Stormwater Management Report
Yarranlea Solar

within
Toowoomba Regional Council

for

YARRANLEA SOLAR PTY LTD

YARRANLEA SOLAR

Project 15-282

icubed consulting
innovation ingenuity inspiration
ABN 89 106 675 156

Level 2, 39 Sherwood Road
Toowong, Qld 4066

mail@icubed.com.au
www.icubed.com.au

P +61 7 3870 8888

consulting

Prepared By	Travis Smith
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Engineers Certification

Travis Smith
RPEQ 6750

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Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

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Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

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Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

1. Introduction

1.1 Background

icubed consulting was commissioned to undertake the stormwater quantity and quality documentation required for a Renewable Energy Facility (100MW) for Yarranlea Solar Pty Ltd over land located at 538 and 752 Yarranlea Road, Yarranlea. The subject land can be further identified as lots 3347 on A341649, 2 on RP18249, 2 on A34925, 2 on RP7475.

The proposed development will comprise of a Renewable Energy Facility (100MW) and ancillary uses, being office and sales display. The development will be completed in up to four (4) stages.

The proposed development is shown on drawing 15-282-A01 in Appendix A.

1.2 Objectives

This report has been compiled to address the stormwater quality and quantity requirements of the State Planning Policy 2014.

1.3 Scope

The scope of this report encompasses in detail the post construction phase of development; however the construction phase is briefly addressed.

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

2. Location

The proposed sites are located at 538 and 752 Yarranlea Road, Yarranlea. The subject land can be further identified as lots 3347 on A341649, 2 on RP18249, 2 on A34925, 2 on RP7475. The site is accessible from Pittsworth Tummaville Road. The site is graded from the east to the west at approximately 1.0%, and has a series of existing diversion bunds across the site.

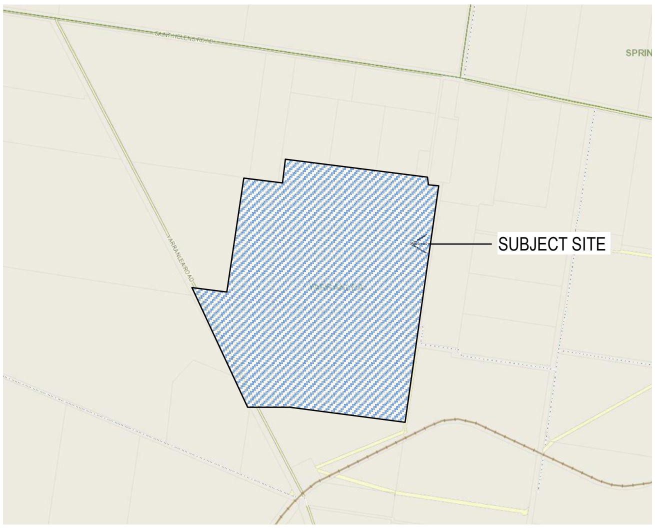

Figure 1: Locality Plan, (2016, Copyright Near Map) – Not to scale, generally indicative only.
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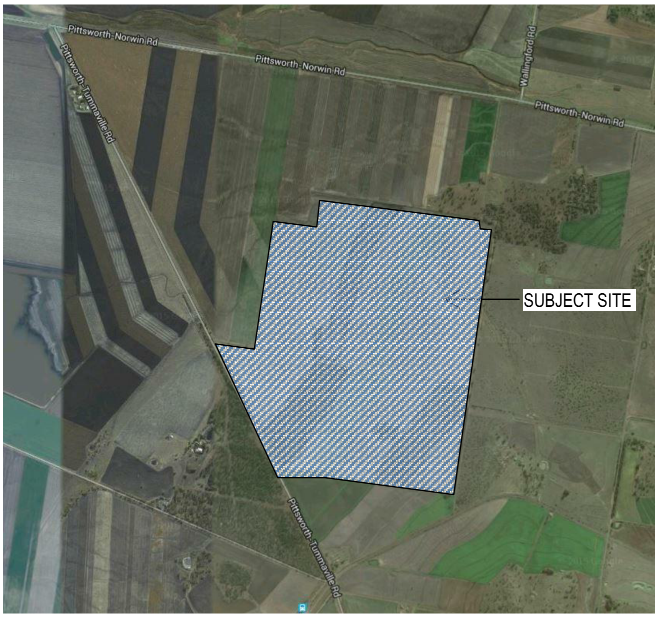

Figure 2: Aerial Photo, (2016, Copyright Near Map) – Not to scale, generally indicative only.
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Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

3. Site Hydrology

3.1 Method and Approach

The stormwater discharges from this site were calculated using the rational method. This method as described in the Queensland Urban Drainage Manual (QUDM) is commonly used in municipal hydrology and is more than adequate for the design requirements. The Rational Method is based around the Rational formula:

$$Q_y = \frac{C_y \, {}^tI_y A}{360}$$

Where:

- Q_y = Peak flow rate (m^3/s) for the average recurrence interval (ARI) of y years
- C_y = Coefficient of runoff for ARI of y years
- A = Area of catchment (ha)
- ${}^tI_y$ = Average rainfall intensity (mm/hr) for design duration of t hours and an ARI of y years.

When designing the stormwater drainage system the following points have been considered:

Stormwater treatment shall be designed for a 3 month storm event, calculated as Q_1 x 0.5; and Stormwater reticulation is to cater for $Q_{3\ month}$ and Q_{20} storm events.

For the purposes of this stormwater quality assessment, the area of the proposed development requiring stormwater quality treatment has been divided up into 2 catchments:

Table 1 details catchment names, areas and storm event flows for each of the 2 catchments based on the Rational Formula. Refer to Appendix B for details of catchment calculations and Appendix A, drawing 15-282-C02, for catchment areas.

Table 1: Catchment and Flow

Catchment	Area	*Minor Storm Event Q_{20}*		*Treatable Storm Event $Q_{3\ month}$*	
		Intensity	Discharge	Intensity	Discharge
Catchment A - PV Array	254.61 ha	65 mm/hr	42.29 m^3/s	17 mm/hr	8.42 m^3/s
Catchment B - Substation Site	1.00 ha	237 mm/hr	0.61 m^3/s	52 mm/hr	0.10 m^3/s

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

4. Upstream Catchment Review

There is an existing upstream catchment located to the east of the development. There is an existing channel along the eastern and northern boundaries of the site that diverts the runoff past the proposed development. This will be maintained as part of the proposed development as such there will be no impact from the development on this catchment. Figure 3 shows the location of the catchment and existing channel. Figure 4 show the existing channel.

The Toowoomba Regional Council planning scheme indicates that there are two waterway corridors which constrain the site as detailed on drawing 15-282-A01. Extensive investigation of the development area has found that this mapping is inaccurate. The historical agricultural activities and soil conservation features are such that drainage flow paths vary significantly from the mapped information. Our investigation has included a full aerial survey of the projected area and physical inspections.

The eastern flowpath is currently fully cultivated and cropped with a significant swale provided on the eastern boundary of the site which diverts the flow to the north and along the northern boundary of the site before being discharge at the north western corner of the site. Based on the site inspection this flow does not reenter the development site.

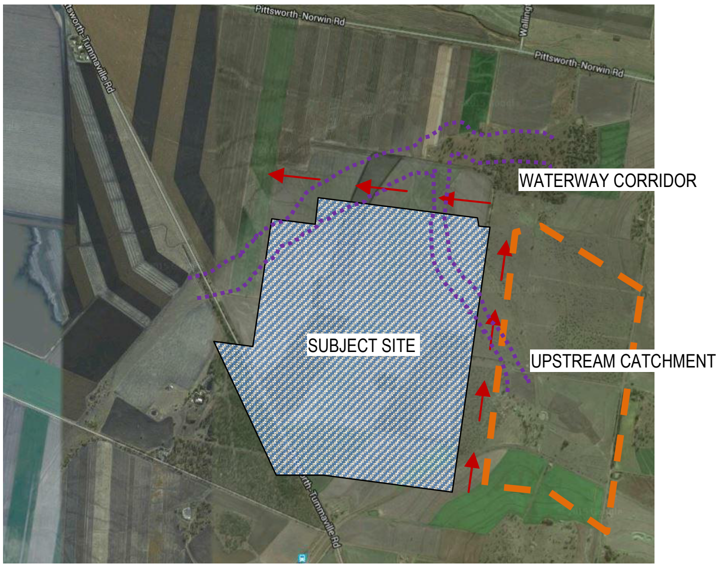


Figure 3: Diversion Plan, (2016, Copyright Near Map) – Not to scale, generally indicative only.
Source: Near Map

Figure 4: Existing Drainage Channel, (2016) – Not to scale, generally indicative only.
Source: Site Inspection 02/06/2016

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

5. Water Quantity

The water quantity strategy for the development will be split into the two distinct areas of the site, the Photovoltaic Array and the Substation. These are discussed in deal below.

5.1 Photovoltaic Array

The Photovoltaic Array ground surface level will remain undeveloped as the panels will be pole mounted with the runoff discharging to the surface and traversing the undeveloped pervious surface to the outlet. The existing soil conservation plan, and contour banks across the site will be repaired as required and maintained for the life of the project. As such there will not be an increase in runoff from the Photovoltaic Array and no water quantity mitigation will be required.

5.2 Substation

The substation stormwater quantity mitigation will consist of a detention basin integrated into the bioretention basin. The modelling for the detention basin has been detailed below.

5.2.1 Predevelopment Flows

The predevelopment flows for the site are based of the catchment characteristics of the predevelopment site. The predevelopment runoff from the site was calculated using the ILSAX method within Watercom Drains. The runoff was calculated at the outlet at the north western corner of the site and has been summarised in Table 2.

5.2.2 Detention Storage

The detention storage within the basin was calculated by Watercom DRAINS. The inflow and outflow hydrographs are shown in Appendix C. The hydrographs clearly show that the runoff entering the system has been greatly reduced so that in conjunction with the remaining unmitigated flow there is less than the existing amount of runoff entering the downstream system. The 15 minute duration storm was found to be the worst case scenario.

The hydrographs are for the storms:

Major events:
- AR&R 100 year, 15 minute storm, Zone 2
- AR&R 50 year, 15 minute storm, Zone 2

Minor events:
- AR&R 20 year, 15 minute storm, Zone 2
- AR&R 10 year, 15 minute storm, Zone 2
- AR&R 5 year, 15 minute storm, Zone 2
- AR&R 2 year, 15 minute storm, Zone 2
- AR&R 1 year, 15 minute storm, Zone 2

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

Designed Basin size:
Basin 1 will be an approximately 20m long by 10m wide with a detention depth of 0.65m. The minimum volume will be approximately 247m³.

