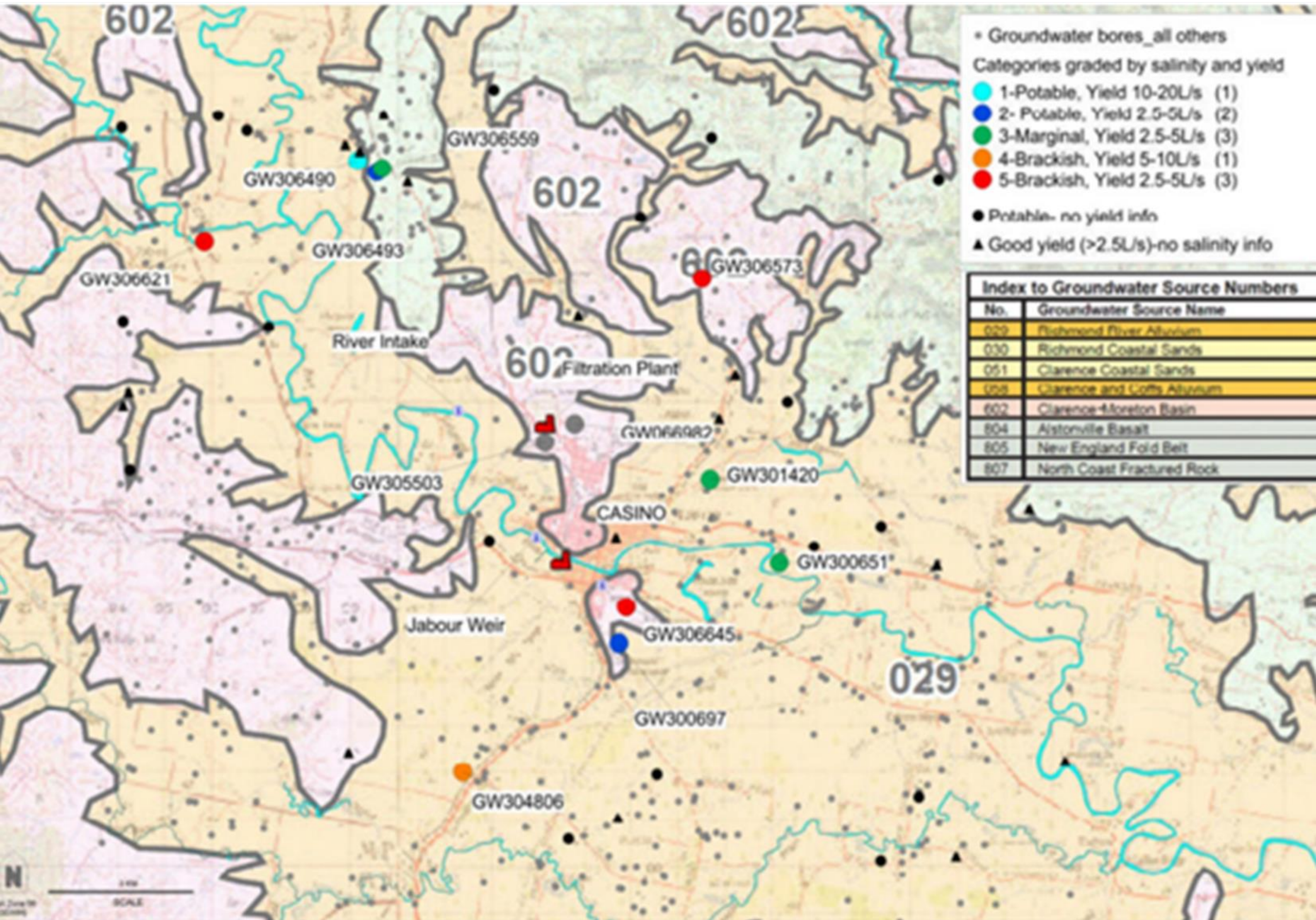
Hydrogeology, water quality and demand

Analysis report

Department of Regional NSW

06 November 2023

→ **The Power of Commitment**



Project name	DRNSW - Richmond Valley RJP
Document title	Hydrogeology, water quality and demand | Analysis report
Project number	12621341
File name	12621341-REP_0_Hydrogeology, Quality and Demand Analysis Report.docx

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	T Cook N Malcolm	T Cook		N Malcolm		26/10/22
S4	1	T Cook N Malcolm	T Cook		N Malcolm		29/11/22
S4	2	T Cook N Malcolm	T Cook		N Malcolm		10/01/23
S4	3	L Sharpe T Cook	T Cook		N Malcolm		29/09/23
S4	4	L Sharpe T Cook	T Cook	[signature]	N Malcolm	[signature]	06/11/23

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→ The Power of Commitment

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1. Introduction

GHD Pty Ltd (GHD) was engaged by Department of Regional NSW (DRNSW) to prepare the Hydrogeology, Quality and Demand Analysis Report for three areas that form the Richmond Valley Regional Job Precincts (RJP's) as located in Casino, NSW as shown in Figure 1.1.

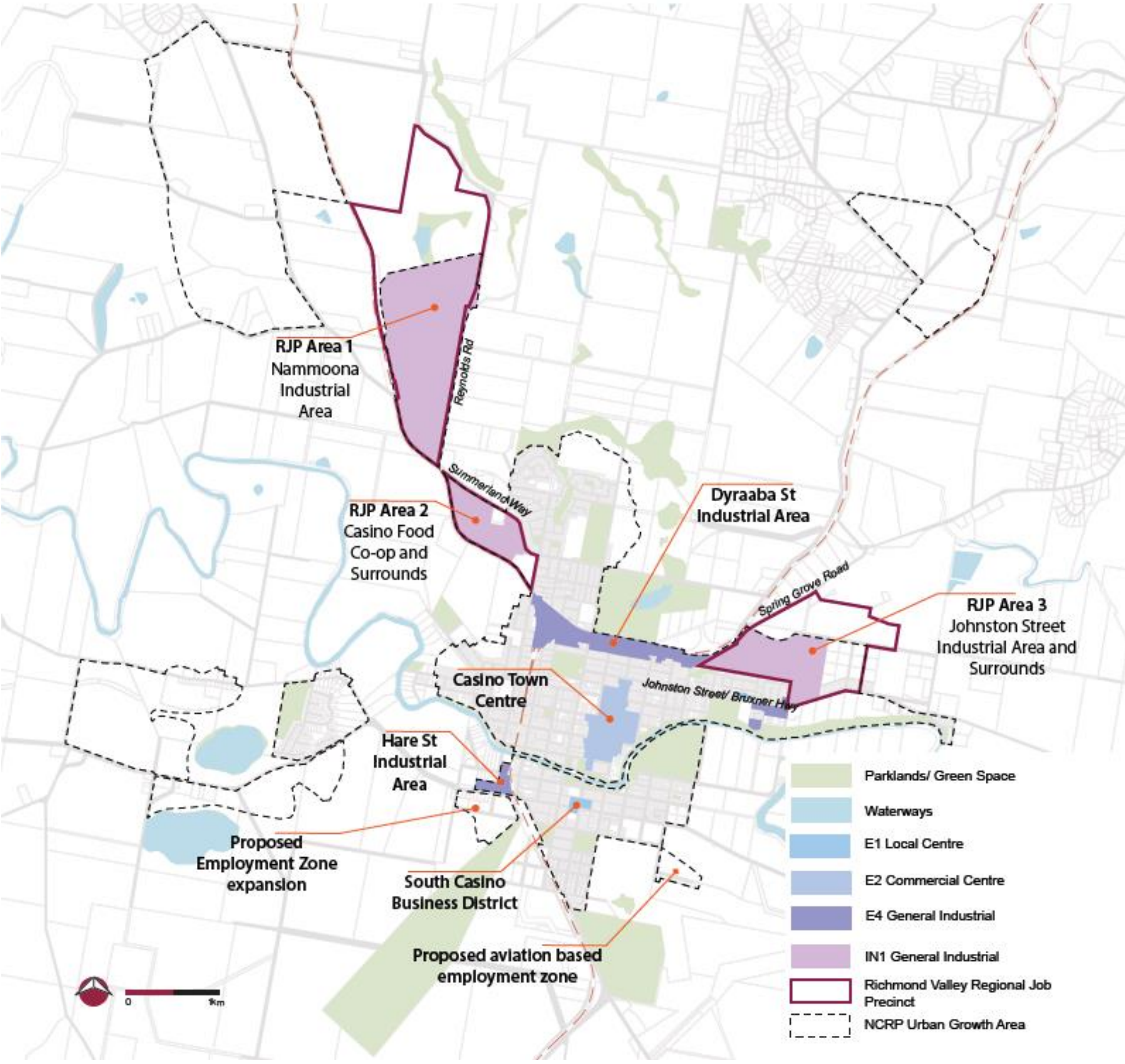

Figure 1.1 Richmond Valley Regional Job Precincts

Source: *Draft Richmond Valley Regional Jobs Precinct Structure Plan*

1.1 Purpose of this report

The purpose of the report is to highlight the key risks, issues, constraints, key insights, opportunities and assess three options associated with the provision of services for the proposed RJP developments. For the preferred option, recommendations are detailed. The outcomes of this report will lead into the development of Draft Structure Plan for the three RJP's. The analysed in this report included:

- Groundwater availability
- Surface water availability
- Water quality
- Water demand

1.2 Scope and limitations

This report: has been prepared by GHD for Department of Regional NSW and may only be used and relied on by Department of Regional NSW for the purpose agreed between GHD and Department of Regional NSW as set out in this report.

GHD otherwise disclaims responsibility to any person other than Department of Regional NSW arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section 1.3 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

This report has been prepared to inform the Draft Structure Plan for Richmond Valley RJP. The findings and recommendations have been developed where possible in collaboration with other disciplines. It is acknowledged that some of the recommendations in this report may not be included in the Daft Structure Plan, such as where they are out of scope for the RJP, conflict with other elements of the project or are proposed to be managed via an alternate mechanism.

1.3 Assumptions

This analysis has relied on data as referenced in the following sections. This data includes but is not limited to Council, State and Australian Government Geographic Information Systems (GIS) data, information and studies which are publicly available. Where consultation has been appropriate this has also been used to support investigation and evaluation of needs within the regional job precincts.

This report is subject to, and must be read in conjunction with, the limitations set out and the assumptions and qualifications contained throughout the report.

2. Review of information

2.1 Data review

The following data was supplied by Richmond Valley Council (RVC), DRNSW and various State and Australian Government agencies:

RJP planning

– Draft Casino Place Plan
– Draft Richmond Valley Regional Jobs Precinct Structure Plan
– Richmond Valley Regional Job Precincts Action Plan

Groundwater availability

– Australian Government Bioregional Assessments
– WaterNSW groundwater database
– Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources (2016)
– Water Sharing Plan for the Richmond area unregulated, regulated, and alluvial water sources (2010)

Surface water availability

– Casino water security studies and regional strategies
– **Water quality**
– RVC website monthly water quality – raw and finished data
– **Water demand**
– Casino water security studies and regional strategies
– Casino water billing and water treatment plant (WTP) production data

Flooding

– Casino flood study 1998
– Casino flood model 1999
– Casino Floodplain Risk Management Plan 2002
– Regional Jobs Precinct Flood Impact Assessment Stage 4 Final Report 2023
– Technical Note – Richmond Valley Regional Jobs Precinct: Additional Fill Scenario Testing 2023

GIS spatial data

– Council and State Government GIS data for the various services
– RVC aerial imagery overlayed road and flooding layers

2.2 Site inspection

A site inspection was undertaken by GHD personnel on 8 December 2021. Photographs were taken of the No. 3 Sewage Treatment Plant (STP) within the RJP and the surrounding area.

3. Regional Job Precincts (RJPs)

3.1 Area 1 – Nammoona industrial precinct

GHD has considered the proposed vision for the precinct, key site attributes, known limitations, key constraints as summarised in the Draft Richmond Valley RJP Structure Plan and Draft Casino Place Plan.

3.1.1 Site summary

The Nammoona Industrial precinct currently contains a mix of infrastructure, agribusiness and both council owned and private industrial uses. The *Draft Richmond Valley RJP Structure Plan* recommendations for the Nammoona industrial precinct are shown in Figure 3.1.

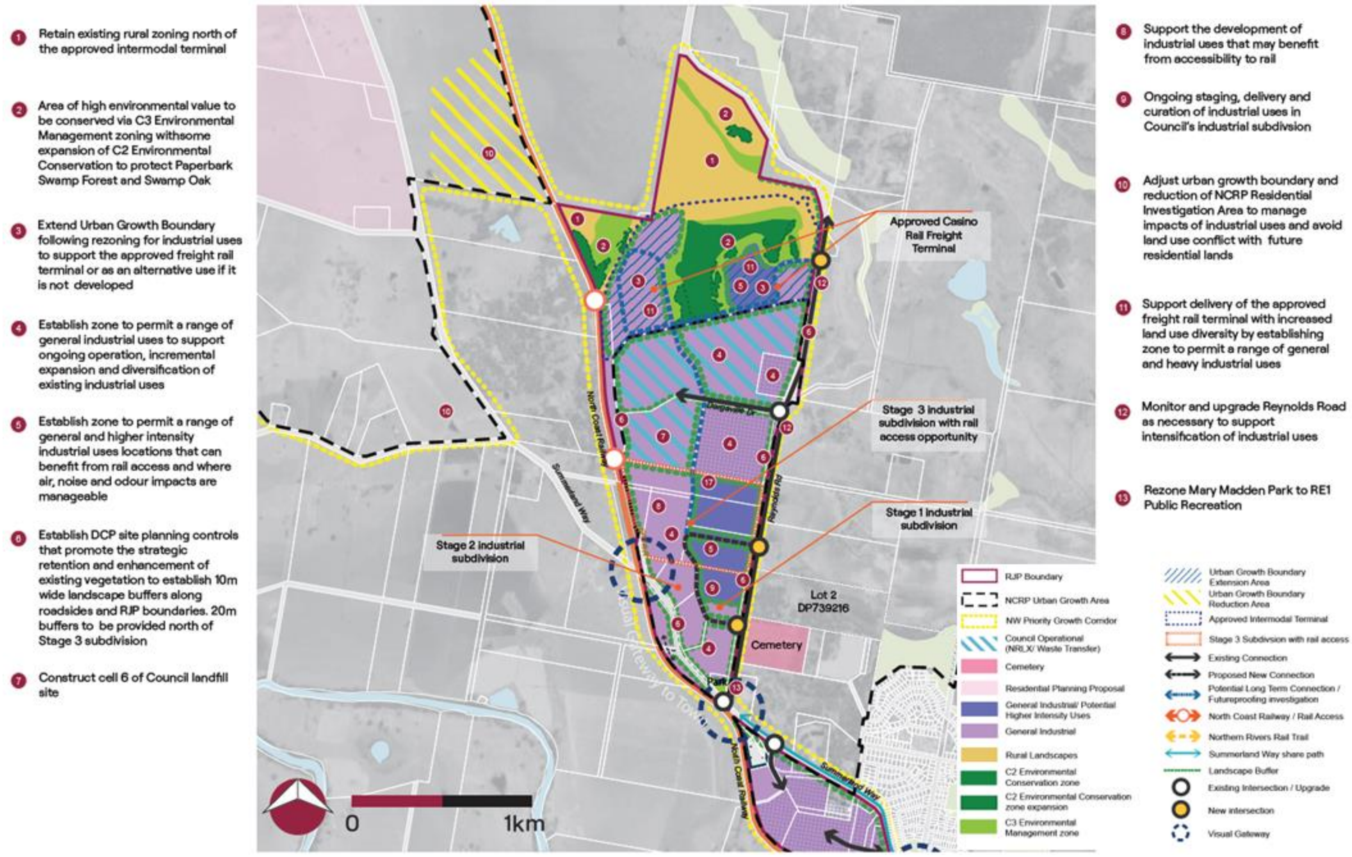

Figure 3.1 Regional Job Precinct 1 – Nammoona Industrial Area

Source: *Draft Richmond Valley Regional Jobs Precinct Structure Plan*

3.1.2 Existing zoning in and around site

Nammoona is zoned IN1, RU1 Primary Production with additional use of a rail freight transport facility is permitted under Schedule 1 of the Richmond Valley Local Environment Plan (RVLEP) for land at Reynolds Road, Casino, being Lot 2, DP 547143. Surrounding land includes zoning E2 Environmental Conservation.

3.1.3 Existing land use

Existing industrial activities are currently focused within the central portion of the area, including Council-owned assets (Northern Rivers Livestock Exchange and Richmond Valley Waste Management Centre) as well as several privately operated industries. This area also has direct heavy rail frontage to the North Coast Railway line but only provides limited access to this infrastructure (e.g., loading/unloading rail ballast). Within the southern portion, 13 ha of land is already under construction to provide nine industrial lots.

3.2 Area 2 – Casino food complex area

GHD has considered the proposed vision for the precinct, key site attributes, known limitations, key constraints as summarised in the Draft Richmond Valley RJP Structure Plan and Draft Casino Place Plan.

3.2.1 Site summary

The Casino food co-op and surrounds precinct is the largest employment centre in Casino. This is currently a single-user area but does support a variety of activities. Several different activities are undertaken within the complex, with cattle yards supporting an abattoir and tannery. The area additionally includes the towns water supply infrastructure. The *Draft Richmond Valley RJP Structure Plan* recommendations for the Casino food co-op and surrounds precinct are shown in Figure 3.2.

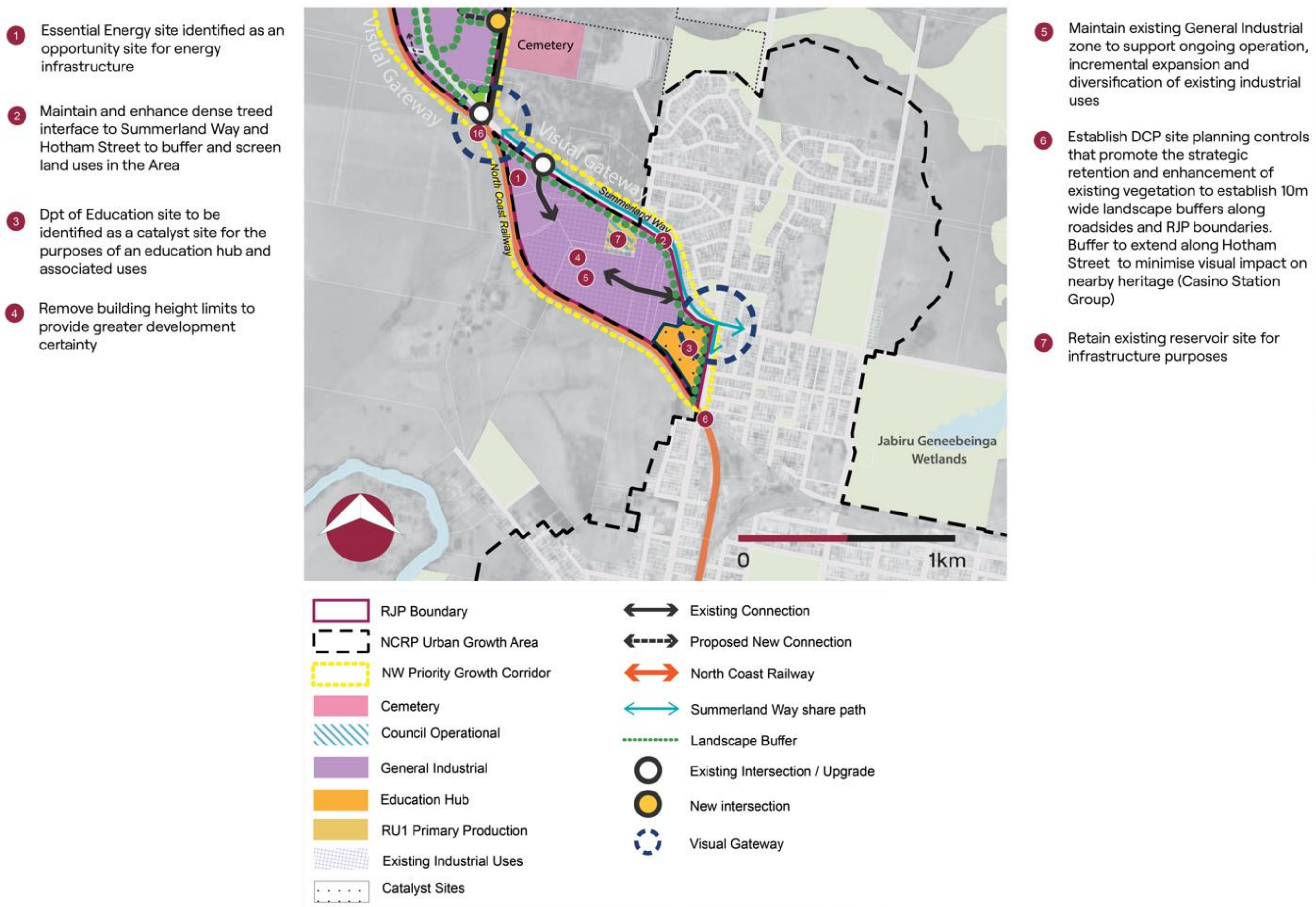

Figure 3.2 ***Regional Job Precinct 2 – Casino Food Co-op Area***
Source: Draft Richmond Valley Regional Jobs Precinct Structure Plan

3.2.2 Existing zoning in and around site

The three properties adjoining the complex are all owned by infrastructure providers, including Essential Energy, Richmond Valley Council, and NSW Education.

