Department of Regional Development, Manufacturing and Water

Biggenden

urban water security assessment

North Burnett Regional Council

Queensland Government

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Summary

The town of Biggenden is located on the Isis Highway, approximately 285 km north-northwest of Brisbane and 85 km west of Maryborough. Biggenden is a small rural service centre supporting the surrounding agricultural sector within the North Burnett region.

The Queensland Government Statistician's Office June 2019 estimate of Biggenden's population was 704. Little change in Biggenden's population is forecast over the next 20 years.

Safe, secure and reliable water supply is an essential resource for Biggenden, not only providing for the health and wellbeing of the community, but also providing opportunities for economic and community enhancement. North Burnett Regional Council (Council) is the registered water service provider, under the *Water Supply (Safety and Reliability) Act 2008*, providing both drinking water and wastewater services.

The Queensland Government, through the Department of Regional Development, Manufacturing and Water, (DRDMW), and Council have in partnership investigated Biggenden's existing urban water supply system and its capacity to support current demands and possible future growth. This urban water security assessment (UWSA) presents an analysis of the balance between Biggenden's water demands and available supplies and the likelihood that there may be future water supply shortages, thereby establishing a shared understanding of Biggenden's urban water supply security and providing valuable information for future water supply management by Council.

Potential future water demands for the Biggenden community were considered to identify the timing and magnitude of potential water supply security risks. Based on the modelling of the groundwater aquifer system behaviour, key findings from the assessment include:

- The groundwater supply at Biggenden is capable of meeting projected water demands to beyond 2041 with a reliability of supply that is appropriate to the size of the community.
- However, there is an inherent risk with the current considerable reliance on Council's main groundwater bore (bore No. 2—RN156052) in a shallow alluvial aquifer located alongside Degilbo Creek to meet Biggenden's urban supply needs.
- This highlights the need for appropriate contingency measures to be available for Council to implement in the event of failure of the main bore (for example, water carting, or providing 100% standby capacity for the current main bore by constructing and equipping an (equivalent) additional bore).
- Additional groundwater take for nearby agricultural purposes is currently not prohibited under the *Water Plan (Burnett Basin) 2014*, therefore any potential changes in water demand in the vicinity of Biggenden's town bores and associated impacts on water levels will need to be monitored and regularly assessed.
- In addition, water restrictions may on occasion need to be applied (primarily during extended dry periods) and reductions made in the rate at which water is extracted from Council's bores.
- Further, although the treated water has consistently met the minimum standards outlined in the Australian Drinking Water Guidelines, the aesthetic quality of the water supplied has been a concern for the community for some time, in particular the high level of total dissolved solids and the hardness of the existing groundwater supply. Biggenden's existing water treatment plant, which is quite old and in poor condition, does not have the capability to address these issues.

Water supply sources

Biggenden's primary water supply source is groundwater accessed from two town bores

Biggenden's two groundwater bores—the main bore No. 2 (RN156052) and the shallower bore No. 1 (RN155332)—are both located northeast of town (Figure 2). These bores access a shallow alluvial aquifer located alongside Degilbo Creek. For convenience and practicality, the bores are mostly operated during standard working hours to enable easier monitoring of their operation. A schematic of the Biggenden town water supply bores is provided in Figure 1.

As Biggenden's bores are not located within a groundwater management area (as defined under the *Water Plan (Burnett Basin) 2014)*, Council and other water users accessing this groundwater are currently not regulated by entitlements, which might otherwise limit the volumes of groundwater that can be extracted.

Water from the bores is treated and delivered to the town's reservoirs for distribution to customers via Biggenden's reticulation network. Although the treated water has consistently met the minimum standards outlined in the Australian Drinking Water Guidelines, the existing groundwater has high levels of total dissolved solids (TDS) and hardness (high in dissolved minerals) which cannot be removed by Council's existing water treatment plant.

(Hard water is not a health risk but is a nuisance in the home because of mineral buildup on plumbing fixtures and poor soap and or detergent performance.) The aesthetic water quality would likely worsen during periods of low groundwater levels due to drainage of poor-quality groundwater from surrounding geological formations into the alluvial aquifer.

To address these issues, Council is investigating options for upgrading or replacing the existing plant (which has deteriorated with age). Council has considered both a more conventional water treatment plant upgrade and a reverse osmosis plant (considered more likely to present difficulties, such as significantly increased water use by the plant itself, and brine disposal issues).

Council also holds a licence to take up to 202 megalitres per annum (ML/a) of surface water from Degilbo Creek, which Council uses as a short-term, emergency supply. The Degilbo Creek supply was briefly used in the second half of 2019; however, had not otherwise been used since 2011–12. In the absence of any storage infrastructure, Degilbo Creek has been found to be an unreliable supply source for Biggenden's water supply.

