WALLBRIDGE & GILBERT
Consulting Engineers

LAURA STORMWATER MANAGEMENT PLAN

Prepared For

Northern Areas Council

JOB NO: C090271

July 2010

Document History and Status

Revision	Date	Comment	Signatures		
			Originated by	Checked by	Authorised by
A	11.11.09	For Comment	EH	NS	NS
B	02.12.09	Final	EH	NS	NS
C	16.12.09	Approval	EH	NS	NS
D	22.07.10	NRM Approval	EH	NS	NS

1 INTRODUCTION

Laura is a small mid north town located on the eastern slopes of the southern Flinders Ranges, approximately 230 km north of Adelaide. There have been recognised and ongoing flooding issues in the township of Laura in recent years.

Wallbridge & Gilbert (W&G) were engaged by the Northern Areas Council to investigate the current flooding issues and devise options for mitigation. In addition we have also undertaken an Integrated Water Reuse Strategy for the township for wastewater and stormwater treatment and reuse. This has demonstrated there is potential to harvest stormwater and blend it with treated wastewater for non-potable municipal reuse applications within the township of Laura.

With average annual rainfall of approximately 400mm water is a valuable resource that should be utilised to its maximum potential. Should the measures outlined in this report be implemented then it will minimise reliance on mains water for non potable uses, decreases stormwater discharge to the adjacent Rocky River, and minimise the impact of stormwater flows of residential and commercial properties within the township of Laura.

2 CATCHMENT AREA

Laura is surrounded by watercourses to the north (Pine Creek), east and west (Rocky River). Existing levees have previously been built up around the town to the northeast and southeast for flood mitigation and appears to be at sufficient heights to prevent flooding from these watercourses for all but extreme events. These watercourses represent the township centre boundaries with Tom Cat Hill Rd representing the southern boundary. Refer tho the catchment plan in Appendix A.

The stormwater catchment consists of the township of Laura itself, with flows upstream being intercepted by the watercourses to the north and east. The site topography of Laura falls from north to south at approximately 0.3% average grade. Stormwater discharges to the Rocky River at the southern end of the township without any form of treatment.

Aerial photography was used to determine the amount of pervious and impervious areas of the catchment in addition to existing land use and current zoning. This information supplemented data collected and observations made during a site inspection.

The catchment comprises an urban catchment of 90ha and a rural catchment of 13ha, hence a total of 103ha. Typically urban blocks are low density with 15-20% directly connected paving. This was used for stormwater runoff for flooding and harvesting modelling.

Future development of allotments north of Victoria Street, including those within West Terrace have been included in the catchment areas.

3 EXISTING STORMWATER ASSETS

Discussions held with Council staff have revealed there is limited stormwater infrastructure within the township. Most stormwater is conveyed by roadside swales (some lined but the majority earth), some kerbing with only a small number of pipes and culverts locally draining intersections. All of these assets are owned by Council.

A field inspection was undertaken to determine and confirm the location, sizes and condition of existing stormwater infrastructure. All stormwater infrastructure inspected is in a serviceable condition.

A summary of infrastructure and sizing is shown below:

Pipes	Length
225mm dia concrete	56m

Concrete Box Culverts (RCBC)	Length
1200mm wide x 900mm high	16m
400mm wide x 200mm high	10m
600mm wide x 250mm high	11m

4 PROBLEMS AND OPPORTUNITIES

In 2007 a Stormwater Drainage Investigation was undertaken by GHD consultants, which reviewed potential flood mitigation measures. In 2008 Wallbridge & Gilbert (W&G) undertook a Stormwater Harvesting and Reuse Option study. In August 2009, Wallbridge & Gilbert (W&G) combined these studies and developed them further to produce an integrated water reuse and flood mitigation strategy. The plan is to implement the strategy, which can be constructed in a number of stages in the coming years.

The Northern Areas Council recognises the issue of climate change is foremost in the mind of the communities, and all levels of Government in Australia. The onset of climate change places uncertainty in the future rainfall patterns and therefore surface water supplies. With the prospect of reducing and/or unusual rainfall, the Northern Areas Council has a desire to improve water security and minimise reliance on potable mains water.

4.1 Problems

Council identified the major issues occurring along the two major drainage flow paths through town, namely Herbert Street and West Terrace, which convey flows north to south following the lie of the land. The main issues highlighted were:

1. Ponding at intersections (especially where swales are unlined).
2. Flooding of the local shop on the south-east corner of Herbert Street and Samuel Street providing economic loss to owners and lack of amenity to residents.
3. Standing water after a minor storm, which takes significant time to drain and/or soak away, due to flat grades and roughness of the roadside swales.
4. Large flow widths along these two main roads (especially the commercial hub Herbert Street) preventing public access to and from vehicles to shop fronts difficult during storm events.
5. Future flows from north of Victoria Street, exacerbating current conditions.
6. Ongoing maintenance of unlined roadside swales required after storm events (scouring).

Hydraulic modelling was undertaken in DRAINS to review capacities of existing overland flow paths and consider potential mitigation designs, including below-ground drains, detention basins and formalised overland flow paths.

Although not highlighted by Council, the outfalls are generally by overland flow to the Rocky River which employs no formal pollution control for gross pollutants, silts or oils.

A stormwater drainage assessment carried out by GHD (2007) was utilised as a guide in developing the location of the collection and conveyance stormwater infrastructure, and as a cross-check against flows calculated by modelling undertaken in this study.

A site survey was undertaken by Allsurv in July 2006. The survey recorded road cross-sections, allotment boundaries, road levels and any existing infrastructure. A meeting with Council and a site inspection were undertaken on the 25th June 2009. The site was reviewed to determine if any works had been undertaken since 2006 to ensure most up to date information was used in the determination of solutions. Local climatic data was utilised for the modelling component of the investigation.

4.2 Modelling Outcomes

The model reviewed drainage conditions along the main drainage routes. The two main drainage networks can be divided into east and west, the eastern catchment draining into Herbert Street and the western catchment into West Terrace. Some smaller branch catchments were also modelled where particular drainage issues had been noted or below ground drainage has been constructed. A summary of findings is provided in Table 1 (reference map Figure 1).

Table 1. Overland flow path capacities (Herbert Street and West Terrace)

EXISTING DESIGN CAPACITY SUMMARY				
	WEST TERRACE		**HERBERT STREET**	
	West	East	West	East
North Tce -Bristow St	5 year ARI	< 5 Year ARI	100 year ARI	5 year ARI
Bristow St -Hughes St	5 year ARI	< 5 Year ARI	100 year ARI	5 year ARI
Hughes St - Whyte St	5 year ARI	< 5 Year ARI	100 year ARI	5 year ARI
Whyte St - South Tce	5 year ARI	< 5 Year ARI	100 year ARI	5 year ARI

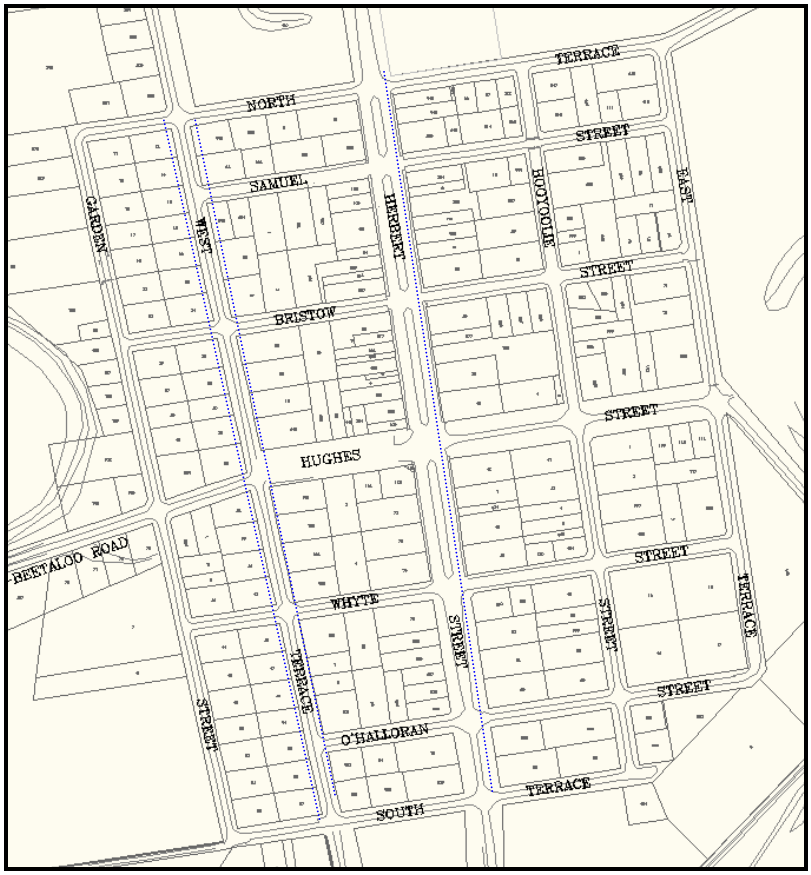

Figure 1. Town Overview –Reference Map

Review of existing overland flow paths found minor flows (5 year ARI) are conveyed effectively along both east and west road reserves of Herbert Street. The flow width does however extend beyond the constructed concrete spoon-drain. Minor flows are conveyed in the road reserve along the western-side of West Terrace. The eastern side of West Terrace, however, cannot convey the 5 year ARI flow within the road reserve therefore this is a critical location for redesign.

100 year ARI major flows are contained within the drainage channel for the length of the western side of Herbert Street. Along the length of the eastern side, capacity is exceeded and the flows will have the potential to breach into property boundaries. The 100 year ARI flow is not contained within the road reserve for the length of West Terrace both east and west side placing abutting properties at risk of flooding.

4.3 Opportunities

Council have highlighted the importance of integrating stormwater harvesting into the potential upgrades to the system. There is increasing development of water harvesting technologies at

present, as availability of water becomes an increasing issue to society, as such there are a number of options for stormwater harvesting.

Key flood mitigation design will involve reducing flows along Herbert Street (particularly along the commercial strip), eliminating large ponding events along Hughes Street and improving the drainage paths down West Terrace. The overall aim will be to reduce nuisance flows and provide safe overland routes for major storm flows across the town. It is proposed a combination of upgrading overland flow paths, new detention ponds and swales and below-ground drainage networks should be able to achieve the above.

The aim of the design was to limit the drainage infrastructure required, understanding the drainage philosophy and budgetary constraints of regional townships. The design ultimately aims to upgrade West Terrace drainage such that it can convey the major 100 year ARI flow for the majority of the town's catchment without inundation of properties, potentially causing economic loss. This could by undertaken by diverting most of the existing upstream flows to West Terrace rather than Herbert Street. West Terrace has been chosen as opposed to Herbert Street for the major drainage route for two main reasons:

1) There is minimal formal drainage currently therefore upgrade work is highly advisable
2) Flows will be diverted away from the commercial centre of town (reducing public nuisance) and reducing Herbert Street flows will allow the existing concrete spoon-drains to function as designed.

Below ground drainage along West Terrace (between Hughes Street and North Terrace) could be designed to a 5 year ARI capacity to remove nuisance flows. Major flows will still be conveyed overland however the volume will be reduced to safe flow rates by the addition of below ground drains and spray-sealing all major flow channels to improve the conveyance of these flows.

To reduce ponding at the Hugh Street/West Terrace and Hugh Street/Herbert Street intersections the design of a large stormwater drain beneath Hughes Street to divert major flows to the Rocky River is recommended. This would also reduce flows downstream of Hughes Street, controlling downstream flow widths and flow volumes in the road reserve. Reduced flows will continue to drain south to the reserve on South Terrace. These flows would collect and infiltrate into the reserve. Ultimately it would form the basis of the stormwater treatment and harvest systems such as bio-filtration and storage.

Integration of detention basins to the north of the town have also been considered to control minor flows and reduce the impact of major flows. Two sites have been considered for detention, the Council reserve and Caravan Park reserve.

Council Reserve: It is understood that the primary purpose of the Council reserve is for amenity and recreation for public and the site currently has a playground and picnic area and rose garden. The integration of detention would be designed with minimal impact on these features. It is envisaged the detention would occur within an oversized drainage swale which would meander across the reserve (avoiding any existing features). The swale would be unobtrusive to current park amenity and would provide a safe overflow path diverting flows away from the playground, residential properties on North Terrace and overflows to the town centre (Herbert Street). The swale would collect flows north of the reserve from Main North Road.

A breakout zone for major flows could also be integrated that would spill over in infrequent major flows into the open grass space. This would require only minor regrading to sink the open lawn approximately 250mm below surrounding road levels. This area would vary rarely be inundated.

The catchment to this system is the upstream, predominantly residential, land draining south along the western roadside swale of Main North Road, see catchment plan Appendix A.

Caravan Park Reserve: It is proposed that a detention facility be constructed in the Council reserve space adjacent the Caravan Park. This detention would capture flows from the currently expanding residential development to the north of Victoria Street and diversion via 375mm diameter from Main North Road. This detention pond may include additional storage capacity for holding stormwater prior to treatment for harvest.

4.4 Stormwater Treatment Options

Water quality will be important for two reason, treated stormwater harvest potential, and water quality discharged to the Rocky River.

As the proposed infrastructure will discharge stormwater flow directly to the Rocky River, an end of line gross pollutant trap (GPT) will be installed to remove a large percentage of the pollutants prior to discharging to the river. Upstream installation of vegetated swales and biofiltration zones will also improve the quality of water travelling through the system. It is important that the natural river ecosystem is maintained.

Treatment of water for harvesting and reuse will require additional treatment processes, two treatment measures have been considered, wetlands and biofiltration, as detailed below. Stormwater can contain chemicals and pathogens collected in passage over road, properties and drains and as such treatment is required to meet a suitable standard for non-potable reuse. While no official regulations exist nationally for treatment for reuse, a number of guidelines have been published. The design of the stormwater reuse treatment components have been based on the 'Australian Guidelines For Water Recycling: Managing Health and Environmental Risk (Phase 2)- Stormwater Harvesting and Reuse'. The Department of Health do not currently regulate

stormwater reuse however, it is likely in future this will be regulated with this document forming the basis of the regulation. Typically biofiltration zones can treat stormwater at a rate 10 times that of a wetland, this has been considered in the sizing of the respective facility.

Stormwater wetlands are constructed capture ponds that incorporate wetland plants in a shallow pool. Treatment occurs as stormwater runs through the wetland. Pollutant removal is achieved by settling and biological uptake. They are among the most effective stormwater pollutant removal techniques, and also offer aesthetic value. While the obvious benefit of a wetland is visual, it provides ecological habitat and potential to store water. The climatic conditions in the mid-north region with high evaporation and low rainfall are not favourable for wetlands and may deem them inefficient.

Bio-filtration involves the retention of stormwater with suitable vegetation. The system is designed to carry out primary and/or secondary treatment processes of stormwater and retard flows. This retention or retardation enables sediments to precipitate out of the water along with some pollutants. The treated water can then be injected into the aquifer or pumped to surface storage. Bio-filtration can commence with a small footprint and can be developed progressively dependant upon funding and/or rate of development. A key benefit of bio-filtration is reduced evaporation losses occur; however there is limited potential to store water within the biolfiltration zone. Thus, balance storage may be required pre and post treatment.

4.5 Storage Options

Storage of treated water can be within surface storages or potentially in the underlying aquifer.

Surface Storage: Surface storage will require suitably graded available open space which for safety will need to be fenced off from the public. The disadvantage of surface storage is that high evaporation rates in the area (approximately 1800mm/m2/pa) will create significant losses.

The other surface storage option is the use of storage tanks. This option provides a closed system and as such reduces evaporation loses however, it can be a costly measure and potentially be visually invasive.

Aquifer Storage Recovery (ASR): Injecting treated water into the underlying aquifer may provide a large storage facility. Injection into the aquifer is subject to bore injection rates and to maintain environmental balance the maximum extraction rate from an aquifer is 80% of injection.

A preliminary desktop study has been undertaken by AGT to assess the potential for ASR. In summary the finding suggest that it is unlikely a large scale (30-40ML/an) ASR scheme would be viable in the town. This is due to geological conditions in the area and the expected low injection

rates achievable, of order 2-3L/s. Due to the large number of bores required, this option is considered cost prohibitive in comparison to surface storage. Refer to Appendix B for AGT Report.

4.6 Stormwater Harvest Options

Based on the options for treatment and storage outlined in Sections 4.4 and 4.5 the preferred method of treatment would be biofiltration, due to the reduced land space required and the lower evaporation losses. Results of a desktop study found ASR potential limited and uneconomical.

South Terrace Reserve: A stormwater harvest site could be established in the open reserve on South Terrace. The site has been chosen due to its location at the downstream end of the town catchment, large available open space, and its location upstream of the river therefore providing a safe overflow path. The concept would be to design a large treatment storage system to capture the minor flows from the greater Laura catchment. The area consists of approximately 3.5ha of open space therefore there is sufficient space for a treatment wetland or bio-filtration zone and surface storage.

In light of the preferred storage option it is recommended that biofiltration be considered a more appropriate treatment method for the site. There will be significant evaporation losses in the storage pond, therefore introducing further losses within the large open water body of the wetland would be counter productive. Additionally the surface storage will occupy a large area of the reserve therefore utilising bio-filtration as the method of treatment will allow the site to maintain some open space.

Preliminary harvest figures have been calculated based on desktop water balance calculations. A summary of findings is shown in Section 4.8.

Caravan Park Reserve: An option for the Caravan Park reserve involves a combined detention retention system that will aim to slow minor flows and where possible treat and store runoff for reuse. It will also detain some major flows, therefore providing flood mitigation and reuse potential. The system will have a detention basin for flood mitigation with an additional surface storage component which could hold water prior to treatment via bio-filtration.

The site is approximately 2.3ha of open space therefore there is sufficient space for detention and a treatment bio-filtration zone. The preferred method of treatment and storage will need to be determined at detailed design, however preliminary harvest figures have been calculated based on a desktop study of a bio-filtration zone with pre and post treatment storage are outlined in Section 4.5.

4.7 Preliminary Stormwater Harvest Figures

Preliminary harvest figures have been calculated based on a desktop water balance model. It is understood that the expected annual reuse demand for Laura is 43.4ML/pa as outlined in Table 2.

Table 2. Predicted Irrigation Demand

Supply sites (prioritised)	Annual volume supply requirement (ML/a)
1. Town Oval	14
2. Caravan Park	10.5
3. Park Land	10.5
4. School grounds	4.2
5. Street median strip	4.2
Total	43.4

Preliminary figures suggest that the proposed CWMS Waste Water Treatment will supply up to 15ML/a of irrigation water when complete. Based on this the aim will be for stormwater harvesting to top up the shortfall of 25-30ML/a.

Preliminary figures considering the surface storage are outlined in Table 3 below. The desktop ASR review found that large scale ASR schemes would not viable.

A wetland has been assumed in the South Terrace reserve as space permits and evaporation losses can be reasonably quantified to give a good representation of the potential losses, and therefore potential available supply. The caravan park has a bio-filtration zone assumed with upstream storage of 0.75ML assumed (in combined detention) and 1ML downstream to balance treatment rate and reuse.

There are a number of variables that need to be confirmed at detailed design stage but the figures below are a good representation of potential supply figures.

Table 3. Preliminary Supply Figures (Surface Storage)

		Surface Storage (ML)	Potential Annual Supply (ML/a)
South Terrace	1ha biofiltration	10ML	16ML
	2m deep surface storage	25ML*	30ML
Caravan Park	Bio-filtration treatment 2m deep surface storage Pre-storage in detention	1ML *(+0.75ML pre-storage)*	2ML

**Subject to available space to achieve 25ML surface storage*

5 STORMWATER MANAGEMENT OBJECTIVES AND OUTCOMES

Work undertaken to date has identified current issues relating to stormwater flows, volumes and quality. There is a range of potential opportunities available to Council which have bee indentified in section 4 of this report. These include:

- Flood mitigation via construction of detention basins, lined swales and an underground drainage system.
- Treatment via biofiltation systems and a pollutant trap at outfall location/s
- Reuse of treated stormwater via detention basins, pump station and rising main system serving Council reserves, ovals and potentially the Caravan Park.

The goals set by Council for Laura are:

- To ensure 5yr ARI flows are contained within an underground pipe for key streets of West Terrace and Herbert Streets.
- 5 year ARI flows are within manageable widths to avoid disruption to cars and pedestrian traffic.
- 100 year ARI flows are wholly contained within the underground pipe and road reserves to avoid inundation of all properties within the township.
- Maximise reuse of stormwater via construction of treatment systems, surface storage, pump station and rising main for non potable uses including the town oval, primary school grounds, caravan park, median landscaping in Herbert Street and other Council reserves. This represents an area of approximately 9 ha.
- Minimise pollutants entering receiving waters via a combination of constructing a gross pollutant trap at river outfalls, bio-retention pits and swales. Outfalls will only occur when water storages and bio-retention systems are at full capacity minimising frequency and volumes of discharge.
- Improving amenity of the township by providing visible outcomes including green playing and recreational fields, improved amenity at school grounds and median landscaping in the main street providing visual appeal.
- Attracting greater investment and population to the township by encouraging land development north of Victoria Street. The reserve on Victoria Street will form part of the bio-filtration and surface storage of the scheme and will act to provide an appealing entry to the new precinct.