The land acquired by Essential Energy previously intended to accommodate a substation. This is currently zoned IN1 Light Industry, so would be immediately capable of supporting a variety of uses, with consent.

Richmond Valley Council-owned land is part of the town's water supply network. This land is zoned RU1 Primary Production, so may rely on a rezoning to facilitate further development (depending on the use).

Land owned by the Minister for Education is currently zoned R1 General Residential and hosts a variety of activities connected to the High School as well as other community uses.

3.2.3 Existing land use

The Casino Food Co-op (formerly the Northern Co-op Meat Company) Complex is already the largest employment centre in Casino. Several different activities are undertaken within the complex, with cattle yards supporting an abattoir and tannery.

3.3 Area 3 – STP and Johnston Street area

GHD has considered the proposed vision for the precinct, key site attributes, known limitations, key constraints as summarised in the Draft Richmond Valley RJP Structure Plan and Draft Casino Place Plan.

3.3.1 Site summary

Johnston Street Industrial area and surrounds precinct currently contains a mix of industrial, agribusiness uses as well as the Casino STP and Richmond Valley Events Centre (Primex). The *Draft Richmond Valley RJP Structure Plan* recommendations for the Johnston Street and STP industrial areas are shown in Figure 3.3.

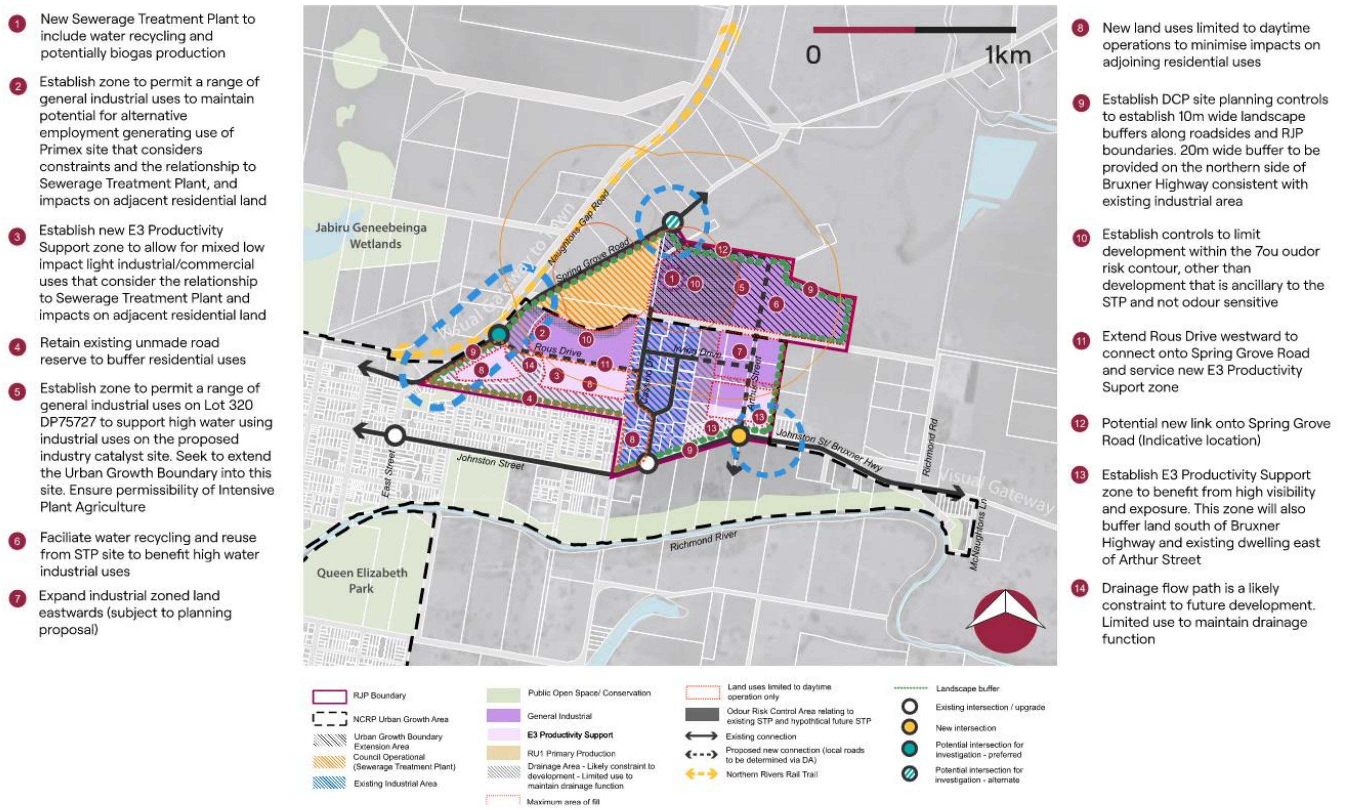

Figure 3.3 Regional Job Precinct 3 –Johnston Street and STP Industrial Areas
Source: Revised Area 3 Structure Plan Concept

3.3.2 Existing zoning in and around site

The existing zoning for Area 3 consists of:

- IN1 General Industrial
- RU1 Primary Production
- E2 Environmental Conservation

3.3.3 Existing land use

Area 3 currently contains a mix of industrial and agribusiness uses, as well as the Casino STP.

4. Groundwater availability

The concept of groundwater availability requires integrating hydrogeological characteristics with government regulatory constraints and opportunities associated with managing the groundwater resource. Section 4.1 provides the hydrogeological characteristics that formulate the physical nature of groundwater availability in the Richmond Valley, while Section 4.2 describes the regulatory impacts on groundwater availability.

4.1 Hydrogeological characteristics

The investigation area lies towards the mid to southern end of the Clarence-Moreton Sedimentary Basin. Extensive basaltic flows occupy most of the elevated country in the north, the sedimentary sequence exposed only in the valleys of the Richmond River and its larger tributaries. The stratigraphic sequence is shown in Figure 4.1.

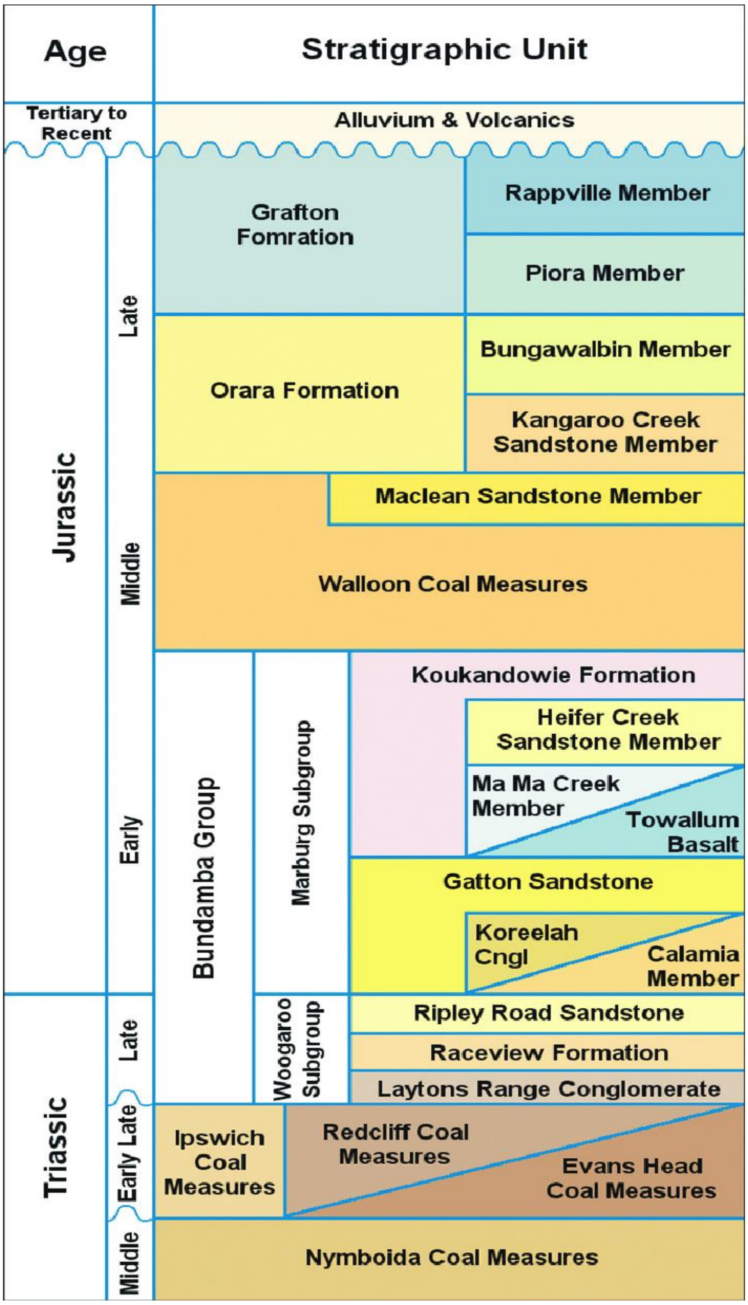

Figure 4.1 The stratigraphic sequence of the Clarence-Moreton Sedimentary Basin

Source: Doig & Stanmore, 2012

Stock water supplies can usually be obtained from bores in the sedimentary strata. The quality of the water is variable and depends on which sedimentary unit the groundwater is being extracted from. Generally, the Mallanganee Coal Measures and Grafton beds yield brackish waters suitable for stock, whilst the Tabulum Group and the Kangaroo Creek sandstones yield good quality groundwater suitable for domestic and garden use. However, yields rarely exceed 0.5 Litres (L) per second (s).

A three-dimensional geological model of the Richmond Valley is illustrated in Figure 4.2. This model indicates that Casino lies in the mid-valley zone where groundwater can be sourced from both alluvial and porous rock aquifers.

Two red lines can be seen perpendicular to each other: A-B and C-D, which represent two cross sections presented as a fence diagram in Figure 4.3, illustrating the sequence of aquifer and aquitard strata. Casino lies to the right side of the intersection of the two cross sections along A-B.

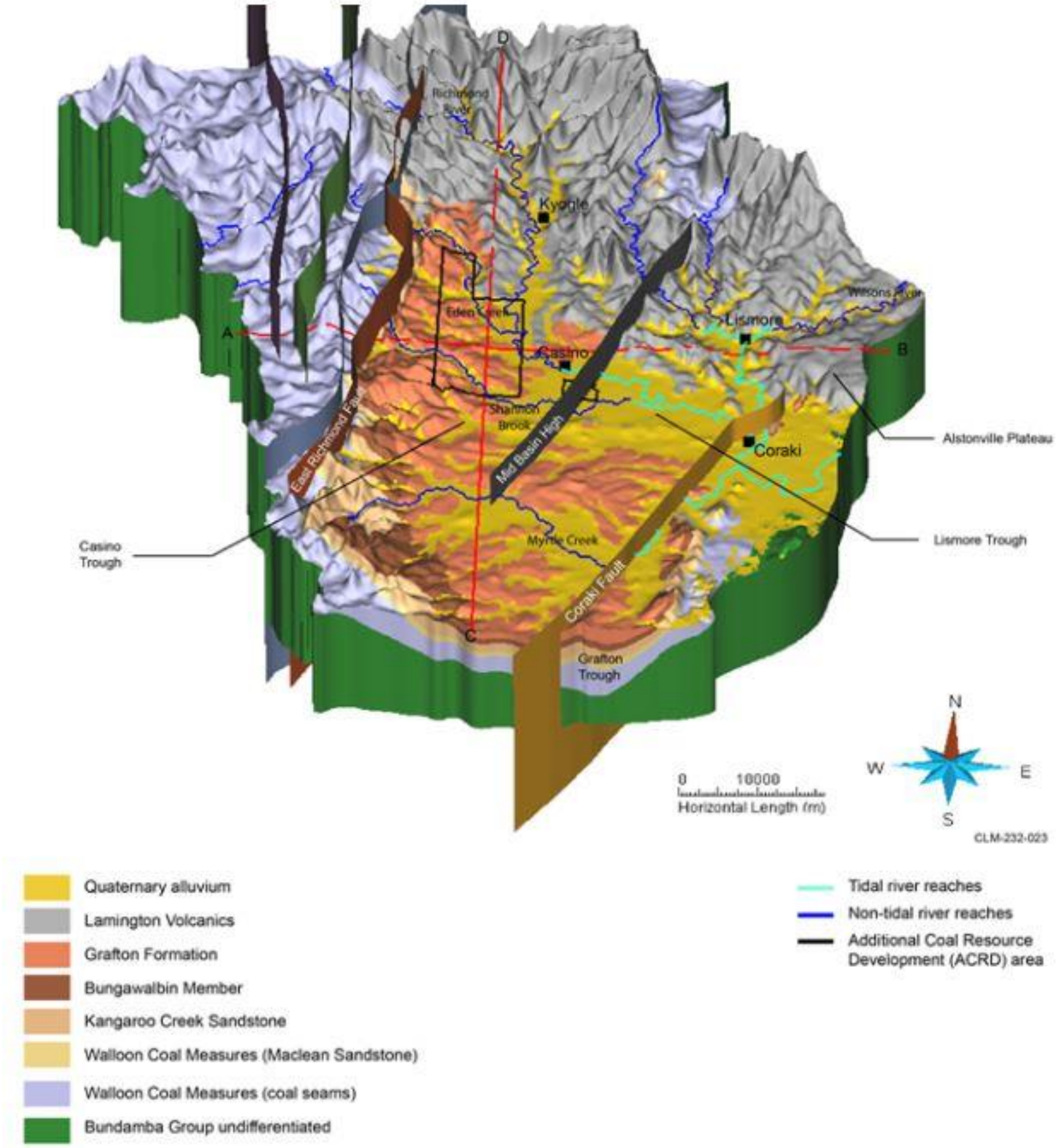

Figure 4.2 Three-dimensional geological model corresponding to the extent of the Richmond River basin groundwater domain

(Reproduced from the Australian Governments Bioregional Assessments website)

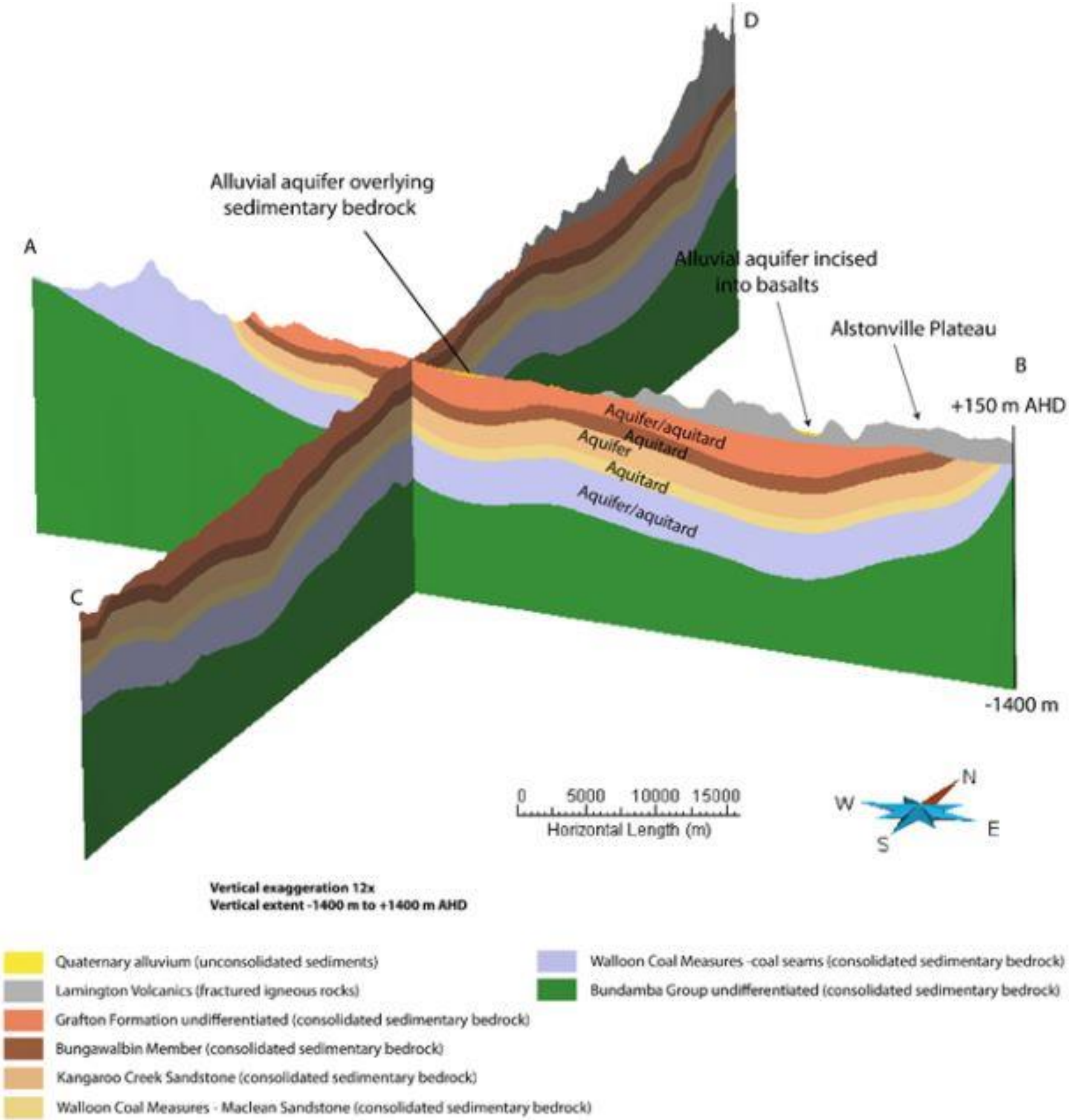

Figure 4.3 ***Fence diagram through the Richmond River basin showing the geometric and thickness relationships between alluvial, volcanic, and sedimentary bedrock hydrostratigraphic units***

(Taken from the Australian Government Bioregional Assessments website).

Analysis of the WaterNSW groundwater bore summary and licence data for a 20 kilometre (km) radius around Casino was conducted. Various groundwater sources were grouped according to average yield, water quality and geological source type as well as recharge to storage ratio characteristics where data was available. This was captured spatially and presented in GIS as shown in Figure 4.4.

Figure 4.4 highlights several key points including:

- Groundwater yields are low and predominate throughout the area.
- Groundwater quality is variable from relatively fresh to saline depending on the aquifer type.
- Basic landholder rights (BLR) predominate as they can utilise the low yields more effectively than higher water demand operations.