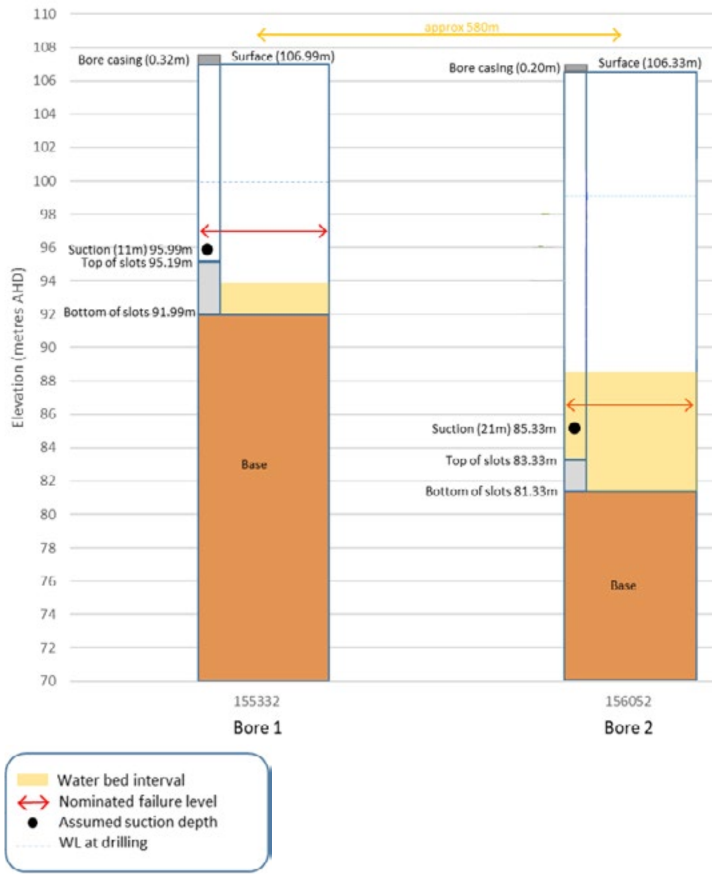

Figure 1: Schematic of Biggenden's groundwater bores

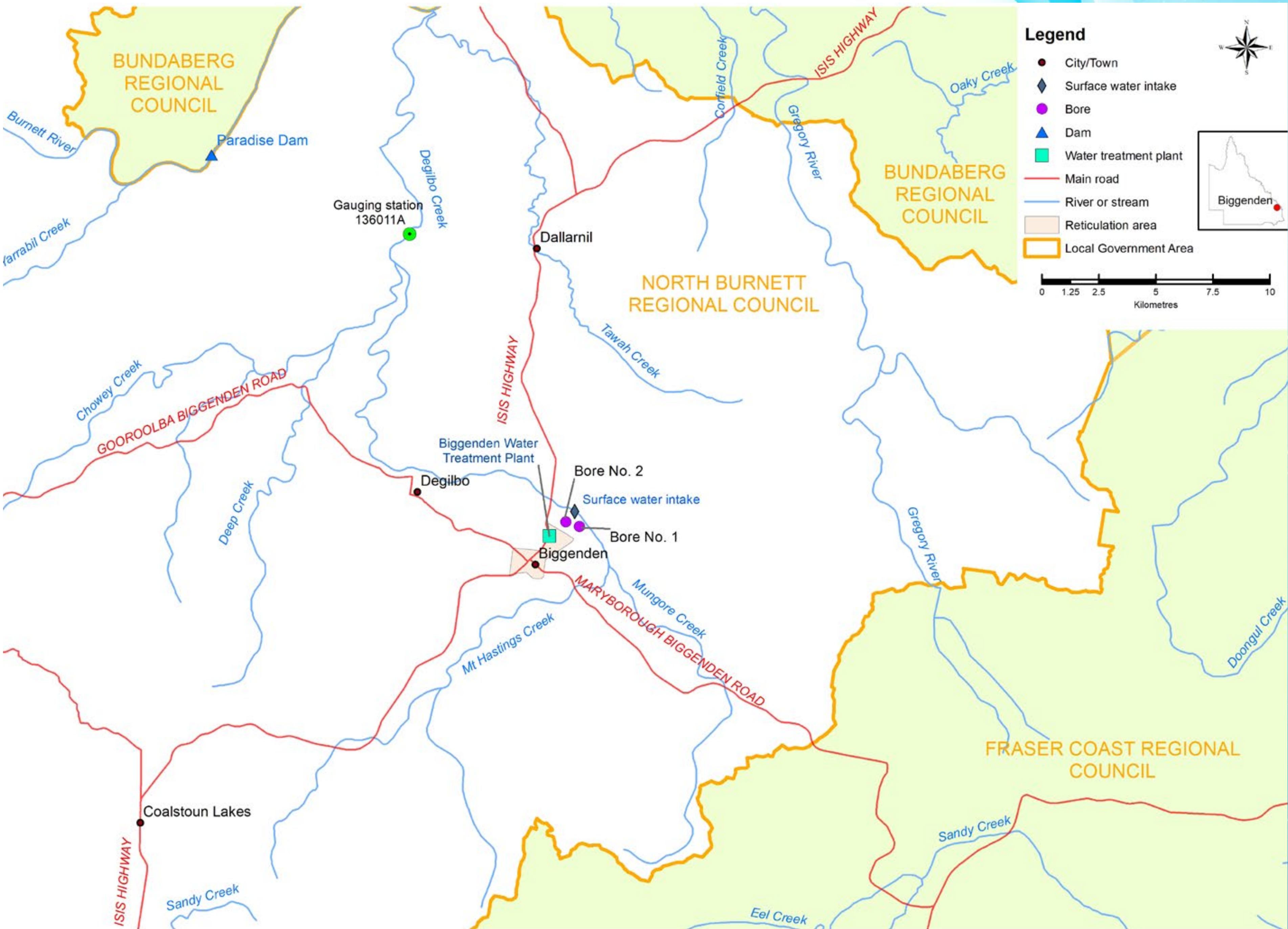

Figure 2: Location of Biggenden's water supply sources

Current water demand and use

Biggenden's reticulation network provides water for urban purposes to about 700 people (as at June 2019).

Information reported to the department by Council via the Statewide Water Information Management database shows that the total volume of water sourced for the Biggenden reticulation network over the 7 years from 2012–13 to 2018–19 averaged 107 ML/a (ranging from 97–122 ML/a).

Based on the total volume of water sourced and the serviced population, the average water demand during this period (2012–13 to 2018–19) was approximately 412 litres per capita per day (L/c/d). This figure accounts for residential, commercial, municipal and industrial water supplied from the reticulation network, plus any system losses. It also includes water use by the transient population (generally only a small number of people), such as tourists and temporary workforces. Water use by the transient population is mostly accounted for under the category of commercial use; hence the transient population is not included in the serviced population figures.

The average residential water use for this period was approximately 268 litres per person per day.

Recycled water use

A portion of the water supplied through Biggenden's reticulation network is ultimately collected and treated at Biggenden's wastewater treatment plant. Some of this water is recycled and used to irrigate the Biggenden golf course. Water demand that is met through the use of recycled water is not included in the current or projected demands on the Biggenden reticulation network.

Climatic (variability) impacts on water demand

Urban water demand varies between years and within each year, depending on various factors including climatic conditions such as rainfall, with higher demands usually occurring during hotter, drier periods. Extended dry periods can also reduce groundwater quality and availability.

Figure 3 shows Biggenden's annual rainfall for the period 2012–13 to 2018–19, and the total volumes of water sourced each year for Biggenden's reticulation network over the same period. During this period, the volume of water sourced varied considerably from year to year, ranging from approximately 374 L/c/d in 2017–18 to 462 L/c/d in 2013–14. During the seven year period shown in Figure 3, 2013–14 was the driest 'water year' (July–June) at 431.8 mm and, as may be expected, had the highest water demand (note that the recorded rainfall for the Biggenden Alert rainfall station in 2019 (calendar year and not plotted) was 388 mm).

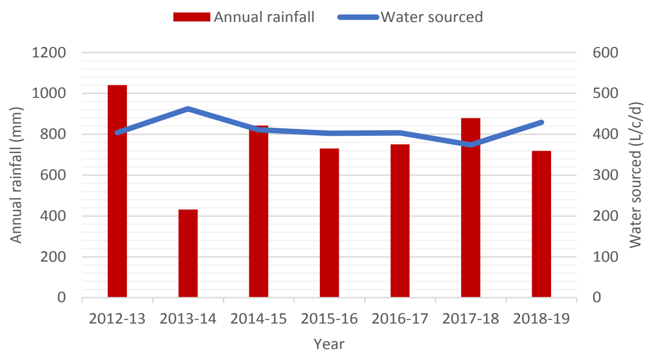

Figure 3: Water sourced and annual rainfall for Biggenden

Climate change

Climate change is a shift in the long-term average weather patterns or trends over many decades. The impacts of climate change will be different across Queensland's diverse communities. To better understand the possible impacts of climate change, regional scale climate change projections based on global climate models have been developed by the Department of Environment and Science[1]. These models have been referenced against the historical period 1986–2005. Climate change projections are frequently reviewed as climate change knowledge evolves.

Long-term historical rainfall data for Biggenden (1899–2019) is summarised in Table 1. Annual rainfall for Biggenden over this period averaged 857 mm. Also shown in Table 1 is the average rainfall over the recent 2012–13 to 2018–19 period (which is about 10% lower than the average over the longer term), and the average rainfall over the climate change reference period (1986–2005).

Table 1: Summary annual rainfall statistics for Biggenden

Rainfall stations 40021 (Biggenden Post Office) and 40334 (Biggenden Alert)	Mean (mm)	Median (mm)	Historic low (mm)	Historic high (mm)
1899 to 2019	857	827	333.7	1576.5
1986 to 2005	793	758	601.0	1076.7
2012–13 to 2018–19	771	751	431.8	1041.1

Note: Biggenden's annual rainfall for the period 1899 to 2019 comprises data from GS 40021 Biggenden Post Office for 1899–2017 and from GS 40334 Biggenden Alert for 2018 and 2019.

Under an unchanged greenhouse gas emission scenario, the projected climatic changes for the North Burnett Regional Council local government area indicate that by 2050 seasonal variations may include:

- warmer temperatures for each season (average, minimum, and maximum)
- higher evaporation rates for each season
- longer durations of droughts.

The possibility of more extreme and longer-duration droughts than have previously been recorded historically for Queensland highlights the need for long term water supply planning processes to be adopted, implemented, and regularly reviewed.

While the average annual rainfall during the recent drier period from 2012–13 to 2018–19 is comparable to the median 2050 projection (for average annual rainfall)—771 mm and 764 mm respectively—projected higher evaporation suggests that Biggenden's average water demands may be higher in the future (with likely increased outdoor water use).