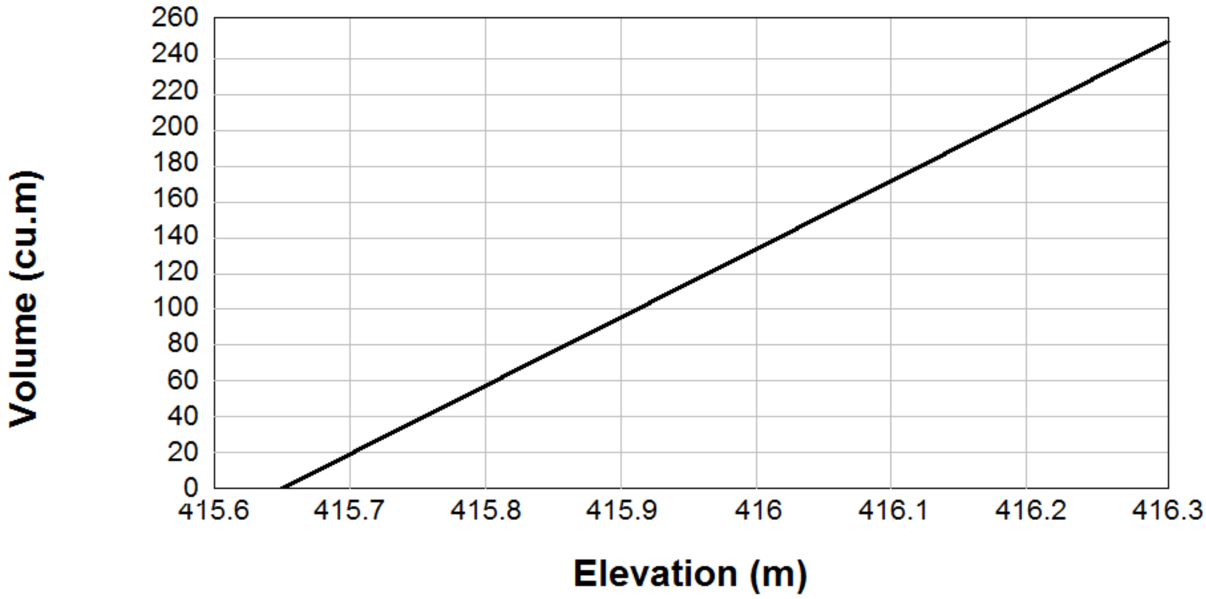


Figure 5: Volume vs Elevation for Basin 1

Based on outputs from DRAINS for Pre development, Post development and Mitigated Flows, the basin is shown to adequately mitigate post development flows at the site outlet for all cases.

Table 2: Detention Basin Flow Mitigation Table

Event Frequency (years)	Pre Development Flows (DRAINS)	Post Development Flows (DRAINS)	Mitigated Flows (DRAINS)
1	0.023 m³/s	0.162 m³/s	0.022 m³/s
2	0.059 m³/s	0.218 m³/s	0.023 m³/s
5	0.094 m³/s	0.274 m³/s	0.024 m³/s
10	0.115 m³/s	0.308 m³/s	0.025 m³/s
20	0.146 m³/s	0.357 m³/s	0.026 m³/s
50	0.188 m³/s	0.412 m³/s	0.115 m³/s
100	0.221 m³/s	0.465 m³/s	0.219 m³/s

Inflow/Outflow and Storage data for worst case durations for each event modeled have been included in Appendix C.

The calibration of the DRAINS model has been checked using the rational method and results have been included Appendix B.

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

6. Water Quality

6.1 Construction Phase

Potential exists during the construction phase for sediment to become mobilised by stormwater as suspended solids from the erosion of exposed soil areas and stockpiles, and as a result of spillages from construction and plant operations.

Stormwater quality during the construction phase of the development should be addressed in an Erosion and Sediment Control Plan. The plan should address construction phase erosion and sediment control issues in accordance with the International Erosion Control Association (IECA) Erosion and Sediment Control Guidelines. The Erosion and Sediment Control Plan should also be in accordance with the Water Sensitive Urban Design Guidelines for South East Queensland.

The following measures should generally be implemented prior to the commencement of construction:

- Education of all site workers in sediment and erosion procedures;
- Specified storage areas for construction materials and plant that are bunded to prevent any spillages from escaping; and
- Construction of silt fences and catch drains adjacent to the downstream boundaries to divert runoff to temporary sediment basins.

The following measures should be implemented during the construction phase of the project:

- Temporary sedimentation basins should be constructed in accordance with Council's requirements;
- Silt fences should be erected downstream of all disturbed areas; and
- All erosion and sediment control devices should be regularly inspected and maintained following storm events.

Level 2, 39 Sherwood Road
Toowong QLD 4066

mail@icubed.com.au
www.icubed.com.au

P: 07 3870 8888
F: 07 3870 8988

6.2 Operational Phase

During the operational stage of the development, the following impacts have been identified in relation to stormwater runoff and water quality of the receiving waterways:

- Potential exists for gross pollutants which include human derived litter, course sediment and vegetation affecting the drainage capacity of stormwater systems. Gross pollutants are also typically unsightly reducing the visual amenity of the site. Gross pollutants can also physically affect the downstream waterway habitats and organisms such as entangling birds and marine animals in plastic;

- Sediment and Suspended Solids can become mobilised by stormwater as suspended solids from the erosion of exposed soil areas, un-mulched garden beds and sediment deposited on car park and hardstand areas by vehicles and by atmospheric deposition of sediment. Sediment can affect receiving waterways physically through smothering aquatic flora and fauna. Sediments can also block stormwater systems leading to local flooding. Suspended solids may also be used as a transport medium for nutrients and heavy metals making their way into waterways; and

- Nutrients can enter the waterways from stormwater runoff through many sources including, detergents used in car washing, fertilizers from landscaping and lawn areas, nitrous oxide deposition from vehicle exhausts, and organic waste. Large nutrient levels can lead to eutrophication of the receiving waterways resulting in algal blooms and excessive macrophyte growth.

Implementation of the appropriate SQID's would ensure that stormwater leaving the developed site shall be acceptable to Healthy Waterways, Water Sensitive Urban Design Guidelines for South East Queensland's requirements.

6.3 Selection of Stormwater Management Objectives

6.3.1 Substation Site

The Performance Criteria required to be met for discharges from development sites during the 'operational' (post-construction) phase of the development is detailed in Table B: Post construction phase – stormwater management design objectives, Part H Appendixes of the State Planning Policy 2014.

The load-reduction targets that must be achieved when assessing the post-developed sites treatment train, (comparison of unmitigated developed case versus developed mitigated case) are listed in Table 3.

Table 3: Stormwater Quality Objectives for the Site. (Operational Stage)

Pollutant Issues	Load Reduction Objectives (%)
Total Suspended Solids	85
Total Phosphorus	60
Total Nitrogen	45
Total Gross Pollutants	90

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

6.3.2 PV Array

Due to the low impact of the PV Array on the water quality in comparison to the existing agricultural land use, the process and objectives as outlined in the State Planning Policy 2014 are not relevant or practical.

The existing agricultural use pollutant load is based on the sediment runoff from cultivation of the land (TSS) and application of the fertiliser (TP & TN). As part of the proposed land use the site is expected to be planted out with legumes to stabilise the soil and no fertiliser will be required.

As such the stormwater management objectives will be based on a baseline of the existing pollutant rates with the objective being to provide an overall reduction.

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

6.4 Predevelopment Catchment Annual Pollutant Loads

An assessment of stormwater quality was undertaken for the developed unmitigated site. The discharge concentrations of key pollutants from the site were then compared to the Water Quality Objectives. The pollutant concentrations were obtained by running a MUSIC model with the model parameters sourced from the Water by Design MUSIC Modelling Guidelines. MUSIC is the Model for Urban Stormwater Improvement Conceptualisation, developed by the MUSIC Development Team of the CRC for Catchment Hydrology.

MUSIC has the ability to simulate quality of runoff from catchments ranging from a single house block up to many square kilometres, and the effect of a wide range of treatment facilities on the quality of runoff downstream. By simulating the performance of stormwater quality improvement measures, MUSIC determines if proposed systems can meet specified water quality objectives.

6.4.1 Substation Site

Table 4 details the MUSIC parameters utilised in running the model.

Table 4: MUSIC Model Parameter Summary

Meteorological Data	TOOWOOMBA (41467) Toowoomba Data 1961-1970 6 minute BOM
Source Node	Industrial
Effective Impervious Area	2%
Effective Pervious Area	98%
Modelling Time Steps	6 Minute
Drainage Link	No Routing
Pollutant Concentration	Industrial
Soil Properties	Industrial
Treatment Devices	Bioretention Basins

MUSIC calculated the following annual pollutant loads for the catchment:

Table 5: Predevelopment Annual Pollutant Loads

Pollutant	**Annual Load**
Total Suspended Solids	379 kg/yr
Total Phosphorus	0.994 kg/yr
Total Nitrogen	6.69 kg/yr
Total Gross Pollutants	93.7 kg/yr

The above loads have been based on land use as an Industrial site as designated in the Water by Design MUSIC Modelling Guidelines.

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

6.4.2 PV Array

Table 6 details the MUSIC parameters utilised in running the model.

Table 6: MUSIC Model Parameter Summary

Meteorological Data	TOOWOOMBA (41467) Toowoomba Data 1961-1970 6 minute BOM	
	Pre Development	**Post Development**
Source Node	Agricultural	Rural Residential
Effective Impervious Area	2%	2%
Effective Pervious Area	98%	98%
Modelling Time Steps	6 Minute	6 Minute
Drainage Link	No Routing	No Routing
Pollutant Concentration	Agricultural	Rural Residential
Soil Properties	Agricultural	Rural Residential
Treatment Devices		Buffer

MUSIC calculated the following annual pollutant loads for the catchment:

Table 7: Predevelopment Annual Pollutant Loads

Pollutant	Annual Load
Total Suspended Solids	20000 kg/yr
Total Phosphorus	21.9 kg/yr
Total Nitrogen	121 kg/yr
Total Gross Pollutants	156 kg/yr

The above loads have been based on land use as an Agricultural site as designated in the Water by Design MUSIC Modelling Guidelines.

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

6.5 Selection of Stormwater Treatment Options

6.5.1 Substation Site

Based on the understanding of Toowoomba Regional Councils requirements for stormwater quality treatment for Industrial sites a Bioretention Basin has been utilised as the Stormwater Quality Improvement Devices for this site.

6.5.1.1 Bioretention Basins

Bioretention basins are vegetated areas where runoff is filtered through a filter media layer as it percolates downwards. It is then collected via perforated under-drains and flows to downstream waterways or to storages for reuse. Bioretention basins often use temporary ponding above the filter media surface to increase the volume of runoff treated through the filter media. They treat stormwater in the same way as bioretention swales; however, 'above design' flows are conveyed through overflow pits or bypass paths rather than over the filter media. This has the advantage of protecting the filter media surface from high velocities that can dislodge collected pollutants or scour vegetation.

Bioretention basins operate by filtering stormwater runoff through densely planted surface vegetation and then percolating runoff through a prescribed filter media. During percolation, pollutants are retained through fine filtration, adsorption and some biological uptake. The vegetation in a bioretention system is a vital functional element of the system providing a substrate for biofilm growth within the upper layer of the filter media. Vegetation facilitates the transport of oxygen to the soil and enhances soil microbial communities which enhance biological transformation of pollutants.

Plants with extensive fibrous or a spreading, rhizomatous root system able to withstand periods of inundation are preferred in bioretention systems. As such, it is recommended that Carex or similar plant selected from the WSUD guidelines be planted in the Bioretention Basins to assist in the uptake of identified pollutants. These plants shall be planted at a density of 6-8 per square metre to provide maximum effect. A sandy loam filtration media with a hydraulic conductivity of 200mm/hr will ensure that filtration media does not become waterlogged (Australian Runoff Quality (ARQ), 2004, Section 9.4). The ARQ states that bioretention systems are efficient in treating, TSS, TN, TP and Hydrocarbons (where attached to fine sediments). Refer to drawings in Appendix A for bioretention basin details.