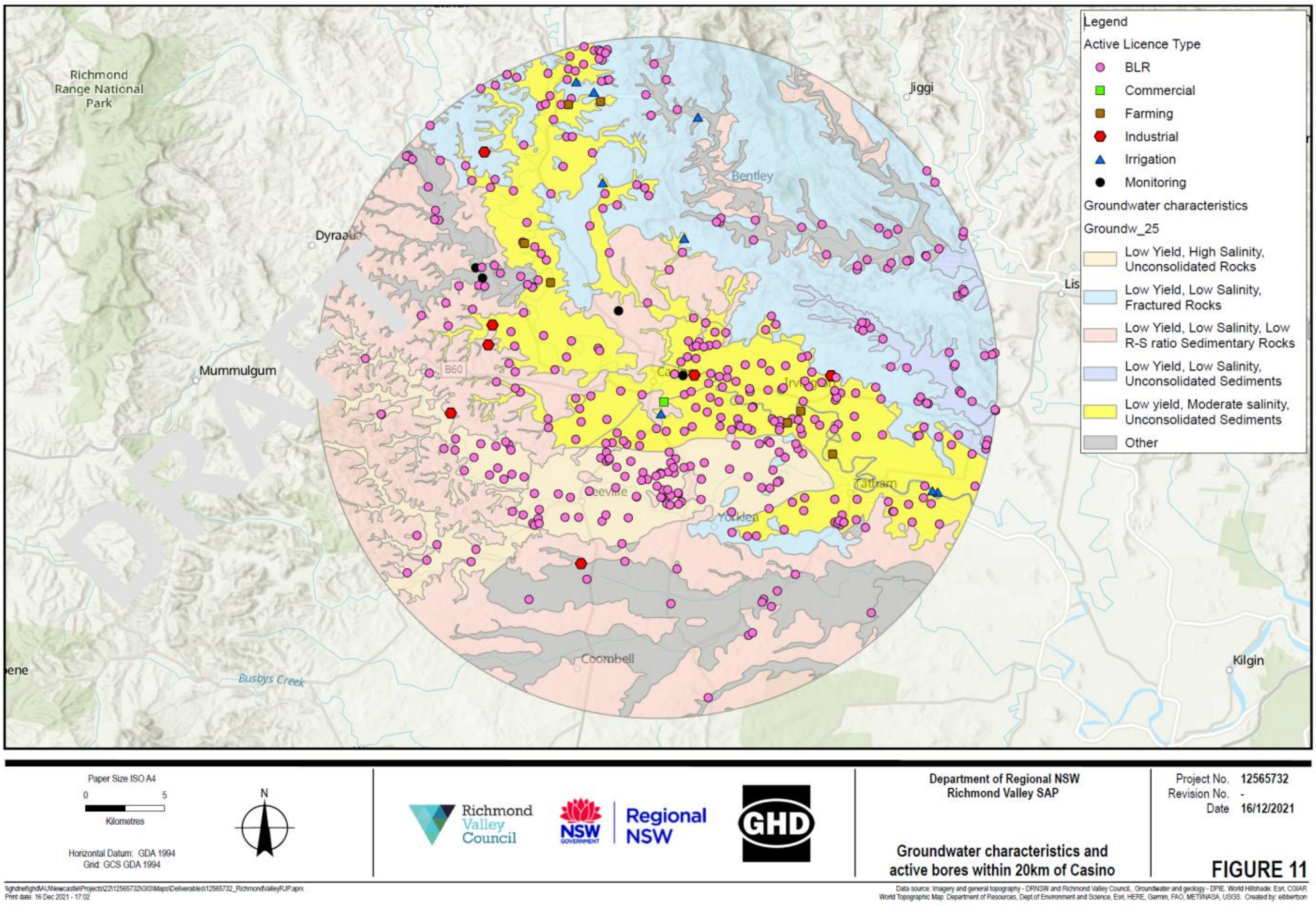

Figure 4.4 Groundwater characteristics within 20 km of Casino highlighting all active bores and their licence types

4.1.1 Porous rock aquifers

The porous rock aquifers that are represented by the various strata in Figure 4.4 are formed from groundwater moving through pore spaces and fractures in these rocks. Yields are typically low where secondary porosity occurs with low fracture density or in primary porosity in pore spaces, being less than 1 L/s. However, at rare locations yields up to 10 L/s are obtained when associated with highly fractured fault systems.

All surface geological units are recharged by direct rainfall recharge with subsequent vertical leakage. The three-dimensional representation shown in Figure 4.3 of the spatial extent of various geological units indicates that the rock types represented would have a high degree of variability in hydraulic conductivity and therefore recharge rates are spatially variable across the region. Deeper units such as the Walloon coal measures may receive some degree of lateral through flow from adjacent systems.

4.1.2 Alluvial aquifers

Early groundwater investigations into the Casino area (Beale, 1966) identified the following characteristics of the alluvial system:

Upgradient of Casino

– The alluvium is entirely fluviatile in origin with the occasional incursions of the sea above Casino as evidenced by shells and silty muds typical of estuarine conditions having been reported in some bores. The implication of this is that the fluviatile sections would have fresh groundwater quality while in these potentially estuarine areas, groundwater is expected to be more saline.

– Overall, water quality varies considerably but most are suitable for irrigation of lucerne and pastures if the soil drainage (permeability) is good.

– The area is considered to have the best potential of all the alluvial flats in the whole Richmond Valley with the expected groundwater yields from bores screened in the alluvials to be from 5 - 8 L/s.

Downgradient of Casino

– Typical of flats deposited under deltaic conditions with broad levees flanking the river. Between the levees and side slopes of the valley are extensive swampy areas.
– Groundwater quality is variable from brackish in the lower lying areas but good quality in shallow sands on the levees confined to shallow depths within 7 m, beyond which the salinity usually increases with depth.
– These shallow aquifers have limited extents and can be over-pumped, resulting in poorer quality water drawn into the aquifer from the same level or from below.
– Groundwater yields are adequate for stock, domestic and garden use, but unlikely that large supplies of good quality water can be obtained due to the limited thickness and extent of the sandy aquifers.
– Yields of up to 2 L/s may be obtained from wells in the levees but irrigation potential is expected to be poor.

More recent studies undertaken as part of the bioregional assessments have produced a significant number of datasets that provide additional insights from further data analysis. The surface alluvium is approximately 40 m thick and represents an unconfined to semi-confined aquifer. As indicated by the above description, these unconsolidated alluvial sediments are heterogeneous in texture providing a wide range in groundwater yields.

The Bioregional Assessment study (available here) describes the alluvial system as part of the mid-catchment of the Richmond River basin, with wider floodplains than the upper catchment (approximately 0.5-2 km wide) and thicker alluvial sequences (approximately 15-30 m thick). The proportion of clay relatively to silt increases, and more likely to form soils above the alluvial sequence. Due to the higher proportion of clay, this results in lower recharge rates when compared to the upper catchment.

Due to a larger thickness and a different sediment composition in this mid-catchment zone, the alluvial aquifers in the mid-catchment respond differently to climatic extremes. During wet periods, they have shallow water levels and are close to full saturation. However, during drier months or periods of severe drought, the larger aquifer thickness and the higher degree of aquifer confinement means that the alluvial aquifers have a larger ‘buffering’ capacity compared to the alluvial aquifers in the upper catchment. As a result, they have more consistent groundwater levels even during extensive drought periods and support a wider range of ecosystems and ecological processes. Furthermore, due to the more complex recharge processes, the groundwater chemical composition becomes more variable in comparison to the upper catchment, as represented by a wider range of electrical conductivities and variable groundwater chemistry.

4.2 Regulatory constraints

4.2.1 Water Management Act 2000

This section provides a summary of relevant aspects of groundwater management in the Richmond Valley RJP region taken from DPIE (2016).

The overall objective of the *Water Management Act* (WMA) 2000 is “sustainable and integrated management of the State’s water” (DLWC 2001). Water sharing plans are the main tool through which the WMA 2000 achieves its objectives. Prior to the commencement of the WMA 2000, the *Water Act 1912* was the key piece of legislation governing extraction of water. The WMA 2000 was a significant shift in the approach to water management in NSW and as a result it has been progressively implemented as the *Water Act 1912* has been phased out.

Under the WMA 2000, water sharing plans must protect water sources and their dependent ecosystems and must protect the basic rights of landholders to extract water. Environmental water and landholder rights are afforded priority over licensed water extractions. Among licensed water users, priority is given to local water utilities and major utilities and licensed stock and domestic use, ahead of commercial purposes such as irrigation and other industries. This order of priority for water access and use is an important point for constraint consideration related to industrial development. However, the following points below illustrate how the WMA 2000 also offer opportunity for new industrial development.

Water sharing plans also recognise the economic benefits that commercial users such as irrigation and industry can bring to a region. When a plan commences, access licences held under the *Water Act 1912* are converted to access licences under the WMA 2000 which separates the water licences from land tenure. This facilitates the trade of access licences and encourages more efficient use of water resources. It also allows new industries to develop as water can move to its highest value use.

In conjunction with the WMA 2000, water sharing plans also set rules so that commercial users can continue to operate productively. In general, commercial licences under the WMA 2000 are granted in perpetuity, providing greater commercial security of water access entitlements. Water sharing plans define the access rules for commercial users for ten years, providing all users with greater certainty regarding sharing arrangements.

4.2.2 Water Sharing Plans

For the Richmond RJP investigation area, groundwater management in the porous media in the vicinity of Casino is regulated by the rules applied in the *Water Sharing Plan (WSP) for the North Coast Fractured and Porous Rock Groundwater Sources (2016)*. The alluvial aquifers are regulated by the *Water Sharing Plan for the Richmond area unregulated, regulated, and alluvial water sources (2010).*

The porous rock groundwater source that the Casino area lies within is the *Clarence Moreton Basin Groundwater Source*. The current groundwater management rules outlined in the plan include:

– Limits to the availability of water:
  - The long-term average annual extraction limit (LTAAEL) is 300,000 mega litres (ML) per year (yr).
  - The volume of unassigned water is 295,438 ML/yr which can change throughout the plan lifetime as new licences are granted or existing licences are cancelled.
  - Available Water Determinations (AWDs) will be made at commencement of each water year for:
    – Domestic and stock, local water utility and other specific purpose access licences as 100% of share component.
    – Aquifer access licences as 1 ML/unit share of a lower amount as a result of a growth-in-use response.
  - Growth in extractions will be assessed against the LTAAEL over a three-year period. Averaged growth greater than 5% will result in a reduced available water determination, in order to keep extractions in line with the LTAAEL.

– Rules for granting access licences:
  - Granting of water access licences may be considered for the following categories:
    – Specific purpose access licences including local water utility, major water utility, domestic and stock and town water supply.
    – Aquifer (Aboriginal cultural) access licences up to a maximum of 10 ML/yr.
    – Aquifer (Aboriginal community development) access licences.
    – Aquifer access licences granted under a controlled allocation order made in relation to any unassigned water in this groundwater source.

– Rules for managing access licences:
  - Carryover of up to 20% of account water is permitted, with a maximum account limit of 120% of share components plus any adjustments made for allocation assignments into or out of the account, subject to the installation of a meter.

– With regard to trading rules:
  - Trades are not permitted into the groundwater source.
  - Trades are permitted within the groundwater source subject to assessment.
  - Trades which result in the conversion of an access licence to another category are not permitted within the groundwater source.

- Rules to minimise interference between bores:
  - No water supply work (bores) to be granted or amended within the following distances:
    - 400 m of an existing bore that is not used for basic rights.
    - 100 m of an existing bore that is used for basic rights.
    - 50 m of the boundary of the property (unless consent gained from neighbour).
    - 1,000 m of a local or major water utility bore.
    - 200 m of a bore used by the Department for monitoring purposes.
    - These rules do not apply to new bores NOT existing or replacement bores.
- Rules for bores located near contamination sources:
  - No water supply work (bores) to be granted or amended within the following distances of a plume associated with a contamination source as identified in the plan:
    - Within 250 m.
    - Between 250 m and 500 m if no drawdown of water will occur within 250 m of the plume.
    - A distance greater than 500 m if necessary to protect the groundwater source, the environment or public health or safety.
    - The plan lists circumstances in which these distance conditions may be varied.
    - These rules do not apply to new bores NOT existing or replacement bores.
    - Contamination sources are identified in Schedule 1 of the plan.
- Rules for bores located near high priority groundwater-dependent ecosystems:
  - No water supply work (bores) to be granted or amended within the following distances of any high priority groundwater-dependent ecosystem (GDE), or a river or stream:
    - 100 m of a high priority GDE for bores that are used for basic rights.
    - 200 m of a high priority GDE for bores that are not used for basic rights.
    - 500 m of a high priority karst environment GDE.
    - 40 m from the top of the high bank of a river or stream.
  - The plan lists circumstances in which these distance conditions may be varied.
  - These rules do not apply to new bores NOT existing or replacement bores.
- Rules for bores located near groundwater-dependent culturally significant sites:
  - No water supply work (bores) to be granted or amended within the following distances of a groundwater-dependent culturally significant site:
    - 100 m for basic landholder rights bores.
    - 200 m for bores not used for basic landholder rights.
  - The plan lists circumstances in which these distance conditions may be varied. Where a culturally significant site is also a high priority GDE, the more restrictive distance restriction applies to the granting or amendment of a water supply work approval.
  - These rules do not apply to new bores NOT existing or replacement bores.
- Rules for replacement groundwater works:
  - The existing water supply work must have a water supply work approval.
  - The replacement groundwater work must be constructed to extract water from the same groundwater source as the existing water supply work.
  - The replacement groundwater work must be constructed to extract water from:
    - The same depth as the existing water supply work, or
    - A different depth if the Minister is satisfied that doing so will result in no greater impact on the groundwater source or its dependent ecosystems.
  - The replacement groundwater work must be located:
    - Within 20 m of the existing water supply work, or

- A distance greater than 20 m of the existing water supply work if the Minister is satisfied that doing so will result in no greater impact on the groundwater source or its dependent ecosystems.

- If the existing water supply work is located within 40 m of the high bank of a river, the replacement groundwater work must be located:
  - Within 20 m of the existing water supply work but no closer to the high bank of the river, or
  - More than 20 m of the existing water supply work, but no closer to the high bank of the river, if the Minister is satisfied that doing so will result in no greater impact on the groundwater source or its dependent ecosystems.
- The replacement groundwater work must not have a greater internal diameter or excavation footprint than the existing water supply work, except where the internal diameter of the casing of the existing water supply work, or except where the internal diameter of the casing of the existing water supply work is no longer manufactured, in which case the internal diameter of the replacement groundwater work is to be no greater than 100% of the internal diameter of the existing water supply work it replaces.

Groundwater management rules associated with the alluvial aquifers within the Casino area are based on the following principles:

- Manage to a combined long-term average annual extraction limit for the unregulated surface water and alluvial groundwater. This would be based on the sum of existing unregulated and alluvial groundwater entitlement, plus a basic landholder rights estimate, plus an allowance for exemptions such as water for Aboriginal Community Development or town water purposes (where these apply).
- Manage growth in use through a common set of available water determinations for both surface and groundwater users.
- Permit within water source licence conversion between licence categories, assignment or allocation of account water from surface to groundwater licences but not the reverse (i.e. one way only).
- Manage the trade of alluvial groundwater licences with the same trading rules as the adjoining surface water. In effect, this would prohibit trading into areas identified as having high instream values or are characterised as having high hydrological stress. Trade, where permitted between water sources, would only be from a river alluvial area to another river alluvial area.
- Manage existing bores located within 40 m of an unregulated river to surface water daily access rules (from year six of the Plan), except access licences for stock and domestic, local water utility or food safety or essential dairy care purposes. These are not subject to access rule constraints.
- Prohibit new bores within 40 m of a third order or higher stream except for bores as a result of a conversion of an unregulated river access licence or when:
  - They are drilled into the underlying non-alluvial material, and the slotted intervals of the production bore commence deeper than 30 m.
  - The applicant can demonstrate that the bore will have minimal impact on base flows in the stream
- Apply the standard local impact rules for alluvial groundwater and standard provisions for identified GDEs.

4.3 Groundwater demand

4.3.1 Historical and current demand

An indicator of groundwater demand is the number and type of active groundwater licences in a region and their relative entitlements and annual usage trends for each licence type within a groundwater source. Until recently, metering of bores for groundwater extraction was not carried out on coastal groundwater systems and was generally confined to the Murray-Darling Basin aquifers. As such, there is little historical groundwater usage data available for the groundwater sources in the Clarence-Moreton Basin and hence none around the Casino area. The only recorded data in the public record in the *Water Sharing Plan for the Richmond River Area Unregulated, Regulated and Alluvial Water Sources 2010* was in the 2017/18 water year with a usage value of 23.4 ML/yr.

Table 4.1 Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016

	2016/17	2017/18	2018/19	2019/20
Total usage	1,157 ML/yr	3,835.1 ML/yr	9,204.2 ML/yr	8,021 ML/yr

The above table highlights the increase in demand for groundwater resources during drought years that occurred particularly in 2018/19 and 2019/20, but also may reflect a growing demand trend for groundwater resources in this region overall. Usage data does not include basic landholder right (BLR) groundwater bore extraction which is limited to 1 ML/yr for domestic, 2 ML/yr for stock and 3 ML/yr for stock and domestic licences. The data does not specifically identify the location of usage and therefore it is not known from this data what the specific groundwater usage is in the Casino area. However, given that Figure 4.4 indicates the majority of groundwater bore licence types around Casino are BLR's, the overall usage could be appreciable due to the density of bores in the area.

The data indicates that the porous rock groundwater sources are under-utilised based on the estimated usage relative to LTAAEL described in Section 4.2.2. This provides opportunity for any increased demand from the proposed growth via the Casino regional job precinct developments. The primary restraint would appear to be the physical characteristics of the groundwater sources rather than the regulatory constraints on extraction at this stage.

4.3.2 Future demand

There is every indication that groundwater demand will continue into the future as water demands for a growing regional community in the Casino area will increase, especially as investment and population growth is expected to increase. In addition, climate extremes with potential for longer lasting droughts into the future could increase the reliance on groundwater sources.

Groundwater yields and water quality could be the limiting factor for growth or increased usage, as the groundwater sources appear to have a low utilisation to regulatory extraction limit (LTAAEL) ratio. Low yielding groundwater sources could provide supplementary water supply for industry however brackish and saline groundwater sources may require water treatment. Costs versus economic benefit to the community will need to be considered in these cases. Groundwater of suitable quality for the precinct operations could be utilised from distant sources (e.g. within a 20 km radius) if identified. The primary consideration would be cost/benefit associated with infrastructure required to pipe the groundwater to the site.

5. Surface water availability

The Jabour Weir on the Richmond River is the source of Casino's water and has a historic secure yield of 3,074 ML/yr which is above the towns current ADD. Council have advised during discussions on 16 November 22, that they have not experienced difficulties is supplying water to the town and bulk water supply is not currently an issue for Richmond Valley LGA. However, with climate change bringing longer periods of drought, inland communities such as Casino will experience greater water security challenges. Council has been preparing for the impacts of climate change and increased development by investigating water supply options to upgrade its bulk supplies over the short-medium term. These options, to be implemented over the next 2-10 years will assist in ensuring there is sufficient water to meet the projected growth in the Casino township due to the RJP and Casino's access to flood safe residential land.

Options used in similar locations for surface water to be captured and beneficially reused for the proposed developments (to offset bulk water supply limitations) are shown in the following subsections. A summary of the surface water options is tabulated below.

Table 5.1 Surface water options summary

Off-river water storage dams	– Construction of a storage adjacent to the Richmond River to store water to provide water town wide security for periods of drought. – Potential volume storage is dependent on land availability outside regular flooding zones.
Large scale stormwater system and reuse	– Capture and transport stormwater to a reservoir or dam to provide town wide water security for periods of drought. – Casino has multiple stormwater networks. The ability to connect these into a single network and location of a dam or reservoir for storage will need to be determined but is unlikely to be cost-effective compared to other options.
Precinct or lot-based stormwater capture and onsite reuse	– Lot based stormwater capture and reuse for non-potable applications such as industrial processes. Reduces water demand of precinct.

5.1.1 Off-river water storage dams

The use of off-river storage (ORS) dams in regional NSW is becoming more common when compared to on-river dams, given the much smoother approval process. On-river dams create significant impacts to flows and ecology and generally face opposition from the local community and environmental groups.

The 4,640 ML Bowraville Off River Storage (BORS), designed by GHD, has been operating for over 10 years now and provides water security for the Nambucca Valley area in times of low flows in the Nambucca River. Walcha Council are proposing to begin construction of a 300 ML off-river storage to address their future water resilience being impacted by climate change.

GHD has identified potential ORS dam locations (as seen in Figure 9.1) and explored the option further in Section 9.1.2.3 to utilise a larger volume of the Richmond River water supply.

5.1.2 Capture from stormwater system on large scale and reuse

There are few large-scale stormwater harvesting schemes for indirect-to-potable usage in Australia, but the system currently operated by Orange City Council (OCC) is of note.

The Blackmans Swamp Creek stormwater harvesting scheme is capable of providing around 1,300 ML of additional water into the Orange's raw water supply each year from the city's stormwater system, meeting around 25% of the city's total water needs (serviced population of around 35,000). This scheme, officially opened in 2009, involved consideration of many other options and an extensive consultation process with the community and multiple government authorities. This occurred over 18 months from concept to operation given the driver of the drought conditions experienced at the time.

A gross pollutant trap and first-flush system remove contaminants before transferring stormwater flows to the Suma Park Dam around 1 km away for storage/dilution before passing to the town's water treatment plant.

