8. Groundwater

8.1 Introduction

This chapter provides an assessment of the potential impacts on the existing groundwater resources of the proposed Emu Swamp Dam Project. The chapter recommends management measures to minimise the potential impacts of the Project.

This section has assessed the potential impacts of the inundation area for Emu Swamp Dam. The section also assesses the potential impacts along the Urban and Irrigation Pipeline routes.

8.2 Existing Environment

An overview of the hydrogeological setting, groundwater users, groundwater occurrence, groundwater quality, groundwater levels and groundwater dependent ecosystems within the vicinity of the proposed inundation area and pipeline routes is presented in this section of the report. The assessment was undertaken on a regional and local scale of the inundation area and the pipeline routes.

8.2.1 Hydrogeological Setting

The hydrogeological setting of the assessment area was assessed using regional (1:250,000) geological mapping records published by Bureau of Mineral Resources (1972) together with regional (1:100,000) mapping records published by the Natural Resources and Water (DNRW) and the Geological Survey of Queensland (GSQ) (2005).

A detailed description of the geological units underlying the Project area is included in the **Section 4** of the EIS. The geological units identified within the Project area include:

- Quaternary Alluvium;
- Ruby Creek Granite; and
- Stanthorpe Adamellite.

The hydrogeological setting within the Emu inundation area and the Urban and Irrigation Pipeline is dominated by the Stanthorpe Adamellite’s. An outcrop of Ruby Creek Granite is situated in the south west section of the proposed dam and underlies parts of the northern section of the pipeline alignment. Quaternary alluvial deposits consisting of clay, silt, gravel and flood plain alluvium are described along drainage lines running intermittently parallel to the pipeline. These units are described in detail in the **Section 4** of the EIS.

Six boreholes and nine test pits were constructed by URS (2006) along the proposed dam footprint as part of preliminary site geotechnical investigations for the dam. Slug tests were conducted in the open boreholes to estimate the hydraulic properties of the bedrock (Stanthorpe Adamellite). Results indicates that the estimated bulk bedrock permeability ranges from $4x10^{-6}$ to $2x10^{-7}$ m/s which is indicative of moderate rock permeability (URS 2006). It should be noted that the results could be potentially influenced by more permeable weathered horizons given that slug tests were undertaken in uncased boreholes. Domenico and Schwartz (1998) indicates that unfractured igneous and metamorphic rocks range from a permeability of $3x10^{-14}$ to $2x10^{-10}$ m/s and fractured igneous and metamorphic rocks range from a permeability of $8x10^{-9}$ to $3x10^{-4}$ m/s. Permeability of granites is in line with literature values. From a groundwater supply perspective, the range of permeabilities for the Stanthorpe Adamellite is low.

A detailed assessment of geologic structures within the Project area has been undertaken in the **Section 4** of the EIS. Inferred faults have been identified to occur within the inundation area and the pipeline alignment. These faults can represent zones of increased permeability indicating localised groundwater occurrence.