Water restrictions

In an effort to reduce water consumption and to extend the duration of the available water supply during extended dry periods, Council has a water restriction regime for Biggenden based on the water levels at Biggenden's No. 2 bore (RN156052). Table 2 shows the water levels at which the various water restriction levels are triggered, and Council's corresponding water use targets, which apply to the town's combined total daily use (note that current average annual demand for Biggenden of 107 ML/a equates to an average daily demand of around 293 kilolitres per day (kl/day), already below the targeted consumption for restriction level 1). It is important to note that these restriction levels relate to the 'standing water level' (i.e. the natural water level in the bore when the pumps are off and the bore water level has 'recovered').

Table 2: Restriction levels for Biggenden's town water supply

Restriction Level	Restriction trigger level	Target consumption (kl/day)	Target consumption (% of current average demand)
0	Standing water level in Bore No. 2 down 9 m	<400	>100%
1	Standing water level in Bore No. 2 down 11 m	<300	>100%
2	Standing water level in Bore No. 2 down 13 m	<200	<68%
3	Standing water level in Bore No. 2 down 15 m	<150	<51%
4	Standing water level in Bore No. 2 down 16 m	<120	<41%

Source: Policy No. 247, Drought Management of Urban Water, North Burnett Regional Council

The water restrictions have both a residential and non-residential component. Council's restriction measures primarily target outdoor water uses including watering of gardens, irrigation of sports fields and swimming pool use. Further details on water restriction rules are available on Council's website (www.nbrc.qld.gov.au).

1 Climate change projections developed by the Queensland Government's Department of Environment and Science https://app.longpaddock.qld.gov.au/dashboard


Image courtesy of North Burnett Regional Council

Other users of the bulk water supply sources

Agriculture

While there are two 'stock and domestic' bores in the vicinity of Council's two town bores, there is no significant agricultural water demand on Biggenden's groundwater supply resource. A number of other production bores located in the general area, along with a number of surface water entitlements from Degilbo Creek are not considered to have any significant impact on Biggenden's town water supply at this time.

Industry

The main industries in the Biggenden area are associated with retail trade, agribusiness, and construction. Water use by businesses accessing the Biggenden town water supply is accounted for within the total water demand figures for the network, under the category of industrial, commercial and municipal water use. Over the period 2012–13 to 2018–19, the combined industrial, commercial and municipal water use in Biggenden was on average about 20% of Biggenden's total water demand.

The Biggenden meatworks, which is one of the more significant industries in the area, has its own groundwater supply and does not access water from the Biggenden town water supply. The meatworks is located on the opposite side of Degilbo Creek about 4 km north of town (and over 2 km from the town bores) and is considered to have no significant impact on Council's town bores. There is no significant industrial water demand on Biggenden's water supply sources from industries outside the Biggenden urban area.

Historical performance of Biggenden's water supply

There has been no recorded urban water supply shortfall in Biggenden to date.

Figure 4 provides information about the behaviour of Biggenden's groundwater supply since 2003. In the absence of long-term water level data for the Biggenden town bores, the nearby DRDMW monitoring bores in close proximity to the town bores provide useful information to better understand the historical behaviour of the groundwater. These monitoring bores are located approximately 200 m northeast of town bore No. 2 (RN156052), and 550 m northwest of town bore No. 1 (RN155332) (refer to Figure A-1 in the appendix for further detail).

As can be seen from Figure 4, the water level in bore No. 2 may at times fall to low levels during periods of pumping. However, these recorded levels are generally well above the level at which bore failure is expected to occur (EL 86.33m AHD—at 20 m depth).

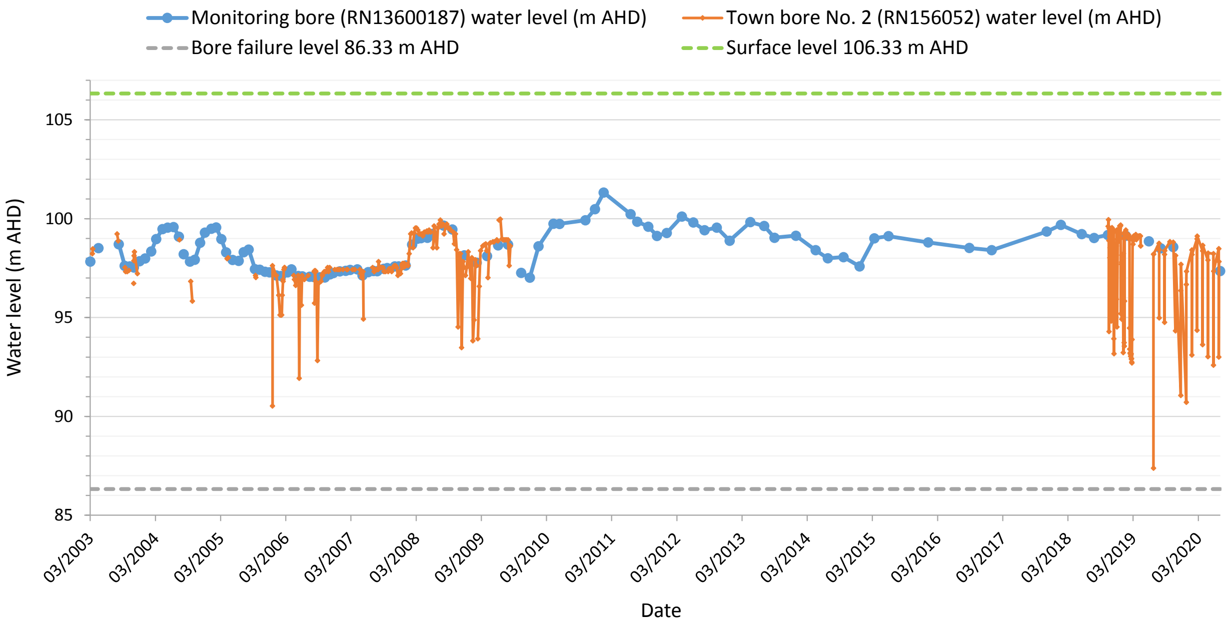

Figure 4: Recorded behaviour of Biggenden's groundwater supply from 2003 to 2020

Note: Selected monthly data only shown for 2019-20; full data for this period is shown in Figure A-2 (appendix)

Image courtesy of North Burnett Regional Council

Future water demand

Well-founded water supply planning necessitates an understanding of the likely (and possible) changes in water demand into the future.

In developing a projection of Biggenden's future water demand, it is essential that all key assumptions, such as rates of water use and population growth, are identified and agreed upon. The projections are subject to ongoing monitoring of actual population growth and variations in water use trends (e.g. changes in water use practices may increase or decrease consumption).

Biggenden's town water demand

The resident population of Biggenden is projected to remain relatively stable in the period up to 2041, with little change from the current population of about 700.

The average daily water demand for Biggenden over the 7 year period 2012–13 to 2018–19 was approximately 412 L/c/d. As Biggenden's population is forecast to remain stable for the period to 2041, minimal change in average urban demand over this timeframe is also expected. However, during particularly dry periods, the demand is likely to be higher than this 'average' demand, and average demands may also be slightly higher in the future as a result of increased evaporation and decreased average rainfall (resulting in increased outdoor water use).

Under the assumption that per capita usage remains at an average of 412 L/c/d, the projected average annual volume sourced would remain around 107 ML/a.

However, if a reverse osmosis component was added to the water treatment plant processes (to address the high TDS and hardness of the groundwater supply) the average total volume of water required to be sourced would be expected to significantly increase, as reverse osmosis processes generally produce significant volumes of wastewater.

Recycled water

As Biggenden's demand for potable water is projected to only marginally increase in the future, it is not anticipated that there will be any significant change in the volumes of recycled water subsequently produced. Therefore, for the purpose of this assessment, recycled water usage at the golf course is excluded from consideration of Biggenden's future urban demands, as it is not expected to have any significant impact on future demands on Biggenden's reticulation network.

