WATER RESOURCES SURVEY OF THE
WESTERN VICTORIA RIVER DISTRICT

FITZROY STATION

REPORT 09/1997
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Water Resources of Fitzroy
WATER RESOURCES SURVEY OF FITZROY STATION
NORTHERN TERRITORY

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Water Resources of Fitzroy
SUMMARY
The accompanying Water Resources Development maps can be used as a guide to determine the type of water supply most appropriate to specific areas of the station. Groundwater sources occur only sparsely in the developed area of the station and considerable effort and expense may be involved in locating it. Drilling several shallow holes rather than a single deep one is recommended as a way to improve chances of success. In situations where surface water flows and soil types are suitable, excavated tanks away from clearly defined drainages, and sited to harvest sheet flow may be an alternative option to bores. Few areas are likely to have sufficient depth of clay soil to enable the construction of tanks with enough storage to last most of the dry season. Sites could be found however for shallower tanks which could supply water at least for the early part of the Dry.

1. INTRODUCTION
This project was started by the Victoria River District Conservation Association (VRDCA). Its aim is to provide station managers with up to date information on water resources, so that they can make more informed decisions about water and land management. It is funded by the Northern Territory Government and the National Landcare Program with a contribution by the VRDCA. A total of 20 properties will be studied between July 1993 and June 1998.

Fitzroy station cover an area of 2312 km² and is located some 200 kilometres southwest from Katherine, the closest major town. Road access is via the Victoria Highway. During the wet season 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 approximately 837mm, occurs in the short hot monsoonal wet season between December and March (Table 1). Little rainfall is experienced during the remainder of the year. Recharge to groundwater aquifers occurs at this time. Evaporation rates of water bodies such as dams or waterholes are between 5 and 9 millimetres per day (average about 7.0 mm per day or 2.6 metres per year). This ensures that water levels in creeks, dams and tanks declines rapidly. Air temperatures are high throughout the year. The average monthly maxima range from about 30.3 degrees in June to 38.5 degrees in November. The corresponding average monthly minima are 12.9 and 25.3 degrees. Timber Creek temperatures are noted here.

Current stock management is based on water availability. At present the station carries about 4,000 head of cattle. Bores supply approximately 10 - 20% of the water need, the remainder coming from excavated tanks and waterholes. Five bores are used, normally in conjunction with steel or cement tanks which act as temporary storages. During the Wet and the early Dry, most of the available surface water that is accessible is used, but as the Dry progresses, these sources become depleted and more reliance is placed on groundwater except for some tanks which are filled by pumping water from Victoria River. There are two excavated tanks which operate in this manner.

2. WATER SUPPLY DEVELOPMENT
An attempt has been made to classify the station according to the type of water resource developments considered most appropriate for particular areas. The results are shown on the accompanying Water Resources Development Map of Fitzroy. The map was made by combining information on existing features (waterholes, dams, bores etc.) with information on groundwater occurrence, topography and soil types. Local conditions, such as soil types can vary considerably, so the maps should not be taken as a definitive guide to cover every

Water Resources of Fitzroy
# TABLE 1

**CLIMATIC AVERAGES - FITZROY STATION**

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<thead>
<tr>
<th></th>
<th>Rainfall (mm)</th>
<th>Rain Days</th>
<th>Daily Min. Temp (°C)</th>
<th>Daily Max. Temp (°C)</th>
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<td>19</td>
<td>24.7</td>
<td>35.6</td>
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<tr>
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<td>196.1</td>
<td>18</td>
<td>24.5</td>
<td>34.3</td>
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<td>15</td>
<td>23.7</td>
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<tr>
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<td>2</td>
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<tr>
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<td>1</td>
<td>17.2</td>
<td>32.6</td>
</tr>
<tr>
<td><strong>JUNE</strong></td>
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<td>.5</td>
<td>13.5</td>
<td>30.3</td>
</tr>
<tr>
<td><strong>JULY</strong></td>
<td>4.8</td>
<td>.3</td>
<td>12.9</td>
<td>30.3</td>
</tr>
<tr>
<td><strong>AUGUST</strong></td>
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<td>.4</td>
<td>15.3</td>
<td>32.7</td>
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<tr>
<td><strong>SEPTEMBER</strong></td>
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<td>.5</td>
<td>19.6</td>
<td>35.6</td>
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<td>23.8</td>
<td>5</td>
<td>24.1</td>
<td>37.6</td>
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<tr>
<td><strong>NOVEMBER</strong></td>
<td>57.0</td>
<td>9</td>
<td>25.3</td>
<td>38.5</td>
</tr>
<tr>
<td><strong>DECEMBER</strong></td>
<td>140.9</td>
<td>14</td>
<td>24.8</td>
<td>36.9</td>
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<td><strong>TOTAL</strong></td>
<td>837.4</td>
<td>84.7</td>
<td></td>
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</tr>
</tbody>
</table>

