40	1L/s, 82m, pumped
32169	25-10-99	617	7.8	346	422	349	379	74	5	8	40	1	3	7	17	0.2	0.1	41	pumped as equipped

Table 3 Water Quality Data - Basalt and Other Aquifers

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
23833	03-05-85	330	7.4	135	165	73	260	8	24	40	13		3	41	11	0.6			
26112	01-10-88	1010	7.1	83	102	236	535	68	228	376	16		4	110	50	0.4	7.4		2L/s, 100m,airlift
27793	28-06-91	1160	7.7	284	346	310		57	191	315									1.5L/s, 73m,airlift
27794	29-06-91	1240	7.5	360	440	418		83	161	265									5L/s, 75m,airlift
27794	24-11-97	1492	6.9	518	632	542.5	898	135	169	279	50	1	4	108	106	0.6	1.4	54	17L/s, 65m, pumped
28086	30-06-92	1010	7.9	91	111	228	520	60	243	400	19	1	4	96	8	2		41	5L/s, 85m,airlift
28190	28-07-92	3920	6.3	14	17	1088	2020	353	1238	2039	50	1	8	292	43	0.2		5	0.5L/s, 125m,airlift
30507	05-06-98	621	6.3	278	339	208.6	375	49	32	53	21	1	4	48	21	0.3		48	Seepage, 60m,airlift
30660	18-04-96	1070	7.5	332	405	298	589	47	122	201	44	1	4	103	61	0.4		38	airlift
30660	23-08-96	1340	7.1	531	647	499	791	121	119	196	48	1	3	97	55	0.2	0.3	48	3L/s, 40m, pumped
30873	27-08-96	468	7.3	238	290	124	288	30	13	21	12	1	2	61	7	0.2	0.1	52	2L/s, 46m, pumped
30873	05-08-96	421	8.1	214	261	79	273	12	13	21	12	1	2	65	9	0.4	1	49	2L/s, 60m,airlift
31393	22-07-98	1160	8.2	229	279	157	649	30	177	292	20	1	2	150	78	0.7	7	36	2L/s, 92m,airlift
31393	25-09-99	1070	7.7	285	347	245	613	65	145	239	20	1	1	135	65	0.8	0.1	48	1.2L/s, 82m, pumped
31394	24-07-98	2010	6	62	76	127	1120	36	572	943	9	1	4	318	1	1.4		16	5L/s, 85.3m,airlift
31394	18-08-98	4370	7.7	38	46	336	2780	118	1392	2294	10	1	5	723	11	1.4	0.2	22	8L/s, 70m, pumped
31394	22-11-99	4480	8	30	37	411	2630	143	1470	2410	13	1	6	805	8	1.3	0.2	22	pumped as equipped
31397	29-07-98	452	8	126	154	84.6	293	24	48	79	6	1	1.3	56	26	0.6		37	0.5L/s, 61.8m,airlift
31397	01-10-98	510	8.3	153	187	38.2	326	12	59	97	2	1	1	92	35	0.8	1.9	41	1L/s, 120m, pumped (packer test)
31398	04-08-98	742	6.8	322	392	68.5	505	11	23	38	10	1	5	133	50	0.2		51	0.3L/s, 49.3m,airlift
31618	15-10-97	1351	7	157	191	164.9	736	43	322	531	14	1	4	191	5	2	5.6	27	1L/s, 78m,airlift
31618	08-06-98	1425	6.3	174	212	184.9	747	51	339	559	14	1	4	209	19	1.6	0.9	33	0.5L/s, 62m, pumped

Table 3 Water Quality Data - Other Aquifers (sandstone)

Bore RN	Sample Date	Conductivity (uS/cm)	pH	Total Alkalinity (mg/L)	Bicarbonate (mg/L)	Total Hardness (mg/L)	TDS (mg/L)	Calcium (mg/L)	Chloride (mg/L)	NaCl (mg/L)	Magnesium (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Sulphate (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Silica (mg/L)	Sampling Data
31618	08-06-98	1425	6.3	174	212	184.9	747	51	339	559	14	1	4	209	19	1.6	0.9	33	0.5L/s, 62m, pumped
28190	06-08-92	5420	7.5	109	131	292	3171	94	1792		14	0.6	18	1023	16				2L/s, 260m,airlift
28190	06-08-92	5460	7.8	89	109	320	3115	100	1733	2855	17	1	14	976	13	1.3		9	2L/s, 260m,airlift
28190	16-10-98	3900	7.5	245	299	254.7	2092	74	1188	1958	17	1	9	660	29	1	0.4	22	pumped as equipped, approx 2L/s
31397	03-08-98	2570	8.2	253	308	65.3	1359	13	660	1088	8	1	6	472	1	2.1		13	4L/s, 229m,airlift
31397	02-10-98	1260	8.2	198	242	40.7	691	13	282	465	2	1	3	243	57	1.7	0.3	28	4L/s, 120m, pumped (packer test)

