Summary of past drilling activity within the Great Artesian Basin

November 2017

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This report should be attributed as

GABCC 2017, Summary of past drilling activity within the Great Artesian Basin, *Great Artesian Basin Coordinating Committee, 2017*

Disclaimer:

"The data provided in this report are estimates only and collated by the GABCC authors based on best available information during 2015 from relevant departmental data bases. While reasonable efforts have been made to ensure that the information is up to date, the authors do not accept responsibility for any errors, accuracy or completeness of the information, and shall not be liable for any loss or damage that may be caused directly or indirectly through the use of, or reliance on, the information in this publication".

Contents

1 Executive Summary

The Great Artesian Basin Coordinating Committee (GABCC) requested bore hole data from the state and territory government databases to be collated to estimate the number of bore holes that have been drilled into the Great Artesian Basin (GAB). This is to inform discussions on the legacy of the 140 years of past drilling activity with respect to the long term management of the groundwater resources of the GAB.

Data from 50,508 bore records were extracted from the Queensland, New South Wales, South Australia and Northern Territory databases during 2015. Fifty six percent of these bore records related to water supply bores with the remaining bore hole data primarily associated with drilling by the mineral and resources industry. The exception to this was the dataset from Queensland which only focussed on water supply bore data from the Queensland groundwater database.

Further review of the dataset was focused on the 38,174 water bores of which over 30% were drilled over 50 years ago. A large number (72%) of the water supply bores are shallow, i.e. 23,507 are less than 200m. These shallower bores are considered to be of a lesser consequence if failure occurs when compared to the deeper bores that are more likely to intercept artesian or significant groundwater pressures.

A total of 6,629 water supply bores have been drilled to depths expected to have artesian, or to depths that have previously been artesian, conditions and therefore requiring pressure cementing. Of these, 57 percent (2,748) were drilled prior to 1960 before pressure cementing of water supply bores was widely adopted. Their current status, whether they have been controlled, have ceased to flow or have been decommissioned, was not able to be determined from the data collated for this report.

There are 535 artesian bores with uncontrolled flow which represent a high risk group with regard to resource management. Of these 463 were constructed prior to 1960 however it is possible a proportion of these bores have been reconditioned since their initial construction.

The estimated replacement value of the existing water supply bores greater than 200 metres is $3,258 million. Improvements in technology and design, particularly for reticulation systems, would result in a smaller number of bores being required to service the current water needs of the GAB industries and communities. For example, one replacement bore could retire 2 or 3 existing bores.

For future data extractions it is recommended that the large number of shallow non-artesian bores in the GAB are not included unless a particular issue regarding these shallow bores is being considered. It is also recommended that consideration of water supply bores be separated from coal, oil and gas exploration and production drilling. The drilling and reporting standards of these two datasets are vastly different and it was not possible to collate all state data for this report. It would be more informative to analyse these separately and then combine the findings to identify high risk groups of bores or drilling activities.

2 Introduction

Since the first flowing bore in the Great Artesian Basin (GAB) was drilled in 1878 near Bourke, New South Wales, over 50,000 bore holes have been drilled across the basin. Drilling was initially focused on securing reliable water supplies in the low rainfall areas that coincide with much of the GAB's geographic extent. Whilst this is still a primary focus of the current drilling activity, in the last thirty years there has been a significant increase in drilling associated with the development of the resource industries.

Given the long history of drilling into the GAB and the continual evolution of technologies and standards for drilling over this time, there have been a range of bore construction materials and design as well as construction and decommissioning methods employed in the existing bore holes. The legacy of this drilling, both in terms of the potential risk to the long term management of the groundwater resources and the ongoing maintenance requirements of the bores, is an issue being considered by the GAB Coordinating Committee (GABCC) in the development of future management options.

To determine the scale of the issue for consideration in the new GAB Strategic Management Plan, the GABCC requested government jurisdictions to collate data on all bores and previous drilling activity in the GAB. This report is a compilation of publicly available data from the state data archives of New South Wales, Queensland, South Australia and the Northern Territory.

2.1 Scope

The scope of this report includes (where possible) all bores drilled into the GAB, including the recharge and non artesian areas of the GAB. This includes

- water supply bores
- groundwater monitoring bores
- groundwater exploration bores
- coal exploration bores
- conventional gas exploration and production bores/wells
- unconventional gas exploration and production bores/wells
- petroleum exploration and production bores/wells
- geothermal energy bores, and
- mineral exploration holes.

Not included in this data compilation are shallow bores that have been completed in sediments overlying the GAB such as the Cenozoic alluvium associated with the present day river systems.

This data is presented in a series of tables and graphs which combines data for the whole of the GAB. Each jurisdiction has compiled a further break up of these data which is reported in the report Appendices.

2.2 Limitations of the Data

With 140 years of drilling history it is to be expected there is considerable variation in the detail and currency of the data record across the Basin states.

In the compilation of the data it has been necessary to interpret, group and filter data to achieve the best estimate for the issue being considered by the GABCC. The use of this data to inform other management decisions outside of the constraints of this compilation may lead to incorrect conclusions. Clarification on any of the data reported here should be directed to the relevant state government agency that manages the data within that jurisdiction.

Queensland provided a subset of this request, providing information from its state groundwater database. This excludes most resource related exploration and production wells but includes groundwater monitoring wells and production wells converted for water supply.

For the purposes of this report the term artesian refers to conditions that result in groundwater rising above the surface of the ground under its own pressure, either via a spring or when accessed by a bore. Sub artesian refers to conditions where the groundwater pressure causes the groundwater to rise in a bore but it is not sufficient for it to rise above the ground surface.

3 Summary of all available data

3.1 Total number of reported bore holes drilled

Table 1 summarises data for 50,508 bore holes recorded as being drilled into or through the GAB across the four jurisdictions according to their intended purpose at the time of construction. The categories were selected after consideration of the capability of each jurisdiction's data bases to provide a consistent reporting base.

The current utilisation of an asset may have changed since construction, or it may be used for multiple purposes, however the original purpose is considered to provide a better indicator of the type of construction used and consequent indicator of potential maintenance issues.

An example of a bore having multiple purposes is a water supply bore also being used as a pressure and flow monitoring point in a state based monitoring program. Its initial and ongoing primary purpose is water supply and it would be reported below in this category.

Table 1: Total number of boreholes and their intended purpose at construction.

Bore purpose	NSW	NT	Qld[1]	SA	Total
Water supply	9,232	125	26,042	2,775	38,174
Groundwater monitoring	299	7	252	61	619
Coal & mineral exploration	326	0	422[2]	6,524	7,272
Oil/gas exploration/production	237	16	428[2]	2,061	2,742
Other / not recorded	811	161	441[2]	288	1,701
Total	10,905	309	27,585	11,709	***50,508***

[1]The Qld groundwater database records the most recently recorded purpose of a water bore, not necessarily the original purpose. This misalignment with other states data is expected to have minimal effect on the results of this assessment as the purpose of most bores does not change over time.
[2]Qld data on coal, mineral, gas and oil wells is not included. Only data from the Qld groundwater database has been included in this report.