As part of most new infrastructure projects, some maintenance will be required for this system although not extensive.

Maintenance of the system would include the following:

- Periodic checking/cleaning of stormwater pits for excessive silt build-up or leaf litter collection.
- Emptying of the proposed GPT outlet at Rocky River, generally at three (3) monthly intervals.
- Periodic mechanical sweeping of sealed roadside swales/shoulder if silt build-up occurs.

Bio-filtration swales and basins generally do not require excessive maintenance; however some maintenance is required as follows:

- Removal of noxious plants/weeds; re-establishment of plants that die and fertilising of plants on a regular basis.
- Sediment removal periodically once noticeable.
- Repair of any scour that may occur at entry locations.
- Removal of litter once noticeable.
- Replacement of filter material at 10-15 years if consolidation occurs whereby vertical flow rates have deteriorated considerably.
- Flushing of flushing points to clear any build-up of debris in collection pipes.

Detention Ponds will require regular slashing/mowing, removal of litter and ensuring entry and exits points are not obstructed.

Pump Station and Rising Main - The pump station will require an quarterly scheduled maintenance check to ensure it is capable of working effectively when required. Periodically replacement of sacrificial or worn parts will be required on occasions.

6 STRATEGIES, PRIORITIES AND COSTS

W&G have undertaken studies to confirm existing stormwater conditions and provide recommendations to Council to mitigate stormwater flooding issues. In conjunction with this we have identified a stormwater collection, treatment and reuse system that will improve amenity of the township and minimise stormwater discharge to Rocky River.

Due to the cost of implementing a system as whole the proposed works have been packaged into 5 stages of similar cost. The overall strategy is to minimise flooding issues within the township and improve the quality of discharge to Rocky River as priority. Following this, the capture and treatment of stormwater with some reuse is considered the next priority. Following this the recycled water distribution main, pump station and storage tank are required to complete the system. The later stage will be incorporated with the CWMS treated effluent distribution network.

Table 4 is included in Appendix A, showing work priorities and costs for the catchment. These are explained in more detail below. Figures 1 to 6 inclusive within Appendix A, show the overall concept staging plans.

The stages in order of priority are as follows:

Stage 1 – Hughes Street Trunk Drain and West Terrace Upgrade

Construction of Hughes St trunk stormwater drain from Herbert St junction to the outfall at Rocky River just north of the Laura-Beetaloo Rd bridge. The outlet would incorporate a gross pollutant trap (GPT) to capture solids, suspended solids, silts oil and grease. Grated outlets would be installed at the Herbert Street, West Terrace and Garden Street junctions.

Along West Terrace, roadside swales would be formalised and re constructed with spray seal surfacing to improve conveyance of stormwater and prevent ponding.

A new stormwater pipe system would also be constructed along West Terrace, from Whyte Street southwards. At Whyte Street junction, previous significant ponding has occurred. Stormwater would be collected from swales in West Terrace. Construction of a stormwater system in South Terrace at the junction of Herbert Street will collect stormwater from existing spoon drains to convey stormwater flows to the South Terrace reserve. Local grading of the reserve will allow free drainage and allow infiltration.

The estimated capital cost of this scheme is $510,000. All estimates provided are excluding GST.

Recurrent and maintenance costs are estimated as $12,000 per annum. This would include cleaning of GPT outlet at Rocky River, generally at three (3) monthly intervals, periodic

checking/cleaning of stormwater pits for excessive silt build-up or leaf litter collection, periodic mechanical sweeping of sealed roadside swales/shoulder if silt build-up occurs and mowing/slashing of grass, silt removal and pollutant removal at reserve outfalls.

Stage 2 – Extension of Underground Drainage

The extension of underground drainage in West Terrace to an ARI of 5 years will prevent nuisance flow and reduce major flow widths. Extending the network east along North Terrace to Herbert Street will capture water that previously flowed into Herbert Street. This will aim to divert upstream flows into the upgraded West Terrace drainage network and away from the town centre. Reconstruction and spray seal across the roadside swales will direct larger flows away from Herbert Street.

The estimated capital cost for this stage is $400,000.

Recurrent and maintenance costs are estimated as $2,500 per annum. This would include periodic checking/cleaning of stormwater pits for excessive silt build-up or leaf litter collection, and periodic mechanical sweeping of sealed roadside swales/shoulder if silt build-up occurs (extended area from Stage 1).

Stage 3 – Detention Ponds

Detention ponds are proposed at the north end of the town which will retard stormwater flows in minor events to reduce nuisance flows, flow widths and overland flow volumes in major events. Potential sites for detention are the Council Reserve and the Caravan Park.

The Council reserve detention would be a meandering channel through the reserve which would provide a safe overland flow path with restricted outlet detention in larger storms. A higher level inundation zone would provide additional detention for larger storms. The passive design and infrequent inundation would mean the system would not impact the everyday amenity of the reserve. The inundation zone would require only minimal earthworks to sink the open lawn space 200-300mm below existing levels.

A combined detention and retention system is proposed for the Caravan Park. A 1500m^2 detention basin would control upstream flows from the residential catchment under construction directly north and capture minor flows from Main North Road (northern continuation of Herbert Street). An additional storage component for balancing storage prior to treatment will allow the integration of stormwater harvesting. It is proposed that a small bio-filtration system could be designed to treat the stormwater. Storage would be surface storage prior to use in the Caravan Park as part of the integrated reuse network.

The estimated capital cost of this stage is $250,000.

Recurrent maintenance for pipework includes periodic checking/cleaning of stormwater pits for excessive silt build-up or leaf litter collection.

Biofiltration swales and basins generally do not require excessive maintenance; however some maintenance is required including: removal of noxious plants/weeds; re-establishment of dead plants; fertilising of plants on a regular basis; sediment removal periodically once noticeable; repair of any scour that may occur at entry locations; removal of litter once noticeable; replacement of filter material at 10-15 years if consolidation of filter material occurs and flushing of flushing points to clear any build-up of debris in collection pipes.

Detention Ponds will require regular slashing/mowing, removal of litter and ensuring entry and exits points are not obstructed.

The estimated annual maintenance cost is estimated at $10,000.

Stage 4 – Integration of Stormwater Harvesting

Integration of stormwater harvesting by conveying minor flows to the large open reserve on South Terrace for treatment and storage. The treated water would be linked to the integrated reuse supply for the town which includes treated effluent for reuse.

To utilise runoff from the greater catchment, capturing runoff discharging to Rocky River has been considered. As only minor flows from the Rocky River trunk drain are required it is proposed that an orifice controlled diversion pipe be installed to allow minor flows to drain to South Terrace.

Treatment of runoff would be by biofiltration. Surface storage is shown which will require suitable open space.

The estimated capital cost of this scheme is $400,000.

Recurrent maintenance for pipework, maintenance of biofiltration treatment and surface storage is estimated at $12,500 per annum.

Stage 5 – Integration with CWMS Reuse Scheme and Distribution Network

Treated stormwater will be distributed to a number of demand sites around the town by a distribution main along the eastern boundary of the town. This network will be integrated with the CWMS treated effluent at a combined storage tank next to the sports oval.

The estimated capital cost of this stage is $150,000 plus GST.

Recurrent maintenance costs for the pump station and rising main is estimated at $5,000 per annum.

7 TIMEFRAMES AND FUNDING ARRANGEMENTS

The proposed mitigation measures have been broken down into five (5) stages which aim to primarily relieve the major flows from the centre of town and then progressively improve flow conveyance across the town and integrate stormwater harvesting potential. It is understood that this is a regional township and as such infrastructure funding and design will not be equivalent to that of densely populated, urban areas. The staging aims to provide Council with a number of affordable packages of construction that can be undertaken separately and in stages with the aim of achieving the ultimate design when funding is secured. While the primary aim will be flood mitigation, this will be designed with respect for future integration of stormwater harvesting.

Figures 1- 6 provide an overview and detail of the four proposed construction stages. Preliminary costing estimates have been provided to enable Council to consider the stages inline with current and future budgets.

Available Council expenditure for implementation of this project is approximately $150,000 per annum. Without any reliance upon State or Federal Government funding, the entire project would require approximately 10-15 years to implement.

It is proposed that Council seek some state and federal funding for as much funds as possible for these capital works to reduce overall timeframe for construction.

At a Federal level, under the National Water Security Plan for Cities and Towns the Australian Government has committed $254.8 million through the National Water Security Plan for Cities and Towns to fund practical projects that save water and reduce water losses in cities and towns nationally with populations of less than 50,000. The grant will cover up to 50% funding for schemes over $500,000 for projects that will be part of, or support, the long-term water supply plan for the city or town. Projects funded by this grant must be completed by 30 June 2012.

At State level, the Stormwater Management Authority (SMA) for South Australia manage some funding for flood management. This program may allocate funding to local drainage works in the Adelaide metropolitan area and regional communities where the catchment is greater than 40 ha, for flood mitigation. Parts of Stages 1, 2 and possibly 3 meet the criteria of the stormwater management plan meet the criteria of this funding, the proposed stages to be submitted for funding are outlined in Table 4 and Table 5 below.

Table 4.Components of design meeting funding conditions (ie. >40ha catchment)

Stage	Item	Cost ($)	Subsidy ($)
1	Drainage downstream of West Terrace & Hughes Street Intersection – including river outfall.	160k	80k
2	Drainage downstream of North Terrace & West Terrace Intersection.	160k	80k

Table 5. Component of design with potential subsidy (subject to SMA discretion)

Stage	Item	Cost ($)	Possible Subsidy ($)
3	Detention Basin in Council Reserve	150k	75k

**This component does not meet standard criteria therefore funding would be allocated at discretion of SMA. The component does however benefit downstream flood mitigation measure of the greater catchment.*

Detailed construction phasing will be confirmed to meet Council's available budget on confirmation of funding.

8 COMMUNICATION AND CONSULTATION

Discussions were held with a Council's officers Allen Thompson and Keith Hope. It was confirmed that there is limited stormwater infrastructure within the township most stormwater is conveyed by roadside swales (some lined but the majority earth), with only a small number of pipes and culverts locally draining intersections.

As part of this investigation, a field inspection was undertaken to determine and confirm the location of stormwater infrastructure, drainage issues, potential suitable locations and anything else that could be of interest to this investigation. On site, Council discussed the major issues occurring along the two major drainage flow paths through town, namely Herbert Street and West Terrace, which convey flows north to south following the lie of the land. The main issue was ponding at intersections (especially where swales are unlined), flooding of the shop on the south-east corner of Herbert and Samuel Street, and standing water after minor storms which takes significant time to drain/soak away, due to poor grading and lining of the roadside swales. The issue of large flow widths along these two main roads (especially the commercial hub Herbert Street) is another increasing problem making public access to from vehicles to shop fronts difficult during storm events.

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9 NATURAL RESOURCE MANAGEMENT BOARD COUNSULTATION

The Natural Resource Management Board (NRM) –Northern and Yorke division were consulted as part of the study to ensure that the work is suitable for the region and be aware of any special conditions to be met, in particular when discharging to the Rocky River.

Section 127 (5) (c) of the Natural Resources Management Act 2004 states that a permit is required for draining or discharging directly or indirectly into a watercourse. As the project involves the construction of a new stormwater discharge point to the Rocky River, this policy must be considered.

There are a number of key objective that must be met to satisfy the NRM objectives to ensure stormwater discharging to the Rocky River is suitably treated and of a quality equivalent or better than existing flows, and will not impact on the river ecology.

The objectives of Section 127 (c)(5) that are relevant to this project are:

1. To manage the draining or discharging of water so that:
    (a) any contaminants in the water that is drained or discharged are contained and managed on site to minimise the conveyance of contaminants into watercourses.
    (b) the quality of water drained or discharged into a watercourse or lake is of a quality similar to or better than that of the receiving waters; and
    (c) stormwater collected and conveyed from a catchment to its receiving waters with minimal adverse impact on the watercourse and ecosystems.
2. To ensure that water that is drained or discharged is of a suitable quality to:
    (a) sustain the existing uses of the water; and
    (b) protect ecosystems dependent on these resources.

Key items of the concept design that must be considered and designed appropriately to meet these objectives are:

- Detention Basin-r to manage flow rate, provide sediment control
- Erosion Control – suitably designed at outfall (scour protection, reinstate river bank)
- Stormwater Reuse- design optimum harvesting potential at proposed sites
- GPT/Litter Traps- suitably sized at outfalls
- Treatment of Stormwater- designed to Best Practice Environmental Management Guidelines
- Infrastructure Management Plan – to be in place to ensure maintenance of new infrastructure
- River Bank Reinstatement- any planting replacement to be with indigenous species

Detailed design must ensure that the design of these elements satisfactorily achieves the objectives as outlined in Volume D: Regulatory & Policy Framework of the Northern and Yorke Regional NRM Plan, and Section 127(5) (c). The final designs will be submitted to the NRM for approval based on detail design.

There will also be a requirement for a Water Affecting Activity (WAA) Permit to be obtained prior to construction; this will be approved subject to the above policy. The requirements of the WAA Permit are outlined in Appendix C.

While not the recommended strategy, if an ASR scheme was to be constructed Section 127 (c)(3) of the Act, Draining or Discharging to a Well would need to be considered. The objectives of this section are:

1. The sustainable operation and management of aquifer storage and recovery schemes.
2. Reasonable and practicable measures taken to avoid the discharge of waste to the receiving underground water resource during the draining or discharge of water into a well.
3. Drainage or discharge into a well so as not to cause environmental harm.
4. Drainage or discharge of water directly or indirectly into the aquifer so as not to adversely affect:

    a. the quality of groundwater;

    b. the integrity of the aquifer, including but not limited to the confining layer of the aquifer and the ability of the aquifer to transmit water;

    c. watertables, including but not limited to water logging, land salinisation and damage to infrastructure (roads, buildings, foundations);

    d. any underground water-dependent ecosystem or ecologically sensitive area that depends on the underground water resource; and

    e. the ability of other persons to lawfully take that underground water.

If further investigations into and ASR scheme move forward, detailed design should be in respect to these objectives, and subject to NRM approval.

10 REFERENCES

Australian Groundwater Technologies "Review of ASR potential for Laura Township" August 2009

GHD "Report for Laura Township – Stormwater Drainage Assessment" March 2007

National Water Quality Management Strategy "Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (Phase 2)-Stormwater Harvesting and Reuse" July 2009

Wallbridge & Gilbert "Laura Preliminary Reuse Capacity Assessment Part C: Stormwater Harvesting & Reuse Options" February 2008

Bureau of Meteorology - Climate Data www.bom.gov.au

APPENDIX A

Figures 1-7 and Catchment Work Priorities Spreadsheet

Work priorities for a Catchment **Laura Stormwater Management Plan** **Table 4**

Priority	Project/Activity Title	Capital Cost ($)	Recurrent Cost ($/annum)	Flood Mitigation Benefit		Water Harvesting Benefit		Water Quality Benefit		Other Benefits	
				Measure Used?	Quantification or Description of Benefit	Measure Used?	Quantification or Description of Benefit	Rating	Qualitative Description of Benefit	Rating	Qualitative Description of Benefit
				(D) AAD Reduction (P) Properties Affected (Q) Qualitative		(V) Volumetric (Q) Qualitative		(H) High (M) Med (L) Low		(H) High (M) Med (L) Low	
1	Construct new trunk main in Hughes St outfall to Rocky River and West Terrace underground stormwater system with reconstruction and spray sealing of roadside swales.	$510,000	$12,000	(D) (Q)	Prevent ingress to properties along Hughes St, Herbert St, west Tce and North St by removing ponding and allowing free discharge of stormwater flow. Improved road safety removing surface ponding and improved public access to commercial precinct and private residences.	(Q)	Part of the stormwater system will free outflow to the reserve on South Tce. This will improve amenity of the reserve and allow infiltration.	L H	Reduced ponding therefore less chance of stagnant water occurring. Construction of a gross pollutant trap (GPT) at the Rocky river outlet will decrease solids, suspected solids, oil and grease from entering the waterway.	M	Public safety increased due to reduced ponding on roadways, providing safer driving conditions.
2	Construct additional below- ground drainage in West Tce between Hughes St and North Terrace Tce. Spray- seal roadside swales along North Tce and Herbert St.	$400,000	$2,500	(D) (Q)	Prevent ingress to properties along West Tce and Herbert St by removing surface ponding by improving conveyance by underground drains at suitable grade. Improved road drainage/safety and public access.	N/A	N/A	L	Reduced ponding therefore less chance of stagnant water.	M	Public safety reduced ponding therefore safer driving conditions.
3	Construct detention ponds/swales, surface storage and biofiltration zones with a new underground pit and pipe network for collection and overflow discharge. This work would be constructed between Victoria St, North Tce and West Tce.	$250,000	$10,000	(D)	Will intercept stormwater runoff north of Victoria St preventing overland stormwater flows into the centre of Town. Overflows would be directed to North and West Terraces.	(V)	Stormwater will be harvested from the system and will provide water for the Caravan Park and reserve. Storage capacity available for harvesting is 1ML.	H	Detention swale, harvesting ponds and biofiltration will provide significant improvement to stormwater quality which would have otherwise been untreated	M	Public safety reduced ponding at junctions, therefore safer driving conditions.
4	Integration of stormwater harvesting by diversion of minor flows into the South Tce Reserve for treatment and storage. The treated water would be linked to the integrated reuse supply for the town which includes treated effluent for reuse.	$400,000	$12,500	(AAD)	Prevent ingress to properties along parts of Herbert St and O'Halloran St by construction of sealed roadside swales. This would decrease surface ponding and improve conveyance by construction of underground drains and pits.	(V)	A large scale harvesting site will be constructed in the reserve including a biofiltration treatment area and 10ML surface treated stormwater storage. This will provided short term local harvest potential until stage 5 is implemented.	H L	Biofiltration area and surface storage will provide significant improvement to stormwater quality which would have otherwise been untreated. Reconstruction of roadside swales would reduce ponding therefore less chance of stagnant water.	M	Improved road drainage/safety and public access.
5	Integration with CWMS reuse scheme and distribution network via construction of a rising main along the eastern boundary of the town. The main would serve demand sites in the town including reserves, Herbert Street landscaping, Caravan Park, town oval and primary school oval and landscaping.	$150,000	$5,000	NA		(V)	The benefit of implementing this stage would be the non reliance upon mains water for irrigation use. It will also enable greater amenity of reserve and oval areas for recreation and sporting activities.	NA		NA	

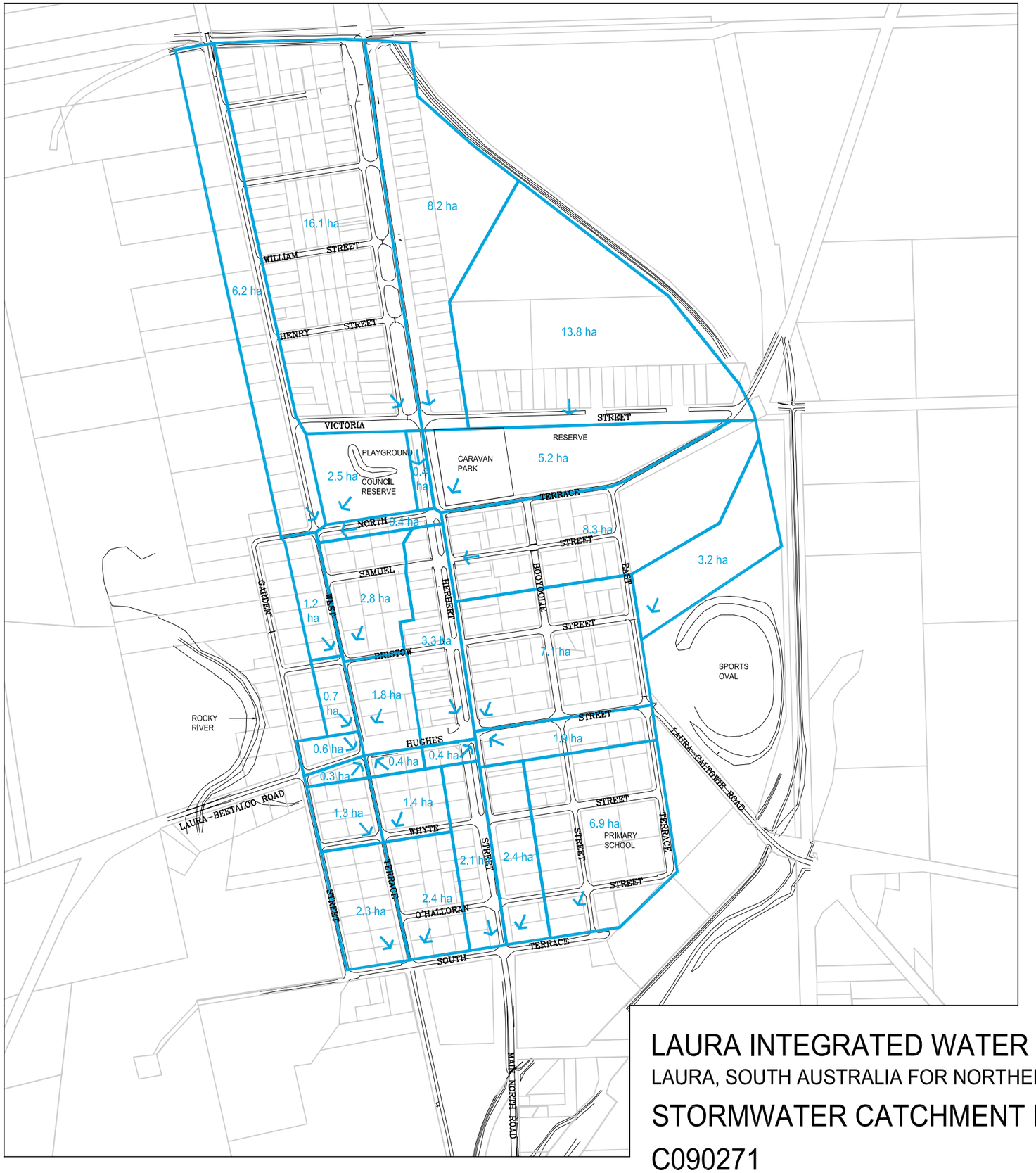
LEGEND

STORMWATER CATCHMENT

EXISTING STORMWATER CATCHMENT AREA BOUNDARY

ha — CATCHMENT AREA IN HECTARES

STORMWATER SURFACE FLOW



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LAURA INTEGRATED WATER REUSE STRATEGY

