Assessment of Groundwater Resources in the Western Davenport Plains Water Control District

E204629
August 2009
## Document information

<table>
<thead>
<tr>
<th>Title</th>
<th>Assessment of Groundwater Resources in the Western Davenport Plains Water Control District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client organisation</td>
<td>Department of Natural Resources, Environment The Arts and Sports</td>
</tr>
<tr>
<td>Client contact</td>
<td>Anne Pye</td>
</tr>
<tr>
<td>Document number</td>
<td>E204629</td>
</tr>
<tr>
<td>Project manager</td>
<td>Eric Rooke</td>
</tr>
<tr>
<td>Project reference</td>
<td></td>
</tr>
</tbody>
</table>

## Revision history

### Revision 0

<table>
<thead>
<tr>
<th>Revision description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepared by</td>
<td>Prepared by</td>
</tr>
<tr>
<td>Reviewed by</td>
<td>Reviewed by</td>
</tr>
<tr>
<td>Approved by</td>
<td>Approved by</td>
</tr>
<tr>
<td>Distributed to</td>
<td>Anne Pye</td>
</tr>
</tbody>
</table>
Contents

1. Scope of Work 7
   1.1 Preamble 7
   1.2 The Study 10

2. Physiography and Rainfall 11

3. Geology 18
   3.1 Introduction 18
   3.2 The Lander Trough 18
   3.3 Wiso Basin (BMR, 1980), Bonney Well (SF53-2) and northern Barrow Creek (SF53-6) 1:250,000 Geological Map sheets 25
   3.4 Georgina Basin and Barrow Creek (SF53-6) 1:250,000 Geological Map sheet 26

4. Water Resources 28
   4.1 Groundwater Investigations Timeline 28
   4.2 Literature Review 29
   4.3 Groundwater Use 46
   4.4 Water Bores 46

5. Surface Water Hydrology 50
   5.1 The Drainage System 50
   5.2 Wetlands 51
   5.3 Davenport Murchison Ranges Bioregion 53
   5.4 Tanami bioregion 53
   5.5 The Wiso Basin 53
   5.6 Possible Groundwater Dependent Ecosystems 54
     5.6.1 Thring Swamp 54
     5.6.2 Piggery Bore "swamp" 55
   5.7 Catchment Yield 55

6. Hydrogeology 57
   6.1 Introduction 57
   6.2 Aquifers 57
   6.3 Alluvial Aquifers 59
   6.4 Cainozoic Aquifers 59
   6.5 Cambrian Sedimentary Aquifers 59
   6.6 Groundwater Quality 61
     6.6.1 Aquifer Storage 62
     6.6.2 Aquifer Throughflow 62
     6.6.3 Recharge 63
     6.6.4 Discharge 63
     6.6.5 Other Aquifers 64

7. Water Resource Assessment Zones 67
   7.1 NRETA's (2007C) WRAZs 67
7.2 Revised WRAZs and Groundwater Storage Volumes

8. Conclusions
   8.1 Current and future Water Use
   8.2 Aquifer Recharge
   8.3 Aquifer Throughflow
   8.4 Aquifer Storage
   8.5 Surface Water Yields
   8.6 Water Dependent Ecosystems

9. Recommendations
   9.1 Water Balance
   9.2 Groundwater Monitoring
   9.3 Aquifer Yields
   9.4 Aquifer Correlation
   9.5 Surface Water Yields

10. References
Appendices

A Water Planning Policy
B Remotely-sensed Imagery
C Hydrochemical Facies

Annexure

List of figures

Figure 1-1 Water Control District and Surface Water Boundaries 8
Figure 1-2 Tenure and Water Bore Locations 9
Figure 2-1 Topography and Ephemeral Swamps and Pans 12
Figure 2-2 Rainfall graphs for Wycliffe Well (BoM DR 15550) 14
Figure 2-3 Rainfall graphs for Alekarenge (BoM DR 15502) 15
Figure 2-4 Rainfall graphs for Barrow Creek (BoM DR 15525) 16
Figure 2-5 Evaporation graphs for Tennant Creek Airport (BoM DE 15135) 17
Figure 3-1 Surface Water Boundaries & 1:250k Map Sheets & Monitoring Bores 20
Figure 3-2 Basins and Bores - with RN number 23
Figure 3-3 Aquifer Systems and Simplified Geology 24
Figure 4-1 Water Bore Drilling History (No. of Bores versus Decadal Years) in the WDP 28
Figure 4-2 Total bore depth (m bg1) vs. No. of bores drilled in the WDP 47
Figure 4-3 Bore Status by Screened Aquifer vs. No. of Bores Drilled 47
Figure 4-4 SWL vs. No. of Bores 48
Figure 6-1 Schematic Hydrogeological Section across WDP 65
Figure 6-2 Block diagram 66
Figure 7-1 Water Resource Assessment Zones and Simplified Geology 73

List of tables

Table 2-1 Western Davenport Plains – Physiographic Description 13
Table 3-1 Western Davenport Plains – Geology 21
Table 3-2 Neighbouring Basin Correlation of Formations (after Wyche et al., 1987) 25
Table 4-1 Western Davenport Plains – Water Resources 45
Table 5-1 Wiso Basin - Summary statistics (extracted form Table 8 of Duguid, et al. (2005) 50
Table 6-1 Hydrostratigraphy 57
Table 6-2 Regional interpretation of geological depths from bores drilled for Western Davenport Plains Assessment and Alekarenge PMG Farm (reproduced from Sumner, 2008 [Table 2]). 60
Table 7-1 Description of Water Resource Assessment Zones (after NRETA,2007C) 68
Table 7-2 Revised Description of Water Resource Assessment Zones 72
Table 7-3 Calculation of order of magnitude Storage Volumes of Groundwater available for Allocation 74
1. Scope of Work

1.1 Preamble

Under section 22 of the Water Act the Minister may declare a part of the Northern Territory (NT) to be a Water Control District (WCD). On 24th October 2007 the Western Davenport Plains Water Control District was officially gazetted. Appendix A provides a background of water policy and planning aspects.

A Water Allocation Planning (WAP) process is commencing for the Western Davenport Plains (WDP) WCD (see Figure 1-1 for boundary of the WCD). The WAP is expected to use a sound scientific basis to make water allocations for non-consumptive use including environmental and cultural values, with allocations then to be made subsequently for consumptive use within the remaining available water resources, and is expected to reflect the allocation framework policy of NRETAS. In the Arid Zone in relation to groundwater this policy dictates that total extraction over at least a century should not exceed 80% of total aquifer storage and there are to be no deleterious impacts on groundwater dependent ecosystems (GDEs). The policy also states that extraction for consumptive use from any river in the Arid Zone shall not exceed 5% of flow at any time in any part of the river.

The WDP is situated about 350 km N of Alice Springs and is bisected by the Stuart Highway (see Figure 1-1 inset). It currently has a population of about 550 including a large Aboriginal community at Alekarenge (aka Ali Curung). Land use across the plains is mainly cattle grazing on the pastoral leases of Singleton, Murray Downs and Neutral Junction. However, there are some expanding water consumptive industries, namely horticultural enterprises being developed by Centrefarm on Aboriginal land and on at least one of the pastoral holdings by the station owner. Land Tenure is shown on Figure 1-2.

The area has been surveyed for wetlands but insufficient studies have been done on individual GDEs. Some wetlands which have been identified as GDEs, such as Thring Swamp may, in fact, be more surface water dependent given the presence of underlying clay layers which may isolate such ‘swamps’ from the aquifers below.

The cultural values of the WDP are also yet to be identified through the community consultation involved in the planning process.
Extensive work has been done by the Northern Territory Department of Natural Resources, Environment, The Arts and Sport (NRETAS) on various areas within the WDP WCD, including a technical and non-technical overview of the land and water resources of the region (NRETA, 200C). However, most of that work has not related to the whole declared WCD, and it is important that the results of these pre-existing studies and investigation work are collated in a logical and independent manner, which will provide a scientific basis for the decisions to be encapsulated in the forthcoming WAP. The WAP should then provide the framework for an environmentally sustainable water extraction regime.

1.2 The Study

Hydro Tasmania Consulting (HTC) was commissioned by NRETAS to undertake a scientific appraisal of the Western Davenport Ranges Water Resources Assessment Project. The scope of work for this commission follows:

**TASK 1**: undertake a desktop analysis and literature review in order to make a meaningful and accurate assessment of the groundwater balance, and of the water resources which can be identified as available for allocation in a forthcoming Water Allocation Plan (WAP) for the Western Davenport Plains (WDP).

(Relevant data produced to include digital data in ‘Arc’ format to allow import of relevant mapping layers to GIS for report presentation).

**TASK 2**: make an accurate assessment of recharge, water quality, regional water throughflow, and aquifer storage broken down into water resource assessment zones (WRAZs) based on hydrogeological boundaries, in order to formulate the sustainable yield of the catchment with some reference to the potential effects to estimated recharge under various climate change scenarios.

The resulting report should inform NRETAS on a sustainable water extraction regime from a hydrogeological perspective that can then be used in tandem with community consultation to fully consider the social, cultural and economic consequences associated with all aspects of the WAP.
2. Physiography and Rainfall

The Davenport Ranges and the adjacent Murchison Ranges form the second largest range system in the arid NT, based on area (not elevation). This broad series of low ranges has a predominant height of 500 - 600 m AHD but rarely exceed 200 m above the surrounding plain (http://www.nt.gov.au/nreta/wildlife/nature/pdf/aridwetlands/bioregion.pdf).

DNRETA (2007C) describes the physiography and land systems. Table 2-1 distils this information. Figure 2-1 is a digital elevation map (AUSLIG Geodata 9 second DEM) with drainage including surface water superimposed.
### Table 2-1
Western Davenport Plains – Physiographic Description

<table>
<thead>
<tr>
<th>Regional location &amp; area / dimensions</th>
<th>Description / Land System</th>
<th>Soils</th>
<th>Settlement / Infrastructure</th>
<th>Land use / Industry Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 km S of Tennant Ck. Barrow Ck Telegraph Stn is 50 km SW of Plains 9,290 km² (7,770 km² sand plains + 1,500 km² wooded alluvial floodout, swamps and clay pans). Covers ~ 10% of 100,000 km², Davenport Region. Broad, flat valley bearing NW 60 km wide by 180 km long between Davenport Range to NE &amp; Osborne, Watt and Spring Ranges to SW. Davenport, Watt and Spring Ranges rise ~ 250 m &amp; Osborne Range, rises to ~ 240 m above Plains.</td>
<td>Part of Davenport Murchison Range bioregion (ANRA, 2008): network of waterholes in Davenport Ranges contains a rich fish fauna, a high plant diversity &amp; endemic &amp; rare plant species. Singleton 'Land System': 5,000 km²; flat or gently undulating plain; intermittent low dune fields and sand plain landforms. Contains alluvial floodout country, ephemeral swamps &amp; clay pans, &amp; chain of rocky ranges. Lightly wooded (low open Eucalypt woodland &amp; acacia sparse shrub-land) &amp; understorey of hummock (Spinifex) grassland on red aeolian sand, with series of large alluvial flood outs and smaller areas of colluvial foot slopes adjacent to ranges.</td>
<td>Soils of bioregion: red earths, red sandy loams; red earthy sands with a gravel or stony crust on lateritic rises in NW.</td>
<td>550 population. Stuart Hwy. bisects the Plains. Crown Land: 3 pastoral leases; Murray Downs, Singleton &amp; Neutral Junction cattle stations. Aboriginal land incl. Warrabri ALT (440 km²) 30 km SE of Wycliffe Well Road-house. Adjacent Hwy. is Adelaide Darwin railway; W of Hwy. is LNG Palm Valley Darwin pipeline. Aboriginal town of Alekarenge (430 persons plus transient 100) &amp; Imangera Aboriginal community.</td>
<td>Potential for horticulture - high value out-of-season crops due to suitable water resources, soils &amp; climate. 20 potential horticultural development locations identified. Area on Warrabri ALT, W of Alekarenge leased to Alekarenge Horticulture Ltd - contracted Centrefarm Aboriginal Horticulture Ltd to establish a 200 ha commercial farm (melons &amp; pomegranates). Old gold mines in the ranges. Mining exploration areas, oil and gas exploration areas. Low stocking rates (order of 5,000 head cattle) on 3 pastoral leases. Proposed Davenport-Murchison National Park 60 km E of Wycliffe Well (on W boundary of Elkedra Station).</td>
</tr>
</tbody>
</table>
The following rainfall graphs appear as Figure 2-2, Figure 2-3 and Figure 2-4.
Figure 2-3
Rainfall graphs for Alekarenge (BoM DR 15502)
Evaporation data is only available for Tennant Creek some 130 km N of Wycliffe Well (see Figure 2-5)
Figure 2-5
Evaporation graphs for Tennant Creek Airport (BoM DE 15135)
3. **Geology**

3.1 **Introduction**

Figure 3-1 shows the coverage of 1:250,000 geological (and topographic) map-sheets across the study region.

Table 3-1 summarises geological provinces and is taken from Barrow Creek and Bonney Well 1:250,000 geology - explanatory notes and the Wiso Basin 1:1,000,000 geology map-sheet.

Figure 3-2 depicts the geological basins; that define the rocks fundamentally belonging to igneous / metamorphic as blocks or inliers; igneous / metamorphic/sedimentary as geosynclines, and sedimentary as basins.

Figure 3-3 presents a simplified geological map; with geological formations classified into:

- Cainozoic sediments;
- Wiso Basin sequence formations;
- Georgina Basin sequence formations;
- Barrow Creek complex (granite rocks of the northern Arunta Block);
- Hatches Creek Group (Davenport Geosyncline);
- Undivided Granite/Gneiss (northern Arunta Block);
- Arunta Inlier (metamorphic rocks of the northern Arunta Block); and,
- Warramunga Group (Tennant Creek Block).

3.2 **The Lander Trough**

The Davenport Plains overlie the Lander Trough (40 km wide trending NW/SE with up to 1 km thickness of sedimentary rocks); a fault-controlled geological structure which links the NW end of the Georgina Basin with the SE end of the Wiso Basin. The NTGS considers that the transition beds between these two Cambrian-aged basins commence at about the Alekarenge access road (NRETA, 2007C) (i.e. the Warrabri ALT / Wycliffe Well area).