3.2 Date of construction

Table 2 reports the date of construction, or drilling, on a decadal basis for all bores within the scope of this report and this is displayed graphically in Figure 1. The date of construction across the whole GAB according to categories is shown in Figure 2.

Table 2: Date of drilling for all bores across the four jurisdictions.

Drilled date	NSW	NT	Qld[1]	SA	Total
Pre 1900	151	0	288	15	454
1900 - 1909	258	1	420	17	696
1910 - 1919	506	0	944	48	1,499
1920 - 1929	918	4	654	220	1,795
1930 - 1939	802	2	1,062	73	1,939
1940 - 1949	652	4	1,326	120	2,102
1950 -1959	1,531	22	2,279	181	4,013
1960 - 1969	1,138	34	3,513	365	5,050
1970 - 1979	564	25	2,607	1,883	5,079
1980 - 1989	941	42	3,525	2,371	6,879
1990 - 1999	1,103	27	3,357	3,458	7,945
2000 - 2009	947	48	4,097	1,952	7,044
2010 - 2015	354	26	1,677	671	2,728
No date recorded	1,040	74	1,836	335	3,285
TOTAL	10,905	309	27,585	11,709	***50,508***

[1]Qld data on coal, mineral, gas and oil wells is not included. Only data from the Qld groundwater database has been included in this report.

Figure 1 Number of bores drilled per decade

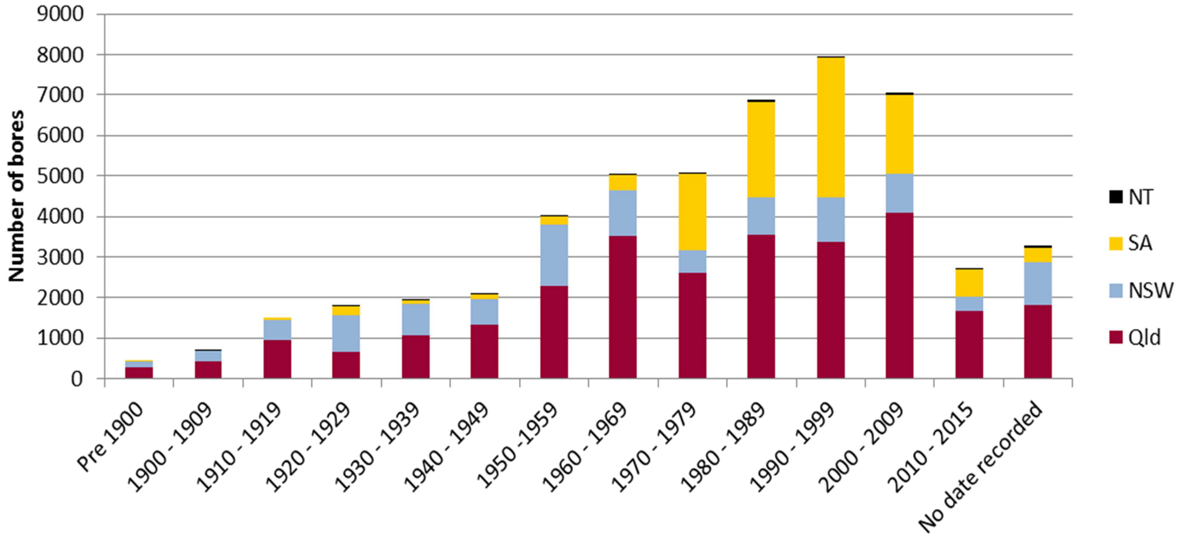
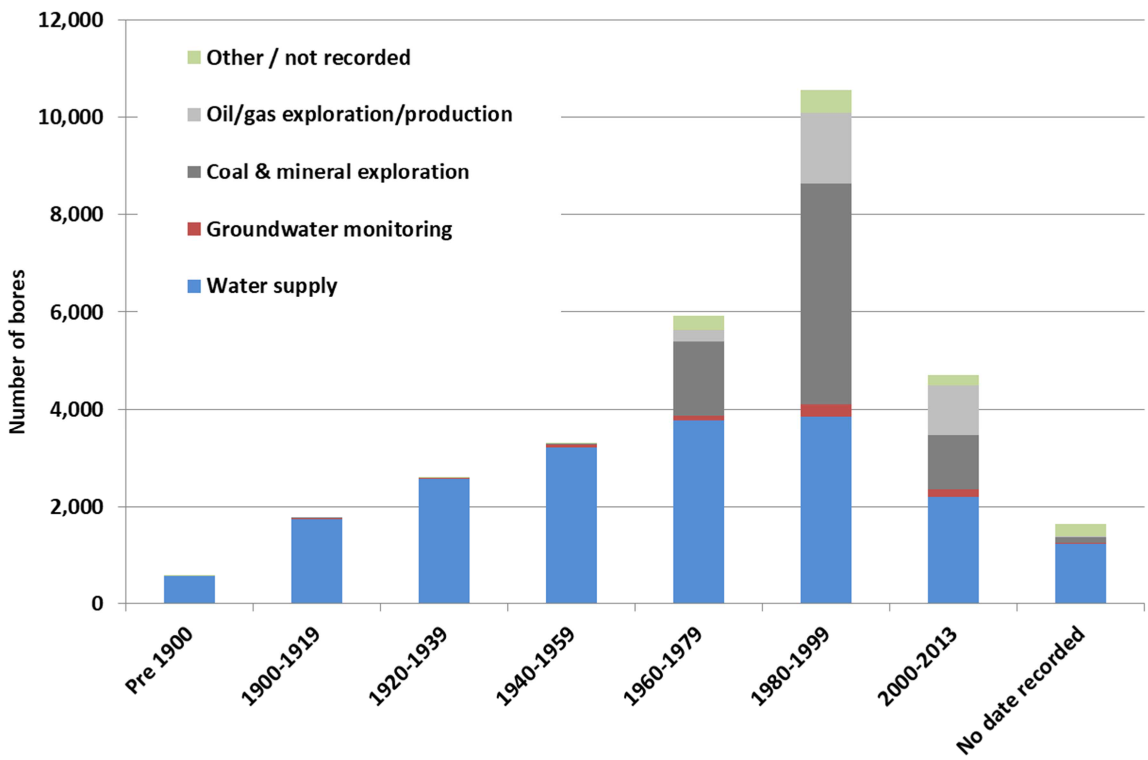


Figure 2 Number of bores drilled showing original purpose of drilling



4 Water bore data

The focus of the data compilation was to establish an understanding of the water supply bore data and how this could inform groundwater resource management within the GAB. As this is the only complete sub set of the data across all jurisdictions further breakdown of the data was limited to water bore information.

4.1 Drilling in areas of artesian conditions

The age profile for water supply bores shown in Figure 2 indicates that over 30 percent of these bores were drilled over 50 years ago. This also includes a significant number of bores that are sub artesian. That is, bores that are either shallower than the underlying artesian aquifers, or are drilled in areas where artesian conditions do not occur.

Drilling and bore construction in artesian conditions must be able to accommodate the higher groundwater pressures and control flows to the surface. Consequently the drilling and construction standards for these conditions are more stringent to cope with this pressure. Early drilling activity, however, will not have employed aquifer isolation techniques as is the current practice and older bores that have not been reconditioned pose a higher risk of allowing flow between aquifers to occur via the borehole. This may be due to breached casing from corrosion, poor or little cementing resulting in ineffective sealing of the bore annulus. Non isolation of aquifers by the bore can compromise groundwater quality if there is a significant difference in groundwater water chemistry. These bores may also not have adequate headworks to control water flow.