The Ploughmans Creek scheme is currently in planning by OCC with potential to provide another 800 ML/yr supply, albeit at a greater operational cost given that this catchment is further from Suma Park Dam.

5.1.3 Precinct or lot-based stormwater capture and onsite reuse

Stormwater harvesting and re-use for non-potable substitution is common practice on industrial and residential developments, usually managed on individual lots. Harvesting of stormwater occurs through the use of rainwater tanks to capture roof water, with re-use of water for replacement of potable sources for uses such as toilet flushing and landscape irrigation.

Decentralised and/or precinct scale stormwater quality improvement measures can provide amenity and other benefits, including improvement of water quality within local creeks. Passive irrigation of vegetation involves directing runoff from non-roof impervious areas to landscaped areas. Orientating developments to focus on open water and landscape features can improve local environmental amenity in industrial areas, without significant land requirements. Water management features can be incorporated in lot set-back areas, or through integration with the overall lot layout and design.

It is beneficial to incorporate trees into bio-retention to increase infiltration/harvesting and achieve other outcomes such as urban cooling. Any increase to tree canopy/health will improve river health and reduce the impacts of flooding, to some extent, although it may not be significant.

Due to the scale of this development within the catchment of the Richmond Valley, relative to the scale of agricultural and other land uses, this is not likely to have a significant benefit to river health (i.e. it appears clear that a whole of catchment response is needed).

6. Water quality

6.1 Groundwater

Groundwater quality is variable within the Clarence-Moreton Basin, and even locally around the Casino area. The Grafton formation, which is the shallowest and youngest unit below the alluvial aquifers, is generally considered to be of poorer water quality due to its higher salt content. The older/lower stratigraphic units (See Table 4.1) generally have water that is of a quality suitable for domestic purposes.

Table 6.1 shows the clusters of groundwater chemistry for the Richmond Valley based on bore electrical conductivity (EC) data (Sourced from the *Australian Government Bioregional Assessments website*).

In the Casino area, the predominant water type is sodium chloride (Na-Cl) and groundwater has moderate salinity levels ranging from 1750 – 4150 µS/cm. Occasionally, groundwater can be potable (<1000 µS/cm) at some sites. Other specific groundwater quality characteristics particularly for alluvial aquifers in the Casino area have been described earlier in Section 4.1.2.

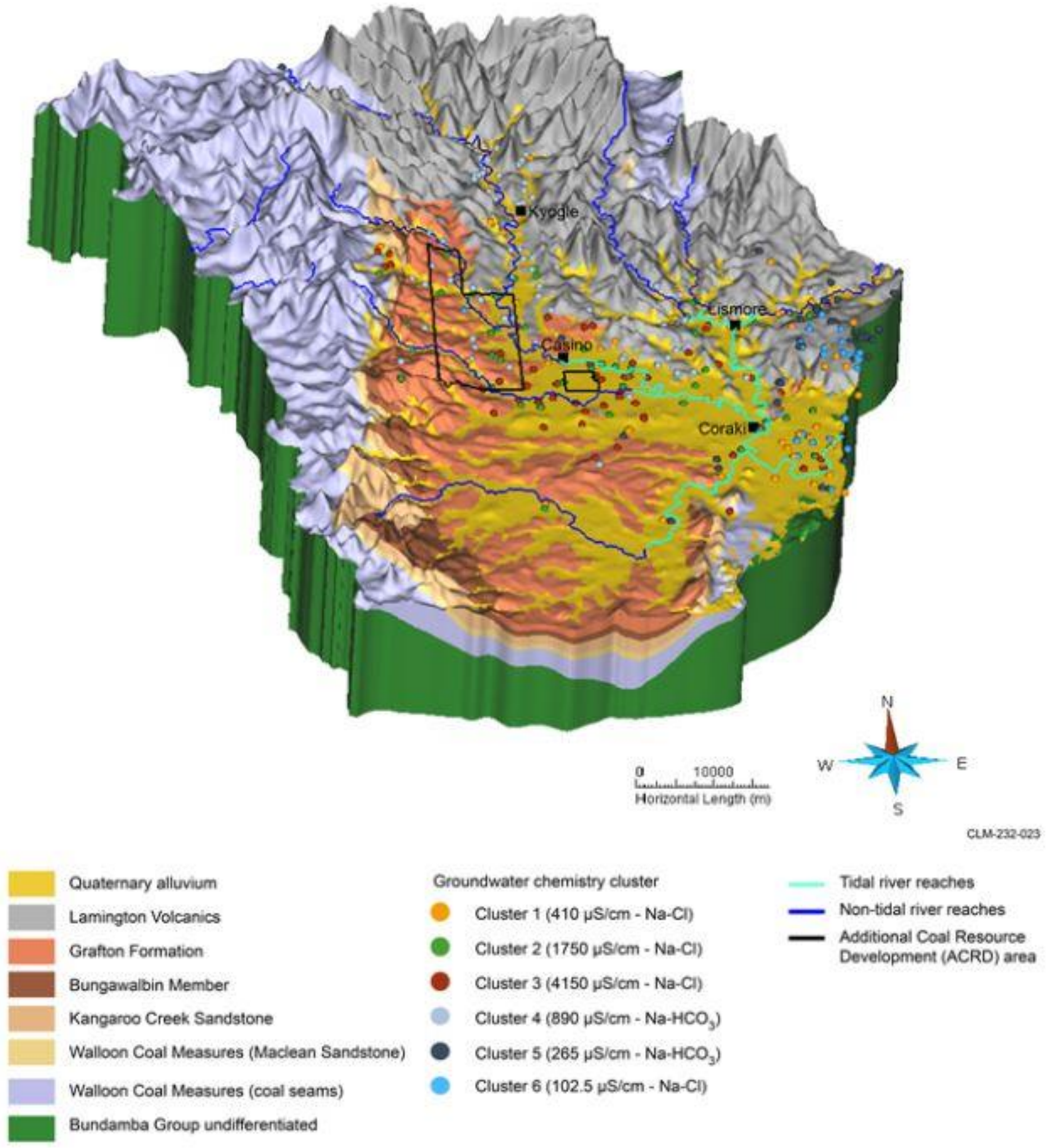

Figure 6.1 Spatial distribution of groundwater chemistry as an indicator of water quality across the Richmond Valley

6.2 Surface water

6.2.1 Typical stormwater runoff

Management of contaminants (such as hydrocarbons from industrial-area roads) from new developments to avoid impacts to environment and waterways is typically catered for by detention systems that also provide filtering and passive treatment as standard.

6.2.2 Stormwater quality assessment

The *Regional Jobs Precinct Flood Impact Assessment* (FIA) includes a stormwater quality assessment for Area 1 and Area 3 which has evaluated three potential stormwater quality management strategies using a MUSIC model. The three strategies included the following stormwater quality improvement methods:

- Wetlands
- Bioretention basins
- Streetscape bioretention

A review of Area 2 was not assessed due the naturally high elevation of the precinct. Outcomes from the stormwater management strategy includes:

- Bioretention systems are recommended as achieving stormwater quality performance targets whilst minimising land use. Indicative areas and locations of bioretention systems have been proposed and are illustrated in Figure 6.2 and Figure 6.3 below.

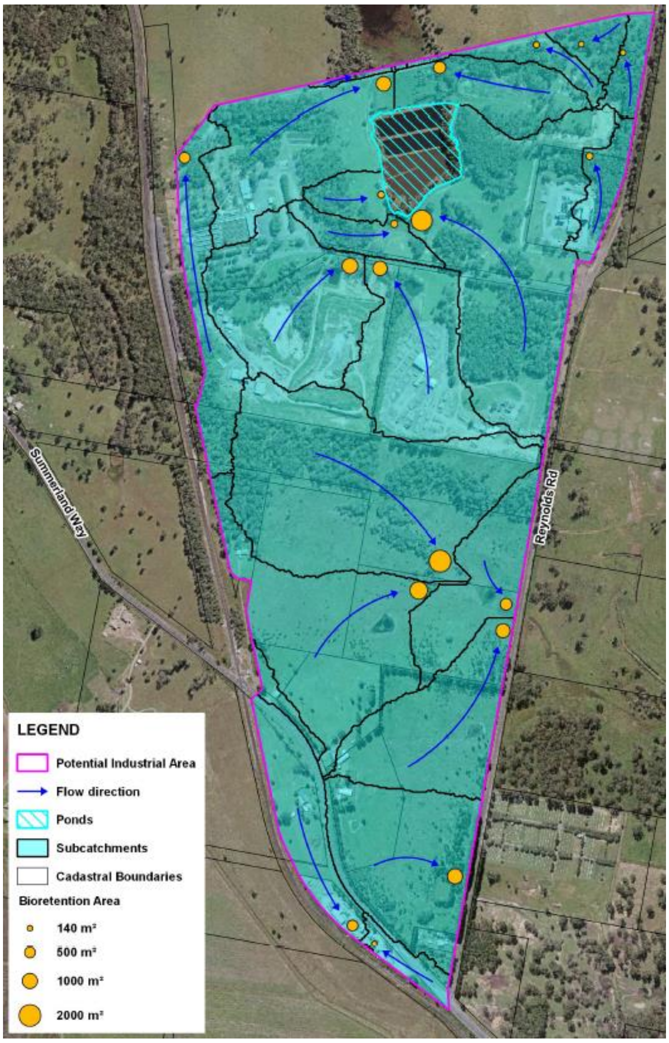

Figure 6.2 Nammoona bioretention indicative location and sizes

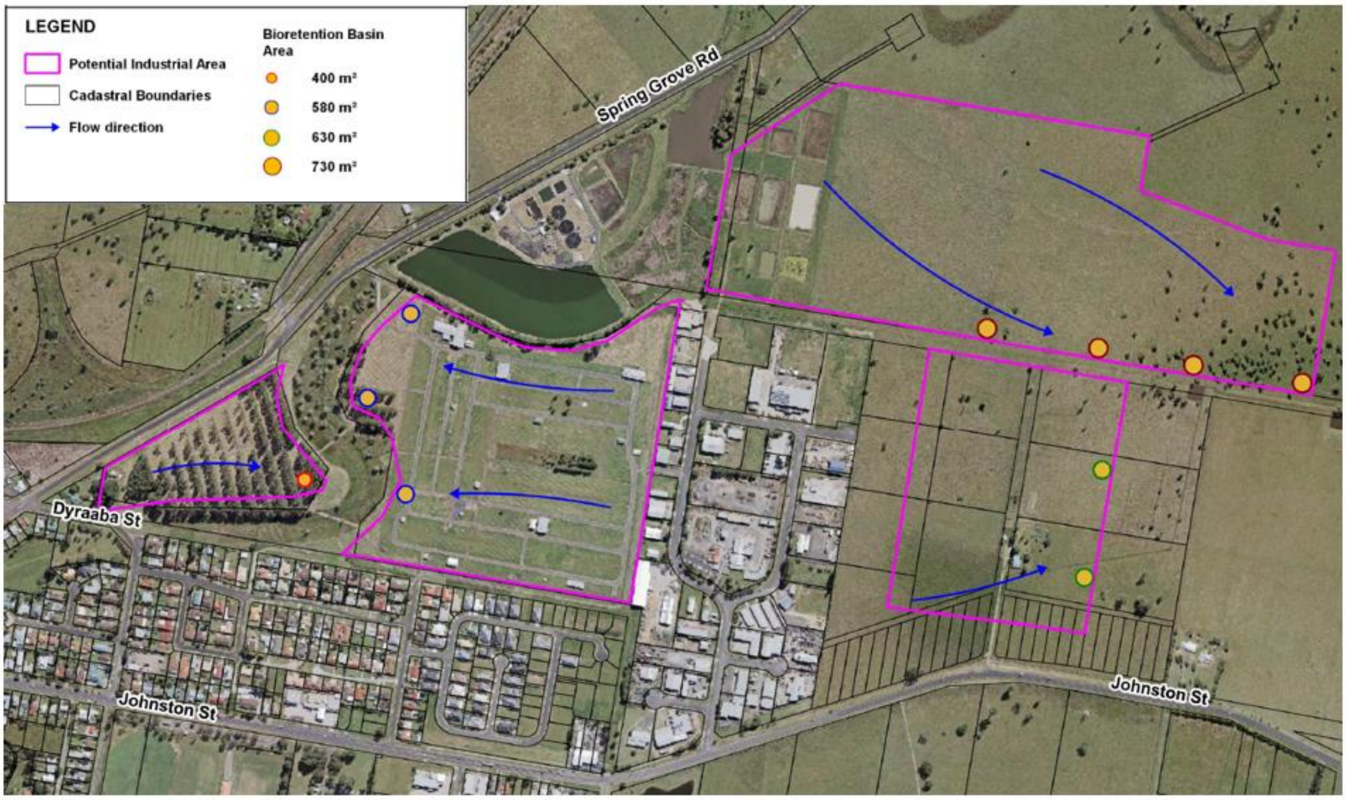

Figure 6.3 Johnston St and STP bioretention indicative location and sizes

- Buffers for waterfront land have been defined for the northern portion of Area 1.
- Removal of some hydrolines in the southern portion of Area 1 are recommended due to absence of bed and banks.

A review of the peak flowrates and a hydrological model of the proposed development is still required to be undertaken.

6.2.3 Stormwater capture for reuse

Collection of urban stormwaters in end of line, above-ground storage basins can be used for local landscaping (open water bodies) or active open space (sportsground) irrigation. This creates benefits in terms of a new source of water supply, as well as reducing stormwater pollution, and reducing stormwater flows to waterways.

Anticipated demand for irrigation of landscape or urban spaces is approximately 2.5 ML/ha (over and above rainfall), with total rainfall of the order of 1 ML/ha (based on Casino average rainfall of 1097 mm). Anticipating a yield of approximately 50% from development areas, a ratio of approximately 5:1 of developed/impervious area to landscaped area is possible. As this is a much higher ratio of landscaped area than is likely to be incorporated into development precincts, this could potentially allow for using stormwater harvesting for other uses, including non-potable replacement such as toilet flushing.

The most cost-effective measures to harvest stormwater from industrial developments, such as the Richmond Valley Regional Job Precincts involve both on-lot harvesting for on-site re-use (i.e. rainwater tanks and non-potable replacement), along with regional basins taking road and lot runoff, with water used for passive irrigation of landscaped features and water quality improvement measures such as bio-retention basins and wetlands.

Refer to the FIA for information on the utilisation of wetlands to harvest stormwater runoff.

6.2.4 Off-river storage

When considering water quality for larger scale schemes such as off-river storage dams, key quality parameters are typically monitored at the offtake point to ensure that only suitable water is transferred for storage. The water quality in the storage is then monitored like a regular storage dam with aeration and/or destratification employed as required.

6.3 River water

From existing studies undertaken by RVC and Public Works Advisory (PWA), the water quality in the river upstream of Jabour Weir has not been identified as a pressing issue, rather, water quantity is, as discussed in other sections. The potential for future degradation of water quality to the weir would be related to issues as follows:

- Low flows, due to future climate change, can result in a change in key water parameters that may adversely impact treatment, but it is believed that this would be incremental over many years and managed by gradually modifying treatment processes at the WTP accordingly.
- Lack of control on development in the drinking water catchment can be a source of ongoing water quality issues. RVC have a mapped drinking water catchment and control any activities within this area to protect the catchment and water quality. Part of the area 1 and 2 are in this catchment, therefore controls on development in those portions of the development area will need to be applied for each lot developed by the individual developer (such as stormwater treatment requirements added for detention basins, live fuel/oil leak detection systems and any other requirements noted for development in the drinking water catchment by RVC).
- As experienced by many locations in NSW in recent summers, the first heavy rainfall in a catchment after a significant portion of the catchment has been affected by bushfires. This emergency situation is normally catered for by implementing temporary water restrictions, monitoring the weather forecast to ensure that service reservoirs are full before the first rainfall event and operating the WTP at a lower capacity where the reduced raw water quality can be managed.

From a review of daily raw water data from RVC back in 2015 for 2009-2015 (see Table 6.1 – values are bold for overall maximum for period for key parameters) and comparison against monthly raw water quality data on RVC’s website from 2017 onwards), it is noted that:

- An increase in average values for any of the parameters is not on a consistent upward trend.
- Average pH is around 7.65 and is easily catered for on most occasions by the WTP process.
- During the event in 2014 (where many key parameters reached either their maximum for the 5-year period or had many other parameters significantly elevated from average), the finished water produced by the plant appeared to meet all Australian Drinking Water Guideline values. This was during winter though with low demands and close to recent rainfall. Given that RVC have noted that filter capacity is an issue for production flows above 18 ML/d, the WTP is susceptible to poor raw water quality events (generally turbidity) in summer when demand is elevated.
- While manganese is noted as an issue, this only occurs periodically and has been managed historically by derating the plant and/or using storage in the town reservoirs to supply to avoid sending poor water quality to customers. Use of potassium permanganate and an associated dosing tank as pre-treatment at WTP may be needed (noting there appears to be suitable area for the footprint of these works at site) but requires further detailed investigation.

Further discussion on alleviating turbidity issue restricting the WTP’s peak flow is discussed in the Utilities Report.

Table 6.1 Yearly maximum and average river raw water characteristics (based on daily samples)

Raw Water Characteristic	Units	2009		2010		2011		2012		2013	
		Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
pH	pH	7.58	7.8	7.61	7.90	7.59	8.05	7.69	8.15	7.85	8.82
Alkalinity	mg/L	104.97	180.00	113.42	175.00	92.73	165.00	87.96	150.00	118.76	185.00
Hardness	mg/L as CaCO3	92.60	170.00	103.24	150.00	74.06	125.00	90.75	205.00	115.52	245.00
Temperature	°C	23.15	31.50	20.98	29.10	20.01	45.40	20.22	28.00	20.89	28.20
Iron	mg/L	0.11	0.87	0.07	0.46	0.14	0.80	0.11	1.02	0.29	3.50
Total Manganese	mg/L	0.06	0.20	0.06	0.40	0.06	1.00	0.06	1.00	0.09	0.70
Dissolved Manganese	mg/L	0.05	0.10	0.13	0.44	0.03	0.05	0.04	0.10	0.03	0.40
Phosphates	mg/L	0.45	1.50	0.49	1.25	0.49	3.50	0.56	42.00	0.55	2.07
Turbidity	mg/L	31.82	520.00	16.66	363.00	53.22	372.00	34.11	357.00	41.10	930.00
Aluminium	mg/L	0.03	0.43	0.02	0.19	0.03	0.14	0.05	0.48	0.07	0.32
Fluoride	mg/L	0.11	0.34	0.11	1.09	0.12	0.99	0.11	0.99	0.11	0.91
Colour	mg/L	72.13	300.00	58.30	300.00	169.76	510.00	174.99	510.00	157.52	1687.00

Raw Water Characteristic	Units	2014		2015	
		Average	Max	Average	Max
pH	pH	7.86	9.91	7.30	7.51
Alkalinity	mg/L	134.16	205.00	125.69	155.00
Hardness	mg/L as CaCO3	102.49	190.00	115.17	145.00
Temperature	°C	21.46	28.60	21.49	23.20
Iron	mg/L	0.22	4.25	0.13	0.19
Total Manganese	mg/L	3.07	1071.00	0.18	0.27
Dissolved Manganese	mg/L	0.04	0.68	0.05	0.18
Phosphates	mg/L	0.44	8.95	0.47	0.60
Turbidity	mg/L	13.09	643.00	5.55	6.70
Aluminium	mg/L	0.06	0.44	0.06	0.11
Fluoride	mg/L	0.10	0.96	0.13	0.78
Colour	mg/L	54.73	1154.00	30.28	44.00

7. RJP options

A total of four workshops were conducted over a four month period involving technical experts, and local and state government stakeholders. The workshops ensured that the options created were tested with the final two workshops focusing on option development scenario testing and refinement of the preferred option. The option development process is described below.

7.1 Option assessment

To develop and compare the three options for each of the RJP's and to identify the preferred RJP options, the following process was undertaken:

1. RJP Scenario Workshop 1 – The workshop included discussion on the optimum scenarios for Area 1 and 2.
2. RJP Scenario Workshop 2 - The workshop included discussion on the optimum scenarios for Areas 3a and 3c.

The RJP Integration Workshop 1 – The workshop included discussion on:

– Key Delivery considerations including:
  - The urban growth boundary
  - Funding mechanisms
  - Anticipating 'shocks'
  - Others raised by participants
– RJP designs based on a unique scenario. Scenarios were prioritised based on:
  - Speed and job creation
  - Sustainable / environmental outcomes
  - Town amenity and housing
  - Scoring and ranking options

RJP Integration Workshop 2 - The workshop included discussions on:

– Summary of the options development process
– Growth story and vision
– Scenarios including:
  - Fixed site considerations
  - Three alternatives
  - Delivery considerations
– RJP designs based on a unique scenario. Scenarios were prioritised based on:
  - Speed and job creation
  - Sustainable / environmental outcomes
  - Town amenity and housing
– Scoring and ranking options

A brief summary of the three options is summarised in Table 7.1.