On its southern boundary (of the Wiso Basin) the trough is faulted against the Arunta Block. A series of parallel ESE faults (throw of > 2 km) displace sedimentary rocks against the Arunta Block. Upper Palaeozoic sandstone overlies these rocks and transgresses this fault. It is covered
with a veneer of Cainozoic sediments that in much of the study region (especially on the WDP proper) conceal underlying Formations.
### Table 3-1
Western Davenport Plains – Geology

<table>
<thead>
<tr>
<th>Formation Name / Lithology</th>
<th>Province</th>
<th>Location</th>
<th>Known Max thickness (m)</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary: aeolian, alluvial and colluvial sediments &amp; chemical rocks</td>
<td>Georgina Basin</td>
<td>In some locations overlie Cambrian aged sandstones, siltstones and dolomites of Georgina &amp; Wiso Basins.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quaternary and Tertiary: siltstones &amp; sandstones. Calcrete, often partly silicified with ferricrete &amp; silcrete / chalcedony</td>
<td>Georgina Basin</td>
<td>The Plains and much of the surface water catchment area is unconformably overlain by Palaeozoic and Proterozoic Rock. Palaeozoic, Cambrian Aged rocks of Georgina and Wiso sedimentary basins occur below the Cainozoic sediments through the central sector of The Plains. Maximum known thickness of 96 m infill Lander Trough and wedge out to NE over Hatches Creek Group at foothills of Davenport Ranges.</td>
<td>96 &amp; 210</td>
<td>Bore Grg 18 &amp; RN 444</td>
</tr>
<tr>
<td>Lake Surprise Sandstone</td>
<td>Wiso Basin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dulcie Sandstone: Sandstone</td>
<td>Georgina Basin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomahawk Beds: Sandstone; siltstone inter-beds</td>
<td>Georgina Basin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrinthurunga Formation: Dolostone &amp; dolomitic sandstone</td>
<td>Georgina Basin</td>
<td></td>
<td>235 &amp; 975</td>
<td>Bore BC1 &amp; ‘types section’</td>
</tr>
<tr>
<td>Chabalowe Formation: Sandstone; dolostone &amp; siltstone inter-beds</td>
<td>Georgina Basin</td>
<td></td>
<td>160 &amp; 223</td>
<td>Bore BC5 &amp; ELK7</td>
</tr>
<tr>
<td>Octy Formation: Sandstone (feldspathic); minor siltstone &amp; conglomerate</td>
<td>Georgina Basin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andagera (incl. Central Mt. Stuart) Formation: Sandstone (feldspathic); siltstone inter-beds &amp; conglomerate</td>
<td>Georgina &amp; Wiso Basin</td>
<td></td>
<td>30</td>
<td>?</td>
</tr>
<tr>
<td>Ali-Curung granite, etc.: granite, schist, some gneiss (Mylonite)</td>
<td>Arunta Block (northern)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formation Name / Lithology</td>
<td>Province</td>
<td>Location</td>
<td>Known Max thickness (m)</td>
<td>location</td>
</tr>
<tr>
<td>----------------------------</td>
<td>----------</td>
<td>----------</td>
<td>-------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Warramunga Formation Siltstones, greywacke</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Western Davenport Plains - Figure 3-3
Aquifer Systems and Simplified Geology

Vector Legend
- Water Control District
- Aquifer Systems

Geological Legend
- Cambrian Sediments
- West Coast Seawater
- Orange Spots
- Dornella Creek Group
- Multicolored Granite Group
- Warringeri Group
- Neutral Creek Group
- Lake Lumsden Group
- Warringeri Group
- Moke Mountain Group

Projection: Transverse Mercator
Datum: GDA94
Scale: 1:700,000

Prepared by: A. Czeczuk
Verified by: Mark Vanderschoot
Approved by: Eric Pickle

Note: Cambrian local & regional scale aquifers - porous & fractured rock at regional contact; aquifers - cover much of Cambrian aquifers & granite aquifers.
Table 3-2 correlates the formations between the sedimentary geological basins.

### Table 3-2

<table>
<thead>
<tr>
<th>Georgina Basin</th>
<th>Eastern Georgina Basin</th>
<th>Wiso Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dulcie Sandstone</td>
<td>Craven Peak Beds</td>
<td>Lake Surprise Sandstone</td>
</tr>
<tr>
<td>Tomahawk Beds</td>
<td>Ninmaroo Formation</td>
<td>-</td>
</tr>
<tr>
<td>Arrinhrungua Formation</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chabalowe Formation</td>
<td>? Arthur Creek &amp; Gum Ridge Formation</td>
<td>? Lothari Hill Sandstone</td>
</tr>
<tr>
<td>Andagera Formation</td>
<td>Mount Baldwin Formation</td>
<td>-</td>
</tr>
<tr>
<td>Kurinelli Sandstone</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### 3.3 Wiso Basin (BMR, 1980), Bonney Well (SF53-2) and northern Barrow Creek (SF53-6) 1:250,000 Geological Map sheets

The WCD occupies the far SE corner of the Wiso special map-sheet and the western third of the Bonney Well 1:250,000) geology map sheet.

The Wiso Basin, a structural down-warp in the central west part of the NT, contains a sequence of near-horizontal Middle Cambrian to ?Upper Palaeozoic sedimentary rocks. It is probably continuous with the Georgina Basin to the SE. Cambrian to Ordovician sediments includes five mapped rock units (including the Lake Surprise Sandstone that lies in the Lander Trough as the uppermost sequence) with disconformities and unconformities.

According to NRETA’s records (A. Pye, pers. comm.), the only bores drilled in the far W of WCD are located along the Hanson River, as part of a 1977 BMR investigation (reported in BMR, 1980).

A seismic survey (Hunting Geophysics Pty Ltd, 1967) conducted over the Lander Trough in the eastern Lander River Map-sheet locality mapped several horizons dipping southwards and faulted against the Arunta Block.

The Lake Surprise Sandstone (a potentially important, but little-exploited aquifer) is horizontal, but fractured and faulted in places, and thins to the NW, and is poorly exposed being covered by Cainozoic sediments. Its type section is described from BMR Lander River 1 (3-62 m bgl) situated on E edge of the Lander River map-sheet. It is described as a very fine-medium sandstone, well rounded and sorted (also bimodally sorted). Hanson River seismic survey (1967)
indicates a maximum thickness of ~ 150 m. It transgresses across the faulted margin of the Arunta Block in the S.

BMR Bonney Well 3 penetrated ?Cainozoic sandstone overlying Arunta Block rocks indicating that Cainozoic sediments extend across the major fault on the southern margin of the Lander Trough in the SW Bonney Well map-sheet.

The Proterozoic Hatches Creek Group has a magnetic signature (refer Appendix B) especially in the E part, where there are basaltic lavas. A magnetic zone extending from Bonney well into Lander River map-sheet may represent a westward extension of the Hatches Creek Group. The Hatches Creek Group outcrop to the E and S of Murray Downs homestead and N of Alekarenge (far N of Barrow Creek map-sheet).

Some shallow magnetic anomalies may indicate Antrim Plateau Volcanics form the basement of the Wiso Basin.

3.4 Georgina Basin and Barrow Creek (SF53-6) 1:250,000 Geological Map sheet

Just W of NTGS stratigraphic bore, ‘BC3’ is Taylor fault. Taylor fault defines the western boundary of the Lander Trough.

The structure of the Cambrian-aged rock of the Georgina Basin below the WDP is known to be complex due to the presence of a series of faults, inferred from airborne geophysical survey and limited NTGS stratigraphic drilling.

Adjacent Stuart Hwy., bore ‘BC3’’s geology is recorded as:

- 56 m Cz sediments (53 m Tertiary);
- 55 - 175 m Arrinthrunga;
- 170 - >385 m Chabalowe Fm

Stratigraphic bore ‘BC5’, adjacent Stuart Hwy; 20 km N of ‘BC3’:

- 63 m Cz sediments (58 m Tertiary);
- 63 - 169 m Arrinthrunga Fm.;
- 169 - 328 m Chabalowe Fm.;
- 328 - >339 m Granite.

BC1, 8 km ENE of BC3 is underlain by the Hatches Creek Group at 315 m.
BC2 (near site of RN 1259, Bluebush Bore), a further 17 km ENE of BC1 is underlain by granite at 59 m with no Cambrian present.

From the 2001 drilling (Paul, 2002) and previous drilling the generalised geology at Bluebush bore (RN 1259) is:

- 0 - 45 m Cainozoic;
- 45- 100 m Chabalowe Formation

The strata is dipping slightly to the N, and at RN 17593 (ESE of Alekarenge) the geology is:

- 0 - 36 m Cainozoic;
- 36 - 100 m Arrinthrunga Formation

Further again to the N, around RN 10841 (Conglomerate bore), the Cambrian sediments appear to thin out and Proterozoic Hatches Creek Group underlie the Cainozoic sediments.

Rocks of the Arunta Block are magnetic; e.g. in the NW corner of the Barrow Creek map-sheet (see Figure B-2).
4. Water Resources

4.1 Groundwater Investigations Timeline

Figure 4-1 summarises the history of bore drilling activity in the WDP study region.

Salient comments based on this graph and the literature review (see Section 4.2) follows:

- 1920s: Water well drilling commenced with well sinking along the main N-S stock route;
- 1940s: World War 2 saw the drilling of N-S ‘road bores’ for provision of water to convoys and for road maintenance;
- 1950s: expansion in head of cattle and concomitant increase in stock bores sunk;
- 1960’s: provision and assistance with dams and production bores for town water supply and horticulture at Alekarenge (Water Resources Branch [WRB] drilled and pump tested agricultural production bores for a piggery, stock water, a market garden and fodder crops),
Wycliffe Well (production bores and a dam used to supply irrigation water to a market garden) and Murray Downs Homestead (advice on production bores and a dam used to supply irrigation water for fodder crops and homestead market garden and trial crops / fruit trees);

- Late 1960’s: WRB drilled several investigation bores on Warrabri ALT and adjacent areas to assess regional aquifer potential for large scale horticulture (see Verhoeven, Read, 1978);

- Early 1990’s: assessment for potential large scale horticultural development (see AGC, Carosone, 1989 and 1990). 3 areas identified for field investigations “Western Davenport Region Prospective Horticultural Areas”. Investigation drilling program was undertaken in ‘Area 1’, mainly NE of the WDP aquifers on parts of Singleton Station. A few bores were drilled in ‘Area 2 (Blue Bush Bore area on Murray Downs Station). The bores were drilled 40 km E of Stuart Highway;

- 2000: NRETA undertook a horticultural land capability survey at a scale of 1: 25,000 of an area on proposed excision from Singleton Station for horticultural development adjacent to the Stuart Highway, S of Hurst Creek where previous WRB investigations had proven the existence of high yielding aquifers;

- 2001: NRETA undertook reconnaissance horticultural land capability survey of a large area on Singleton Station and Murray Downs. The area included ‘Areas 1 and 2’ previously identified by Carosone, (1989 and 1990) as having best prospects for horticultural water with a salinity, (total dissolved solids), TDS < 1,000 mg/L;

- Approx. 2001 -2003: a line of bores were sunk along the proposed route of the Alice Springs – Darwin railway to provide construction water;

- Post 2001: groundwater investigations by NRETA to locate potential borefield areas for horticultural development and expand the groundwater monitoring bore network (including drilling and pump testing) at several locations on Murray Downs and Warrabri ALT;

- 2006-7: NRETA drilled two investigation bores (3 monitoring bores) near Thring Swamp, to E of Wycliffe Well (airlift 30 – 40 L/s of good to fair quality groundwater).

- 2008: (NRETA, 2008B) drilling investigation at Neutral Junction to address dearth of information on groundwater availability and quality W of Stuart Highway.

4.2 Literature Review

The following provides salient, dot-point format findings / conclusions from reports reviewed (see Section 10 for list of references).
Verhoeven and Read, 1978

- report pertains to Warrabri region;
- Cainozoic and Cambrian aquifers contain some carbonate, but are mainly sandstone and siltstone units with variable clay content;
- Aquifers are semi-confined;
- Regional groundwater gradient slopes NW;
- Recharge is local infiltration plus runoff from Davenport, ‘Froiland’ and Osborne Ranges;
- Cambrian and Proterozoic aquifers are recharged (by leakage) from the Cainozoic aquifers;
- Groundwater storage volume of Cainozoic sediments at year, 1975 = 15,000 GL; based on following assumptions;
  - an area delimited by the distance between Osborne and Davenport Ranges, and 28 km NW of Alekarenge to Wycliffe Well, and 28 km SE to Chabalowe Bore;
  - regional depth to standing water level (SWL) = 10 m bgl;
  - regional depth to top of Cainozoic aquifer = 20 m bgl;
  - saturated sediments porosity = 0.3;
  - assumption that 50% of volume of Cainozoic sediments are impermeable; and,
  - assuming semi-confined storage coefficient, $S_c = 1 \times 10^{-3}$
- Between November 1975 and June 1978, 17 GL of water was added to this storage following year 1974 recharge event:
  - net regional rise in SWL was 5 m;
  - (This represents a rainfall input for the 30 month period of 5 mm depth over the area during a period in which the rainfall exceeded 1,500 mm. This gives a recharge coefficient of 0.003).
- No estimate made of groundwater storage volume of Cambrian and Proterozoic aquifers;
- Estimated throughflow at Alekarenge = 550 kL/day/km width of aquifer for the combined Cainozoic and Cambrian aquifers; based on;
  - hydraulic gradient, $i = 0.001$ for Cainozoic and Cambrian aquifers;
  - average transmissivity, $T = 50$ m$^2$/day for Cainozoic aquifer;
  - average $T = 500$ m$^2$/day for Cambrian aquifer;
Bore RN 1178 (partially penetrates Cambrian aquifer); $T = 700 \text{ m}^2/\text{day}$ (based on a ‘long term’ pump test);

- Water consumption (at 1979) $\approx 430 \text{ kL/day}$. ‘Design and peak requirements’ $= 860$ and $1,300 \text{ kL/day}$, respectively;

- Nitrate in groundwater increased in direction of throughflow;

- Up to 1978, nitrate in water from Alekarene town supply bores increased, in some cases doubling; believed to be pollution of Cainozoic aquifers within Alekarene and leaching from unsaturated zone resulting from irrigation returns from adjacent market gardens;

- Fluoride in groundwater increased in direction of throughflow. (Provenance as fluorspar in sedimentary rocks and cryolite in igneous rock);

- Fluoride concentrations in the Cambrian and Proterozoic aquifers $= 0.5$ to $4.2 \text{ mg/L}$; elevated concentrations were located in aquifers underlying Alekarene; average concentration E of Alekarene $= 1 \text{ mg/L}$.

**Carosone, 1990**

- Assessed horticultural development potential of 3 areas of WDP;

- Investigated 2 of the recommended areas. (Most of the assessment was undertaken over Singleton Station, E of Stuart Highway within aquifers of WDP. Some fieldwork was carried out on Murray Downs between Chabalowe and Bluebush Bores);

- Concluded that groundwater resources exist which are capable of sustaining large scale horticultural projects;

- Recommended that investigation drilling programs be carried at the most prospective sites identified below:
  - between Stuart Highway and Singleton homestead near the floodout of Hurst Creek adjacent to bore, RN 15578;
  - 3 km S of Hurst Creek and the Homestead adjacent RN 15586;
  - adjacent to Wycliffe Creek near RN 15587; and,
  - 1 km E of Stuart Highway between Wauchope Creek and Hurst Creek adjacent RN 15579.

- Cainozoic calcrete and sandstones both form good aquifers;
- Sandstones and siltstones commonly well cemented, often with kaolinitic matrix and have secondary permeability due to interconnected joints and fractures. Occasional layers of sandstone have primary permeability due to interconnected porosity and vughs; particularly ferruginized horizons;
- Although clay layers are present acting locally as confining beds, regionally all aquifers are interconnected and share a similar or common potentiometric surface;
- As aquifers are semi-unconfined and regionally interconnected, inter-aquifer leakage represents an important mode of recharge;
- Throughflow roughly parallels surface drainage; flow lines converge towards middle of the plain, then swing NW; i = 0.0005. Hydraulic gradient varies significantly over periods of months / years, after major recharge events.
- Local reversals of gradient and groundwater flow resulting from recharge mounds. In some locations - correlation between floodouts, ephemeral swamps and lakes, and these recharge mounds;
- At Alekarengge a sand aquifer occurs between 18 m and 24 m bgl. Where this is absent groundwater is obtained from calcrete at a similar depth. Bore RN 10744 ‘Warrabri production bore #7’ at Alekarengge can be pumped continuous rate =<30 L/s in a (?) silcrete/calcrete aquifer. At Wycliffe Well, calcrete aquifer yields 9 L/s, but usual yield is ~ 2 L/s.