The uPVC slotted pipe will collect the treated Q3 Month flow after it has filtered through a layer of sandy loam. The treated runoff water in the slotted pipe will connect into the side of the field inlet. The treated flow will be piped from the field inlet together with the collected minor flow via the sites stormwater drainage network. The MUSIC parameters used for the Bioretention Basin are shown on Table 8.

Table 8: Bioretention Basin MUSIC Parameters

Parameter	Basin 1
Extended detention depth (m)	0.290 m
Seepage Loss (mm/hr)	0 mm/hr
Filter Depth (m)	0.5 m
Particle Diameter (mm)	0.45 mm
Saturated Hydraulic Conductivity (mm/hr)	200 mm/hr
Depth below underdrain pipe (% of Filter Depth)	0 %

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

6.5.2 PV Array

Based on the understanding of Toowoomba Regional Councils requirements for stormwater quality treatment for Rural sites, a buffer has been utilised as the SQID's for this site.

6.5.2.1 Buffer

Buffer strips are primarily intended to remove sediment, as well as some nutrients and hydrocarbons. Buffer strips can be used as edges to swales, particularly where flows are distributed along the banks of the swale, as an alternative to kerb and gutter drainage systems.

Buffers strips provide a number of functions including:

- The removal of sediments by filtration through the vegetation;
- A reduction in runoff volumes (by promoting some infiltration to the subsoils);
- A delay in runoff peaks by reducing flow velocities;
- With appropriate vegetative cover and diversity, buffer strips can form part of a multi-use habitat (i.e. provide a habitat corridor for wildlife); and
- Effective pre-treatment for other WSUD measures such as bioretention and infiltration systems.

Buffer strips initially immobilise pollutants by binding them to organic matter and soil particles. Ultimate pollutant removal is achieved by settling, filtration and infiltration into the subsoil. Certain pollutants, such as nutrients and hydrocarbons, may be digested and processed by the soil microorganisms in the filter strip. Consequently, adequate contact time between the runoff and the vegetation and soil surface is required to optimise pollutant removal. The MUSIC parameters used for the Bioretention Basin are shown on Table 9.

Table 9: Buffer MUSIC Parameters

Parameter	Buffer 1
Percentage of upstream area buffered (%)	100%
Buffer Area (% of upstream impervious area)	50%
Exfiltration Rate (mm/hr)	0 %

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

6.6 Treatment Train effectiveness in Pollution Reduction

The MUSIC Model was run calculating the effectiveness in pollution reduction for the substation and PV Array based on treatment being undertaken by Bioretention Basins and Grass Buffers respectively. Table 10 and 11 shows the post treatment pollutant loads in comparison to their water treatment objectives for both stages of the development.

Table 10: Substation Site MUSIC Output Results

Pollutant	Post Development Load	Post Treatment Load	Water Quality Objectives	Reduction in Pollutant
TSS	379 kg/yr	37.2 kg/yr	85 %	**90.2 %**
TP	0.994 kg/yr	0.395 kg/yr	60 %	**60.2 %**
TN	6.69 kg/yr	3.16 kg/yr	45 %	**52.8 %**
GP	93.7 kg/yr	0 kg/yr	90 %	**100 %**

Table 11: PV Array MUSIC Output Results

Pollutant	Pre Development Treatment Load	Post Development Treatment Load	Reduction in Pollutant load from existing Agricultural use
TSS	20000 kg/yr	7910 kg/yr	**39.6 %**
TP	21.9 kg/yr	11.7 kg/yr	**53.3 %**
TN	121 kg/yr	112 kg/yr	**92.6 %**
GP	156 kg/yr	156 kg/yr	**0.0 %**

(Refer to Appendix D for Treatment Train Effectiveness)

The MUSIC treatment measures and assumptions adopted for this development include:

- Bioretention Basin Area:
  - Basin 1 = 200sq.m
- Buffer Area:
  - Buffer 1 = 100% Site Area

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

7. Water Quality Maintenance

The following maintenance protocols detailed in Section 7 have been adapted from the Healthy Waterways Water Sensitive Urban Design Engineering Guidelines for South East Queensland – Version 1 June 2006. They should generally be adopted as standard maintenance procedures upon construction of stormwater treatment devices.

7.1 Bioretention Basins

Bioretention Basins require ongoing maintenance to ensure water treatment efficiencies are maintained. Attached in Appendix E is a Bioretention Checklist adapted for the WSUD Guidelines.

Vegetation plays a key role in maintaining the porosity of the filter media of a bioretention basin and a strong healthy growth of vegetation is critical to its performance. Therefore the most intensive period of maintenance is during the plant establishment period (first two years) when weed removal and replanting may be required.

Inflow systems and overflow pits require careful monitoring, as these can be prone to scour and litter build up. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly, and debris should be removed whenever it is observed on a site. Where sediment forebays are adopted, regular inspection of the forebay is required (3 monthly) with removal of accumulated sediment undertaken as required.

For larger bioretention basins, it is essential that a maintenance access point is designed for and maintained in the bioretention basin. The size and complexity of the system will guide its design and may involve provision of a reinforced concrete ramp/ pad for truck or machinery access.

Typical maintenance of bioretention basin elements will involve:

- Routine inspection of the bioretention basin profile to identify any areas of obvious increased sediment deposition, scouring from storm flows, rill erosion of the batters from lateral inflows, damage to the profile from vehicles and clogging of the bioretention basin (evident by a ‘boggy’ filter media surface).
- Routine inspection of inflows systems, overflow pits and under-drains to identify and clean any areas of scour, litter build up and blockages.
- Removal of sediment where it is smothering the bioretention basin vegetation.
- Where a sediment forebay is adopted, removal of accumulated sediment.
- Repairing any damage to the profile resulting from scour, rill erosion or vehicle damage by replacement of appropriate fill (to match onsite soils) and revegetating.
- Tilling of the bioretention basin surface, or removal of the surface layer, if there is evidence of clogging.
- Regular watering/ irrigation of vegetation until plants are established and actively growing.
- Removal and management of invasive weeds (herbicides should not be used).
- Removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule.
- Pruning to remove dead or diseased vegetation material and to stimulate growth.
- Vegetation pest monitoring and control.

Resetting (i.e. complete reconstruction) of the bioretention basin will be required if the system fails to drain adequately after tilling of the surface. Maintenance should only occur after a reasonably rain free period when the soil in the bioretention system is dry. Inspections are also recommended following large storm events to check for scour and other damage.

Level 2, 39 Sherwood Road
Toowong QLD 4066

mail@icubed.com.au
www.icubed.com.au

P: 07 3870 8888
F: 07 3870 8988

All maintenance activities must be specified in an approved Maintenance Plan (and associated maintenance inspection forms) to be documented and submitted to Council as part of the Development Approval process. Maintenance personnel and asset managers will use this Plan to ensure the bioretention basins continue to function as designed. An example operation and maintenance inspection form is included in the checking tools provided in Appendix D. These forms must be developed on a site-specific basis as the nature and configuration of bioretention basins varies significantly.

7.2 Buffer

Buffer treatment relies upon good vegetation establishment and therefore ensuring adequate vegetation growth is the key maintenance objective. In addition, they have a flood conveyance role that needs to be maintained to ensure adequate flood protection for local properties. The most intensive period of maintenance is during the plant establishment period (first two years) when weed removal and replanting may be required. It is also the time when large loads of sediments may impact on plant growth, particularly in developing catchments with an inadequate level of erosion and sediment control.

The potential for rilling and erosion over a buffer needs to be carefully monitored, particularly during establishment stages of the system.

Typical maintenance of buffer elements will involve:

- Routine inspection of the buffer to identify any areas of obvious increased sediment deposition, scouring of the buffer from storm flows, rill erosion of the diversion batters from lateral inflows or damage to the diversion profile from vehicles;
- Repairing damage to the swale diversion bund resulting from scour, rill erosion or vehicle damage;
- Regular watering/ irrigation of buffer until plants are established and actively;
- Mowing of turf or slashing of vegetation (if required) to preserve the optimal design height for the Vegetation;
- Removal and management of invasive weeds;
- Litter and debris removal.
- Vegetation pest monitoring and control.

Inspections are also recommended following large storm events to check for scour. All maintenance activities must be specified in a maintenance plan (and associated maintenance inspection forms) to be developed as part of the design procedure. Maintenance personnel and asset managers will use this plan to ensure the buffer continues to function as designed. Maintenance plans and forms must address the following:

- inspection frequency
- maintenance frequency
- data collection/ storage requirements (i.e. during inspections)
- equipment needs
- maintenance techniques
- occupational health and safety
- public safety
- environmental management considerations
- disposal requirements (of material removed)
- access issues
- stakeholder notification requirements

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

7.3 Vegetation Maintenance Management Plan

In order to ensure the vegetated stormwater assets continue to function as intended, regular maintenance activities are required. The process in which this maintenance will be implemented has been developed based on the "Water by Design – Maintaining Vegetated Stormwater Assets Guideline". Inspection of the vegetated stormwater assets will be carried out using the checklist supplied in section 4 of the "Water by Design – Maintaining Vegetated Stormwater Assets Guideline, with all and any rectifications being carried out as required.

Where required as part of the checklist, suitably qualified personal will be required to carry out the assessment. i.e. Engineering or Horticultural.

Inspections are to be initially carried out on a quarterly basis. Where an asset fails to meet one or more of the performance indicators on at least two consecutive maintenance inspections, the frequency of inspections is to be increased. One of the inspections annually should be carried out directly after a major rainfall event to ensure the asset is operating properly in wet conditions.

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

8. Chemical and Hydrocarbon Assessment

8.1 Cleaning of panels following installation and during maintenance

The panels shall be cleaned up to twice annually, dependent upon observed soiling rates. Cleaning is undertaken using only de-ionised water. No chemicals and detergents are used in the cleaning of panels as this can impact the long term performance of the panels and vendor warranties.

8.2 Chemicals used for maintenance of the PV Tracking System and the site generally

8.2.1 Tracking System

The panels will be mounted on a tracking system to improve the output and productivity of the completed facility. As the tracking structures contain slow moving parts such as worm gear threads, pivots and roller bearings, lubricant must be introduced to the sealed bearing via a Zerk fitting during routine annual maintenance.

The biodegradable grease Mobilux EP 2 is the preferred lubricant for this system. We note that the maintenance program will be undertaken in accordance with a strict Work Method Procedure and any spillage of grease during the maintenance procedure would be collected and disposed of in accordance with the Hydrocarbon spill procedure, which will be prepared as part of the Operations and Maintenance Manual for the project. This procedure will eliminate the opportunity for hydrocarbons to enter the environment.

8.2.2 Mobile Plant

Maintenance vehicles such as water carts, tractors used for weed control and grass slashing etc. will be diesel powered. The spill procedure for the maintenance of the tracking system will be identical for these vehicles. Periodic maintenance servicing of these vehicles will be offsite.

8.2.3 Static Plant

The proposed inverters are air cooled and do not require any liquid coolant. Inverter transformers are oil filled with mineral oil and are expected to contain less than 7,000 litres. The inverter transformers will be sealed and fully bunded for 110% of capacity to ensure that in the event of a leak or complete loss of fluid, any oil spilled from the steel enclosed transformer is captured by the outer bunding.