Issues associated with inter aquifer leakage due to drilling or bore construction is not limited to artesian conditions. It can also be an issue in sub artesian areas if multiple aquifers are intersected with different pressure heads. However areas with artesian pressure conditions, or had artesian conditions before widespread aquifer depressurisation, are known areas that have potential for aquifer leakage if not managed appropriately.

Table 3 includes the number of

- water bores that obtained a flowing supply at the time of construction, and
- water bores drilled into areas to depths where artesian conditions exist, or previously existed under pre development pressure heads.

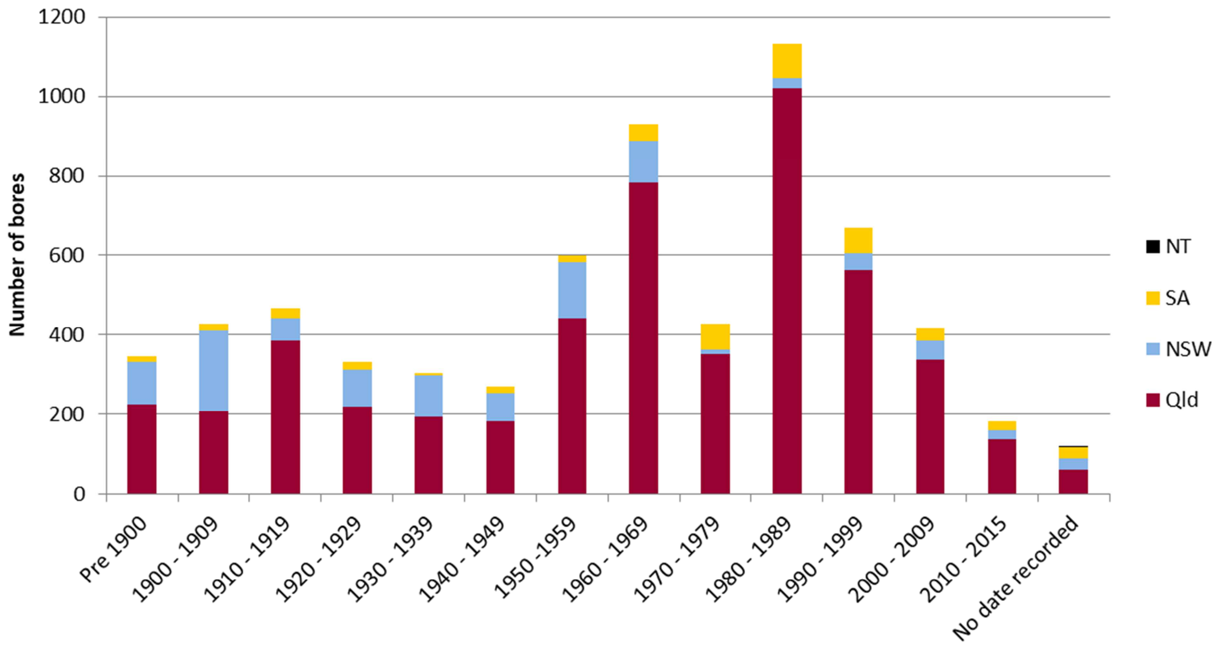
This data is also shown graphically in Figure 3.

It should be clarified this is not an indication of the water bores that are currently flowing or have flowed in the past, nor of the number of bores where the casing or sealing is compromised. The data indicates the minimum number of bores that required drilling and construction standards to ensure aquifer isolation and sealing. This data can inform an understanding of the potential risk from bores drilled prior to widespread adoption of aquifer isolation during drilling and construction. It has less relevance to more recent drilling activity. This is an underestimate of the bore holes in which there is potential for inter aquifer flow exchange as bores in areas of sub artesian pressure also have this potential. A more conservative approach would be to suggest all bores have the potential to allow inter aquifer exchange.

Table 3: Number of water supply bores drilled in artesian conditions, or previously artesian, at the time of construction.

Drilled date	NSW	NT	Qld	SA	Total
Pre 1900	107		226	14	347
1900 - 1909	205		207	17	429
1910 - 1919	56		385	27	468
1920 - 1929	94		218	19	331
1930 - 1939	105		194	5	304
1940 - 1949	72		182	15	269
1950 -1959	141		442	17	600
1960 - 1969	104		784	42	930
1970 - 1979	11		352	65	428
1980 - 1989	24		1,020	89	1,133
1990 - 1999	42		564	64	670
2000 - 2009	49		338	31	418
2010 - 2015	24		137	21	182
No date recorded	29	1	62	28	120
TOTAL	1,063	1	5,111	454	***6,629***

Figure 3: Number of water supply bores drilled in artesian conditions, or previously artesian, at the time of construction



4.2 Water supply bore depths

To provide an indication of the value of the water supply bore assets in the GAB that are currently being utilised, the total combined depth of all water supply bores not recorded as decommissioned is given in Table 4 below with the number of bores in each category.

Water bores that are reported to be decommissioned, that is appropriately sealed or plugged, does not include those bores that are reported to be abandoned, i.e. no longer used. There are relatively few bores where this information is reported outside Queensland which has 1,051 artesian water supply bores listed as decommissioned with an additional 4,872 sub-artesian bores. South Australia has 245 water supply bores reported as decommissioned and 167 water bores are reported decommissioned in NSW.

Whilst information on bores decommissioned under the GAB Sustainability Initiative (GABSI) is available, the decommissioning of private bores is not routinely provided to some State agencies so the information available on the current status of bores is not complete.

Of the 38,174 water supply bores registered on the state databases, 14% have no depth data and consequently these bores are not included in the depth totals in Table 4.

Table 4: Number and total depth (metres) of current water supply bores

Bore depth category	NSW		NT		Qld		SA[2]		Total	
	No.	Depth	No.	Depth	No.	Depth	No.	Depth	No.	Depth
Less than 200m	6,300	500,655	107	9,117	16,970	1,394,082	130	13,047	23,507	1,916,901
200-400m	1,199	339,806	10	2,745	3,603	1,012,120	67	19,187	4,879	373,858
400-600m	383	184,153	8	11,216	1,257	614,936	39	19,729	1,687	830,034
600-800m	154	103,824			549	376,422	19	12,022	722	492,268
800-1,000m	38	32,731			399	356,184	4	3,477	441	392,392
1,000-1,200m	49	53,132			331	364,220	5	5424	385	421,515
Greater than 1,200m	12	15,514			1,126	1,980,069[1]	24	33,409	1,162	2,028,992
TOTAL	8,135	1,229,815	125	23078	24,235	6,098,033	288	104, 098	***32,783***	***7,455,024***

[1]There are a number of petroleum wells converted to water bores in this group and an estimate of the total depth is provided here.

[2] – figures for SA are for artesian wells only.