‘Area 1’ field investigations findings:
- i = 0.0005 throughflow = 500 to 25,000 m3/d/km width of aquifer;
- T = 150 to 5,000 m2/d (short term pumping tests of a few bores),
- Regional T expected to be 1,000 to 5,000 m2/d;
- specific yield, Sy not determined as limited number of pump tests incorporating observation bores;
- Local aquifers storage volume = 750 – 2,500 GL; based on:
  - aquifer area of 500 km2 (area enclosed by 1,000 mg/L TDS contour);
  - aquifer is semi-confined;
  - Sy taken as 0.03 to 0.1;
  - mean aquifer thickness = 50 m with 1,000 mg/L TDS;
- gave a nominal borefield capacity of 1 GL/year;
50% of the 10 investigation bores showed increasing TDS with depth; 1 had no change; others improved TDS with depth;

- Proximity to creeks did not imply better recharge conditions and lower salinity groundwater;

- Hypothesised that structural geology influences groundwater quality;

- Hydrochemically closely grouped except in ‘Area 2’ investigation bore, located E of Bluebush Bore;

- Bore near Bluebush Bore shows relationship Mg>Ca>Na>Cl - indicates a dynamic regime with a recharge component;

- Relationship Na>Mg>Ca characteristic of seawater but also HCO3>S04 which indicates water in some dynamic phase;

- 2 bores between Wauchope and Hurst Creeks show more typical relationship, SO4>HCO3 indicating water in stasis (despite their location at foot of Davenport Ranges (cf likely recharge zone).

NRETA (R Paul), 2002 & 2005

- Aquifers were described in Georgina Basin sandstones (Chabalowe Formation), and limestones (Arrinthurunga Formation), and Tertiary sediments with and without chalcedony;

- Identified WRAZs to calculate storage and throughput;

- Estimate (total of 4 WRAZs in the plains was 1,900 – 13,170 ML/a throughput and 330 – 3,300 GL in storage;

- [Comment in NRETA (2007C) – assessment based on much lower aquifer parameters than that established by NRETA (2007A) – latter allowed for partial penetration of tested bores in calculating T];

- Identified recharge areas and noted they contained better salinity water.

- WDP TDS < 2,000 mg/L, and frequently < 1,500 mg/L;

- Paul (2005) extended known area of Cambrian aquifers with groundwater < 1,000 mg/L to 10 km to W of previous assessments;

- < 1000 mg/L TDS groundwater is located in aquifers along foothills of Davenport Range, and S of Murray Downs Homestead at Bluebush and Chabalowe Bores;

- Localised areas of higher TDS groundwater near Davenport Ranges (e.g. parts of Singleton) may be due to evaporites in rocks;
• Brackish to salty groundwater associated with Osborne, Crawford and Watt Ranges to SW. In this area salinity improves down-gradient with some lower TDS groundwater along Taylor River. Noted water quality distribution in this area is erratic; probably reflects rock-water interaction associated with underlying Arunta Complex;

• Hydrographs of Cainozoic and Palaeozoic aquifers show substantial SWL variations in response to above average rainfall periods;

• Years 1973-77 rainfall exceeded annual average (of 312 mm); (maximums of 953 mm at Barrow Creek in 1974 and 836 mm at Tennant Creek in 1977);

• Wycliffe Well and Alekarenge located along a line parallel to Davenport Ranges and along central drainage depression which continues to Green Swamp Well. At Wycliffe Well recorded SWL = 2.5 and 4.5 m and > 8 m at Alekarenge;

• Noted that areas around Bluebush and Chabalowe bores are subject to flooding and ponding;

• Alekarenge 1990 SWLs were still ~ 3.5 m above SWLs of 1966 - 1973, indicating a rate of decline of the potentiometric surface of approximately 0.4 m/year.

• Using hydraulic parameters identified for ‘Area 1, SWL rise corresponded to 240 - 800 mm of infiltration, or between 7 % and 22 % of rainfall.

• Concluded – significant recharge across the plains occurs only after rare substantial rainfall events – manifest in SWL hydrographs as a series of peaks probably every 20-30 years followed by slow decline with occasional minor peaks following greater than average rainfall events;

• For ‘Area 1’, using 500 km2 area with < 1,000 mg/L TDS, the 1973-77 event = 120 - 400 GL water added to aquifer storage.

NRETA (2006) (Bob Read)

• Tara is an excision on Neutral Junction Station, near Stuart Highway;

• Geology - Central Mount Stuart Formation and older, Arunta metamorphic and igneous rocks;

• Historically, many investigations around Tara have failed to find much potable water;

• Central Mount Stuart Formation contains moderate aquifers. It is flat-lying to gently dipping and occurs in down-faulted blocks;

• water supply – bore RNs 14833 and 16917 in the Central Mount Stuart Formation sandstone with interbedded siltstone;
- Tara’s water use only ~ 3 - 5 ML/a;
- No environmental use has been identified, though any River Red Gums on Donkey Creek would be evapo-transpiring some groundwater.
- RN 14833, T = 6 m²/day;
- Test pumping analysis indicates radial flow; surprising in view of failure of nearby bores to yield useful supplies of water.
- Cambrian age Neutral Junction and Octy Formations, and the Cainozoic units are above the water table;
- groundwaters from the Central Mount Stuart Formation indicate magnesium rich (cf dolomite); while ‘other waters’ (from older rocks?) are more calcium rich;
- attempt to correlate TDS versus rainfall in the previous 10 days, 30 days, 100 days and 1 year, without success;
- production bore would be recharged from flows in nearby Donkey Creek; no data for flow frequency (and duration), but it is ‘likely that flows would occur in most years, with no flow periods of 2 to 3 years being possible’.

**NRETA (2007A) (Peter Jolly)**

- Pertains to Warrabri/ Murray Downs/ Singleton area;
- Multiple aquifer system is extensive and complex;
- NRETA’s investigation bores cover discrete areas rather than uniformly spread across whole system;
- cost of undertaking detailed groundwater investigations of each aquifer across the whole WDP would be prohibitive;
- Aquifer thickness > 300 m in SW to 20 m at edge of Davenport Range – average of order of 150 m thick (‘refer NTGS cross section’).
- i = 0.0005 from Bluebush bore area to Wycliffe Well. Noted that hydraulic gradient from Bluebush Bore area slopes both ways (i.e. groundwater flows to NW and SE with similar gradients);
- T (test pumping using partially penetrating bores) = 150 - 5,000 m²/d. (Hence; full thickness) aquifer T estimate = 1,000 - 5,000 m²/d;
Throughflow from Bluebush Bore area to NW = (1,000 to 5,000) x 0.0005 x 40,000 m (aquifer width) = 20 - 100 ML/day = 7.3 to 36.5 GL/a.

Sy 0.03 (carbonate) to 0.07 (Cainozoic);

In 40 years since monitoring began, total of SWL rises due to recharge events = ~ 14 m. Most monitoring bores are relatively close to Davenport Range leading to an over-estimate of recharge; (hence) assume regional rise = ~ 7 m. Equates to annual recharge of 5 - 12 ML/km².

Aquifer area E of Stuart Highway underlying Warrabri, Singleton and Murray Downs = ~ 5000 km². Recharge should be order of 25 - 60 GL.

In 1990 annual recharge was estimated to be 6 to 40 GL for ‘Area 1’.

Recharge minus throughflow for whole area estimates = -11.5 to 52.7 GL

Area NW of Bluebush Bore, ET = say 1 mm/day; therefore be 0 - 150 km².

Approximate volume in storage = 150 x 5,000 x 10⁶ x 0.05 = 37,500 GL;

~ 10 % of this storage, say, 4,000 GL appears to contain water with < 1,000 mg/L TDS;

Carosone (1990) estimated volume of good quality water = ~ 1,500 - 5,000 GL (i.e. twice amount in Area 1);

Annual recharge estimate = 10 - 50 GL/a for aquifer system in Murray Downs/Alekarenge/Singleton area;

Evapotranspiration from swamps in area probably discharge most of this water;

Volume of good quality water in storage in the Murray Downs/Alekarenge/Singleton area order of 2,000 - 4,000 GL;

Bore monitoring network and spread of groundwater quality monitoring sites need to be expanded as per recommendations in Gilbert and Jolly (1990);

Need a numerical groundwater model to determine optimal placement of production bores and impact on groundwater dependent ecosystems;

(Ride’s additions to?) Jolly’s notes:

Numerical modelling should be undertaken in ~ 5 years time with input from monitoring data on SWLs and groundwater chemical quality changes following extraction of 4-5 GL/a.;

WLs in Wycliffe Swamp and SWLs in underlying aquifers need to be monitored in a specially constructed monitoring bore.
NRETA (2007C) (Graham Ride)

- sets out interpretations and assessments of both recent and earlier, land and water resource assessment technical reports, notes and maps;
- care is needed in extracting and comparing calculations and data from the various technical reports prepared over the past 20 years in that the analysis often refers to quite different areas or different natural resource parameters;
- “prepared key set of maps to meet water resource management and development needs as identified by the Controller of Water, landholders and agribusiness companies interested in establishing commercial farms in the region”. The sets are:
  - the ‘Water Resources of the Western Davenport Plains’; a set of 6, B1-sized, 1: 250 000 maps, and 2 large-scale, schematic hydrogeological cross-sections, July 2007.

These maps identify:

- WRAZs;
- catchment boundaries; and,
- other key water resource information including the potentiometric surface, direction of groundwater flow and groundwater chemical quality zones.

- presented tabulations of water resource assessment information; e.g. volumes of different quality groundwater in storage in WRAZs using parameters from Verhoeven and Read (1979), Paul (2003 and 2005) and NRETA (2007A).

- calculations are based on WRAZ boundaries determined from the hydrogeological characteristics of the aquifers, recharge zones and hydrological boundaries (area of each zone calculated from TDS contour map. Some of these totals are quoted from NRETA (2007C) in Section 6.6.1 and discussed and critically reviewed in that section.

- because of lack of bores between Stuart Highway and Paul’s (2005) investigation area, it is possible that the actual location of 1,000 mg/L TDS contour is further to the W

- some evidence that SWLs rises above ground level at Bluebush, Chabalowe Bores and possibly in other locations such as Thring Swamp; yet to be confirmed with properly constructed monitoring bores.

---

1 this paradigm is perpetuated through this consultancy, as the study boundary of the WCD is different (envelopes a larger area) than that used as a basis for NRETA’s (2007c) water resources assessment.
- Water quality areas based on TDS contours drawn from groundwater sampling analyses at May 2007.
- Calculation of water in storage volumes utilised estimated “low” SWLs above AHD based on NRETA monitoring program data.
- SWL fluctuations of 8 - 12 m are known in the Alekarenge area as a result of major recharge events and natural discharge.
- SWL fluctuations of ~ 3 m occur in Wycliffe Well area as a result of major recharge events and natural discharge.
- Extensive Cainozoic aquifers overlie Cambrian Aged sandstones and limestone within the main aquifer zone.
- Cainozoic aquifers are primarily Tertiary aged sands, gravels, calcrete, chalcedony and sandy clays (up to 95 m thick).
- Variable yields from Cainozoic aquifers within close proximity (2 - 30 L/s).
- Estimates of the volume of Cainozoic and Cambrian sediments within the Shirley, Chabalowe, Spinifex, Conglomerate WRAZs used estimated, average strata thicknesses.
- Above calculations use a conservative Cainozoic aquifer thickness (28-80 m).
- Cainozoic, Cambrian and Proterozoic Aged aquifers are interconnected on a regional basis; main aquifers are fractures but there are porous beds.
- In places Cambrian aged sediments are > 325 m thick. Above calculations assume 200 m thickness.
- Conglomerate Bore area has high yielding aquifers in the Proterozoic Andagera Formation.
- Best Cambrian yields to date are from Chabalowe formation sandstone; with reasonable yields from Arrinhrunga formation limestone.
- Spinifex and Conglomerate WRAZs mark the transition zone between the Georgina and Wiso Basins.
- Considerable faulting of the Cambrian formations evident from geophysical survey, this complicates the hydrogeology but has improved the storage.
- Sy values used in the calculations as identified by Jolly (NRETA 2007A).
Australian Groundwater Technologies (AGT, 2007A)

- AGT reviewed the hydrogeology of the Alekarene area and identified an area of land suitable to develop a water supply borefield for a horticultural farm;
- Pertinent recommendations were:
  - development of a borefield tapping the Chabalowe Formation aquifer;
  - the proposed borefield to be situated within a 5 km W – E by 2.5 km N – S block bounded by bores RNs 18000/18117 and 18001, adjacent to, and S of, the Stuart highway – Alekarene / Murray Downs homestead access road.

AGT, 2007B

Following from AGT (2007A), a detailed concept design for the proposed borefield was undertaken. Pertinent aspects from scope of work included estimating the water demand and the potential impacts arising from the proposed operational philosophy of the proposed borefield. A borefield numerical model and wider ‘environmental-impact’ model was set-up to investigate amongst other aspects, pumping interference impacts and possible impacts to other users including possible GDEs. Key, pertinent, findings were:

- projected irrigation water demands indicated that some 190 GL of groundwater would be extracted over some 45 years;
- based on the storage volume estimate in the Spinifex WRAZ (NRETA, 2007C) encompassing the proposed borefield site, the volume extracted would represent some 15% of total storage in low salinity (< 1,000mg/L TDS), Cambrian aquifers, and 3% in the total Cambrian aquifers;
- under the pumping regime envisaged (2008 - 2010) an average, instantaneous production of 80.5 L/s increasing to 145 L/s post-2011 (with various bore Nos. / configurations), the pumping cone of influence to the 5 m drawdown contour is 2.3 km;
- steady-state drawdown conditions quickly prevail, and the cone does not spread over many years due to good transmissivity of the aquifer and leakage to the Cambrian aquifer form overlying Cainozoic aquifer;
- with years of pumping because of leaky nature of aquifer, drawdown in Cambrian and Cainozoic is similar;
- radius of influence is predicted to extend to a radius of ~ 7.5 km after 43 years of production;
- drawdown is restricted to ~ 0.5 m in Cainozoic aquifer at Alekarene (closest third-party water supply) after 43 years of production;
all other users, chiefly Murray Downs and Singleton Stations and Wycliffe Roadhouse, are situated far beyond the radius of influence;

possible GDEs; chiefly Thring Swamp and Wycliffe Creek, are situated well beyond the radius of influence. Piggery Bore Swamp lies ~ 800 m E of the modelled zero drawdown contour and, on this basis, will be unaffected, too. The downstream outlet of Warrabri Swamp (at bore, RN 2881) lies at about the 2 m drawdown contour;

with 50 years of pumping, the model indicates only minor ingress of slightly more saline groundwater (commencing after some 20 years of pumping).

