Great Artesian Basin Monitoring Network Implementation (Stage 2)

Final Report

March 2015
trees (after desert rains), discharge from flowing artesian bore at McDills (bore RN 5028).

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1. **Introduction**

The Great Artesian Basin (GAB) is Australia’s largest water resource and is one of the largest artesian groundwater basins in the world. It extends over 1.7 million km² or 22% of the Australian continent and underlies a significant proportion of Queensland and large areas of New South Wales, South Australia and the Northern Territory. The GAB occupies the south-east corner of the Northern Territory and extends over 84,500 km² - around 6% of the total area of the NT (Refer Figure 1 and inset). Relative to the other states the NT contains only a small proportion of the GAB – less than 5% of the total basin area.

![The NT Great Artesian Basin](image)

**Figure 2** The NT Great Artesian Basin

Discovery of the groundwater resource in the 1880’s enabled the population of previously uninhabitable country and was the catalyst for the development of the pastoral industry in arid inland Australia. More recently the GAB provides an increasingly important source of water for the mining industry. There are thousands of springs tapping the GAB, arguably the most significant are the iconic mound springs located on the south-west margin of the basin in South Australia. These natural discharge features have immense cultural and environmental value. Their cultural significance to Aboriginal Australians indigenous to the area is well documented and extends for thousands of years prior to European settlement. From an environmental perspective, the mound springs represent a unique ecosystem in the arid zone and sustain important populations of endemic plants, fish and invertebrates.

The first recorded bore drilled into the NT GAB was in 1894 at Charlotte Waters on the NT/SA border. The bore was drilled by the South Australian Government as a water supply for the Charlotte Waters telegraph station. This was followed shortly after in 1898 by the completion of the first artesian bore named Anacoora (Registered Number 977). Over the last 110 years a further 200 bores have been drilled in the GAB aquifer in the NT - the vast majority of these are located along the basin margin and are predominantly used to provide stock and domestic water supply.
### 2. Project Overview

This report fulfils the final reporting requirement for the NT GAB Monitoring Network Implementation (Stage 2). The project began in July 2009. In 2014/15, work to fully deliver this project was completed.

The $112,561 project was established under the Commonwealth of Australia Department of the Environment (previously the Department of the Environment, Water, Heritage and the Arts) with in-kind contribution of the Water Resources Division of the Northern Territory Government Department of Land Resource Management (previously the Department of Natural Resources, Environment, the Arts and Sport).

The second phase of the GAB Sustainability Initiative (GABSI Phase 2) commenced in 2004 following the successful completion of the 5-year GABSI Phase 1 program. This program facilitated the rehabilitation of several hundred uncontrolled flowing bores within the GAB. A mid-term review of GABSI Phase 2 undertaken by Sinclair Knight Merz (2008) assessed:

- the performance of the Initiative to date against its objectives;
- the appropriateness of those objectives for ongoing use; and
- ways to improve implementation of the Initiative now and in the future.

The GAB Monitoring Network Implementation (Stage 2) was hence developed in 2009 as a result of the Sinclair Knight Merz review in following up Recommendation 2 - Implementation of a basin-wide monitoring program. Information provided by the network would thus enable monitoring of the recovery in basin-wide water levels and pressure heads through the GABSI Phase 2 program, and provide information for the development of future management approaches for the GAB through annual monitoring.

A key element of the GAB Monitoring Network Implementation (Stage 2) was to establish a network of basin-wide monitoring bores. Eleven of these bores were eventually located in the Northern Territory. Bores within the wider network were proposed to be monitored annually between June and September for pressure, temperature, flow, electrical conductivity and pH. Under this Program, selected monitoring bores would be equipped (where required) with specially designed headworks to enable monitoring. In the Northern Territory, these monitoring bores were instrumented with water level measuring devices, with one of these equipped to provide a suite of parameters including pressure, temperature, flow and electrical conductivity.

Each bore within the greater GAB Monitoring Network, including the monitoring bores located in the Northern Territory were required to be surveyed to provide accurate bore elevations, allowing comparison of pressure data between bores across the Basin.
3. The Northern Territory Project

The Northern Territory GAB Monitoring Network project required the following general activities to be undertaken by the Department of Land Resource Management (previously the Department of Natural Resources, Environment, the Arts and Sport):

- Select bores to represent the NT GAB Monitoring Network
- Undertake elevation surveys of the monitoring network bores
- Install automatic monitoring equipment on the selected bores.

3.1 The NT GAB Monitoring Network

At the time the project agreement was being struck, there were only two bores in the NT GAB which could potentially serve the desired purpose as monitoring bores. Most of the previous groundwater investigations conducted in the NT GAB were concentrated in the south-western part in the vicinity of the Finke community and in the sub-artesian areas. Here, the GAB sandstone aquifer is reasonably shallow (<400m in depth) and within the depth range of moderate capacity water well drilling rigs. There were none suitably constructed as monitoring bores.

Only two flowing artesian bores exist in the NT GAB. These are registered numbers 5028 (McDills) and 977 (Annacoora). McDills was drilled in 1965 to a depth of 3205m as a petroleum exploration bore. Some years after it was abandoned, the casing adjacent the GAB aquifer corroded and the bore flowed uncontrolled at over 120 L/s (est). In 2002, a project was successfully undertaken to rehabilitate the bore and control the flow. The upper 200m of the bore was re-constructed and it currently flows at 7 L/s (Humphreys and Kunde, 2004). Annacoora was drilled in 1898 to a depth of 381m as a water supply bore and flowed uncontrolled at a moderate 2 L/s. It was rehabilitated in 1999 and the flow is now controlled by valved headworks. Both bores were selected for ongoing monitoring of artesian pressures.