Table 7.1 RJP options summary

Option	Nammoona Industrial Area	Casino Food Co-op and surrounds	Johnston Street Industrial area and surrounds
Option 1	Northern intermodal opportunity (Casino Rail Freight Terminal). An AWTS facility co-located with the northern intermodal opportunity A master planned estate for heavy industrial users	"Opportunity Sites" for specialists' users, including educational facilities and other specialist users	A dedicated event space An agribusiness specialising in medicinal oils Maximising industrial subdivision, subject to flood limitations as described in the *Regional Jobs Precinct Flood Impact Assessment* (FIA)
Option 2	Southern rail access opportunity An AWTS facility co-located with the rail access opportunity A master planned estate for heavy industrial users, potentially co-located with the rail access opportunity	"Opportunity Sites" for specialists' users, including educational facilities and other specialist users	A dedicated event space, with mixed light industrial/ commercial uses adjoining an established residential area A rezoned area for industrial land uses Maximising industrial subdivision, subject to flood limitations as described in the FIA
Option 3	An agribusiness specialising in medicinal oils An AWTS facility co-located with the existing landfill site A master planned estate for heavy industrial users	"Opportunity Sites" for specialists' users, including educational facilities and other specialist users A vocational training or specialised facility complementary to the current co-op land uses	A dedicated event space A rezoned area for industrial land uses Maximising industrial subdivision, subject to flood limitations as described in the FIA

It is noted that all three options include:

– The upgrade of the intersection of Reynolds Road and Summerland Way.

– The upgrade of Reynolds Road.

7.2 RJP preferred options

Based on the outcomes of the options development and comparison workshops, the preferred RJP options were selected utilising the following process:

– RJP Integration Workshops 3 and 4 - The workshops included:
  - Development of the vision statement
  - Scoring criteria
  - Discussion on options
  - Selection of the preferred RJP options

A plan showing the development of the preferred option is located in the *Draft Richmond Valley RJP Structure Plan*.

A summary of the preferred RJP is provided below.

7.2.1 Area 1 - Nammoona industrial area

Key aspects of the preferred Nammoona industrial area include:

– Potential provision of the northern intermodal opportunity (Casino Rail Freight Terminal).

– Potential provision of an industrial land uses/agribusiness if the northern intermodal opportunity (Casino Rail Freight Terminal) is not developed.

– The incremental expansion of the existing industrial land uses.

- Provision of industrial land uses in the Stage 1 and Stage 2 subdivisions.
- Protection of the Stage 3 subdivision for heavy industrial land uses or potentially a southern rail access opportunity.
- The potential provision of an AWTS facility.

7.2.2 Area 2 - Food Co-op and surrounds

Key aspects of the preferred Casino food Co-op and surrounds include:

- Three "opportunity sites" available for specialist users. The anticipated user types are not currently defined.
- One of the sites has been designated for a potential vocational college (similar to a TAFE), providing courses to support the proposed RJP land uses.

7.2.3 Area 3 –Johnson Street industrial area and surrounds

Key aspects of the preferred Johnson Street industrial area and surrounds include:

- Upgrades to the current infrastructure to support energy intensive developments, including an industry catalyst site.
- Proposed rezoning land for industrial purpose.
- Maximising the industrial land uses adjacent to the north of the Bruxner Highway, subject to flooding limitations as described in the FIA.
- Investigate low impact light commercial uses (with appropriate buffers) adjacent to establish residential areas.

Following the completion of the Regional Jobs Precinct Flood Impact Assessment (FIA) in 2023, the following items were added:

- Staged filling of some parts of Area 3 without the need for the major drainage options as shown in Figure 7.1.
- Filling of land for development and implementation of one of the following two major drainage options:
  - Option 1B: Reinstatement of a broad flow path through the natural depression blocked by the STP tertiary treatment pond and associated infrastructure, along with increasing the drainage capacity under Spring Grove Road as shown in Figure 7.2 (noting this option relies on the construction of a new STP and decommission of the existing STP).
  - Option 2B: A new broad channel within Crown Land adjacent to Naughtons Gap Road to provide a link between the two natural gullies which bypasses the existing STP, along with additional drainage under Spring Grove Road as shown in Figure 7.3.
- Relocation of the Casino STP and establishment of controls to limit development within the 7ou contour, other than development that is ancillary to the STP and not odour sensitive.

Figure 7.1 Staged filling of Area 3 (1% AEP + Climate Change Flood Event)

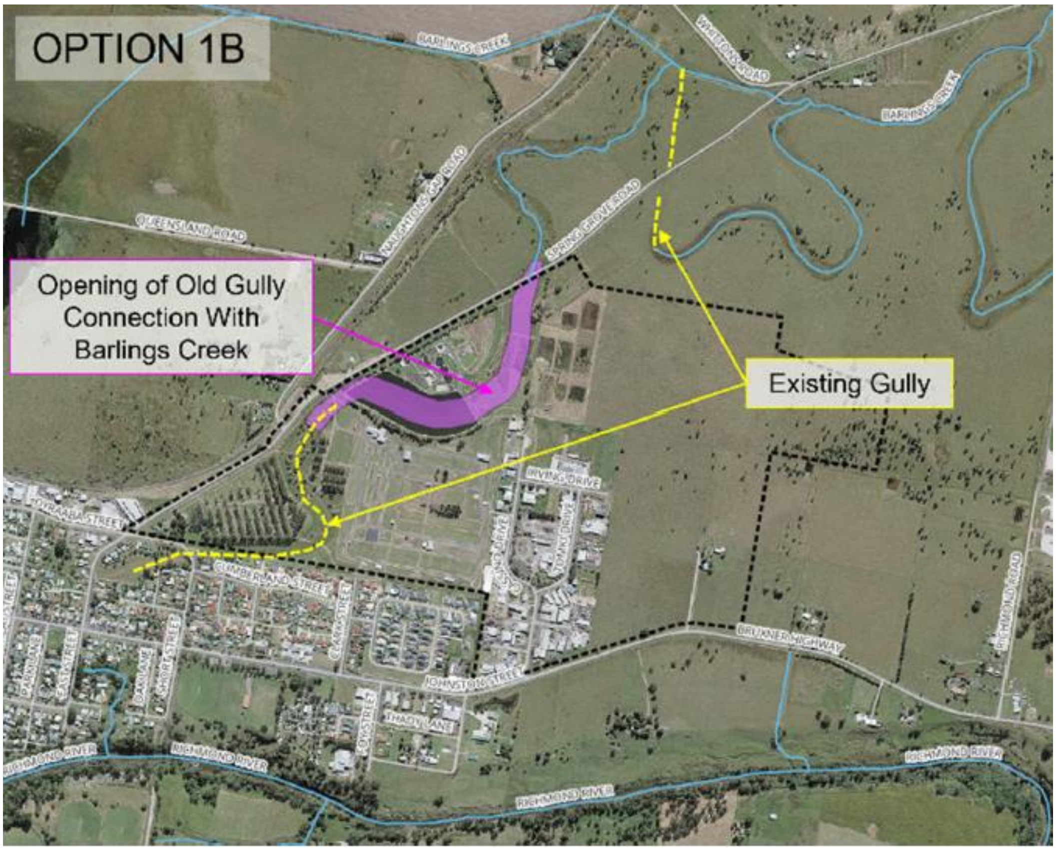

Figure 7.2 Major drainage option 1B

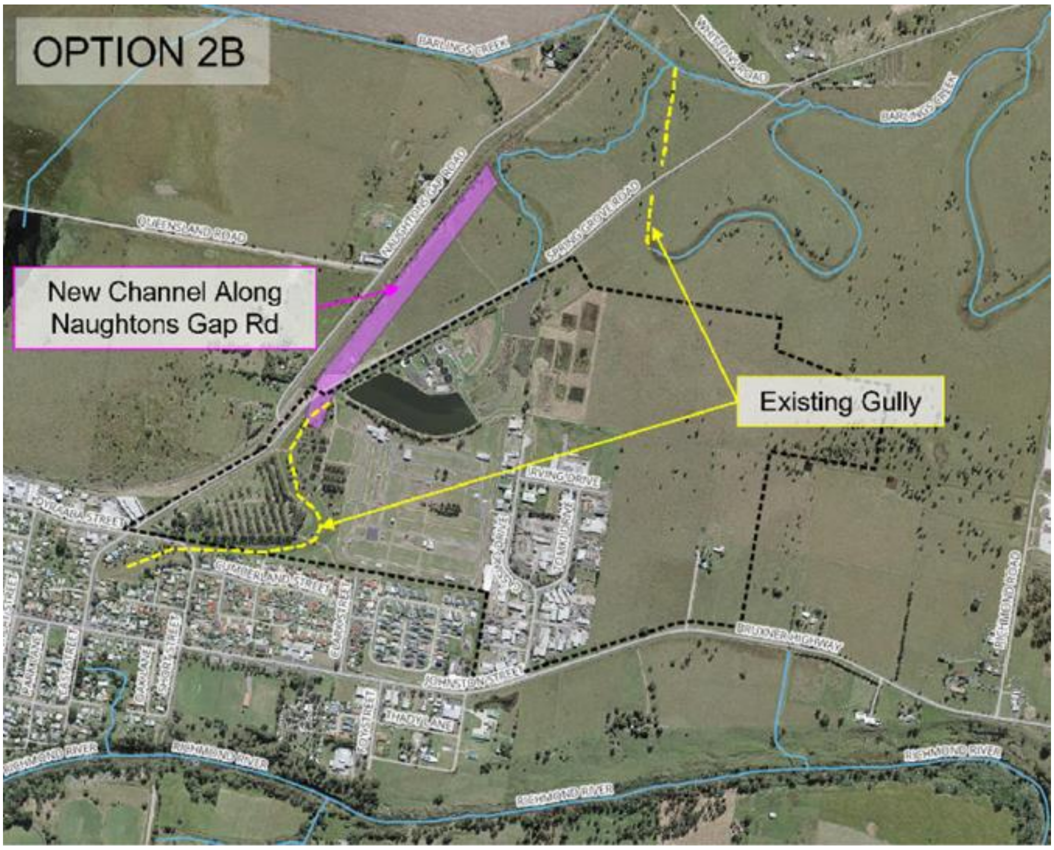

Figure 7.3 Major drainage option 2B

8. Demand analysis

8.1 Casino water network and supply

The town of Casino has its raw water sourced from the Richmond River, upstream of Jabour Weir with treatment at the Casino Water Treatment Plant (WTP) to the North-West of the township along Summerland Way. The WTP has a nominal treatment capacity in excess of 22.1 ML/d but only a reliable capacity of 18 ML/d (noted by RVC in meeting on 30 November 2021). Recent water demands within Casino have not been increasing (noted by RVC in meeting on 30 November 2021) as predicted in the 2015 GHD Northern No.1 Reservoir Investigation where 0.5%, 1% and 1.5% growth to PDD was modelled. The *Casino Water Security Assessment* notes of a 0.5% growth to be used as recommended by RVC.

Storage from the WTP is in the three primary Northern Reservoirs (located at the junction of Summerland Way and Rosewood Av), totalling 17.75 ML with TWL 70.71 m which supplies the areas North of the Richmond River. A secondary Southern Reservoir (located at the junction of Hare Street and Walker Street and fed via gravity from the Northern Reservoirs) of 3.26 ML with TWL 70.67 m supplies to the remaining areas south of the Richmond River. A booster pump (currently not required) is maintained and operated with a re-chlorination station both located after the rail bridge river crossing on a DN300 main. The main increases chlorine levels in the south Casino supply zone and directly supplies the southern reservoir. An additional DN300 main connection at the Centre St River crossing provides security to the southern supply zone though is currently valved off to distinguish the different supply zones.

The RVC has a desired standard of service (DSS) minimum pressure of 12 m with the peak day demand (PDD) services pressure throughout the town. The general pressures ranged from 30 - 59.4 m, with the lowest of 0-12 m pressure directly surrounding the Northern reservoirs and WTP, and the largest of 40-59.4 m being predominantly throughout central to eastern Casino. The pressures from the reservoirs are generally related to the difference in elevation between the level in the reservoirs and the customer location (i.e. minimal headloss in the network modelled).

Currently Jabour Weir, where Casino sources its water, has a secure yield determined by the 5/10/10 rule set out in the DPE Water's draft guidelines for "Assuring future urban water security – Assessment and adaption guidelines for NSW local water utilities". Following this standard, Casino has a secure yield of 3,074 ML/yr with the township's ADD of 2,482 ML/yr. Therefore, the town currently has sufficient bulk water supply to meet the community's needs. However, as the town grows, and climate patterns change (bringing longer periods of drought) Casino will experience greater water security challenges in the future. If the temperature was to change by 1°C due to climate change, the current secure yield would decrease to 2,355 ML/yr and Casino would be unable to meet unrestricted water demand during a drought. Richmond Valley Council is currently exploring three options to improve future water security and address the anticipated impacts of climate change.

8.2 Water demand in Casino

8.2.1 Demand analysis

The 2015 GHD investigation (for the Casino Northern No.1 Reservoir) estimated the future peak day demand (PDD) under 0.5%, 1% and 1.5% growth scenarios as an extrapolation of historical total water usage values. Projections do not consider impacts from climate change.

As noted by RVC (in the meeting on 30 November 2021) water demands within Casino have not been increasing as predicted. As seen below with the 2015 predictions compared to the 2015-2021 demands which has shown a highly variable but overall, a small trend downwards in PDD (noting variability between drier and wetter years) and a flat average day demand (ADD) trend around 6.8 ML/d. The peak clear water production in 2011 was a result of operational error where the WTP failed to shut down and continued water treatment. GHD concurs with RVC in regard to there being little change in underlying demand over recent years.

The water demand showing growth scenarios of under 0.5%, 1% and 1.5% are shown in Figure 8.1 and population projection utilising 0.5% in Table 8.1.

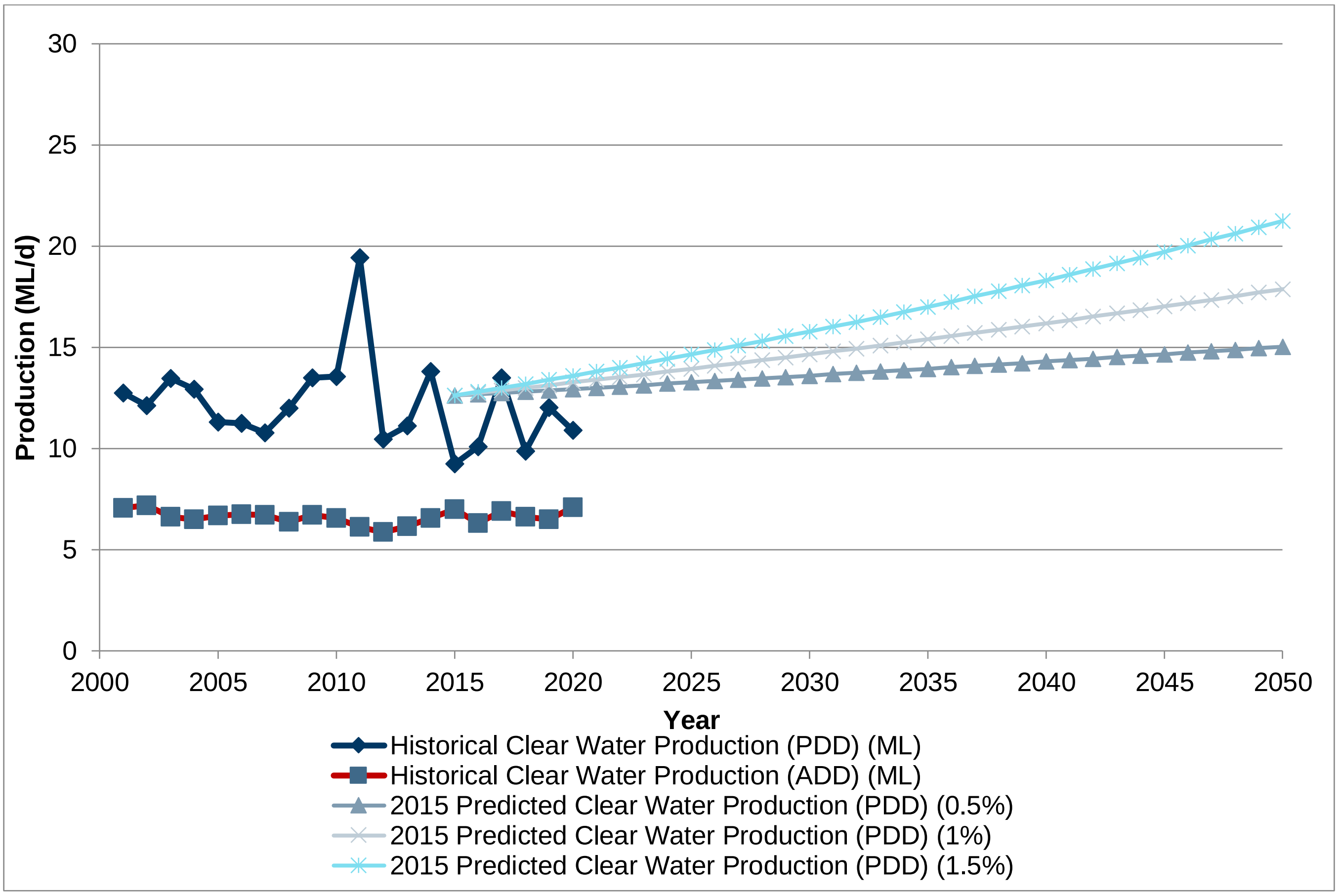

Figure 8.1 Estimated vs real clear water demand growth

RVC has advised that the adopted 0.5% growth rate (as per the 2022 PWA Casino Water Supply Scoping Study) had adopted some element of RJP development growth. A reduction of the 'underlying' growth rate (i.e. growth not within the RJP or Fairy Hill development areas) to 0.15% was deemed to be appropriate. Applying the 0.15% per annum population growth rate to recent data results in the forecasted PDD water demand values below, additionally the combined RJP PDDs (for scenario two) and PDD for Fairy Hill have been included to outline the future demand on the Casino water network.

Table 8.1 Casino serviced population demand projections

	2020	2025	2030	2035	2040	2045	2050
Casino PDD (ML/d)	12.89	12.96	13.05	13.15	13.25	13.35	13.45
RJP Scenario 2 (ML/d)	0	0	0.19	0.54	0.88	1.11	1.11
Fairy Hill PDD (ML/d)	0	0.6	1.4	2.4	3.1	3.7	4.4
Total PDD (ML/d)	12.9	13.56	14.64	16.09	17.23	18.16	18.96

8.2.1.1 Climate correction

From the PWA 2021 studies, the secure yield of Jabour Weir was determined for 1°C climate warming (noting 1°C is not equivalent to projected temperature changes) with the current 700 ML dead storage, and then if half of the dead storage became accessible (i.e. 350 ML). The results can be seen in the Table 8.2.

Table 8.2 Secure Yield Summary (PWA, 2021)

Jabour Weir Scenario	Secure yield (ML/yr)		% reduction
	Historic climate	1 °C climate warming	
700 ML dead storage (current situation)	3,075	2,355	23
Additional 350 ML accessed from dead storage	4,169	3,395	19

The 2,355 ML/yr value corresponds to around 6.5 ML/d ADD and is slightly below the ADD value shown in Figure 8.1 of 6.8 ML/d. This corresponds to an annual yield shortfall of a bit over 100 ML. Any future increases in demand from new development will clearly worsen this deficit.

8.2.1.2 Purified Recycled Water (PRW)

Purified Recycled Water (PRW) is the name now given to high-quality recycled water in NSW suitable for producing drinking water. Many PRW systems for drinking water supply are now being considered. This new terminology replaces indirect potable reuse (IPR) that involved releasing treated wastewater into the environment for future collection, treatment and provision to the drinking water system. Direct potable reuse (DPR) was the term where the treated wastewater was connected more directly to the drinking water system.

Producing PRW involves a higher level of treatment (after a traditional wastewater treatment process like at Casino STP) to remove microbial and chemical hazards typically includes advanced oxidation and disinfection processes and reverse osmosis. Many of the new developments attracted to Casino may be able to connect to a new PRW system (as well as the existing potable system for drinking water purposes only) to offset demand on the existing water supply network.