Note: Temperatures are from Timber Creek

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**Water Resources of Fitzroy**
situation. Rather they are broad scale maps which are intended to give an overall picture of possible development options. Detailed on-ground investigations are recommended when considering specific developments.

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

- areas which are unsuitable for surface water storages or bores (option 1).
- areas in which groundwater is the best option and where moderate yields can be expected (option 2).
- areas in which surface water is the best option (option 3).
- areas in which surface water and groundwater may both be viable options (option 4).

Some of the main features of the maps are:

- groundwater availability is very limited in most of the developed areas of the station.
- the more rugged areas in the west and northwest, underlain by dolomite are the most prospective for groundwater.
- areas suitable for the construction of excavated tanks are those with alluvial and colluvial soils and those underlain by shale and siltstone.

3. GROUNDWATER

Groundwater conditions across the station have been assessed using geological information, satellite images, aerial photos and information from existing boreholes. The results are presented as the Groundwater Resources Map, a small side maps on the accompanying map of Fitzroy station.

Technical information on water bores is shown in Appendix 1. Further details on individual bores are held on the Water Resources Division's files and are available on request. Chemical analyses of groundwaters and recommended limits for common uses are listed in Appendix 2 and 3, while the results of pump testing are presented in Appendix 4.

Groundwater is stored in and moves through minute spaces in rocks caused by fractures (cracks), the spaces between sand grains or spaces where minerals have dissolved away. If economically viable quantities of water can be extracted, the water bearing horizon is termed an aquifer. The zones of groundwater yield shown on the maps are meant to give an indication of the most likely yield which could be expected. Natural variations in the properties of rocks means that variation also occurs in groundwater yields. For example in a zone mapped as 0.5 to 5.0 L/s a certain percentage of bores may obtain higher yields and some may be lower but most will fall within the range. At a specific site, yield is often highly dependent on the number of water bearing fractures intersected. There are generally too few existing bores to determine the likely yields with statistical certainty. Rather they are based on a combination of geological knowledge and known yields. The groundwater map is therefore intended to identify the prospectivity of broad areas only. When selecting specific bore sites it is useful to observe local rock types and to study aerial photographs and topographic maps for signs of linear features which may indicate the presence of fractures.

A paddock holding 1000 head of cattle (each consuming 50 litres per day) requires a bore capable of pumping between 0.5 and 1 L/s continuously. Bores yielding less than 0.5 L/s are generally regarded as being uneconomic.

Water Resources of Fitzroy
Stock water is presently obtained from only five bores; Winton, Red Bull, Bardia, Unstead and Leonhardt's bores. Water drilling has been relatively unsuccessful with only eight of the forty-five bores drilled on the station having airlift yields more than 0.5 litres/second. Of those eight the actual sustainable yield is probably less than the airlift yield. For example Unstead bore (RN 24496) had a reported airlift yield of 4.5 L/sec but was only tested for one hour. It presently pumps 1.5 L/sec and reportedly forks at times. Standing water levels in bores are shallow, with most less than 20 metres below ground level.

Water quality is generally suitable for stock although fluoride levels are above the recommended limit in Leonhardt's bore (RN 24744). Veterinary advice should be sought on this matter. Some other groundwaters are unsuitable for human consumption also due to excess fluoride.