NRETA (2008A) (Jon Sumner)

Groundwater assessment of Iliyarne ALT (May 2008) to assist with developing WDP WRAP, and to assess potential for horticultural development;

3 investigation bores, RNs 18241 & 2, and 18338, drilled in 2008, ~ 10 km apart;

This report reported the 4th, and most westerly bore, in a series of investigation bores drilled in the area;

NTGS modelling indicates Hatches Creek Group basement occurs at approximately 240 m bgl.

Bore RN 18401, drilled TD 225 m, encountered Cainozoic, Arrinthrunga and Chabalowe Formations; did not penetrate basement;

Completed as a monitoring bore;

Stratigraphic hole, ‘BC-5’, situated 15 km S of RN 18401;

Chabalowe Formation aquifer intersected 160 - 200 m ; 1,100 mg/L TDS; SWLs = ~ 5 m bgl;

Magnetic modelling of Hatches Creek Group (NTGS) indicates basement high due to block faulting commencing 4 km E of Stuart Highway at S edge of map sheet. Magnetic and gravity contour maps (Bonney Well Explanatory Notes) show fault strikes to be NW and divide basement granite into stepped blocks upon which sedimentary formations drape;

Alekarenge PMG Farm is on a basement high;

Depth to basement increases to SW;

In S of Bonney Well (SF53-2) 1:250,000 geology map-sheet occurs the junction of Wiso Basin to W, and Georgina Basin to E;
Proterozoic rocks outcrop in Davenport Range 20 km NE of Iliyarne ALT;

upper 10 m is weathered to pink/white/yellow/grey clay, as at Alekarenge Farm, underlain by a white friable sandstone aquifer (‘top of’ Chabalowe Formation).

boundary is best determined by gamma logging (cf significant drop from average 120 cps in Arrinthrunga to 60 cps in Chabalowe);

Calliper log should show slightly larger hole diameters due to the more friable nature of Chabalowe Formation;

RN 18401: Cainozoic aquifer 4 m thick; Arrinthrunga Formation aquifer ~ 20 m thick; Chabalowe Formation aquifer 12 m thick.

Section shows an E dipping basement high at Alekarenge PMG Farm bounded by faults at 420000E and 422000E;

Sumner (his Figure 4) extrapolated faults along NW structural trend to form stepped blocks;

Fall of 50 m interpreted to top of Chabalowe Formation between Alekarenge PMG Farm (RNs 18000 and 18390) and Thring Swamp (RNs 18242 and 18338);

A further drop of 50 - 60 m interpreted on the block containing RNs 18401 and 18241 which lies between Alekarenge Farm and Thring Swamp blocks, suggesting this block is lower than the others;

SW of fault at 420000E, ‘BC-5’ struck Chabalowe Formation at 169 m and granite basement at 328 m. The basement may drop further still toward the Lander Trough in the SW;

(Frogtech, 2006 reported in Sumner, 2008A) interpreted NW – SE, moderately dipping, normal, and NE - SW vertical transfer structures in basement;

RNs 18401 and 18338 were logged with gamma, calliper and conductivity probes;

Gamma log of RN 18338, Thring Swamp shows an identical sequence to RN 18242 which is approximately 1 km to S;

Gamma logging at Alekarenge Farm (RNs 18387 – 90 drilled in March/April 2008) showed geology there is, essentially, flat-lying;

RN 18000, adjacent Alekarenge Road, encounters Chabalowe Formation closer to surface which suggests a gentle dip to E. (Paul, 2005, comments that the basement surface appears to be dipping to E between RN 18000 and Alekarenge);
RN 18338, 1.5 km N of RN 18242, yielded significantly more;

RN 18401, 5.5 km W of RN 18338 had similar yields;

possible that groundwater is draining to RN 18401 from the Davenport Range via Thring Swamp;

RN 18401 test pumped for 1,500 minutes at 16 L/s (July 2008). T = 69 m2/day (‘upper’ Chabalowe Formation aquifer 160 - 170 m bgl);

Sc = ~ 5 x 10-5;

RN 18241 shows increase in EC with depth;

Cainozoic aquifers EC = 1,550 µS/cm; below 90 m, EC increases to 1700 µS/cm;

RN 18338 EC = 2,200 µS/cm near surface reducing to 1,290 µS/cm at 36 m bgl, rising to 1,780 µS/cm and consistent with depth. Evaporation concentrated salts in Thring Swamp may be responsible for higher EC near surface. The lower value at 36 m may correspond to W groundwater flow recharging from the Davenport Range;

RN 18401 EC increases from 1,400 µS/cm in Cainozoic and upper Arrinthrunga Formation at ~ 80 m depth to 1,800 µS/cm in Chabalowe Formation at 160 m.

Groundwater at Alekerange PMG Farm is fresher than at Iliyarne.

Gamma most diagnostic tool for Iliyarne region. Chabalowe aquifer (45m+) discernible from overlying Arrinthrunga Formation (latter contains more clay – higher gamma response. More clayey bands are shown as spikes in the Chabalowe Formation).

NRETA (2008B) (Anne Pye)

Bore sites selection to provide:

- information for preparation of draft WDP WRMP;
- to extend SWL monitoring network across WDP (per 1990 recommendations).

4 bores RNs 18402-5 and 3 bores RNs 18346-8 inclusive were drilled along N boundary of Neutral Junction (opposite Alekarengue turnoff, S of Wycliffe Well) in June and September 2008, respectively;

Bore sites located in extensive Singleton spinifex red sand plains intersected by a Sandover alluvial Coolibah floodout;

Only RN 18403 drilled > 100 m penetrated Arrinthrunga Formation (dolomite) at 117 m;
All but one of bores encountered a Tertiary aquifer (fine, white quartz arenite);

- 214 to 1,020 µS/cm EC in 6 western-most bores;
- RN 18404, the eastern-most bore drilled (closest to Stuart Highway), recorded salinities up to 1,710 µS/cm EC;
- Field EC indicated that salinity deteriorated with depth, except in RN 18403;
- RN 18403: EC improved on penetrating dolomite at depth;
- Ostensibly, yields increased with depth;
- Airlift yields in 2 most western bores RNs 18347 & 8 were 1 L/s; the other 5 bores yielded 4 – 17 L/s;
- Same aquifer was intersected by 4 bores, RNs 18387-90 drilled at Alekarenge for PMG Farms in April 2008. PMG Farm bores yielded 10 - 20 L/s and EC’s of 590 – 970 µS/cm. Gamma logs of RN 18000, and composite logs of RNs 18117 & 8 (drilled 2004) sited < 3 km NW of PMG bores were consistent with intersection of this sandstone aquifer;
- The aquifer appears to be oriented E – W;

Geological and gamma logs of investigation bores drilled to NE, viz. RNs 18401 (drilled 15 km N on Iliyarne ALT), 18338, 18241, and 18242, in the vicinity of Thring Swamp, and on Iliyarne ALT (S of Wycliffe Well), indicate that the aquifers lie in a different formation;

- Gamma logs and ECs indicate RNs 10223 (1 km E of RN18402 and 18403) and RN 15966, the bores closest to 2008 drilling, appear to intersect the same aquifer;
- RN 17182 (‘BC-5’) contain similar sediments to Neutral Jcn. bores;
- Other bores in a central corridor adjacent the Stuart Highway were gamma logged. These logs did not indicate dominance of same fine, quartz arenite beds, which comprise main aquifer in the newer PMG Farm and Neutral Jcn. bores. Moreover, their historic salinities are comparable with higher EC’s shown in RN 18404 (the most proximate of new bores to Stuart Highway);
- Possible that aquifer intersected at Neutral Jcn. and PMG Farms (2008) is overlain by more saline clay sediments in areas adjacent the Highway, and that recharge filtering through these sediments has an adverse impact on the water quality in these areas;
- RN 18403 (sited on W side of Taylor’s Creek floodout), major sandstone aquifer underlain by very hard dolomite beds of the Arrinhrunga Formation. Cores from nearby NTGS stratigraphic
bores (RNs 17177-17182) shows this dolomite to include vughs, minor solution cavities and fractures;

- RN 18403 test pumped (12 hours constant rate): \( T = 250 \text{ m}^2/\text{day} \) and \( Sc = 10^{-6} \)\(^2\) and indicates a slight delayed yield effect indicating leakage from overlying storage.

**NRETA (2008D) (R. Read)**

- Desktop study of Munkarta (McClaren Creek) community N of northern boundary of WCD.
- Bores drilled near McClaren Ck. homestead have produced reasonable yields of TDS \(< 1,000 \text{ mg/L})\);
- McLaren Creek provides potential recharge; however salinity is variable and there are only local lenses of lower salinity groundwater, not exclusively recharged from major creeks;
- SW corner (SW of Younghusband Range), S of Mungkarta: good yields of marginal salinity water found near Wycliffe Well in a small, NW trending (?Cainozoic) basin recharged by Wycliffe Creek;
- Salinity increases to NW in this basin;
- NW corner underlain by Warramunga Formation;
- Bores near Bonney Creek have saline water;

*Table 4-1* summarises water resources data gleaned from NRETA (200C).

---

\(^2\) incorrectly analysed – needs checking?
Table 4-1
Western Davenport Plains – Water Resources

<table>
<thead>
<tr>
<th>Climate</th>
<th>Surface water area / drainage morphology</th>
<th>Groundwater catchments, storage &amp; salinity</th>
<th>Groundwater recharge &amp; throughflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. of frost line, mean temperatures</td>
<td>Tennant Creek 24-36°C January; 14-26°C July.</td>
<td>2 catchments: southern catchment covers 75% of Plains &amp; a large catchment area up-gradient (main drainage line to NW); northern catchment covers NW 25% of Plains &amp; a catchment area up-gradient to E of Hanson River.</td>
<td>Recharge pulse every 35 years or so from large rainfall events (&gt; 400 mm) raise SWL ~ 8-12 m in some locations, 2-3 m in others or as small as a few cms; e.g. 1973 rainfall event) with ongoing SWL decay from this event to date.</td>
</tr>
<tr>
<td>Alekarenge (19 years record):</td>
<td>Average annual rainfall = 398 mm/a; Median annual = 320 mm/at; Tennant Creek:</td>
<td>Estimated 56,000 GL groundwater storage in 6 interconnected major aquifers below Plains (volumetrically, ~ 50% is situated E of Stuart Hwy; estimated 21,000 GL &lt; 1,500 mg/L TDS; DNRETA (2007)).</td>
<td>Groundwater recharge / discharge fluxes have been estimated on a regional basis.</td>
</tr>
<tr>
<td>Average annual rainfall = 375 mm</td>
<td>75-80 % of annual rainfall during summer thunderstorms. Drought-dominated regime. Rainfall much greater than annual average falls for a few days ~ 1 in every 30 years; e.g. Jan 2007 &amp; in 1973 &gt; 400 mm fell over a few days. Evaporation order of magnitude greater than rainfall</td>
<td>E of Stuart Hwy, 75% of groundwater within main aquifers has TDS &lt; 1,500 mg/L &amp; &gt; 50% is &lt; 1,000 mg/L. Plains have salinity by surface area &lt; 1,500 mg/L &gt; 4,000 km² &amp; &lt; 1,000 mg/L &lt;= 2,000 km² (NRETA, Nov 2007).</td>
<td>Based on post-1973 SWLs rise, and aquifer storativity values, annual recharge E of Stuart Hwy, for 8 main WRAZs in SE plains is c. 18,000 to 40,000 ML/a (NRETA, Nov 2007).</td>
</tr>
<tr>
<td></td>
<td>Catchment area = 14,700 km² to drainage outlet of Plains NW of Wauchope (7.770 km² of sand plains + 6,900 km² of ranges, hills, rocky plains &amp; floodouts).</td>
<td>Limited hydrogeological information W of Hwy (an area of &gt; 3,500 km²) so storage volume estimates less reliable: 28,000 GL W (?) of Stuart Hwy.</td>
<td>Aquifer throughput at Bluebush Bore section = c. 7,300-36,500 ML/a (NRETA, Nov 2007).</td>
</tr>
<tr>
<td></td>
<td>2 catchments 9,000 km²: NW catchment (abuts SE catchment to NW, W of Stuart Highway) &amp; SE catchment to an outflow zone NW of Wauchope (NRETA, Nov 2007).</td>
<td>SWL = 2-30 m bgl</td>
<td>Following recharge, throughflow increases due to increased thickness of saturated sediments &amp; increased hydraulic gradient. In some locations, groundwater flow direction is reversed; changes of throughflow direction believed to occur over months or years.</td>
</tr>
<tr>
<td></td>
<td>Volume of groundwater in storage calculated for aquifers below Plains for 4 main SE ‘water resource assessment zones’ DNRETA (2007C).</td>
<td>2,000 ML/a allocation to Centrefarm Block 1.</td>
<td>From a regional perspective, aquifers have a common water table / potentiometric surface.</td>
</tr>
</tbody>
</table>

2,000 ML/a allocation to Centrefarm Block 1.
4.3 Groundwater Use

Groundwater accounts for 100% of water supplies in the WDP so that, essentially, all public water supplies, and the pastoral and horticulture industries rely on it. However, it is likely that some pastoral water use is semi-reliant on water-holes, off-stream farm dams, excavated tanks, and turkey's nest storages, particularly on the rocky ranges. These diversions would be negligible and certainly well below the permissible 5% of flow.

There are neither springs nor dry weather flows i.e. rivers and creeks are all ephemeral (refer to Figure 1-1 for surface water catchment and sub-catchment boundaries).

The aquifers currently provide domestic water supplies to Alekarenge, several Aboriginal outstations, two homesteads, one roadhouse and associated tourist facilities. Stock water for three cattle stations is extracted stock bores across the plains and in adjacent areas. The annual extraction from the aquifers is estimated to be less than 200 ML/a.

4.4 Water Bores

Whilst many bores have been drilled across the WDP they are not uniform in total depth (see Figure 4-2), separation or reliability of the data (see Figure 1-2 for distribution), and, as such, do not provide an overall understanding of the extent, variability and characteristics of the main aquifers. There are clusters of bores in localised areas e.g. Alekarenge and Wycliffe Well, and only a relatively limited number of bores drilled into the deep Chabalowe and Arrinthrunga Formations aquifers.

There are extensive areas within the WDP where few bores have been drilled.

Several cored stratigraphic bores have been drilled by the NTGS and the old BMR (refer Section 3.4. These bores provide key information on the stratigraphy of the Chabalowe and Arrinthrunga Formations.

Many of the bores which have been drilled across the WDP were drilled as stock or community bores where drilling ceased after obtaining limited yields required. This is illustrated by Figure 4-2 whereby it is observed that most of the bores drilled penetrate down to a maximum depth of 120 m bgl; with the majority terminating between 40 and 80 m bgl, indicating completion in the Cainozoic / upper Cambrian aquifers, or the weathered, fractured rock in fractured (‘bedrock’) rock aquifers.