PRW for domestic uses such as toilet flushing and clothes washing, often called “dual reticulation” or “third pipe” systems, reduces the demand for potable water for those uses. PRW may also be used as a substitute for potable water for some industrial water uses.

8.3 Forecasting future water demands

8.3.1 Forecasting approach

The Water Service Association of Australia (WSAA) have a design manual named Water Supply Code of Australia, Part 1: Planning and Design Third Edition, WSA03 – 2011-3.1. The Demands Assessment section of this manual (similar to the NSW Water Directorate guidelines) refers to calculating applicable L/s/ha rates for commercial and industrial developments based on known existing data or specific requirements of the local water utility (LWU).

As RVC have very limited data and no LWU standards, they default to the guidelines referenced above. From our experience in this common occurrence when working for regional NSW councils, adoption of the Hunter Water Corporation (HWC) version of the WSAA guidelines (2017 version) provides guidance regarding demands of increasingly water intensive industry as per Table 8.3. This has been used for comparison against RVC limited demand data to assist determining appropriate demand scenarios. Note that the value in the ADD column is then multiplied by each factor, in each column up to and including that column, for that demand scenario.

Table 8.3 Industrial and Commercial Demands (HWC, 2017)

Development Type	ADD (kL/d/ha)	PDD Factor	Peak Hour Demand Factor	Extreme Day Factor
Industrial – light	11.5	1.2	1.3	1.15
Industrial – medium	26.5	1.2	1.3	1.15
Industrial – heavy	68.5	1.2	1.3	1.15
Commercial	11.5	1.6	1.9	1.15

There is reasonable difficulty in estimating demands for future developments due to unknown future development types and how water intensive they will be. As noted earlier in this report, the increase in adopted water efficiency for new developments in recent years is predicted to increase further but magnitude and timing is unclear and as a result, a conservative 15% reduction to demand calculations is applied (with also the conservative assumption that the Catalyst site adjacent to the STP would not be supplied by recycled wastewater). This reduction is from GHD's experience (where the local council pushes this through modifications to development standards) and the implementation of steps outlined in the Regional Demand Management Plan: 2019-2022 (Hydrosphere, 2018). Such reductions to water demand can be a cause of a combination of industries who do not require high quality potable water, to utilise stormwater capture and reuse, or where industries are unable to utilise stormwater, reduced water demand is from a desire to increase water efficient processes to meet corporate sustainability targets or reduced potable water costs. It is noted the demand reduction is likely to only be realised if these demand reduction objectives are added to the DCP for these areas, therefore it is recommended that changes accordingly are made to the RVC DCP for these areas.

Due to the aforementioned difficulty determining demands, results from a recent GHD consulting study with Icon Water and from the current water intensive industries data (supplied by RVC and outlined in Table 8.4) within the Casino township were examined to assist in defining varying demand scenarios.

To determine an appropriate demand per area (kL/d/ha) value, the annual demands of the top water intensive industries within Casino were averaged over their lot area. Comparing the demand per area value (outlined in Table 8.4) to the HWC guidelines. The highest demand industries were determined to be greater than the heavy industry HWC demand with the highest demand within Casino (the Food Co-op and Tannery located in area 2) having a demand near three times the HWC heavy recommended value. From discussions with RVC on 16 November 2022, RVC advised that any future development proposals for high demand water industries to be considered for development would need to demonstrate they will not have an adverse impact on Casino's water security by for example, proposing an alternative water supply option.

Table 8.4 RVC water intensive user data

Industry	Lot ID	Lot area (ha)	Water usage (ML/yr)	Water Usage (ML/yr/ha)	Water Usage (kL/d/ha)
Food Co-op + Tannery	DP1164153 and DP1172525	10.70	736	68.8	188.5
Richmond Dairies	DP1124270	2.06	60	29.2	79.9
Seine Pty Ltd	DP1068179	0.32	11	34.4	94.2
New World Foods	DP571851	1.30	5.2	4.0	11.0
Spring Grove Foods	DP1269942	0.52	2.5	4.8	13.2

Comparing the water intensive industries currently within Casino to the expected industry types as provided by Gyde on 14 April 2022 shows little comparison with the top three water demand industries. Therefore, these water demands are viewed as outliers and not considered in determining a standard demand for new industrial development. As the final two industries in the table above (New World Foods and Spring Grove Foods) have a demand close to the 'light' HWC demand, this is considered the minimum demand potential. From GHD's experience with regional councils, types of industry are rarely consistent and do not have the same water demand rates, therefore a range of demand scenarios have been assessed. The light and medium HWC demand rates have been used, as well as an intermediate (light-medium) demand rate, as seen in Table 8.5.

The potential industries provided by Gyde used to determine demands include:

- Logistics suppliers – intermodal cold chain solutions
- Engineering services to support food processing industry
- Bio-degradable and/or compostable packaging manufacturers
- Renewable, circular economy energy providers
- Food Processing – soybeans
- Medical grade processors (e.g. tea tree and honey)

The 11.5-26.5 kL/d/ha water usage demand rate was applied to the gross floor areas (GFA) information provided by Gyde to determine the three demand scenarios (to convey the varying impacts of differing water intensive industries being developed in the RJP's) as seen in Table 8.5. The GFA data and individual industry contributions to the total demand can be seen in Appendix A.

An increasing flat demand not dependent on area was applied to the AWTS, facility located in the Nammoona development, which can be seen below. The scenario conditions and demands applied can be seen below and results in Table 8.6.

Table 8.5 Future industrial water demands

Scenario	Demand intensity	Industrial Demand (kL/d/ha)	AWTS Demand (kL/d)
1	Light	11.5	100
2	Light-medium	19	150
3	Medium	26.5	200

Table 8.6 Water demand calculation results

		Scenario 1:			Scenario 2:			Scenario 3:		
		PDD		ADD	PDD		ADD	PDD		ADD
	GFA (ha)	**(L/s)**	**(ML/d)**	**(ML/yr)**	**(L/s)**	**(ML/d)**	**(ML/yr)**	**(L/s)**	**(ML/d)**	**(ML/yr)**
Area 1 – Nammoona[1]	24.6	5.2	0.4	136.8	8.4	0.7	220.5	11.6	1.0	304.1
Area 2 – Food Co-op	8.9	1.4	0.1	37.3	2.3	0.2	61.6	3.3	0.3	85.9
Area 3 – Johnson St and STP surrounds	16.8	2.7	0.2	70.7	4.4	0.4	116.8	6.2	0.5	163.0
Total	50.3	9.3	0.8	244.8	15.2	1.3	398.9	21.0	1.8	553.0
***With 15% water efficiency reduction**		7.9	0.7	208.1	12.9	1.1	339.1	17.9	1.5	470.0
1. Includes AWTS unique (non-area dependent) demand										

8.4 Forecasting future sewer loads

To determine the sewer loads, the average 2012 to 2018 WTP ADD production and STP ADWF (from the 2019 GHD STP investigation) values were compared to determine a return sewer rate (also known as discharge factor). The average 6.8 ML/d WTP production and STP inflow of 2.4 ML/d results in a return rate of 35%. This very low return rate does not consider flows from the WTP ADD production that are lost due to leakage or not accounted for due to unmetered usage. Visualised in Figure 8.2 is the Casino water consumption estimations sourced from the PWA *Casino Water Security Assessment* (2022). Applying a water loss factor (leakage etc) of 10% results in a total billed WTP ADD production of approximately 5.85 ML/d, therefore the billed discharge factor would be 41%.

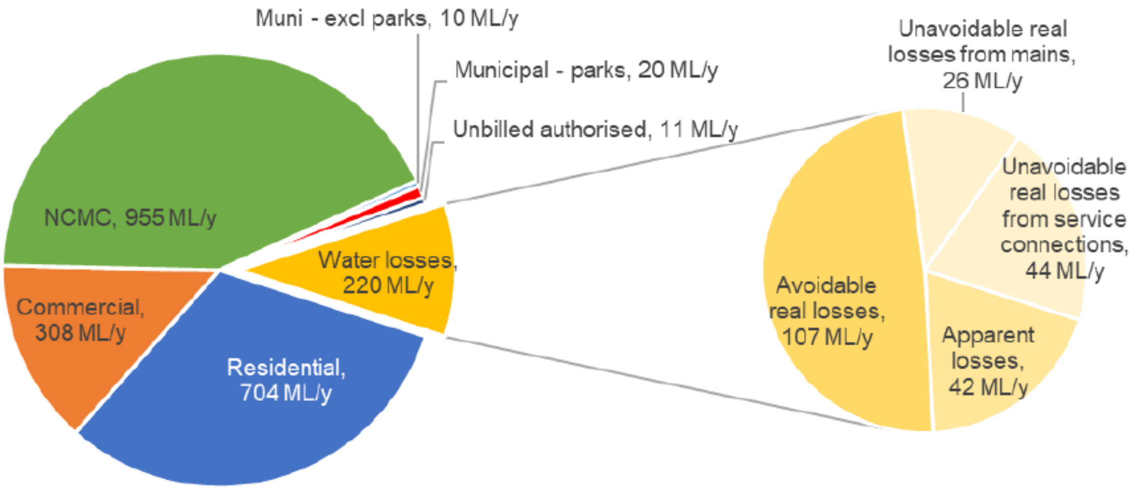

Figure 8.2 Casino water consumption and loses (PWA, 2022)

Due to the low discharge factor, which is below typical residential and industry published factors, a conservative 78% sewer return rate instead was applied as advised by the Sydney Water – Wastewater usage charges for non-residential customers (2021) and applied to the total water demand including 10% reduction to water consumption due to reduced water usage. The unique industries whilst included in the below calculations will likely not be experienced due to any site discharges being planned at low flows or via a slow controlled release during system over, as to not overload the STP. The following are the sewer loads for the three scenarios.

Table 8.7 Sewer load results

	Scenario 1			Scenario 2			Scenario 3		
	L/s	ML/d	ML/a	L/s	ML/d	ML/a	L/s	ML/d	ML/a
Existing STP catchment	24.67	2.13	778	24.67	2.13	778	24.67	2.13	778
New residential developments	8.05	0.70	254	8.05	0.70	254	8.05	0.70	254
Area 1 – Nammoona	2.23	0.19	70	3.69	0.32	116	5.14	0.44	162
Area 2 – Food Co-op and surrounds	0.83	0.07	26.17	1.37	0.12	43.24	1.91	0.17	60.31
Area 3 – Johnson St industrial area and surrounds	1.57	0.14	49.65	2.61	0.22	82.01	3.63	0.31	114.39
Total	**37.4**	**3.23**	**1,177.8**	**40.4**	**3.5**	**1,273.3**	**43.4**	**3.8**	**1,368.7**

8.5 Additional developments contributions

Due to the increase in industry within the Casino township and resulting population growth r to operate the new industries) additional housing requirements have been identified by RVC to support the growth in population. RVC estimated an approximate 1,700 additional houses will be required in the next 30 years to support the additional influx of people and families.

RVC has identified through the Urban Land Release Strategy 2005 (ULRS), several future growth areas for Casino as seen in Figure 8.3. GHD has performed an investigation to determine demand and infrastructure requirements to service three of the potential residential development areas being Fairy Hill, North Casino (limited to 1000 lots) and West Casino (identified as Gays Hill in Figure 8.3).

The infrastructure requirements for the areas can be found in their respective servicing strategy reports. The summarised water demands, and sewer loads of the fully developed areas can be seen below in Table 8.8 and Table 8.9.

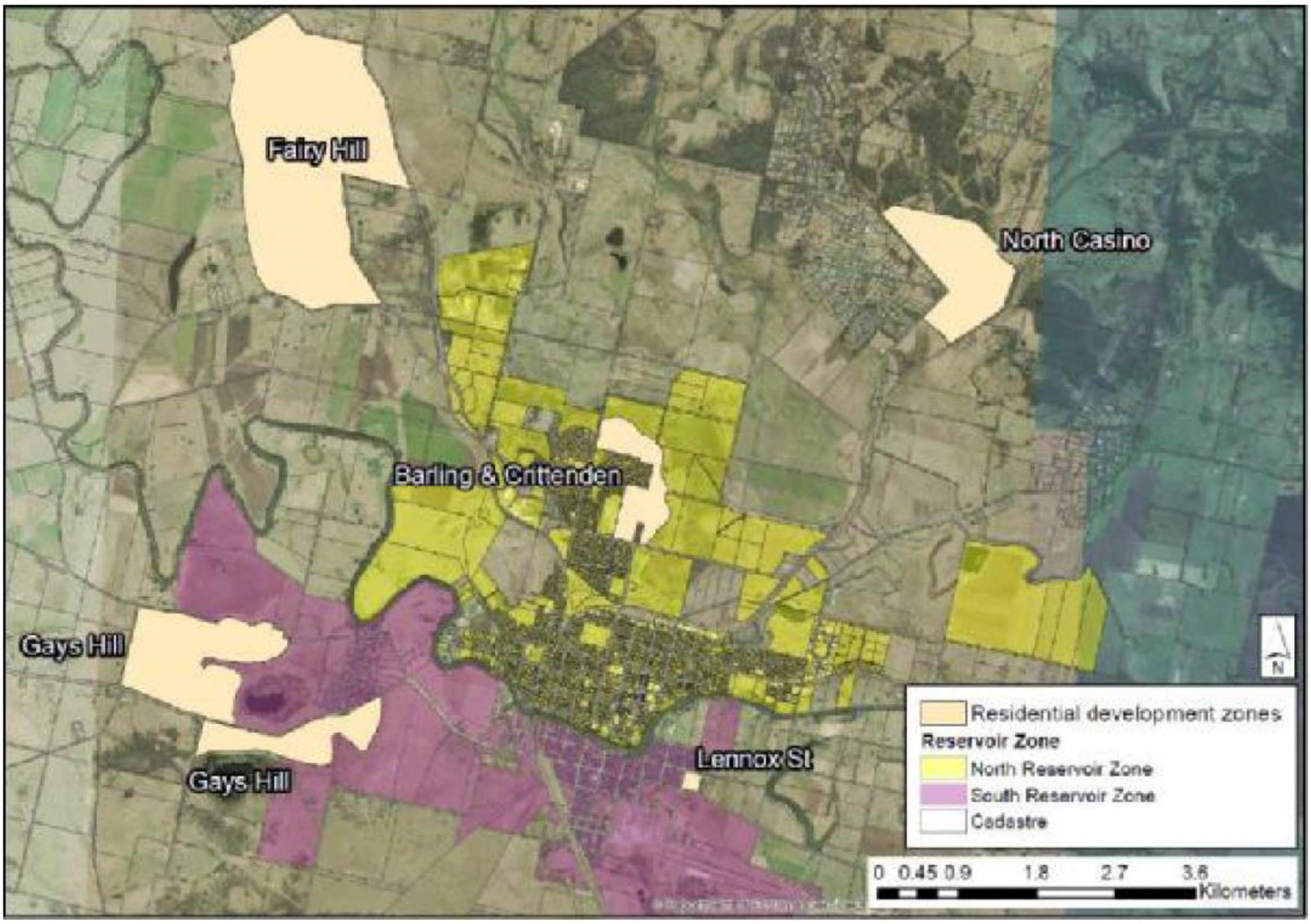

Figure 8.3 RVC proposed residential subdivisions

Table 8.8 Future residential growth areas water demands

Residential growth area	Total Lots	Cumulative Average Day Demand (ADD)			Cumulative Peak Day Demand (PDD)		Cumulative Peak Hour Demand (PHD)
		L/s	ML/d	ML/yr	L/s	ML/d	L/s
Fairy Hill	1700	21.2	1.8	667.5	50.0	4.4	76.0
West Casino	1700	18.9	1.6	595.7	44.6	3.9	91.8
North Casino	1000	13.8	1.2	435.6	34.1	2.9	68.6

Table 8.9 Future residential growth areas sewer loads

Residential growth area	Cumulative Peak Wet Weather Flow (PWWF)		Cumulative Average Dry Weather Flow (ADWF)
	L/s	ML/d	ML/yr
Fairy Hill	130.0	11.2	3206.8
West Casino	112.3	9.7	3080.8
North Casino	95.9	8.3	1859.3

9. Key insights and opportunities

9.1 Bulk water supply solutions

RVC follow the 5/10/10 rule set out in the DPE Water's draft guidelines for "Assuring future urban water security – Assessment and adaption guidelines for NSW local water utilities" to determine water security. With the current estimated 3,074 ML/yr secure yield from Jabour Weir, RVC advised during discussions on 16 November 2022 they have not experienced difficulties supplying sufficient water to the town of Casino.

Therefore, bulk water supply is not currently an issue for RVC, but as climate patterns change, bringing longer periods of drought, inland communities such as Casino will experience greater water security challenges in the future. Council has been preparing for the impacts of climate change and increased development by investigating options to upgrade its bulk supply over the short-medium term. These options, to be implemented over the next 2-10 years will help to ensure there is sufficient water to meet the projected growth in the Casino township due to the Regional Jobs Precinct and Casino's access to flood-safe residential land.

9.1.1 Demand reduction

As noted in the PWA *Casino Water Security Assessment* (2022), leakage reduction is the most beneficial demand reduction option. Casino has an infrastructure leakage index (ILI) of 2.8 with a total of 10% of water produced being lost via varying forms as seen in Table 9.1.

Table 9.1 Casino Losses Summary (PWA, 2021)

Loss Type	Total Loss per Year (ML/yr)	Loss %	
		of Total Water Produced	of Total Water Loss
Unavoidable Real Losses from Mains	26	1.17	11.8
Avoidable Real Losses from Service Connections	44	1.97	20
Avoidable Real Losses	107	1.89	19.1
Apparent Losses	42	4.8	48.6

Reduction of this leakage to an ILI of 2.0 or 1.0 will save 66 ML/yr and 137 ML/yr by 2050 respectively. Reduction to an ILI of 1.0 is often very difficult and costly to achieve.

Other options investigated by this assessment include whole house efficiency retrofit that estimated with a 20-50% uptake would save 49-123 ML/yr and effluent reuse (unclear as to end user assumed in report) of 33 ML/yr. Council rebates to retrofit existing fixtures are typically in order of showerheads at $60, toilets at $100, outdoor fixtures and fittings at $20 and rewater tank at $750.

The Unavoidable Real Loss is the empirically determined lowest level of losses that is technically achievable for a water network based on its pipe lengths, number of connections and average water pressure.

Real Losses are the physical water losses from the pressurised system and storage reservoirs/tanks, up to the point of the customer's meter or if no meter, where the customer is responsible for piping maintenance and repairs.

Apparent losses are the-water losses associated with inaccuracies of customer billing meters, systematic data handling errors, plus unauthorised consumption due to theft or illegal use of water. These non-physical losses result in uncaptured revenue, distort water balance calculations, and hence introduce errors to the level of non-revenue water and real losses.

To target Real Losses, Councils typically undertake comprehensive leak detection surveys of the distribution, reticulation, and service pipes by specialist contractors. The scope of works generally consists of the following:

– Survey of water main and metered connections for leaks including a visual and acoustic examination of all surface fittings (valves and hydrants).
– Installation, monitoring and analysis of data from high accuracy insertion flow meters.
– Installation, monitoring and analysis of data from pressure transducers and loggers at selected sites.
– Conducting of step-testing of selected areas as the result of the above activities.
– Undertaking meter readings of selected large residential, commercial, and industrial customers.
– Analysis of data and reporting of results.

GHD has also observed Councils implementing measures such as extensive monitoring campaigns (either via operations staff or residents) where leakages are reported via an app and PRVs are installed with flowmeters to reduce pressure in high pressure areas that in turn reduce leakages. This segmentation of the network then also assists to analyse night-time flows to target leakage monitoring. A residential or household focused method adopted by Councils (such as Narrabri Shire Council) has involved rolling out new live monitoring flowmeters that empower customers to investigate leakages on the side of the meter and to consider ways to reduce usage.

9.1.2 Supply augmentation

9.1.2.1 Regional options

A proposed augmentation to Casino's water network (PWA, 2021) is the utilisation of the Toonumbar Dam via the following options:

– Pipe from dam wall to Casino WTP
– Pipe from end of Eden Creek to Casino WTP
– Deliver along existing river to Jabour Weir (non-build and therefore lowest cost)

An additional augmentation being considered is via connection to the Rous bulk supply distribution network that runs through Lismore which is situated 22 km to the North-East. The 2012 study between Rous Water and RVC determined a combined secure yield of 900-1800 ML/yr. Rous County Council currently have proposed future water plan through strategic use of various groundwater, dam, desalination and weir accessed water to provide security. Investigation into the potential to become integrated within this plan will need to be investigated.