Other users of the bulk water supply sources

Agriculture

Agricultural water demand in the vicinity of Biggenden's town bores appears unlikely to change significantly in the short to medium term. However, additional groundwater take for nearby agricultural purposes is currently not prohibited under the Water Plan (Burnett Basin) 2014, therefore any potential changes in water demand in the vicinity of Biggenden's town bores and associated impacts on water levels will need to be monitored and assessed.

Industry

Future growth in industry, and associated industrial water demand, is largely subject to changes in population and/or changes in the global economic environment resulting in increased demands for exported products from the region (e.g. processed meat). At this stage, there are no large scale industrial developments or changes anticipated that are considered likely to significantly impact on water demand from the water supply sources used for Biggenden.

Water supply system capability

Hydrologic assessments have been undertaken to ascertain the capability of Biggenden's water supply sources to meet current and projected future water demands.

The key outcomes from the modelling assessments undertaken are discussed below. Because the water availability from the existing groundwater system is a major component of this assessment, a more comprehensive technical coverage of the hydrologic modelling (including an overview of the model design, assumptions and operational arrangements, modelling results and analysis) are provided in the appendix: Hydrologic assessment of Biggenden's water supply system.

Assuming that demand remains at the current average of around 412 L/c/d, Biggenden's average water demand is anticipated to remain relatively stable at the current average of about 107 ML/a. However, it may be higher during prolonged hot, dry periods, or if sustained population growth occurs, or some other additional demand comes on line.

Historical and stochastic predictive modelling of Biggenden's groundwater supply indicates that the groundwater supply source is likely to be sufficient to meet Biggenden's projected average water demands to beyond 2041 with a reliability of supply that is appropriate to the size of the community. While Council's bore No. 1 (RN155332) can provide useful supplementary supplies, its capacity is limited due to its shallowness, and therefore there is currently a higher level of reliance on the ongoing operability of bore No. 2 (RN156052) in order for supplies to be maintained.

The assessment also found that, in most years, Council will be able to meet even the higher demands modelled (up to 150 ML/a) with some degree of operational flexibility—that is, daily demands could be met by pumping for timeframes well below 24 hours per day. However, it was found that with high demands Council would need to wind back the rate of extraction for some period during the year (in about 1 in 2.4 years on average for demands of 150 ML/a, or 1 in 4 years on average for demands of 125 ML/a), while water restrictions may also be required. Carting on a short-term basis could also be used to occasionally supplement supply when needed.

The volume of water required to supply the Biggenden community would likely increase towards these higher demands if Council incorporated a reverse osmosis component into an upgraded water treatment plant to deal with the high TDS levels and hardness of the bore water. However, the assessment found that Council's existing supply system can meet these elevated demands, albeit with some management of extraction rates and demand at times.

The high level of reliance on supplies from a single bore (bore No. 2) poses some level of inherent risk, which necessitates that contingency plans exist that could be effectively implemented in the unlikely event of bore failure (for example, an equivalent standby bore, or water carting, which to meet 70% of unrestricted demand may require around 10 trucks per day, assuming a 20 000 litre capacity per truck). Alternatively, further investigation could occur into the feasibility of an adequate alternate/supplementary source and associated treatment—noting there may be limited groundwater supplies and marginal water quality from other geological formations outside of the immediate alluvial aquifer. The timing of action taken could be a key consideration as the availability of licensed water bore drillers can be limited during dry periods when demand for drillers is high.

While there are currently no restrictions on drilling new or additional bores in the area, this means that other users in the area could potentially drill new bores, placing additional strain on the current aquifer.

A recent 'water supply options' study undertaken by Council (through external consultants) will aid in the process of identification and analysis of longer-term options.


Image courtesy of North Burnett Regional Council

Moving forward

This UWSA was a collaboration between the Queensland Government and North Burnett Regional Council to develop a shared understanding of the existing security of Biggenden's water supply and its capacity to support future growth.

Council has effectively operated the Biggenden potable water scheme for many years without the source failing. Although perceived changes in the environment may provide some concern over the ability to provide sufficient water for the township into the future, unless there is an unexpected influx of residents and industry to the area, this assessment indicates that the current supply from the local groundwater will be able to continue to meet demand for the foreseeable future (to at least 2041).

Water service management considerations include the issues of standby capacity, aesthetic water quality or periodic need for restrictions on the township based upon climatic or seasonal fluctuations. The assessment findings indicate that a more proactive restriction regime would lead to less regular requirements to impose severe restrictions.

Further, accepting a more modest improvement in aesthetic qualities (for example, through an upgraded or new water treatment plant) would ensure fewer severe restrictions would be required into the future, compared to high-cost improvements to the treatment plant (such as incorporation of a reverse osmosis component) that would pose environmental challenges and large waste streams to deal with. A sound technical solution is likely to be found that could both make noticeable improvements in the aesthetic qualities of the drinking water and a more balanced and measured approach to usage at the same time.

At this point in time, it is not considered to be cost effective to seek other supply sources from further afield for a population the size of Biggenden. As the water is currently able to be treated simply to a level that is safe to drink, Council will work with the community and other tiers of government to provide an appropriate future level of aesthetic water quality for the scheme.

Appendix: Hydrologic assessment of Biggenden's water supply system

The assessment of Biggenden's water supply security incorporates hydrologic modelling, the results of which were analysed in conjunction with other hydrologic data, to better inform the assessment process. For the purposes of this UWSA, the assessment excluded consideration of Biggenden's surface water supply from Degilbo Creek (i.e. the modelling that was undertaken assumes that Biggenden's water demands are met solely from Council's groundwater bores).

Modelling is best used to understand source of supply responses to demands and give an indication of the supply reliability rather than be definitive because of modelling uncertainties.

Both historical and predictive modelling techniques were used to simulate the performance of Biggenden's water supply. This included development of a numerical (monthly time-step) groundwater flow model (Biggenden model) specifically focussed on that part of the groundwater system immediately around the location of Biggenden's town water supply bores. Figure A-1 shows the extent of the Biggenden model, which is some 4.5 km long in the north–south direction and 3 km wide in the east–west direction.

The Biggenden model is discretised into a grid of variably sized cells, which can also be seen in Figure A-1 (cyan hatching), with the smallest cells in the vicinity of the town bores (5 metres by 5 metres in size) and Degilbo Creek (10 metres by 10 metres in size), and the largest cells (40 metres by 40 metres in size) away from the town bores.