Concurrent with the NT GAB Monitoring Network project was the “Allocating Water and Maintaining Springs in the Great Artesian Basin” project. This project was funded by the (then) National Water Commission. As a collaborative partner to this project, the Department’s role was to assess the NT GAB aquifer - investigating the local stratigraphy, testing aquifer hydraulic characteristics, mapping its extent and developing a knowledge basis for the recharge mechanism on the GAB western margin. This work resulted in the quantification of recharge which predominantly feeds the mound spring discharges at Dalhousie (SA) and the Mulligan River Spring area (Qld) (Fulton, 2010) and provided the essential basis for the development of a Water Allocation Plan for the NT GAB. The investigations extended to the northern rivers area of the NT GAB to increase spatial coverage of groundwater levels and provide a reasonably representative network for the purposes of ongoing GAB monitoring. The Mound Springs project was completed in 2012 and the NT GAB Monitoring Network benefitted from the legacy of this investigation project.

A map showing the location of the NT GAB Monitoring Network is in Appendix A Figure 1 and the details of their location, aquifer condition and instrumentation are provided in Table A1.
3.2 **Bore Elevation Survey**

A survey to obtain accurate elevation measurements for all bores within the network is essential to allow the comparison of pressure measurements between bores and the production of accurate basin wide pressure maps.

The original agreement specified that this activity required only 6 existing bores to be surveyed. However, a variation to the agreement was later applied for to deliver a survey of all 11 nominated monitoring sites.

The results of the survey are provided in Table B1 in Appendix B.

3.3 **Installation of Automated Monitoring Equipment**

The intent of this activity was to facilitate continuous pressure and flow monitoring of selected artesian bores across the wider network thus allowing accurate bore discharge to be calculated. In terms of the original agreement, this required the purchase and fitment of automated monitoring instrumentation and data logging devices to the 2 artesian bores and 10 sub artesian bores within the network. The instrumentation to be fitted to the 2 artesian bores was required to include a pressure sensor, a temperature sensor, an electrical conductivity sensor and a digital flow meter and for all sensors to feed data to an externally fitted data logger. This activity included the fitment of an external power supply to run the equipment (eg a solar panel and/or battery). The data logger fitted to the bore was also required to have a facility allowing data to be telemetered in the future. The 10 remaining sub-artesian bores selected for the monitoring network were required to be fitted with automatic water level monitoring data loggers. This specification also included the manufacture of any devices required to prevent damage to the automated monitoring and associated equipment.

The telemetered system specification for the ‘dynamic’ installation at McDills is as provided in Appendix C with the componentry detailed in Table C1 and Figures 3 to 8. The system was designed and installed by Hydroterra Pty Ltd. with componentry specified to meet the 60°C temperatures experienced at this bore.

The ‘static’ groundwater level logging installations on the remaining bores currently use Level TROLL® 300 absolute logging systems and BaroTROLL instruments to compensate for atmospheric pressure. The specifications of these instruments are provided in Appendix C Tables C2 and C3.
4. **Activity Benefits and Outcomes**

This section discusses the benefits and outcomes of each project activity against the following criteria:

- **Outcomes/Objectives**: The degree to which each activity has achieved the Objectives.
- **Appropriateness**: The appropriateness of the approaches used in the development and implementation of each activity.
- **Effectiveness**: The degree to which each activity has effectively met its stated objectives.

4.1 **The NT GAB Monitoring Network**

**Outcomes**

The NT GAB has not previously been studied in detail. The main reason is that it is largely uninhabitable and has a low level of current development with one community and several pastoral stations collectively using less than an estimated 2500 ML/annum. Furthermore, the foreseeable future is not considered to hold any significant developments except for the possibility of coal seam gas production from the Pedirka Basin.

Previous investigative efforts and opportunities focussed on identifying the GAB as a water source for the existing developments. The undertaking of a regional scale study of the system to understand its natural behaviour, and recharge and discharge regime was therefore unwarranted.

During the late 2000’s, the NT found focus on the GAB. The “Allocating Water and Maintaining Springs in the Great Artesian Basin” project (Love et al, 2013) provided the NT an opportunity to embark on work to gain an understanding of the system. As well, the development of the NT GAB Water Allocation Plan being undertaken concurrently meant that there was now a need to acquire general water resource monitoring data on a regional scale.

Therefore, the identification of a regional network of bores selected for the NT GAB monitoring network would prove somewhat convenient in that this network would serve purposes in addition to those identified under the GABSI program.

**Appropriateness**

The identified network is considered to provide an appropriate representation of resource behaviour on the GAB western margin. However, in terms of monitoring the recovery of pressures through the GABSI program, it is unlikely that any effects could be discerned. Most bores, except McDills and the bores on Numery and New Crown Stations, are located within the ‘unconfined’ part of the aquifer. As well, the GAB western margin probably represents the most remote part of the system from the more populous and highly developed areas of Queensland and New South Wales. Therefore it is considered unlikely that drawdown emanating from these areas would have been experienced in the NT. Given this understanding, it may not have been entirely appropriate to select monitoring bores in this
part of the NT GAB. However, there are no available monitoring bores further east in the NT GAB. The aquifer becomes inaccessible due to its depth which is beyond the capacity of most moderate size drilling rigs and the terrain becomes predominantly sand dunes. Therefore no other options were available.

**Effectiveness**

The likely small magnitude of drawdown (if any) coupled with the lack of baseline water level data for this region, means that it is unlikely that any recovery gains due to the GABSI program could be discerned from any natural behaviours.

### 4.2 Bore Elevation Survey

**Outcomes**

This activity was successfully completed.

The budget provided for the elevation survey was $6,000. As the project unfolded, it became apparent that this budget was not nearly adequate to undertake the enormity of the work program that would be required to deliver this data. Given the remoteness of the locality and that no benchmarks existed in the region – except near the community of Finke, it was impossible to secure surveying services within the $6,000 budget. The budget for this activity was revised and negotiations began with a surveying group within the Northern Territory Government. It is gratefully acknowledged that these services were made available within the project’s remaining budget seeking only to recover operational costs. Approximately $40,000 was contributed as in-kind.

**Appropriateness**

The survey is an essential ‘value add’ to the water level data from bores in the network and therefore entirely appropriate that this activity was undertaken.

**Effectiveness**

The work was successfully undertaken by NT Government surveyors using dual frequency geodetic GPS receivers, differential techniques and AUSPOS solutions (Dawson et al, 2012). The high quality data acquired will enable the GAB water levels to be mapped.