Several oil filled transformers are proposed to be installed in the Yarranlea solar project substation, which will be modern variation of those currently installed at the existing Ergon substation adjacent to the proposed project. The proposed Yarranlea solar farm substation will contain one large oil filled power transformer and 7 smaller oil filled transformers. The substation design will comply with AS1940 and AS2067, with oil capture bunding supplied as is required by the aforementioned standards. The large power transformer will contain approximately 42,000 litres of non-PCB transformer oil according to AS1767, with the smaller transformers containing less than 1,000 litres each.

Depending on auxiliary power supply access limitations. There may be a permanent back-up emergency diesel generator in the substation, which would contain up to 1300 litres of diesel fuel held within a skid underneath the generator set, environmental spills would be prevented via a bund to AS1940 with 110% containment capacity.

Compliance with AS1940 will prevent any hydrocarbons associated with these plant items from entering the environment.

Level 2, 39 Sherwood Road
Toowong QLD 4066

mail@icubed.com.au
www.icubed.com.au

P: 07 3870 8888
F: 07 3870 8988

8.3 Chemicals used for dust suppression and weed control

During the operational phase of the project, no chemicals or dust surfactants will be applied to the perimeter access track. The need to traffic these areas will be limited and applied speed controls of 10km per hour will be implemented and strictly enforced.

The project area will be largely vegetated with a mix of perennial grasses and legumes. These areas and the vegetated buffer will need to be managed with respect to potential herbaceous weeds. This will include occasional spaying with selective herbicides such as 24D and for more invasive weed species, spot spraying with glyphosate. Both of these products are not systemic and will not accumulate. As the site grasses and vegetated buffer become more established, the need and frequency of weed control will significantly diminish.

8.4 Impact of Chemicals on Stormwater Quality Improvement Devices

The primary means of stormwater quality improvement devices for this project comprise Vegetated buffers for the main part of the project and a bio-retention system for the substation area, which will cater for this area which comprises largely sealed pavements. Effective management of the site spill control measures and implementation of bunding in accordance with AS1940 and AS2067 will prevent release of any hydrocarbons to the treatment systems.

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

9. Conclusion

Based on a review of the, site the upstream catchment has been diverted around the site and will require no further works as part of the development.

The water quality and quantity mitigation elements are summarised for each of the catchments below:

PV Array

No stormwater quantity mitigation will be required as part of the PV Array works.

The MUSIC modelling results in Section 6.6 indicate that a Buffer will adequately treat the identified pollutants associated with the $Q_{3\ Month}$ stormwater runoff. The development will significantly reduce pollutant load in comparison to the existing agricultural use.

Substation

The DRAINS modelling indicates that the detention basin will adequately mitigate the site runoff to predevelopment flows.

The required Detention Basin size is:

- Basin 1 = 247cu.m

The MUSIC modelling results in Section 6.6 indicate that a Bioretention Basin will adequately treat the identified pollutants associated with the $Q_{3\ Month}$ stormwater runoff.

The required size of the Bioretention Basin is:

- Basin 1 = 200sq.m

The required bioretention filter depth is 0.5m with a 100mm uPVC slotted pipe located 0.8m below the surface of the filter material and will carry the Q3 Month stormwater runoff to the outlet drain, as per drawing 15-282-C01 and C02.

In addition, adherence to the maintenance measures detailed in Section 6 will ensure the ongoing effectiveness and longevity of the proposed SQID's.

Based on the existing site conditions and the above DRAINS and MUSIC results, i^3 consulting considers that proposed treatment with Bioretention/Detention Basins for the substation and a buffer for the PV Array will satisfy Toowoomba Regional Council's requirements for stormwater quantity and quality treatment for the proposed development.

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

10. Reference List

Healthy Waterways, Water Sensitive Urban Design Guidelines for South East Queensland – Version 1, June 2006.

Water by Design, MUSIC Modelling Guidelines
Version 1.0, 2010

SPP, State Planning Policy, July 2014

Level 2, 39 Sherwood Road
Toowong QLD 4066

mail@icubed.com.au
www.icubed.com.au

P: 07 3870 8888
F: 07 3870 8988

Appendix A – Drawings

Table 12: Drawings prepared by i3 consulting pty ltd

Drawing Number	Drawing Description
15-282-A01	Project Overview
15-282-C01	Stormwater Plan
15-282-C02	Stormwater Details Plan

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

Appendix B – Calculations

Table 13: Discharge Calculation Table

Catchment	Area	*Minor Storm Event* Q_{20} Intensity	*Minor Storm Event* Q_{20} Discharge	*Treatable Storm Event* $Q_{3\ month}$ Intensity	*Treatable Storm Event* $Q_{3\ month}$ Discharge
Catchment A - PV Array	254.61 ha	65 mm/hr	42.29 m^3/s	17 mm/hr	8.42 m^3/s
Catchment B - Substation Site	1.00 ha	237 mm/hr	0.61 m^3/s	52 mm/hr	0.10 m^3/s

Sample Calculations

MINOR STORM EVENT Q_{20}

AREA = 254.61 ha

RAINFALL INTENSITY

I_{20} = 65 mm/hr (From AR&R)

For 45 minute duration

COEFICIENT OF RUNOFF

C_{20} = 0.92

DISCHARGE

$$Q_{20} = \frac{CIA}{360} = 42.29\ m^3/s$$

TREATABLE STORM EVENT $Q_{3\ month}$

AREA = 254.61 ha

RAINFALL INTENSITY

$I_{3\ month}$ = 17 mm/hr (From AR&R)

For 45 minute duration

COEFICIENT OF RUNOFF

$C_{3\ month}$ = 0.7

DISCHARGE

$$Q_{3\ month} = \frac{CIA}{360} = 8.42\ m^3/s$$

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

Table 14: Rational Check Table

Event Frequency (years) & Duration	Post-development Flows (DRAINS)	Post-development Flows (RATIONAL)	Flow Variation
1 year, 15 minute	0.162 m^3/s	0.134 m^3/s	1.21%
2 year, 15 minute	0.218 m^3/s	0.181 m^3/s	1.20%
5 year, 15 minute	0.274 m^3/s	0.251 m^3/s	1.09%
10 year, 15 minute	0.308 m^3/s	0.295 m^3/s	1.04%
20 year, 15 minute	0.357 m^3/s	0.355 m^3/s	1.00%
50 year, 15 minute	0.412 m^3/s	0.456 m^3/s	0.90%
100 year, 15 minute	0.465 m^3/s	0.530 m^3/s	0.88%

Sample Calculations

MINOR STORM EVENT Q_1
AREA = 1.00 ha
RAINFALL INTENSITY
I_1 = 71mm/hr (From AR&R)s
For 10 minute duration

COEFICIENT OF RUNOFF
C_1 = 0.680
DISCHARGE
$Q_1 = \frac{CIA}{360} =$ 0.134 m^3/s

MINOR STORM EVENT Q_2
AREA = 1.00 ha
RAINFALL INTENSITY
I_2 = 90mm/hr (From AR&R)
For 10 minute duration

COEFICIENT OF RUNOFF
C_2 = 0.723
DISCHARGE
$Q_2 = \frac{CIA}{360} =$ 0.181 m^3/s

MINOR STORM EVENT Q_{10}
AREA = 0.1994 ha
RAINFALL INTENSITY
I_{10} = 125mm/hr (From AR&R)
For 10 minute duration

COEFICIENT OF RUNOFF
C_{10} = 0.850
DISCHARGE
$Q_{10} = \frac{CIA}{360} =$ 0.295 m^3/s

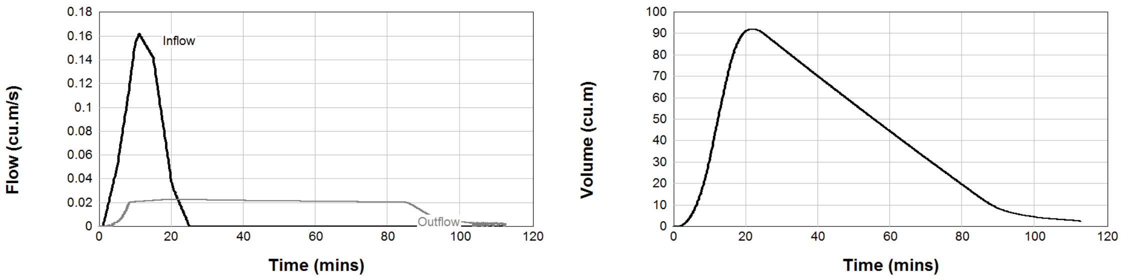
MINOR STORM EVENT Q_{20}
AREA = 1.00 ha
RAINFALL INTENSITY
I_{20} = 143mm/hr (From AR&R)
For 10 minute duration

COEFICIENT OF RUNOFF
C_{20} = 0.893
DISCHARGE
$Q_{20} = \frac{CIA}{360} =$ 0.355 m^3/s

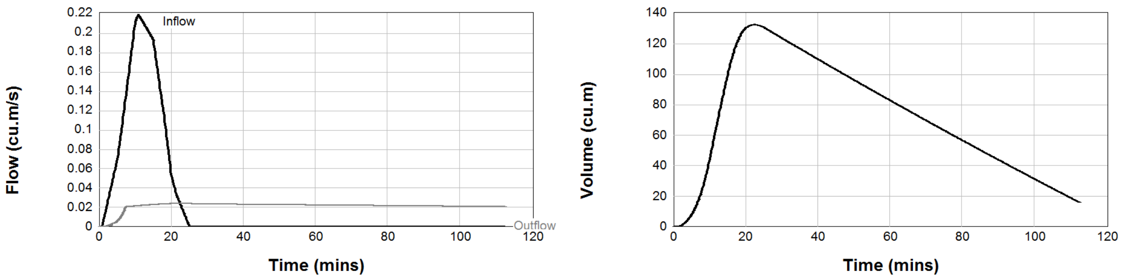
Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

Appendix C – DRAINS Modelling

BASIN 1



Q1



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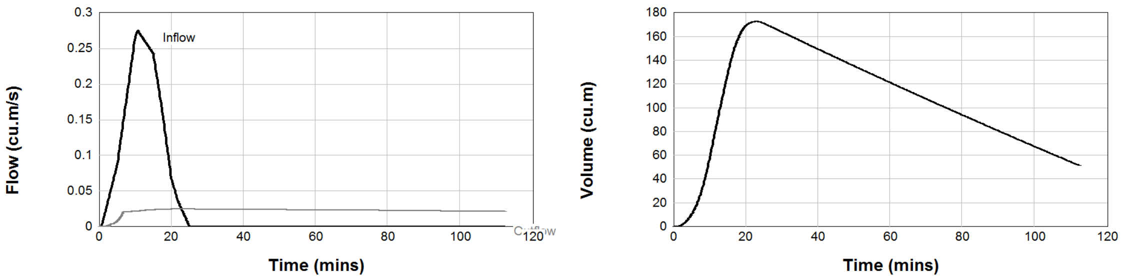