LAURA, SOUTH AUSTRALIA FOR NORTHERN AREAS COUNCIL

STORMWATER CATCHMENT PLAN

C090271

FIGURE 7

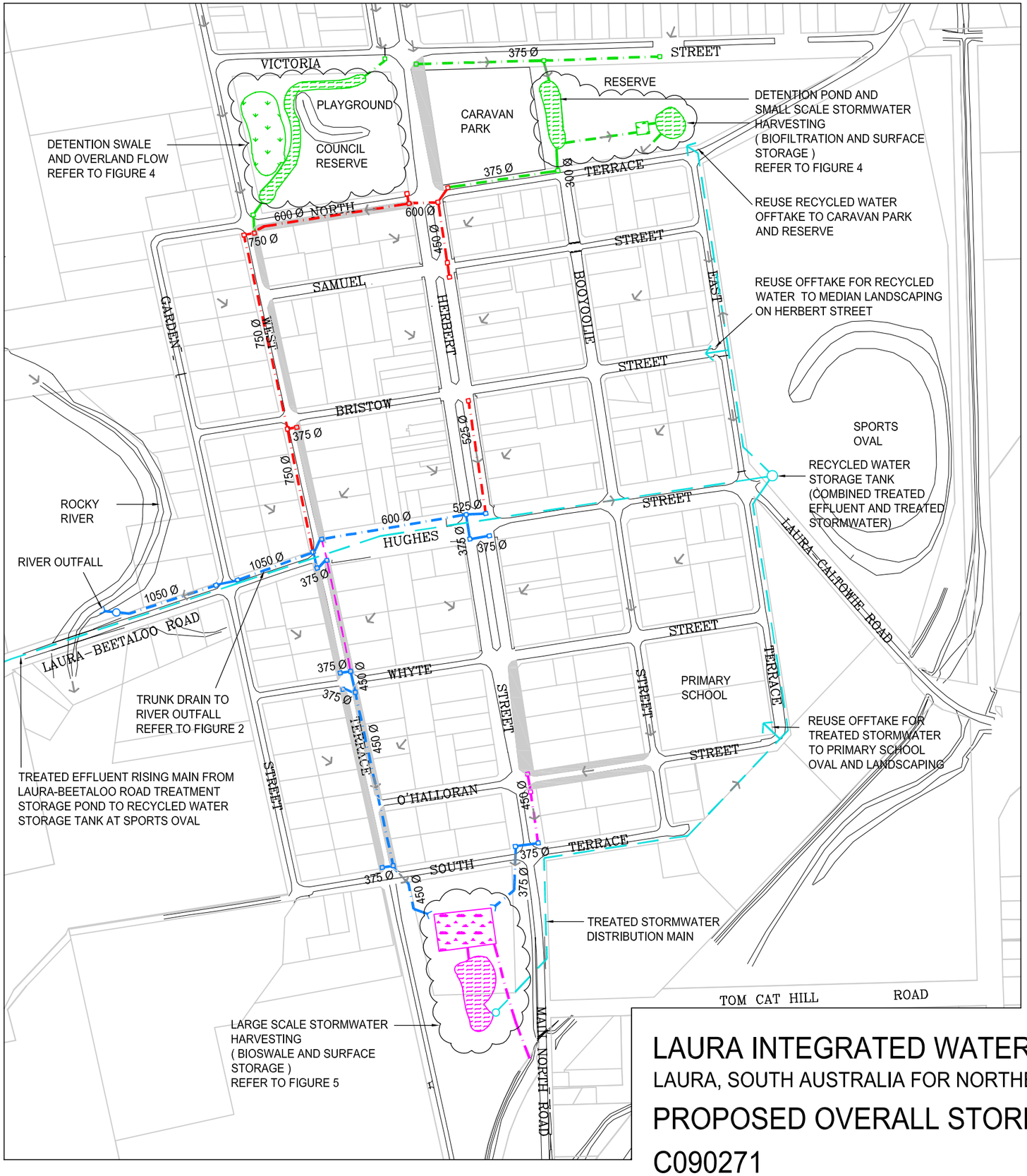
LEGEND

PROPOSED STORMWATER SYSTEM

- PROPOSED PIPE AND PIT
- BIOSWALE
- 1 IN 100 YEAR INUNDATION ZONE
- WATER STORAGE
- SPRAY SEAL AT EDGE OF ROAD
- STAGE 1 SYSTEM - BLUE
- STAGE 2 SYSTEM - RED
- STAGE 3 SYSTEM - GREEN
- STAGE 4 SYSTEM - MAGENTA
- STORMWATER SURFACE FLOW

PROPOSED REUSE SYSTEM

- STAGE 5 SYSTEM - CYAN RECYCLED WATER DISTRIBUTION MAIN (INTEGRATION WITH C.W.M.S. TREATED EFFLUENT AND TREATED STORMWATER DISTRIBUTION NETWORK)



50 25 0 50 100 150 200 250 metres

SCALE 1:5000

W&G

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LAURA INTEGRATED WATER REUSE STRATEGY

LAURA, SOUTH AUSTRALIA FOR NORTHERN AREAS COUNCIL

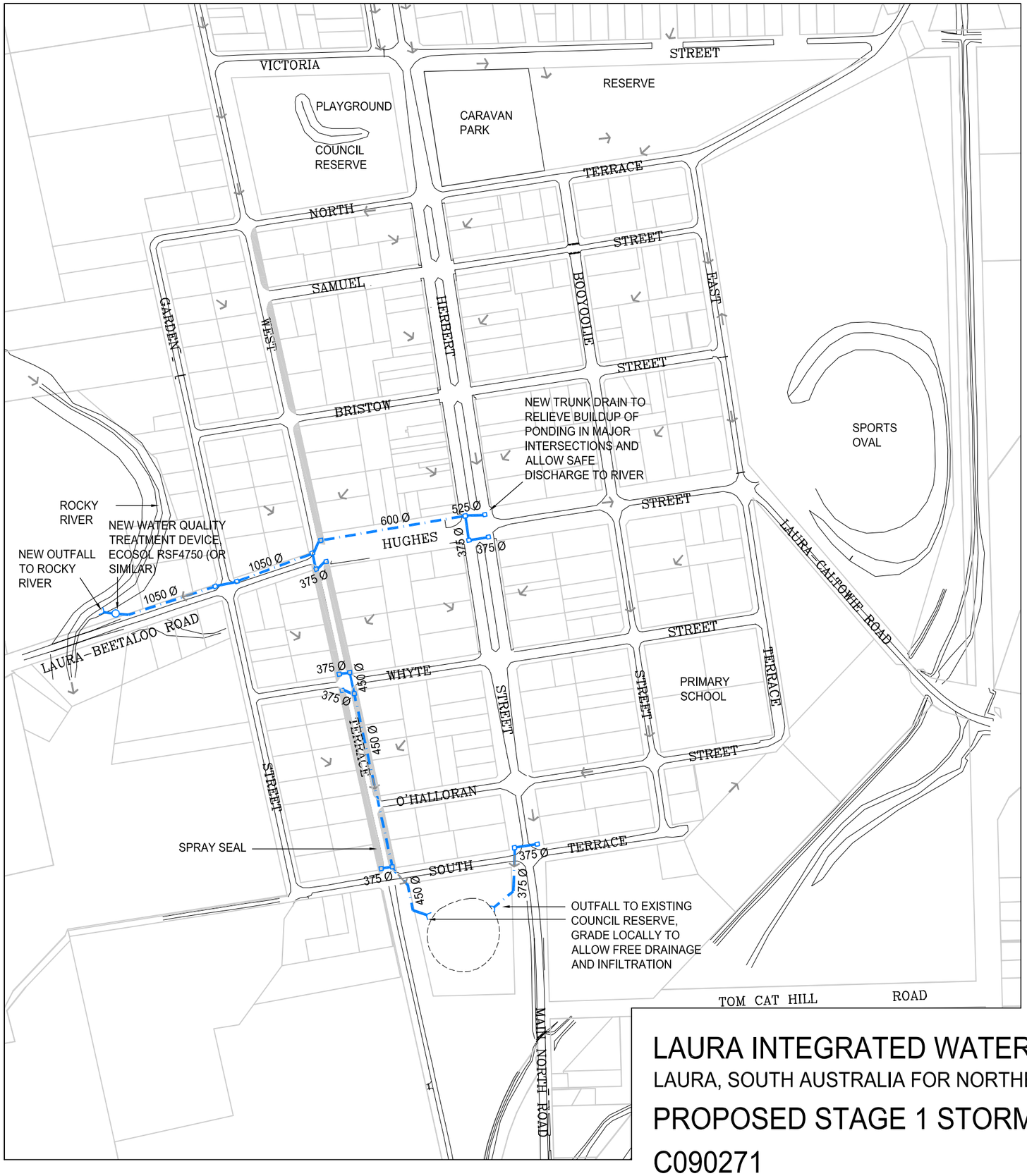
PROPOSED OVERALL STORMWATER CONCEPT PLAN

C090271 FIGURE 1

LEGEND

PROPOSED STORMWATER SYSTEM

- PROPOSED PIPE AND PIT
- BIOSWALE
- 1 IN 100 YEAR INUNDATION ZONE
- WATER STORAGE
- SPRAY SEAL AT EDGE OF ROAD
- STAGE 1 SYSTEM - BLUE
- STAGE 2 SYSTEM - RED
- STAGE 3 SYSTEM - GREEN
- STAGE 4 SYSTEM - MAGENTA
- STORMWATER SURFACE FLOW



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STAGE 1 (STAGE 1a AND STAGE 1b) :

STAGE 1a : HUGHES STREET TRUNK DRAIN

Major flows diverted out of the centre of town via a new 1050mm trunk along Hughes Street, discharging to a new outfall to the river north of the Laura-Beetaloo Road bridge. Major flows along West Terrace north of Hughes Street are to be improved by formalizing the roadside swales and spray sealing surface to improve conveyance.
To meet NRM water quality targets for stormwater discharging to Rocky River, a treatment device such as Ecosol will be required to capture grease, oil, silt and gross pollutants.

STAGE 1b : WEST TERRACE UPGRADE
At the Whyte Street / West Terrace intersection grated inlet pits and below ground drainage will be installed to prevent ponding at a known problem point.

On South Terrace grated inlet pits and the below ground drain are to be installed to collect the overland flows from West Terrace and Herbert Street spoon drains and discharge flows to the reserve south of town, with local grading of the reserve to allow sheet flow and infiltration across the reserve.

Estimated capital cost STAGES 1a AND STAGE 1b: $510,000
STAGE 1a, estimated : $300,000
STAGE 1b, estimated : $210,000

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LAURA INTEGRATED WATER REUSE STRATEGY

LAURA, SOUTH AUSTRALIA FOR NORTHERN AREAS COUNCIL

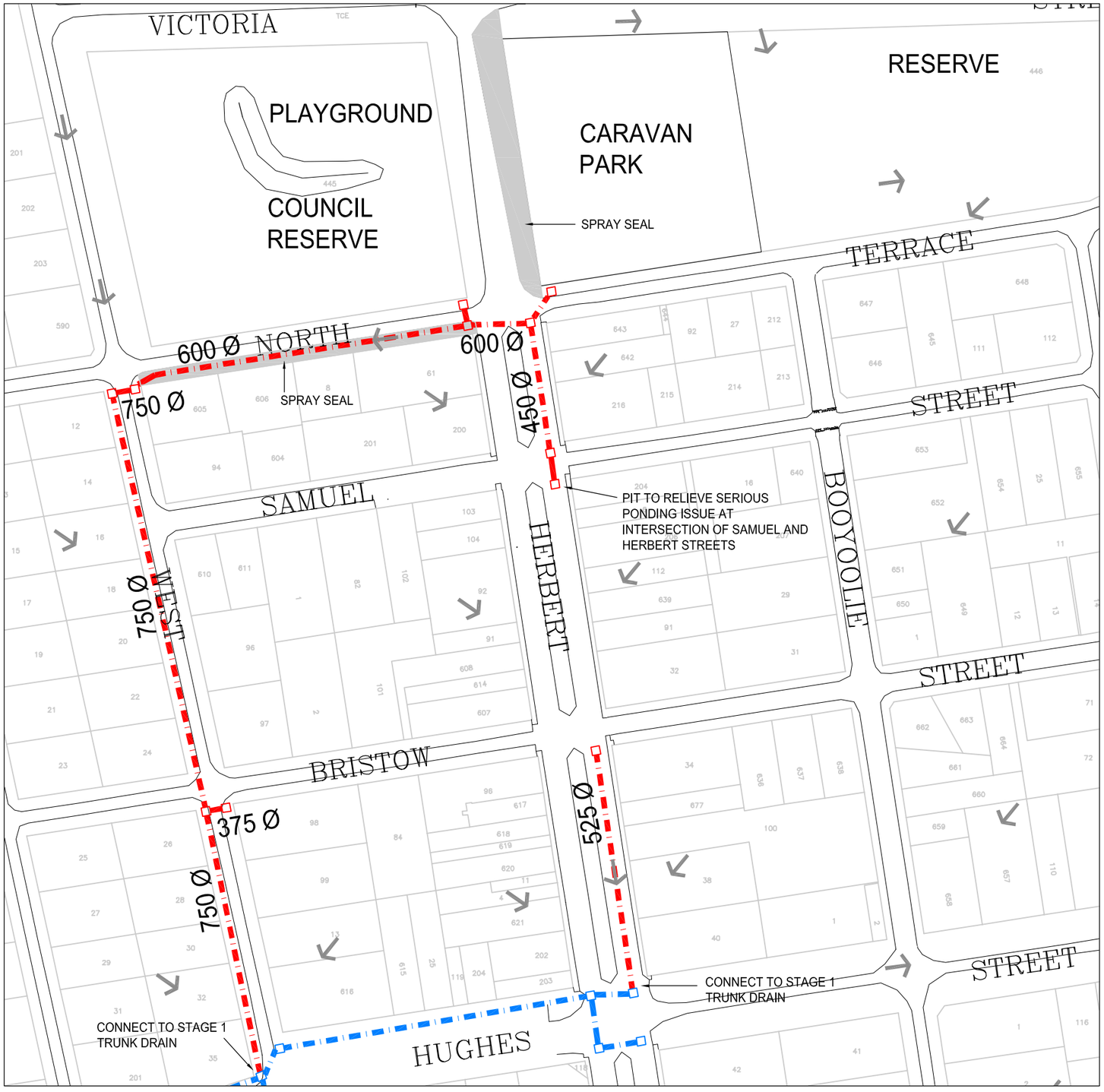
PROPOSED STAGE 1 STORMWATER CONCEPT PLAN

C090271 FIGURE 2

LEGEND

PROPOSED STORMWATER SYSTEM

- PROPOSED PIPE AND PIT
- BIOSWALE
- 1 IN 100 YEAR INUNDATION ZONE
- WATER STORAGE
- SPRAY SEAL AT EDGE OF ROAD
- STAGE 1 SYSTEM - BLUE
- STAGE 2 SYSTEM - RED
- STAGE 3 SYSTEM - GREEN
- STAGE 4 SYSTEM - MAGENTA
- STORMWATER SURFACE FLOW



STAGE 3 : EXTENSION OF UNDERGROUND DRAINAGE

The extension of underground drainage in West Terrace to a 5 year ARI minor flow standard will prevent nuisance flow and reduce the major flow widths. Extending this network east along North Terrace to Main North Road will allow the capture of flows which currently flow down Herbert Street. This will aim to divert upstream flows to the upgraded West Terrace drainage network an away from the town centre. Spray seal across the roadside swales will direct larger flows away from Herbert Street.

Estimated capital cost $400,000.

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LAURA INTEGRATED WATER REUSE STRATEGY

LAURA, SOUTH AUSTRALIA FOR NORTHERN AREAS COUNCIL

PROPOSED STAGE 2 STORMWATER CONCEPT PLAN

C090271 FIGURE 3

LEGEND

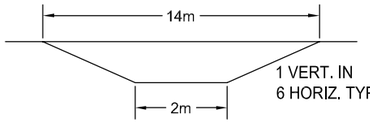
PROPOSED STORMWATER SYSTEM

- PROPOSED PIPE AND PIT
- BIOSWALE
- 1 IN 100 YEAR INUNDATION ZONE
- WATER STORAGE
- SPRAY SEAL AT EDGE OF ROAD
- STAGE 1 SYSTEM - BLUE
- STAGE 2 SYSTEM - RED
- STAGE 3 SYSTEM - GREEN
- STAGE 4 SYSTEM - MAGENTA
- STORMWATER SURFACE FLOW

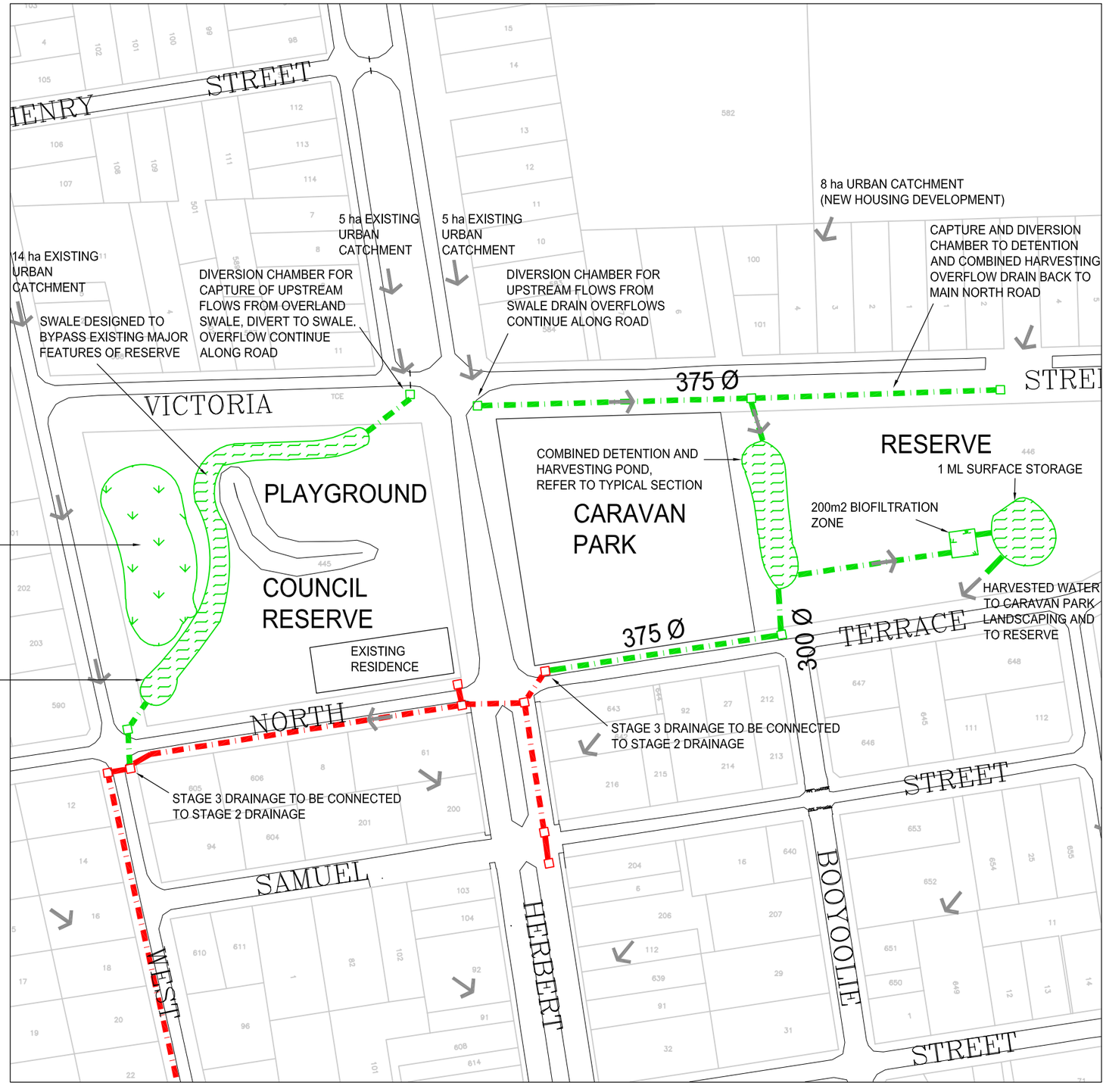
INUNDATION ZONE. 200mm DEEP DEPRESSION IN GRASS LANDSCAPE. INFREQUENT INUNDATION WITH MINIMAL IMPACT ON PARK / OPEN SPACE AMENITY

DETENTION SWALE

LENGTH 180m
HOLDING CAPACITY APPROX. 1500m3
RESTRICTED DISCHARGE AT DOWNSTREAM OUTFALL
OVERFLOW TO INUNDATION ZONE IN MAJOR STORM EVENT



DETENTION SWALE TYPICAL SECTION



STAGE 2 : DETENTION PONDS

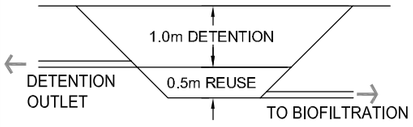
Detention ponds are proposed in the north of the town which will retard flows in minor storm events to reduce nuisance flows, flow widths and overland flow volumes in major events. Potential sites for detention are the Council Reserve and Caravan Park.