### 4.3 Installation of Automated Monitoring Equipment

**Outcomes**

This activity resulted in the installation of a telemetered system at McDills bore and automatic water level loggers on the remaining monitoring network bores.
Only two bores in the NT GAB, registered numbers 5028 (McDills) and 977 (Annacoora), are known to exist under artesian conditions\(^1\). A controlled flow of 7 L/s is released from McDills bore as an environmental provision, and Annacoora bore is now capped after its rehabilitation in 1999. As such, the installation of telemetry equipment is only warranted at McDills bore to capture dynamic conditions. Plates 1 to 6 in Appendix D

Annacoora bore, and the other monitoring bores which exist under sub-artesian conditions, were proposed for “static” groundwater level logging installations only. A variation was sought which would require a telemetered multi-sensor installation at McDills bore only.

The use of Annacoora bore as a monitoring site proved problematic. Its remote locality, the harshness of the environment, difficult access and the lack of any permanent track to the site (all tracks to the site are only temporary due to shifting sand dunes) raised issues of high risk to personnel involved in the monitoring site visitations (ie. OH&S issues). After engaging with monitoring staff and determining that none had the confidence to navigate to it and return safely, and further undertaking a controlled site visit in November 2012, it was assessed as an unviable monitoring option. It was then decided to abandon the proposal to use Annacoora bore.

The telemetered data for McDills may be downloaded via the internet link to the service provider site below:


The remaining 9 bores have been equipped with automatic water level monitoring data loggers.

All data acquired from the monitoring sites are entered into the Water Resources Division’s HYDSTRA database. This data is publicly accessible through Water Resources’ Water Data Portal via the following link:


**Appropriateness**

The use of technology in water resources has been an area of rapid expansion in the last 15 to 20 years. Current day downhole logging systems have good battery life (~ 5 years) and high memory storage capacity to capture data at high resolution (twice daily). The data available from continuous logging systems yields valuable information regarding aquifer behaviour and response to recharge events. The deployed logging systems have sub-centimetre resolution in water level data and therefore the small changes in water levels that may be anticipated can be detected.

In the arid zone, most aquifer recharge occurs episodically and on the GAB western margin, it has been proven that infiltration occurs where river systems traverse the outcropping sandstone which hosts the GAB aquifer (Fulton, 2010). River flows may be short lived and opportunities to gauge flows and measure groundwater levels in response to each event are usually missed. Automatic logging systems almost eliminate the risk of missed data.

\(^1\) A third bore RN012431, also known as Dakota bore existed as a ‘rogue’ artesian flowing bore until 2002 when it was rehabilitated. The flow was either killed during the rehabilitation process or is now discharging to the subsurface.
The telemetered installation at McDills bore is the most appropriate for this application. The sensors monitor pressure head, flow, electrical conductivity and temperature and well as battery charge. The internet link to the site via satellite provides real time data from the instrumentation if this is required. It also provides assurance that the sensors and logging system is operational. McDills is a difficult and hazardous site to access and the ability to remotely access data provides options regarding the frequency of site visitations.

The equipment selected for installation is indeed the most appropriate for this application.

**Effectiveness**

An analysis of data from the logging systems has not yet been undertaken to gauge the effectiveness of the system in detecting the response of the resource to the GABSI program. However, in the eventual analysis, it needs to be considered that the data from the GAB western margin is a significant distance from the area of high extraction (refer Section 4.1) and a nil response would not necessarily mean that the GABSI program has been unsuccessful.
5. Discussion

The aims of the Great Artesian Basin Monitoring Network Implementation (Stage 2) project have been successfully delivered. The major activities (specific objectives) in the agreement were modified during the course of the project due to a number of reasons – these reasons and the lessons learned in the undertaking of this project are discussed below.

**Overall Project Outline**

Difficulties were experienced in undertaking several activities during this project. This is attributed somewhat to the highly ‘unknown’ nature of the aquifer and study area, the harsh environment and difficult remote access conditions. However, these factors only exacerbated the problems resulting from an inappropriately scoped project. The enormity of this project was not realised until its execution. Subsequently resourcing, budgetary and timing issues all conspired to hamper the project’s eventual delivery. The importance of a well-researched and appropriately briefed project is a valuable lesson learned.

**The NT GAB Monitoring Network**

The identification of an appropriate monitoring network is discussed Section 4 above. The project commenced with no available monitoring sites and was dependent on the results of the “Allocating Water and Maintaining Springs in the Great Artesian Basin” project (Love et al 2013) to progress. Ironically, this project was hampered by poor access conditions resulting from unusually high rainfall during the 2008/9 and 2010/11 seasons. It was not until 2010 that monitoring bores became available in the area of the Finke Community and New Crown Station where the initial investigation concentrated.

The appropriateness of this network for the purpose intended of this project is discussed in Section 4. In hindsight, the NT is probably not a realistic vantage point from which to monitor and expect any discernable effects to be detected. However, from a GAB basin-wide perspective and given that the NT was previously the only jurisdiction to not undertake GAB monitoring, it is perhaps justifiable that a monitoring program in this sector of the GAB was commenced to fill the data void. For the NT, the advantage of this data capture is that it provides the baseline data that is required for the water allocation planning process, and the basis for impact assessment in the event of development activity in the future.

**Bore Elevation Survey**

With few benchmarks across the region, and the logistical challenges posed by the region’s remoteness and difficult terrain, delivering the surveying requirements of this project would prove a somewhat difficult challenge. In retrospect, it was unrealistic to expect that an elevation survey of 12 bores could be conducted over a regional area covering more than 30,000 square kilometres on the edge of the Simpson Desert within an allocated budget of $6000.

Enquiries with some surveying companies proved unattractive in terms of cost while others were uninterested. Negotiations with the NT Government’s surveying function proved optimistic – however, there was little opportunity to utilise their services as they were mostly
engaged in other higher priority work. The first available opportunity to engage these services arose in May 2014 when this work was conducted.