APPENDIX 3

WATER QUALITY STANDARDS FOR STOCK AND DOMESTIC USE

1. WATER QUALITY STANDARDS FOR STOCK USE

SUBSTANCE	GUIDELINE VALUE
pH range	6.5 - 8.5
Total dissolved solids	10000mg/L
Sodium chloride	Not more than 75% when total dissolved solids near limit
Sulphate	2000mg/L
Nitrate	400mg/L
Fluoride	2.0mg/L
Magnesium	300mg/L

The composition of mineral supplements to stock feed must be considered when stock waters are near to the guideline limits, especially for fluoride and sulphate. Further information is available from the Chief Veterinary Officer, Northern Territory Department of Primary Industry and Fisheries.

2. WATER QUALITY STANDARDS FOR DOMESTIC USE (NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL, AUSTRALIAN DRINKING WATER GUIDELINES 1996)

Analyses of water intended for human consumption should lie within the guidelines listed below. Discussion relating to the quality of domestic water should be addressed to the Northern Territory Department of Health and Community Services.

SUBSTANCE	GUIDELINE VALUE	
pH range	6.5 - 8.5	*
Total dissolved solids	500mg/L	#
Chloride	250mg/L	#
Sulphate	250mg/L	#
Nitrate	50mg/L	+
Fluoride	1.5mg/L	
Hardness (as Calcium Carbonate)	200mg/L	*
Sodium	180mg/L	*

(*) Values outside of the guidelines for pH and hardness may result in either build-up of scale in pipes or corrosion of pipes but they do not pose a health problem.

(#) Above these limits the taste may be unacceptable but they do not pose a health problem.

(+) For nitrate, a limit of 50mg/L is recommended for babies less than 3 months old, 100mg/L is the guideline for older children and adults.

APPENDIX 4

EXCAVATED TANK SITE INVESTIGATIONS

Having determined a catchment capable of supplying stock quality water for the required stock numbers, site investigations must be undertaken to confirm that the proposed tank site is suitable. The site investigation guidelines presented here are based on a booklet entitled "Design and Construction of Small Earth Dams" (Reference 4). The key investigation method is to auger a series of investigation holes. In an excavated tank situation this helps to:

- determine the extent of impermeable soils and the presence of any layers which are likely to present leakage problems
- show if there is any impermeable and soft rock present, such as rippable hard clays or laterite
- ascertain whether shallow groundwater is present, and if so, is it suitable for stock
- provide information on the soils to ensure the tank sides will be stable

- If an on-stream tank is proposed, then spillway conditions will also require investigation. If it is too sandy it will erode and wash away or if it is in rock, excavation could be very expensive.

A hand operated 100 mm earth auger capable of drilling to between 5 and 6 metres is the basic tool for the sub-surface investigations. Auger holes are sunk in soil to one metre deeper than the tank design depth, with minimum 500 gram samples taken wherever there is a change in soil. A plan of the soil changes down each hole should be kept to compare variations from hole to hole. Excavated tanks require a minimum five test holes, one in the centre and the other 4 positioned at the mid point of each corner slope of the proposed tank (Figure 5). For the modification of an existing waterhole, auger holes are sunk at 50 metres apart along the centre of the bed, and 100 metres apart along the edges of the bed.

- The site for proposed excavation must fulfil three main conditions :
- the loss by seepage must be relatively low
- the sides must be stable
- silting must not be excessive

1. Seepage Loss

In most areas, the water table will be deeper than the proposed 3 to 4 metre tank depth. Hence leakage of stored water through the sides and base of the tank is possible. A simple permeability test can give an indication of potential leakage from the tank using the series of auger holes used for soil sampling. The following procedure is proposed but is only indicative:

- Pre-soak each hole for at least 1 hour before starting the test by filling the hole to exactly 0.5 metres below ground level. Maintain the water at this level by topping up as necessary.
- The test is a measurement of the amount of water needed to maintain the water level at 0.5 metres below ground level for one day. Once the test is commenced, the amount of water added is recorded. This should continue for one day.