The Council Reserve detention would be within a constructed drainage channel meandering through the reserve, which would provide a safe overland flow path and with restricted outlet detention in larger storms. A higher level inundation zone would provide additional detention in major storms, the passive design and infrequent inundation would mean that this system would not impact on the everyday amenity of the reserve. The inundation zone would require only minimal earth works to sink the open lawn space 200 to 300mm below existing levels.

A combined detention and retention system is proposed for the Caravan Park. A 1500m2 detention basin would control upstream flows from the residential catchment under construction directly north and capture of minor flows from Main North Road. An additional storage component for balancing storage prior to treatment will allow the integration of stormwater harvesting. It is proposed a small biofiltration system could be designed to treat the stormwater. Storage would be by surface storage prior to reuse in the Caravan Park or as part of the integrated reuse network.

Estimated capital cost $250,000 (Excluding landscaping cost).

SURFACE AREA 1500m2
1m DEPTH DEDICATED DETENTION (1500m3 VOLUME)
0.5m DEPTH BALANCE STORAGE FOR STORMWATER TREATMENT



COMBINED DETENTION AND HARVESTING POND TYPICAL SECTION

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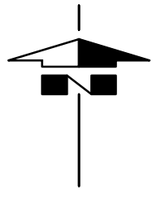

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SCALE 1:2500

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LAURA INTEGRATED WATER REUSE STRATEGY

LAURA, SOUTH AUSTRALIA FOR NORTHERN AREAS COUNCIL

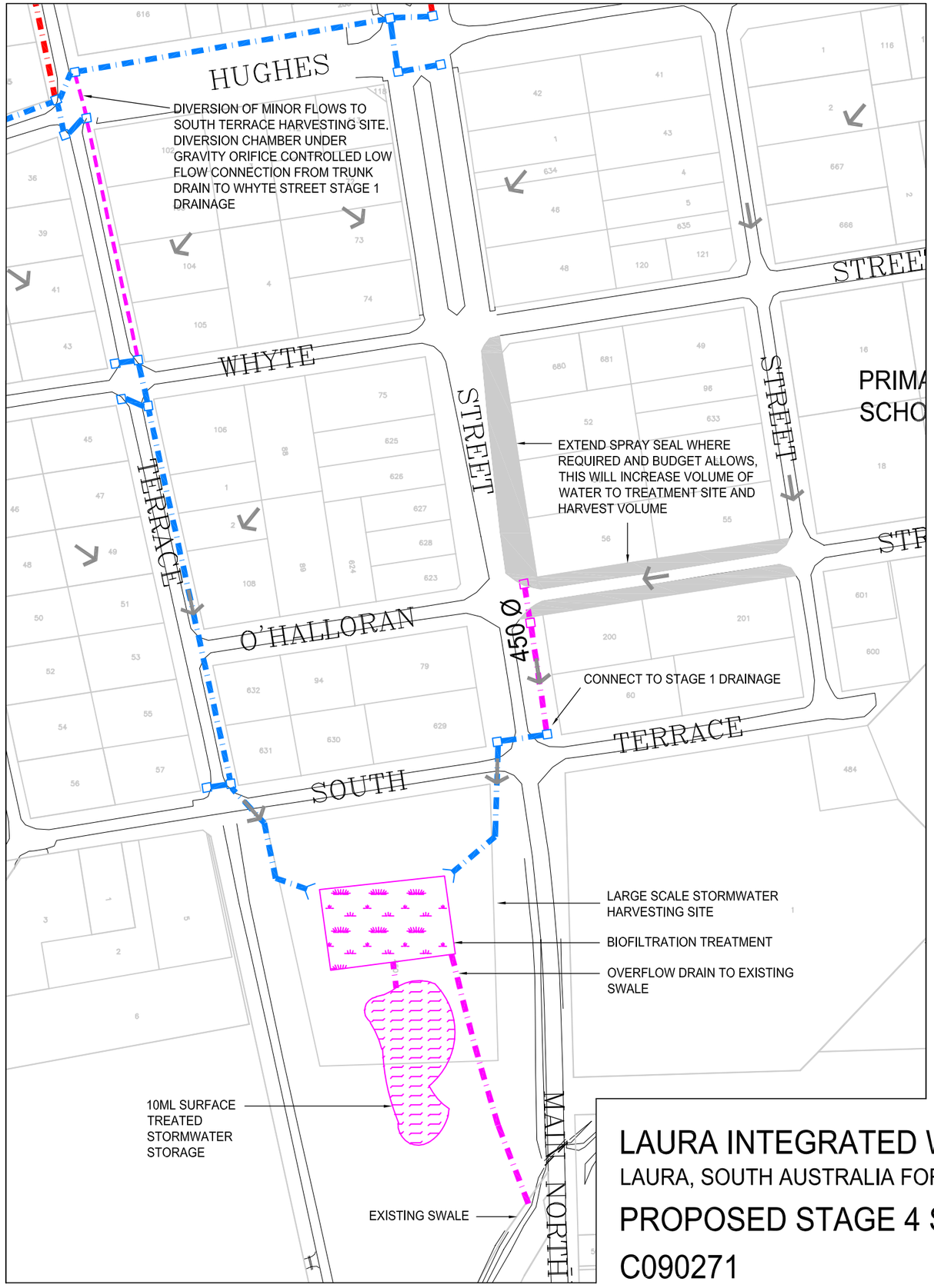
PROPOSED STAGE 3 STORMWATER CONCEPT PLAN

C090271 FIGURE 4

LEGEND

PROPOSED STORMWATER SYSTEM

- PROPOSED PIPE AND PIT
- BIOSWALE
- 1 IN 100 YEAR INUNDATION ZONE
- WATER STORAGE
- SPRAY SEAL AT EDGE OF ROAD
- STAGE 1 SYSTEM - BLUE
- STAGE 2 SYSTEM - RED
- STAGE 3 SYSTEM - GREEN
- STAGE 4 SYSTEM - MAGENTA
- STORMWATER SURFACE FLOW



STAGE 4 : INTEGRATION OF STORMWATER HARVESTING

Integration of stormwater harvesting by conveying minor flows to the large open reserve on South Terrace for treatment and storage. The treated water would be linked to the integrated reuse supply for the town which includes treated effluent for reuse.

To utilize runoff from the greater catchment capturing runoff discharging to Rocky River has been considered. As only minor flows from the Rocky River trunk drain are required it is proposed that an orifice controlled diversion pipe be installed to allow minor flows to drain to South Terrace.

Treatment of runoff would be by biofiltration. Surface storage is shown which will require suitable open space.

Estimated capital costs $400,000

20 10 0 25 50 75 100 125

SCALE 1:2500

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LAURA INTEGRATED WATER REUSE STRATEGY

LAURA, SOUTH AUSTRALIA FOR NORTHERN AREAS COUNCIL

PROPOSED STAGE 4 STORMWATER CONCEPT PLAN

C090271 FIGURE 5

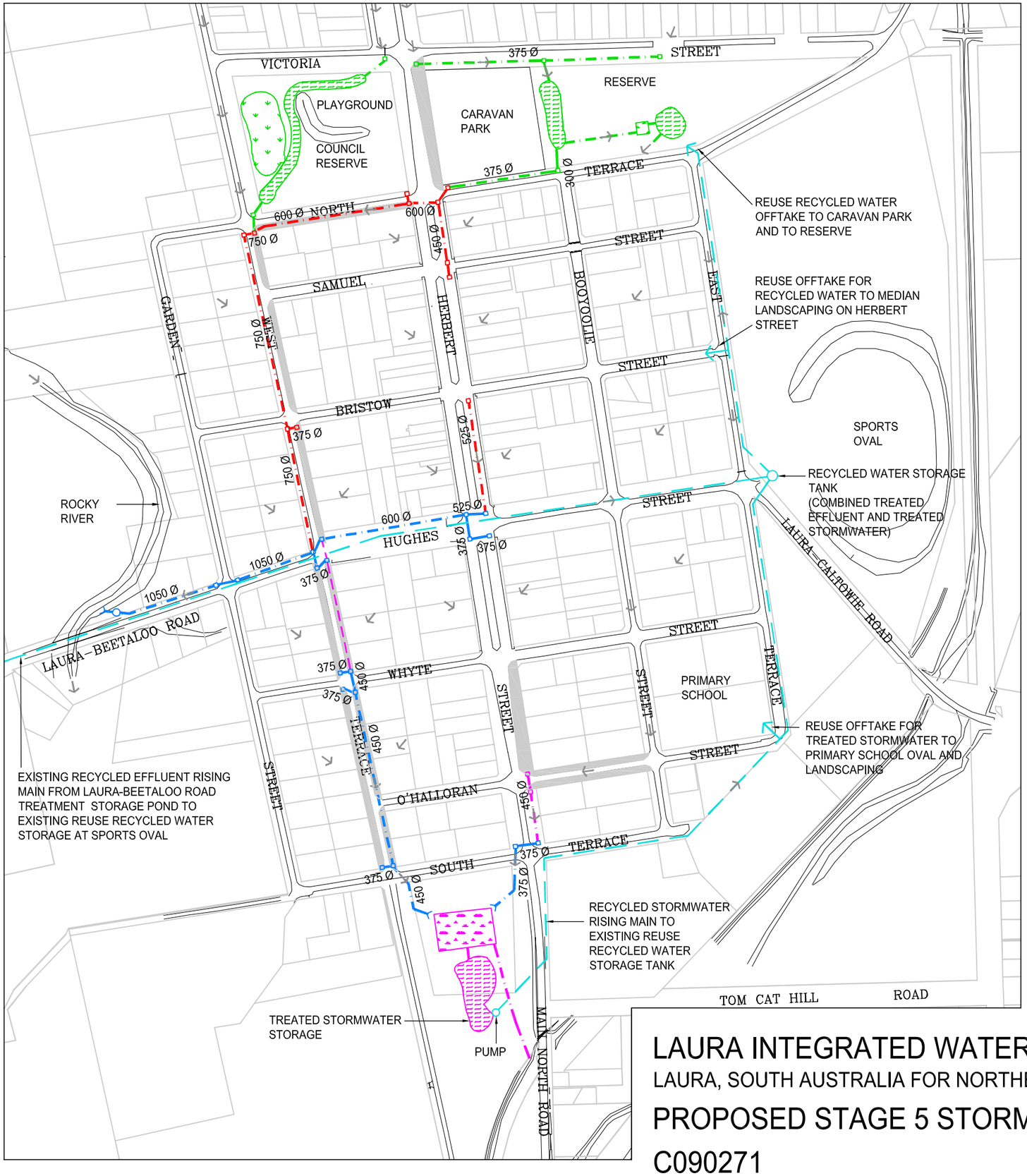
LEGEND

PROPOSED STORMWATER SYSTEM

- PROPOSED PIPE AND PIT
- BIOSWALE
- 1 IN 100 YEAR INUNDATION ZONE
- WATER STORAGE
- SPRAY SEAL AT EDGE OF ROAD
- STAGE 1 SYSTEM - BLUE
- STAGE 2 SYSTEM - RED
- STAGE 3 SYSTEM - GREEN
- STAGE 4 SYSTEM - MAGENTA
- STORMWATER SURFACE FLOW

PROPOSED REUSE SYSTEM

- STAGE 5 SYSTEM - CYAN RECYCLED WATER DISTRIBUTION MAIN (INTEGRATION WITH C.W.M.S. TREATED EFFLUENT AND TREATED STORMWATER DISTRIBUTION NETWORK)



50 25 0 50 100 150 200 250 metres

SCALE 1:5000

STAGE 6 : INTEGRATION WITH C.W.M.S. REUSE SCHEME AND DISTRIBUTION NETWORK

Treated stormwater will be distributed to a number of demand sites around the town by a distribution main running along the eastern boundary of the town.
This network will be integrated with the C.W.M.S. treated effluent at a combined storage tank located next to the sports oval.

Estimated capital cost $150,000

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LAURA INTEGRATED WATER REUSE STRATEGY

LAURA, SOUTH AUSTRALIA FOR NORTHERN AREAS COUNCIL

PROPOSED STAGE 5 STORMWATER CONCEPT PLAN

C090271 FIGURE 6

APPENDIX B

AGT Report

Australian
Groundwater
Technologies Pty Ltd

AGT

MECRUS

REVIEW OF ASR POTENTIAL FOR LAURA TOWNSHIP

Prepared for

Wallbridge and Gilbert

AGT Report No. 2009/968

Date - 19/08/2009

AUSTRALIAN GROUNDWATER TECHNOLOGIES PTY LTD
ABN 97 110 928 928
Unit 5, 1 London Road, MILE END SOUTH SA 5031

Tel: (08) 8352 4262
Fax: (08) 8354 3076
www.agwt.com.au

Emma Hendy
Civil Engineer
Wallbridge and Gilbert
60 Wyatt Street
Adelaide S.A 5000

Dear Emma,

Background

Wallbridge and Gilbert engaged Australian Groundwater Technologies Pty Ltd (AGT) on 23rd July 2009 to undertake a desktop review of ASR potential for Laura Township. Laura is located in mid-north South Australia, approximately 230km North of Adelaide and 25km East of Port Pirie (Figure 1).

Peak annual harvest volumes for ASR would be of the order 35-45ML/an, with a 1-2ha wetland in operation. There is also potential for a number of smaller bioretention systems with annual catchment runoff in the order 10ML/an.

Figure 1: Locality Plan - Laura (sourced from www.whereis.com)

Geology

The study area is located within the Adelaide Geosyncline and forms a small basin located south of the Willochra Basin and south west of the Walloway Basin and separated from them by higher bedrock. The Laura basin occupies a series of bedrock depressions or a graben delineated by possibly north- south trending faults. A map of the surface geology is seen in Figure 2.

The geology of the Laura area consists of unconsolidated Quaternary and Tertiary sediments underlain by fractured hard rock.

The alluvial sediments have an irregular distribution, with the thickest sediments (possibly 40 - 60m). Several different units are recognised in the unconsolidated sediments, including fluviatile quartz sand and gravel with clay lenses, silt and sand and undifferentiated Quaternary sediments. The Tertiary formation outcrops in the area and was recognised as undifferentiated Early Tertiary sand with some clay and silt.

The bedrock surrounding the basin is of the Burra group (Torrensian) and consists of the following formations;

- Rhynie Sandstone, located mostly west and south of the basin. Consisting dominantly of sandstone, channel filled conglomerates, minor dolomite and dark grey siltstone,
- East of the basin is dominated by Undalya Quartzite, Woolshed Flat Shale and Saddleworth Formation. The Undalya Quartzite generally consists of clean feldspathic quartzite with sandstone and siltstones interbeds. The Saddleworth Formation is predominately grey- green calcareous siltstone, arkose sandstone and some dolomite bands. The Woolshed Flat Shale consists of laminated grey siltstone with fine sandy bands, and
- North of the basin is mostly dominated by Saddleworth Formation.

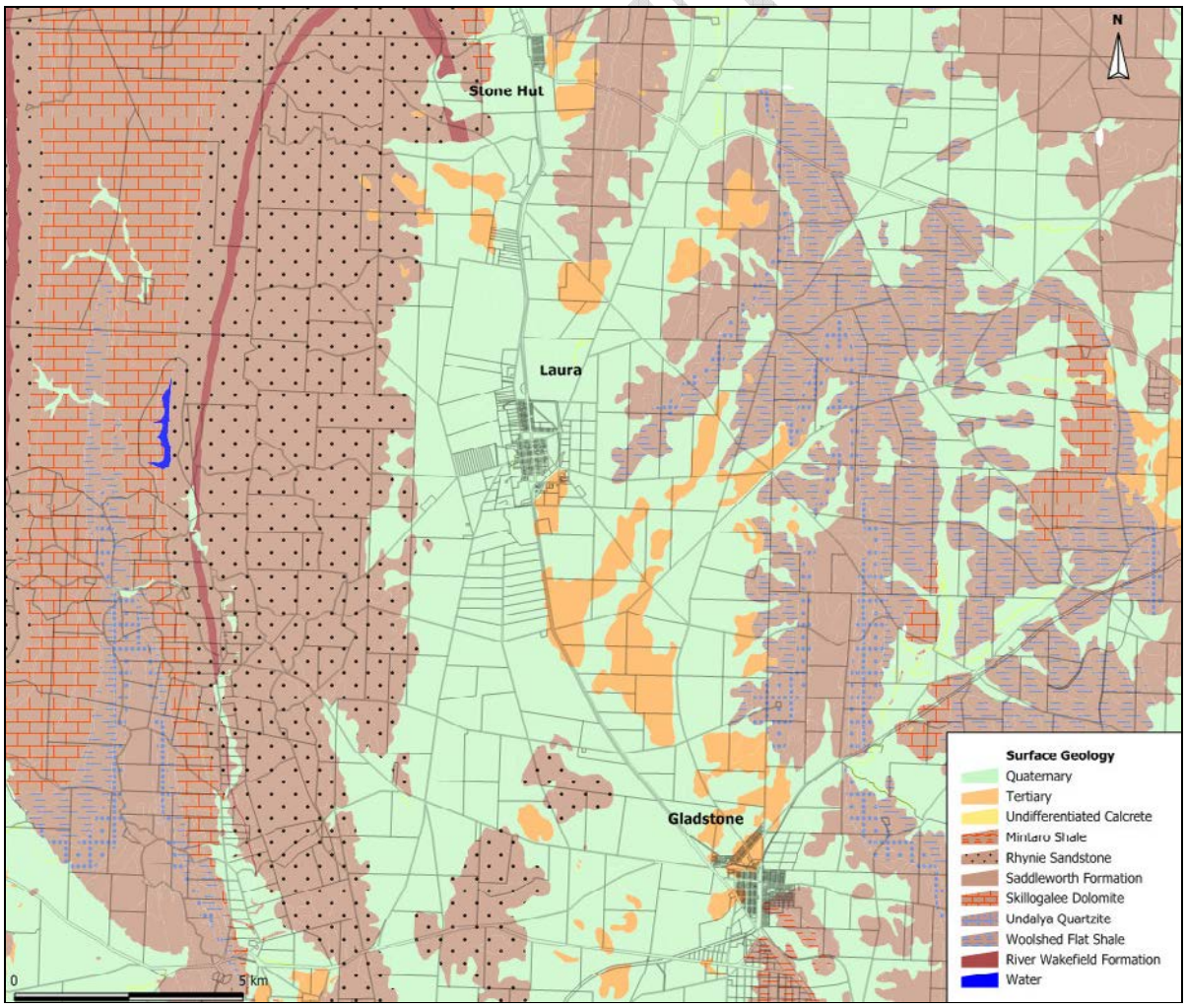

Figure 2: Surface Geology Map - Laura Township Area

Hydrogeological Review

The drillhole enquiry system (DES) held by the Department of Water, Land and Biodiversity Conservation (DWLBC) was accessed to acquire available data for all recorded wells in the Laura Township area.

Records for a total of 259 wells were retrieved. A complete set of data for each well would typically consist of: well ID, depth, depth to water (Static Water Level, or SWL), airlifted yield, salinity and drillers logs. However, as a significant portion of the wells were drilled before legislation was introduced to mandate the recording of the above basic parameters, there are significant gaps in the data set, as can be seen in the appended summary of well data (Appendix A).

A review of this data has been undertaken with the following key outputs:

Table 1: Key Drillhole Data within 15 km of Laura

Description	Number of recorded values
Borehole maximum drilled depth	
< 20 m	134
20 – 30 m	44
30 – 50 m	46
50 – 100 m	31
>100 m	4
Salinity (mg/L)	
<1,000	15
1,000 - 2,000	68
2,000 - 3,000	36
3,000 – 5,000	47
5,000 – 10,000	51
>10,000	2
Yield (L/s)	
<0.5	78
0.5 – 1	31
1 – 5	48
5 - 10	17
>10	3

The wells with records of depth/salinity and/or yield data were then located on a geological map of the area, to determine if there is any correlation between rock type and well yield/salinity/depth (Figures 3 and 4). Only wells deeper than 20mBGL were included.