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

3.1 Areas with yields 0 to 0.5L/sec, alluvial deposits
Minor aquifers occur in alluvial sands and gravels along a narrow zone flanking the Victoria River. The aquifers vary up to two metres in thickness and are at depths of about 20 metres. Water levels are also at a similar depth, so in places the sands sit above the watertable and are dry. Aquifers occur where the base of the old river channel is below the depth of the watertable. Yields of about 0.2 L/sec can be expected. The homestead bore had a reported airlift yield of 0.8 L/sec, however it could not sustain that rate with constant usage. The reason for that is most likely because the aquifer is of limited extent combined with the fact that there is insufficient depth of water above the slots. Further test drilling is the only method to locate another supply for the homestead. Boreholes need be no deeper than 25 metres and once water has been struck the bore should be constructed with stainless steel screens rather than slotted casing to keep out the sand and to allow the maximum amount of water to enter the bore.

3.2 Areas with yields 0 to 0.5L/sec, siltstone and shale
This zone, coloured brown on the Groundwater Resources Map includes most of the flat to gently undulating country which is currently used for grazing. It is underlain by siltstone and shale which is dolomitic in places. The rocks locally contain small to moderate amounts of water in faults and fractures. Most water intersections are shallow where the rocks are weathered and any cracks are more open. Of the thirty bores drilled in the area only a few yielded above 0.5 L/sec. The area as a whole is therefore classed as having poor prospects for groundwater supplies. At this stage test drilling is the only reliable method for locating water in this type of country. When looking for a supply several holes should be budgeted for due to the low chance of success. Test holes should be no deeper than 40 metres. It would be wise to drill say several 40 metre deep holes than a single 120 metre deep one. All the previous drilling points to shallow holes being the most successful (Figure 1).

3.3 Areas with yields 0.5 to 5.0 L/sec, dolomite
Dolomite and chert are the rocks which form aquifers in this zone. It is shown in blue on the Groundwater Resources Map and includes much of the area north of the highway and that west of the Top Springs road. Much of the country is rugged and rocky and not easily accessible except on its southeast margin. Water intersections are also generally shallow in these aquifers (less than 40 metres) but exceptions occur such as the road bore RN 27084 which struck water at a depth of 79 metres. Information from both Fitzroy and neighboring

Water Resources of Fitzroy
Airlift yield (L/s)

0.0 0.5 1.5 2 2.5 3 3.5 4 4.5

Unsteared bore

20.0

Bardia bore

40.0

40.0

Winton bore

60.0

Red Bull bore

80.0

100.0

Leemharota bore

120.0

* Note the yield achieved under long term pumping is usually less than the airlift yield

Figure 1 Bore yield Vs Depth

Water Resources of Fitzroy
properties suggests that chances of success are higher when drilling in dolomite than in siltstone.

3.4 Areas with yields more than 5.0 L/sec, dolomite and siltstone
A narrow zone of high yielding aquifers occurs in the Timber Creek valley in the vicinity of Timber Creek township. Yields averaging between 5 and 10 L/sec are obtained from dolomite beds interbedded with siltstone. Exceptional yields of up to 30 L/sec have been encountered. Aquifer depths are variable, most being between 20 and 40 metres, but some are as deep as 76 metres. The relatively high yields encountered in this zone are probably related to a major fracture which has allowed groundwater to penetrate the dolomite, dissolve it away more than usual, forming an abundance of cavities. Similar but as yet unidentified narrow zones could occur in the main dolomite area. Areas to target in such cases would be those where there are indications of fractures or faults such as long straight valleys.

4. SURFACEWATER

Surface water flow in the creeks and on the floodplains is largely confined to the wet season. An effective annual evaporation rate of about 2.6 metres is responsible for the subsequent rapid loss of stored water from tanks and waterholes. During the average Wet, flow of the Victoria River, and its tributaries is sometimes accompanied by sheet flow over the adjacent floodplains. After the Wet, all drainages deplete to form unconnected waterholes, the majority of which are dry by about July. Surface water studies have been directed at designing structures to conserve enough of the wet season flow to provide reliable stock supplies for the duration of the Dry. An example of typical storage requirements would be 1.8 megalitres (million litres) for a paddock holding 300 head (50 litres/head/day) after allowance is made for evaporation losses. That would ensure a 4 month daily stockwater supply soon after the Wet. For its stock water supplies from surface water the station is dependent on waterholes and excavated tanks. About 80% of the stock water demand on Fitzroy is supplied from natural and artificial surface water sources.