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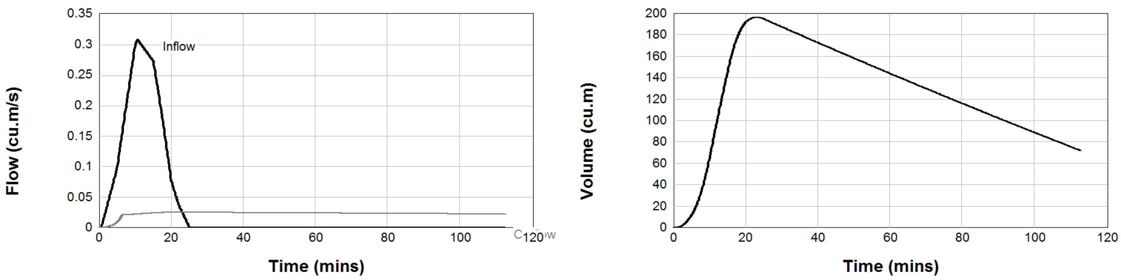

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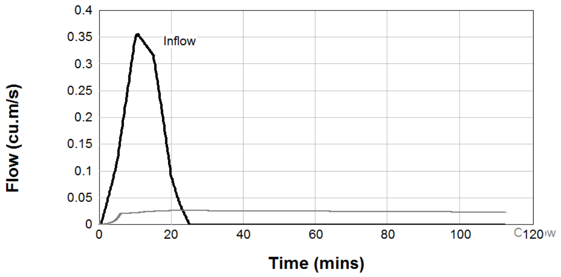
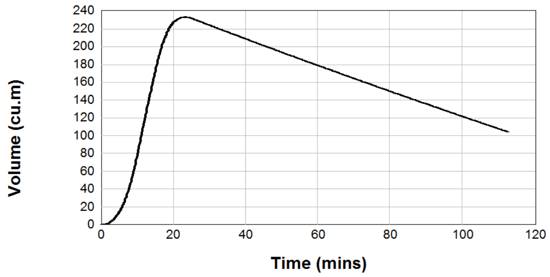
Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988





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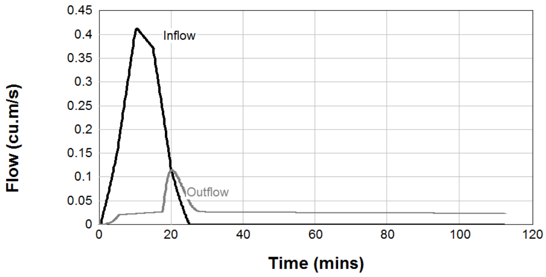

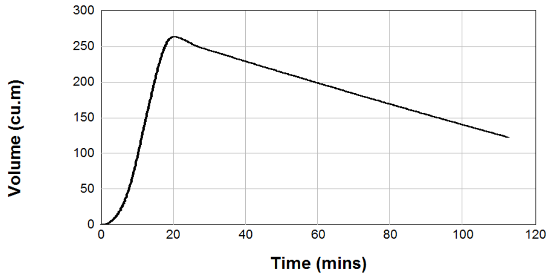

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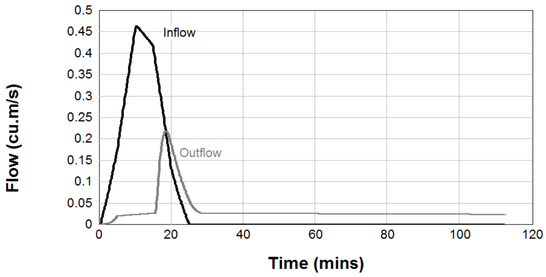
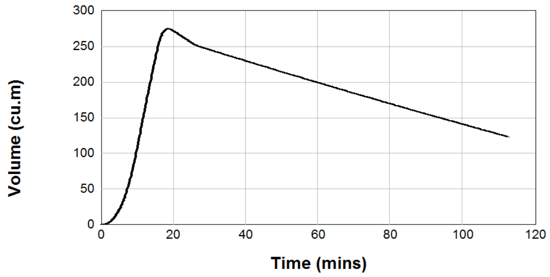




Q100

Level 2, 39 Sherwood Road
Toowong QLD 4066

mail@icubed.com.au
www.icubed.com.au

P: 07 3870 8888
F: 07 3870 8988

solutions
WATER MODELLING

GPO Box 664
Brisbane CBD
QLD 4001

Tel: 07 3236 2693
Ref: 10089-R04

Date: 17/11/2016

icubed Consulting Pty Ltd
Suite 2, 39 Sherwood Rd
Toowong QLD 4066

PO Box 878
Toowong QLD 4066

Attn: Travis Smith
Civil Engineer
T: 07 3870 8888
E: travis.smith@icubed.com.au

Yarranlea Solar Farm Flood Assessment

Dear Travis,

As requested, we have undertaken a flood impact assessment of the proposed Yarranlea Solar Farm, 538 and 752 Yarranlea Road, Yarranlea. The following letter report summarises the work undertaken and highlights the findings.

1. Background

Toowoomba Regional Council has identified 538 and 752 Yarranlea Road as affected by overland flooding. As such, a flood impact assessment is required as part of the development application. The area is not currently covered by any existing fine resolution hydraulic model. Therefore a new model suite (hydraulic and hydrologic) was developed to undertake the flood impact assessment.

2. Available Data

Data for the study was provided by icubed and acquired from the Department of Natural Resources and Mines (DNRM). icubed provided a series of design drawings, aerial imagery of the site and a 1 m gridded Digital Elevation Model (DEM) for both existing conditions and post development conditions. This data was used to inform the topographic amendments of the design within the hydraulic model. LiDAR-derived topographic data was sourced from DNRM. The DEM was provided as a series of 1 km by 1 km tiles with a 1 m spatial resolution. This data was used as the basis of the 2D hydraulic model of the site. Where LiDAR data was not available, it was supplemented with Shuttle Radar Topography Mission (SRTM) data with a spatial resolution of 1 arc second (app. 30 m). The SRTM dataset was used to inform the development of the hydrologic model upstream of the site.

3. Hydrologic Model Development and Validation

Flood discharges within the catchment were estimated using the XP-RAFTS runoff-routing model (XP Software, 2016) for existing conditions. No changes were made to the hydrologic model for developed conditions. The installation of solar panels is unlikely to affect catchment parameters such as runoff or fraction impervious. These factors are instead influenced by the actual ground cover, such as grass or concrete and the topography of the ground surface. In addition, catchment runoff upstream of the proposed solar farm is far greater than any local runoff in the area of interest.

Due to absence of historical flood information the existing scenario model was validated against the Rational Method estimates at six locations. The routing parameters of the model were then ‘fine-tuned’ based on the channel velocities estimated from the hydraulic model. The methodology and results of the hydrologic model validation are presented in the following.

3.1. Model Configuration

The hydrologic model of the site and its upstream catchment was developed based on available topographic data and aerial photography. As LiDAR-derived topographic data is not available for the whole catchment, it was supplemented with SRTM data. XP-RAFTS sub-catchment boundaries were delineated using the available DEM data and road network. The configuration of the XP-RAFTS model is shown in Figure 1. The model consists of 48 sub-catchments with the area totalling 9,647 ha.

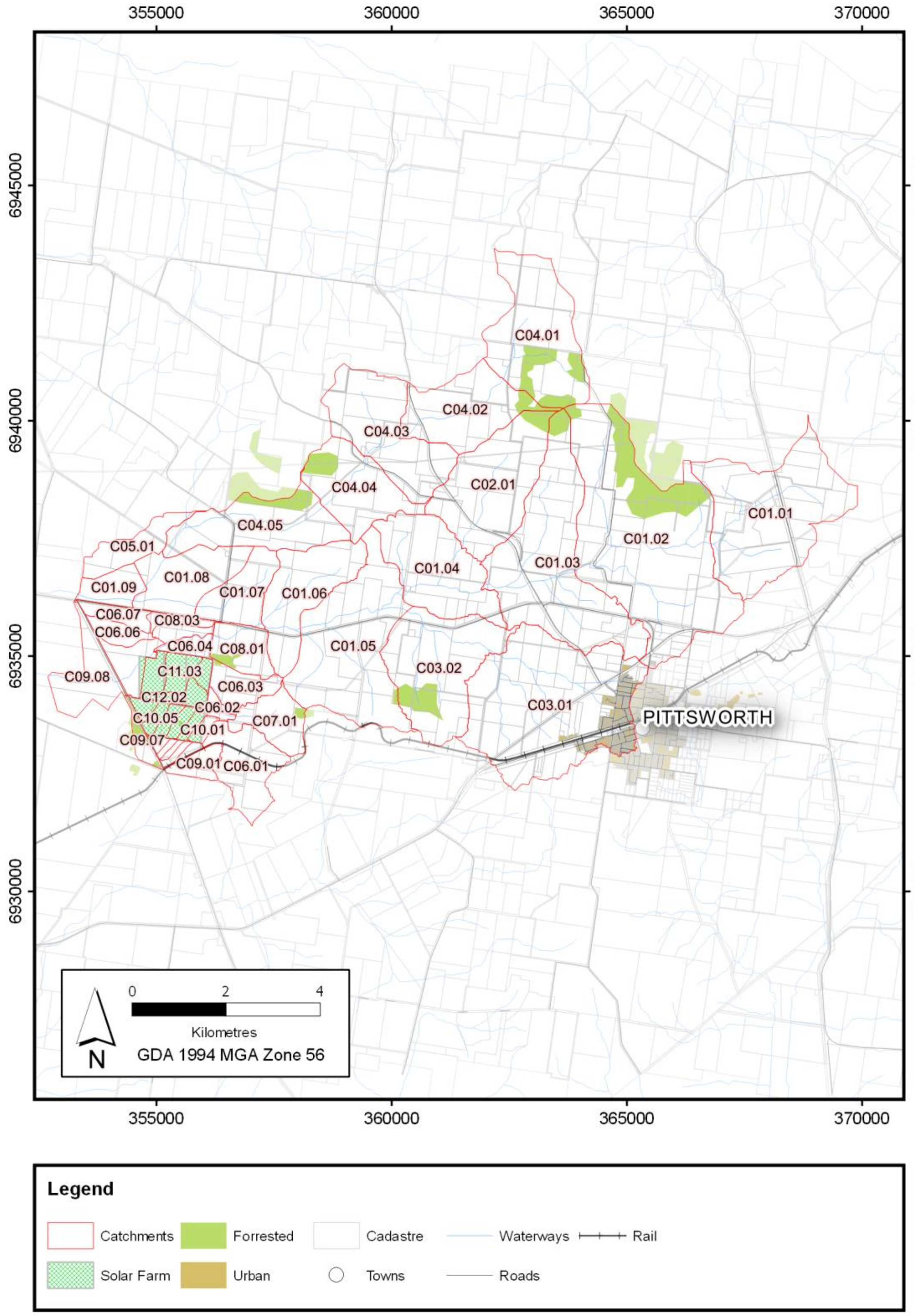


Figure 1 - XP-RAFTS sub-catchments

3.3.1 RAFTS Model Parameters

The adopted sub-catchment parameters are listed in Table 1. The adopted fraction impervious for each land use is based on the Queensland Urban Drainage Manual (QUDM, 2013) recommendations, see Table

2. Where there was more than one land use in each sub-catchment, the percentage impervious and PERN 'n', which represents the average sub-catchment roughness, were factored in proportion to catchment area.