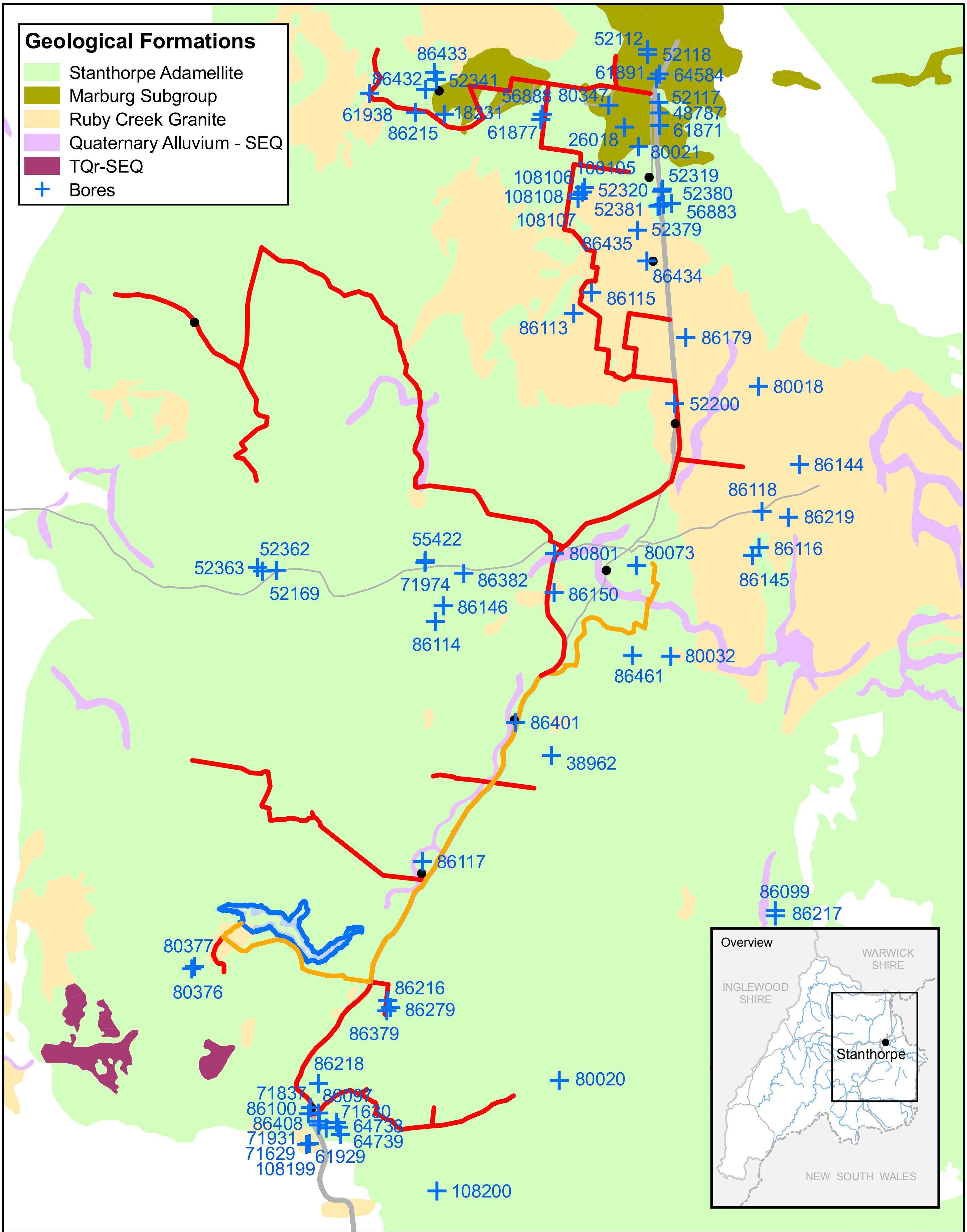
Based on the available data and geotechnical investigations undertaken by URS (2006), permeability characteristic of the Stanthorpe Adamellite are low to moderate. The Ruby Creek Granite is likely to display low permeability characteristics. The Quaternary Alluvium is likely to display high permeability characteristics based on findings in the soil surveys (refer to **Section 4** of the EIS).

8.2.2 Groundwater Users

A facility survey was undertaken within the vicinity of the assessment area (water supply dam and pipeline) using records within the DNRW groundwater database. The groundwater records within this database are likely to be associated with private investigative one-off drilling programs, the results of which are required to be registered under the *Water Act 2000*. Database records recovered for this assessment range from 1975 to 2005, and there is no indication from these results that regional groundwater quality or levels in the Project area has changed over time. The location of groundwater facilities in the Project area is shown in **Figure 8-1**.Forty-nine groundwater facilities have been identified within a 20 km radius of the inundation area. Seventy-four (including the 49 identified for the water supply dam) registered groundwater facilities as shown in **Figure 8-1** have been identified within a 20 km radius of the Urban and Irrigation Pipeline. Of the registered bores identified a total of 74 were classified as existing. Within a 3 km radius of the dam, only 6 existing groundwater bores (Registration no. 86117, 80377, 80376, 86216, 86279, 86379) have been identified, 5 of which are down-gradient of the inundation area and 1 which is located up-gradient.

No groundwater users have been identified within a 1 km radius of the proposed Emu Swamp Dam. However a series of bores have been identified within the immediate vicinity of the Urban and Irrigation Pipeline. An analysis of the bore data indicates that the majority of the bores are constructed within the Stanthorpe Adamellite, which is the dominant geological unit in the Stanthorpe area. The remaining bores are constructed within the Ruby Creek Granites with six groundwater bores (Registration no. 52362, 38962, 86179, 64739, 80689 and 86279) identified to be constructed in alluvium associated with the existing water courses.

A review of DNRW licensed water allocation records was also undertaken. The results are presented in **Table 8-1**. In most instances, water allocation limits are applied by DNRW where groundwater extraction is undertaken for non stock and domestic purposes in a declared Groundwater Management Unit (GMU). Based on these records the majority of bores with allocations entitlements were classified as repealed (no longer active) with only three stock intensive bores identified as being issued. It should be noted that none of the bores with allocation entitlements were located within 10 km of the site.