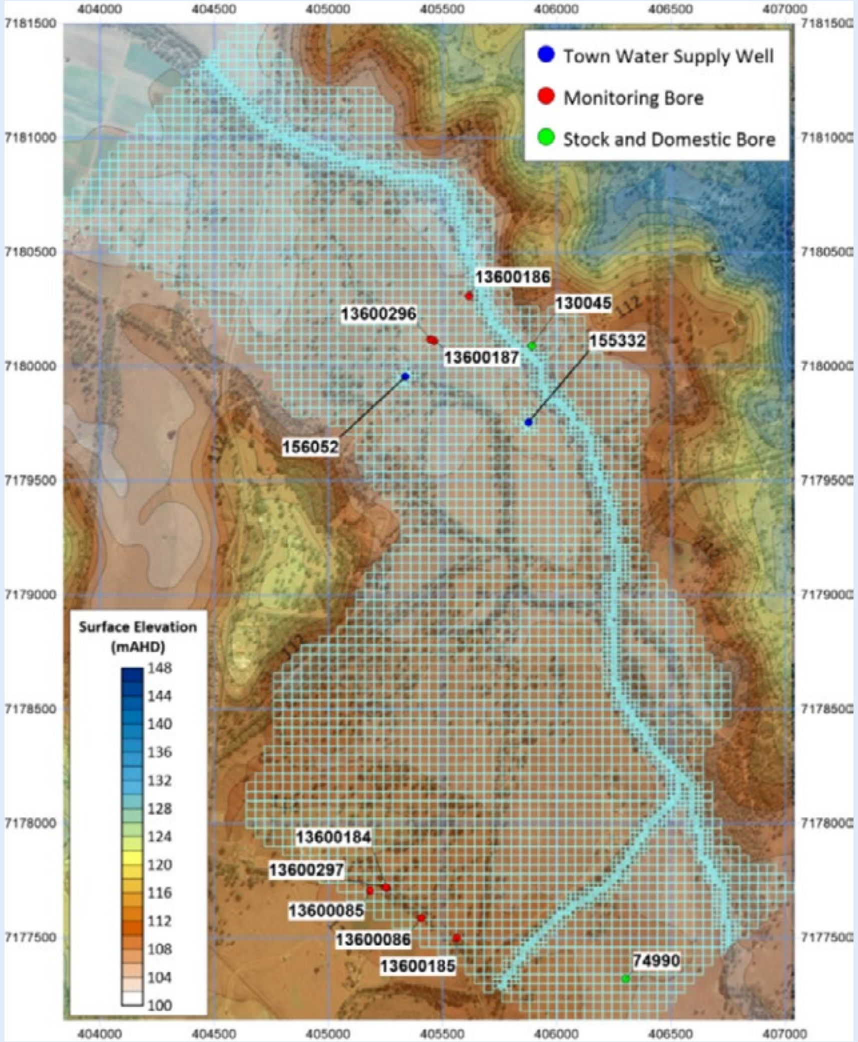

Figure A-1: Biggenden model layout

Modelling was used to show how the water supply would have performed under historical climatic conditions for a range of water demands and operating arrangements. This modelling was based on the use of rainfall and evaporation data (from the SILO database hosted by the Queensland Department of Environment and Science (DES)) for the Biggenden Post Office, available for the 125 year period from 1894–2018, and a calibrated version of the Biggenden model, hereafter referred to as the 'base model'. The base model uses a single set of groundwater model parameters that pertain to aquifer properties (hydraulic conductivity and specific yield) and boundary conditions that were tuned to observed system response over a 15-year period from 2003–2017 (the calibration period).

However, predictions of water supply sustainability made by groundwater models are often accompanied by a high degree of uncertainty. Furthermore, while the historical performance of a water supply system offers an indication of supply security, its application to future performance is limited. Therefore, stochastic predictive modelling was used to demonstrate how the water supply may perform under a wider variation of potential climatic scenarios, including more severe droughts than those observed in the historical period of record. Thus 100 replicates of rainfall and evaporation data spanning 125 years were stochastically generated for the area, with each replicate serving as an input to a predictive version of the base model (i.e. for each climate sequence the single calibrated set of groundwater model parameters was employed).

Assessment of risks to groundwater supply security must not only accommodate uncertainties associated with future rainfall patterns but also uncertainties in groundwater parameters that are often at least as high as those associated with future rainfall patterns. Consequently, 250 sets of stochastically-generated groundwater parameters (e.g. hydraulic conductivity and specific yield) that satisfactorily matched (were calibrated to) the observed datasets were derived. Each of these were paired with the 125 year historical climate record for predictive simulations. Median outputs from the stochastic modelling have been presented in this document.

Modelling assumptions and operational arrangements

For the purposes of this UWSA, the following assumptions/arrangements were used for the modelling of Biggenden's groundwater supply:-

- Two operational arrangements were assessed for Biggenden's bores, namely:-

1. Biggenden's demand was met solely from bore No. 2 (RN156052) (i.e. 100% of the daily demand is met from bore No. 2 and nil from bore No. 1 (RN155332)); or
2. Biggenden's demand was met through the conjunctive use of both bores. It was assumed that 75% of the demand was met from bore No. 2 with the remainder (25%) met from bore No. 1 in order to reduce the frequency of low water levels in the former. In so doing, the potential limitations on available supply from the much shallower bore No. 1 were also assessed.

For modelling of the shared supply arrangement (point 2 above), if either bore was unable to meet its aforementioned monthly share of the total demand, the rate of take from the other bore in that month was not increased to compensate for the reduced supply.

A range of annual water demands was assessed, namely:-

- for Biggenden's town water supply
  - water demands of 80 ML/a, 100 ML/a, 115 ML/a, 125 ML/a and 150 ML/a.
- for other water users
  - stock and domestic take of 1.85 ML/a for each of two bores (see Figure A-1)
  - there are no irrigation demands within the extent of the Biggenden model (there are, however, irrigation demands nearby and their historical influence has been indirectly incorporated in the assessment via the calibration of the Biggenden model boundaries).

A range of pumping rates for Council's bores was assessed.

- In addition to allowing for a range of annual average water demands, the groundwater assessment considered the impact of operating Council's bores under a range of pumping rates to achieve these demands. Under certain circumstances the bores may not be able to deliver or otherwise sustain the higher rates of take—for example, when Council is only able to access one of its bores and the standing water level in the bore is already low.

- For Biggenden's current (and projected 2041) demand of around 107 ML/a, if the bores were operated continuously for 24 hours per day the pump rate would equate to an average of about 3.4 litres per second (L/s). In practice, the bores will not be able to be operated continuously (for example, the water supply system will at times require planned and unplanned maintenance and repairs) and desired operating arrangements may at times require significantly higher rates of take (for example pumping 12 hours per day would require an average rate of take of 6.8 L/s to access 107 ML/a).
- The measured historical response of water levels in Biggenden's bores to various pumping rates is shown in Figure A-2. There are about 30 water level readings taken for each day shown in Figure A-2, illustrating how water levels varied between periods when the bore pump was turned on or off. Recorded data shown in Figure A-2 illustrates that when bore No. 2 (RN156052) was operated in isolation at a pump rate of 7.8 L/s, water levels in the bore dropped from around 99 m AHD to about 87 m AHD—i.e. while pumping, the water level in the bore was about 12 m lower. Similarly, operated in isolation at a pump rate of 4.5 L/s, water levels in bore No. 2 dropped about 4 m. Water levels in bore No. 2 also dropped about 4 m when bore No. 2 was operated at 3.5 L/s at the same time as bore No. 1 (RN155332) was operated at 3 L/s.