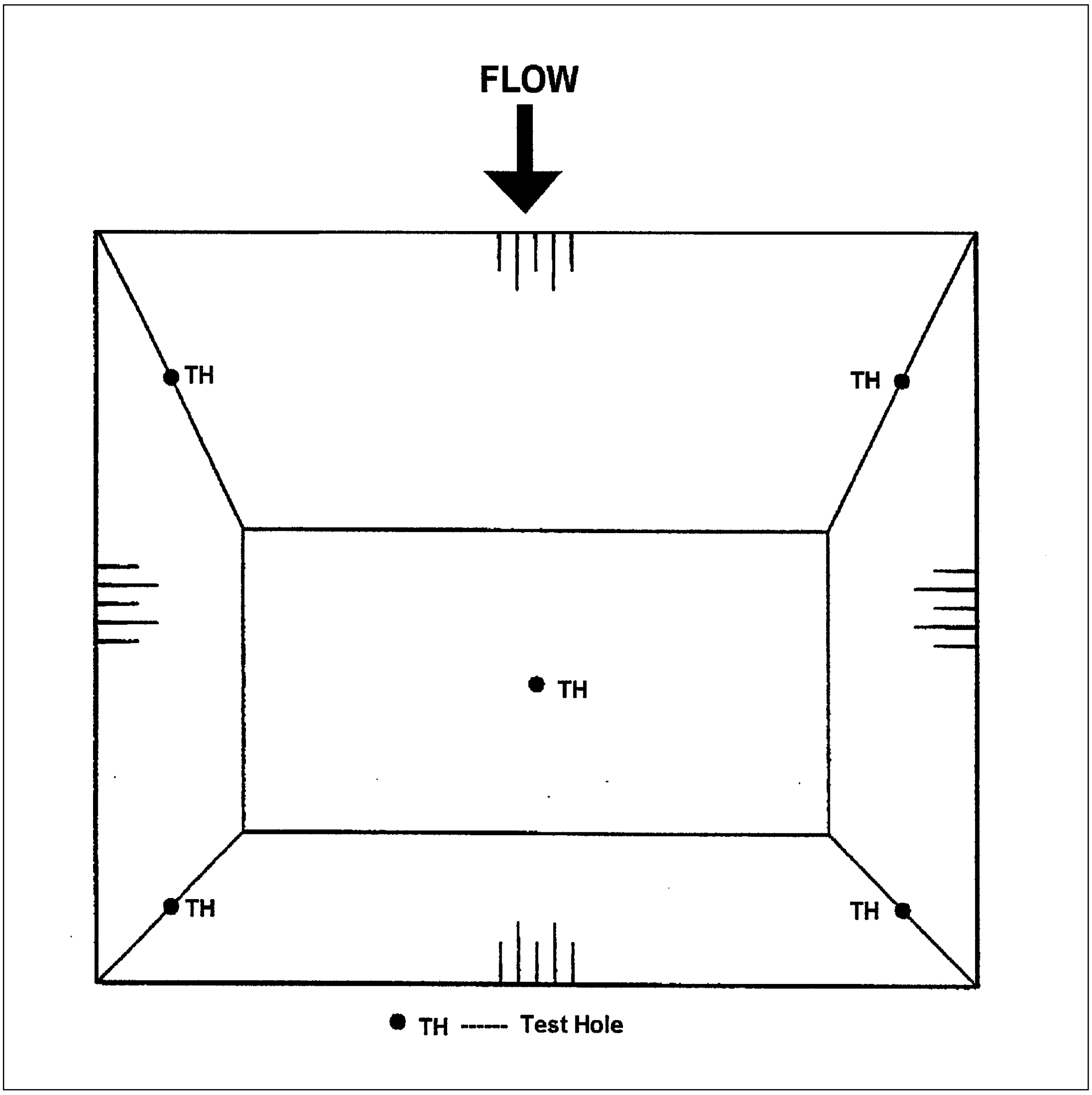

Figure 5 Test hole plan for an excavated tank

If the water added exceeds 30 litres per hour, then the site is too permeable for an excavated tank. If it is between 3 and 30 litres per hour then the site is considered doubtful. Some work would be needed to limit the water loss rate or to increase the sealing capacity of the tank floor (eg. use plastic liner or clays). Seepage rates less than 3 litres per hour indicate that leakage will not be a serious problem.

2. Tests on Soil Samples

Soils commonly consist of particles ranging in size from coarse gravels, through sands and silts, to very fine clays. Gravels and sands can be readily identified by appearance and feel, and unless they are mixed with finer silts and clays, will be prone to leakage. Clays and silts are indistinguishable when dry. While clay is one of the most useful soils in dam building, silt, when wet, is the most troublesome. It tends to be unstable in the presence of water, often collapsing when saturated.