The region has been divided into four zones showing the suitability for surface water development for stock watering. They are based on soil type, geology, topography and runoff characteristics. The results are presented as the Surface Water Resources Map, one of the two small side maps accompanying the Water Resources Development Map.

4.1 Surface Water Storage Types
Three types of excavated tanks are suitable for flat to gently sloping alluvial plains, onstream tanks, offstream tanks, and drainage-line tanks (Figure 2). An onstream tank is one dug in a well defined stream channel. Offstream 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 onstream excavated tank requires a high standard of design and construction and is prone to erosion or silting because of its location in a fast flowing main stream channel. The offstream design (Figure 3) reduces these problems by using a man-made channel to divert water from the stream to the tank. This is an improvement on the onstream design, but has excessive excavation costs because to take advantage of short lived stream flows, the tank level must be below that of the natural stream bed.

The drainage-line tank is an excavated tank constructed in flat to moderately sloping areas.

Water Resources of Fitzroy
Figure 2 Types of tanks and dams

*Water Resources of Fitzroy*
Figure 3 Typical offstream excavated tank

*Water Resources of Fitzroy*
where there are no clearly defined incised creeks. The tank itself is of the same design as the
offstream one, but without an inlet channel (Figure 4). Sheet flow on the plains, with its low
silt load, may be harvested using catch drains or wing walls.

Another type of dam, the gully dam is suited to gently undulating to hilly country and
consists of an embankment built across a drainage line. Structural failures are high amongst
gully dams, as they require a high standard of design, construction and management.
Construction of these dams in much of the low hilly country on Fitzroy may not be
economically feasible due to the thin permeable soils and hard shallow bedrock. The
minimum average depth of a gully dam should be 4.5 metres in order to compensate for the
high evaporation, and to maintain a high reliability. All excess runoff has to be taken through
a by-wash or spill. Constructing a gully dam at an appropriate location in the region would
involve high costs in coping with the foundation condition and flood flows. It is
recommended to consult a Civil Engineer before planning to construct these dams on rock
foundation. Embankments more than 3 metres high need licensing from the Water Resources
Division.

Details of the station’s key surface water storages and an assessment of their
capabilities are given in Appendix 5. The existing man made reservoirs are shallow excavated tanks with
bunds made from the excavated material and open on the upstream side. From the top of the
bund these tanks are about 2 to 2.5 metres deep, but with a maximum excavated depth of less
than 2 metres. Some problems experienced by the existing tanks include rill erosion of the
bunds, silting of the tanks and silting of catch drains. Regular maintenance is required before
the next Wet to correct damage due to these problems. The current design does not give
sufficient storage capacity for cattle requirements, due mainly to high evaporation losses. The
depth of excavated tanks should be more than 3 metres, if daily supply is needed till the end
of the Dry. As the depth increases beyond 3.5 metres, the tank’s reliability increases.

4.2 Selection of Sites for Excavated Tanks
The selection of a site for an excavated tank is determined by the availability of runoff and
the water holding capacity of the ground. A drainage-line tank is best located on flat or gently
sloping ground. Excavation will be minimised where the tank site has some slope, say about
1%, to allow bunds constructed from excavated material to add to the storage volume of the
tank. On areas mapped as "gently undulating, and alluvial plains" on the Surface Water
Resources Map, clays soils may extend in places to depths of up to 2 metres and will be
suitable for excavated tanks. However it should be noted that over most of that area it is likely
that there will be insufficient depth of suitable soil for tank construction. Places with sandier
soils should be avoided. Drainage-line tanks may be feasible in areas immediately adjacent to
the low hilly country if clayey soils with sufficient depth underlain by siltstone are present.
Areas suitable for consideration are also summarised on the Water Resources Development
Map. Following selection of a general area, more detailed investigation is required (Appendix
6).

For drainage-line storages a minimum catchment area of 1.5 km² is required. Other types of
excavated tanks require a minimum catchment area of 4 km². Cracking clay soils are
suitable for holding water. Remedial work such as installing a clay liner, or reselection of the
site will be necessary where dispersive or sandy soils, or high permeability zones are
encountered.