Figure 4-3 indicates the number of bores drilled classified by type (‘currently known status’) and by aquifer screened. This figure is discussed further in Section 6.
Figure 4-2
Total bore depth (m bgl) vs. No. of bores drilled in the WDP

Figure 4-3
Bore Status by Screened Aquifer vs. No. of Bores Drilled
Figure 4-4 graphs SWL class intervals (10 m) versus No. of Bores. It indicates that the majority of bores are completed in formations with SWLs of (5 m) to 20 m bgl; these bores are mainly but not exclusively completed in Cainozoic and into the Cambrian aquifers.

SWLs in the Hatches Creek Group tend to be deeper (20-50 m bgl), and variable in the Andagera and granites of the Arunta block (10-40 m bgl), indicating aquifer compartmentalisation.
Only a limited number of high yielding production bores have been drilled and test-pumped for short durations. Primarily, the testing was undertaken to establish production bore pumping rates, and secondarily to determine aquifer hydraulic characteristics. The majority of bores have only been airlifted at completion of drilling. Such air-lift yields tend to underestimate the yield of the aquifer and are of little use in determining aquifer sustainable yields (and wellfield yields or capacity).

Bore yields for the same type of aquifers have been quite variable. In view of the limited number of investigation production bores that have been drilled to date and the known variability of the strata, some caution should be exercised in projecting the potential for the upper range of continuous bore yields in the same formations across the region.

All water bores with useful data are plotted on Figure 1-2 in relation to land tenure. Some 290 bores are displayed and were used to inform this study. They were culled and collated from 3 databases supplied by NRETA for this commission. Appendix B utilises this database to classify the bores into the major aquifer formations on various map backdrops (these maps then assisted to draw up the WRAZs; see Section 7.2).

Figure 3-1 indicates the groundwater monitoring bore network [plotted from data provided in NRETAS (2009) and NRETA, (2007C)]. The bore network is clustered geographically into six monitoring areas, as follows:

- Ali-Curung / Warrabri;
- Warrabri;
- Murray Downs;
- Neutral Junction;
- Singleton Station; and,
- ‘Railway Corridor’.

---

3 The bore databases supplied by NRETAS have been collated, sorted and culled to erase bores with little or no associated hydrogeological data (i.e. neither/nor SWL, EC/TDS, dubious airlift Yield, driller’s/geological logs).
5. **Surface Water Hydrology**

5.1 **The Drainage System**

Drainage divisions and river basins defined by the Australian Water Resources Commission (Environment Australia 2001) indicate that the WCD lies wholly within the Wiso Basin surface water catchment. The main surface water catchment within the WCD occupies some **14,850 km²**.

Table 5-1 summarises geomorphic data and categorise creek reaches in terms of the bioregion they reside within.

![Table 5-1](image)

<table>
<thead>
<tr>
<th>Drainage System / Major Tributaries</th>
<th>Initial Bioregion</th>
<th>Interim &amp; Terminal Bioregions</th>
<th>Highest Point in Catchment (m asl)</th>
<th>Height of highest Major Channel (m asl)</th>
<th>Lowest Point in NT (m asl)</th>
<th>Straight Line Length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>flowing W &amp; SW from Davenport &amp; Murchison Ranges</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edinburgh Ck.</td>
<td>DAV</td>
<td>DAV</td>
<td>525</td>
<td>425</td>
<td>390</td>
<td>15</td>
</tr>
<tr>
<td>McClaren Ck.</td>
<td>DAV</td>
<td>TAN</td>
<td>556</td>
<td>390</td>
<td>340</td>
<td>25</td>
</tr>
<tr>
<td>Wauchope Ck.</td>
<td>DAV</td>
<td>TAN</td>
<td>500</td>
<td>425</td>
<td>350</td>
<td>15</td>
</tr>
<tr>
<td>Wycliffe Ck.</td>
<td>DAV</td>
<td>TAN</td>
<td>570</td>
<td>390</td>
<td>350</td>
<td>30</td>
</tr>
<tr>
<td>Skinner Ck.</td>
<td>DAV</td>
<td>TAN</td>
<td>625</td>
<td>450</td>
<td>385</td>
<td>35</td>
</tr>
<tr>
<td>Murray Ck.</td>
<td>DAV</td>
<td>TAN</td>
<td>605</td>
<td>460</td>
<td>385</td>
<td>35</td>
</tr>
<tr>
<td><strong>flowing N into or towards the Tanami Desert</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hanson R (Woodforde R &amp; Bloodwood Ck.</td>
<td>BRT</td>
<td>TAN</td>
<td>1,001</td>
<td>625</td>
<td>350</td>
<td>250</td>
</tr>
<tr>
<td>Taylor Ck.</td>
<td>BRT</td>
<td>TAN</td>
<td>697 Mt Gwynne</td>
<td>540</td>
<td>400</td>
<td>75</td>
</tr>
</tbody>
</table>

There are no surface water gauging stations within the study region (A. Pye, pers. comm.).

Water flows into or across the floodout as either sheet-flow or by minor channels, which can occur in braided patterns (also called anastomosing or reticulated). In extreme rainfall events water may flow across the land surface in vast sheets for substantial periods of time (days and possibly weeks).
Palaeodrainage channels occur in some of the flat areas. These are subterranean features where relatively unconsolidated sediments have filled in ancient valleys and watercourses, providing a conduit for groundwater flows.

There is a small S – N drainage line through the Centrefarm Block 1. Satellite images there appears to be a relict drainage line extending back to the gap in the Osborne Range through which Taylors Creek flows (the pass used by the Stuart Highway through the range). Currently Taylors Creek flows to the NNW from this pass; but may have once flowed through parts of Centrefarm’s block or environs. There also could be palaeochannels associated with ancient flows of Taylors Creek, but there is no stratigraphic evidence to date.

5.2 Wetlands

Figure 2-1 indicates the locations of ephemeral swamps and pans draped on a DEM.

Whilst Environment Australia (2001) cites there are no ‘nationally important wetlands’ in the study region, Duguid, et al. (2005) indicates otherwise, as expounded below. Reference is also made to http://www.nt.gov.au/nreta/wildlife/nature/aridwetlands.html

The following areas within the WCD hold significant arid ‘wetlands’:

- Chabalowe and Thring ephemeral swamps;
- Bluebush bore ephemeral ‘lake’;
- intermittent clay-pan;
- waterholes associated with deeply incised creeks and rocky outcrop country in the ranges;
- in-stream waterholes within The Plains e.g. Wycliffe Well; and,
- Murray Creek Floodout.

Floodouts such as the one along Murray Creek can flood up to 0.5 m deep over an area estimated to be 183 km². Floodwater can spill out of the floodouts onto adjacent plains over periods of weeks. This has occurred quite frequently over the main Alekarenge, Murray Downs Homestead access road S and SW of Bottom Bore on Murray Downs (NRETA, 2007C).

The ephemeral lake at Bluebush Bore and Chabalowe Bore swamp appear to have formed as a result of relatively recent geological barriers across the main NW drainage line. These may be calcrite or

---

4 The definition of a wetland used in the Directory is that adopted by the Ramsar Convention under Article 1.1, namely: “wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.” ... modified slightly to suit the Australian situation in describing wetlands of national importance. Notable alterations to the Ramsar classification system included the addition of non-tidal freshwater forested wetlands and rock pools.

5 The nearest one catalogued is Lake Surprise (Yinapaka) of area 800 ha in the Tanami west of the study region.
sand, gravel and calcrete barriers formed from formation of the limestone and deposition of fluvial and alluvial deposits (NRETA, 2007C).
5.3 Davenport Murchison Ranges Bioregion

The Davenport and the Murchison Ranges encompass the Davenport Murchison Ranges Bioregion. They contain many semi-permanent waterholes, including many of the largest in the arid NT. There is no indication of the extent permanence being due to groundwater discharge (viz. spring-fed). Three creeks generate medium to long lasting swamps. The Elkedra River is the longest of the Davenport’s rivers.

The abundance of waterholes in rock-holes and isolated drainage systems is an important biological characteristic, and includes semi-permanent waterholes in Whistleduck Creek, S of Kurundi and Old Police Station Waterhole, S of Epenarra and Errorola Rock-hole (all part of Frew River system and all lie just beyond NE and E of the WCD boundary.), plus others in the Elkedra River system.

The waterholes of the bioregion are divided into those that occur in the rocky ranges and those that lay beyond the ranges (‘lowland waterhole wetland type’). Most of these are a result of bedrock confining the water and possibly promoting scour, and can be very large (> 1 km long).

The waterholes in the ranges provide an important drought refuge for seven (one species may be endemic) indigenous fish species, as well as waterbirds and terrestrial fauna. There are also some long-lasting waterholes on neighbouring pastoral leases and Aboriginal freehold; however, the majority of the large, semi-permanent waterholes are in the conservation reserve (Davenport Ranges ‘National Park’). The area is nationally significant as a drought refuge for fishes; categorised as ‘Significance for Biodiversity Conservation: (National/International)’. The water bodies are also regionally significant for waterbirds and are undoubtedly important for terrestrial fauna.

5.4 Tanami bioregion

The Tanami bioregion is characterised by large sand plains and low calcrete rises, large areas of sand dunes and occasional low rocky ranges. In the WCD, it includes the floodout system of the Hanson River with adjacent dune fields.

Warrabri Swamp-Skinner Creek is a floodout swamp that probably holds water for substantial periods, whilst Wycliffe Creek floodout is an aggregation of various wetland types associated with the floodplain and floodout of Wycliffe Creek.

5.5 The Wiso Basin

From Duguid et al, 2005. The Wiso Basin incorporates the eastern part of the Tanami Desert. It contains several, mostly unconnected drainage systems. On the W and SW sides of the Davenport Ranges are several rivers including Skinner and Murray Creeks, which share a joint floodout, Wycliffe
Creek, Bonney Creek, McClaren Creek and Gilbert Creek. Inspection of satellite imagery indicates that the floodouts of several of these creeks may be joined in large flood events. Skinner and Murray Creeks probably join in typical floods. Skinner Creek then floods out towards Thring Swamp and Wycliffe Creek. Bonney Creek is probably joined by Gilbert and McClaren Creek in large floods.

Taylor Creek rises in the hills around Barrow Creek Roadhouse and floods out to the N of the Osborne Ranges. Satellite imagery and anecdotal evidence indicate that the floodwaters of the Taylor can reach those of Wycliffe Creek.

The Hanson River rises in the Anmatjira Range to the SW of Ti-Tree Community, and flows N, flooding out into the Tanami Desert. It has several large tributaries and is connected to Stirling swamp (located within the Ti-Tree WCD). There are no natural permanent waterholes in this drainage system and no documented major swamps in the terminal floodout, but two major swamps in the mid reaches; a large complex of wetland types at Stirling Swamp, which is connected and adjacent to the river; and a large gum-barked Coolabah swamp at Mud Hut Well on Bloodwood Creek. Surface water in this floodout extends for over 1 km wide in places and many kilometres long. Several broader basins have been identified from imagery, but neither their vegetation nor longevity has been investigated.

5.6 Possible Groundwater Dependent Ecosystems

Thring and Warrabri swamps may be locations of ecosystems associated with presumed groundwater discharge zones (indicated by shallow SWLs).

These swamps are dominated by Eucalyptus victrix (gum-barked Coolabah). It is likely that maintenance of the biomass an ecosystem is reliant on periodic flooding with surface water (rather than groundwater discharge). However, large perennial plants and trees may tap groundwater and therefore perhaps can be dependent on it.

5.6.1 Thring Swamp

Thring swamp located on the southern side of Wycliffe Creek is a tiered set of discontinuous clay pans from E to W. In actuality it is more a drainage line than a swamp.

Adjacent to the salt pans within the swamp are small grassy plains with open to dense woodland of mallee, acacia (including tall mulga) melaleuca sp. and other trees and shrubs.

NRETA (2007C) has undertaken preliminary, exploratory soil surveys over Thring swamp. There is minimal salt on the surface of the soil (and none at Warrabri swamp). Surface pH is slightly alkaline in sand increasing to very high levels in sand and clay by 0.7 m bgl in the unsaturated zone. The pH of the soil then reduces to ‘normal’ with depth above decomposed rock in the saturated zone.
In the few investigation bores drilled below the swamp, groundwater salinity has improved with depth.

Since 2004 there has been surface water in clay pans in Thring swamp. The water table is ~ 5 m bgl (at January 2007 ?), though the potentiometric surface of the deep aquifers is ~ 2.5 m bgl, and there was water lying on the surface of the clay pans at January 2007 ? (NRETA, 2007C).

5.6.2 Piggery Bore “swamp”

Piggery Bore swamp is situated near Alekarenge. This swamp appears to be more like a collapsed doline NRETA (2007C). A creek flows into this swamp from the Murray Creek floodout to the SE; when full the lake overflows to the NE into Warrabri swamp. There was water lying on the surface at piggery at January 2007 ? (NRETA, 2007C).

5.7 Catchment Yield

The discussion below is summarised from NRETA (2007C).

Significant recharge to groundwater systems and growth of the floodout vegetation biomass is dependent on major rainfall events resulting in major runoff and flooding. Historically these major events have occurred about once every 30 - 35 years (based on interpretation of the long term rainfall records at Barrow Creek and Tennant Creek).

There is no long term river gauging station providing scientific data on the runoff estimates of the hard rock catchments.

To provide an estimate of the average annual runoff from the Davenport Catchment, a catchment yield of 10 % was used to estimate the annual average yield of a 100 mm rainfall event by Paul (2005). He estimated that with such an event, 3,530 ML of runoff would flow off the Davenport Range portion of the Murray Creek catchment. This preliminary estimate is considered to be ultra conservative, as the actual catchment yield is likely to be much greater than 10 %.

The average catchment yield currently used for catchments within the arid zone of the NT is 7 %. The actual catchment yield is known to vary considerably between catchments and for each catchment depending on catchment condition. The Todd River catchment up-gradient of Alice Springs has a catchment yield varying between about 3 % and 21 % depending on catchment and antecedent conditions.

---

6 Average annual catchment yield provides average estimates of volumes of annual stream flow. Actual annual runoff varies significantly and is dependent on rainfall intensity, areal extent of rain, duration of the rainfall and catchment antecedent conditions.
The catchment area of Murray Creek is 1,426 km²; comprising its floodout east of Alekarenge (183 km²), and rocky range and hill country (1,100 km²). The catchment yield is probably closer to two to three times, Paul’s calculation (NRETA, 2007C).

Using a catchment of 7 %, the volume of runoff generated by an extreme rainfall event, say, 300 mm, is calculated to be some 55 GL from the western side of the Davenport Range.

Using a catchment of 7 %, the volume of runoff generated by an extreme rainfall event, say, 300 mm, is calculated to be some 170 GL from the Osborne / Crawford / Watt / Forster Ranges, roughly 50 % draining onto the WDP via Taylor Creek, and 50 % draining to Stirling Swamp and possibly into the Hanson River.
6. Hydrogeology

6.1 Introduction

Regional investigations have not covered the whole WP uniformly, but have concentrated on areas where there was believed to be moderate to high yields of good quality groundwater; i.e. TDS less than 1,000 mg/L, or for Aboriginal town or outstation water supplies.

Currently there are groundwater data over a 40 year period at Alekareng, intermittent data over the 40 years period in the Wycliffe Well region, intermittent data in a number of other locations but only minimal data across much of the WDP Plains with large knowledge gaps of regional groundwater level changes.