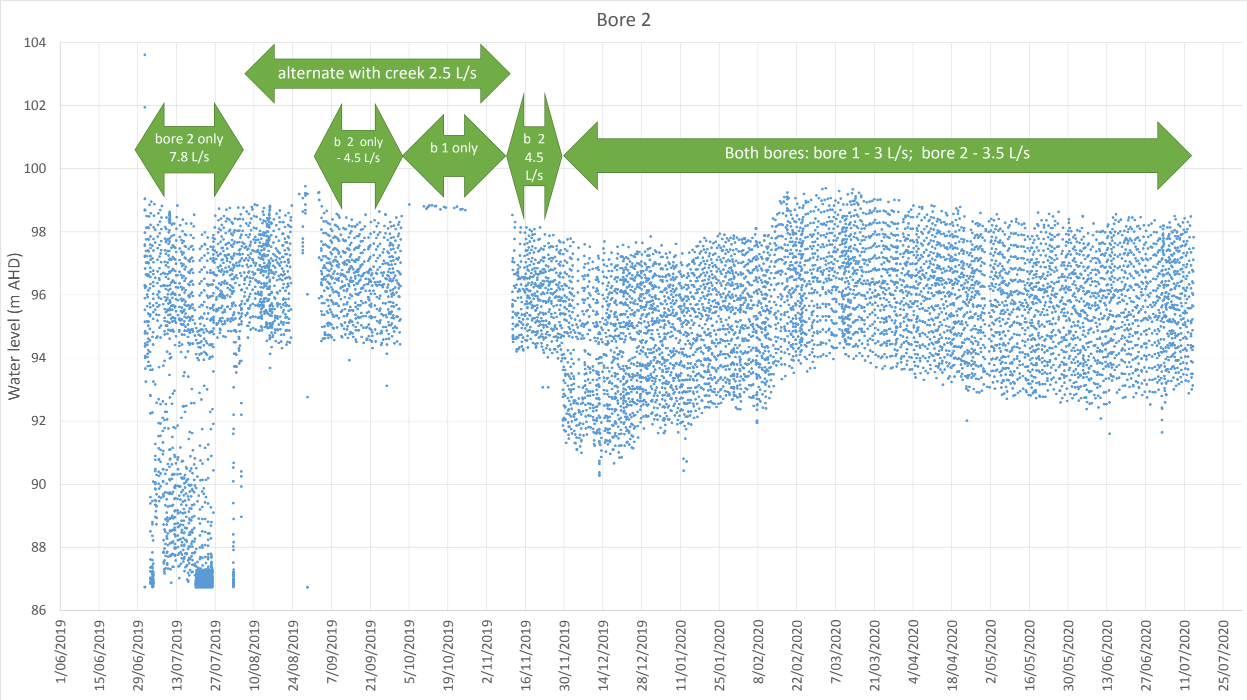

Figure A-2: Effect of varying pumping rates on water levels in bore No. 2 (RN156052)

'Offsets' were applied to reflect the differences between water levels when pumps were switched on or off.

- Water levels calculated by the Biggenden model represent the 'cone of depression' in the regional water table around the bore that is produced under a consistent pumping regime. Within the bore annulus however, they reflect periods when the pumps are intermittently 'off'. When the pumps are turned on, water levels within the bores are lowered further. Therefore, for assessment of water supply failure at the point of take, corrections to simulated water levels in the form of 'offsets' were applied to each town bore in order to compensate for the difference between simulated water levels within the bore when the pump is 'on' or 'off'. These corrections are as follows:
  - As the water level lowers towards the bottom of the bore, the extraction rate is hydraulically restricted in accordance with the adopted offsets for each bore as follows:
    - a 2.5 m offset for bore No. 1 (RN155332) when operated at a rate of take of around 4 L/s. This imposes a linear reduction in take from 100% at EL98.5 m AHD to 0% at EL96 m AHD.
    - a 5 m offset for bore No. 2 (RN156052) when operated at a rate of take of around 4 L/s. This reduces the extraction rate linearly from 100% at EL91.33 m AHD to 0% at EL86.33 m AHD. (Note that a 12 m offset was superimposed on model outputs for rates of take of around 8 L/s - refer Figure A-2).
- Additionally, in practice, when the water level in the bore falls below the pump suction elevation, a failure to supply will occur and water cavitation effects may also damage the pump. Therefore, for each bore a 1.0 m bulwark (or defensive correction) was added to the pump suction elevation for the purposes of water security assessment.
- Biggenden's town water supply was assessed under scenarios with and without demand restrictions.
  - There were no instances of standing (pump off) water levels in bore No. 2 (RN156052) falling below Council's water restrictions trigger levels (refer Table 2 in the main document text) in the historical records or the modelling.
  - Hence, for the purposes of this assessment, an alternative demand restriction regime was modelled, as shown in Table A-1. While the alternative demand restriction regime is similar to the existing Council restrictions shown in Table 2, restriction levels are applied at a depth-to-water that is 5 m shallower than Council's existing restriction regime, demonstrating the potential impact of a revised restrictions regime. However, the modelled restrictions were only applied to demands on bore No. 2 (the demand restriction was not applied to modelled demands on bore No. 1 given its relatively low usage).
  - The modelling assumed that the targeted reductions in take for each level of restriction would be achieved in practice.

Table A-1: Modelled water restriction arrangements for bore No. 2 (RN156052)

Restriction Level	Depth to ground water from surface (m AHD)	Groundwater Elevation (m AHD)	Demand Level (with restrictions applied)
0 and 1	less than 8	above 98.33	100%
2	8–10	98.33–96.33	68%
3	10–11	96.33–95.33	50%
4	More than 11	95.33–86.33	40%

Performance of Biggenden's existing groundwater supply

Likelihood of water supply failures

For this assessment, Biggenden is considered to have experienced a water supply shortfall when the groundwater supply is unable to meet the water demands placed on it by Biggenden's community. This could, for example, be a result of significant declines in groundwater levels at Biggenden's bores due to extended drought.

As this assessment is about the capability of Biggenden's existing bulk groundwater resource, the potential for water supply shortfalls resulting from other factors has not been accounted for—for example, an inability to meet demand as a result of a bore casing collapse, pump or pipeline failure, or water quality constraints (that can't be appropriately addressed through a treatment process).

Historical modelling assessment

Water level response at Biggenden's town bores was simulated with the base model for a range of supply demands using a 125-year period of historical rainfall and evaporation data (SILO) from Biggenden Post Office spanning the period 1894–2018.

The modelling showed that for demands up to 125ML/a and extraction rates of around 4 L/s for each bore in operation, no supply shortfalls would have been experienced, even when supply was solely from bore No. 2 (RN156052) without restrictions.

For the simulated water levels shown below in Figures A-3 and A-4, the model sought to extract 75% of the water demand from bore No. 2 and 25% from bore No. 1, without water demand restrictions imposed on either bore.

Figure A-3 shows the simulated 'standing water levels' for bore No. 2. At a pump rate of about 4 L/s, it is estimated that bore No. 2's capability to extract water starts to reduce when the standing water level falls below EL91.33m AHD (i.e. the commencement of well de-rating, or hydraulic restriction). Note that the simulated standing water levels for bore No. 2 remained well above EL91.33m AHD throughout the historical period (even without restrictions). For the shallower bore No. 1 (RN155332), this de-rating (hydraulic restriction) commences at EL98.5m AHD and, as shown in Figure A-4, the simulated standing water levels at bore No. 1 fall below this level relatively frequently.

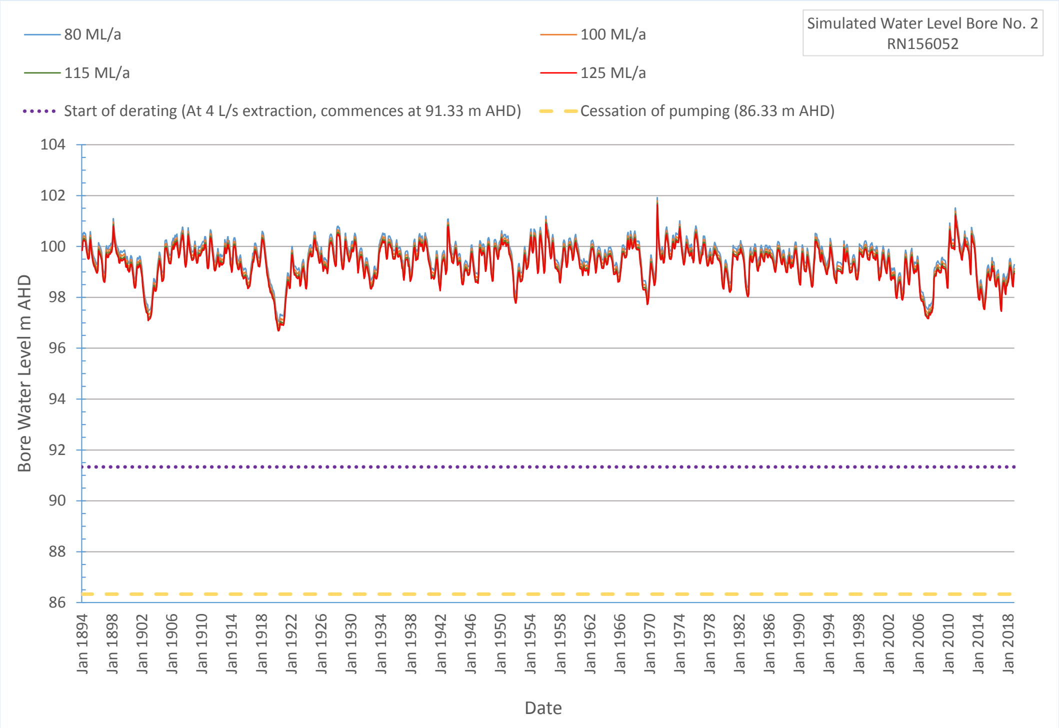

Figure A-3: Simulated standing (pump 'off') water levels for bore No. 2 (RN156052) with 75% or the water demand supplied by bore No. 2 and 25% by bore No. 1, without water demand restrictions on either bore