4.3 Design and Construction of Excavated Tanks
Design dimensions for an excavated tank are determined by the number of stock to be
Figure 4 Typical Drainage-line excavated tank

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watered. This is also dependent on the carrying capacity of the paddock, typically varying between 100 and 500 head. At a consumption of 50 litres per head per day, the corresponding water requirement for five months is between 0.75 and 3.75 megalitres. The amount of runoff that can be captured by a tank increases with catchment area.

A drainage-line tank of the design shown in figure 4 and with a catchment area of 1.5 km$^2$, would supply 350 head of stock, over a five month period on a daily basis with 90% reliability (i.e., for 9 years out of 10). This same tank with a depth of 2.5m would supply water daily to 600 head over a five month period from April with a reliability of 92%. Tank sizes of 60 x 60 x 2 or 80 x 80 x 2.5 metres could supply stock water on a daily basis for 300 to 600 head with a reliability of 90% over a five month period.

An offstream tank of the design shown in Figure 3 and with a catchment area of 4 km$^2$ should supply 300 head of cattle with 90% reliability over a period of five months. If shallower than 2 metres or if the catchment area is less than 4 km$^2$, it would be unable to cater for a continuous water demand over a reasonable period. Due to the limitation on the depth of suitable subsoil, the daily supply over a period of four to seven months might be considered satisfactory. An Offstream tank of size 80 x 80 x 2.5m with a catchment area of 4 km$^2$ should cater for 300 head of stock on a daily basis over a 6 month period with 90% reliability. However, the daily supply could be extended to seven months to cater for 400 head with 90% reliability, if the catchment area is doubled.

The design of excavated tanks is covered in more detail in the internal Water Resources Division Report No 03/1997D, entitled "Surface Water Storage Potential - Fitzroy Station". The proposed design is relatively simple. Excavated spoil can be dumped to waste or used to build a bund on three sides of the tank. A 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. Excavated volumes are large for the proposed design dimensions (approximately 14,000 m$^3$) so construction costs will be high. Cost will also be influenced by ground conditions. Tank construction is described in more detail in Appendix 7.

4.4 Waterholes and Springs

Natural waterholes are present during the Dry, in depressions in streambeds. The Victoria River has numerous waterholes, some of which are very long and deep and which generally last for most of the Dry. A few of these are inaccessible. The available capacity of some waterholes may be increased by excavation of the base (Appendix 7), but only where the site is underlain by clay or arippable and impermeable rock such as shale. The widespread occurrence of hard rock at shallow depths makes this an unlikely option on Fitzroy. 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.

Springs usually occur on hill slopes and in stream beds. There are no major springs in the station but some are found south of the southern boundary and cattle have direct access them. A spring with a flow of more than 2 litres per second at the end of Dry, should be able to supply a turkey nest designed to store three days supply of stock water for 500 head of cattle. Piping water from springs to areas where groundwater or surface water are not available may be an option in some situations.

**Water Resources of Fitzroy**
4.5 Piping of Surface Water

On some stations surface water has been piped from borrow pits into turkey nests and this practice could be utilised as an alternative low cost water supply option where possible. Pumping direct to turkey nests is the preferred option because of the smaller volumes of water lost to evaporation.

Fifty millimetre polythene pipe, buried where possible, can be used to pipe water up to 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.

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 7. 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.

5. RECOMMENDATIONS

The water resources development map can be used to determine the type of water supply most appropriate to a specific area on the Station. In areas where alternative options are available economics will normally determine the final development type selected.

Groundwater availability over the accessible parts of the station is limited, however 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 option to bores.

The provision of reliable water supplies with a maximum grazing radius of six kilometres should be a priority, in order to reduce over-grazing and 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

In many parts of the V.R.D. over-grazing has resulted in a reduction of ground cover and in places, in soil erosion. Another unwanted result is degradation of pasture quality by allowing unbeneﬁcial 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 turkey nests or directly to troughs in appropriate locations. The piping of water away from

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supplies sited in the corners of paddocks may decrease the grazing pressure by keeping the
cattle spread over a greater area. (Figure 5).