SHIRE OF STANTHORPE

Legend

- Urban Pipeline
- Irrigation Pipeline
- FSL 734.5m AHD
- FSL 738m AHD

N W E S

0 0.5 1 2 3 4 5
Kilometres
Scale - 1:150,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Project Area

Figure 8-1
Ground Water Facilities in the Project Area

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Table 8-1 Current uses of licensed groundwater facilities within the Project area

Registration Number	Purpose	Allocation (ML)	Status
52169	School	-	Repealed
52362	Irrigation/ Stock	19	Repealed
52363	Irrigation/ Stock	19	Repealed
61929	Irrigation/ Stock	15	Repealed
64738	Irrigation/ Stock	15	Repealed
64739	Irrigation/ Stock	15	Repealed
71629	Domestic Supply/ Stock	-	Repealed
71630	Domestic Supply/ Stock	-	Repealed
71974	Public Supply	-	Repealed
80801	Industrial	1	Repealed
86114	Irrigation	1	Repealed
86146	Stock	-	Repealed
86216	Irrigation	6	Repealed
86279	Domestic Supply/Irrigation/Stock	12	Repealed
86379	Irrigation	14	Repealed
86401	Industrial	2	Repealed
86461	Stock	-	Repealed
108373	Stock Intensive	24	Issued
108374	Stock Intensive	24	Issued
108375	Stock Intensive	24	Issued

8.2.3 Groundwater Occurrence and Yield

Geological mapping records, borehole logging data and results from investigations undertaken by URS (2006) suggest that the Stanthorpe Adamellite, from a hydrogeological perspective, has low permeability. This is indicative of poor aquifer prospects with groundwater occurrence within the Stanthorpe Adamellite likely to be limited to zones of structural deformation.

Regionally, faults and other lineaments may host groundwater however the hydrogeological significance of these features in the vicinity of the dam and pipeline has not been ascertained. During the geotechnical drilling program (URS, 2006) within the vicinity of the proposed dam, open fractures were encountered resulting in lost circulation during drilling. Although the location of distinct water bearing joints could not be ascertained, observations indicated that the majority of groundwater was encountered within the upper three to four meters of the foundation. As a result foundation grouting to reduce seepage and drainage to relieve groundwater pressures has been outlined by URS (2006). Reference should be made to URS (2006) for detailed engineering and geotechnical specifications for the proposed grouting.

Groundwater level observation data recovered by URS (2006) when reviewed in conjunction with borehole records suggest that shallow groundwater within the weathered zone of the Stanthorpe Adamellite is unconfined. Given the relative homogeneity of this unit and shallow depth of weathering it is considered unlikely that deeper, potentially confined aquifer systems exist.

Based on an assessment of facility data available and geological records, permeability of the Ruby Creek Granite is likely to be low to moderate. Like the Stanthorpe Adamellite, groundwater occurrence within the Ruby Creek Granite is likely to be limited to zones of structural deformation. As such, aquifer prospects within the Ruby Creek Granite are poor to reasonable.

On a local scale, groundwater within the Stanthorpe Adamellite and the Ruby Creek Granite is likely to be hosted in joints, weathered zones and small scale defects. Two approximate faults (DNRW, GSQ; 2005) inferred to run through the proposed dam are likely to be zones of increased permeability relative to the surrounding strata and are in turn likely to represent a localised secondary porosity aquifer system which is in hydraulic connection with the existing Severn River. Increased permeability relative to the surrounding strata may be encountered as a result of fracturing along and adjacent to the fault which is inferred from aeromagnetic interpretation to intersect the proposed Urban Pipeline just north of the township of Glen Aplin. Groundwater flow direction could not be ascertained due to insufficient surveyed groundwater level data. Movement is expected to vary at a local scale and is likely to be controlled largely by geological structure

The available geological data and the general absence of registered groundwater users suggest that the Stanthorpe Adamellite and the Ruby Creek Granite within the Project area do not host any groundwater resource of significance. Minimal groundwater bore data is available within the vicinity of the proposed Emu Swamp Dam however groundwater yield within the granites, based on the available bore data is low to very low as is shown in **Table 8-2**. This suggests that the groundwater resource within the immediate vicinity of the Project area is likely to be minimal.

- **Table 8-2 Groundwater Yield (L/sec) in the Inundation Area**

Registration Number	Year Drilled	Bore Lithology	Yield (L/sec)
52362	1978	Unconsolidated sand and gravel	1.3
52363	1980	Decomposed Granite	2.5
52169	1980	Sand (0-0.9m) Granite (0.9-2.9m)	0.25
64739	1981	Sand (0-9.1m) Granite (9.1-82.3m)	0.63
71629	1985	Red rock	0.14
71630	1985	Granite/Sand (1.8-3.5m) Sand/Clay (3.59m)	1.3
71974	1987	Granite	0.31
80689	1995	Gravel	1.63
80801	1995	Granite	0.04
86098	1989	Granite	1.1
86100	1989	Granite	0.15
86114	1989	Granite	0.35
86115	1989	Granite	0.07
86146	1989	Granite	0.2
86215	1989	Granite	0.65
86216	1989	Granite	0.8
86218	1989	Granite	0.5
86279	1991	Sand (0-3m) Granite (3-12m)	1.8
86401	1991	Granite	1.5
86408	1991	Granite	0.25
86421	1991	Granite	0.3