6.2 Aquifers

Six major aquifers and a range of limited, localised aquifers are considered by NRETA (2007C) to underlie the WDP. They are summarised below as Table 6-1.

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Lithology</th>
<th>Aquifer Type</th>
<th>Yields</th>
<th>Basin</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cainozoic</td>
<td>calcrete, sand &amp; sandstones, silt &amp; clay Quaternary gravel</td>
<td>Primary porosity; some secondary porosity in calcretes, etc. Semi-unconfined</td>
<td>&lt; 96 m thick; wedge out along Plains / Ranges boundary. 9-30 L/s in chalcedony/silcrete; 2-5 L/s in calcrete, sand or gravel beds.</td>
<td>Shallow Tertiary basin across the WDP overlying the Cambrian &amp; isolated outliers over granite and Hatches Ck. Gp.</td>
<td>Shallow phreatic to semi-unconfined aquifer. Widespread &amp; localised</td>
</tr>
<tr>
<td>Lake Surprise Sandstone</td>
<td>Well-sorted, fine-medium sandstone</td>
<td>Primary porosity. Semi-confined?</td>
<td>Up to 20 L/s ?</td>
<td>Wiso</td>
<td>Occur W of Stuart Hwy. NW sector of The Plains – lack of hydrogeological study &amp; drilling in region</td>
</tr>
<tr>
<td>Dulcie Sandstone</td>
<td>Sandstone well sorted fine-medium qtz arenite</td>
<td>Dual porosity</td>
<td>10 - 20 L/s ?</td>
<td>Georgina</td>
<td>Occurs just inside Plains southern groundwater catchment boundary in SE.</td>
</tr>
<tr>
<td>Tomahawk Beds</td>
<td>Sandstone qtz arenite Thin siltstone interbeds of micaceous silt, shale &amp; minor dolostone</td>
<td>Fractured (?dual porosity)</td>
<td>5 L/s ?</td>
<td>Georgina</td>
<td>Limited to outside southern groundwater catchment boundary.</td>
</tr>
<tr>
<td>Aquifer</td>
<td>Lithology</td>
<td>Aquifer Type</td>
<td>Yields</td>
<td>Basin</td>
<td>Comments</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>--------------------------------</td>
<td>--------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Chabalowe Formation</td>
<td>limestone and sandstones, dolomitic quartz arenite, siltstone, dolostone some evaporites</td>
<td>Dual porosity. Semi-confined</td>
<td>Sandstones 10 - 30 L/s where weakly lithified.</td>
<td>Georgina Formations structurally complex due to faults.</td>
<td>Widespread high yielding &lt;= 300 m thick</td>
</tr>
<tr>
<td>Arrinthrunga Formation</td>
<td>limestone and minor sandstones, dolostone &amp; dolomitic sandstone</td>
<td>Dual porosity. Semi-confined</td>
<td>Limestones yield 5 - 20 L/s.</td>
<td>Georgina- outcrop near Chabalowe Bore and at the southern extremity of The Plains.</td>
<td>Widespread high yielding &lt;= 300 m thick</td>
</tr>
<tr>
<td>Andagera Formation</td>
<td>Conglomerate &amp; pebbly sandstone</td>
<td>Fractured rock</td>
<td>Localised high yielding (up to 20 L/s ?) aquifers in basement rocks.</td>
<td>Georgina</td>
<td>Only known presence at few locations in NE on Singleton, and Murray Downs Stations from limited number of bores drilled</td>
</tr>
<tr>
<td>Kurinelli Sandstone</td>
<td>Arenite, conglomerates, lava &amp; tuff, minor (micaceous) siltstone.</td>
<td>Fractured rock</td>
<td>Localised high yielding (up to 20 L/s ?) aquifers in basement rocks; e.g. near Conglomerate Bore on Murray Downs</td>
<td>Davenport Province</td>
<td>Only limited number of bores drilled</td>
</tr>
<tr>
<td>unidentified formation of the Hatches Creek Group</td>
<td>sandstone</td>
<td>Fractured rock</td>
<td>Localised high yielding (up to 20 L/s ?) aquifers in basement rocks; e.g. SE of Wauchope.</td>
<td>Davenport Province</td>
<td>Occurs SE of Wauchope. Only limited number of bores drilled</td>
</tr>
<tr>
<td>Hatches Creek Group and the Arunta Complex</td>
<td>Metamorphic, volcanics, granite, gneiss and schist</td>
<td>porous and/or fractured rock aquifers</td>
<td>Yields &lt; 1 L/s (NRETA, Nov 2007).</td>
<td>Davenport Province &amp; Arunta Block</td>
<td>Localised, minor aquifers in regional basement rock. Some aquifers yet to be identified in Hatches Creek Group?</td>
</tr>
<tr>
<td>Warramunga</td>
<td>Siltstone, shale &amp; volcanics</td>
<td>Non-aquifer</td>
<td>Negligible</td>
<td>Tennant Creek Block</td>
<td>V. local, saline aquifers</td>
</tr>
</tbody>
</table>
6.3 Alluvial Aquifers

It appears that no investigation has taken place of alluvial aquifers within the WDP. Given the extensive creek network, there is probably a large volume of water stored temporarily within these sediments that either infiltrates into Cainozoic aquifers (or ‘bedrock’ where creeks flow over the rocky ranges) or is evapo-transpirated when held above clayey substrate and/or tapped directly by tree roots.

BMR (1980) notes that alluvium of the Hanson River floodout (situated in the eastern Lander River map-sheet) yielded ‘seepages of water with low salt content’.

6.4 Cainozoic Aquifers

A large portion of the WDP is covered with Cainozoic sediments that contain aquifers including a regional aquifer overlying the Wiso and Georgina Basins. There is also a veneer of Cainozoic sediments covering the granite and Hatches Creek Group rocks, possibly including unmapped palaeochannels.

The high yields from the Cainozoic are associated with calcrete and chalcedony deposits (vuggy porosity).

Thicknesses vary from about 5 to 65 m with 1 to 40 m saturated thickness. The base of the Cainozoic in the WDP proper has an almost ubiquitous sandy clay (rarely claystone) layer up to 25 m thick that may retard the vertical recharge of water to the Cambrian formations. However, this may be expected to provide delayed drainage upon regional pumping creating a driving head that may sustain production from the Cambrian aquifers.

6.5 Cambrian Sedimentary Aquifers

The only bores drilled in the W are situated along the Hanson River (on eastern margin of Lander River map-sheet in the Wiso Basin) as part of a 1979 BMR mapping investigation, (BMR, 1980). Stratigraphic drill-holes, BMR Lander River 1 - 5 and Bonney Well 1 - 2 yielded flows of 0.8 – 1.6 L/s of ‘generally good quality stock water’ in the Hanson River Beds. Three stratigraphic holes (BMR Land River 1, 6 and 7) penetrated very porous Lake Surprise Sandstone, yielding 1.6 – 3.3 Ls of ‘good quality stock water’.

Along with overlying Cainozoic sediments, the Georgina Basin Cambrian aquifers, namely the Arrinthrunga and Chabalowe Formations constitute the regional aquifers of the WDP.

Sumner (2008) produced a handy summary of the stratigraphy reproduced as
Table 6-2.

Table 6-2
Regional interpretation of geological depths from bores drilled for Western Davenport Plains

<table>
<thead>
<tr>
<th>Bore</th>
<th>Cainozoic (m)</th>
<th>Arrinthrunga (m)</th>
<th>Chabalowe (m)</th>
<th>Granite (m)</th>
<th>Distance from RN018401</th>
</tr>
</thead>
<tbody>
<tr>
<td>RN018401</td>
<td>3</td>
<td>54</td>
<td>160</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>BC-5 NTGS</td>
<td>3</td>
<td>63</td>
<td>169</td>
<td>328</td>
<td>15 km south</td>
</tr>
<tr>
<td>RN018241</td>
<td>3</td>
<td>69</td>
<td>152</td>
<td>-</td>
<td>13.0 km south east</td>
</tr>
<tr>
<td>RN018338</td>
<td>2</td>
<td>74</td>
<td>98</td>
<td>-</td>
<td>5.5 km east</td>
</tr>
<tr>
<td>RN018242</td>
<td>3</td>
<td>70</td>
<td>94</td>
<td>-</td>
<td>6.1 km east</td>
</tr>
<tr>
<td>RN018000</td>
<td>2</td>
<td>4</td>
<td>43</td>
<td>-</td>
<td>18.5 km south east</td>
</tr>
<tr>
<td>RN018390</td>
<td>-</td>
<td>3</td>
<td>48</td>
<td>-</td>
<td>20.5 km south east</td>
</tr>
</tbody>
</table>

Assessment and Alekarenge PMG Farm (reproduced from Sumner, 2008 [Table 2]).

Note: RN 18118 378.3 m AHD to TOC (Paul, 2005).

The top sandstone beds in the (Arrinthrunga?) sequence are found below limestone in some locations, and are filled with calcite and are chemically altered so that groundwater occurs in fractures. The underlying (Chabalowe?) beds have a calcite matrix with some interstitial porosity and fracture porosity along bedding, and the deeper beds are non-calcareous and exhibit excellent primary porosity and possibly secondary porosity (bedding planes) (G.Ride, pers. comm. via A.Pye). The Arrinthrunga Formation is ubiquitous in the SE of the WDP-Central and WDP-SE WRAZs (refer Section 7.2). It is generally harder and has more fracture (secondary) porosity than the Chabalowe.

Structurally, the formations appear to be block faulted (ibid.). The presence of faulting is likely to complicate the hydrogeological interpretation. Recent test pumping undertaken at PMG Farms block 1 indicates leakage from Cainozoic and possibly Cainozoic / Cambrian junction, but also the presence of hydraulic barrier boundaries, often of a subtle nature (in one case obvious) that could indicate intra-formational facies changes and/or faults. Paul (2005) in discussing rapid changes in TDS (< 600 mg/L at RN18113 to ~ 1000 mg/L at Alekarenge in 1 km to W) suggested that these bores are situated in separate, poorly connected groundwater systems.

From a regional perspective, the current interpretation is that the Wiso and Georgina Basins’ aquifers are interconnected based on the current potentiometric surface drawn from both levelled standing water levels and AHD estimated water levels.

SWL is deeper in some locations in the SE sector and generally shallower in the NW sector of the main aquifer zone.


6.6 Groundwater Quality

The TDS map (NRETA, 2007C) provides one composite interpretation of salinity from water samples from different aquifers from bores at different periods in the natural recharge / discharge cycle. Salinity varies with depth, distance from recharge zones, permeability of the aquifer, aquifer type and in some locations phase when sampled and age of the groundwater. The lack of an even spread of sampling points affects the accuracy of the map particularly in areas where there are few bores.

To enable groundwater storage estimates to be calculated for the WRAZs a 1:250,000 scale groundwater salinity zone map was produced by NRETA (2007C). Salinity zones were demarcated for ranges < 1,000 mg/L, 1,000 to 1,500 mg/L, 1,500 to 2,000 mg/L and > 2,000 mg/L TDS.

The direction of groundwater flow shows salinity improves down-gradient within the ‘Spinifex assessment zone’ (includes Centrefarm’s commercial block on the Warrabri ALT; located in lower salinity groundwater within this WRAZ).

Generally, there is an increase in salinity down-gradient. Paul’s (2005) Durov diagrams confirm this trend (decrease in bicarbonate and increase in chloride). Paul interpreted a trend line from some bores as the mixing of two different groundwaters, one reflecting recharge and the other water that has been in the system for a long time.

Anomalously, localised TDS highs occur; e.g. at bore RN 14355 near Chabalowe stock bore on Murray Downs, and RN 2047 adjacent to Thring Swamp on Singleton Station. The data E of Bluebush Bore RN 1259 is also anomalous in that there is conflicting interpretations of samples from a series of bores. This may be due to samples taken from different aquifers at different periods of the natural recharge/ discharge phase.

Nitrate higher values near the groundwater catchment divide to the SE, near the Murray Downs / Alyawarra ALT boundary reducing to the NW to Thring Swamp. There are a few locations where there are localised higher values along this gradient e.g. E of Bottom Bore on Murray Downs. There are locations with high yielding aquifers with low nitrate e.g. Conglomerate Bore area on Murray Downs.

Fluoride exhibits moderate to high concentrations in the Alekarenge region, reasonably high in the Thring Swamp and Wycliffe Well area then reduces to the NW. Very high values were present at depth in RN 18111 (6.2 mg/L from 120 mbgl), 5 km west of Alekarenge but reduced significantly to low values measured from investigation bores at the Warrabri Centrefarm block 1 (RN 18117 < 1.5 mg/L).
Uranium is elevated in an area of 20 km by 40 km N-S in the Alekarenge area extending just S of Nelsons Bore on Murray Downs with a concentration =< 10 ug/L. Surface uranium levels shown on airborne radiometric maps indicate that these relative low, uranium levels are probably quite extensive across the WDP particularly in association with calcrites and adjacent source basement rock (see Figure B-4).

6.6.1 Aquifer Storage

NRETA (2007A) estimated groundwater storage volume E of the Stuart Highway as 37,500 GL based on an aquifer area of 5,000 km² (assumed that only 10% of this volume was groundwater with a TDS < 1,000 mg/L). This assessment was refined using the same aquifer hydraulic parameters but adjusted to reflect TDS map and simplified hydrogeological sections (NRETA, 2007C). The area of the four main WRAZs E of the Stuart Highway (Spinifex, Conglomerate, Shirley and Chabalowe) is estimated at 3,127 km². The estimated total groundwater storage is **28,200 GL**; nearly **12,000 GL** of **< 1,000 mg/L TDS and 21,000 GL < 1,500 mg/L TDS**.

6.6.2 Aquifer Throughflow

NRETA (2007A) estimated throughflow in a (Cainozoic aquifer) section through Blue Bush Bore (RN 1259) as 7,300 - 36,500 ML/a; based on an estimated aquifer transmissivity, 1,000 - 5,000 m²/d and a hydraulic gradient of 0.0005 (1:2,000).

The NTGS stratigraphic holes (Section 3.4) indicate a **25 km wide**, wedge-shaped cross-section to the **aquifer** in the central sector of the WDP with Chabalowe wedging out towards the E and, whereas the southern sector has a greater width of **aquifer (~ 60 km)** with a more complete and thicker sequence of Cambrian. Hence throughflow is ‘funnelled’ through the section Alekarenge to Wycliffe well as reflected by greater hydraulic gradients than to the S of Alekarenge (see Dwg NRASP264, etc. NRETA,2007C)

Using a gradient of 0.001, T = 1,000 m²/d and W = 25 km give a **throughflow of 9 GL/a**. Using a more conservative gradient of 0.005, T = 80 m²/d (cf Arrinthrunga) and W = 25 km gives a throughflow of **3.6 GL/a**

There are likely to be significant changes to the gradient in various locations during the different recharge / discharge phases. In some locations such as SE of Bluebush Bore gradients will be reversed for a period following major recharge events (NRETA, 2007C).

---

*This map is somewhat misleading in that it reflects analyses from only a few bores which are concentrated mainly in the immediate vicinity of Alekarenge (NRETA, 2007C)*.
6.6.3 Recharge

Hydrochemistry, the potentiometric surface and SWL measurements at different times indicate that there are significant recharge zones across the WDP (NRETA, 2007C).