**Installation of Automated Monitoring Equipment**

Initially, it was considered that most sites would be fitted with telemetry systems to provide water level data only. A custom built system would service the requirement for a multi-sensor telemetry system for McDills bore. However, it was realised that the budget was grossly inadequate for this level of equipment. A single sensor system would include water level transducer, battery/solar power supply, data logger, modem, secure system housing valued at $12,000 each plus site works and installation, and the ongoing cost of maintaining satellite modem services at $1000 annually made it necessary to revise the equipment specification for the monitoring sites. It was decided to downgrade the equipment for the bulk of installations to a single water level transducer which would be manually serviced.

Despite the advantages of this technology (refer Section 4.3 above), it is still developing and reliability is an issue with failed transducers resulting in lost data. This risk is somewhat reduced in some bores where an additional logger has been installed.

The McDills installation was designed, built and installed by Hydroterra Pty Ltd. The multi-sensor system includes high specification pressure and temperature transducers, electrical conductivity sensor and flow cell, flow meter, dual power system (battery/solar), data logger and satellite modem. The componentry is housed in secure and animal proof enclosures (particularly for camels which are notorious for destroying equipment). As an indication of the aggressive nature of the groundwater at this site, during the first year of operation, the pressure transducer failed due to corrosion of the external housing and sensor. Its replacement required Hydroterra’s instrumentation technician to undertake this work on-site. The next replacement transducer will have a compensator to combat the effect of electrolytic corrosion. Furthermore, for cost efficiency, this exercise used a helicopter to McDills rather than travel more than two days by road. This is a difficult site to access and risks to personnel during each site service are duly recognised.

The data retrieved thus far is not fully entered into the corporate database. Constraints in staff resourcing have meant that a backlog currently exists in logger data processing, checking and entry. Furthermore, servicing the instrumentation is currently on an opportunistic basis rather than with any regularity. This is expected to continue into the foreseeable future.

**Project Outcomes**

Notwithstanding the difficulties, delays and problems experienced in undertaking this project, it is important to realise that tangible outcomes were successfully achieved. High quality, surveyed GAB monitoring data is now available from what is arguably the most remote part of the continent, and serves a number of purposes. It provides an insight into the behaviour of the groundwater resources in the NT GAB and a baseline to assess the impact of any potential future development. Not least, it will inform of the wider scale impact of GAB usage (if any) and the recovery gains through the GABSI Program.
6. **Financial Report**

6.1 *Income – Expenditure Statement*

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**Great Artesian Basin Monitoring Network Implementation**

**Income & Expenditure Statement for the period 1 July 2008 to 15 March 2015**

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I, **Joanna Frankenfeld**, Chief Financial Officer of the Department of Land

a. all Funding received was spent for the purposes of the

b. salaries and allowances paid to persons involved in the

c. the unspent portion of the funds (if any) was available

d. any financial information required is presented in

e. where an Asset has been acquired with the Funds,

---

Joanna Frankenfeld  
30 April, 2015
6.2 Financial Controller’s Statement

I, Joanna Frankenfeld, Financial Controller of the Department of Land Resource Management (DLRM), in respect of the Great Artesian Basin Monitoring Network Implementation (Stage 2), am satisfied that:

a) All Funding received was spent for the purposes of the Project and in accordance with the Agreement and that DLRM has complied with this Agreement;

b) salaries and allowances paid to persons involved in the Project are in accordance with the applicable award or agreement in force under the relevant Law on workplace relations;

c) the unspent portion of the Funds (if any) was available for use within the next reporting period;

d) any financial information required is presented in accordance with any other financial reporting requirements about which the Commonwealth may notify DLRM; and

e) where an Asset has been acquired with the Funds, paragraphs 7.5(d) and (g) (where applicable) have been complied with in respect to the Asset.

Joanna Frankenfeld
30 April, 2015
7. **Acknowledgements**

The author wishes to gratefully acknowledge the assistance and valuable contribution of a number of people involved in this project.

Firstly, many thanks to Simon Fulton who coordinated all field operations, and undertook the liaison with the consultant for the design and sourcing of the equipment for the telemetered site at McDills. Simon was instrumental in the on-site installation and the subsequent recovery effort when the water level logger failed.

Grateful thanks go to the surveyors at the NT Department of Lands, Planning and the Environment. Roland Maddocks and his team undertook to survey all the bores in this GABSI program so this project could be brought to a successful completion.

Finally, thanks to the Water Resources staff who contributed to this project in many ways. Ian Mcmasters undertook trips to McDills and Annacoora as one of the few with the bush navigational skills to get there and back over the sand dunes and desert country. Ian also drilled some of the bores used in the monitoring program. Thomas Jacko installed the logging systems in these bores. Thanks also to John Wischusen and Noel Gibbons for their contribution in getting the data into the database.
8. References


Appendix A

The NT GAB Monitoring Network
Figure 3  The NT GAB Monitoring Network
### Table A1  NT GAB Monitoring Bore Details