4.3 Estimated replacement value of water supply bores

Indicative replacement costs of the water supply bores in the GAB are given in Table 5. These values are very rudimentary as drilling and construction costs vary with depth, drilling conditions, site accessibility, casing specifications, bore and headwork design. In addition, each state has used a different method to place a valuation on these assets.

Notwithstanding these limitations, the values given below provide an order of magnitude estimate of the replacement costs of the water supply bore assets of the GAB. It also provides an indication of the magnitude of investment made in the GAB to secure groundwater supplies that are reliant on future management of the GAB to ensure ongoing access to the resource.

Table 5: Indicative costs ($ million) of replacement of water supply bores

Bore depth	NSW	NT	Qld	SA[1]	Total
Less than 200m	250.33	5.47	828.08	9.13	1,093.02
200-400 m	163.11	2.52	601.20	13.43	780.25
400-600 m	88.39	6.66	365.27	22.10	482.43
600-800 m	45.68		223.59	12.85	282.12
800-1,000 m	13.09		211.57	5.84	230.51
1,000-1,200 m	21.25		216.35	6.99	244.59
Greater than 1,200 m	6.21		1,176.16	56.13	1,238.49
TOTAL	588.06	14.65	3,622.23	126.47	***4,351.41***

[1] – figures for SA are for artesian wells only.

Data on the current status of the bores is not always available and it is expected that this total includes water supply bores that are no longer in service. There would also be some water supply bores that are not registered on State data systems. The likelihood of this is expected to diminish with the depth of the bore due to the size of the investment involved and consequent risks to that investment, and compliance oversight by drilling contractors.

This estimate excludes the replacement cost of the 14% of water supply bores that have no depth data as these could not be included in the cost estimate. It is unknown what proportion of these bores would be greater than 200 metres.

Improvements in technology and design compared to the original date of construction of the existing water supply bores, particularly for reticulation systems, is expected to result in a smaller number of bores to service the current water needs of the GAB industries and communities. That is one replacement bores may retire 2 or 3 existing bores. This has been the case for many of the GABSI bore capping projects.

4.4 Number of bores with uncontrolled artesian flow

Changes to the artesian flow status of water bores are not always reported, but there is more consistent reporting associated with a state monitoring program or where bores have been part of GABSI programs. Similarly, changes to bores' structural integrity and their capability to shut off or restrict artesian flows changes with time and are not necessarily reported to state government agencies and captured on the relevant databases. The number of bores under artesian conditions varies in response to changes to the groundwater pressure distribution across the GAB. To reliably report the condition of the bores at any particular time a comprehensive census would be required.

The data reported in Table 6 is based on the best available information however in some cases this information may be more than 20 years old and consequently not considered up to date.

Table 6: Number of boreholes that have an uncontrolled artesian flow in 2015.

Drilled date	NSW	NT	Qld	SA (as at Dec 2015)	Total
Pre 1900	24		46		70
1900 - 1909	45		26		71
1910 - 1919	9		50	4	63
1920 - 1929	38		34	4	76
1930 - 1939	42		30		72
1940 - 1949	25		21	3	49
1950 -1959	34		26	2	62
1960 - 1969	13		22	2	37
1970 - 1979			12	1	13
1980 - 1989			14	2	16
1991 - 1999					0
2000 - 2009					0
2010 - 2015					0
No date recorded	1			5	6
TOTAL	231	0	281	23	***535***

5 Discussion

The compilation of this data was initiated to inform discussions on the legacy of past drilling activity with respect to the long term management of the groundwater resources of the GAB. It has provided an overview of the age profile of boreholes and the basic data on which to estimate the replacement costs of the water supply bore infrastructure in the GAB. There is potential to further inform this discussion with more tailored data extractions.

The scope of this report included all water supply bores within the GAB, including shallow bores completed in the unconfined sections of the GAB. These shallow bores are typically located along the margin of the GAB and generally do not require specialist drilling equipment to manage high pressure or flows.

As a broad category, bores less than 200m may be considered to be of lesser consequence if failure occurs when compared to the deeper bores. However it should be recognised that within this depth category there would be areas of the GAB that both artesian and sub artesian conditions exist. Future data extractions could consider a more targeted approach in identifying the higher risk water bores in terms of their construction within this zone.

Whilst the total estimated replacement costs of those water supply bores in the GAB that depth data is available is $4,351 million, excluding the shallower bores (a total number of 23,507 bores), the estimated replacement value of the 9,276 water supply bores that are greater than 200m is $3,258 million.

Pressure cementing of water supply bore holes was not widely adopted until the 1950s-1960s when jurisdictions required artesian flows of new bores to be controlled and capped. Of the 38,174 water bores drilled, at least 6,629 were drilled to depths expected to have artesian, or previously artesian, conditions and therefore requiring pressure cementing. Of these, 57 percent (2,748) were drilled prior to 1960. From the data available for this review the proportion of these bores that have been decommissioned or reconditioned to current standards to prevent inter-aquifer leakage and to manage artesian flows via appropriate headworks could not be ascertained. The government databases could be interrogated specifically to do this in the future although there is limited information on the current condition status of private bores in NSW.

The 535 bores with uncontrolled flow represent a high risk group with regard to resource management. Of these 463 were constructed prior to 1960. For many of these the actual flows to surface are very small however given their age and likely casing integrity there is expected to be many that have flow loss through breached casing below ground surface. States have been progressing the repair or capping of these bores (refer Appendix E). There may also be a proportion of currently sub artesian bores which will become artesian as basin pressure increases due to the previous water saving programs. The increase in basin pressures can also result in an increase in the rate of inter aquifer leakage via breached casing.

It is recommended that future reviews of drilling activities in the GAB consider water supply bores separately from coal, oil and gas exploration and production drilling. The drilling and reporting standards are vastly different and it would be more informative to analyse these separately and then combine the findings to identify high risk groups of bores or drilling activities.

Appendix A. NSW Data

NSW GAB groundwater management units

There are eight groundwater sources within the GAB in NSW. These are managed across two water sharing plans. These are the

- Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008, and the
- Water sharing plan for the NSW Great Artesian Basin Shallow Groundwater Sources 2011.

Map 1 shows the five groundwater sources defined in the Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008 which primarily manages groundwater within the principal Jurassic and Cretaceous aquifers that supply artesian water supplies. Two of these groundwater sources cover the recharge areas of the NSW GAB, these are the Eastern Recharge Groundwater Source and the Southern Recharge Groundwater Source. The Surat Groundwater Source, Warrego Groundwater Source and the Central Groundwater source typically have artesian conditions.

Shallow bores, less than 60m, also obtain supplies from the near surface Cretaceous sequences. These are typically low yielding bores of brackish to saline groundwater. These shallow aquifers are managed separately to the underlying artesian aquifers under the Water sharing plan for the NSW Great Artesian Basin Shallow Groundwater Sources 2011. The water sources are the Surat Shallow Groundwater Source, Warrego Shallow Groundwater Source and the Central Shallow Groundwater Source.

These shallow groundwater sources are identical in spatial extent to the underlying deep GAB water sources and for the purposes of this report the shallow and deep groundwater sources are reported together in Table 7 as they represent the same geographic area.