Generally, a favourable site investigation result will confirm the presence of non-dispersive clays that bind together any coarser particles to create a water holding material. Accurate classifications of soil types can be undertaken by sending at least 100 gram of sample to a soil laboratory to provide confirmation of soil suitability. However, simple field tests can give a good indication for the likely behaviour of the soils.

- A simple test to differentiate clay from silt is to moisten the sample and feel it. Clay should be sticky. Pinch a sample between the thumb and forefinger; if it is clay it should be possible to form a flexible ribbon about 1.5 mm thick and at least 40 mm long.

- If the presence of clay is established, then the water holding potential of the soil can be tested using the "bottle test". The bottom of a one litre plastic drink bottle is cut off. The bottle is inverted and one-third filled with the soil to be tested. The bottle is filled with water. If no water seeps through the soil in 24 hours, it has good water-holding properties.

- All clays should be tested for dispersion. Some clays break down in water to form a suspension of clay particles throughout the water. This is dispersion and has been the cause of many dam failures. To test for dispersion, take 5 to 10 grams of air dried soil crumbs and drop them into 100 ml of distilled water in a cup. Allow it to stand for at least one hour without shaking. If the water appears cloudy then dispersion has occurred and special care will be needed if building tanks in these materials. The presence of deep erosion gullies suggests markedly dispersive soils and that these sites should be avoided.

If site investigations show that there is likely to be problems with any of these factors then professional advice should be sought, and remedial measures may be possible. However it may also be necessary to abandon the proposed site.

APPENDIX 5

CONSTRUCTION DETAILS OF EXCAVATED TANKS, TURKEY NESTS AND MODIFIED WATERHOLES

Assume preliminary investigations (Appendix 4) have been conducted and indicate that suitable conditions exist for the proposed construction. The integrity of the structure now hinges on the construction methods utilised.

1. Drainage-Line Excavated Tanks

The site is first cleared of vegetation and the planned tank laid out on the ground using marker pegs. Excavation is commonly carried out using scrapers or bulldozers. If the tank is in an area with some slope (say greater than 1 in 100), excavated material can be used to construct bunds around three sides of the excavation to increase the storage capacity. The bund should have a minimum berm width of 5 metres (Figure 3). Topsoil with potential for leakage must be removed down to an impervious layer before the bund is built, and compaction may be undertaken using the available machinery. The ideal time to achieve optimum compaction is early in the dry season when soils are still slightly moist.

Three sides of the tank are excavated with a slope of 1 in 3, and flow enters the tank through the side with a mild slope, as low as of 1 in 10. The inflow side may be rubble packed to prevent erosion. Where the excavation is in rock, with little chance of erosion, the inlet batter may be increased to 1 in 4 to decrease the volume of material to be removed. The recommended slopes allow for machinery to enter the tank, excavate, turn and exit with ease.

Catch drains can also be constructed (eg. using a tilted grader blade) to effectively increase the interception capacity of sheet flow towards the tank.

2. Modifying Waterholes

Modifying a waterhole usually means constructing a narrow excavated tank within the waterhole to increase its storage capacity. Site investigations are critical. If the subsoil is impermeable, non-dispersive, and there is no rock within two metres depth, then excavation should be possible using a scraper. The presence of rock will usually require the use of rippers for excavation. The longitudinal batter could be 1 in 3 or less, while the cross sectional batter should not be more than 1 in 2.

3. Turkey Nests

The current design and construction techniques for turkey nests are quite sound although special attention should be paid to:

- removal of leaky topsoil from the base before construction
- the selection of a non-dispersive soil as the construction material
- compaction at optimum moisture content. This can be achieved if construction is undertaken early in the dry season while the soil is still moist. Every 100 mm layer of loose soil should be compacted.

The table below gives examples of recommended dimensions, sized for turkey nests of a three day water supply capacity.

Number of Cattle	Inner Diameter At Base (m)	Inner Diameter at Top (m)	Total Height of Turkey Nest (m)	Draught (m)
250	4	13	1.8	0.8
400	6	15	1.8	0.8
600	6	16	2.0	1
1000	6	18.5	2.5	1.5

These figures are based a slope of 1 in 2.5 for the inner sides. The capacity of the tank (in terms of number of cattle) allows for leakage, the overflow standpipe to be 0.5m below the top of the tank and the outlet pipe supported 0.5m above its base. The draught is the depth of available water in the tank and is effectively the tank's storage capacity.