Table 1: Adopted XP-RAFTS sub-catchment parameters

Sub-Catchment	Catchment Area (ha)	Catchment Slope (%)	Percent Impervious (%)	'PERN' 'n'
C01.01	676	4.69	1.03	0.069
C01.02	1131	6.60	2.31	0.070
C01.03	740	5.50	1.66	0.069
C01.04	384	4.29	1.15	0.068
C01.05	636	6.61	0.85	0.069
C01.06	314	5.49	0.37	0.069
C01.07	165	3.22	1.16	0.068
C01.08	244	2.26	0.52	0.068
C01.09	87	1.29	0.00	0.068
C02.01	462	4.53	1.98	0.069
C03.01	914	3.60	5.32	0.065
C03.02	483	6.15	1.68	0.069
C04.01	494	8.44	2.07	0.070
C04.02	331	5.35	1.62	0.069
C04.03	409	4.19	1.60	0.068
C04.04	289	4.74	2.22	0.069
C04.05	345	5.62	1.89	0.069
C05.01	122	0.75	0.00	0.070
C06.01	206	4.54	0.01	0.069
C06.02	21	1.37	1.43	0.068
C06.03	95	4.47	0.44	0.069
C06.04	39	0.94	0.00	0.070
C06.05	82	0.54	0.15	0.069
C06.06	49	0.54	0.00	0.070
C06.07	54	0.67	3.17	0.067
C07.01	136	5.07	1.86	0.068
C08.01	118	4.10	1.61	0.068
C08.02	35	0.64	0.00	0.070
C08.03	30	0.74	3.53	0.067
C09.01	53	5.19	0.17	0.069
C09.02	11	3.52	0.00	0.070
C09.03	11	2.41	1.62	0.068
C09.04	6	2.12	0.00	0.070
C09.05	7	1.66	2.19	0.068
C09.06	10	1.24	4.79	0.066
C09.07	37	1.70	4.11	0.072
C09.08	159	1.15	1.40	0.068
C10.01	19	2.15	0.93	0.069
C10.02	18	1.65	1.87	0.068
C10.03	20	1.27	1.21	0.069
C10.04	20	1.22	1.63	0.068
C10.05	20	1.01	2.33	0.068
C10.06	19	0.90	1.60	0.068
C11.01	24	1.11	0.00	0.070
C11.02	21	1.14	0.00	0.070
C11.03	48	0.94	0.00	0.070
C12.01	38	0.94	0.00	0.070
C12.02	18	0.90	1.37	0.068

Table 2: Adopted land use parameters

Land Usage	Typical Lot Size (ha)	Fraction Impervious (f^i)	Percent Impervious (%)	Catchment 'PERN' 'n'
Urban Residential	0.04 to 0.2	0.70	50	0.035
Rural Residential (High Density)	0.2 to 1.0	0.40	30	0.040
Rural Residential (Low Density)	1.0 to 10	0.20	15	0.045
Rural	>10	0.05	5	0.060
Open Space	Varies	0.00	0	0.070

Channel lag times were used to route the flow between catchments. Lag times were calculated based on channel reach lengths and average channel velocities estimated from the hydraulic model results:

$$\text{Lag} = \frac{\text{Reach Length [m]}}{\text{Average Velocity [m/s]}}$$

The XP-RAFTS model was run for the 5% AEP and 1% AEP design events for 1.5-hour and 2-hour storm durations. The adopted initial and continuing losses are listed in Table 3. The losses have been adopted based on the relationship with percentage impervious and are in accordance with *A Guide to Flood Estimation* (Pilgrim, 1998) recommending design initial loss rates of 15-35 mm and a median continuing loss of 2.5 mm/h for eastern Queensland up to and including the 1% AEP event.

Table 3: Initial and continuing losses

Percentage Impervious (%)	IL (mm)	CL (mm/hr)
< 25	15	2.5
25 to 40	10	1.5
> 40	5	1

3.3.2 Design Rainfall and Temporal Patterns

Design rainfall and temporal patterns were derived in accordance with Australian Rainfall and Runoff (AR&R) (Pilgrim, 1998) as the new Intensity-Frequency-Duration (IFD) design rainfalls developed as part of the AR&R revision project are still being reviewed.

Design rainfall intensities for storms of varying durations for all design events up to and including the 100 year ARI were determined at the centroid of the catchment using BOM's AR&R87 IFDs tool (BOM, 2016). The IFD parameters are shown in Figure 2.

An areal reduction factor of 1 was adopted for all design events. This will result in slightly conservative results. The catchment is within the transition zone between Zone 2 and Zone 3. In this study, Zone 3 temporal patterns were adopted, as the nature of the weather systems that result in large floods in the study area tend to be rainfall from ex-tropical cyclone activity.

The difference between AEP and ARI is minimal for the 10 year ARI event and above. This means that the 20 year and 100 year ARI events closely correspond to 5% AEP and 1% AEP design events. The design events will therefore be referred to in terms of AEP in the following.

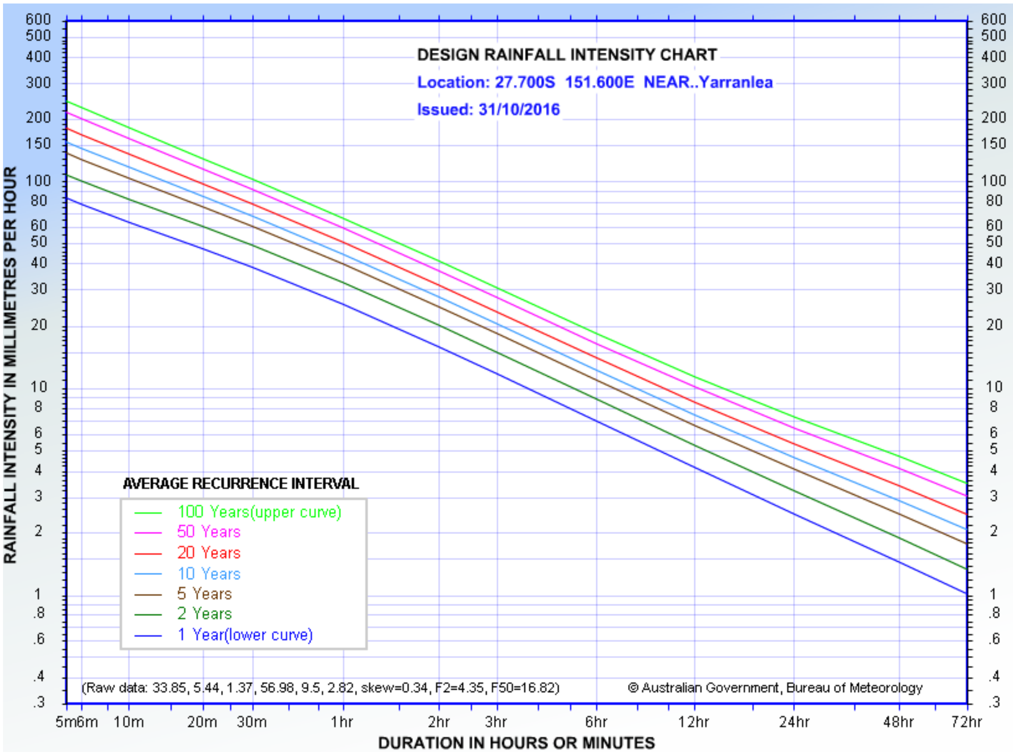


Figure 2: IFD chart for Yarranlea

3.2. Model Validation to Rational Method

The existing conditions XP-RAFTS model was validated against the Rational Method at six locations using the methodology recommended in QUDM (2013) for rural and urban catchments. The model was validated at sub-catchments C01.06, C02.01, C03.01, C04.02, C07.01 and C11.03 (see Figure 1 for locations).

3.3.3 Rational Method Estimates

The Rational Method estimates of the 1% AEP design discharges at the selected six locations are listed in Table 5. The Rational Method discharges were calculated assuming the following:

- A catchment-weighted fraction impervious and catchment slope based on existing conditions land uses (see Table 1);
- A catchment-weighted C_{10} value assigned to each catchment based on the values recommended in QUDM (2013);
- For catchments within the TUFLOW model domain, the stream velocity was selected based on the TUFLOW model results; and
- For catchments upstream of the TUFLOW model domain, the stream velocity was estimated based on catchments within the TUFLOW model domain with comparable catchments characteristics.

Table 4: Rational Method - 1% AEP discharges

Parameter	Sub-Catchment ID			
	C01.06	C02.01	C03.01	C07.01
Catchment Area (ha)	313	462	914	136
Travel Time				
Stream Length (km)	3.15	3.66	3.1	2
Equal Area Slope (m/m)	0.0220	0.0450	0.0201	0.0210
Time of Concentration (min)	**85**	**85**	**80**	**60**
Rainfall Intensity				
1% AEP event (mm/hr)	**51.7**	**51.7**	**51.7**	**51.7**
Coefficient of Discharge				
Fraction Impervious (%)[a]	0.37	1.98	5.2	1.86
C_{100} (-)	0.47	0.48	0.50	0.48
1% AEP Discharge (m^3/s)	**21**	**32**	**70**	**12**

[a] Values based on Table 2.

3.3.4 Comparison of Rational Method and XP-RAFTS Estimates

Table 5 compares the 1% AEP peak discharges estimated using the Rational Method with XP-RAFTS model predicted peak discharges at the four selected locations. The comparison shows that the XP-RAFTS peak discharges match reasonably well with the Rational Method discharges and that the differences are less than 20%.

Table 5: Comparison of rational method and XP-RAFTS model peak discharges for the 1% AEP event

Sub-Catchment ID	Rational Method (m^3/s)	XP-RAFTS (m^3/s)	Difference (%)
C01.06	21	25	+19
C02.01	32	33	+3
C03.01	70	60	-14
C07.01	12	14	+17

4. Hydraulic Model Development

The following section documents the development of the TUFLOW hydrodynamic model, selection of key model parameters and assumptions made. The TUFLOW model was developed using the double precision version of Build 2016-03-AC, which was the most recent version available at the time of the project. TUFLOW is a widely recognised and established modelling software used to analyse and predict hydraulic behaviour. The model is based on a finite difference numerical scheme and solves the shallow water equations throughout a square element mesh.

4.1. Model Topography

The model domain and existing topography are shown in Figure 3. A spatial resolution of 5 metres was chosen as a compromise between model detail and run times. The extent of the model domain was defined based on the 1 m LiDAR-derived DEM.