Table 7: Distribution of boreholes across the NSW groundwater sources

Bore purpose	Eastern Recharge	Southern Recharge	Surat & Surat Shallow	Warrego & Warrego Shallow	Central & Central Shallow	Total
Water supply	1,215	4,054	2,229	773	961	9,232
Groundwater monitoring	16	74	207	2	0	299
Coal & mineral exploration	12	212	80	9	13	326
Oil/gas exploration/production	4	188	35		10	237
Other / not recorded	26	194	233	90	268	811
Total	1,273	4,722	2,784	874	1,252	***10,905***

Summary of Groundwater monitoring data in NSW

The current NSW GAB monitoring program includes a range of monitoring frequency from telemetered data loggers providing real time data via the internet or mobile devices to manual monitoring on a biennial frequency. Therefore to obtain the full suite of GAB monitoring sites in NSW Table 8 summarises the data archived over the last two years.

Table 8: Pressure and temperature data monitored in NSW from 2013 - 2015

	Number of bores monitored	Max value	Min value
Pressure at headworks (kPa)	74	830	7
Unrestricted Flow (L/s)	69	54	0.5
Temperature (^{o}C)	70	74	23

Summary of NSW borehole data

Table 9 provides a summary of the 10,905 boreholes in NSW portion of the GAB based on the initial bore purpose and the year of its construction.

These are also shown spatially in the accompanying map.

Map 1: Groundwater sources of the Water Sharing Plan for the NSW Great Artesian Basin

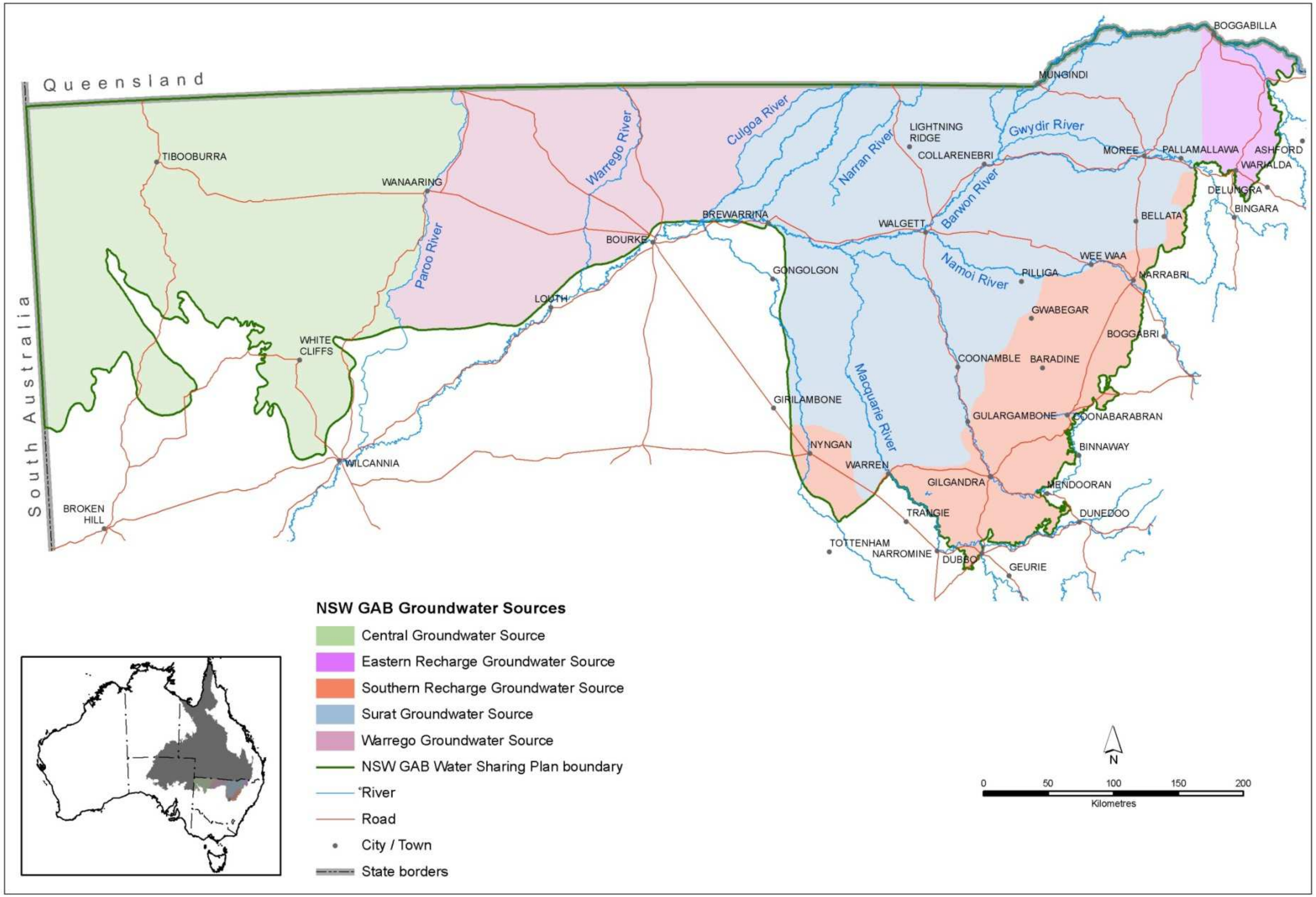
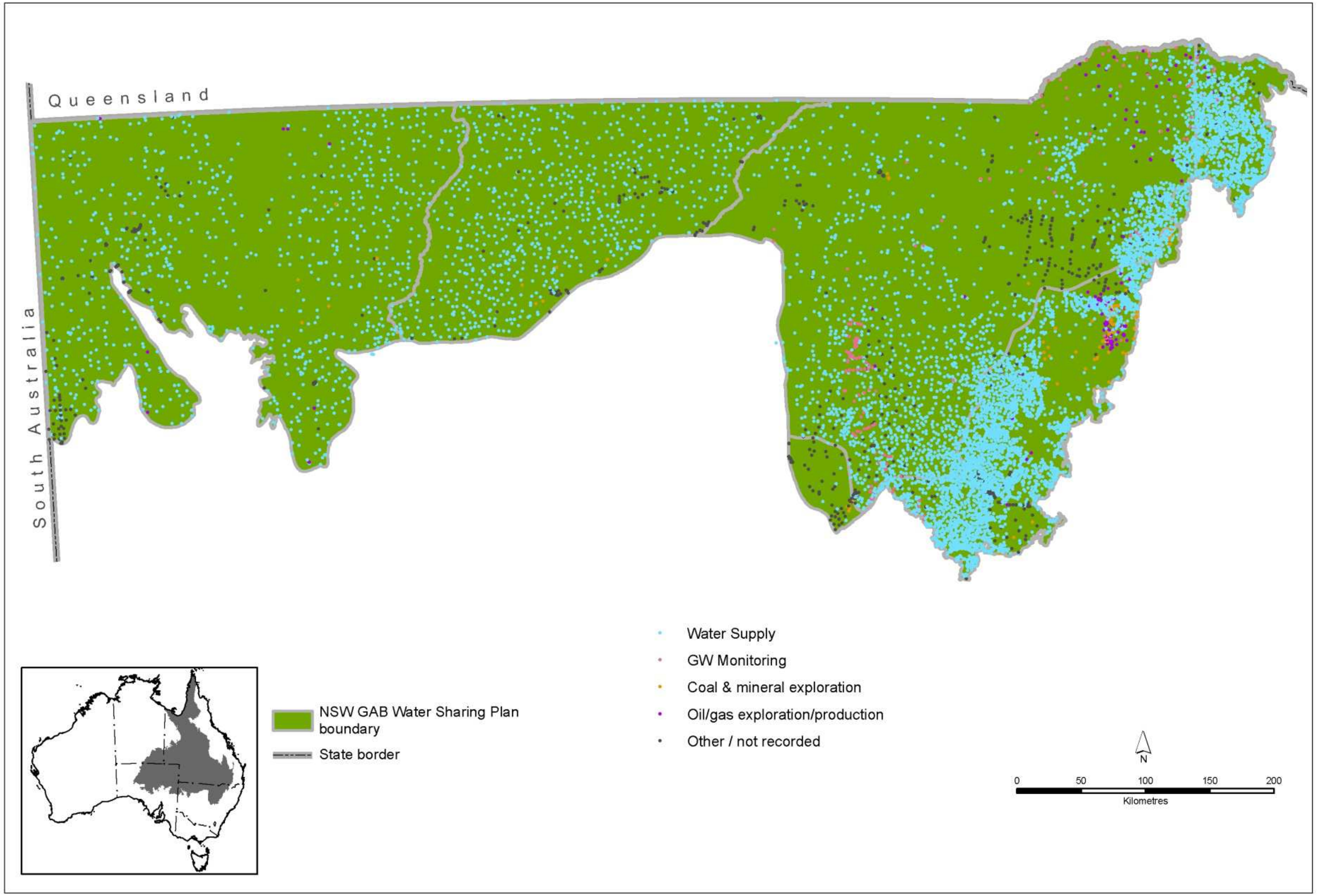