5.2 Groundwater
Careful site selection can improve the chances of successful drilling. In the accessible parts of
the station underlain by siltstone prospects for obtaining groundwater supplies are low with a
success rate to date of less than 20%. Future drilling should target shallow aquifers. For
example instead of drilling one, one hundred and twenty metre bore it may be better to limit
the maximum depth to forty metres and then drill three bores if necessary. The chances of
success would be improved by locating the sites as far from each other as practical. Drilling
deeper than forty metres is risky because there are usually no indications at the surface of
deep water.

Areas underlain by dolomite and chert have better prospects for groundwater but they are
generally more rugged. Water could be piped from bores on the eastern margin of that area to
the flatter areas to the east.

5.3 Surface Water
Drainage-line and offstream type excavated tanks are recommended for areas with cracking
clay soils (black and grey soils) at least 2.5 metres deep. Excavated tanks could also be
constructed where there is as little as 2 metres of soil but the reliability would be as low as
80% and the supply would be confined from four to five months in the Dry, depending on the
catchment area, and the cattle strength. Selection of sites depends on the presence of suitable
sub-soils. Deepening or enlarging the surface area of existing surface water storages should
be subject to satisfactory sub-soil investigations. Site investigations are an essential
prerequisite for any construction work. All existing and planned surface water storages
(excavated tanks, waterholes, springs etc.) should be fenced and stock watering infrastructure
such as troughs, windmills, turkey nests or on-ground fabricated tanks should be provided.

6. ACKNOWLEDGMENTS
The authors would like to thank Des Stenhouse of Fitzroy Station for his assistance during the
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Farrow and Rob Roos who carried out the GPS surveys and to the drilling crew. The staff of
the Pastoral Branch of the Department of Lands and Housing also provided much assistance
in the form of pastoral maps, inspection reports and general advice.
Figure 5 Sketch showing improved size of grazing area due to piping away from a reliable bore or tank

Water Resources of Fitzroy
APPENDIX 1

STATION BORES

The following table is a list of bores drilled on the station together with selected details about their location, construction and groundwater intersections. More detailed information on many bores is available on request from the Water Resources Division in Darwin. Some of the headings on the table are explained below:

- **BORE RN** A registered number assigned to each bore by the Water Resources Division.

- **AMG EASTING** The east-west coordinates of the bore in metres. It refers to the grid lines on the map.

- **AMG NORTHING** The north-south coordinates of the bore in metres. It refers to the grid lines on the map.

- **DEPTH DRILLED** The total depth of the bore in metres below ground level.

- **CASING** The length of casing in the hole in metres and its internal diameter in millimetres.

- **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.

- **SWL** Standing water level, the depth below ground level that water rises to in the bore.

- **SLOTS** The depths in metres below ground level between which the bore casing is slotted.

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*Water Resources of Fitzroy*
## APPENDIX 1 STATION BORES FITZROY

<table>
<thead>
<tr>
<th>BORE NO.</th>
<th>BORE NAME</th>
<th>COMPLETION DATE</th>
<th>AMG EASTING</th>
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APPENDIX 2

CHEMICAL ANALYSES OF GROUNDWATERS

The following table lists chemical analyses performed on groundwaters on Fitzroy. See Appendix 3 for an explanation of the main factors which limit water use for stock and domestic consumption.

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<td>13</td>
<td>560</td>
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Water Resources of Fitzroy
APPENDIX 3