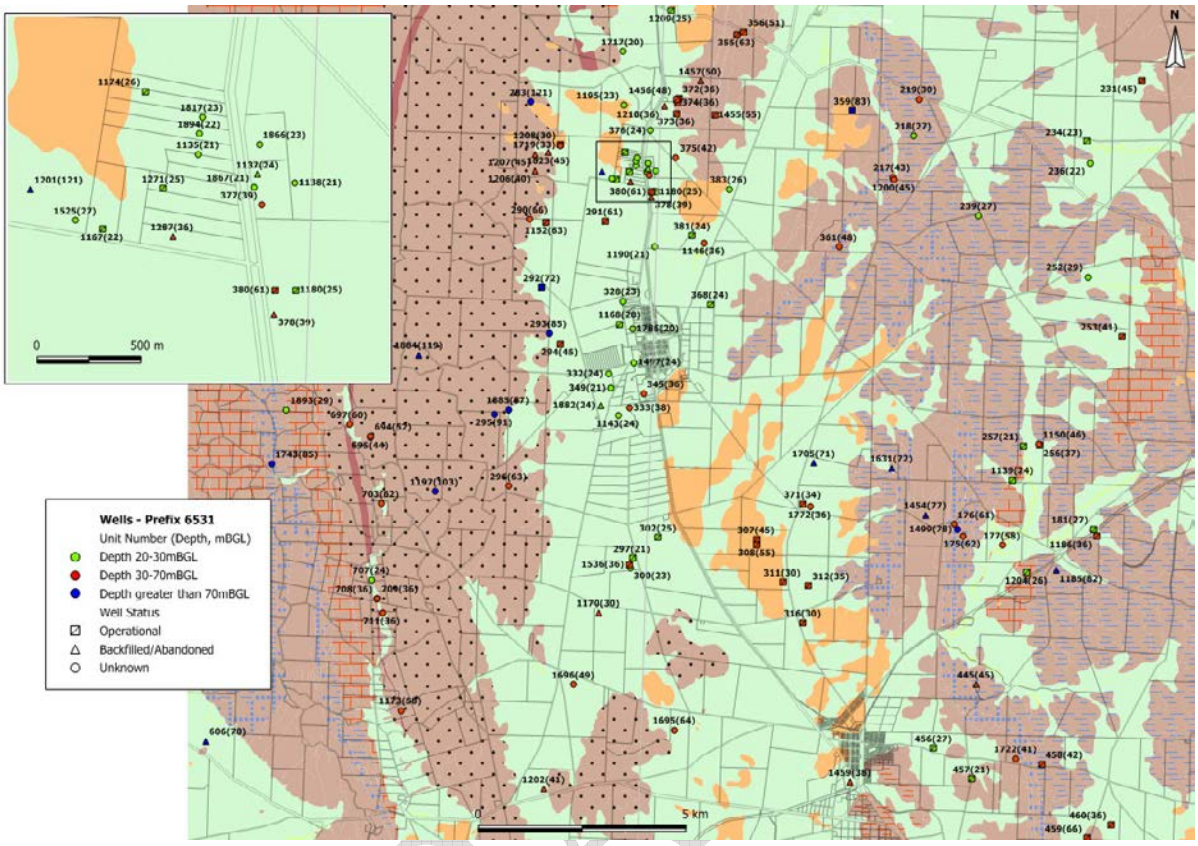

Figure 3: Well Location Plan - Laura Township Area

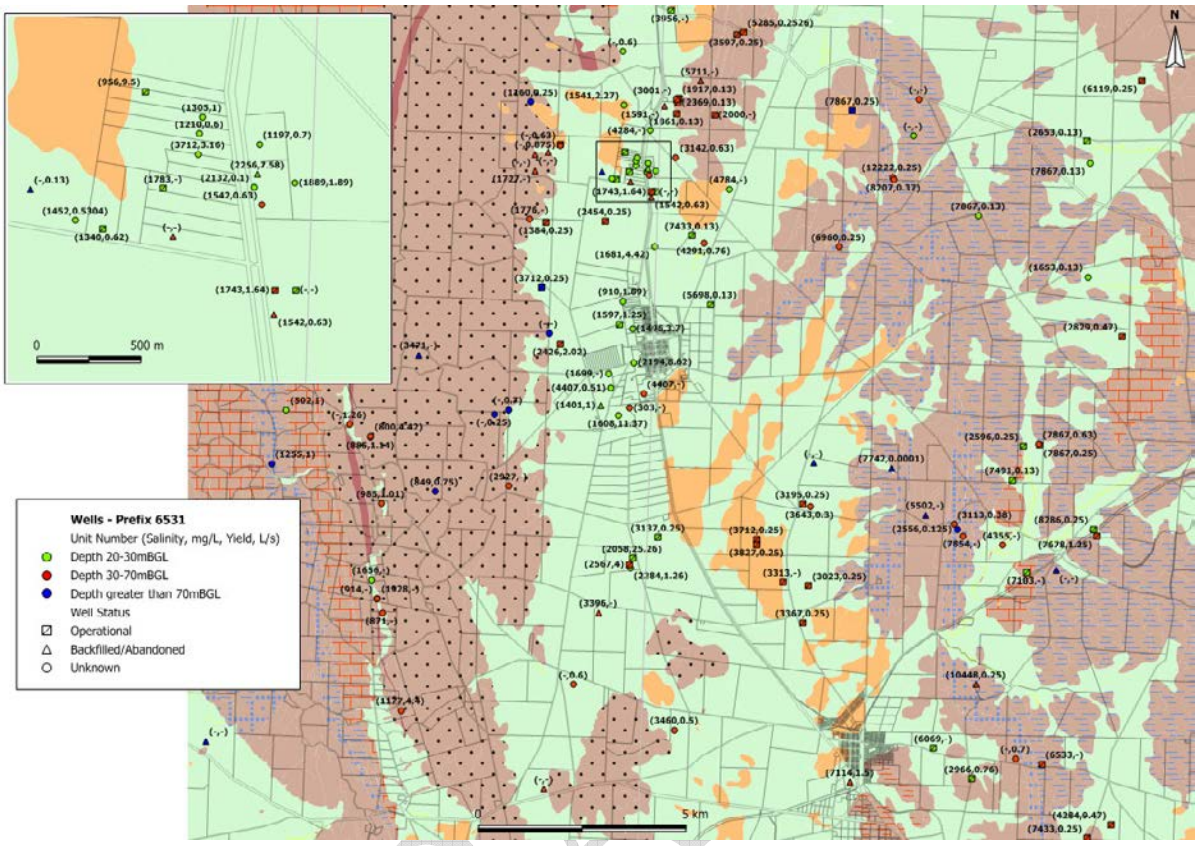

Figure 4: Salinity/Yield Plan - Laura Township Area

Lithological and/or drillers logs were available for 64 drill holes, 23 of which had a depth greater than 20mBGL (Appendix B), the vast majority of information available is for shallow drillholes.

Well 6531-1885 (Long. 138o15'47", Lat. 33o11'52"), located approximately 4km South West of Laura township provides lithological information to 87m. Lithological descriptions are reproduced from the Drillhole Enquiry System (DES). Well 6531-1885 was drilled 15th May 2008 and recorded a yield of 0.7 L/s.

Table 2: Lithology of well 6531-1885

Unit No	Depth From	Depth To	Lith Code	Description
6531-1885	0	3	CLYU	Red sandy CLAY
6531-1885	3	20	CLYU	Sticky red CLAY
6531-1885	20	35	SDST	White SANDSTONE
6531-1885	35	80	SDST	Yellow SANDSTONE hard bars, quartz
6531-1885	80	82	QUAR	Broken white QUARTZ cutting water
6531-1885	82	87	QUAR	Hard yellow QUARTZ

Well 6531-1536 (Long. 138o17'44", Lat. 33o13'50"), located approximately 6km South of Laura township provides lithological information to 36m. Lithological descriptions are reproduced from the Drillhole Enquiry System (DES). Well 6531-1536 was drilled 10th April 1997 and recorded a salinity of 2567 mg/L and a yield of 4 L/s. The well is used for irrigation purposes.

Table 3: Lithology of Well 6531-1536

Unit No	Depth From	Depth To	Lith Code	Description
6531-1536	0	2	LOAM	brown loam
6531-1536	2	34	CLYU	yellow clay
6531-1536	34	36	GRVL	creek gravel

Well 6531-1497 (Long. 138o17'44", Lat. 33o13'50"), located approximately in the Laura township provides lithological information to 24m. Lithological descriptions are reproduced from the Drillhole Enquiry System (DES). Well 6531-1497 was drilled 4th November 1992, is cased to a depth of 18m and recorded salinity of 2194 mg/L and yield of 8.62 L/s. The well is used for recycling purposes.

Table 4: Lithology of well 6531-1497

Unit No	Depth From	Depth To	Major Lith	Minor Lith	Description
6531-1497	0	9	SAND		Sand, very poorly sorted, mainly 0.2 to 2 mm, rounded to angular, limonite staining, minor (?limonite) cementing. Red 10R 5/6.
6531-1497	9	16	SAND		Sand with sandstone. Very poorly sorted, limonite staining. Weak red 10R 4/4.
6531-1497	16	23	SDST	SLST	Sandstone, siltstone and quartz, multicoloured.
6531-1497	23	24	SAND	GRVL	Sand & gravel, composed of sandstone & siltstone fragments and quartz sand. Pinkish white 7.5YR 8/2, some sandstone fragments are dark reddish brown.

The combination of available lithological logs and the geological map indicates the occurrence of 20 to 40m of clay and relatively thin sand/gravels (1 to +2m) overlying sandstone and quartzite of the Rhynie Formation, or possibly siltstone of the Saddleworth Formation.

Aquifer ASR Potential

The following describes the potential for ASR for the various formations identified.

Shallow Sediments

In these shallow sediments most of the water supply is produced from sand layers or lenses in between the clay. This sand typically produces 0.5 L/s to 3 L/s.

Of the 25 shallow wells drilled within 5km of the Laura Township with yield data, 8 have yields greater than 3 L/s. The depths of these wells range from 24-26mBGL to the North of the Township and 20-24mBGL in the Laura Township. These wells have likely been completed in the thin sand/gravel layers located less than 40m below ground level. The salinities of these wells range from 1,000 to over 4,000 mg/L.

On rare occasions it is seen that a shallow well (6531-1174), located approximately 5km North – West of Laura has intersected the sand at 26mBGL and produced up to 9 L/s with a good salinity of 956 mg/L. Whilst a well drilled at the southern end of the Laura Township drilled to a depth of 24mBGL (6531-1497) produced a yield of 8.62 L/s, but a marginal salinity of 2194 mg/L.

A marginal supply of 3.7 L/s was reported from a 20mBGL well drilled in the middle of the town (6531-1786). A deep well (6531-1201) drilled to a total depth of 121mBGL possibly reaching the underlying bedrock (personal interpretation) produced almost 0.1 L/s. This mixed information suggests that either distribution of the sandy aquifer is variable and is in the form of lenses or there is a problem with well completion. Well 6531-1174 that produced good water quality and high yield is located near the Tertiary outcrop approximately 5km North of Laura.

Bedrock

Of the 11 wells completed in bedrock within 5km of the Laura Township with yield data, none have yields greater than 3 L/s. The majority of well yields are all under 1 L/s.

Wells drilled in the surrounding bedrock area reached various depths ranging between 36m and up to the maximum of 119mBGL (6531-4884). Available information shows that a maximum yield of 4 L/s was reported from 2 wells (6531- 694, 1173) drilled to 52 and 58mBGL and completed in the Rhynie Sandstone formation. Salinity of this formation ranges between 800 – 3000 mg/L, but is mostly around 1000 mg/L. The Undalya Quartzite and Woolshed Flat Shale produced very low yields, under 0.1 L/s with high salinities suggesting low permeability of this formation Similarly, the Saddleworth Formation did not produce the expected yields documented in the Adelaide western hills face area. It is possible that the wells were located and drilled without any scientific understanding. There are possibilities that major structures including lineaments will be able to supply a moderate supply of water.

The risk with ASR in the bedrock aquifer is the potentially low recovery efficiency, defined as volume of recovered water that is adequate for the intended use, expressed as a percentage of the volume of injected water. Recovery efficiencies are very unpredictable in fractured rock aquifers and are best determined by undertaking an injection trial of 5-7 days duration with either mains water or wetland water, if available.

Conclusions

It is evident that the sediments have produced better supply than the fractured rock aquifer. If the sand typically produces 0.5L/s to 3 L/s, the injection rate can be expected to range between 0.3L/s to 2L/s.

Furthermore, the observed wide range in yields from the shallow sediments suggests that the distribution of the sandy aquifer is variable. This in turn suggests a moderate to high risk that the aquifer storage capacity may be inadequate for the envisaged 45ML/year, potentially leading to water logging.

There is thus a reasonably moderate to high risk that the aquifer systems are not suitable for the larger scale ASR (35-45ML), but may be more suitable for smaller bioretention systems with smaller capacity in the order of 10ML/year.

Should the viability of ASR be further investigated by drilling, it is recommended to drill the full thickness of the sediments west of the town and, if adequate thicknesses of sand/gravels are not intersected, possibly examine the fractured rock aquifer under the sediments. The salinity and yield from the Rhynie Sandstone formation west of the town is far more superior than those from the Undalya Quartzite and Saddleworth Formation east of the town, suggesting a low permeability of the latter.

Location of the well should be based on LANDSAT interpretation and a field visit to confirm the occurrence of Tertiary outcrops.

Order of magnitude costs for the field investigations are outlined below:

Drilling 30m deep hole	$10,000
Drilling 100m deep hole	$30,000
Well discharge testing	$3,500
Site walk over, drilling supervision, analysis and reporting	$6,000-$10,000

References

Drexel, J.F., Preiss, W.V. and Parker, A.J. (Eds), 1993. "The Geology of South Australia. Vol. 1, The Precambrian". South Australia Geological Survey. Bulletin, 54.

Drexel, J.F. and Preiss, W.V. (Eds), 1995. "The Geology of South Australia. Vol. 2, The Phanerozoic". South Australia Geological Survey. Bulletin, 54.

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Preiss, W.V., 1987. "The Adelaide Geosyncline: Late Proterozoic stratigraphy, sedimentation, palaeontology and tectonics". South Australia Geological Survey. Bulletin, 53.

Yours Sincerely,

Nikki Fotheringham

APPENDIX A BOREHOLE DATA (SOURCED FROM DES)

UNIT_NO	LABEL	CLASS	MAX_DRILL_	Depth	DRILL_DATE	CASED_TO	PURPOSE	LATE_STATU	SWL	WATER_LEVE	TDS	SALINITY_D	YIELD	DATE_YIELD	DECIMAL_LO	NEG_DECIMA	DRILL_LOG	LITH_LOG
6531-175	175	WW	62.48	30-70m	27/01/1959	0			0	30/11/1999	7854	27/01/1959	-	30/11/1999	138.3817	-33.22207	N	N
6531-176	176	WW	60.96	30-70m	6/02/1962	0			58.52	6/02/1962	3113	7/02/1962	0.38	6/02/1962	138.37933	-33.21968	N	N
6531-177	177	WW	57.91	30-70m	27/01/1959	0			0	30/11/1999	4355	27/01/1959	-	30/11/1999	138.39209	-33.22387	N	N
6531-178	178	WW	18.80	Less than 30m	3/05/1977	0	STK	OPR	13	3/05/1977	8286	3/05/1977	0.25	3/05/1977	138.40307	-33.2225	N	N
6531-179	179	WW	18.10	Less than 30m	3/05/1977	0	STK	OPR	13.9	3/05/1977	8708	3/05/1977	0.25	3/05/1977	138.40398	-33.21949	N	N
6531-180	180	WW	19.81	Less than 30m	10/05/1977	0			9.14	10/05/1977	1446	10/05/1977	0.25	10/05/1977	138.41376	-33.21613	N	N
6531-181	181	WW	27.00	Less than 30m	5/05/1977	0	STK	OPR	21.1	5/05/1977	8286	5/05/1977	0.25	5/05/1977	138.41555	-33.21976	N	N
6531-214	214	WW	18.29	Less than 30m	17/05/1977	0	STK	OPR	10.97	17/05/1977	8708	17/05/1977	0.25	17/05/1977	138.37396	-33.13729	N	N
6531-217	217	WW	42.68	30-70m	17/05/1977	0			27.13	17/05/1977	12222	17/05/1977	0.25	17/05/1977	138.3605	-33.14482	N	N
6531-218	218	WW	27.43	Less than 30m	30/11/1999	0			0	30/11/1999	-	30/11/1999	-	30/11/1999	138.36566	-33.13576	N	N
6531-219	219	WW	30.48	30-70m	30/11/1999	0			0	30/11/1999	-	30/11/1999	-	30/11/1999	138.36674	-33.12775	N	N
6531-231	231	WW	45.40	30-70m	4/05/1977	0	STK	OPR	40.17	4/05/1977	6119	4/05/1977	0.25	4/05/1977	138.42436	-33.12225	N	N
6531-234	234	WW	22.90	Less than 30m	4/05/1977	0	STK	OPR	15.9	4/05/1977	2653	4/05/1977	0.13	4/05/1977	138.41072	-33.13582	N	N
6531-236	236	WW	22.10	Less than 30m	4/05/1977	0			17.7	4/05/1977	7867	4/05/1977	0.13	4/05/1977	138.41159	-33.14045	N	N
6531-239	239	WW	27.10	Less than 30m	4/05/1977	0			17.8	4/05/1977	7867	4/05/1977	0.13	4/05/1977	138.3832	-33.15263	N	N
6531-252	252	WW	28.70	Less than 30m	4/05/1977	0			25.45	4/05/1977	1653	4/05/1977	0.13	4/05/1977	138.41201	-33.16512	N	N
6531-253	253	WW	41.15	30-70m	30/11/1999	24.38	STK	OPR	39.01	5/10/1953	2829	5/10/1953	0.47	5/10/1953	138.42148	-33.17785	N	N
6531-256	256	WW	36.60	30-70m	3/05/1977	0	STK	OPR	19.09	3/05/1977	7867	3/05/1977	0.25	3/05/1977	138.40088	-33.20187	N	N
6531-257	257	WW	21.10	Less than 30m	3/05/1977	0	STK	OPR	14.54	3/05/1977	2596	3/05/1977	0.25	3/05/1977	138.39681	-33.20227	N	N
6531-283	283	WW	121.10	Greater than 70m	4/04/1977	0			90.4	4/04/1977	1160	4/04/1977	0.25	4/04/1977	138.26641	-33.13097	N	N
6531-284	284	WW	17.80	Less than 30m	1/01/1936	0	DOM,STK	OPR	7.5	4/04/1977	1530	4/04/1977	1.26	4/04/1977	138.29157	-33.13158	N	N
6531-285	285	WW	9.60	Less than 30m	4/04/1977	0	DOM,STK	OPR	7.7	4/04/1977	3943	4/04/1977	0.25	4/04/1977	138.29072	-33.1322	N	N
6531-286	286	WW	14.60	Less than 30m	1/04/1977	0			9.9	1/04/1977	1602	1/04/1977	0.51	1/04/1977	138.29066	-33.1452	N	N
6531-287	287	WW	17.83	Less than 30m	14/05/1957	15.79			12.19	14/05/1957	2913	14/05/1957	2.53	14/05/1957	138.2882	-33.14611	N	N
6531-288	288	WW	11.60	Less than 30m	13/04/1977	0			8.5	13/04/1977	1804	13/04/1977	0.13	13/04/1977	138.29332	-33.14578	N	N
6531-289	289	WW	11.50	Less than 30m	13/04/1977	0			8.6	13/04/1977	1850	13/04/1977	0.13	13/04/1977	138.29333	-33.14672	N	N
6531-290	290	WW	66.05	30-70m	24/04/1977	0			50.05	4/04/1977	1776	4/04/1977	-	30/11/1999	138.26708	-33.15643	N	N
6531-291	291	WW	60.60	30-70m	13/04/1977	0	STK	OPR	21.21	13/04/1977	2454	13/04/1977	0.25	13/04/1977	138.28647	-33.15634	N	N
6531-292	292	WW	72.50	Greater than 70m	1/04/1977	0	STK	OPR	34.5	1/04/1977	3712	1/04/1977	0.25	1/04/1977	138.27075	-33.1711	N	N
6531-293	293	WW	85.34	Greater than 70m	30/11/1999	0			0	30/11/1999	-	30/11/1999	-	30/11/1999	138.27285	-33.1809	N	N
6531-294	294	WW	45.40	30-70m	1/04/1977	0	DOM,STK	OPR	33.3	1/04/1977	2426	1/04/1977	2.02	1/04/1977	138.2759	-33.18314	N	N
6531-295	295	WW	90.90	Greater than 70m	31/03/1977	0			41.25	31/03/1977	-	30/11/1999	0.25	31/03/1977	138.25942	-33.19883	N	N
6531-296	296	WW	63.40	30-70m	29/07/1958	0			0	30/11/1999	2927	29/07/1958	-	30/11/1999	138.26373	-33.21429	N	N
6531-297	297	WW	21.00	Less than 30m	30/03/1977	0	IRR	OPR	2.2	30/03/1977	2058	31/03/1977	25.26	30/03/1977	138.29635	-33.22909	N	N
6531-298	298	WW	6.70	Less than 30m	31/03/1977	0			2.2	31/03/1977	1872	31/03/1977	0.25	31/03/1977	138.29437	-33.227	N	N
6531-299	299	WW	4.55	Less than 30m	31/03/1977	0			2.5	31/03/1977	2284	31/03/1977	0.25	31/03/1977	138.29661	-33.2284	N	N
6531-300	300	WW	23.40	Less than 30m	30/03/1977	0			2.7	30/03/1977	2284	31/03/1977	1.26	30/03/1977	138.29581	-33.23118	N	N
6531-301	301	WW	5.30	Less than 30m	30/03/1977	0			4.2	30/03/1977	5109	30/03/1977	0.13	30/03/1977	138.29628	-33.2344	N	N
6531-302	302	WW	24.84	Less than 30m	30/03/1977	0	STK	OPR	2.63	30/03/1977	3137	30/03/1977	0.25	30/03/1977	138.3029	-33.22452	N	N
6531-303	303	WW	5.80	Less than 30m	30/03/1977	0	STK	OPR	3.1	30/03/1977	2510	30/03/1977	0.25	30/03/1977	138.29672	-33.22281	N	N
6531-304	304	WW	3.70	Less than 30m	30/03/1977	0	STK	OPR	2.6	30/03/1977	3712	30/03/1977	0.25	30/03/1977	138.30253	-33.22794	N	N
6531-305	305	WW	4.30	Less than 30m	30/03/1977	0	STK	OPR	2.5	30/03/1977	3712	30/03/1977	0.25	30/03/1977	138.3043	-33.23578	N	N
6531-306	306	WW	3.60	Less than 30m	6/04/1977	0			3.2	6/04/1977	3832	6/04/1977	0.13	6/04/1977	138.31818	-33.22691	N	N
6531-307	307	WW	45.45	30-70m	1/01/1946	0	STK	OPR	27.27	6/03/1977	3712	6/04/1977	0.25	6/03/1977	138.3284	-33.22427	N	N
6531-308	308	WW	54.54	30-70m	6/04/1977	0	DOM,STK	OPR	27.27	6/04/1977	3827	6/04/1977	0.25	6/04/1977	138.32852	-33.22532	N	N
6531-309	309	WW	6.60	Less than 30m	6/04/1977	0	DOM,STK	OPR	4.4	6/04/1977	2493	6/04/1977	1.26	6/04/1977	138.32197	-33.23122	N	N
6531-310	310	WW	8.00	Less than 30m	6/04/1977	0	IRR	OPR	5.1	6/04/1977	4291	6/04/1977	1.26	6/04/1977	138.32189	-33.2343	N	N
6531-311	311	WW	30.48	30-70m	8/02/1960	0	IRR,STK	OPR	0	30/11/1999	3313	8/02/1960	-	30/11/1999	138.33548	-33.23337	N	N
6531-312	312	WW	35.00	30-70m	4/04/1977	0	STK	OPR	18	4/04/1977	3023	4/04/1977	0.25	4/04/1977	138.34222	-33.23392	N	N
6531-315	315	WW	5.35	Less than 30m	6/04/1977	0	STK	OPR	3.15	6/04/1977	5994	6/04/1977	0.13	6/04/1977	138.33167	-33.24058	N	N
6531-316	316	WW	30.00	30-70m	4/04/1977	0	STK	OPR	14.8	4/04/1977	3367	4/04/1977	0.25	4/04/1977	138.34106	-33.24198	N	N
6531-318	318	WW	10.80	Less than 30m	13/04/1977	0			8.1	13/04/1977	1127	13/04/1977	1.26	13/04/1977	138.29669	-33.16665	N	N
6531-319	319	WW	9.50	Less than 30m	1/04/1977	0	IRR	OPR	6.55	1/04/1977	1631	1/04/1977	0.25	1/04/1977	138.28855	-33.18382	N	N
6531-320	320	WW	16.15	Less than 30m	18/01/1960	0			7.01	18/01/1960	1000	18/01/1960	3.79	18/01/1960	138.2933	-33.1779	N	N
6531-321	321	WW	14.02	Less than 30m	21/01/1960	0			8.23	21/01/1960	1742	29/02/1960	0.63	21/01/1960	138.29514	-33.18088	N	N