Table 9: Date of construction

Bore purpose	Pre 1900	1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2015	No Date
Water supply	151	258	506	918	802	652	1,531	1,101	433	694	669	557	185	775
Groundwater monitoring									8	7	131	73	79	1
Coal & mineral exploration									12	101	72	42	29	70
Oil/gas exploration/production								22	4	10	19	136	46	
Other / not recorded								15	107	129	212	139	15	194
Total	151	258	506	918	802	652	1,531	1,138	564	941	1,103	947	354	1,040

Map 2 Boreholes in NSW GAB showing the intended purpose at the time of construction



Appendix B. Northern Territory Data

NT GAB groundwater management

The NT GAB Water Control District was declared in 2010 to enable regulation of all water extraction under the NT Water Act as a prerequisite to the water allocation planning process. A draft GAB Water Allocation Plan was released for public comment in 2012. The final Plan is anticipated to be declared in 2018/19.

The draft Plan area in the south-east corner of the Northern Territory is equivalent to about six per cent of the Northern Territory. This area of approximately 86 500 km^2, is based upon the sediments and outcropping of the Eromanga Basin within the Northern Territory. In the NT, the sediments of the Algebuckina Sandstone and Cadna-owie Formation represent the GAB aquifer.

Groundwater is the important consumptive water resource within the District and is currently extracted for unlicensed stock and domestic use, and for a licensed public water supply to the community of Finke. However, surface water has environmental and cultural significance and as a source of recharge to the GAB aquifer.

A significant increase in groundwater extraction may be anticipated should the current wave of oil, coal and gas mining exploration materialise as on-ground developments. Water use associated with mining activities is currently exempt from water licensing requirements under the *Water Act.* This exemption is expected to be removed in 2018, enabling the finalised Plan to include consideration of water extraction made for mining purposes.

The most significant consumptive groundwater resource within the District is the water from the GAB, which is also believed to support important interstate GAB springs in South Australia and Queensland. However up to a third of current water use within the District, particularly for pastoral purposes, is considered to be from non-GAB aquifers. Due to the relative paucity of available information about the groundwater resources within the District, the whole of the District is considered as a single management zone for the purposes of the Plan.

Table 10: Total number of boreholes in the NT groundwater management unit

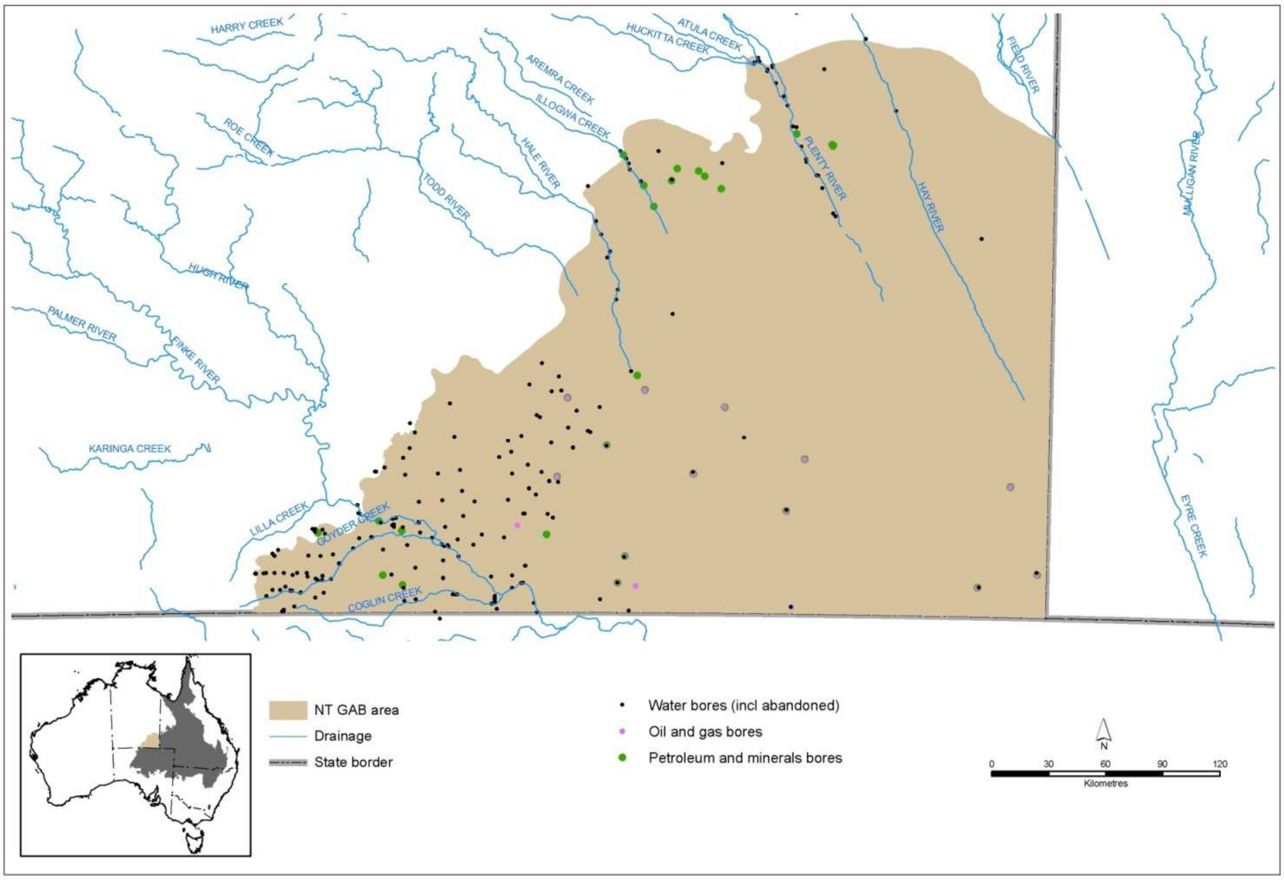
Bore purpose	GAB-NT
Water supply	125
Groundwater monitoring	7
Coal & mineral exploration	0
Oil/gas exploration/production	16
Other / not recorded	161
Total	309