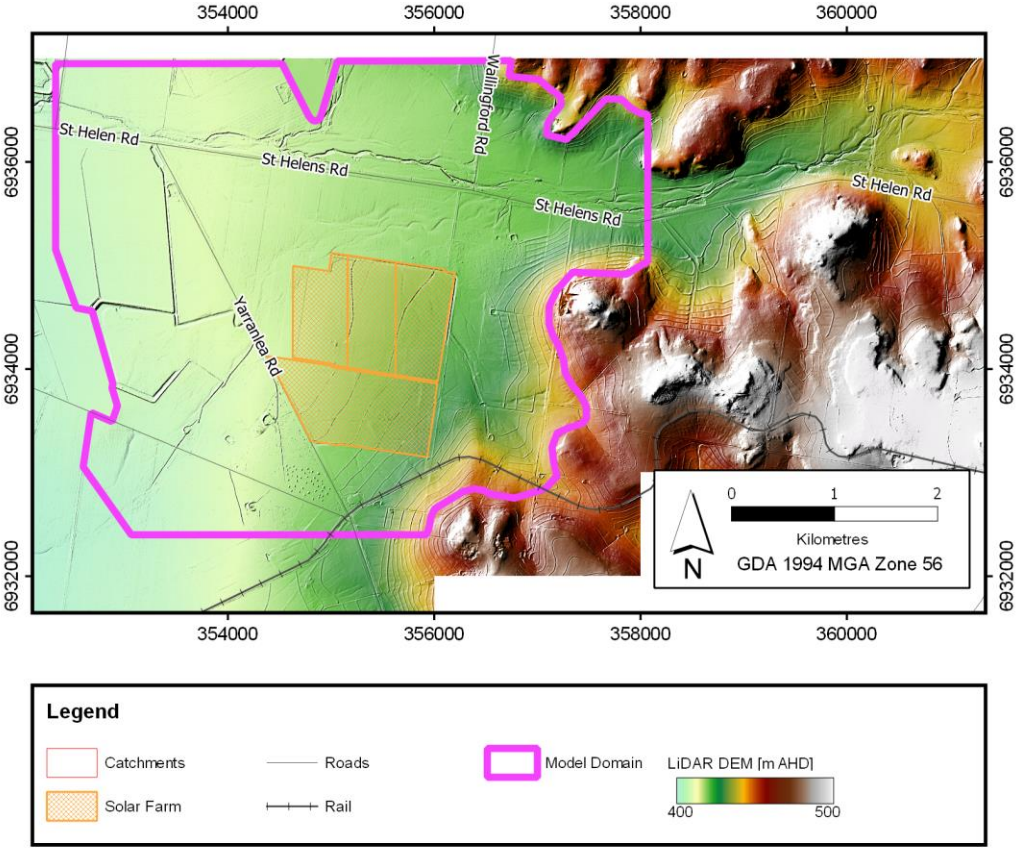


Figure 3: Model domain and topography - existing case

The existing DEM was modified in the design case to enforce the reinstated soil conservation bunds, as well as the infill pad for the Solar Farm substation. Additional modification were also made to the design to mitigate affluxes off-site:

- Digging out the drain running along the south of the site. Ensuring the channel is 5m wide, with a constant grade to the infill pad.
- A drain along the eastern side of the infill pad, through to the northern edge of the infill pad.

The existing and design topography around the proposed solar farm are shown in Appendix B.

4.2. Hydraulic Roughness

The adopted hydraulic roughness (Manning's 'n') values for each land use type are listed in Table 6. These values are based on the Australian Rainfall and Runoff (ARR) Revision Project's valid Manning's 'n' ranges for different land use types (Smith and Wasko, 2012). The spatial distribution of roughness is shown in Figure 4.

Table 6: Adopted hydraulic roughness values

Land Use Type	Adopted Manning's 'n'
Roads	0.025
Waterways	0.033
Dense Vegetation	0.080
Open Areas	0.050
Maintained Grass	0.040

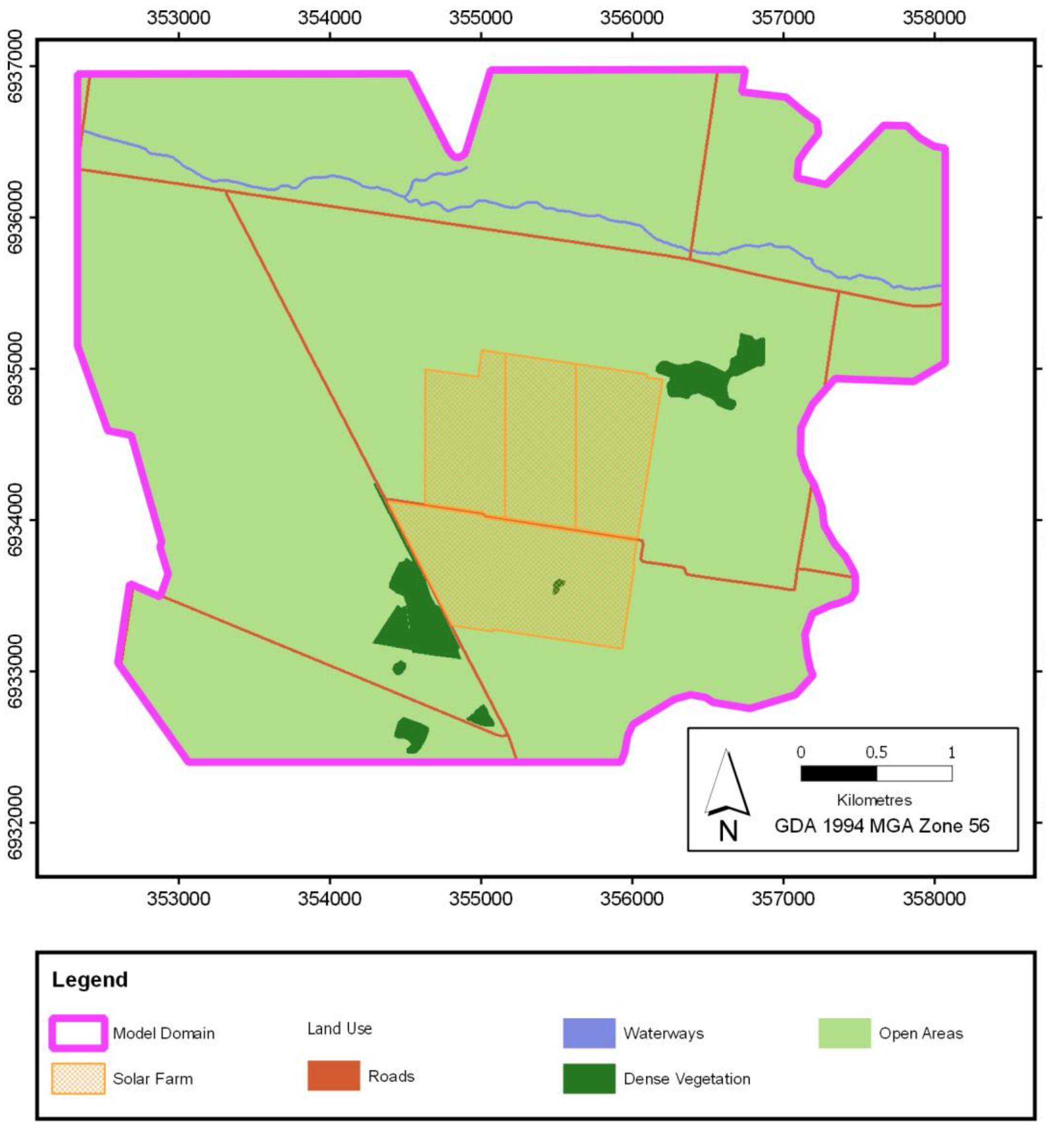


Figure 4: Spatial distribution of roughness – existing case

For the developed scenario, the roughness map was updated by assigning a Manning's 'n' value of 0.04 (Maintained Grass) to the solar farm footprint.

4.3. Model Boundaries

A fixed water level (HT) boundary of 405 mAHD was implemented at the downstream model boundary. This water level was chosen to prevent backwater effects.

4.4. Structures

No structures were modelled in the TUFLOW model. The culverts under the Wallingford Road causeway were omitted as their relative size to the volume of flow overtopping the road is minimal.

4.5. Initial Conditions

The initial water level was set to match the fixed water level adopted at the downstream model boundary.

4.6. Time Step

The 2D time step was set at 1 second. The mass balance error was less than 1% for all simulated events, indicating a healthy model.

5. Design Simulations

The hydraulic model was run for the 5% AEP and 1% AEP events for the 1.5-hr and 2-hr storm durations for both existing and design conditions. It was found that the 2-hour storm duration was critical in the area of interest for creek flooding and the 1.5-hour storm duration was critical for overland flow flooding.

6. Results

Peak of peak depths, water levels and velocities are provided in Appendices C, D and E, respectively. Afflux mapping showing differences in peak water levels between developed and existing conditions are provided in Appendix F. Areas which were wet and are now dry and vice versa are also shown. The differences in peak velocities between design and existing conditions are provided in Appendix G. A summary of the findings for 1% AEP is provided below.

The model results indicate the development (including reinstating soil conservation bunds) has limited flood impacts to areas surrounding the site. To the south of Stage 1, a confined increase in flood extent has been observed, this is due to new breakouts along the east-west channel, see note A in Figure 5. The increase in flow through the southern drain resulted in isolated affluxes up to 0.03 m on Yarranlea Road (note B). The small change in levels has not resulted in any increase in flood hazard classification (QRA definition) on the western side of Yarranlea Road. Above the northwest corner of Stage 1, an isolated area of afflux (up to 0.02 m) is indicated, resulting from redirection of flows adjacent to that location (note C).

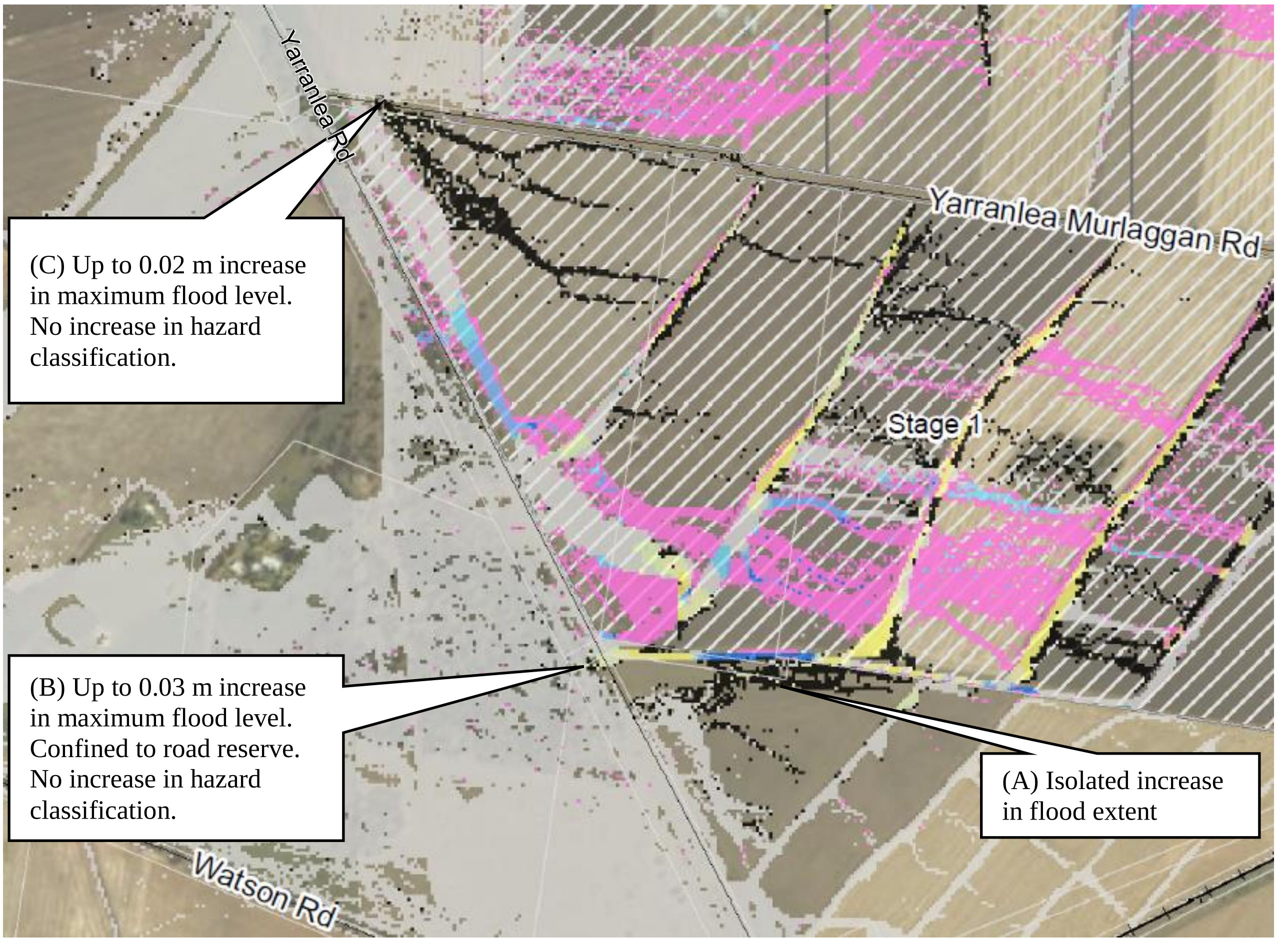


Figure 5: Afflux map Appendix F figure F.4 1% AEP Event 2-Hour Storm Duration

The changes to flood extents within the site are primarily due to the reinstatement of the soil conservation bunds and generally result in a reduction in flood extent.