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Appendix B

Bore Elevation Survey
## Table B1  Bore Elevation Survey

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<td>213.25</td>
<td>0.16</td>
<td>213.09</td>
<td></td>
</tr>
<tr>
<td>RN002607</td>
<td>53</td>
<td>665381</td>
<td>7391312</td>
<td>225.06</td>
<td>0.3</td>
<td>224.76</td>
<td>MP is south eastern corner steel plate.</td>
</tr>
<tr>
<td>RN004236</td>
<td>53</td>
<td>457913</td>
<td>7169308</td>
<td>275.73</td>
<td>0.54</td>
<td>275.19</td>
<td>Top of 3cm square steel cap. NS &amp; concrete pad 0.54 below cap.</td>
</tr>
<tr>
<td>RN005028</td>
<td>53</td>
<td>579139</td>
<td>7153603</td>
<td>120.79</td>
<td>0.58</td>
<td>120.21</td>
<td>McDill's Bore. Top 0.61 diam steel cap.</td>
</tr>
<tr>
<td>RN013046</td>
<td>53</td>
<td>564146</td>
<td>7330258</td>
<td>264.76</td>
<td>0.37</td>
<td>264.39</td>
<td>MP is south western corner steel plate.</td>
</tr>
<tr>
<td>RN015351</td>
<td>53</td>
<td>567034</td>
<td>7323351</td>
<td>256.86</td>
<td>0.4</td>
<td>256.46</td>
<td>MP is south eastern corner steel plate.</td>
</tr>
<tr>
<td>RN016483</td>
<td>53</td>
<td>457302</td>
<td>7173544</td>
<td>247.86</td>
<td>0.15</td>
<td>247.71</td>
<td>Top 0.22 diam steel cover plate.</td>
</tr>
<tr>
<td>RN018349</td>
<td>53</td>
<td>484640</td>
<td>7159319</td>
<td>217.98</td>
<td>0.6</td>
<td>217.38</td>
<td>Top 0.22 diam steel cap.</td>
</tr>
<tr>
<td>RN018350</td>
<td>53</td>
<td>484645</td>
<td>7159321</td>
<td>217.83</td>
<td>0.61</td>
<td>217.22</td>
<td>MP but centre 0.17 diam cap.</td>
</tr>
<tr>
<td>RN018351</td>
<td>53</td>
<td>484644</td>
<td>7159322</td>
<td>218.05</td>
<td>0.79</td>
<td>217.26</td>
<td>Top 0.22 diam steel cap.</td>
</tr>
<tr>
<td>RN018352</td>
<td>53</td>
<td>486123</td>
<td>7159765</td>
<td>217.51</td>
<td>0.65</td>
<td>216.86</td>
<td>Top 0.22 diam steel cap. NS &amp; concrete pad 0.65 below cap.</td>
</tr>
<tr>
<td>RN018354</td>
<td>53</td>
<td>484241</td>
<td>7159204</td>
<td>218.27</td>
<td>0.5</td>
<td>217.77</td>
<td></td>
</tr>
<tr>
<td>RN018355</td>
<td>53</td>
<td>484242</td>
<td>7159202</td>
<td>218.30</td>
<td>0.54</td>
<td>217.76</td>
<td>Top of 0.22 diam steel cap.</td>
</tr>
<tr>
<td>RN018589</td>
<td>53</td>
<td>471046</td>
<td>7171627</td>
<td>237.27</td>
<td>0.55</td>
<td>236.72</td>
<td>Concrete pad 0.45 below MP.</td>
</tr>
<tr>
<td>RN018590</td>
<td>53</td>
<td>471107</td>
<td>7171549</td>
<td>237.37</td>
<td>0.35</td>
<td>237.02</td>
<td>Concrete pad 0.28 below MP.</td>
</tr>
<tr>
<td>RN018592</td>
<td>53</td>
<td>470967</td>
<td>7171751</td>
<td>236.64</td>
<td>0.71</td>
<td>235.93</td>
<td></td>
</tr>
<tr>
<td>RN018593</td>
<td>53</td>
<td>470967</td>
<td>7171751</td>
<td>236.66</td>
<td>0.75</td>
<td>235.92</td>
<td></td>
</tr>
<tr>
<td>RN018789</td>
<td>53</td>
<td>657196</td>
<td>7411966</td>
<td>249.44</td>
<td>0.94</td>
<td>248.50</td>
<td>MP is top 100mm PVC pipe.</td>
</tr>
<tr>
<td>RN018791</td>
<td>53</td>
<td>654515</td>
<td>7409259</td>
<td>248.65</td>
<td>0.94</td>
<td>247.71</td>
<td></td>
</tr>
<tr>
<td>RN018792</td>
<td>53</td>
<td>654512</td>
<td>7409262</td>
<td>248.68</td>
<td>0.97</td>
<td>247.71</td>
<td></td>
</tr>
<tr>
<td>RN018793</td>
<td>53</td>
<td>658789</td>
<td>7402841</td>
<td>239.49</td>
<td>0.5</td>
<td>238.99</td>
<td>Measuring point is top of steel casing.</td>
</tr>
<tr>
<td>RN018815</td>
<td>53</td>
<td>566944</td>
<td>7323292</td>
<td>256.71</td>
<td>0.95</td>
<td>255.76</td>
<td>Mp is top of PVC casing.</td>
</tr>
<tr>
<td>RN018818</td>
<td>53</td>
<td>564152</td>
<td>7330248</td>
<td>265.39</td>
<td>1.15</td>
<td>264.24</td>
<td>Top 8&quot; steel casing is 0.16 above MP.</td>
</tr>
</tbody>
</table>
Appendix C

Instrumentation Specification
### Table C1 Instrument Specifications – Hydroterra Pty Ltd Designed System Installed at McDills Bore (RN005028)