Table 8-3 Groundwater Yield (L/sec) near the Pipeline Routes

Registration Number	Year Drilled	Bore Lithology	Yield (L/sec)
38962	1980	Unconsolidated sand and gravel	8.8
52362	1978	Unconsolidated sand and gravel	1.3
80032	1991	Granite	0.9
80073	2003	Granite	0.14
86114	1989	Granite	0.35
86116	1989	Granite	0.6
86118	1989	Granite	0.12
86145	1989	Granite	0.15
86146	1989	Granite	0.2
86150	1990	Granite	0.6
86179	1989	Sandy Loam (0-0.5) Granite (0.5-21.3)	1
86216	1989	Granite	0.8
86219	1989	Granite	0.75
86279	1991	Sand (0-3m) Granite (3-12m)	1.8
86379	1991	Granite	0.3
86382	1991	Granite	0.25
86401	1991	Granite	1.5
86461	1991	Granite	0.15
108105	2002	Granite	1.1
108106	2002	Granite	1.4
108107	2002	Granite	1.51
108108	2002	Granite	0.3
108199	2003	Granite	3.5
108200	2003	Granite	0.5

High permeability characteristics are likely to be limited to the sands and gravels within the alluvium. Low permeability, however, is likely to exist within the clays and silts. Groundwater yields obtained from bores identified to be constructed in alluvium, is however low to very low. Quaternary Alluvium within the Project area is likely to be in hydraulic connection with the Severn River. Based on available data aquifer prospects within the Quaternary Alluvium in the Project area are reasonable to good.

8.2.4 Groundwater Quality

The quality of the groundwater resource within the Project area has been assessed based on data from the DNRW Groundwater database. This data is based on results from private investigative groundwater drilling programs. These records were not verified as part of this study. Twenty-one water quality data records which are within close vicinity of the proposed dam are presented in **Table 8-4**.

Table 8-4 Groundwater Quality in the Inundation Area

Registration Number	Year Drilled	Bore Lithology	Conductivity (μS/cm)	pH
52362	1978	Unconsolidated sand and gravel	320	7.6
52169	1980	Sand (0-0.9m) Granite (0.9-2.9m)	220	ND
61929	1981	Granite	365	8.5
64738	1981	Sand (0-2.43m) Granite (2.43m – 83.82m)	460	7.4
71629	1985	Red rock	ND	ND
71630	1985	Granite/Sand (1.8-3.5m) Sand/Clay (3.59m)	120	6
71931	1987	ND	470	6.8
80689	1995	Gravel	1084	7.4
80689	1999	Gravel	986	8
80689	1999	Gravel	990	7.9
86097	1989	Sandy Loam (0-0.2m) Granite (0.2-18.3m)	465	6.7
86100	1989	Granite	1550	6.8
86114	1989	Granite	1900	6.6
86117	1989	Granite	780	8.3
86146	1989	Granite	1200	6.7
86216	1989	Granite	485	7.4
86218	1989	Granite	325	8.2
86279	1991	Sand (0-3m) Granite (3-12m)	266	7.8
86401	1991	Granite	662	6.9
86408	1991	Granite	413	7.1
86421	1991	Granite	315	7.8

ND = Not Defined

Based on the data presented in **Table 8-4**, groundwater bores have been constructed within two main aquifer types, the granites and the alluvium. It should be noted that the bores constructed in the alluvium associated with existing water courses are not within the immediate vicinity of the Project area except bore number 86279 which is located approximately 2 km southeast of the dam.

Groundwater quality within the granites ranges from slightly acidic to slightly alkaline with pH fluctuating from 6 to 8.5. Conductivity results indicate that groundwater is fresh to slightly brackish. Groundwater quality within the alluvium is generally slightly acidic with conductivity results indicating that groundwater is fresh.

Water quality results from 21 registered groundwater facilities which are within approximately 4 km of the proposed pipeline are shown in **Table 8-5**.

Table 8-5 Groundwater Quality in the Project Route

Registration No.	Year Drilled	Lithology	Conductivity (µS/cm)	pH
38962	1980	Unconsolidated sand and gravel	ND	ND
52362	1978	Unconsolidated sand and gravel	320	7.6
61929	1981	Granite	365	8.5
80032	1991	Granite	ND	ND
80073	2003	Granite	ND	ND
86097	1989	Sandy Loam (0-0.2m) Granite (0.2-18.3m)	465	6.7
86114	1989	Granite	1900	6.6
86116	1989	Granite	620	6.6
86117	1989	Granite	780	8.3
86118	1989	Granite	205	7.4
86145	1989	Granite	2000	6.7
86146	1989	Sandy Loam Granite	1200	6.7
86150	1990	Granite	1250	6.6
86179	1989	Sandy Loam Granite	600	6.9
86216	1989	Sandy Loam Granite	485	7.4
86219	1989	Granite	195	7.1
86279	1991	Sand (0-3m) Granite (3-12m)	266	7.8
86379	1991	Granite	ND	ND
86382	1991	Granite	735	7.2
86401	1991	Granite	662	6.9
86461	1991	Granite	1060	6.6

ND = Not Defined

Based on the data presented in **Table 8-5**, groundwater bores have been constructed in two main aquifer types, the granites and the alluvium. Groundwater quality within the granites ranges from slightly acidic to slightly alkaline with pH fluctuating from 6.6 to 8.5. Conductivity results range from 195 to 2000 µS/cm indicating that groundwater is fresh to slightly brackish. Groundwater quality within the alluvium is slightly acidic with conductivity results indicating that groundwater is fresh.