WATER QUALITY REQUIREMENTS FOR STOCK AND DOMESTIC WATER

1. WATER QUALITY STANDARDS FOR STOCK USE

<table>
<thead>
<tr>
<th>SUBSTANCE</th>
<th>GUIDELINE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH range</td>
<td>5.5 - 9.0</td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>8000 mg/L</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>Not more than 75% when total dissolved solids near limit.</td>
</tr>
<tr>
<td>Sulphate</td>
<td>2000 mg/L</td>
</tr>
<tr>
<td>Nitrate</td>
<td>400 mg/L</td>
</tr>
<tr>
<td>Fluoride</td>
<td>5.0 mg/L</td>
</tr>
<tr>
<td>Magnesium</td>
<td>300 mg/L</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>SUBSTANCE</th>
<th>GUIDELINE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH range</td>
<td>6.5 - 8.5*</td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>500 mg/L**</td>
</tr>
<tr>
<td>Chloride</td>
<td>250 mg/L**</td>
</tr>
<tr>
<td>Sulphate</td>
<td>250 mg/L**</td>
</tr>
<tr>
<td>Nitrate</td>
<td>50 mg/L***</td>
</tr>
<tr>
<td>Fluoride</td>
<td>1.5 mg/L</td>
</tr>
<tr>
<td>Hardness (as Calcium Carbonate)</td>
<td>200 mg/L*</td>
</tr>
<tr>
<td>Sodium</td>
<td>180 mg/L*</td>
</tr>
</tbody>
</table>

(* ) 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 50 mg/L is recommended for babies less than 3 months old, 100 mg/L is the guideline for older children and adults.

Water Resources of Fitzroy
The results of pumping tests carried out on bores on Fitzroy are summarised in the following table. More detailed information is available from the Water Resources Division in Darwin.

<table>
<thead>
<tr>
<th>RN</th>
<th>BORE NAME</th>
<th>PUMP RATE (L/s)</th>
<th>PUMP SETTING (m)</th>
<th>BORE DIAMETER (mm)</th>
<th>SWL (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25211</td>
<td>GiliwiOutstation</td>
<td>3.0</td>
<td>15</td>
<td>150</td>
<td>3.7</td>
</tr>
<tr>
<td>26746</td>
<td>Road bore</td>
<td>0.2</td>
<td>60</td>
<td>148</td>
<td>9.4</td>
</tr>
<tr>
<td>27083</td>
<td>Road bore</td>
<td>1.0</td>
<td>18</td>
<td>152.4</td>
<td>6.9</td>
</tr>
<tr>
<td>27084</td>
<td>Road bore</td>
<td>2.5</td>
<td>50</td>
<td>152.4</td>
<td>6.4</td>
</tr>
</tbody>
</table>

**PUMP RATE**  
-The recommended pump rate in litres per second

**PUMP SETTING**  
-The recommended depth below ground level at which the pump intake should be set

**BORE DIAMETER**  
-The minimum internal bore diameter in millimetres

**SWL**  
-The standing water level in the bore, in metres below ground level, measured immediately prior to the test
APPENDIX 5

WATERHOLES AND DAMS

1. Turtle Lagoon:

Cattle water directly from this waterhole and it dries by end of September. Runoff calculations indicate that it should be able to water 350 head from April to September, on a daily basis with 90% reliability.

2. Kellog Paddock Excavated tank:

This is a drainage-line excavated tank with an inlet channel. It fills every year but generally dries by September. It should be able to water 100 head with 90% reliability from April to September.

3. Milton Paddock Dam:

This is a drainage-line excavated tank which holds water till July. It should be able to water 250 head on a daily basis, with 90% reliability, from April to July.

4. Milton Paddock Excavated tank:

This is a small and shallow drainage-line tank located in an erosion gully. It catches little of its own water but water is pumped into it from Victoria River on a regular basis, and serves 200 to 400 head of cattle.

5. Billycan Waterhole:

This waterhole is on Sandy Creek, and lasts till the end of September. It should be able to water 200 head on a daily basis, with 90% reliability.

6. Brownies Dam:

This is an off stream excavated tank near Brownies Creek. It fills every year and dries by September. Some 200 head of cattle can be supplied on a daily basis from April to August with 90% reliability.

7. Brumby Dam:

The tank fills every year and dries by August. It leaks because it has been partly dug on porous dolomitic silstone. It is not used at present.

Water Resources of Fitzroy
APPENDIX 6

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 very useful booklet entitled "Design and Construction of Small Earth Dams" (Nelson, 1985, Inkarta Press, Melbourne). 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 have leakage problems
- show if there is any impermeable and soft rock present, such asrippable shale
- 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 onstream 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 subsurface 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 6). 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 of the plains country the watertable will be deeper than the proposed 3 to 3.5 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:

1. 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 and maintaining it at this level by addition of water.

2. The test involves maintaining this water level (0.5 metres below ground level). The amount of water added to keep the water level is recorded. Continue the test for one day.