Summary of Groundwater monitoring data in NT GAB

Table 11: Pressure and temperature data monitored in NT from 2013 - 2015

	Number of bores monitored	Max value	Min value
Pressure at headworks (kPa)	1	242.1	238.6
Unrestricted Flow (L/s)	0		
Temperature (^oC)	1	59.8	59.6

Map 3: Location of boreholes in the Northern Territory portion of the GAB



Summary of NT borehole data

Table 12: Date of construction

Bore purpose	Pre 1900	1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2015	No Date
Water supply		1	0	1	0	1	6	22	19	28	5	15	13	14
Groundwater monitoring												6	1	
Coal & mineral exploration														0
Oil/gas exploration/production														16
Other / not recorded				3	2	3	16	12	6	14	22	27	12	44
Total		1	0	4	2	4	22	34	25	42	27	48	26	74

Appendix C. Queensland Data

Queensland groundwater management

The Queensland portion of the Basin includes the Eromanga, Surat, Mulgildie Clarence-Moreton and Carpentaria sedimentary basins. These are managed now under the *Great Artesian Basin and Other Regional Aquifers Water Plan 2017* (GABORA) which replaced the *Great Artesian Basin Water Plan* 2006 on 2 September 2017.

The GABORA plan also deals with some aquifers in; the Clematis Sandstone (in the Galilee and Bowen Basins), the Laura and Karumba Basins, the Normanton Formation, parts of the Winton Mackunda Aquifer located in the Cooper Creek, Georgina and Diamantina, and Gulf water plan areas and the Betts Creek Beds (Galilee Basin), that are not considered part of the Basin.

The most significant groundwater systems in the Queensland Basin occurs in the Late Jurassic to Early Cretaceous aquifer sequence, collectively termed the Cadna-owie–Hooray Aquifer. The Cadna-owie–Hooray Aquifer extends across nearly the entire plan area, although its thickness and hydraulic properties may vary. Other significant aquifers that underlie the Cadna-owie - Hooray include the Adori Sandstone, Hutton Sandstone, and Precipice Sandstone.

Queensland basin aquifers contain groundwater ranging from potable to brackish to saline, often varying widely within a given formation. However, water quality in the main aquifers is generally good. High temperatures (up to 100 degrees Celsius) and salinity levels in some areas may make the water unsuitable for many uses, including stock watering and irrigation. However, treatment of the water (e.g. cooling) or soils (in irrigation areas) can overcome some water quality limitations.

Under the GABORA plan, aquifers are to be used as groundwater units and these units are divided into sub-area for local rules. Reporting of the purpose of bore holes across these units was not possible in the time period, however, substantial information on the current and future water use in Queensland can be found in three recent reports on the major Queensland basins: Carpentaria, Eromanga and Surat that can be found at: https://www.dnrm.qld.gov.au/water/catchments-planning/catchments/great-artesian-basin

The department’s Great Artesian Basin Ambient Network and the bores monitoring plan aquifers in the Groundwater Level Network together deliver a regional scale pressure monitoring network for the plan. The data collected is representative of the aquifer intercepted by the bore and collates over a hundred years of pressure and flow data.

This report does not document the gas production wells in Queensland. The recent underground water impact report shows that about 5,600 CSG production wells had been constructed in the Surat cumulative management area as at January 2015 (4,600 in the Surat Basin and 1,000 in the southern Bowen Basin). The CSG companies estimate that development of all tenure areas will require the installation of a total of 17,900 CSG wells. These wells are constructed to a higher construction standard than water bores. (Source: https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0007/345616/uwir-surat-basin-2016.pdf)

Summary of Queensland borehole data

Table 13 provides a summary of 27,552 boreholes in Queensland portion of the GAB based on the initial bore purpose and the year of its construction sourced from the Groundwater database.

Table 13: Date of construction

Bore purpose	**Pre 1900**	**1900-1919**	**1920-1939**	**1940-1959**	**1960-1979**	**1980-1999**	**2000-2013**	**No Date**
Water supply	284	1,351	1,698	3,553	5,767	6,304	5,278	1,807
Groundwater monitoring	2	13	18	52	88	58	14	7
Coal & mineral exploration	2	0	0	1	229	120	64	6
Oil/gas exploration	0	0	1	0	11	400	13	3
Other / not recorded								441
Total	288	1,364	1,717	3,606	6,095	6,882	5,369	2,264

Note:. Gas and/or petroleum production wells in Queensland are not stored in the same database as water supply or monitoring wells and this data has not been collated in this report.

Appendix D. South Australian data

The Far North Prescribed Wells Area covers a large part of the South Australia and includes the artesian and sub-artesian underground water resources of the Great Artesian Basin (GAB) in South Australia. Located in the far north-eastern corner of the State, the arid climate of the area is characterised by very low average annual rainfall and very high summer temperatures. The majority of the underground water recharge occurs in the GAB recharge zones in eastern Queensland and New South Wales.

GAB water extraction is managed through a approach based on an acceptable fall in pressure head, with water extraction allocated by volume against pressure targets. The approach is based on:

- Extent of the aquifer system and response time
- Vertical leakage in South Australia
- The volume of water in storage that can buffer the impacts of temporary water needs.

Pressure, and hence spatial distribution of the discharge, is the main variable rather than the volume of discharge, as falling artesian heads, particularly in low-pressure areas near the basin margins, will:

- Gradually reduce spring flows, to the point that flow will stop when the head locally falls below ground level.
- Increase the cost of water extraction if pumps are required to supplement or replace artesian pressure.
- Potentially allow the downward leakage of poorer quality water from other aquifers into the main aquifer.