An assessment of major ion chemistry for groundwater was undertaken using a Piper-Trilinear diagram. Ionic data was recovered from the DNRW Groundwater database. Analysis of major cation and anion data using Piper-Trilinear diagrams allows for the comparison and discrimination between different water types. Since groundwater quality evolves through water-rock interaction, the concentration of individual ionic species is different to that found in surface waters and rainfall. Based on this data, ionic composition of groundwater is generally Na-Cl type. However, based on this data different groundwater types have been identified to exist, such as that for bore 52169 which is situated approximately 10 km north of the dam.

8.2.5 Groundwater Levels

8.2.5.1 Inundation Area

Geotechnical investigations undertaken by URS (2006), involved the installation of six boreholes along the proposed dam alignment and nine test pits within the proposed inundation area. As part of these investigations, borings along the dam alignment encountered groundwater. Field measurements indicate groundwater occurrence at a depth ranging from 3 to 12 mBGL. Static (recovered) water levels ranged from 0.8 to 4 m.

Available standing water level data for bores in the vicinity of the dam (within 7 km radius of the proposed inundation area) is presented in **Table 8-6**. Results shown below have been extracted as part of the facility survey from the DNRW groundwater database and were not verified as part of this study.

- **Table 8-6 Standing Water Levels for the Inundation area**

Registration Number	Proximity to Dam	SWL (mBGL)	Screen Details	Description
86117	~3.7 km NE	6.1	Perforated 15.2-23m	Granite 3-18.3m
86216	~2.4 km SE	4	Perforated 13-18.3m	Granite 3-18.3m
86097	~4.5 km SE	8	Perforated 12.2-18.3m	Granite 0.2-18.3m
86100	~4.5 km SE	4	Perforated 9.2-15.2m	Granite 0.5-15.2m
86218	~3.7 km SE	10	Perforated 28-34m	Granite 1-34m
86279	~2.6 km SE	2	Open 5-12m	Sand 0-3m Granite 3-12m
86379	~2.6 km SE	2.2	Open 7-13m	Sand 0-3m Granite 3-13m
61929	~5 km SE	34.24	Open 18.3-91m	Granite 0.6-91m
64739	~5.1 km SSE	1.22	Open 18.3-82.3m	Sand 0-9.1m Granite 9.1-82.3m
71629	~5.3 km SSE	3.1	Perforated 2-4.7m	Clay/Sand 0.5-3.3m Red rock 3.3-9.8m
108199	~5.4 km SSE	10	Open 7-50m	Granite 0-50m

SWL = Standing Water Level

mBGL = meters below ground level

Based on the data presented in **Table 8-6**, groundwater levels vary between 1.22 to 34.24 mBGL. Standing water level variations are likely to be due to differences in topographical elevations of the monitoring areas as well as a result of seasonal and climatic differences due to differences in monitoring dates. These results are generally comparable to groundwater level results obtained as part of geotechnical investigations undertaken by URS (2006).

In the immediate vicinity of the proposed dam, groundwater recharge is likely to be predominantly from rainfall. Groundwater level time series data was, not available, and as a result comparisons with Stanthorpe rainfall data were unable to be determined. In turn, seasonal variations of standing water levels were unable to be assessed.

Following the increase in inundation associated with the proposed dam, there is likely to be a localised rise in standing water levels particularly in zones of structural deformation.

8.2.5.2 Urban Pipeline

Groundwater bores containing available standing water level data within a 2 km radius of the Urban Pipeline are presented in **Table 8-7**. Results shown below have been extracted as part of the facility survey from the DNRW groundwater database and were not verified as part of this study.

- **Table 8-7 Standing Water Levels for the Urban Pipeline**

Registration Number	Proximity to Pipeline	SWL (mBGL)	Screen Details	Description
86117	~ 500m E	6.1	Perforated 15.2-23	Granite 3-18.3m
86150	1.3 km NW	3.5	Perforated 5-10m	Granite 4-10m
86216	750 m SE	4	Perforated 13-18.3m	Granite 3-18.3m
86279	1 km SE	2	Open 5-12m	Sand 0-3m Granite 3-12m
86379	1 km SE	2.2	Open 7-13m	Sand 0-3m Granite 3-13m
86401	~200m W	5	Perforated 3-8m	Granite 0-11m
86461	~1.5km E	4	Open 5-21m	Granite 0-9m
80073	~580m W	5	Perforated 7.5-14.6m	Granite 3-8.1m
38962	~1.3 km E	Surface	Concrete 0-3m	Sand and Gravel 0-3m

SWL = Standing Water Level

mBGL = meters below ground level

Standing water levels near the Urban Pipeline vary from the surface to 6.1 mBGL. Contrasts between standing water levels are likely to be due to differences in topographical elevations of monitoring parts as well as a result of seasonal and climatic differences due to differences in monitoring dates. Following the installation of the urban pipeline, it is unlikely that any changes to the standing water levels within the vicinity of the Project will occur.