Appendix C presents an exercise that attempts to classify hydrochemical signatures into zones of like groundwater chemistry. The class scatter plots indicate prominent recharge source is water flowing off the Davenport Range, centred especially on Wycliffe and Skinner Creeks where they disgorge from the foothills. Poorer water quality is associated with the granites of the Forster Range. There is complex mixing within the Plains proper caused by a ‘belt’ of poorer quality water that appears to be associated with Taylor’s Fault that results in a ‘plume of brackish groundwater (on Neutral Junction PL, mapped E of the Stuart Highway). Groundwater salinity increase uniformly down-gradient to the N and NE, N of Wauchope.

The water chemistry time series plots C-8 to C-11 of Appendix C indicate historical recharge pulses associated with the 1973/4 floods and lesser rainfall events of 1968 and 1991. Paul (2005) documents hydrographs that show the impact of the 2000/1 rainfall event, too on SWLs.

Between November 1975 and June 1978 the net regional water level rise was 5 m. Based on a Sy of 5 - 7 %, recharge during this period equated to 250 - 350 mm (Paul, 2002).

NRETA (2007A) estimated annual recharge for the area E of the Stuart Highway in the order of 25 - 60 GL; based on an area of 5,000 km2.

Using the area covered by the four WRAZs E of the Stuart Highway (Spinifex, Conglomerate, Shirley and Chabalowe) of 3,127 km2 the recharge estimates are 16 - 38 GL/a, or about 18 - 40 GL/a when the Turkey and part of the Braitling WRAZs are included.

The runoff yield calculated for this study took 5 mm effective rainfall (i.e. infiltrating) over the Davenport Range catchment area of some 2,500 km2 (draining S onto the WDP) was 12.74 GL available for recharge.

The runoff yield calculated for this study took 2 mm effective rainfall (i.e. infiltrating) over the Osborne / Crawford / Watt / Forster Ranges catchment area of some 1,300 km2 (draining W to Stirling Swamp and an equal area draining W onto the WDP) was a total of 8.5 GL available for recharge.

6.6.4 Discharge

NRETA (2007C) states that groundwater discharge zones are likely to be present in many areas where the water table is shallow (cf Thring Swamp). Others occur in the Wycliffe Well area and other areas.
to the NW. NRETA (2007C) concludes that there is insufficient data to draw definitive volume discharged by evaportranspiration but as identified by NRETA (2007A), it is probably in the order of 1 mm/day.

6.6.5 Other Aquifers

There are aquifer systems of limited areal extent outside the major aquifer zone of the WDP e.g. significant aquifers at Murray Downs Homestead and Imangara Aboriginal Outstation, and localised, useful aquifers at Wauchope. It is also likely there are aquifers with useful yields and with good to fair salinity groundwater within the adjacent Davenport Range and possibly in the Mungkarta ALT, E and N of Wauchope.

Other, yet to be identified, significant aquifers may occur in the Hatches Creek Group underlying the WDP e.g. at Conglomerate Bore, Paul (2002) tentatively identified Kurinelli Sandstone underlying Cainozoic sediments.

Figure 6-1 provides a very simple section taken across the WDP from SW to NE. No attempt has been made to differentiate the various Cambrian sedimentary rocks into their component formations. Figure 6-2 provides a schematic block diagram based on this section. This illustration could be used as a basis of presenting a simple water balance once more study is done (see Section 9).
Figure 6-1 Schematic Hydrogeological Section across WDP
7. Water Resource Assessment Zones

7.1 NRETA's (2007C) WRAZs

To assist assessment of the water resources and future water resource planning and development of the WDP, nine WRAZs were identified by NRETA (2007C). The boundaries of these zones were said to have been determined from ‘geological, hydrogeological and hydrological boundaries and/or system boundaries’.

The estimated volume of groundwater in storage and its chemical quality were calculated for each zone. The regional throughflow was not calculated for each WRAZ. Initial cross sections were produced to perform storage calculations.

A summary description of the WRAZs is presented in Table 7-1.
### Table 7-1
Description of Water Resource Assessment Zones (after NRETA, 2007C)

<table>
<thead>
<tr>
<th>WRAZ Name and description</th>
<th>Area (km²)</th>
<th>Geological Basin</th>
<th>Boundaries</th>
<th>Stratigraphy</th>
<th>Water quality</th>
<th>Groundwater potentiometric gradient</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shirley</strong>&lt;br&gt;mainly over the SW corner of Murray Downs PL</td>
<td>1,240</td>
<td>Georgina</td>
<td>W - Taylor’s Fault between Georgina Basin formations &amp; Hatches Creek Gp.&lt;br&gt;S - groundwater divide;&lt;br&gt;E - surface water drainage line &amp; fault-controlled&lt;br&gt;N - groundwater divide;&lt;br&gt;surface drainage NE, but in the SW corner is NNW</td>
<td>Cainozoic; Tomahawk Beds; Arrinthrunga Sandstone; Chabalowe Limestone; Hatches Creek Group; Arunta Complex; (and granitoids).</td>
<td>NE, but to the NW along eastern boundary.</td>
<td></td>
</tr>
<tr>
<td><strong>Chabalowe</strong>&lt;br&gt;Covers SE sector of The Plains &amp; is over a small portion of the central area of Murray Downs PL. Includes ephemeral lake / swamp nr. Chabalowe Bore.</td>
<td>298</td>
<td>Georgina</td>
<td>W - surface water drainage line &amp; ? fault in Georgina Basin formations.&lt;br&gt;S – groundwater divide;&lt;br&gt;E fault between Georgina Basin formations &amp; Hatches Creek Gp.&lt;br&gt;N - groundwater divide&lt;br&gt;surface drainage trend across this zone is to WNW &amp; NW along western boundary.</td>
<td>Cainozoic sediments; Arrinthrunga Sandstone; Chabalowe Limestone; Lake Surprise Sandstone; Hatches Creek Group &amp; granitoids</td>
<td>WNW; NW along eastern boundary.</td>
<td></td>
</tr>
<tr>
<td><strong>Spinifex</strong>&lt;br&gt;Spinifex Sand plain with discontinuous low sand hills trending NW-SE near SE boundary.&lt;br&gt;Taylor Ck. cuts through SW corner of WRAZ, ~ 4 km W of Stuart Hwy. Catchment area upstream of the WRAZ = ~ 1,700 km².&lt;br&gt;Covers western central sector of The Plains &amp; is mainly over the Warrabri ALT &amp; NW corner of Murray Downs PL. Includes Alekarenge &amp; Centrefarm Commercial Farm block #1.</td>
<td>986</td>
<td>Georgina</td>
<td>W – eastern extent of granite sub-crop – Hatches Ck. Gp. – Osbourne Range&lt;br&gt;surface drainage to NE</td>
<td>Near S boundary adjacent Stuart Hwy; stratigraphic bore ‘BC3’ drilled by NTGS.&lt;br&gt;55 m Cz sediments (53 m Tertiary);&lt;br&gt;&gt; 330 m Cambrian sedimentary rock;&lt;br&gt;(170 m Arrinthrunga Fm. + 160 m of Chabalowe Fm.&lt;br&gt;Basement (Hatches Creek Gp. or granite not reached). Nearby bore RN 13752 (railway&lt;br&gt;&gt;50 % = &lt; 1,500 mg/L TDS deteriorating to SW to &gt; 2000 TDS adjacent to W. boundary</td>
<td>Below sand plain (SW sector) 1:1,250 flowing to the N; across strike in granite 1:130 &amp; Range 1:70 Through Centrefarm block potentiometric surface trends NWW at 1:1,200. E of Stuart Hwy, GL falls to NE at 1:700; through Centrefarm</td>
<td></td>
</tr>
<tr>
<td><strong>Conglomerate</strong></td>
<td>Over NW corner of Murray Downs PL &amp; portions of Warrabri ALT &amp; Singleton PL, incl. E boundary of Alekarengue.</td>
<td>601</td>
<td>W - surface water drainage line &amp; fault within Georgina Basin S - ground water divide E - hydrogeological boundary between high yielding Adagera Fm. aquifers to W &amp; Hatches Creek Gp. to E; N - extension of N boundary of Spinifex zone to NE &amp; matches surface water catchment. Surface drainage is to WSW &amp; NW along western boundary.</td>
<td>Cainozoic; Arrinthrunga Sandstone; Chabalowe Limestone; Hatches Creek Gp.</td>
<td>E &amp; SE to NW along eastern boundary</td>
<td></td>
</tr>
<tr>
<td><strong>Ghost Gum</strong></td>
<td>Covers western central sector of Plains; over a portion of Singleton &amp; Neutral Jcn. PLs.</td>
<td>1,001</td>
<td>Georgina / Wiso</td>
<td>W - fault (Taylor’s fault); S - partly located on basis of flow-net &amp; partly on characteristics of surface water catchment. E - surface water drainage line &amp; fault within Georgina / Wiso Basin; N - ground water divide; Surface drainage trend to N.</td>
<td>Cainozoic; Arrinthrunga Sandstone; Chabalowe Limestone, Hatches Creek Gp. / Arunta Complex (and granitoids)</td>
<td>NNE, with one area to S in a SE.</td>
</tr>
<tr>
<td><strong>Young-Husband</strong></td>
<td>covers NW sector of Plains over the western portion of Singleton PL &amp; areas within Karlantijpa S &amp; Mungkarta ALTs.</td>
<td>1,859</td>
<td>SW - partly based on boundary between Wiso Basin &amp; Hatches Creek Gp.; SE - groundwater divide; NE - fault between Wiso Basin &amp; Hatches Creek Gp. which forms Young Husband Range; N - surface water catchments.</td>
<td>Hansen River Beds, Lake Surprise sandstone; Hatches Creek Group (or granitoids).</td>
<td>N. Surface drainage trend to N.</td>
<td></td>
</tr>
</tbody>
</table>
7.2 Revised WRAZs and Groundwater Storage Volumes

NRETA’s (2007C) WRAZs have been examined and simplified; bearing in mind that these original WRAZs did not cover the whole WCD.

This revision is described in Table 7-2 including reasoning behind selection of the boundaries.

Figure 7-1 maps the revised WRAZs.

Table 7-3 summarises groundwater storages for each WRAZ.

Figure C-7 presents a hydrochemical facies map. The boundaries interpreted as (subtle) changes in groundwater chemistry are broadly similar to those determined by interpretation of the physical hydrogeology.

Key information is:

- Groundwater storage available from Cainozoic aquifers underlying the plains proper is in the order of 12,800 GL
- Groundwater storage available from Cambrian aquifers underlying the plains proper is in the order of 16,000 GL
- **Total groundwater storage** available from the aquifers underlying the plains proper is in the order of 28,800 GL
- Total groundwater storage available from the above aquifers having TDS concentrations less than 1,000 mg/L (i.e. suitable for long term irrigation) underlying the plains proper is in the order of 8,600 GL;
- Total groundwater storage available from local-scale, fractured aquifers underlying the Davenport Range is in the order of 70 GL;
- Total groundwater storage available from local-scale, fractured aquifers underlying the Osborne / Crawford / Watt / Forster Ranges is in the order of 150 GL;

These are the amounts that, effectively, are considered to be the best available estimates based on present understanding of the aquifer systems available for allocation.

They are conservative estimates (for instance only 20% of the thickness of the Cambrian formations has been considered to be saturated (i.e. allowance has been made for discrete aquifer horizons associated with fracture conditions; e.g. bedding plan fractures and dissolution (‘micro-karst’))
features, particularly in the Arrinthrunga Formation. Further, the Cainozoic saturated thicknesses used are extremely conservative. Lastly, only 10% the thickness of the fractured sedimentary rocks and granites of the Davenport and Osborne and other ranges has been considered to be saturated (i.e. allowance has been made for discrete aquifer horizons associated with fracture conditions and weathered surfaces (‘palaeosols’). Furthermore, conservative specific storage values have been used.
# Table 7-2
Revised Description of Water Resource Assessment Zones

<table>
<thead>
<tr>
<th>WRAZ Name and description</th>
<th>Area (km²)</th>
<th>No. of bores drilled within WRAZ</th>
<th>Geological Basin</th>
<th>Boundaries</th>
<th>Stratigraphy</th>
<th>Water quality</th>
<th>Groundwater potentiometric gradient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davenport Range</td>
<td>5,096</td>
<td>60</td>
<td>Davenport Geosyncline</td>
<td>S - Boundary between Davenport Province to N &amp; Georgina Basin TMI map (Fig B-2) shows Hatches Ck Gp.</td>
<td>Hatches Creek Gp. &amp; Warramunga Gp. in far N</td>
<td>Regionally poor. Pods of good quality</td>
<td>Groundwater catchment divide along top of Davenport Range. SW, S of Range, &amp; NE N of Range.</td>
</tr>
<tr>
<td>Western Davenport Plains – NW</td>
<td>4,092</td>
<td>3</td>
<td>Wiso</td>
<td>SW - based on boundary between Wiso Basin &amp; Hatches Creek Gp.; SE - groundwater divide; NE - fault between Wiso Basin &amp; Hatches Creek Gp. which forms Young Husband Range. DEM (Fig B-1) indicates low elevation. Gravity map (Fig B-3) g low – indicates thick Wiso sediments. Cainozoic sediments; Lake Surprise Sandstone; Arrinthrunga Sandstone; Chabalowe Limestone; Hatches Creek Group &amp; granitoids</td>
<td>Good; poor N of Wauchope</td>
<td>N &amp; NW</td>
<td></td>
</tr>
<tr>
<td>Western Davenport Plains - Central</td>
<td>4,278</td>
<td>109</td>
<td>Georgina / Wiso</td>
<td>W - fault (Taylor’s fault); SE - groundwater catchment divide N &amp; NE - Boundary between Davenport Province to N &amp; Georgina Basin to S. Fig B-3 g intermediate – indicates Georgina sediments. Cainozoic; Arrinthrunga Sandstone; Chabalowe Limestone.</td>
<td>Good; poor in SW pod associated with granite (fault)</td>
<td>NW &amp; N.</td>
<td></td>
</tr>
<tr>
<td>Western Davenport Plains – SE</td>
<td>2,613</td>
<td>4</td>
<td>Georgina</td>
<td>N – groundwater catchment divide. W – Spring Range fault + change in water chemistry Fig B-3 g intermediate – indicates Georgina sediments. Thin Cainozoic; Ducite Sandstone, (Tomahawk Beds – Arrinthrunga Sdst.; Chabalowe Limestone.</td>
<td>Good? – extent unknown</td>
<td>NE to E</td>
<td></td>
</tr>
<tr>
<td>Osborne / Crawford / Watt / Forster Ranges</td>
<td>8,499</td>
<td>117</td>
<td>Georgina / Arunta Block</td>
<td>E – Taylor Fault N – Hatches Ck. /granite sub-crop with Georgina TMI map (Figure B-2) shows Hatches Ck Gp. Gravity map (Fig B-3 g high – indicates Arunta rocks Fig B 4 – high radiometric count Andagera Fm incl. Central Mt Stuart &amp; Octy Fms., granites, granites, schists</td>
<td>Poor. Pods of good quality</td>
<td>Stuart Hwy. follows groundwater divide. W to W of Hwy. &amp; E to E. of Hwy.</td>
<td></td>
</tr>
</tbody>
</table>
### Table 7-3: Calculation of order of magnitude Storage Volumes of Groundwater available for Allocation