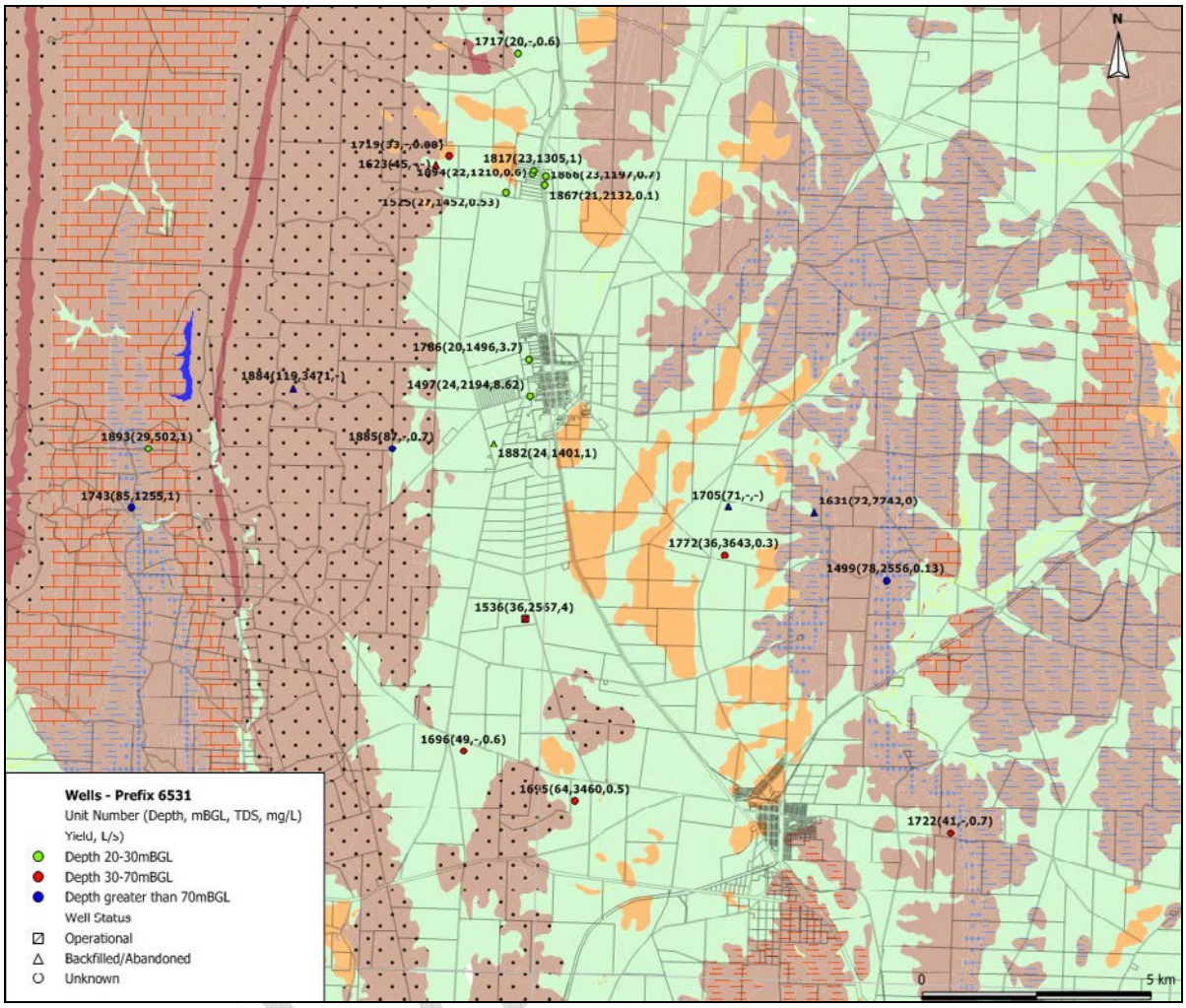
UNIT_NO	LABEL	CLASS	MAX_DRILL_	Depth	DRILL_DATE	CASED_TO	PURPOSE	LATE_STATU	SWL	WATER_LEVE	TDS	SALINITY_D	YIELD	DATE_YIELD	DECIMAL_LO	NEG_DECIMA	DRILL_LOG	LITH_LOG
6531-322	322	WW	13.35	Less than 30m	1/04/1977	0	IRR	OPR	7.45	1/04/1977	1138	1/04/1977	0.51	1/04/1977	138.28845	-33.18151	N	N
6531-323	323	WW	12.80	Less than 30m	30/11/1999	0			0	30/11/1999	1242	30/11/1999	6.32	30/11/1999	138.28945	-33.17497	N	N
6531-324	324	WW	7.62	Less than 30m	21/05/1943	0			6.71	21/05/1943	2071	21/05/1943	-	30/11/1999	138.28619	-33.18028	N	N
6531-326	326	WW	13.35	Less than 30m	1/04/1977	0			6.25	1/04/1977	506	1/04/1977	1.26	1/04/1977	138.28985	-33.18373	N	N
6531-327	327	WW	9.70	Less than 30m	1/03/1977	0			7.05	1/03/1977	1832	1/03/1977	0.25	1/03/1977	138.29384	-33.18288	N	N
6531-328	328	WW	22.55	Less than 30m	29/06/1979	22.55			10.97	29/06/1979	910	27/06/1979	1.89	29/06/1979	138.29176	-33.17348	N	N
6531-329	329	WW	10.67	Less than 30m	21/01/1960	0			6.1	21/01/1960	1585	2/03/1960	7.58	21/01/1960	138.29192	-33.19271	N	N
6531-330	330	WW	15.24	Less than 30m	21/05/1943	0			5.49	21/03/1943	1585	21/05/1943	-	30/11/1999	138.28878	-33.20169	N	N
6531-331	331	WW	12.19	Less than 30m	21/05/1943	0			0	30/11/1999	1613	21/05/1943	-	30/11/1999	138.29151	-33.18811	N	N
6531-332	332	WW	24.38	Less than 30m	21/05/1943	0			0	30/11/1999	1699	21/05/1943	-	30/11/1999	138.28861	-33.18939	N	N
6531-333	333	WW	38.24	30-70m	20/05/1943	0			6.85	20/05/1943	303	20/05/1943	-	30/11/1999	138.29445	-33.19667	N	N
6531-334	334	WW	12.80	Less than 30m	15/02/1968	0			9.14	15/02/1968	1515	15/02/1968	8.84	15/02/1968	138.29139	-33.19125	N	N
6531-335	335	WW	10.97	Less than 30m	15/02/1968	0			8.53	15/02/1968	2900	15/02/1968	-	30/11/1999	138.29287	-33.1912	N	N
6531-336	336	WW	9.50	Less than 30m	31/03/1977	0	STK	OPR	6.9	31/03/1977	2001	31/03/1977	1.26	31/03/1977	138.29476	-33.19155	N	N
6531-337	337	WW	12.19	Less than 30m	19/02/1960	0			8.53	19/02/1960	2028	19/02/1960	-	30/11/1999	138.29519	-33.19649	N	N
6531-338	338	WW	8.23	Less than 30m	20/05/1943	0			6.71	20/05/1943	2470	20/05/1943	3.79	20/05/1943	138.29578	-33.1966	N	N
6531-340	340	WW	9.14	Less than 30m	30/04/1937	0			3.66	30/04/1937	2013	30/04/1937	1.26	30/04/1937	138.29677	-33.19703	N	N
6531-341	341	WW	9.75	Less than 30m	30/04/1937	0			6.1	30/04/1937	2185	30/04/1937	-	30/11/1999	138.29749	-33.19701	N	N
6531-342	342	WW	9.30	Less than 30m	20/05/1943	0			5.79	20/05/1943	4355	20/05/1943	-	30/11/1999	138.29695	-33.1969	N	N
6531-343	343	WW	9.14	Less than 30m	1/01/1937	0			3.66	1/01/1937	1842	21/05/1943	-	30/11/1999	138.29751	-33.19713	N	N
6531-345	345	WW SW	36.36	30-70m	1/08/1975	0		UKN	7.87	14/04/1977	4407	14/04/1977	-	30/11/1999	138.2978	-33.19343	N	N
6531-347	347	WW	19.09	Less than 30m	1/08/1975	0	IRR	OPR	7.87	14/04/1977	4595	14/04/1977	11.37	14/04/1977	138.29652	-33.19089	N	N
6531-348	348	WW	11.10	Less than 30m	14/04/1977	0	IRR	OPR	7.2	14/04/1977	4291	14/04/1977	9.60	14/04/1977	138.29762	-33.18676	N	N
6531-349	349	WW	21.00	Less than 30m	26/05/1977	19.8			6.9	26/05/1977	4407	26/05/1977	0.51	26/05/1977	138.28934	-33.19252	N	N
6531-350	350	WW	5.50	Less than 30m	30/03/1977	0			3.6	30/03/1977	4370	21/05/1943	0.13	30/03/1977	138.29635	-33.21053	N	N
6531-351	351	WW	8.00	Less than 30m	30/03/1977	0	IRR	OPR	3.75	30/03/1977	2795	30/03/1977	-	30/11/1999	138.29949	-33.21103	N	N
6531-353	353	WW	9.75	Less than 30m	21/01/1960	0			0	30/11/1999	1471	21/01/1960	8.84	1/01/1960	138.29169	-33.2079	N	N
6531-354	354	WW	12.50	Less than 30m	31/03/1977	0			8.5	31/03/1977	292	31/03/1977	0.25	31/03/1977	138.2858	-33.20134	N	N
6531-355	355	WW	63.33	30-70m	12/04/1977	0	STK	OPR	0	30/11/1999	3597	12/04/1977	0.25	1/01/1977	138.31908	-33.11499	N	N
6531-356	356	WW	50.90	30-70m	12/04/1977	0	STK	OPR	0	30/11/1999	5285	12/04/1977	0.25	1/01/1977	138.32092	-33.11444	N	N
6531-359	359	WW	83.33	Greater than 70m	7/04/1977	0	STK	OPR	0	30/11/1999	7867	7/04/1977	0.25	1/01/1977	138.3497	-33.13077	N	N
6531-361	361	WW	48.01	30-70m	3/09/1953	1.98			0	30/11/1999	6960	7/04/1977	0.25	1/01/1977	138.34728	-33.16032	N	N
6531-362	362	WW	6.10	Less than 30m	30/11/1999	0			4.88	30/11/1999	4884	30/11/1999	-	30/11/1999	138.32841	-33.13546	N	N
6531-363	363	WW	7.70	Less than 30m	7/04/1977	0			5.8	7/04/1977	5698	7/04/1977	0.25	7/04/1977	138.3307	-33.15143	N	N
6531-364	364	WW	9.00	Less than 30m	7/04/1977	0			5.8	7/04/1977	5698	7/04/1977	0.25	7/04/1977	138.33173	-33.15065	N	N
6531-365	365	WW	6.00	Less than 30m	7/04/1977	0	STK	OPR	5.2	7/04/1977	5698	7/04/1977	0.25	7/04/1977	138.33123	-33.13986	N	N
6531-366	366	WW	13.63	Less than 30m	1/01/1943	0	STK	OPR	9.69	13/04/1977	5698	13/04/1977	0.13	13/04/1977	138.32206	-33.15263	N	N
6531-367	367	WW	14.24	Less than 30m	13/04/1977	0	STK	OPR	10.3	13/04/1977	4874	13/04/1977	0.13	13/04/1977	138.31964	-33.15993	N	N
6531-368	368	WW	24.24	Less than 30m	13/04/1977	0	STK	OPR	15.51	13/04/1977	5698	13/04/1977	0.13	13/04/1977	138.31444	-33.17359	N	N
6531-369	369	WW	18.29	Less than 30m	20/05/1943	0			8.23	20/05/1943	6012	20/05/1943	0.76	20/05/1943	138.30862	-33.19811	N	N
6531-370	370	WW	18.80	Less than 30m	6/04/1977	0			17.3	6/04/1977	1810	6/03/1977	0.76	6/04/1977	138.32877	-33.20677	N	N
6531-371	371	WW	34.13	30-70m	6/04/1977	0	STK	OPR	29.85	6/04/1977	3195	6/04/1977	0.25	6/04/1977	138.3401	-33.2162	N	N
6531-372	372	WW	36.36	30-70m	12/04/1977	0	STK	OPR	21.21	12/04/1977	1917	12/04/1977	0.13	12/04/1977	138.30453	-33.12934	N	N
6531-373	373	WW	36.36	30-70m	12/04/1977	0	STK	OPR	21	12/04/1977	1861	12/04/1977	0.13	12/04/1977	138.30422	-33.13246	N	N
6531-374	374	WW	36.36	30-70m	12/04/1977	0	DOM	OPR	21.21	12/04/1977	2369	12/04/1977	0.13	12/04/1977	138.30442	-33.13023	N	N
6531-375	375	WW	41.76	30-70m	30/11/1999	0			0	30/11/1999	3142	30/11/1999	0.63	30/11/1999	138.30435	-33.14205	N	N
6531-376	376	WW	24.38	Less than 30m	10/02/1960	0			0	30/11/1999	4284	10/02/1960	-	30/11/1999	138.2976	-33.13642	N	N
6531-377	377	WW	38.71	30-70m	30/11/1999	0			15.24	30/11/1999	1542	30/11/1999	0.63	30/11/1999	138.29746	-33.14601	N	N
6531-378	378	WW	38.71	30-70m	31/07/1957	0		ABD	12.19	31/07/1957	1542	31/07/1957	0.63	31/07/1957	138.29825	-33.15072	N	N
6531-379	379	WW	13.00	Less than 30m	13/04/1977	0			11.2	13/04/1977	2795	13/04/1977	0.06	13/04/1977	138.29866	-33.1515	N	N
6531-380	380	WW	60.60	30-70m	13/04/1977	0	IRR	OPR	41.32	13/04/1977	1743	13/04/1977	1.64	13/04/1977	138.29823	-33.14969	N	N
6531-381	381	WW	23.63	Less than 30m	13/04/1977	0	STK	OPR	11.51	13/04/1977	7433	13/04/1977	0.13	13/04/1977	138.30925	-33.15894	N	N
6531-382	382	WW	6.10	Less than 30m	29/08/1958	0			0	30/11/1999	4727	29/08/1958	-	30/11/1999	138.32263	-33.13931	N	N
6531-383	383	WW	25.91	Less than 30m	29/08/1958	0			6.1	29/08/1958	4784	29/08/1958	-	30/11/1999	138.3183	-33.14856	N	N
6531-384	384	WW	13.63	Less than 30m	14/04/1977	0	STK	OPR	9.2	14/04/1977	5109	14/04/1977	0.13	14/04/1977	138.30191	-33.17565	N	N