8.2.5.3 Irrigation Pipeline

Available standing water level data within an 800m radius of the Irrigation Pipeline are presented in **Table 8-8**. Data was obtained from bores identified within the DNRW groundwater database and were not verified as part of this study.

Table 8-8 Standing Water Levels for the Irrigation Pipeline

Registration Number	Proximity to Pipeline	SWL (mBGL)	Screen Details	Description
86216	~50 m E	4	Perforated 13-18.3m	Granite 3-18.3m
86379	~50 m E	2.2	Open 7-13m	Sand 0-3m Granite 3-13m
86279	~50 m E	2	Open 5-12m	Sand 0-3m Granite 3-12m
80801	~400 m W	1	Perforated 3-35m	Granite 0-35m
86097	~100 m S	8	Perforated 12.2-18.3m	Granite 0.2-18.3m
86100	~100 m S	4	Perforated 9.2-15.2m	Granite 0.5-15.2m
86115	~100m E	5	Perforated 9.1-15.2	Granite 1-22.9m
86150	~30 m E	3.5	Perforated 5-10m	Granite 4-10m
86179	800 m SE	Surface	Perforated 16.2-21.3m	Sand 0-0.5m Granite 0.5-21.3m
86215	~100 m S	3	Perforated 46-61m	Granite 0.5-61m
86408	~200 m S	11	Open 12-17m	Granite 6-17 m
108105	~300 m E	6	Perforated 9-16m	Granite 5-18m
108106	~300 m E	10	Perforated 12-18m	Granite 5-21m
108107	~300 m E	5	Perforated 6-17m	Granite 5-23m
108108	~300 m E	4	Perforated 9-21m	Granite 1-21m

SWL = Standing Water Level

mBGL = meters below ground level

Standing water levels near the Irrigation Pipeline vary from the surface to 11 mBGL. Variations between standing water levels are likely to be due to differences in topographical elevations of monitoring parts as well as a result of seasonal and climatic differences due to differences in monitoring dates. Following the installation of the Irrigation pipeline, it is unlikely that any changes to the standing water levels within the vicinity of the Project will occur.

8.2.6 Groundwater Dependent Ecosystems

8.2.6.1 Introduction

Groundwater Dependant Ecosystems (GDEs) are ecosystems which have their species composition and natural ecological processes determined by groundwater (ARMCANZ & ANZECC, 1996). Hatton and Evans (1998) defined four functional groups of GDEs including terrestrial vegetation, river baseflow systems, aquifer and cave systems and wetlands. Clifton and Evans (2001) expanded this list to include fauna and estuarine systems dependant upon groundwater discharge.

Groundwater Dependant Ecosystem function (ie. health) is generally defined by four parameters: flux, level, pressure and quality (SKM, 2000; Clifton and Evans, 2001) with dependence potentially being a function of one or all of the above factors. Groundwater dependency can also vary spatially and temporally and is dependent upon whether the system represents a local or regional GDE (Froend and Zencich, 2002).

Water available to ecosystems may include a mix of groundwater with soil water (unsaturated zone) and surface water. The current hydrological regime is likely to differ from the pre-European condition and as a result of these changes, the mix of soil water, surface water and groundwater used by GDEs may have changed over time. In some cases the GDE communities themselves may also have changed or evolved. The hydrological regime and GDE water requirements may also vary seasonally. Therefore water requirements for any identified GDEs must be assessed and may need to be maintained for critical periods through the year.

8.2.6.2 Methodology

The occurrence of GDEs in the vicinity of the inundation area, Urban and Irrigation Pipeline has been determined by reviewing published Environmental Protection Agency (EPA); (2006) Regional Ecosystem (RE) mapping data, standing water level data, soils and geology. REs identified within the Project area are presented as **Table 8-9**.

Table 8-9. Regional Ecosystems units within the vicinity of the dam site.

Regional Ecosystem	Description	Vegetation Management / Biodiversity Status
13.3.1	*Eucalyptus blakelyi* woodland on alluvial plains	Endangered / Endangered
13.12.2	*Eucalyptus andrewsii, E. youmanii* woodland on igneous rocks	Not of concern / No concern at present
13.12.8	*Eucalyptus melliodora* and/or *E. moluccana/ E. microcarpa* and/or *E. conica* woodland on igneous rocks	Endangered / Endangered
13.12.9	*Eucalyptus blakelyi* and/or *E. caliginosa* woodland to open forest on igneous rocks	Endangered / Endangered
13.12.5	*Eucalyptus youmanii* on igneous rocks	Not of concern / No concern at present
13.12.6	Shrubland on igneous rocks	Of concern / Of concern

8.2.6.3 Assessment of GDE Occurrence

Terrestrial vegetation on shallow residual soils underlain by Stanthorpe Adamellite represents the predominant vegetative cover in the Project area. RE mapping suggests that Eucalypt woodlands and open forests dominate uncleared areas, most of which are located within the dam footprint. Where depth to groundwater is less than plant rooting depth terrestrial vegetation may utilise groundwater for environmental water requirements. The degree of groundwater reliance is dependant on a number of ecosystem-specific factors however it should be noted that a rooting depth greater than depth to groundwater is not necessarily a precursor for groundwater dependence.