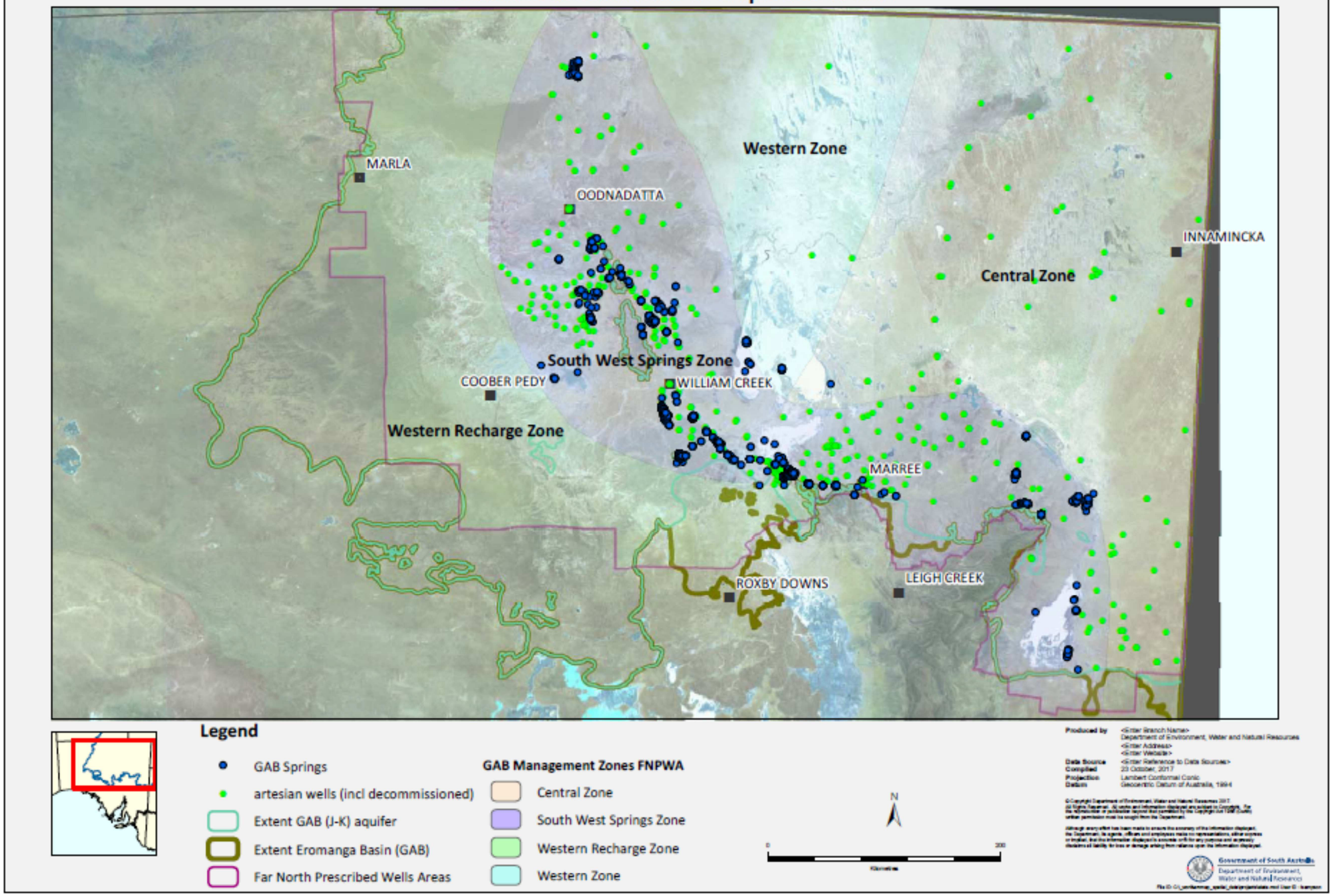
The discharge volume is defined as a volume that produces an acceptable fall in artesian head, and what is acceptable is spatially variable and dependent on acceptable impacts on the underground water resources, underground water dependent ecosystems and existing users. Extraction is managed according to acceptable target pressure distribution across four management zones, namely the Western Recharge Zone, the Southwest Springs Zone, the Western Zone and the Central Zone.

The majority of extraction in the South Australian area is from the artesian aquifer, and is the major water supply for mining and petroleum industries, the pastoral industry and domestic purposes and to support the expanding tourism industry. A number of natural artesian mound springs of high ecological, cultural and social value occur in the area, many of which are listed as threatened ecological communities under the *Environmental Protection Biodiversity and Conservation Act 1999* (Cth). The Great Artesian Basin Sustainability Initiative (GABSI) program implemented over the past decade has seen stabilisation (and localised increases) in pressure levels across the basin.

Table 14: Date of construction

Bore purpose	Pre 1900	1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2015	No Date
Water supply	14	15	47	216	73	113	164	260	369	290	143	356	454	261
Groundwater monitoring		1						2	1	32	24			1
Coal & mineral exploration	0	1	1	3	0	5	8	42	1,225	1,403	2,826	915	52	43
Oil/gas exploration/production						2	4	46	156	611	422	662	156	2
Other / not recorded	1			1			5	15	132	35	43	19	9	28
Total	15	17	48	220	73	120	181	365	1,883	2,371	3,458	1,952	671	335

Location of artesian wells in SA portion of GAB



Appendix E. Great Artesian Basin Sustainability Initiative

Throughout the last 140 years, water has been extracted from the aquifers of the GAB through manmade bores. Approximately one third of the original artesian bores have ceased to flow, and the loss of over 1,000 natural springs (and their ecosystems) has occurred.

In 1939, at an interstate conference it was recognised that the wastage of water from free-flowing bores was a major problem. This report was completed in 1945, however it was not until 1954 that the Artesian Waters Investigations Committee provided a report that was published and addressed the problems separately in each State. At that time there were more than 1,500 flowing bores discharging more than 1,200 ML/day into an estimated 34,000 km of open bore drains across the Basin. Well over 90% of this water was being wasted.

Some gains were made over the first half of the last century but in many regions pressures continued to diminish and many bores ceased to flow. Inadequate knowledge of the Basin, too little legislative control over water extraction, and ineffective infrastructure technology and management practices meant that valuable water resources continued to be wasted. Improvements in technology, management practice and legislation over the past several decades resulted in some incremental improvements, but lasting solutions for Basin-wide problems proved difficult. The SA bore rehabilitation project commenced in 1977. In 1989, the Commonwealth and State Governments initiated the Great Artesian Basin Rehabilitation Program, with work in Queensland, NSW and SA. The program shared the cost of capping bores between land managers and the Commonwealth and State Governments.

By the mid 1990's more than two-thirds of the water extracted from the GAB was still being wasted and the artesian pressure was still falling in the Basin. The rate of investment and control from governments and landholders was not sufficient and a more concerted and coordinated effort was required. Even after more than eighty years, the core problem was still the continued waste of water into open bore drains, and the continued decline in artesian pressures.

The Great Artesian Basin Consultative Council (GABCC) was established in 1998 in response to longstanding concern from the water users and governments about the need to control flowing bores and eliminate the waste of water in the GAB. A Strategic Management Plan for the Great Artesian Basin was developed under the auspices of the Council and signed off by State and Australian Government Ministers and released in 2000. The Plan provided a comprehensive fifteen-year strategy to improve the water delivery infrastructure and management of the Basin. A new Plan is currently in development.

The Great Artesian Basin Sustainability Initiative (GABSI) was established as the enabling programme under the Strategic Management Plan to provide funding support to repair uncontrolled bores and replace bores drains with pipeline reticulation systems to ensure the long-term sustainability of the Great Artesian Basin. It is a joint program between the Australian, New South Wales, Queensland, South Australian and Northern Territory governments and landholders. GABSI and its predecessor programs have focused on the rehabilitation of free-flowing bores and the replacements of open bore drains with pipes. This has resulted in pressure increases and significant water savings in many areas. To date 756 bores have been rehabilitated and 21,375 kilometers of bore drain have been replaced with piping, saving an estimated 252,556 megalitres of water every year.