From these options, it was determined 9.5 ML/d will need to be sourced to provide Casino's water network with security. Negotiation with Water NSW to access this amount for a 60-day period (as a high-security or emergency licence) via extraction from the Jabour Weir is the lowest cost option.

9.1.2.2 Headworks options

Potential solutions involve the modification of Jabour Weir. To note, that any modifications to Jabour Weir would trigger DPI Fisheries to request an upgrade of fish passage at the site. This can add several millions of dollars in additional expenditure depending on the ecology conditions and river geometry at the site.

9.1.2.2.1 Raising Jabour Weir

Due to the Casino WTP sourcing raw water along the Richmond River, upstream of the Jabour Weir, a possible headworks solution has been investigated by raising the Jabour Weir from its current 13.4 m AHD level to allow more storage and/or the use of off-river storage.

These augmentations would be required to follow all current water sharing conditions and rules with the possibility of changes to existing or new guidelines. Through testing of varying nominated rules for the Jabour Weir raising and off-stream storage, it was determined by PWA that up to 1,419 ML can be accessed. A 2010 investigation by Hydrosphere Consulting regarding the raising of Jabour Weir up to an extra 3.0 m found no significant reason or obstacle to raise the weir to increase yield, however, recommended an alternative source be investigated as the yield or water supply benefits appear to be negligible. The primary constraints to weir raising are riverbank vegetation and associated fauna impacts which will require substantial offset.

9.1.2.2.2 Access of Jabour Weir dead storage

Another headworks solution involves accessing the dead storage of the Jabour Weir which has a currently estimated capacity of 700 ML. Casino's current ADD WTP production (as outlined in Table 7.1 with a 0.5% per annum growth rate) and the ADD demands (with 15% demand reduction) determined for the new developments (outlined in Table 9.2) was compared to the secure yield of the current Jabour Weir secure yield and if half the dead storage (i.e. 350 ML) is accessed. The secure yield values are assumed to be the result of a one-degree climate change increase. Additionally, the comparison was undertaken with demands from the Fairy Hill development.

For ease of comparison, a traffic light system as follows was used to highlight the more advantageous options for multiple design aspects:

- GREEN – Sufficient secure yield
- YELLOW – Marginally sufficient secure yield
- RED – Insufficient secure yield

Table 9.2 Staged ADD demands (RJP areas with 15% demand reduction)

Area		Demand scenario (ML/yr)		
	Year	1	2	3
Area 1 - Nammoona Industrial Precinct	2026	20.3	32.7	45.1
	2031	56.6	91.3	125.9
	2036	91.5	147.5	203.5
	2041	116.3	187.4	258.5
Area 2 - Casino Food Co-op and surrounds precinct	2026	5.5	9.1	12.7
	2031	15.4	25.5	35.6
	2036	24.9	41.2	57.5
	2041	31.7	52.4	73.0
Area 3a - Primex	2026	3.7	6.2	8.6
	2031	10.4	17.2	24.0
	2036	16.8	27.8	38.8
	2041	21.4	35.3	49.3
Area 3c – STP residue	2026	6.8	11.2	15.6
	2031	18.9	31.2	43.5
	2036	30.5	50.4	70.3
	2041	38.7	64.0	89.2
Fairy Hill	2025	85.2		
	2030	194.1		
	2035	342.3		
	2040	450.6		
	2045	588.8		
	2050	667.5		
Township ADD (including 0.15% growth)	2025	2482.0		
	2030	2500.7		
	2035	2519.5		
	2040	2538.4		
	2045	2557.5		
	2050	2576.8		

Table 9.3 Jabour Weir secure yield comparison

	Current operational storage			Potential additional dead storage accessed (i.e. 350 ML of the 700 ML theoretically available)		
Remaining dead storage (ML)	700			350		
Historical secure yield 1890-2020 (ML/yr)	3074					
Secure yield (ML/yr) with 1°C climate warming	2355			3395		
Casino 2025 ADD (ML/yr)	2482			2482		
Year	**Demand scenario**					
	1 (ML/yr)	**2 (ML/yr)**	**3 (ML/yr)**	**1 (ML/yr)**	**2 (ML/yr)**	**3 (ML/yr)**
2026	2603.5	2626.4	2649.2	2603.5	2626.4	2649.2
2031	2796.1	2860.0	2923.8	2796.1	2860.0	2923.8
2036	3025.6	3128.7	3231.8	3025.6	3128.7	3231.8
2041	3197.1	3328.1	3459.1	3197.1	3328.1	3459.1
2045	3354.4	3485.4	3616.4	3354.4	3485.4	3616.4
2050	3452.3	3583.3	3714.3	3452.3	3583.3	3714.3

As shown above, if the effects of a 1°C climate warming are experienced, the Jabour Weir's current secure yield is insufficient to reliably supply the Casino township's ADD (i.e. all values for all demand scenarios for all years for the current operational storage scenario are higher than 2,355 ML/yr). To provide water security to the current township, let alone with the addition of any future developments, the secure yield must be increased.

If half of the current dead storage is accessed (right hand side column in table above), there is marginally enough secure yield for all water demand scenarios until 2036 (based on Gyde land development uptake estimates).

9.1.2.3 Off-river storage

Agricultural land adjacent to Jabour Weir that is elevated out of flooding extents (i.e. rural properties on north-eastern side of river accessed from Summerland Way upstream of the weir) would be a logical location for an off-river storage dam. It is noted that the lead time for an off-river storage is multiple years.

As can be seen in the Figure 9.1 below, three locations for potential off-river storage are proposed. To represent rough sizes, locations are sized for approximately 210 ML with water level at 30 m RL and a 1% slope to the south. Option 1 utilises natural waterways which have the potential to be dammed and assist with water collection. As a consequence, volume of earthworks required to achieve sufficient volume is reduced however construction will be impeded due to dewater or diversion requirements. On the contrary, option 2 and 3 are not located along a waterway and will require more earthworks. Additionally, option 1 and 2 have close proximity to the WTP intake pipeline. Therefore, limited augmentation to the pipeline will be required to access the stored water unlike option 3 which will require a new pipeline branch.

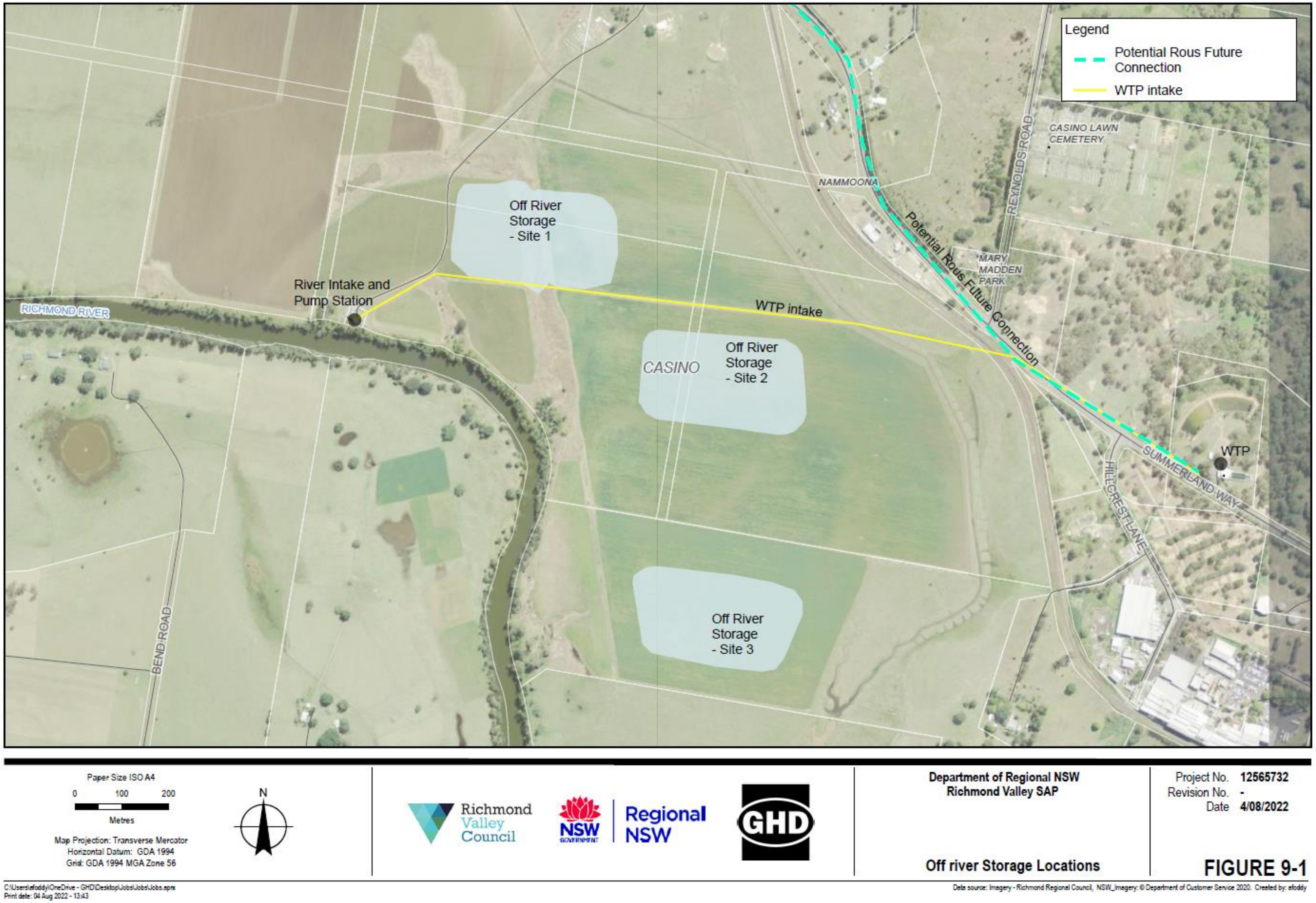

Figure 9.1 ORS location

9.1.2.4 Large-scale stormwater capture and treatment

Unlike Orange, Casino does not have one main existing stormwater channel/pipe to offtake flows direct to a nearby storage dam. There are at least 10 stormwater sub catchments that discharge to the Richmond River. Pumping from any or multiple of these catchments to a new storage or upstream of Jabour Weir is unlikely to be as cost effective as other supply options discussed in this report.

9.1.2.5 Smaller-scale stormwater capture and recycling

On-lot or part precinct scale stormwater harvesting, and reuse projects are discussed in Sections 5.1.3 and 6.2.3. On-lot treatment systems would be able to be implemented on each lot within each of the development areas. Planning controls could include specifying minimum lot areas draining to storage, along with volume requirements for storage and re-use requirements such as all toilets connected to harvested re-use.

RVC's development control plan (DCP 2021) I-9.5 Stormwater Generation Policy Requirements 3(d) Subdivision, Commercial, Industrial, Tourism and Other Development to which this Policy Applies notes that the following additional requirements apply:

– A Stormwater Management Plan may be required to be submitted.
– Development must demonstrate adherence to the objectives and targets of this policy by reducing stormwater volumes, peaks, and velocities in a method consistent with the waste management hierarchy and principles of Water Sensitive Urban Design as described in section I-9.3.
– The harvesting of stormwater and roof water for non-potable uses should be used where possible as a method of reducing stormwater volumes, reducing stormwater peaks, reducing stormwater contaminants, and conserving potable water supplies.

It is assumed that RVC would make these items, in particular the third dot point above, a development requirement given the underlying future bulk water supply issue as result of RJP development and climate impacts.

9.1.2.6 Purified Recycled Water (PRW)

As noted above, PRW be able to offset water supply demands from new development in Casino. A 'third pipe' reticulation system (sewer, drinking water and PRW as the third pipe) is most cost effective to install for new developments like this, compared to existing developments where surface restoration and coordination with existing services increase complexity and cost.

Provision of recycled wastewater flows from the STP to the industry catalyst site, and the treatment required, are covered in the Utilities Report. The estimated demand for PRW is approximately 715 kL/d but GHD has been advised development of this site is unlikely to occur in the short term.

While many schemes for outdoor and industrial PRW usage are already in operation around NSW, only a few utilities and LWU's are proposing to trial pilot PRW plants for residential drinking water supply in coming years. Of note locally is that Rous County Council is proposing to invest an estimated $10M to build and operate a pilot plant on the council-owned Perradenya Estate near Lismore. Gaining Section 60 approval from DPIE, along with community acceptance and education, is expected to be the greatest project development challenge once all funding is secured. The supply of PRW could amount to approximately 1.7 ML/d, or 610 ML/a, being approximately 70% of the Casino STP average dry weather flow. The remaining 30% of flow would remain with the sludge, RO brine and other process concentrates. The RO brine or similar concentrates are likely to be too saline for discharge to surface waters or for use as PRW.

9.1.2.7 Water treatment plant filter backwash

RVC have noted that surplus backwash water from the filters at the water treatment plant (WTP) has been previously discussed to be used as supply water for a nearby (i.e. in Nammoona precinct) AWTS facility. Filter backwash water would be suitable for use in boilers and for dust suppression but not drinking. The quantity produced by the WTP should be sufficient for some of the use at the proposed AWTS plant, estimated to be an average of 350 kL/d or 128 ML/a.

9.1.2.8 Alternate water source

Groundwater has been the focal investigation to find new water sources for back-up/emergency water supply. A 2012 study by Hydrosphere Consulting determined the yields and depth for several ground water locations as seen below and found whilst there is potential to source ground water, costs for pumping and treatment need to be considered. The yields predominantly ranged between 1.4-4.5 L/s with two yielding 9 and 10.1 L/s (GW304806 and GW206490), and depth varying between 15-182 m.

An investigation by PWA of 3 bore holes (unspecified locations) had a total yield of 1.25 ML/d which is insufficient to provide security to the Casino network.

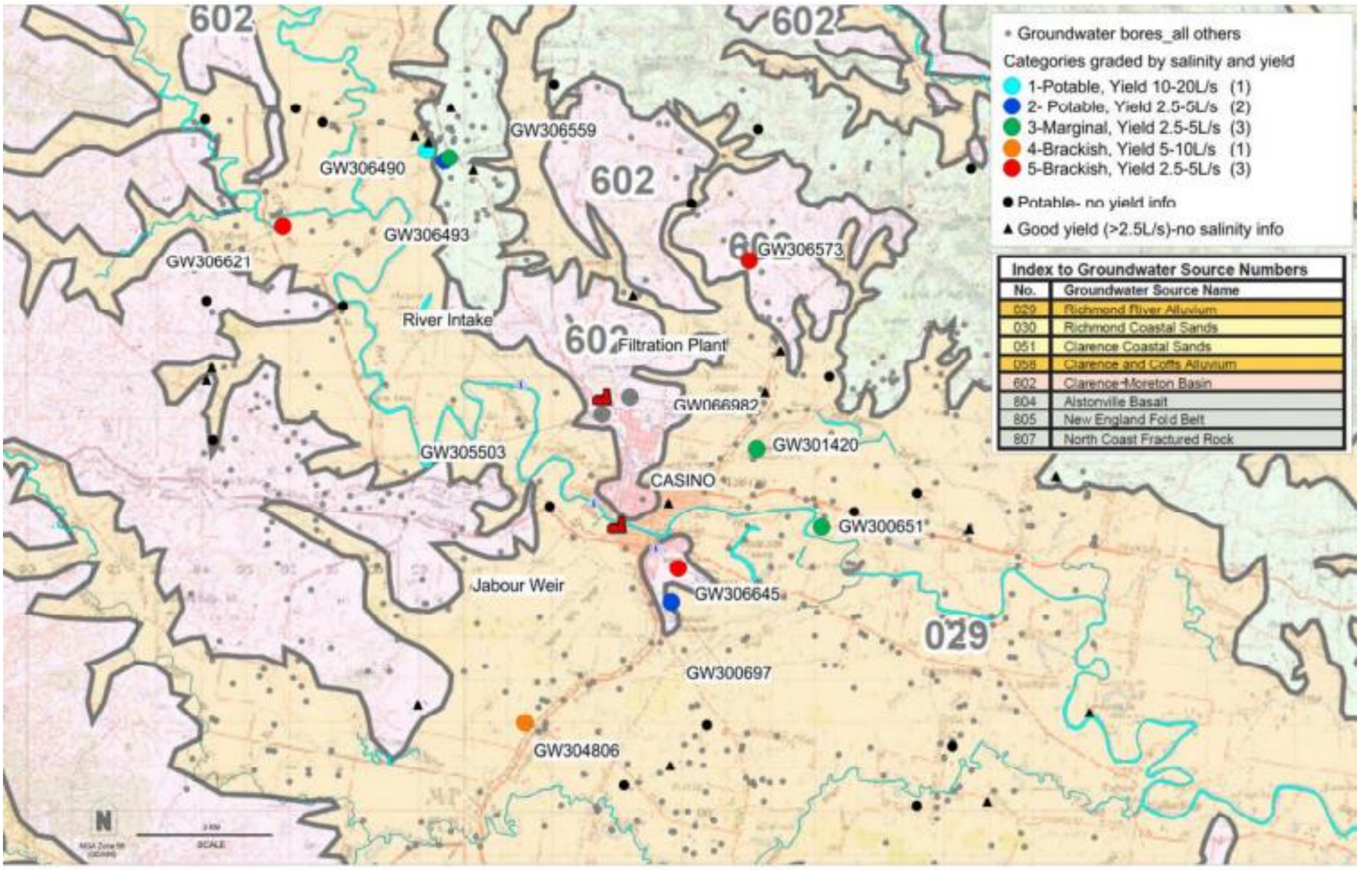

Figure 9.2 Bore locations surrounding Casino

Based on information obtained from the bioregional assessment studies[1] by Beale in 1966, and GHD's database created for DPIE (DPE) in 2021 the following analysis of hydrogeological data west of Casino can be deduced:

– Average yield in the alluvial system west of Casino appears to be around 1 to 2 L/s (0.2ML/d), although yields are highly variable in the alluvial system. The variability of yield is dependent on the proportion of silts, clays and sand in a given location, based on the depositional environment that is both estuarine and fluvial throughout its geological history.
– The general depth that bores are installed are 15-30 m in the alluvial. Less is known about the yield in the deeper hard rock aquifers which would rely more on higher fracture density for higher yields.
– Moderate salinity (as depicted as yellow in Figure 4.4) refers to electrical conductivity (EC) values ranging between 1500 – 3000 Micro-Siemens per centimetre (uS/cm), although most bore data appear to be around 1750uS/cm. Salinity is variable in the alluvial and relates to its original depositional environment (estuarine or fluviatile).

[1] Australian Government Bioregional Assessment website

9.1.2.9 Staging and trigger points for upgrades

Staging and trigger points to address RVC's water security issues are described in the table below.

Table 9.4 Staging and trigger points for upgrades

Precinct	Priority	Trigger	Staging
Area 1, 2, 3	1	Water infrastructure capacity and levels of service for storage, pressure and flow nearing design limits based on proposed developments.	Staged options for Casino's water security include: 1. Access dead storage at Jabour to increase water security 2. Then, prior to 2036 (recommended to start investigations in next few years given the lead times on these options, listed in order of priority for RVC to investigate): a. Negotiate with Water NSW for a licence to access high security/emergency supply for peak of drought period from Toonumbar Dam storage b. Off river storages (210ML), associated pipelines and WPSs c. 22 km pipeline to connect to Rous County Council pipeline now to achieve water security due to current water secure yield shortfall d. Raising Jabour Weir GHD is undertaking strategies to service new release areas of Fairy Hill, West Casino and North Casino, noting the demand from the Fairy Hill development has been included in each demand scenario for the overall considerations.