Based on available data records, depth to groundwater within RE-mapped eucalypt woodland areas in the Project area varies from near-surface to approximately 10 mBGL. Given that groundwater levels are relatively shallow it is possible that terrestrial vegetation communities within the vicinity of the dam may use groundwater to some degree to satisfy plant water requirements. The vegetation species and regional soil/geology types suggest that the level of groundwater dependence is likely to be relatively low and vegetation is likely to be able to satisfy plant water requirements using retained soil moisture.

8.2.6.4 Stream Baseflow and Riparian Vegetation

The predominant RE mapped along the Severn River riparian corridor is 13.3.1. This RE is described as being comprised of *Eucalyptus blakelyi* grassy woodland or open-forest ± *E. conica* ± *E. bridgesiana* ± *E. melliodora* on Cainozoic alluvial plains.

In the vicinity of the inundation area, the Severn River is an ephemeral watercourse which flows only for short periods following relatively heavy rainfall. Analysis of available hydrograph data (DNRW Station 416310A, Farnbro) indicates that baseflow (groundwater discharge to surface water) does not represent a significant proportion of river flow and as such, is unlikely to contribute significantly to environmental water requirements for vegetation within the riparian corridor.

It should be noted that the relatively shallow depth to groundwater in the hyporheic zone of the Severn River may create an opportunity for riparian vegetation to be at least opportunistically dependant upon groundwater for environmental water requirements. In particular, low lying in-stream areas in the vicinity of water table windows where vegetation rooting depth is greater than groundwater depth may provide plants with the opportunity to access groundwater. Within the Project area the occurrence of potentially groundwater dependant riparian GDEs is spatially limited to localised areas of alluvium along the watercourse. Potential riparian GDEs are also likely to be highly modified through previous development and the creation of weirs along the Severn River.

8.3 Impact Identification and Mitigation Measures

A review of dewatering management, groundwater levels, groundwater quality, groundwater users and groundwater dependent ecosystems to determine any associated impacts within the vicinity of the inundation area and the Urban and Irrigation Pipeline presented in this section of the report. Mitigation measures based on the impacts identified have also been included in this section.

8.3.1 Impact Identification

8.3.1.1 Dewatering Management

Whist the construction methodology for the dam wall has yet to be finalised it is possible that excavation works may be required to facilitate the installation of dam wall foundations. If necessary, these works would be likely to intercept alluvium hosted groundwater and dewatering may be required for the duration of the construction phase. Dewatering has the potential to result in groundwater drawdown which in turn has the potential to reduce water availability to groundwater users and potential riparian GDEs. It is understood that any dewaterings will be used on-site during construction-phase works.

It should be noted that there are no registered groundwater users associated with Severn River alluvium in the vicinity of the proposed dam (including the dam wall). The nearest registered users with a groundwater bore constructed in the alluvium is located approximately 2 km southeast of the proposed dam. As such, the potential for any localised dewatering to impact existing groundwater facilities is considered negligible. Impacts to potential GDEs have been considered in **Section 8.3.1.5**. It should be noted that where construction phase dewatering is undertaken all waters will be used on site and no discharge to the surrounding environment will be undertaken.

8.3.1.2 Groundwater Levels

Where water levels within the dam are greater than in the surrounding Stanthorpe Adamellite/Ruby Creek Granite seepage loss from the dam to the surrounding bedrock may potentially occur. In turn, hydraulic losses from the dam to the surrounding bedrock have the potential to result in a localised increase in groundwater levels in the vicinity of the area of inundation.

The magnitude and extent of localised groundwater mounding has been assessed qualitatively from available information. The Stanthorpe Adamellite and Ruby Creek Granite have a low inferred *in situ* permeability indicating that hydraulic loss and resultant groundwater mounding is likely to be relatively negligible and regionally insignificant. Furthermore, the absence of matrix permeability within the bedrock limits potential groundwater movement to fractures, joints and faults. Regional interconnectivity between these structural defects is likely to be limited given the general absence of local and regional deformation. As such, the potential for seepage loss and changes in regional groundwater levels to occur as a result of the proposal is considered negligible.

It should be noted that engineering solutions to downstream seepage losses were proposed by URS (2006). It is understood that these measures will limit hydraulic losses from the dam to downstream alluvium during the operational phase of the Project.