<table>
<thead>
<tr>
<th>WRAZ</th>
<th>Area (m2)</th>
<th>Sub-area (m2)</th>
<th>SWL (m bgl)</th>
<th>av strata thickness (m)</th>
<th>av aquifer thickness (m)</th>
<th>saturated volume (kL)</th>
<th>specific yield</th>
<th>groundwater storage (GL)</th>
<th>storage (GL) TDS &lt;1000 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Davenport Plains - NW</td>
<td>4,092,450,725</td>
<td>5</td>
<td>12</td>
<td>200</td>
<td>7</td>
<td>28,647,155,077</td>
<td>0.07</td>
<td>2,005</td>
<td>163,698,029,013</td>
</tr>
<tr>
<td>Western Davenport Plains - Central</td>
<td>4,278,047,584</td>
<td>15</td>
<td>45</td>
<td>250</td>
<td>30</td>
<td>128,341,427,570</td>
<td>0.07</td>
<td>8,984</td>
<td>213,902,379,178</td>
</tr>
<tr>
<td>Western Davenport Plains - SE</td>
<td>2,613,018,041</td>
<td>15</td>
<td>25</td>
<td>300</td>
<td>10</td>
<td>26,130,180,409</td>
<td>0.07</td>
<td>1,829</td>
<td>156,781,082,456</td>
</tr>
<tr>
<td>Davenport Range</td>
<td>5,096,462,469</td>
<td>26</td>
<td>54</td>
<td>2.8</td>
<td>Sdst</td>
<td>14,270,094,914</td>
<td>0.005</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Osborne / Crawford / Watt / Forster Ranges</td>
<td>8,498,567,258</td>
<td>20</td>
<td>54</td>
<td>3.4</td>
<td>28,895,128,676</td>
<td>0.005</td>
<td>144</td>
<td>28,895,128,676</td>
<td></td>
</tr>
<tr>
<td>8,498,567,258</td>
<td>25</td>
<td>28</td>
<td>0.3</td>
<td>granite</td>
<td>granite</td>
<td>2,549,570,177</td>
<td>0.001</td>
<td>3</td>
<td>2,549,570,177</td>
</tr>
</tbody>
</table>

Total: 12,818,16,031,28,850,3,845,4,869,8,655
8. Conclusions

8.1 Current and future Water Use

- The annual extraction from the aquifers is estimated to be less than 200 ML/a;
- At PMG Farm the projected irrigation water demand indicated that some 190 GL of groundwater would be extracted over some 45 years (AGT, 2007B);

8.2 Aquifer Recharge

- Annual recharge of 5 - 12 ML/km² equates to 25 - 60 GL for an area (~ 5000 km²) of the aquifer E of Stuart Highway underlying Warrabri, Singleton and Murray Downs (NRETA, 2007A);
- In 1990 annual recharge was estimated to be 6 - 40 GL for ‘Area 1’ (Carosone, 1990);
- Annual recharge estimate = 10 - 50 GL/a for aquifer system in Murray Downs/Alekarenge/Singleton area (NRETA, 2007A);
- This study assumed an effective rainfall of 5 mm from the Davenport Range and 2 mm the Osborne, etc. ranges that could potentially recharge aquifers giving:
  - 12.7 GL from the Davenport Range sub-catchment area (~ 2,500 km²);
  - 8.5 GL from the Osborne / Crawford / Watt / Forster Ranges catchment areas (~ 1,300 km²)
  - Some 34 GL would also directly recharge (using 2 mm effective rainfall) the aquifers giving;
  - a cumulative recharge of some 55 GL.

8.3 Aquifer Throughflow

- At Bluebush Bore aquifer section throughflow was calculated to be 7.3 to 36.5 GL/a (NRETA, 2007A);
- This study, [using a gradient of 0.005 - 0.001, an aquifer width of 25 km (along Murray Downs homestead access road), and transmissivity of 80 -1,000 m²/d] gives:
  - throughput of 3.6 - 9 GL/a;
• There are likely to be significant changes to the gradient in various locations during the different recharge / discharge phases. In some locations such as SE of Bluebush Bore gradients will be reversed for a period following major recharge events (NRETA, 2007C).

8.4 Aquifer Storage

• Approximate volume in storage = 37,500 GL (NRETA, 2007A);

• ~ 10% of storage, say, 4,000 GL appears to contain water with < 1,000 mg/L TDS (NRETA, 2007A);

• ~ 1,500 - 5,000 GL with < 1,000 mg/L TDS (Area 1); Carosone (1990);

• Volume of good quality water in Murray Downs/Alekarenge/Singleton area order of 2,000 - 4,000 GL (NRETA, 2007A);

• NRETA, (2007C) estimated total groundwater storage as 28,200 GL; nearly 12,000 GL of < 1,000 mg/L TDS and 21,000 GL < 1,500 mg/L TDS;

• This study estimates groundwater storage as follows:
  o Groundwater storage available from Cainozoic aquifers underlying the plains proper is in the order of 12,800 GL
  o Groundwater storage available from Cambrian aquifers underlying the plains proper is in the order of 16,000 GL
  o Total groundwater storage available from the aquifers underlying the Plains proper is in the order of 28,800 GL
  o Total groundwater storage available from the above aquifers having TDS concentrations less than 1,000 mg/L (i.e. suitable for long term irrigation) underlying the Plains proper is in the order of 8,600 GL;
  o Total groundwater storage available from local-scale, fractured aquifers underlying the Davenport Range is in the order of 70 GL;
  o Total groundwater storage available from local-scale, fractured aquifers underlying the Osborne / Crawford / Watt / Forster Ranges is in the order of 150 GL;

8.5 Surface Water Yields

• The main surface water catchment within the WCD occupies some 14,850 km2;
Paul (2005) used a catchment yield of 10% to estimate the annual average yield of a 100 mm rainfall giving 3.5 GL of runoff from the Davenport Range portion of the Murray Creek catchment. This study, using a runoff coefficient of 0.07, the volume of runoff generated by an extreme rainfall event, say, 300 mm, would be some:

- 55 GL from the western side of the Davenport Range;
- 170 GL from the Osborne / Crawford / Watt / Forster Ranges, roughly 50% draining onto the WDP via Taylor Creek, and 50% draining to Stirling Swamp and possibly into the Hanson River.

8.6 Water Dependent Ecosystems

The Davenport Murchison Ranges Bioregion encompasses the Davenport Range that contains many semi-permanent waterholes, including many of the largest in the arid NT. There is no indication of the permanence being due to groundwater discharge (including being spring-fed);

Thring and Warrabri swamps may be locations of ecosystems associated with presumed groundwater discharge zones (indicated by shallow SWLs). Other ‘swamps’ occur in the Wycliffe Well area and other areas to the NW;

The ecosystem of these swamps is probably reliant on periodic flooding with surface water (rather than groundwater discharge). However, large perennial plants and trees may tap groundwater and therefore perhaps can be dependent on it;

Significant recharge to groundwater systems and growth of the floodout vegetation is dependent on major rainfall events resulting in major runoff and flooding. Historically these major rainfall events have occurred about once every 30 - 35 years;

Evapotranspiration, as identified by NRETA (2007A), is probably in the order of 1 mm/day from these swamps;

In modelling the proposed PMG farm borefield, AGT (2007B) concluded:

- under the pumping regime envisaged (2008 - 2010) an average, instantaneous production of 80.5 L/s increasing to 145 L/s post-2011 (with various bore Nos. / configurations), the pumping cone of influence to the 5 m drawdown contour is 2.3 km;
- radius of influence is predicted to extend to a radius of ~ 7.5 km after 43 years of production;
- drawdown is restricted to ~ **0.5 m in Cainozoic aquifer at Alekarene** (closest third-party water supply) after 43 years of production;

- all other users, chiefly Murray Downs and Singleton Stations and Wycliffe Roadhouse, are situated far beyond the radius of influence;

- possible GDEs; chiefly **Thring Swamp** and **Wycliffe Creek**, are situated well **beyond the radius of influence**;

- **Piggery Bore Swamp** lies ~ **800 m E** of the modelled **zero drawdown** contour and, on this basis, will be **unaffected**, too;

- The downstream outlet of **Warrabri Swamp** (at bore, RN 2881) lies about the **2 m drawdown** contour;
9. Recommendations

9.1 Water Balance

- A conceptual hydrogeological model needs to be formulated for the WDP that is represented visually as a block diagram(s) with associated sections;
- A formal water balance for the WDP needs to be prepared;
- The North Australian Sustainable Yields project (CSIRO, 2009 - current) will examine a range of different climate and development scenarios for the NT. Its data and models generated could be used in the water balance to run scenarios (e.g. more intense but less frequent rainfall events) for water planning;
- Numerical modelling should be undertaken following extraction of 4-5 GL/a (per NRTA, 2007A recommendation) from PMG Farm with input from monitoring data on SWLs and groundwater chemical quality changes. This model could assist in refining aquifer storage estimates and identify any impact on any ‘groundwater dependent ecosystems’.

9.2 Groundwater Monitoring

- The existing groundwater monitoring bore network is clustered geographically into six monitoring areas (Ali-Curung-Warrabri / Warrabri / Murray Downs / Neutral Junction / Singleton Station / ‘Railway Corridor’). (Also, it is somewhat unclear what aquifers are being monitored by these bores; most monitor Cainozoic aquifers - author). An evenly spread bore monitoring (including water quality) network with properly constructed bores, particularly targeting the Cambrian aquifers needs to be set-up;
- SWLs in Wycliffe Swamp and in underlying aquifers need to be monitored in a specially constructed monitoring bore (piezometer).

9.3 Aquifer Yields

- The majority of bores have only been air-lifted at completion of drilling. Such air-lift yields tend to underestimate the yield of the aquifer and are of little use in determining aquifer sustainable yields (and wellfield yields or capacity). Only a limited number of high yielding production bores have been drilled and test-pumped for short durations. Therefore, investment needs to be made in undertaking long-duration (24-48 hours), large discharge test-pumping with
associated observation bores. (Also a separate database is needed by NRETAS to make access to this data easier - author);

9.4 Aquifer Correlation

- Per NRETA (2008A), (to correlate the aquifers to assist with the development of the conceptual model) it is recommended to:
  - review all geophysical bore logs for the Plains; especially the gamma data;
  - log calliper, temperature/fluid conductivity and gamma as a minimum standard in all future bores drilled;
  - survey AHDs of all geologically significant bores in the Plains, and compile sections to compare SWLs, gamma and geological logs;
  - contact NTGS and Geoscience Australia to access any further basement modelling results;
  - inspect ‘Ozseebase’ Proterozoic and Palaeozoic datasets for basement interpretation.
  - (Also a separate geophysical logging database is needed by NRETAS to make access to this data easier - author).

9.5 Surface Water Yields

- A relationship between rainfall and runoff for the Davenport Range need to be established by:
  - constructing gauging stations (or as a minimum perform cross- and longitudinal surveys) on Wycliffe, Taylor and Skinner creeks to monitor flood flows and baseflow recession;
  - rating a gauging station, G0290003, operated near Epenarra homestead on the Frew River from 1975 to 1987. [This station was never rated (Paul, 2005)];
Addendum

RECHARGE AND CLIMATE CHANGE

All scenarios take the 50 percentile level of prediction for ‘medium’ scenario emissions to years, 2030 and 2050 (using year, 1990 as baseline).

<table>
<thead>
<tr>
<th>Season</th>
<th>Year</th>
<th>Rainfall change (%)</th>
<th>Temperature change (°C)</th>
<th>Potential Evapotranspiration change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>summer</td>
<td>2030</td>
<td>0</td>
<td>+1.0 - 1.5</td>
<td>2 to 4</td>
</tr>
<tr>
<td></td>
<td>2050</td>
<td>0</td>
<td>+1.5 - 2.0</td>
<td>2 to 4 possibly up to - 6 in N sector</td>
</tr>
<tr>
<td>winter</td>
<td>2030</td>
<td>-5 to -10</td>
<td>+1.0 - 1.5</td>
<td>2 to 4</td>
</tr>
<tr>
<td></td>
<td>2050</td>
<td>-10 to -20</td>
<td>+1.5 - 2.0</td>
<td>2 to 4</td>
</tr>
</tbody>
</table>

The rainfall change is considered to be insignificant as most recharge events come from summer storms. Further, it is predicted that whilst rainfall frequency may decrease (i.e. longer dry spells), rainfall events may increase in their intensity. (This increase in intensity is likely to occur more in northern Australia than in southern Australia).

Given that recharge to groundwater over the WDP is said to occur from extreme events over very infrequent (decadal) intervals, then the volume of rainfall-runoff available for recharge (from such events) may actually increase.

However, on the debit side of the water balance, from increase in temperature (and solar radiation and relative humidity), there is the probability of greater evapotranspiration. Given the increased (but possibly less frequent) runoff events, if water is ponded before infiltration (that seems the case in many of the run-on area of the Plains [where anecdotal reports speak of ponding of huge volumes (and depths of water)]) then more water may be lost through evapotranspiration before it can infiltrate to recharge groundwater.


FURTHER RECOMMENDATION

- Consideration should be given to further understanding and estimating groundwater recharge / discharge in the WDP by tracer studies, using:
  - environmental tracers; especially Chloride (but also Oxygen isotopes, and possibly Strontium and Bromide) as a simple tool with measurements of Cl taken from a number rainfall events, from cored holes through the vadose zone, as well as from groundwater from the Cainozoic and Cambrian aquifers);
  - Radioactive isotopes such as Sulphur35, tritium and/or chlorofluorocarbons (for modern water), carbon-14 (for 200 to 20,000 year-old waters), and chlorine-36 (for ancient waters) to date the groundwater.

Hydro Tasmania Consulting
LEADERS IN CONSULTABILITY
10. References


Department Natural Resources, Environment and the Arts, Land and Water Division (2007B).
File: *WDP supplementary info volumes gw*. GR 17 5 07.doc. May 2007

Department Natural Resources, Environment and the Arts, Land and Water Division (2007C).
*Land and Water Resources of the Western Davenport Plains – Preliminary Technical Overview.*
WRA07022. August 2007


Department Natural Resources Environment and the Arts, Land and Water Division (2007E).
ISBN 1 920772 67 7

Department Natural Resources Environment and the Arts, Land and Water Division (2008A).

Department Natural Resources Environment and the Arts, Land and Water Division (2008B).

Environment Australia, Canberra.

Environment Australia (2001). Drainage divisions and river basins refined as defined by the Australian Water Resources Commission

Frogtech, 2006, Oz Seabase Proterozoic Basins Study


*Explanatory Notes SE53-6*
Assessment of Groundwater Resources in the Western Davenport Plains Water Control District
Revision No: 0
E204629 July 2009

Department Natural Resources Environment, the Arts & Sport, Land & Water Division, 2009. *Catalogue of Groundwater Monitoring Bores in the Southern Region of NT 36. Western Davenport Ranges Water Control District*

Northern Territory Groundwater Map and Explanatory Notes

Northern Territory Government. *Understanding Water Allocation Planning In the Northern Territory.* Fact Sheet. Undated