<table>
<thead>
<tr>
<th>Power</th>
<th>System is 12v, solar panel is 20watt, solar regulator is: Steca Solum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Works</td>
<td>Piping is all 40mm Diameter Stainless, all fittings are standard 40mm Stainless Fittings using 1&amp;1/2&quot; NPT thread sizes. The &quot;Flush Cut Pipe Joiner&quot; is a: Straub - Grip-L (Type: 20300)</td>
</tr>
<tr>
<td>Telemetry System</td>
<td>Telemetry system is a Unidata Neon RTU (Satellite Version - Serial Number: 5462. The Telemetry Unit is setup to log Hourly, and communicate with the Web server every Six Hours.</td>
</tr>
<tr>
<td>Sensor System</td>
<td>There are two Sensor setups as follows:</td>
</tr>
<tr>
<td>Flow Meter</td>
<td>The Flow Meter is a Arkon Flow Systems - MAG-X2 (Part Number: D40HR40SS - Fitted with a Pulse Output)</td>
</tr>
<tr>
<td>Module</td>
<td>Flange Version, 40mm Diameter. The MAG-X2 is provides a pulse output that is read by the Neon RTU. Wiring as follows:</td>
</tr>
<tr>
<td></td>
<td>Red &amp; White: 12v Positive Supply</td>
</tr>
<tr>
<td></td>
<td>Black &amp; Blue: Negative Supply</td>
</tr>
<tr>
<td></td>
<td>Brown: GND for Relay Reference</td>
</tr>
<tr>
<td></td>
<td>Green: RE1 Output from MAG-X2 to A0 input on Neon RTU. This is an error output.</td>
</tr>
<tr>
<td></td>
<td>Orange: RE2 Output from MAG-X2 to A1 input on Neon RTU. This is an error output.</td>
</tr>
<tr>
<td></td>
<td>Purple: RE3 Output from MAG-X2 to C0 input on Neon RTU. This provides a pulse per 5kilolitre.</td>
</tr>
<tr>
<td></td>
<td>Yellow: RE4 Output from MAG-X2 to C1 input on Neon RTU. This provides a pulse per 5kilolotre. (Back up output to RE3)</td>
</tr>
<tr>
<td>INW Sensor</td>
<td>The remaining sensor setup is a combination of INW products as follows:</td>
</tr>
<tr>
<td>Compensator</td>
<td>The INW Compensator measures Temperature and Barometric Pressure and is an interfacing box for other INW sensors. This unit communicates to the Neon RTU via SDI-12 (It is set to SDI-12 address 1). It also is connected to the CT2X noted below.</td>
</tr>
<tr>
<td>CT2X</td>
<td>The CT2X is a modified version of the standard CT2X. The CT2X measures Temperature, Pressure and Conductivity. It has been inserted into the Flow Cell via one of the female NPT fittings on top. It communicates with the Compensator via Modbus (it is set to Modbus Address2). Due to the high temperature expected in the FlowCell, the main electronics have been moved from the sensor housing to a remote Jiffy Box mounted on the underside of the Cage lid onsite. Wiring is as follows for the Compensator:</td>
</tr>
<tr>
<td></td>
<td>White: 12v Positive Supply</td>
</tr>
<tr>
<td></td>
<td>Blue: Negative Supply</td>
</tr>
<tr>
<td></td>
<td>Brown: SDI-12 Output to SDI-12 Input on Neon RTU.</td>
</tr>
</tbody>
</table>
Figure 3  McDills Pipework Layout
The 2015D Neon Remote Terminal – Globalstar Satellite

- Internet enabled
- Coverage in most countries
- Built-in logger
- Expandable via the Starlogger interface
- Modbus RS485 Interface
- SDI-12 interface for connection to a wide range of low power instruments
- On-board digital and analogue interfaces for direct connection to sensors and other instruments
- Built in logger with optional 8Mb on-board non-volatile flash memory archive

The 2015D NRT Satellite is a small self-contained unit which connects to sensors in the field, collects readings from those sensors, and transmits the collected data to a central server via satellite communications.

The Neon central server system is provided on a Neon Data Service basis and on a Neon Client System basis and provides a central computer system to monitor and receive data from many NRT units in the field.

The 2015D NRT Satellite is designed to automate collection of remote data from environmental monitoring, industrial measurements, and utility metering via the international Globalstar LEO Satellite network from any location on the globe, except the Arctic, Antarctica, and Africa.

Fully bi-directional communications are possible via the Neon server. Data can be collected directly and the NRT can be programmed from any internet connection.

The 2015D NRT Satellite supports integrated logging or automated collection of data from an external datalogger.

The 2015D NRT Satellite’s built-in modem supports packet data. Long battery life and low operating costs are made possible through use of advanced microcontroller technology and an efficient protocol that takes advantage of Globalstar’s packet transfer capability.

The 2015D NRT Satellite supports integrated logging or automated collection of data from an external datalogger.

Inputs include analog, digital and SDI 12 datalogger interface standard. There is also Modbus support, a partial implementation of the Modbus protocol which allows for extract data (get) and place data (put) from/to a specific register within the Modbus RTU on an RS485 connection.

(Further details on request)

---

Physical specifications
- **Material**: Anodised aluminium
- **Size**: 200 mm x 112 mm x 56 mm (ntwxh)
- **Weight**: 206 grams (including battery pack)
- **Operating temperature**: -20°C to 60°C. Not affected by humidity
- **Antennas**: External conical dielectric resonator 150 mm x 63 mm (DxH), (optional 1 metre cable)

Electrical specifications
- **Battery**: 10.5V/1.3Ah lithium (non-rechargeable)
- **Battery life**: 5 years (based on duty cycle)
- **External power**: 10.5 to 24V DC input available if required
- **Instrument power**: 5V unregulated supply (SMA max) plus 2.5V ref (SMA max)
- **IO**:
  - 4 x analog Inputs – 12 bit resolution
  - 1 x counter input – 16 bit/3MHz,
  - 3 x counter inputs – 16 bit/300kHz,
  - 3–5V DC signal (opto)
  - 1 x open collector output, 250mA maximum
  - 1 x MO (16 x 16 bit bi-directional, synchronous data) channel
- **SDI-12**: SDI-12 V1.3 encoder
- **Modbus**: R445/RTU, 19200 bps max, Funducable 0 to 2, 0, 04, 05/15, 36/16

Integrated logger specifications
- **Storage memory**: 30kB/15,000 readings – non-rotatable flash memory
- **Optional storage memory**: 8MB/40,000 readings – non-rotatable flash memory
- **Time clock**: Crystal regulated, +/- 10 seconds/month – automatically network synchronized
- **Scan rate**: Programmable from 1 second to 5 minutes

---

Figure 4 Satellite Remote Terminal Specifications
### Mechanical

**WEATHERPROOF BOX**

<table>
<thead>
<tr>
<th>Enclosure Material</th>
<th>ABS - IP66/67</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (box)</td>
<td>9.1” x 3.1” x 2.6” (23 x 8 x 6.5 cm)</td>
</tr>
<tr>
<td>Dimensions (incl connectors)</td>
<td>9.1” x 3.6” x 2.6” (23 x 9.1 x 6.5 cm)</td>
</tr>
</tbody>
</table>

### Operational

**TEMPERATURE CHANNEL**

<table>
<thead>
<tr>
<th>Element Type</th>
<th>Digital Temp. Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>± 0.5° C</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.06° C</td>
</tr>
<tr>
<td>Range</td>
<td>-40° C to 80° C</td>
</tr>
</tbody>
</table>