Water Resources of Fitzroy
Figure 6 Test hole plan for an excavated tank

Water Resources of Fitzroy
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 area should be considered as doubtful and should only be accepted with professional advice. 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 which may range 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 the Land Conservation Branch, Department of Lands Planning and Environment and these provide a very good indication of soil suitability. However simple field tests can give a good feel for the likely behaviour of the soils.

1. 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.

2. 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 1.25 ml 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.

3. 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 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 be necessary to abandon the proposed site.
CONSTRUCTION DETAILS OF EXCAVATED TANKS, TURKEY NESTS AND MODIFIED WATERHOLES

Assuming preliminary investigations (Appendix 6) have shown the suitability of a site for a specific structure then construction can begin. No matter how good the design, poor construction methods can lead to a less than perfect structure.

1. 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 its storage capacity. The bund should have a minimum berm width of 5 metres (Figure 4). Topsoil with potential for leakage must be removed down to an impervious layer before the bund is built, and compaction should be undertaken using the available machinery. The ideal time to achieve optimum compaction is early in the Dry 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. For offstream excavated tanks catch drains can be constructed, eg. using a tilted grader blade, to direct an increased volume 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 adequate although special attention should be paid to:

- removal of leaky topsoil from the base before construction;
- the selection of a non-dispersive soil construction material (Appendix 6);
- compaction at optimum moisture content. This can be achieved if construction is undertaken early in the Dry while soil is still moist. Every 100 mm layer of loose soil should be compacted.

Water Resources of Fitzroy
For three days water supply from a turkey nest the following dimensions are recommended:

<table>
<thead>
<tr>
<th>NUMBER OF CATTLE</th>
<th>INNER DIAMETER AT BASE (metres)</th>
<th>INNER DIAMETER AT TOP (metres)</th>
<th>HEIGHT (metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>6</td>
<td>13</td>
<td>1.1</td>
</tr>
<tr>
<td>500</td>
<td>8</td>
<td>16</td>
<td>1.5</td>
</tr>
</tbody>
</table>

These figures are based on sides with a 1 in 2.5 slope.
## APPENDIX 8

### GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AQUIFER</strong></td>
<td>A body of rock that is sufficiently permeable to conduct groundwater and to yield economically significant quantities to bores and springs.</td>
</tr>
<tr>
<td><strong>BATTER</strong></td>
<td>Slope expressed as a ratio of horizontal to vertical distance.</td>
</tr>
<tr>
<td><strong>BERM</strong></td>
<td>Flat area between excavated area of tank and bund.</td>
</tr>
<tr>
<td><strong>BORE</strong></td>
<td>Small diameter hole constructed with a drilling rig, and down which a pump is lowered to extract groundwater.</td>
</tr>
<tr>
<td><strong>BUND</strong></td>
<td>Bank, constructed of compacted fill, used to contain water.</td>
</tr>
<tr>
<td><strong>DEMAND</strong></td>
<td>The volumetric flow rate required for stock watering, therefore the rate at which water would be supplied if available.</td>
</tr>
<tr>
<td><strong>DRAINAGE -LINE TANK</strong></td>
<td>Excavated tank built in an area which does not have a defined creek.</td>
</tr>
<tr>
<td><strong>GROUNDWATER</strong></td>
<td>Water contained in rock below the water table.</td>
</tr>
<tr>
<td><strong>OFFSTREAM TANK</strong></td>
<td>Excavated tanks built near creeks, and connected to the creek by a channel to tap the creek flow.</td>
</tr>
<tr>
<td><strong>ONSTREAM TANK</strong></td>
<td>Excavated tanks built across a well defined stream.</td>
</tr>
<tr>
<td><strong>RELIABILITY</strong></td>
<td>The frequency at which a tank would be able to supply the annual stock water demand, eg. 90% reliability means that the tank should be able to supply annual stock demand for on average every nine years out of ten.</td>
</tr>
</tbody>
</table>

*Water Resources of Fitzroy*
**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.

**WATERTABLE**  
The surface resulting when the standing water levels in adjacent bores in the same aquifer are connected.

*Water Resources of Fitzroy*