Where trenching is required to facilitate pipeline installation the proposed excavation depths are relatively shallow and are unlikely to intercept groundwater. Impacts on groundwater levels are not anticipated. Leakage from the pipeline during the operational phase will be deliberately minimised (through design) so as to ensure wastage is reduced.

8.3.1.3 Groundwater Quality

In the vicinity of the proposed dam groundwater hosted within alluvial deposits and the Ruby Creek Granite/Stanthorpe Adamellite is typically fresh to brackish. Surface waters stored within the dam will also be of low salinity (potable quality) and as such will be of a comparable raw water quality to surrounding groundwater. As such, where minor seepage from the dam to the surrounding groundwater occurs water quality impacts are not anticipated.

Improper storage and use of chemicals, fuels and waste products during construction and operational phases of the Project have the potential to locally impact upon groundwater quality. Provided these activities are undertaken in an appropriate manner and with respect to relevant guidelines the potential for groundwater impacts to arise from these activities is considered negligible.

8.3.1.4 Groundwater Users

The facility survey undertaken as part of the baseline study indicated that within a 3 km radius of the inundation area only six existing groundwater bores were identified. The general absence of groundwater users in the vicinity of the site.is not surprising given that the hydrogeological setting of the site and surrounds is unlikely to support a groundwater resource of any useable significance. Fourteen groundwater bores identified within a 3 km radius of the proposed Irrigation Pipeline are generally concentrated in the northern and southern sections.

The proposed pipeline is unlikely to have any impact on groundwater users along or near the proposed alignment due to the likely absence of groundwater at the proposed depths of excavation. Furthermore, the pipeline may ultimately reduce existing groundwater usage through the provision of an alternative and more reliable water supply.

Similarly, the proposed dam may provide an opportunity to reduce existing regional groundwater use by providing an alternate local water supply. From a groundwater users perspective water levels and quality are unlikely to be impacted deleteriously by the current proposal (**Section 8.3.1.2** and **8.3.1.3**) and as such existing and future groundwater users in the area are unlikely to be impacted by the current proposal.

8.3.1.5 Groundwater Dependant Ecosystems

Under the current proposal all vegetation within the area of inundation (regardless of its potential level of groundwater dependence) will be resumed to facilitate construction of the Emu Swamp Dam. Groundwater availability to riparian vegetation downstream of the dam wall will likely remain unchanged (due to environmental releases) or increase slightly as a result of minor seepage beneath the dam wall. Water availability to vegetation upstream of the dam (and in the greater catchment) is likely to remain unchanged as a result of the current proposal.

Whilst no GDE-specific site-based assessment has been undertaken as part of this study it is considered that vegetation in the vicinity of the area of inundation is likely to be at most opportunistically dependant upon groundwater. Under the current proposal water availability to any potential GDEs is unlikely to change and as such, impacts are not anticipated.

8.3.1.6 Conclusion

Given the absence of any groundwater resource of significance within the vicinity of the supply dam and pipeline the potential for groundwater impacts to arise as a result of the proposal is considered low. There is also a general absence of groundwater impacts and groundwater-related sensitive receptors associated with the current proposal and as such, no mitigation measures were considered necessary beyond a need to monitor changes in regional groundwater levels and quality prior to and during the first 12 months of operational phase works.

8.3.2 Mitigation Measures

It is recommended that a network of observation bores be installed in the vicinity of the dam to monitor changes in groundwater level and quality 12 months prior to development and during the first 12 months of operational phase works. Groundwater level monitoring should be undertaken on at least a quarterly basis with levels referenced to both AHD and ground level. Groundwater quality monitoring should be undertaken on at least a quarterly basis for pH, conductivity, dissolved oxygen, REDOX potential and temperature. Since groundwater level monitoring may be required as part of the geotechnical program it is recommended that site selection be undertaken primarily to satisfy geotechnical requirements and used as dual-purpose groundwater level and quality observation locations where possible. Drilling and construction required for the installation of groundwater monitoring bores should be undertaken in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (ARMCANZ 2003). Bores installed to a depth of greater than 6 mBGL should be registered with DNRW in accordance with the *Water Act 2000*.

8.4 Conclusions

Assessment of existing data indicates that there is likely to be no regional groundwater resource of significance within the vicinity of the Project area. The Stanthorpe Adamellite's dominate the local geological setting in which available data and geotechnical investigations indicate low to moderate permeability. Assessment of facility survey data indicates the presence of low to very low yields of groundwater within the area.

An assessment of the potential for environmental impacts on groundwater as a result from the Emu Swamp Dam and the Urban and Irrigation Pipeline development has been considered. A review of impacts indicates that a localised increase in groundwater levels may potentially occur within the immediate vicinity of the Emu Swamp Dam however given the quality of stored surface waters, the absence of local or regional sensitive receptors and the absence of a groundwater resource impacts are not anticipated.

Whilst mitigation measures for groundwater are not specifically considered necessary a series of observation points for groundwater monitoring within the vicinity of the Project area should be installed and monitored for the construction and operation of the Project as a due diligence measure.