**PRESSURE CHANNEL**

<table>
<thead>
<tr>
<th>Element Type</th>
<th>0-16 PSIA (110 Kpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>±0.1% FSO (maximum)</td>
</tr>
<tr>
<td>(B.F.S.L 25° C)*</td>
<td>±0.06% FSO</td>
</tr>
<tr>
<td>Maximum</td>
<td>±0.25% FSO</td>
</tr>
<tr>
<td>Zero Offset at 25° C</td>
<td></td>
</tr>
<tr>
<td>Over Range Protection</td>
<td>2x</td>
</tr>
</tbody>
</table>

**VOLTAGE CHANNELS**

<table>
<thead>
<tr>
<th>Power Supply Channel</th>
<th>Range: 6-24 VDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Voltage Channel</td>
<td>Range: 0-28 VDC</td>
</tr>
</tbody>
</table>

### Power

<table>
<thead>
<tr>
<th>Supply Voltage</th>
<th>6-24 VDC</th>
</tr>
</thead>
</table>

### General

**COMMUNICATION**

<table>
<thead>
<tr>
<th>Communication</th>
<th>RS485 Modbus RTU &amp; SDI-12 (ver.1.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Modbus Read Output</td>
<td>32-bit IEEE Floating point</td>
</tr>
<tr>
<td>SDI-12 Output</td>
<td>ASCII</td>
</tr>
<tr>
<td>Internal Math</td>
<td>32 bit floating point</td>
</tr>
</tbody>
</table>

---

**Figure 5 Aquistar® Compensator Specifications**
<table>
<thead>
<tr>
<th>Dimensions and Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MECHANICAL</strong></td>
</tr>
<tr>
<td><strong>SENSOR</strong></td>
</tr>
<tr>
<td>Body Material</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Probe Material</td>
</tr>
<tr>
<td>Electrode</td>
</tr>
<tr>
<td>Wire Seal Materials</td>
</tr>
<tr>
<td>Desiccant</td>
</tr>
<tr>
<td>Terminating Connector</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Length</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Diameter</td>
</tr>
<tr>
<td><strong>CABLE</strong></td>
</tr>
<tr>
<td>OD</td>
</tr>
<tr>
<td>Break Strength</td>
</tr>
<tr>
<td>Maximum Length</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td><strong>ELECTRICAL</strong></td>
</tr>
<tr>
<td>CONDUCTIVITY</td>
</tr>
<tr>
<td>Static Accuracy</td>
</tr>
<tr>
<td>Range - Conductivity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Resolution</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Over Range Protection</td>
</tr>
<tr>
<td>Operating Temp. Range</td>
</tr>
<tr>
<td><strong>PRESSURE</strong></td>
</tr>
<tr>
<td>Static Accuracy</td>
</tr>
<tr>
<td>(B.F.S.L. 25°C)</td>
</tr>
<tr>
<td>Maximum Zero Offset</td>
</tr>
<tr>
<td>at 25°C</td>
</tr>
<tr>
<td>Resolution</td>
</tr>
<tr>
<td>Over Range Protection</td>
</tr>
<tr>
<td>Compensated Temp. Range</td>
</tr>
<tr>
<td><strong>TEMPERATURE</strong></td>
</tr>
<tr>
<td>Accuracy</td>
</tr>
<tr>
<td>Resolution</td>
</tr>
</tbody>
</table>

Figure 6 Aquistar® CT2X Specifications
<table>
<thead>
<tr>
<th>Module Name:</th>
<th>Symbol:</th>
<th>Ordering Code:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Module</td>
<td></td>
<td>‘230’****</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘24’****</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘12’****</td>
</tr>
</tbody>
</table>

**APPLICATIONS:**
Industrial Power Supplies 90-250 V AC, 24 V DC or 12 V DC Distributed Power Systems. This module is necessary for the complete flowmeter.

**Electrical Specifications**
- **Input Voltages ±5% / AC 90 - 250V / max. 15 VA**
- **possible current DC 24 V / max. 600mA**
- **consumption DC 12 V / max. 1050mA**
- **Output Voltages 3.3V / 2A**
- **23.6V/300mA**
- **Frequency Outputs 50-60Hz**
- **Temp. Range -20 – 70 °C**
- **Dimensions:**
  - R = 50mm
  - H(230V) = 58mm
  - H(12,24V) = 68mm
- **Weight** 300g

The device does not have a network power switch. For any electrical work or housing open it is necessary to disconnect the device from the network power, and this has to be done via a switch. The mains protective earth wire has to be connected to the PE terminal (power supply class 1). A switch or circuit breaker (max. 15A) has to be in the building installation if mains supply 90 – 250 V AC from building installation is connected to the power supply module. It must be in close proximity to the equipment and within easy reach of the operator, and it shall be marked as the disconnecting device for the flowmeter.

<table>
<thead>
<tr>
<th>90-250 V AC / 15VA</th>
<th>24 V DC / 600mA</th>
<th>12 V DC / 1050mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended power supply cable minimum 3xØ1mm²</td>
<td>Recommended power supply cable minimum 2xØ0.5mm²</td>
<td>Recommended power supply cable minimum 2xØ0.5mm²</td>
</tr>
</tbody>
</table>

All used wires have to be round crosscut cables.

Any connection or disconnection of any module has to be done with the network power to the meter switched off.