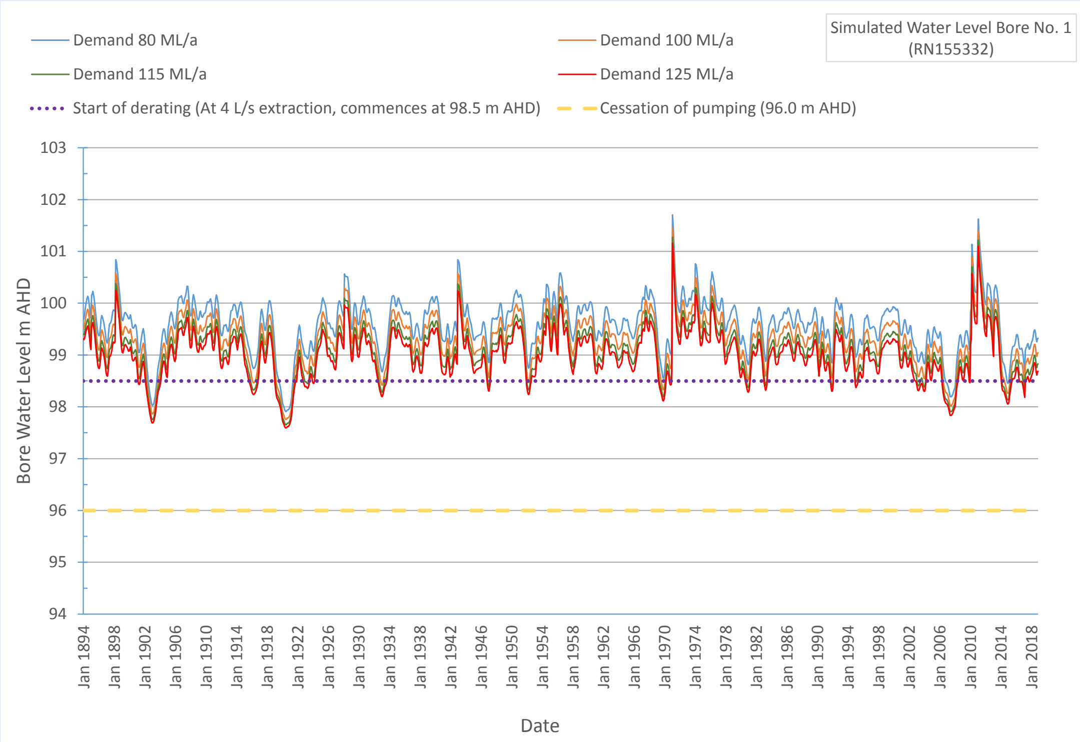

Figure A-4: Simulated standing (pump 'off') water levels for bore No. 1 (RN155332) with 75% or the water demand supplied by bore No. 2 and 25% by bore No. 1, without water demand restrictions on either bore

Stochastic Modelling Assessment

For this UWSA, the predictive simulation of water level response over a 125-year period incorporated 100 varied climate replicates (using stochastically generated rainfall and evaporation data) and 250 groundwater parameter sets. This modelling found that, when operated at a pump rate of around 4 L/s, bore No.2 (RN156052) could (including when operating alone) meet the Biggenden community's water demands of up to 125 ML/a without experiencing a water supply shortfall, even without the application of water restrictions.

As mentioned earlier, operation of the bore No. 2 at an extraction rate of around 8 L/s may cause water levels within the bore to be drawn down by around 12 m while the pump is on. This means that this extraction rate may not be sustainable when standing (pump off) water levels in the bore are below about 98.33 m (AHD) and that a lower rate of extraction may need to be adopted until the water levels recover after the pump is switched off. For a water demand of 125 ML/a, the assessment found that bore No. 2 may need to operate at a rate lower than 8 L/s on average about 1 in 3–4 years.

The stochastic modelling also highlighted that Council's much shallower bore No. 1 (RN155332) could contribute to Biggenden's overall water supply in most years; however, at times it was also susceptible to periods of reduced supply capability because of low water levels relative to the pump intake level. This is illustrated in Figure A-5, which provides an indication of the likelihood of the water level at bore No. 1 being below EL98.5 m AHD (i.e. the adopted level below which the bore's supply capability reduces at an extraction rate of about 4 L/s).

Note that the recurrence interval statistic shown in Figure A-5 is calculated by dividing the number of water years in the simulation by the number of occurrences of water supply 'failure', thus lower values indicate a greater likelihood of such failure. Furthermore, these results pertain to an arrangement where 75% of Biggenden's demand was met from bore No. 2, and the remainder was met from bore No. 1. The modelled demand at bore No. 1 under this arrangement thereby ranges between 20 ML/a and 31.25 ML/a.

However, this modelling also indicated that in most of the years during which bore No. 1 did experience reduced supply capability, the resultant annual shortfall was small relative to Biggenden's total water demand. Accordingly, it is anticipated that periods of reduced supply capability in bore No. 1 would in most instances be managed by, for example, an increase in the proportion of Biggenden's demand taken from bore No. 2 and/or application of water restrictions to reduce the supply of water that is required.

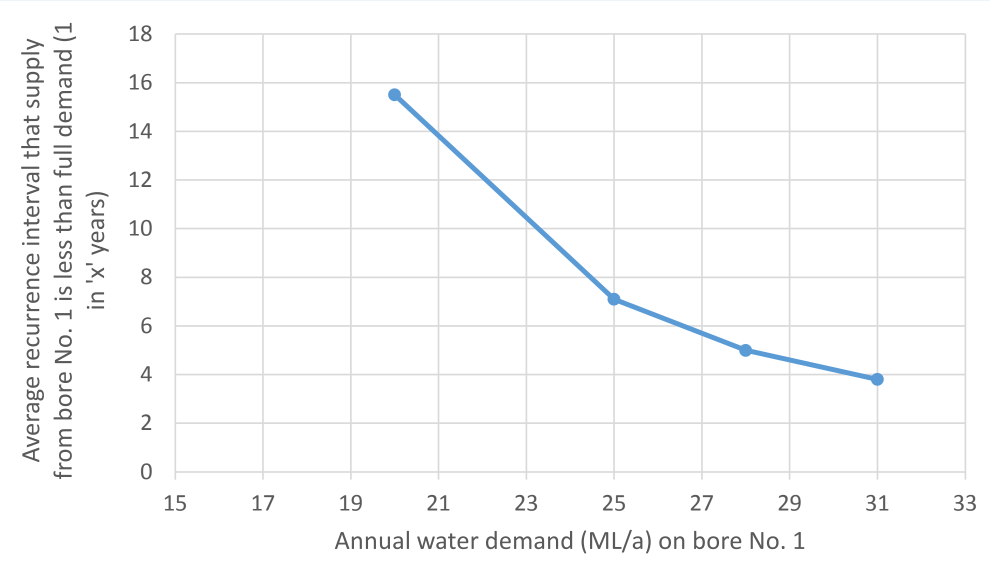

Figure A-5: Likelihood of water level in bore No. 1 (RN155332) being below EL98.5 m AHD at a pumping rate of about 4 L/s

Likelihood, duration and severity of water restrictions

It is important to note that all of the modelling results referred to in the following section relate solely to the restriction levels associated with the more stringent restriction regime modelled as per Table A-1, rather than Council's current restriction triggers given in Table 2.