UNIT_NO	LABEL	CLASS	MAX_DRILL_	Depth	DRILL_DATE	CASED_TO	PURPOSE	LATE_STATU	SWL	WATER_LEVE	TDS	SALINITY_D	YIELD	DATE_YIELD	DECIMAL_LO	NEG_DECIMA	DRILL_LOG	LITH_LOG
6531-385	385	WW	18.59	Less than 30m	30/07/1977	18.59			7.92	30/07/1977	4001	27/09/1977	6.06	30/07/1977	138.30057	-33.17708	N	N
6531-386	386	WW	13.11	Less than 30m	30/11/1999	0			0	30/11/1999	5855	30/11/1999	-	30/11/1999	138.30322	-33.1793	N	N
6531-388	388	WW	14.54	Less than 30m	1/04/1977	0	IRR	OPR	8.4	1/04/1977	5285	1/04/1977	5.05	1/04/1977	138.30435	-33.18347	N	N
6531-390	390	WW	6.10	Less than 30m	21/05/1943	0			0	30/11/1999	5883	21/05/1943	-	30/11/1999	138.30295	-33.19407	N	N
6531-391	391	WW	8.23	Less than 30m	20/05/1943	0			7.01	20/05/1943	5998	20/05/1943	-	30/11/1999	138.3019	-33.18563	N	N
6531-392	392	WW	8.99	Less than 30m	21/05/1943	0			7.31	21/05/1943	5554	21/05/1943	-	30/11/1999	138.29875	-33.18123	N	N
6531-400	400	WW	5.10	Less than 30m	30/03/1977	0	STK	OPR	2.3	30/03/1977	6119	30/03/1977	-	30/11/1999	138.33032	-33.25981	N	N
6531-401	401	WW	3.10	Less than 30m	30/03/1977	0	STK	OPR	1.5	30/03/1977	2262	30/03/1977	-	30/11/1999	138.32491	-33.25448	N	N
6531-402	402	WW	4.80	Less than 30m	30/03/1977	0	STK	OPR	2.5	30/03/1977	5109	30/03/1977	0.25	30/03/1977	138.33279	-33.25461	N	N
6531-403	403	WW	4.00	Less than 30m	29/03/1977	0	STK	OPR	1.45	29/03/1977	5698	29/03/1977	0.25	29/03/1977	138.34204	-33.26916	N	N
6531-404	404	WW	7.92	Less than 30m	24/06/1958	0			6.1	24/06/1958	7140	24/06/1958	-	30/11/1999	138.34152	-33.27508	N	N
6531-407	407	WW	4.30	Less than 30m	29/03/1977	0	STK	OPR	2.1	29/03/1977	5285	29/03/1977	0.25	30/11/1999	138.33214	-33.27403	N	N
6531-408	408	WW	3.66	Less than 30m	1/06/1959	0	IRR	OPR	3.66	1/06/1959	7968	7/08/1959	-	30/11/1999	138.30966	-33.2841	N	N
6531-423	423	WW	9.30	Less than 30m	28/03/1977	0			6	28/03/1977	854	28/03/1977	-	30/11/1999	138.35181	-33.28708	N	N
6531-445	445	WW	45.40	30-70m	14/03/1977	0		BKF	18.6	14/03/1977	10448	20/03/1977	0.25	14/03/1977	138.38651	-33.25412	N	N
6531-446	446	WW	15.00	Less than 30m	18/03/1977	15			3	18/03/1977	6960	19/03/1977	0.25	18/03/1977	138.38907	-33.25037	N	N
6531-447	447	WW	16.60	Less than 30m	27/04/1977	0	STK	OPR	9.6	27/04/1977	4595	27/04/1977	-	30/11/1999	138.39364	-33.25248	N	N
6531-448	448	WW	15.05	Less than 30m	27/04/1977	0	STK	OPR	10.3	27/04/1977	6533	27/04/1977	-	30/11/1999	138.40588	-33.25357	N	N
6531-449	449	WW	7.50	Less than 30m	27/04/1977	0	STK	OPR	4.2	27/04/1977	6119	27/04/1977	0.13	27/04/1977	138.4115	-33.25517	N	N
6531-450	450	WW	12.10	Less than 30m	21/04/1977	0	STK	OPR	6.05	21/04/1977	5698	21/04/1977	0.25	21/04/1977	138.41689	-33.25485	N	N
6531-456	456	WW	27.43	Less than 30m	27/02/1956	0	STK	OPR	0	30/11/1999	6069	27/02/1956	-	30/11/1999	138.37602	-33.26825	N	N
6531-457	457	WW	21.21	Less than 30m	18/04/1977	0	STK	OPR	15.15	18/04/1977	2966	18/04/1977	0.76	18/04/1977	138.38621	-33.27468	N	N
6531-458	458	WW	42.40	30-70m	27/03/1977	0	STK	OPR	33.3	27/03/1977	6533	27/04/1977	-	30/11/1999	138.40414	-33.27101	N	N
6531-459	459	WW	66.06	30-70m	21/04/1977	0	STK	OPR	64.24	21/04/1977	7433	21/04/1977	0.25	21/04/1977	138.41651	-33.28672	N	N
6531-460	460	WW	36.27	30-70m	5/08/1958	0	IRR	OPR	0	30/11/1999	4284	5/08/1958	9.47	1/01/1958	138.42276	-33.28364	N	N
6531-599	599	WW	18.90	Less than 30m	26/12/1934	0			17.68	26/12/1934	1357	26/12/1934	2.02	26/12/1934	138.23403	-33.25939	N	N
6531-606	606	WW	70.00	Greater than 70m	30/11/1999	0		ABD	49	11/02/1975	-	30/11/1999	-	30/11/1999	138.18713	-33.27145	N	N
6531-694	694	WW	52.43	30-70m	18/01/1960	0			10.97	18/01/1960	800	18/01/1960	4.42	18/01/1960	138.22755	-33.20448	N	N
6531-695	695	WW	44.20	30-70m	30/11/1999	0			0	30/11/1999	885	29/04/1958	1.14	1/01/1958	138.22756	-33.2046	N	N
6531-696	696	WW	5.50	Less than 30m	25/03/1977	0		ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.22134	-33.20013	N	N
6531-697	697	WW	60.35	30-70m	25/03/1977	0			26.45	25/03/1977	-	30/11/1999	1.26	25/03/1977	138.22197	-33.20199	N	N
6531-698	698	WW	14.00	Less than 30m	25/03/1977	0	STK	OPR	5.2	25/03/1977	1754	24/03/1977	0.25	25/03/1977	138.18922	-33.21317	N	N
6531-702	702	WW	5.94	Less than 30m	31/03/1960	0			2.43	31/03/1960	1157	31/03/1960	-	30/11/1999	138.22305	-33.21672	N	N
6531-703	703	WW	61.57	30-70m	30/11/1999	39.62			0	30/11/1999	985	29/04/1958	1.01	1/01/1958	138.23074	-33.21888	N	N
6531-704	704	WW	1.50	Less than 30m	24/03/1977	0	DOM,STK	OPR	0	30/11/1999	827	24/03/1977	-	30/11/1999	138.21926	-33.22868	N	N
6531-705	705	WW	6.10	Less than 30m	24/03/1977	0	DOM,STK	OPR	5.2	24/03/1977	1216	24/03/1977	0.06	24/03/1977	138.22151	-33.23447	N	N
6531-706	706	WW	4.30	Less than 30m	24/03/1977	0			3.9	24/03/1977	1143	24/03/1977	-	30/11/1999	138.22078	-33.23342	N	N
6531-707	707	WW	24.38	Less than 30m	26/06/1941	0			10.67	26/06/1941	1656	26/06/1941	-	30/11/1999	138.22893	-33.23547	N	N
6531-708	708	WW	36.00	30-70m	24/03/1977	8			10.5	24/03/1977	914	4/07/1941	-	30/11/1999	138.2306	-33.23959	N	N
6531-709	709	WW	36.20	30-70m	24/03/1977	8			11.1	24/03/1977	1928	24/03/1977	-	30/11/1999	138.23061	-33.23955	N	N
6531-710	710	WW	14.70	Less than 30m	24/03/1977	0			6.2	24/03/1977	1021	24/03/1977	0.13	24/03/1977	138.23144	-33.24186	N	N
6531-711	711	WW	35.66	30-70m	26/06/1941	0			7.62	26/06/1941	871	26/06/1941	-	30/11/1999	138.23194	-33.24258	N	N
6531-712	712	WW	17.90	Less than 30m	24/03/1977	0			9.7	24/03/1977	1300	24/03/1977	-	30/11/1999	138.2336	-33.24505	N	N
6531-1135	1135	WW	21.34	Less than 30m	18/01/1980	18.28			7.31	18/01/1980	3712	19/01/1980	3.16	18/01/1980	138.29406	-33.14389	N	N
6531-1137	1137	WW	24.38	Less than 30m	18/01/1980	0		BKF	10.67	18/01/1980	2256	18/01/1980	7.58	18/01/1980	138.29718	-33.1447	N	N
6531-1138	1138	WW	21.34	Less than 30m	23/01/1980	21.34			8.84	23/01/1980	1889	21/01/1980	1.89	23/01/1980	138.29912	-33.14501	N	N
6531-1139	1139	WW	24.40	Less than 30m	3/05/1977	0	STK	OPR	18.78	3/05/1977	7491	3/05/1977	0.13	30/11/1999	138.39422	-33.20958	N	N
6531-1143	1143	WW	24.00	Less than 30m	20/10/1980	0			4	20/10/1980	1608	20/10/1980	11.37	20/10/1980	138.29148	-33.19827	N	N
6531-1146	1146	WW	36.00	30-70m	15/04/1981	36			10	15/04/1981	4291	15/04/1981	0.76	15/04/1981	138.31227	-33.16034	N	N
6531-1150	1150	WW	45.72	30-70m	31/12/1981	45.72			16.15	31/12/1981	7867	31/12/1981	0.63	31/12/1981	138.40075	-33.20172	N	N
6531-1152	1152	WW	63.48	30-70m	1/04/1982	25.6	STK	OPR	54.2	1/04/1982	1384	1/01/1982	0.25	1/04/1982	138.27135	-33.15693	N	N
6531-1161	1161	WW	12.00	Less than 30m	1/03/1983	12			4	1/03/1983	4640	1/03/1983	2.00	1/03/1983	138.31735	-33.23063	N	N
6531-1167	1167	WW	22.00	Less than 30m	11/07/1982	19.2	STK	OPR	8	11/07/1982	1340	20/10/1982	0.62	1/01/1983	138.28921	-33.14726	N	N
6531-1168	1168	WW	28.20	Less than 30m	16/03/1983	16.2	IRR	OPR	5.6	16/03/1983	1597	15/03/1983	1.25	16/03/1983	138.29121	-33.17848	N	N
6531-1170	1170	WW	30.00	30-70m	9/06/1983	0		BKF	11.88	9/06/1983	3396	6/12/1983	-	30/11/1999	138.28805	-33.2411	N	N

UNIT_NO	LABEL	CLASS	MAX_DRILL_	Depth	DRILL_DATE	CASED_TO	PURPOSE	LATE_STATU	SWL	WATER_LEVE	TDS	SALINITY_D	YIELD	DATE_YIELD	DECIMAL_LO	NEG_DECIMA	DRILL_LOG	LITH_LOG
6531-1173	1173	WW	58.20	30-70m	26/01/1984	15.5			21.3	26/01/1984	1177	26/01/1984	4.40	26/01/1984	138.23754	-33.26353	N	N
6531-1174	1174	WW	26.00	Less than 30m	23/03/1984	24.73	IRR	OPR	8.74	23/03/1984	956	8/02/1984	9.50	23/03/1984	138.29122	-33.14125	N	N
6531-1180	1180	WW	25.00	Less than 30m	20/11/1984	25	IRR	OPR	12	20/11/1984	-	30/11/1999	-	30/11/1999	138.29933	-33.14965	N	N
6531-1185	1185	WW	82.30	Greater than 70m	25/09/1985	0		BKF	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.40616	-33.22897	N	N
6531-1186	1186	WW	35.90	30-70m	2/10/1985	17.9	STK	OPR	10	2/10/1985	7678	2/10/1985	1.25	2/10/1985	138.41662	-33.22133	N	N
6531-1190	1190	WW	20.70	Less than 30m	10/02/1986	19			8.6	10/02/1986	1681	8/03/1985	4.42	10/02/1986	138.29948	-33.16138	N	N
6531-1194	1194	WW	5.23	Less than 30m	30/09/1986	0			2	6/10/1986	311	6/10/1986	0.40	30/09/1986	138.2349	-33.26509	N	N
6531-1195	1195	WW	22.80	Less than 30m	19/04/1986	17.69			9.7	4/02/1987	1541	4/02/1987	2.27	19/04/1986	138.29047	-33.13106	N	N
6531-1197	1197	WW	103.00	Greater than 70m	29/04/1987	103			52.1	22/05/1987	849	22/05/1987	0.75	29/04/1987	138.24457	-33.21601	N	N
6531-1200	1200	WW	44.80	30-70m	4/03/1988	6.5			30.3	25/10/1988	8207	25/10/1988	0.37	4/03/1988	138.36096	-33.14539	N	N
6531-1201	1201	WW	121.00	Greater than 70m	30/05/1988	0		BKF	27.2	30/05/1988	-	30/11/1999	0.13	30/05/1988	138.28543	-33.14565	N	N
6531-1202	1202	WW	41.10	30-70m	17/08/1988	0		BKF	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.27536	-33.27964	N	N
6531-1204	1204	WW	26.00	Less than 30m	9/03/1988	18	STK	OPR	18	6/03/1989	7103	6/03/1989	-	30/11/1999	138.39866	-33.22955	N	N
6531-1206	1206	WW	39.60	30-70m	28/05/1989	0		ABD	0	30/11/1999	1727	1/06/1989	-	30/11/1999	138.2681	-33.14584	N	N
6531-1207	1207	WW	45.40	30-70m	31/05/1989	0		ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.26797	-33.14218	N	N
6531-1208	1208	WW	30.30	30-70m	5/06/1989	30.3	STK	OPR	15.7	5/06/1989	-	30/11/1999	0.63	5/06/1989	138.27444	-33.14007	N	N
6531-1209	1209	WW	25.00	Less than 30m	18/04/1989	19.5	DOM	OPR	0	30/11/1999	3956	18/04/1989	-	30/11/1999	138.30178	-33.11026	N	N
6531-1210	1210	WW	36.00	30-70m	12/11/1989	0		BKF	8.5	12/11/1989	1591	12/11/1989	-	30/11/1999	138.30088	-33.13102	N	N
6531-1271	1271	WW	25.00	Less than 30m	29/09/1989	25	DOM	OPR	10	29/09/1989	1783	29/09/1989	-	30/11/1999	138.29232	-33.14544	N	N
6531-1275	1275	WW	11.20	Less than 30m	19/12/1990	11.2	IRR	OPR	6.5	19/12/1990	4503	20/12/1990	0.50	19/12/1990	138.29689	-33.18634	N	N
6531-1276	1276	WW	18.20	Less than 30m	19/12/1990	18.2	IRR	OPR	6.4	19/12/1990	2801	18/12/1990	6.30	19/12/1990	138.28972	-33.179	N	N
6531-1287	1287	WW	36.10	30-70m	29/05/1990	0		BKF	6	29/05/1990	-	30/11/1999	-	30/11/1999	138.29286	-33.14751	N	N
6531-1293	1293	WW	12.80	Less than 30m	25/09/1991	12.8	IRR	OPR	6	25/09/1991	4302	25/09/1991	0.60	25/09/1991	138.29705	-33.18454	N	N
6531-1296	1296	WW	19.00	Less than 30m	15/02/1992	18	DOM	OPR	10	24/03/1992	2063	24/03/1992	0.25	15/02/1992	138.30263	-33.12412	N	N
6531-1454	1454	WW	77.00	Greater than 70m	24/06/1992	0		BKF	40	24/06/1992	5502	5/06/1992	-	30/11/1999	138.37196	-33.21776	N	N
6531-1455	1455	WW	55.00	30-70m	7/11/1991	6.3	STK	OPR	13	7/11/1991	2000	1/11/1991	-	30/11/1999	138.31397	-33.1326	N	N
6531-1456	1456	WW	48.00	30-70m	24/10/1991	18	STK	OPR	13	24/10/1991	3001	16/08/1991	-	30/11/1999	138.30396	-33.12957	N	N
6531-1457	1457	WW	50.00	30-70m	26/10/1991	0		BKF	17.25	26/10/1991	5711	16/08/1991	-	30/11/1999	138.31004	-33.12537	N	N
6531-1459	1459	WW	38.10	30-70m	8/04/1992	0		BKF	4.5	8/04/1992	7114	8/04/1992	1.50	8/04/1992	138.35467	-33.27613	N	N
6531-1462	1462	WW	6.00	Less than 30m	1/03/1993	0			4.3	1/03/1993	1043	1/03/1993	-	30/11/1999	138.35346	-33.28061	N	Y
6531-1463	1463	WW	12.00	Less than 30m	1/03/1993	0			4	1/03/1993	7318	1/03/1993	-	30/11/1999	138.35346	-33.28061	N	Y
6531-1497	1497	WW	24.00	Less than 30m	4/11/1992	18	RCL		7	4/11/1992	2194	9/11/1992	8.62	4/11/1992	138.29517	-33.18672	Y	Y
6531-1498	1498	WW	9.70	Less than 30m	16/12/1993	9.7	IRR		0	30/11/1999	5647	16/12/1993	1.25	16/12/1993	138.30227	-33.19314	Y	N
6531-1499	1499	WW	78.00	Greater than 70m	28/01/1994	59.3	STK		51	28/01/1994	2556	31/01/1994	0.13	28/01/1994	138.38021	-33.22077	Y	N
6531-1503	1503	WW	17.00	Less than 30m	7/07/1994	17	DOM		0	30/11/1999	3052	8/07/1994	0.50	7/07/1994	138.2965	-33.17841	Y	N
6531-1504	1504	WW	13.10	Less than 30m	12/07/1994	13	DOM		0	30/11/1999	1412	12/07/1994	3.00	12/07/1994	138.29102	-33.18911	Y	N
6531-1505	1505	WW	13.40	Less than 30m	14/07/1994	13	IRR		0	30/11/1999	1396	13/07/1994	3.00	14/07/1994	138.2889	-33.19177	Y	N
6531-1506	1506	WW	15.10	Less than 30m	14/04/1994	0	IRR	ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.29952	-33.18478	Y	N
6531-1525	1525	WW	27.00	Less than 30m	9/02/1996	26	STK		0	30/11/1999	1452	9/02/1996	0.53	9/02/1996	138.28782	-33.14693	Y	N
6531-1536	1536	WW	36.00	30-70m	10/04/1997	36	IRR	OPR	3	10/04/1997	2567	10/04/1997	4.00	10/04/1997	138.29554	-33.2305	Y	N
6531-1538	1538	WW	15.20	Less than 30m	19/02/1997	15.2	IRR		7	19/02/1997	1765	19/02/1997	0.50	19/02/1997	138.29796	-33.17646	Y	N
6531-1623	1623	WW	45.00	30-70m	16/12/1997	0	STK	ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.27137	-33.1418	Y	N
6531-1631	1631	WW	72.00	Greater than 70m	7/11/1996	0	STK	ABD	66	7/11/1996	7742	7/11/1996	0.00	7/11/1996	138.36284	-33.20787	Y	N
6531-1642	1642	WW	16.00	Less than 30m	24/10/1997	16	IRR		8	24/10/1997	2210	24/10/1997	5.00	24/10/1997	138.29875	-33.19261	Y	N
6531-1643	1643	WW	19.80	Less than 30m	22/12/1998	19.8	STK		5.4	22/12/1998	1479	22/12/1998	7.50	22/12/1998	138.29224	-33.20527	Y	N
6531-1656	1656	WW	17.60	Less than 30m	25/11/1999	17.6	IRR		9	25/11/1999	1951	25/11/1999	6.00	25/11/1999	138.29031	-33.19525	Y	N
6531-1658	1658	WW	9.90	Less than 30m	2/06/2000	0		ABD	8.53	2/06/2000	-	30/11/1999	-	30/11/1999	138.29546	-33.16933	N	N
6531-1695	1695	WW	64.00	30-70m	16/08/2000	64			38.7	16/08/2000	3460	16/08/2000	0.50	16/08/2000	138.30873	-33.26603	Y	N
6531-1696	1696	WW	48.70	30-70m	27/09/1999	48.7	STK		12	27/09/1999	-	30/11/1999	0.60	27/09/1999	138.28218	-33.25688	Y	N
6531-1705	1705	WW	71.00	Greater than 70m	5/02/2001	0	STK	ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.34263	-33.20731	Y	N
6531-1709	1709	WW	7.50	Less than 30m	27/11/1996	0		BKF	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.35716	-33.26918	Y	N
6531-1710	1710	WW	6.50	Less than 30m	27/11/1996	0		BKF	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.35777	-33.26892	N	Y
6531-1711	1711	WW	7.00	Less than 30m	28/11/1996	0		ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.3578	-33.26959	Y	N
6531-1712	1712	WW	7.00	Less than 30m	3/03/1997	0		ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.35776	-33.2709	Y	N
6531-1713	1713	WW	7.00	Less than 30m	4/03/1997	0		ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.35783	-33.26969	Y	N