**Figure 7 MAGX2 Power Supply Module Specifications**
Figure 8  arkon® Flow System Controller (MAGX2) Module
Table C2  Instrument Specification – In-Situ® Level TROLL 300 used in GAB Sub-Artesian Monitoring Bores

<table>
<thead>
<tr>
<th>Product Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level TROLL 300 instrument</strong></td>
</tr>
<tr>
<td><strong>General</strong></td>
</tr>
</tbody>
</table>
| Temperature ranges¹ | Operational: -20-60° C (-4-140° F)  
| Storage: -40-60° C (-40-140° F)  
| Calibrated: -5-60° C (-23-122° F) |  
| Diameter | 2.08 cm (0.82 in.) |  
| Length | 22.0 cm (0.87 in.) |  
| Weight | 245 g (8.6 oz) |  
| Materials | Stainless steel body; Delrin nose cone |  
| Output options | Modbus RS485, SDI-12, 4-20 mA |  
| Battery type & life² | 3.6V lithium, 10 years or 2M readings |  
| External power | 8-36 VDC |  
| Memory | 1.0 MB |  
| Data records³ | 86,000 |  
| Data logs | 2 |  
| Log types | Linear, Fast Linear, and Event |  
| Fastest logging rate & Modbus rate | 2 per second |  
| Fastest SDI-12 & 4-20 mA output rate | 1 per second |  
| Real-time clock | Accurate to 1 second/24-hr period |  
| Sensor Type/Material | Piezoresistive, stainless steel |  
| Range | Absolute (non-vented) |  
| 30 psia: 10.9 in (55.5 ft) |  
| 100 psia: 60.1 m (197.3 ft) |  
| 300 psia: 200.7 m (656.7 ft) |  
| Burst pressure | Max. 2x range; burst > 3x range |  
| Accuracy @ 15°C¹ | ±0.1% full scale (FS) |  
| Accuracy (FS)² | ±0.2% FS |  
| Resolution | ±0.01% FS or better |  
| Units of measure | Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH₂O, inH₂O  
| Level: in, ft, mm, cm, m |  
| Temperature Sensor | Accuracy & resolution | ±0.1°C; ±0.01°C or better |  
| Units of measure | Celsius or Fahrenheit |  
| Warranty | 1 year |  
| Up to 5-year extended warranties are available for all instruments—call for details |  

¹ Temperature range for non-freezing liquids  
² Typical battery life when used within the factory-calibrated temperature range.  
³ 1 data record = date/time plus 2 parameters logged (no wrapping) from device within the factory-calibrated temperature range  
⁴ Across factory-calibrated pressure range  
⁵ Across factory-calibrated pressure and temperature ranges  
Specifications are subject to change without notice. Delrin is a registered trademark of E.I. du Pont de Nemours and Company.

Footnotes

1-800-446-7488  
www.in-situ.com
### Table C3  Instrument Specification – In-Situ® BaroTROLL

**BaroTROLL Instrument**

The titanium BaroTROLL measures and logs barometric pressure and temperature. Use the BaroTROLL in conjunction with non-vented In-Situ Instruments.

Win-Situ BaroMerge Software simplifies post-correction of water level data by automatically subtracting barometric readings from data collected by a non-vented instrument to compensate for changes in pressure due to barometric fluctuations.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>Temperature range(^1)</td>
<td>Operational: -20-80°C (-4-176°F)</td>
</tr>
<tr>
<td></td>
<td>Storage: 40-80°C (40-176°F)</td>
</tr>
<tr>
<td></td>
<td>Calibrated: -5-50°C (-21-122°F)</td>
</tr>
<tr>
<td>Diameter</td>
<td>1.83 cm (0.72 in.)</td>
</tr>
<tr>
<td>Length</td>
<td>21.8 cm (8.6 in.)</td>
</tr>
<tr>
<td>Weight</td>
<td>107 g (3.93 lb)</td>
</tr>
<tr>
<td>Material</td>
<td>Titanium body; Delrin nose cone</td>
</tr>
<tr>
<td>Output options</td>
<td>Modbus/RS485, SDI-12, 4-20 mA</td>
</tr>
<tr>
<td>Battery type &amp; life(^2)</td>
<td>3.6V lithium; 10 years or 2M readings</td>
</tr>
<tr>
<td>External power</td>
<td>6-35 VDC</td>
</tr>
<tr>
<td>Memory</td>
<td>1.0 MB</td>
</tr>
<tr>
<td>Data record</td>
<td>65,000</td>
</tr>
<tr>
<td>Data logs</td>
<td>2</td>
</tr>
<tr>
<td>Log type</td>
<td>Linear</td>
</tr>
<tr>
<td>Fastest logging rate &amp; Modbus rate</td>
<td>1 per minute</td>
</tr>
<tr>
<td>Fastest SDI-12 &amp; 4-20 mA output rate</td>
<td>1 per second</td>
</tr>
<tr>
<td>Real-time clock</td>
<td>Accurate to 1 second/24-hr period</td>
</tr>
<tr>
<td>Sensor Type/Material</td>
<td>Piezoresistive, titanium</td>
</tr>
<tr>
<td>Range</td>
<td>0 to 16.5 psi; 0 to 1.14 bar</td>
</tr>
<tr>
<td>Burst pressure</td>
<td>Vacuum/over-pressure above 16.5 psi damages sensor</td>
</tr>
<tr>
<td>Accuracy @ 10°C(^4)</td>
<td>±0.1% FS</td>
</tr>
<tr>
<td>Accuracy (°F)(^5)</td>
<td>±0.2% FS</td>
</tr>
<tr>
<td>Resolution</td>
<td>±0.015% FS or better</td>
</tr>
<tr>
<td>Units of measure</td>
<td>Pressure: psi, kPa, bar, mbar, mmHg, in Hg, cm H₂O, inH₂O</td>
</tr>
<tr>
<td>Temperature Sensor</td>
<td></td>
</tr>
<tr>
<td>Accuracy &amp; resolution</td>
<td>±0.1°C; 0.01°F or better</td>
</tr>
<tr>
<td>Units of measure</td>
<td>Celsius or Fahrenheit</td>
</tr>
<tr>
<td>Warranty</td>
<td>2 years</td>
</tr>
<tr>
<td>Footnotes</td>
<td>See See page 9.</td>
</tr>
</tbody>
</table>

Up to 5-year extended warranties are available for all instruments—call for details.

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1-800-446-7488

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Appendix D

McDills Telemetered Installation
Plate 1  Discharge Pipe at McDills Bore

Plate 2  McDills Bore Discharging into Pool
Plate 3 McDills Bore (under cover)

Plate 4 Headworks at McDills Bore (discharge line top right corner)
Plate 5 Instrumentation Setup (caged) at McDills Bore

Plate 6 McDills Instrumentation