Figure A-6 provides an indicative likelihood of modelled Level 2 water restrictions being triggered for a range of annual Biggenden water demands (when Biggenden's bores are operated at a pumping rate of around 4 L/s). As an example, at Biggenden's current average annual demand of around 107 ML/a, modelled Level 2 water restrictions might occur about once in 6 years on average if 75% of Biggenden's demand was being met from bore No. 2 (RN156052), or about once in 4.5 years on average if demand is met solely from bore No. 2 (extrapolating the results produced for the 115 ML/a and 125 ML/a demands). For the scenarios assessed in this UWSA, there were no occurrences of modelled Level 3 or Level 4 water restrictions being triggered.

Considerations such as an acceptable frequency of the various restriction levels being applied, and the underlying likelihood of not being able to meet demand, are critical and fundamental parts of the water supply planning currently being undertaken by North Burnett Regional Council and generally by councils across Queensland.

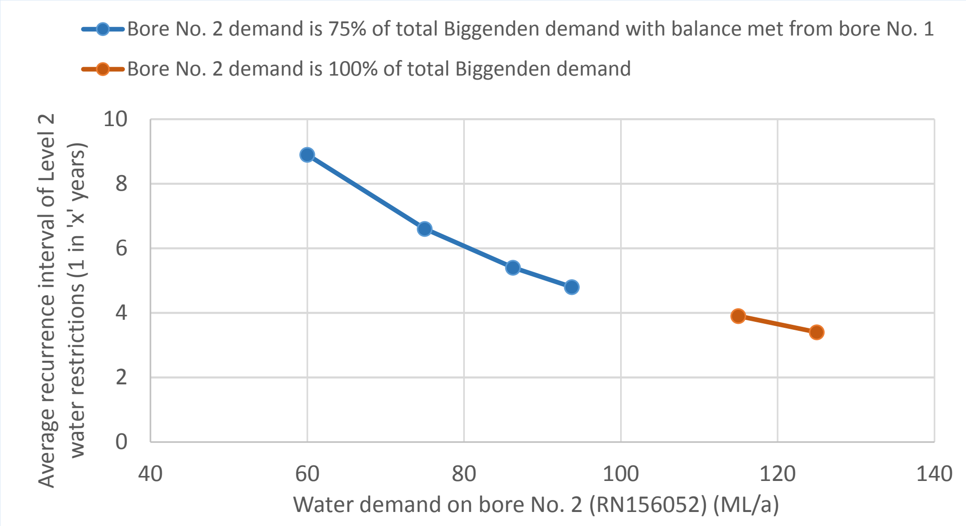

Figure A-6: Likelihood of modelled Level 2 water restrictions on Biggenden's water supply

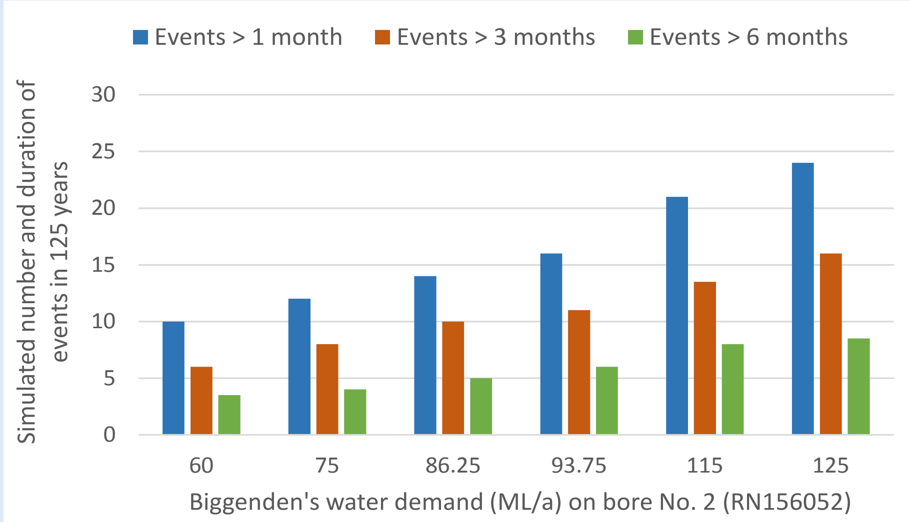

Figure A-7: Number and duration of modelled Level 2 water restriction events for various annual water demands

Although the frequency of water restrictions is an important consideration, the duration and severity of each restriction period may be more important for many water users. For example, it may be more acceptable to experience less severe and shorter periods of water restrictions more frequently, than to experience more severe and longer periods of water restrictions less frequently.

Figure A-7 shows the median number of occurrences of modelled Level 2 water restrictions lasting for longer than 1 month, 3 months and 6 months over a 125 year simulation period. This indicates the extent to which occurrences of water restrictions and their duration increase with increasing water supply demands. For example, when a water demand of 115 ML/a is placed on bore No. 2 (RN156052) exclusively, there are 21 occurrences of modelled Level 2 water restrictions lasting longer than 1 month, of which 13 extend longer than 3 months and 8 extend longer than 6 months.

Note the results shown in Figure A-7 for water demands on bore No. 2 of 93.75 ML/a or less are for an arrangement where 75% of Biggenden's water demand is via bore No. 2 and 25% is via bore No. 1 with a pumping rate of around 4 L/s. Under this scenario, it should be noted that the unrestricted demand on bore No. 1 may marginally influence the water levels in bore No. 2 (thereby potentially increasing the frequency and duration of these events).

Together, the frequency, severity and duration of water restrictions, along with the ability to maintain a minimum supply during drought, are fundamental parts of water supply planning and are referred to as 'level of service'. The level of service for Biggenden is a matter for council to determine, in discussion with the community.

Increased water demand from augmentation of water treatment system

As previously mentioned, Council has considered an option to upgrade its aging water treatment plant with a suitable reverse osmosis component to ameliorate persistently high TDS levels and hardness. However, this could markedly increase the total volume of water required to be sourced, as reverse osmosis processes generally produce significant volumes of wastewater.

Therefore, additional hydrologic assessment was undertaken to assess the potential impact of an increased demand on Biggenden's supply sources. This additional assessment looked at the effects of increasing demand to 150 ML/a, with demands managed under the restriction regime annotated in Table A-1.

Meeting this higher demand would require a higher pumping rate—around 4.75 L/s if operated continuously 24 hours per day, or even higher pumping rates over shorter durations. As mentioned previously, when the pumps are turned on to extract water from the bores, water levels within the bores instantaneously begin to fall—the higher the rate and duration of pumping, the greater the extent that water levels within the bore are lowered.

The modelling found that, with the more stringent restrictions regime in place (as per Table A-1) and with continuous pumping (at 4.75 L/s), a demand of 150 ML/a could be met by bore No. 2 (RN156052) alone without experiencing a supply shortfall. The assessment also found that although bore No. 2 could be operated at the higher pumping rate of 8 L/s in most years without supply issues, water extraction from this bore may need to be at a reduced rate in around 1 in 2.4 years on average (more than 75% of these occasions are for less than 6 months duration, and around half are for less for than 3 months duration).

Historically, the effects of the various pumping rates and operational arrangements (e.g. using one or both bores, with or without supplementary supplies from Degilbo Creek) have been managed by Council in their day to day operation of the bores. In the past the resulting operational limitations have meant that, on occasions, Council has needed to impose water restrictions even though the pre-defined restriction trigger levels (shown in Table 2) have not been reached, in order to maintain sufficient supply to meet the community's essential daily water requirements.

Increasing the volume of water sourced from the bores would therefore require appropriate monitoring and management of the water levels and pumping regime. As a result, this could potentially increase the occurrence of restrictions which may therefore, at times, require reaching an appropriate balance between water demand and water availability.

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