UNIT_NO	LABEL	CLASS	MAX_DRILL_	Depth	DRILL_DATE	CASED_TO	PURPOSE	LATE_STATU	SWL	WATER_LEVE	TDS	SALINITY_D	YIELD	DATE_YIELD	DECIMAL_LO	NEG_DECIMA	DRILL_LOG	LITH_LOG
6531-1714	1714	WW	7.00	Less than 30m	4/03/1997	0		ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.35774	-33.27106	Y	N
6531-1715	1715	WW	7.00	Less than 30m	5/03/1997	0		ABD	0	30/11/1999	-	30/11/1999	-	30/11/1999	138.35775	-33.27115	Y	N
6531-1716	1716	WW	19.00	Less than 30m	28/03/2001	19	IRR		9.4	28/03/2001	2036	28/03/2001	6.00	28/03/2001	138.2969	-33.14377	Y	N
6531-1717	1717	WW	20.40	Less than 30m	30/03/2001	20.4	DOM,STK		10.3	30/03/2001	-	30/11/1999	0.60	30/03/2001	138.28978	-33.11948	Y	N
6531-1719	1719	WW	33.00	30-70m	31/12/1999	33	STK		16.5	31/12/1999	-	30/11/1999	0.88	31/12/1999	138.27436	-33.14011	Y	Y
6531-1721	1721	WW	15.00	Less than 30m	26/11/2001	15	STK		8	26/11/2001	-	30/11/1999	0.15	26/11/2001	138.3996	-33.25813	Y	N
6531-1722	1722	WW	41.00	30-70m	23/11/2001	41	STK		20	23/11/2001	-	30/11/1999	0.70	23/11/2001	138.39739	-33.26994	Y	N
6531-1723	1723	WW	18.00	Less than 30m	5/02/2002	18	IRR		8	5/02/2002	-	30/11/1999	4.00	5/02/2002	138.29202	-33.19107	Y	N
6531-1727	1727	WW	19.00	Less than 30m	23/10/2001	19	IRR		8	23/10/2001	-	30/11/1999	5.60	23/10/2001	138.28988	-33.18446	Y	N
6531-1728	1728	WW	14.00	Less than 30m	25/10/2001	14	IRR		8.5	25/10/2001	-	30/11/1999	2.20	25/10/2001	138.29471	-33.1707	Y	N
6531-1743	1743	WW	85.00	Greater than 70m	13/02/2003	85	IRR		64	13/02/2003	1255	13/02/2003	1.00	13/02/2003	138.20209	-33.21099	Y	N
6531-1752	1752	WW	12.00	Less than 30m	22/05/2003	9	IRR		5	22/05/2003	3563	22/05/2003	2.00	22/05/2003	138.29935	-33.21066	Y	N
6531-1753	1753	WW	15.00	Less than 30m	26/06/2003	9	IRR		9	26/06/2003	1912	26/06/2003	2.00	26/06/2003	138.29405	-33.18378	Y	N
6531-1770	1770	WW	18.20	Less than 30m	25/03/2004	12	IRR		9.4	25/03/2004	1194	25/03/2004	3.70	25/03/2004	138.28988	-33.17834	Y	N
6531-1772	1772	WW	35.60	30-70m	22/04/2004	31.6	STK		28.3	22/04/2004	3643	22/04/2004	0.30	22/04/2004	138.34194	-33.21677	Y	N
6531-1782	1782	WW	18.00	Less than 30m	16/11/2004	18			10	16/11/2004	1288	16/11/2004	1.00	16/11/2004	138.29515	-33.14602	Y	N
6531-1783	1783	WW	19.00	Less than 30m	19/11/2004	19	DOM		11	19/11/2004	1278	19/11/2004	1.00	19/11/2004	138.29538	-33.1464	Y	N
6531-1784	1784	WW	19.00	Less than 30m	23/11/2004	13			10	23/11/2004	2688	23/11/2004	1.00	23/11/2004	138.28546	-33.18709	Y	N
6531-1786	1786	WW	20.00	Less than 30m	31/03/2005	14			9.7	31/03/2005	1496	31/03/2005	3.70	31/03/2005	138.29449	-33.17943	Y	N
6531-1789	1789	WW	12.40	Less than 30m	24/05/2005	9	STK		3	24/05/2005	2534	24/05/2005	0.50	24/05/2005	138.29537	-33.22672	Y	N
6531-1790	1790	WW	12.00	Less than 30m	26/05/2005	7	STK		4.2	26/05/2005	4008	26/05/2005	0.50	26/05/2005	138.31415	-33.22077	Y	N
6531-1817	1817	WW	23.00	Less than 30m	17/10/2005	20			9	17/10/2005	1305	17/10/2005	1.00	17/10/2005	138.2942	-33.14228	Y	N
6531-1832	1832	WW	8.20	Less than 30m	4/11/2003	2.4	INV		5.3	4/11/2003	-	30/11/1999	-	30/11/1999	138.35594	-33.27437	N	Y
6531-1833	1833	WW	8.10	Less than 30m	4/11/2003	3.5	INV		5	4/11/2003	-	30/11/1999	-	30/11/1999	138.35617	-33.27459	N	Y
6531-1834	1834	WW	8.30	Less than 30m	4/11/2003	3.5	INV		4.9	4/11/2003	-	30/11/1999	-	30/11/1999	138.35668	-33.27394	N	Y
6531-1835	1835	WW	8.00	Less than 30m	4/11/2003	3.5	INV		4.7	4/11/2003	-	30/11/1999	-	30/11/1999	138.35637	-33.27387	N	Y
6531-1836	1836	WW	8.20	Less than 30m	5/11/2003	3.25	INV		5	5/11/2003	-	30/11/1999	-	30/11/1999	138.35594	-33.27402	N	Y
6531-1837	1837	WW	8.40	Less than 30m	5/11/2003	3.4	INV		5	5/11/2003	-	30/11/1999	-	30/11/1999	138.35606	-33.2739	N	Y
6531-1866	1866	WW	23.00	Less than 30m	24/11/2006	19			9	24/11/2006	1197	24/11/2006	0.70	24/11/2006	138.2972	-33.14339	Y	N
6531-1867	1867	WW	20.70	Less than 30m	2/12/2006	15.7			13	2/12/2006	2132	2/12/2006	0.10	2/12/2006	138.29701	-33.14525	Y	N
6531-1870	1870	WW	19.20	Less than 30m	26/05/2007	12			8.5	26/05/2007	3494	26/05/2007	3.00	26/05/2007	138.29297	-33.19349	Y	N
6531-1873	1873	WW	19.00	Less than 30m	3/04/2007	19			9	3/04/2007	1519	3/04/2007	2.00	3/04/2007	138.2958	-33.17935	Y	N
6531-1882	1882	WW	24.00	Less than 30m	8/05/2008	0		BKF	8.5	8/05/2008	1401	8/05/2008	1.00	8/05/2008	138.28683	-33.1963	Y	N
6531-1883	1883	WW	16.00	Less than 30m	9/05/2008	16			8.5	9/05/2008	1423	9/05/2008	3.70	9/05/2008	138.28845	-33.1961	Y	N
6531-1884	1884	WW	119.00	Greater than 70m	14/05/2008	0		BKF	0	14/05/2008	3471	14/05/2008	-	30/11/1999	138.23944	-33.18646	Y	N
6531-1885	1885	WW	87.00	Greater than 70m	15/05/2008	40			42	15/05/2008	-	30/11/1999	0.70	15/05/2008	138.26301	-33.19776	Y	N
6531-1893	1893	WW	28.60	Less than 30m	23/01/2008	25			19	23/01/2008	502	23/01/2008	1.00	23/01/2008	138.20553	-33.19926	Y	N
6531-1894	1894	WW	22.00	Less than 30m	25/01/2008	22			9	25/01/2008	1210	25/01/2008	0.60	25/01/2008	138.2941	-33.143	Y	N
6531-1895	1895	WW	13.00	Less than 30m	24/01/2008	11			10	24/01/2008	4671	24/01/2008	0.60	24/01/2008	138.2969	-33.18395	Y	N

APPENDIX B DRILLERS AND/OR LITHOLOGY LOGS


N
1717(20,-,0.6)
1719(33,-,0.08)
1623(45,-,-)
1817(23,1305,1)
1694(22,1210,0.6)
1800(23,1197,0.7)
1867(21,2132,0.1)
1525(27,1452,0.53)
1786(20,1496,3.7)
1884(119,3471,-)
1497(24,2194,8.62)
1893(29,502,1)
1885(87,-,0.7)
1882(24,1401,1)
1743(85,1255,1)
1705(71,-,-)
1631(72,7742,0)
1772(36,3643,0.3)
1499(78,2556,0.13)
1536(36,2557,4)
1696(49,-,0.6)
1695(64,3460,0.5)
1722(41,-,0.7)
Wells - Prefix 6531
Unit Number (Depth, mBGL, TDS, mg/L)
Yield, L/s)
Depth 20-30mBGL
Depth 30-70mBGL
Depth greater than 70mBGL
Well Status
Operational
Backfilled/Abandoned
Unknown
0
5 km

Unit No	Log Date	Logger Name	Depth From	Depth To	Lith Code	Description
6531-1497	4/11/1992	ASLAT C H	0	18	TPSL	TOP SOIL sand and gravel
6531-1497	4/11/1992	ASLAT C H	18	24	GRVL	GRAVEL sand to pipe clay silted sand
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1499	28/01/1994	ASLAT C H	0	6	CLYU	Red clay
6531-1499	28/01/1994	ASLAT C H	6	11.3	SDST	Yellow sandstone quartz boulders
6531-1499	28/01/1994	ASLAT C H	11.3	12.3	SLST	Yellowy siltstone
6531-1499	28/01/1994	ASLAT C H	12.3	14.6	SLAT	Grey yellow slate
6531-1499	28/01/1994	ASLAT C H	14.6	21	CLYU	Mottled yellow pipe clay
6531-1499	28/01/1994	ASLAT C H	21	24	SDST	Yellow & white sandstone
6531-1499	28/01/1994	ASLAT C H	24	26.3	SLAT	Blue yellow slate
6531-1499	28/01/1994	ASLAT C H	26.3	32	SDST	Brown sandstone soft
6531-1499	28/01/1994	ASLAT C H	32	54	SDST	White sandstone yellow siltstone content
6531-1499	28/01/1994	ASLAT C H	54	58	SLAT	Blue black slate with yellow siltstone & clay quartz / sandstone
6531-1499	28/01/1994	ASLAT C H	58	58.3	CLYU	Pipe clay content
6531-1499	28/01/1994	ASLAT C H	58.3	78	SDST	Grey brown white sandstone to quartzite - variations in hardness
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1525	9/02/1996	ASLAT C	0	6	CLYU	Sandy clay, limestone rubble
6531-1525	9/02/1996	ASLAT C	6	7	SDST	Sandstone
6531-1525	9/02/1996	ASLAT C	7	8	CLYU	Red clay
6531-1525	9/02/1996	ASLAT C	8	9.3	SDST	Grey sandstone
6531-1525	9/02/1996	ASLAT C	9.3	11	CLYU	White red clay
6531-1525	9/02/1996	ASLAT C	11	11.3	CLYU	Yellow sandy clay
6531-1525	9/02/1996	ASLAT C	11.3	19	CLYU	Yellow white sandy clay
6531-1525	9/02/1996	ASLAT C	19	26	SAND	Fine white sand
6531-1525	9/02/1996	ASLAT C	26	27	CLYU	Yellow white mottled clay

Unit No	Log Date	Logger Name	Depth From	Depth To	Lith Code	Description
6531-1536	10/04/1997	THOMAS D	0	2	LOAM	brown loam
6531-1536	10/04/1997	THOMAS D	2	34	CLYU	yellow clay
6531-1536	10/04/1997	THOMAS D	34	36	GRVL	creek gravel
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1623	16/12/1997	MAYNARD S	0	3	SDST	Sandstone & rubble
6531-1623	16/12/1997	MAYNARD S	3	15	CLYU	Red clay
6531-1623	16/12/1997	MAYNARD S	15	24	CLYU	Very sandy clay
6531-1623	16/12/1997	MAYNARD S	24	45	SAND	Sand
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1631	7/11/1996	ASLAT C H	0	3	CLYU	Red clay
6531-1631	7/11/1996	ASLAT C H	3	35	SDST	Yellow clayey sandstone
6531-1631	7/11/1996	ASLAT C H	35	38	SLST	Yellow siltstone
6531-1631	7/11/1996	ASLAT C H	38	49	SDST	White sandstone
6531-1631	7/11/1996	ASLAT C H	49	60	SLST	Brown clayey siltstone
6531-1631	7/11/1996	ASLAT C H	60	62	SDST	Grey-brown sandstone
6531-1631	7/11/1996	ASLAT C H	62	72	SDST	Harder, white-brown sandstone
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1695	16/08/2000	THOMAS D	0	5	CLYU	red clay
6531-1695	16/08/2000	THOMAS D	5	25	SDST	red sandstone
6531-1695	16/08/2000	THOMAS D	25	38	SDST	white sandstone
6531-1695	16/08/2000	THOMAS D	38	50	SDST	hard sandstone and quartz
6531-1695	16/08/2000	THOMAS D	50	52	ROCK	broken rock
6531-1695	16/08/2000	THOMAS D	52	64	QUAR	white quartz
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1696	27/09/1999	THOMAS D	0	3	CLYU	sticky red clay
6531-1696	27/09/1999	THOMAS D	3	40	SDST	white sandstone
6531-1696	27/09/1999	THOMAS D	40	48.7	SDST	hard sandstone to quartzite

Unit No	Log Date	Logger Name	Depth From	Depth To	Lith Code	Description
6531-1705	5/02/2001	THOMAS D D	0	3	SOIL	red soil
6531-1705	5/02/2001	THOMAS D D	3	71	SDST	grey sandstone NO WATER
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1717	30/03/2001	THOMAS D D	0	3	TPSL	Red dirt
6531-1717	30/03/2001	THOMAS D D	3	4	GRVL	Gravel
6531-1717	30/03/2001	THOMAS D D	4	7	CLYU	Red clay
6531-1717	30/03/2001	THOMAS D D	7	19	CLYU	Yellow gravelly clay
6531-1717	30/03/2001	THOMAS D D	19	20.5	SAND	White sand
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1719	31/12/1999	ASLAT C H	0	12	TPSL	Top soil
6531-1719	31/12/1999	ASLAT C H	12	29	SAND	White sand
6531-1719	31/12/1999	ASLAT C H	29	30	SDST	Very hard brown sandstone
6531-1719	31/12/1999	ASLAT C H	30	30.1	SAND	Sand, white and silica content
6531-1719	31/12/1999	ASLAT C H	30.1	30.6	SAND	Sand
6531-1719	31/12/1999	ASLAT C H	30.6	32	SDST	Hard brown sandstone
6531-1719	31/12/1999	ASLAT C H	32	33	SAND	Sand, silica
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1722	23/11/2001	THOMAS D D	0	3	TPSL	Red top soil
6531-1722	23/11/2001	THOMAS D D	3	6	CLYU	Yellow clay
6531-1722	23/11/2001	THOMAS D D	6	20	SHLE	Yellow shale
6531-1722	23/11/2001	THOMAS D D	20	38	SLAT	Grey slate
6531-1722	23/11/2001	THOMAS D D	38	39	ROCK	Broken rock
6531-1722	23/11/2001	THOMAS D D	39	41	ROCK	Blue rock
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1743	13/02/2003	THOMAS D D	0	5	SOIL	red dirt and clay
6531-1743	13/02/2003	THOMAS D D	5	76	SDST	yellow sandstone
6531-1743	13/02/2003	THOMAS D D	76	78	SDST	broken sandstone
6531-1743	13/02/2003	THOMAS D D	78	85	SDST	yellow sandstone

Unit No	Log Date	Logger Name	Depth From	Depth To	Lith Code	Description
6531-1772	22/04/2004	THOMAS D D	0	5	CLYU	Brown sticky clay
6531-1772	22/04/2004	THOMAS D D	5	10	CLYU	Red sticky clay
6531-1772	22/04/2004	THOMAS D D	10	31	SDST	Mainly white sandstone
6531-1772	22/04/2004	THOMAS D D	31	35.6	SAND	Sand, carrying water
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1786	31/03/2005	THOMAS D D	0	15	CLYU	Red gritty clay
6531-1786	31/03/2005	THOMAS D D	15	18	CLYU	Gravelly clay
6531-1786	31/03/2005	THOMAS D D	18	19	GRVL	Gravel and sand, cuttting water
6531-1786	31/03/2005	THOMAS D D	19	20	CLYU	Red clay
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1817	17/10/2005	THOMAS D D	0	3	CLYU	Red sandy clay
6531-1817	17/10/2005	THOMAS D D	3	15	CLYU	Red gravelly clay
6531-1817	17/10/2005	THOMAS D D	15	22	CLYU	Yellow clay
6531-1817	17/10/2005	THOMAS D D	22	23	SAND	Sand and gravel
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1866	24/11/2006	THOMAS D D	0	5	CLYU	Red silty clay
6531-1866	24/11/2006	THOMAS D D	5	16	CLYU	Red gravelly clay
6531-1866	24/11/2006	THOMAS D D	16	22	SDST	Pink sandstone
6531-1866	24/11/2006	THOMAS D D	22	23	SAND	Sand, cutting water
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1867	2/12/2006	THOMAS D D	0	8	CLYU	Red silty clay
6531-1867	2/12/2006	THOMAS D D	8	19.7	CLYU	Pink clay
6531-1867	2/12/2006	THOMAS D D	19.7	20.7	SAND	Yellow sand
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1882	8/05/2008	THOMAS D D	0	10	CLYU	Red silty CLAY
6531-1882	8/05/2008	THOMAS D D	10	22	CLYU	Gravelly CLAY
6531-1882	8/05/2008	THOMAS D D	22	23	GRVL	GRAVEL cutting water
6531-1882	8/05/2008	THOMAS D D	23	24	CLYU	Yellow CLAY

Unit No	Log Date	Logger Name	Depth From	Depth To	Lith Code	Description
6531-1884	14/05/2008	THOMAS D D	0	7	CLYU	Red sandy CLAY
6531-1884	14/05/2008	THOMAS D D	7	15	SDST	Red SANDSTONE
6531-1884	14/05/2008	THOMAS D D	15	33	SDST	Yellow SANDSTONE
6531-1884	14/05/2008	THOMAS D D	33	119	SDST	Grey SANDSTONE with red bars, no water at all
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1885	15/05/2008	THOMAS D D	0	3	CLYU	Red sandy CLAY
6531-1885	15/05/2008	THOMAS D D	3	20	CLYU	Sticky red CLAY
6531-1885	15/05/2008	THOMAS D D	20	35	SDST	White SANDSTONE
6531-1885	15/05/2008	THOMAS D D	35	80	SDST	Yellow SANDSTONE hard bars, quartz
6531-1885	15/05/2008	THOMAS D D	80	82	QUAR	Broken white QUARTZ cutting water
6531-1885	15/05/2008	THOMAS D D	82	87	QUAR	Hard yellow QUARTZ
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1893	23/01/2008	THOMAS D D	0	3	TPSL	Brown TOP SOIL and clay
6531-1893	23/01/2008	THOMAS D D	3	8	QUAR	Hard blue QUARTZ
6531-1893	23/01/2008	THOMAS D D	8	26	SDST	Yellow SANDSTONE
6531-1893	23/01/2008	THOMAS D D	26	28.6	QUAR	Broken blue and white QUARTZ cutting water
Unit No	**Log Date**	**Logger Name**	**Depth From**	**Depth To**	**Lith Code**	**Description**
6531-1894	25/01/2008	THOMAS D D	0	6	CLYU	Red CLAY
6531-1894	25/01/2008	THOMAS D D	6	8	GRVL	Creek GRAVEL
6531-1894	25/01/2008	THOMAS D D	8	15	CLYU	Yellow CLAY
6531-1894	25/01/2008	THOMAS D D	15	20	SDST	White SANDSTONE
6531-1894	25/01/2008	THOMAS D D	20	22	SAND	SAND cutting water

APPENDIX C

WAA Permit

STANDARD CONDITIONS – likely to be included on WAA permit for watercourse/floodplain works

1. Construction must be completed within 12 months of the date of this permit.
2. All work must be in accordance with the permit application received by the Northern & Yorke Natural Resources Management Board (XX/XX/XX).
3. Where possible, habitat must be protected during the undertaking of the works.
4. The excavation of rock, sand or soil must not adversely impact on either the ecology of the subject watercourse or the migration of aquatic biota.
5. The excavation of rock, sand or soil must not result in erosion to the site.
6. The excavation of rock, sand or soil must not cause bed or bank instability to the watercourse.
7. The excavation of rock, sand or soil must not result in sedimentation to the watercourse.
8. The excavation of rock, sand or soil must not result in a decline of water quality in the water course or alter the natural flow regime of the watercourse.
9. If any work is undertaken when there is water present in the watercourse, erosion control measures, such as hay bale barriers and sediment fences, must be employed to prevent sediment washing downstream.
10. The placement of structures shall not affect the natural flow regime of the watercourse.
11. Structures placed in the watercourse must not interfere with the migration of aquatic biota, result in an increase in erosion up or downstream of the structure or have detrimental off-site impacts.
12. There must be a minimum distance of 40 metres between the watercourse and the fuelling site for machinery used to undertake the work.
13. Material placed over culverts must be compacted to prevent movement of loose material.
14. Any soil stockpiled during construction, must be located away from the bed and tops of the banks of the watercourse to prevent erosion and sedimentation to the watercourse.
15. The works undertaken must not increase flooding upstream or downstream of the work or cause an alteration to the natural flow regime of the watercourse.

ADDITIONAL CONDITIONS (if required)

16. Pipes must be laid parallel to the bed of the watercourse and located so that the invert is below the bed of the watercourse by an amount 0.25–0.3 times the thickness of the pipe.
17. There must be adequate airspace in the concrete pipes above the typical base flow in the stream to ensure reasonable light in the culverts and thus encourage fish passage, and allow the capacity for flow of water.
18. Rock armour must be used on the bed and banks of the watercourse for a distance of no less than 3 metres downstream of the crossing and for a distance of no less than the length of the pipes upstream of the crossings.
19. To ensure stability of the site, the area around the works should be fenced off and revegetated with suitable indigenous plants once construction is complete.
20. Earth embankments over the concrete pipe should be compacted to achieve 95% maximum dry density.

21. Riprap consisting of rock of a thickness of a minimum of 300 mm should be placed immediately downstream of the culvert to prevent scouring and watercourse erosion.
22. The pipe must be buried below the bed of the watercourse to facilitate the movement of aquatic biota.
23. All work must be carried out in accordance with the additional information submitted with and forming part of the permit application.
24. The alteration/repair/construction of the crossing must not result in a change to the natural timing or duration of ponding upstream or result in a loss of downstream/upstream connectivity of ecosystems.
25. The alteration/repair of the crossing must not cause detrimental impacts on water dependent ecosystems through, but not limited to, habitat destruction, alteration of flows or structures affecting fauna migration.
26. Construction of the crossing must not result in the destruction of native vegetation or vegetation significant as habitat.
27. The removal of any non-native vegetation during the excavation works must not cause erosion to the bed or bank of the watercourse.
28. The excavation of rock, sand or soil must not adversely impact on either the ecology of the subject watercourse or the migration of aquatic biota.

Notes:

1. Upon completion of the subject works the WAA Works Completion Form must be completed and returned to the issuing authority within 7 (seven) days.
2. In South Australia, native vegetation is protected by the *Native Vegetation Act 1991*. In most cases, the clearance of native vegetation requires the consent of the Native Vegetation Council.
3. This permit is not transferable.