10. Recommendations

The following recommendations are made for the next phase of this project:

- Hydrogeology:
  - Further investigation of suitable new bore locations should be undertaken. Groundwater is unlikely to be the primary long-term water supply source and should be considered as an emergency supply option. If groundwater utilisation is to be developed, recommendations regarding groundwater are as follows:
    - Based on the existing data and depending on location, there are both shallow and deep aquifers that have potential to supplement water demand. The shallow alluvial aquifers upgradient of Casino is considered best potential with the expected groundwater yields from bores screened in the alluvials from 5 – 8 L/s. Yields in the fractured igneous rocks are low unless fracture density is high where yields can reach up to 10 L/s. Drilling in fractured rock terrain for high yields is higher risk in finding high yield water supply relative to associated costs. Shallow alluvial aquifers are more consistent in identifying a potential groundwater source and less associated costs.
    - Groundwater from the shallow alluvial aquifers is likely to be connected to the river and have a similar water quality due to the high connectivity. Whilst the groundwater quality would need to be confirmed that is adjacent to the river offtake pump station that feeds into the existing WTP, there is potential for "shandying" the river water with groundwater of similar chemical composition for key water treatment parameters like hardness, pH, EC, metals, and turbidity.
- Surface Water:
  - Planning for lot-based (as permitted in RVC's DCP) and development scale stormwater reuse.
  - Refer to Table 9.4 in section above for priority order for future bulk water supply options to explore.
  - Turbidity issues in the river are further discussed in the Utilities Report.
- Demand Analysis:
  - Based on discussions with RVC and the future industrial development forecast information provided by Gyde, GHD recommends scenario 2 (light-medium industrial development mix) as an appropriate design scenario to be used to guide future capital works planning and developer contributions.
  - As the current Casino demand and the demands of the three RJP precincts are to be considered (plus the Fairy Hill residential development), then the proposed accessing of the Jabour Weir's dead storage is recommended to occur as soon as possible.
  - An alternative solution involves the raising of Jabour weir. This option however will similarly need to be supplemented by an additional supply method if the highest demand scenario (or a few large industries that represent the highest demand scenario eventuate in the shorter term) occurs.

11. Recommended updates to contribution plans

11.1 Updates to DSP's

Section 64 of the *Local Government Act, 1993* enables a local government Council to levy developer charges for water supply, sewerage, and stormwater. This derives from a cross-reference in that Act to Section 306 of the Water Management Act 2000. The Development Servicing Plans (DSP's) for water supply, sewerage and stormwater detail the water supply, sewerage, and stormwater developer charges to be levied on development areas using a local utility's water supply, sewerage and stormwater infrastructure.

Council currently has a Water Supply Services DSP 2010. Council is required to prepare DSP's in accordance with the *2016 Developer Charges Guidelines for Water Supply, Sewerage and Stormwater (2016)* issued by the Minister for Lands and Water, pursuant to section 306 (3) of the Water Management Act, 2000. Recommendations for updates to a DSP's post 2016 would include updates to the following sections:

– Executive Summary
– 2.7 Out-of-sequence development
– 3.1 Growth projections
– 3.2 Land use information
– 4.1. Existing and future water and sewerage services
– 4.3 Future capital works program
– 7. Calculated developer charges
– 9. Background information
– 13. ET Projections
– 15. Future capital works program
– 16. Calculation of capital charge
– 17. Calculation of reduction amount (review)
– 18. Cross-subsidy calculations (review)
– 19. Calculation of developer charge

Information to inform the revised DSP's requires further refinement (design development is required to produce realistic cost estimates). For the bulk water DSP elements relating to approximate cost (noting water network, water treatment, sewer network and sewer treatment are shown in the Utilities Report), refer to the table below, noting that the other non-ET or cost information listed above is in the project reports. Note that final costs also cannot be determined without existing operational costs that are held by RVC to calculate the 'reduction amount' and that cross subsidies are to be determined by RVC also.

It is recommended that a conservative 15% reduction in the demand calculations be applied to industries in the RJP areas for implementation of water efficiency measures for new developments which includes the utilisation of stormwater capture and reuse.

11.2 Future capital works program

Based on the analysis of the proposed RJP developments, the estimated future bulk water and WTP capital works to inform the Water supply DSP is listed below. Note the future network water and wastewater capital works program is detailed in section 9 of the *Utilities Infrastructure Analysis Report*.

11.2.1 Water supply

Casino supply bulk water supply augmentation options

- Water main from Toonumbar Dam wall to Casino WTP.
- Water main from end of Eden Creek to Casino WTP.
- Access dead storage at Jabour Weir.
- Raise Jabour Weir including fish ladder.
- Off river storages (210 ML), water mains and WPS's.
- 22 km water main to connect to Rous County Council pipeline.

Casino WTP

- WTP filter backwash storage upgrade and DN200 main to Nammoona precinct for industrial reuse.
- UV plant and process control system improvements.

11.3 DSP guidance information

Table 11.1 provides guidance information for updating the Council's Water Supply DSP.

Table 11.1 Bulk water supply and WTP DSP guidance information

	Demand Scenario 1	Demand Scenario 2	Demand Scenario 3
Total ET projections[1]	6,603	7,729	9,290
Future capital works program	Dead storage access upgrade	Dead storage access upgrade Weir height raising (and fishway) Small filter/storage upgrade at WTP	Dead storage access upgrade Weir height raising (and fishway) Medium filter/storage upgrade at WTP
Order of magnitude costs ($M)	$0.5M	$3M[3]	$4M[3]

1. Based on 2.6 EP:ET ratio from Casino STP strategy report (GHD, 2019). 1 EP is 180 L/EP/day
2. 'Raw' refers to charge without reduction amount
3. Based on recent weir/fishway upgrade experience

A Planning Agreement (PA) is a voluntary agreement or other arrangement between Council and a developer under which the developer is required to:

- Dedicate land free of cost
- Pay a monetary contribution
- Provide any other material benefit or
- Provide any combination of the above
- To be used for or applied towards a public purpose

Council maintains a PA register. The register currently has one agreement listed, VPA2021/0001 between Council and Peter Croke Holdings Pty Ltd. The agreement related to Lots 86 & 87 DP7555627 bounded by Hare Street, East Street and Boundary Street, Casino. The PA does not relate to land within Area 1, 2 and 3 therefore there are no updates to the PA required.

12. Development Control Plan provisions

Relevant sections from the *Richmond Valley Development Control Plan 2021* to be considered for planning and design of infrastructure for the RJP's is outlined below*:*

- Part H Natural Resources and Hazards:
  - H-1 Flood Planning.
  - H-2 Acid Sulfate Soils.
  - H-3 Natural Resources:
    - H-4.2 LEP NRS Mapping.
    - H-4.3 Terrestrial Biodiversity.
    - H-4.5 Riparian Land and Watercourses.
    - H-4.6 Drinking Water Catchments:
      - Potential off river storages totalling 210 ML are within the existing drinking water catchment area. Development of the storage would result in the revision of RVC's Drinking Water Quality Management Plan.
    - H-4.7 Wetlands.
- Part I Other Considerations:
  - I-1 Environmental Heritage:
    - I-1.12 Aboriginal Cultural Heritage.
  - I-9 Water Sensitive Urban Design—WSUD.
  - 1-11 Land Use Conflict Risk Assessment— LUCRA.
  - 1-12 Context and Site Analysis.

13. References

Beale, J.G. (1966) "Water resources of the Richmond River Valley." Survey of thirty NSW River Valleys. Report No. 2 – May 1966. Water Conservation and Irrigation Commission.

BMT (2023), Regional Jobs Precinct Flood Impact Assessment Stage 4 Final Report

DLWC (2001) "Water Management Act 2000 – What it means for NSW." Department of Land and Water Conservation, Sydney.

Doig, A. & Stanmore, P. (2012) "The Clarence-Moreton Basin in New South Wales; geology, stratigraphy and coal seam gas characteristics".

DPE Water Draft Guidelines for "Assuring future urban water security – Assessment and adaption guidelines for NSW local water utilities".

DPIE (2016) "Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources: background document." Department of Primary Industries; a division of NSW Department of Industry, Skills and Regional Development.

GHD 2022. Utilities Infrastructure Analysis Report.

GHD 2019. Casino STP Long-Term Strategy Report.

Gyde 2022. Draft Casino Place Plan.

Gyde 2023. Draft Richmond Valley Regional Jobs Precinct Structure Plan.

Gyde 2021. Richmond Valley Regional Job Precincts Action Plan.

Public Works Advisory 2021. Casino Water Security Assessment.

Public Works Advisory 2022. Casino Water Supply Scoping Study.

Richmond Valley Council 2002. Casino Floodplain Risk Management Plan 2002.

Richmond Valley Council 2010. Development Servicing Plan Water Supply Services 2010.

Richmond Valley Council 2020. Local Strategic Planning Statement Beyond: 20-20 Vision.

Richmond Valley Council 2021 GIS data.

WBM 1998. Casino flood study.

WBM 2009 Casino flood model.

Appendices

Appendix A

Water Demand Breakdown

		Land Area (sqm)	FSR	GFA (ha)	Average Day: Scenario 1	Average Day: Scenario 2	Average Day: Scenario 3		Peak Day: Scenario 1	Peak Day: Scenario 2	Peak Day: Scenario 3	
					11.5	19	26.5					
					kL/d	kL/d	kL/d		kL/d	kL/d	kL/d	
	Area 1 Nammoona Industrial Area											
	Land use yields	**Land Area (sqm)**	**FSR**	**GFA (ha)**				**Factor**	1.20			
1_A	**Existing Industries - General (heavy / high impact) consisting of:**	475,492	0.1	4.75	54.68	90.34	126.01		65.62	108.41	151.21	
	Northern Rivers Livestock Exchange											
	Council Landfill Facility											
	Riverina Stockfeeds											
	Pentach Timber Products											
1_B	**Intermodal - Logistics (Intermodal facility operations)**	42,170	0.3	1.27	14.55	24.04	33.53		17.46	28.84	40.23	
1_C	**Intermodal - Logistics (Warehousing)**	101,942	0.3	3.06	35.17	58.11	81.04		42.20	69.73	97.25	
1_D	**Intermodal - General industrial (low to moderate impact) potentially including:**	124,059	0.3	3.72	42.80	70.71	98.63		51.36	84.86	118.35	
	Logistics suppliers who provide intermodal/cold chain solutions											
1_E	**Heavy Industry - Food Processing – soybeans (heavy/ high impact) - Non Constrained Area**	65,322	0.3	1.96	22.54	37.23	51.93		27.04	44.68	62.32	
1_F	**Heavy Industry - Food Processing – soybeans (heavy / high impact) - Biodiversity Offset Dependent**	15,391	0.3	0.46	5.31	8.77	12.24		6.37	10.53	14.68	
1_G	**Renewable/circular economy energy providers - EfW (heavy / high impact)**	33,726	0.2	0.67	**100**	**150**	**200**		120.00	180.00	240.00	
1_H	**General industrial Stage 1 (low to moderate impact) potentially including:**	48,066	0.3	1.44	16.58	27.40	38.21		19.90	32.88	45.85	
	Bio-degradable and/or compostable packaging manufacturers											
	Technical/ Engineering service providers support to the regional food processing industry											
	Logistics suppliers who provide intermodal/cold chain solutions											
	Medical grade processors (e.g. tea tree and honey)											
1_J	**General industrial Stage 2 (heavy/ high impact)**	79,348	0.3	2.38	27.37	45.23	63.08		32.85	54.27	75.70	
1_K	**General industrial Stage 2 (low to moderate impact) potentially including:**	44,095	0.3	1.32	15.21	25.13	35.06		18.26	30.16	42.07	
	Bio-degradable and/or compostable packaging manufacturers											
	Technical/ Engineering service providers support to the regional food processing industry											
	Logistics suppliers who provide intermodal/cold chain solutions											
	Medical grade processors (e.g. tea tree and honey)											
1_L	**General industrial Stage 3 (low to moderate impact) potentially including:**	117,559	0.3	3.53	40.56	67.01	93.46		48.67	80.41	112.15	
	Bio-degradable and/or compostable packaging manufacturers											
	Technical/ Engineering service providers support to the regional food processing industry											
	Logistics suppliers who provide intermodal/cold chain solutions											
	Medical grade processors (e.g. tea tree and honey)											
	Total	**1,147,169**		**24.57**	**374.77**	**603.98**	**833.18**		**449.73**	**724.77**	**999.81**	**Kl/d**
					136.79	**220.45**	**304.11**					**ML/y**
	Area 2 Northern Co-op Meat Company Complex											
	Land use yields	**Land Area (sqm)**	**FSR**	**GFA (ha)**								
2_A	**Existing Industries - General (heavy / high impact) including future bioenergy facility on Co-op Land**	333,386	0.2	6.67	76.68	126.69	176.69		92.01	152.02	212.03	
2_B	**Catalyst Industries - Light/ General Industrial (Low impact). Uses unspecified at this stage**	110,723	0.2	2.21	25.47	42.07	58.68		30.56	50.49	70.42	
	Total	**444,109**		**8.88**	**102.15**	**168.76**	**235.38**		**122.57**	**202.51**	**282.45**	**Kl/d**
					37.28	**61.60**	**85.91**					**ML/y**
	Area 3a Johnston Street Industrial Area											
	Land use yields	**Land Area (sqm)**	**FSR**	**GFA (ha)**								
3A_A	**Existing Industries - General (low to moderate impact)**	183,767	0.2	3.68	42.27	69.83	97.40		50.72	83.80	116.88	
3A_B	**General industrial (low to moderate impact) - Extension north of Johnston Street potentially including:**	115,857	0.2	2.32	26.65	44.03	61.40		31.98	52.83	73.69	
	Bio-degradable and/or compostable packaging manufacturers											
	Technical/ Engineering service providers support to the regional food processing industry											
	Logistics suppliers who provide intermodal/cold chain solutions											
	Medical grade processors (e.g. tea tree and honey)											
3A_C	**General industrial - South of Johnston Street (low to moderate impact)**	268,631	-	-	-	-	-		-	-	-	
	Total	**568,255**		**5.99**	**68.91**	**113.86**	**158.80**		**82.70**	**136.63**	**190.56**	**Kl/d**
					25.15	**41.56**	**57.96**					**ML/y**
	Area 3b Sewerage Treatment Plant and Surrounds											
	Land use yields	**Land Area (sqm)**	**FSR**	**GFA (ha)**								
3B_A	**Sewerage Treatment Plant (STP)**	154,030	-	-	-	-	-		-	-	-	
3B_B	**Lot 320 - Catalyst | Intensive Agriculture | High Water High Voltage user**	190,329	0.3	5.71	65.66	108.49	151.31		78.80	130.19	181.57	
3B_C	**Primex - Light industrial/ commerical (Low impact industries)**	78,131	0.3	2.34	26.96	44.53	62.11		32.35	53.44	74.54	
	Medical grade processors (e.g. tea tree and honey)											
3B_D	**Primex site - General Industrial (Low to medium impact industries)**	93,364	0.3	2.80	32.21	53.22	74.22		38.65	63.86	89.07	
	Bio-degradable and/or compostable packaging manufacturers											
	Technical/ Engineering service providers support to the regional food processing industry											
	Logistics suppliers who provide intermodal/cold chain solutions											
	Medical grade processors (e.g. tea tree and honey)											
	Total	**515,854**		**10.85**	**124.83**	**206.24**	**287.65**		**149.80**	**247.49**	**345.18**	**Kl/d**
					45.56	**75.28**	**104.99**					**ML/y**

Average Day: 1	2	3		Peak Day: 1	2	3	
7.76	12.65	17.53	L/s	9.31	15.18	21.04	**L/s**
0.67	1.09	1.52	**Kl/d**	0.80	1.31	1.82	**ML/d**
244.79	398.88	552.98	**ML/y**				**ML/y**

ADD Development (ML/y):

*no demand percentage reduction

	Scenario	1				2				3			
Year	% Developed	Nammoona	Food Co-op	Johnston St	STP	Nammoona	Food Co-op	Johnston St	STP	Nammoona	Food Co-op	Johnston St	STP
2026	17.45%	23.9	6.5	4.4	8.0	38.5	10.7	7.3	13.1	53.1	15.0	10.1	18.3
2031	48.72%	66.6	18.2	12.3	22.2	107.4	30.0	20.2	36.7	148.2	41.9	28.2	51.2
2036	78.73%	107.7	29.4	19.8	35.9	173.6	48.5	32.7	59.3	239.4	67.6	45.6	82.7
2041	100.00%	136.8	37.3	25.2	45.6	220.5	61.6	41.6	75.3	304.1	85.9	58.0	105.0

Population growth PDD projections

*Source PWA Casino Water Supply Scoping Study (2022)

Year	2020	2025	2030	2035	2040	2045	2050
Population	9920	10170	10430	10690	10960	11240	11520
Average year customer demand (ML/y)	2010	2030	2060	2080	2100	2130	2150
Peak day production (ML/d)	12.86	12.96	13.05	13.15	13.25	13.35	13.45
Fairy Hill peak day prodcution							
Fairy Hill (ML/d)	0.00	0.60	1.40	2.40	3.10	3.70	4.40
Peak day production including scenario demands							
Scenario 1 (ML/d)	12.86	13.68	14.79	16.09	17.04	17.74	18.54
Scenario 2 (ML/d)	12.86	13.75	15.00	16.43	17.47	18.17	18.97
Scenario 3 (ML/d)	12.86	13.83	15.21	16.77	17.90	18.60	19.40

Average day Water Security

*With 15% reduction due to increased water reuse and stormwater capture

			Demand (ML/y)		
Area	% Developed	Year	1	2	3
Area 1 - Nammoona Industrial	17.45%	2026	20.3	32.7	45.1
	48.72%	2031	56.6	91.3	125.9
	78.73%	2036	91.5	147.5	203.5
	100.00%	2041	116.3	187.4	258.5
Area 2 - Food Co-op	17.45%	2026	5.5	9.1	12.7
	48.72%	2031	15.4	25.5	35.6
	78.73%	2036	24.9	41.2	57.5
	100.00%	2041	31.7	52.4	73.0
Area 3a - Primex	17.45%	2026	3.7	6.2	8.6
	48.72%	2031	10.4	17.2	24.0
	78.73%	2036	16.8	27.8	38.8
	100.00%	2041	21.4	35.3	49.3
Area 3b - STP residue	17.45%	2026	6.8	11.2	15.6
	48.72%	2031	18.9	31.2	43.5
	78.73%	2036	30.5	50.4	70.3
	100.00%	2041	38.7	64.0	89.2
Fairy Hill		2025	85.2		
		2030	194.1		
		2035	342.3		
		2040	450.6		
		2045	588.8		
		2050	667.5		
Township PDD		2025	2482.0		
		2030	2500.7		
		2035	2519.5		
		2040	2538.4		
		2045	2557.5		
		2050	2576.8		

Existing secure yield	2355	ML/yr	*1 degree climate warming
Deep storage secure yield	3395	ML/yr	*1 degree climate warming

Year	1	2	3	1	2	3
2026	2603.5	2626.4	2649.2	2603.5	2626.4	2649.2
2031	2796.1	2860.0	2923.8	2796.1	2860.0	2923.8
2036	3025.6	3128.7	3231.8	3025.6	3128.7	3231.8
2041	3197.1	3328.1	3459.1	3197.1	3328.1	3459.1
2045	3354.4	3485.4	3616.4	3354.4	3485.4	3616.4
2050	3452.3	3583.3	3714.3	3452.3	3583.3	3714.3

Peak day WTP capacity

*With 15% reduction due to increased water reuse and stormwater capture

			Demand (ML/d)		
Area	% Developed	Year	1	2	3
Area 1 - Nammoona Industrial	17.45%	2026	0.07	0.11	0.15
	48.72%	2031	0.19	0.30	0.41
	78.73%	2036	0.30	0.49	0.67
	100.00%	2041	0.38	0.62	0.85
Area 2 - Food Co-op	17.45%	2026	0.02	0.03	0.04
	48.72%	2031	0.05	0.08	0.12
	78.73%	2036	0.08	0.14	0.19
	100.00%	2041	0.10	0.17	0.24
Area 3a - Primex	17.45%	2026	0.01	0.02	0.03
	48.72%	2031	0.03	0.06	0.08
	78.73%	2036	0.06	0.09	0.13
	100.00%	2041	0.07	0.12	0.16
Area 3b - STP residue	17.45%	2026	0.02	0.04	0.05
	48.72%	2031	0.06	0.10	0.14
	78.73%	2036	0.10	0.17	0.23
	100.00%	2041	0.13	0.21	0.29
Fairy Hill		2025	0.60		
		2030	1.40		
		2035	2.40		
		2040	3.10		
		2045	3.70		
		2050	4.40		
Township PDD		2025	12.96		
		2030	13.05		
		2035	13.15		
		2040	13.25		
		2045	13.35		
		2050	13.45		

Typical capacity	18	ML/d	*CWT WTP Assessment 2021
Design capacity	22.1	ML/d	*CWT WTP Assessment 2021

Year	1	2	3	1	2	3
2026	13.7	13.8	13.8	13.7	13.8	13.8
2031	14.8	15.0	15.2	14.8	15.0	15.2
2036	16.1	16.4	16.8	16.1	16.4	16.8
2041	17.0	17.5	17.9	17.0	17.5	17.9
2045	17.7	18.2	18.6	17.7	18.2	18.6
2050	18.5	19.0	19.4	18.5	19.0	19.4