7. Assumptions & Limitations

The modelling results should be viewed in light of the following assumptions and limitations:

- The model has not been calibrated; however, the flows from the hydrologic model have been validated to the Rational Method; and
- Model sensitivity to hydraulic roughness and inflows has not been assessed.

8. Summary

Hydraulic and hydrology models were developed for to undertake the flood impact assessment. The model flows were validated against the rational method. Through the hydrological analysis the critical duration for creek flooding was determined to be 2-Hours, and a critical duration for overland flow of 1.5-Hours. The hydraulic model was run for these two storm durations for both the 1% AEP and 5% AEP events.

The model results indicate that minimal changes to flooding occur off-site. Isolated areas of increased flood extent and afflux exist along with isolated areas of decreased peak flood level and extent. For 1% AEP, afflux the minor afflux that does occur, does not extent west of Yarranlea Rd. It should also be noted that the modelled afflux does not result in a change to flood hazard classification or flood behaviour.

Please do not hesitate to contact me if you have any questions.

Yours sincerely,
Water Modelling Solutions Pty Ltd

Blake Boulton
Director

Appendix A – Design Layout
Appendix B – Model Topography – Existing and Design
Appendix C – Depth Mapping
Appendix D – Water Level Mapping
Appendix E – Velocity Mapping
Appendix F – Afflux Mapping
Appendix G – Velocity Afflux Mapping

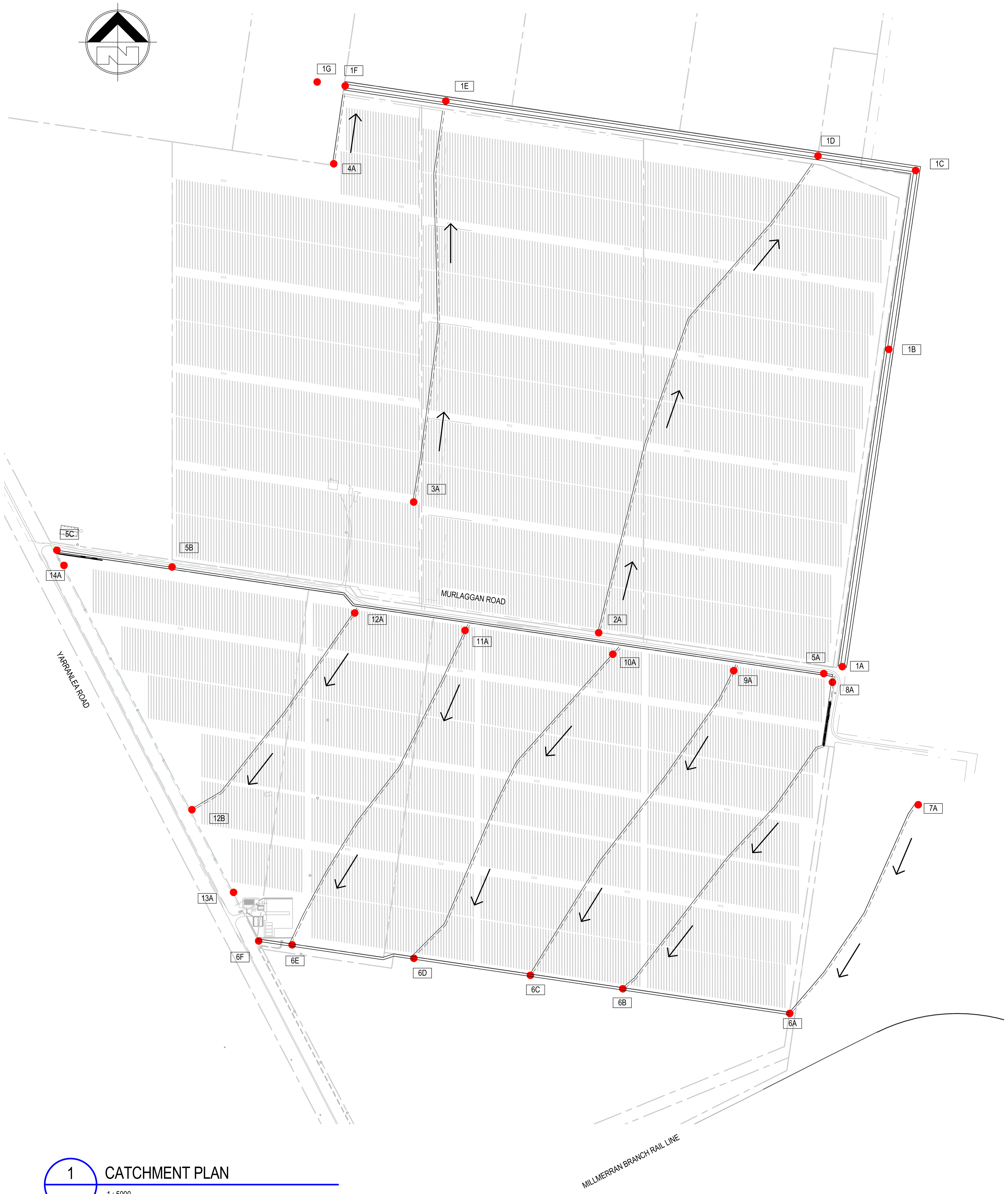
9. References

BOM (2016) *AR&R87 IFDs,* http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml, Commonwealth Bureau of Meteorology, accessed October 2016.

Pilgrim (1998) Australian Rainfall and Runoff – *A Guide to Flood Estimation, Book II, Section 3, Storm Losses and Design Rainfall Excess*, Cordery, I. (Ed.s), Revised Edition, Institution of Engineers Australia, 1998.

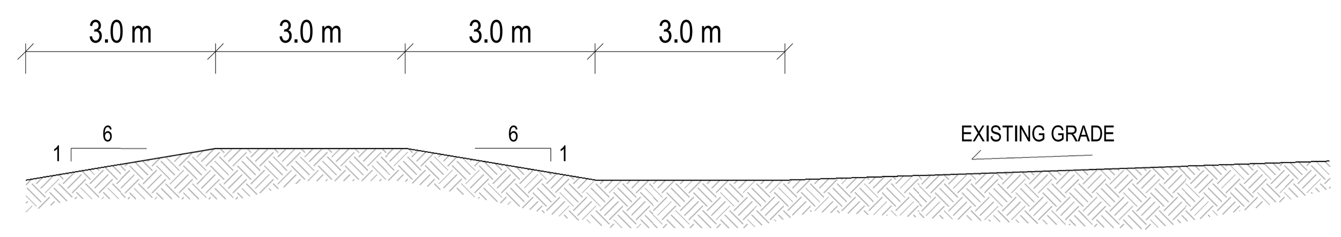
QUDM (2013) *Queensland Urban Drainage Manual*, Third Edition – provisional, Department of Energy and Water Supply, April 2013

Smith and Wasko (2013) Australian Rainfall and Runoff Revision *Project 15: Two Dimensional Modelling in Urban and Rural Floodplains - Representation of Buildings in 2D Numerical Flood Models* Stage 2 Report, Engineers Australia, Barton, ACT, 2600, WRL Technical Report, WRL TR2013/22

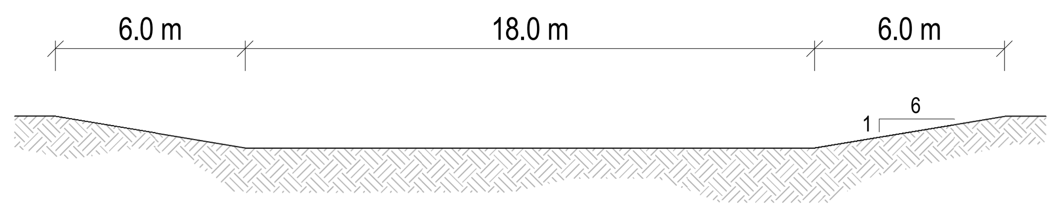


1 CATCHMENT PLAN

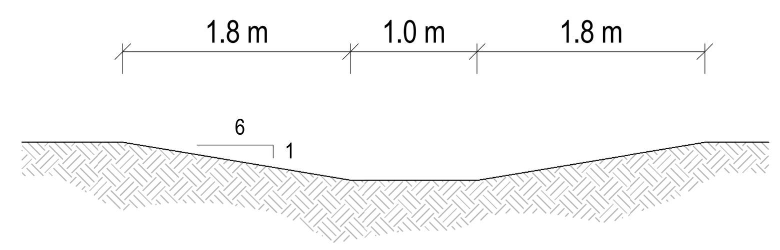
1 : 5000



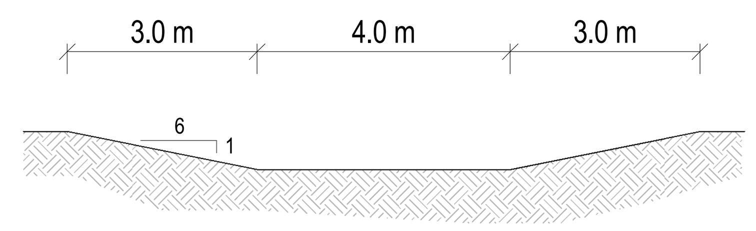
TYPICAL SOIL CONSERVATION BUND



TYPICAL DRAINAGE CHANNEL 1 SECTION



TYPICAL DRAINAGE CHANNEL 5 SECTION



TYPICAL DRAINAGE CHANNEL 6 SECTION

PROJECT TEAM

Consulting Engineer:

i3 consulting pty ltd
engineering consultants
innovation, ingenuity, inspiration
LV2, 39 Sherwood Rd, Toowong, Qld 4066
www.icubed.com.au
ABN 89 106 675 156
PO Box 878, Toowong, Qld 4066
mail@icubed.com.au
ACN 106 675 156
p 07 3870 8888

YARRANLEA SOLAR

REV	DESCRIPTION	DATE	BY

Status

FOR APPROVAL

NOT TO BE USED FOR CONSTRUCTION

Project

PROPOSED YARRANLEA SOLAR FARM
538 AND 752, YARRANLEA ROAD, YARRANLEA
for
YARRANLEA SOLAR PTY LTD

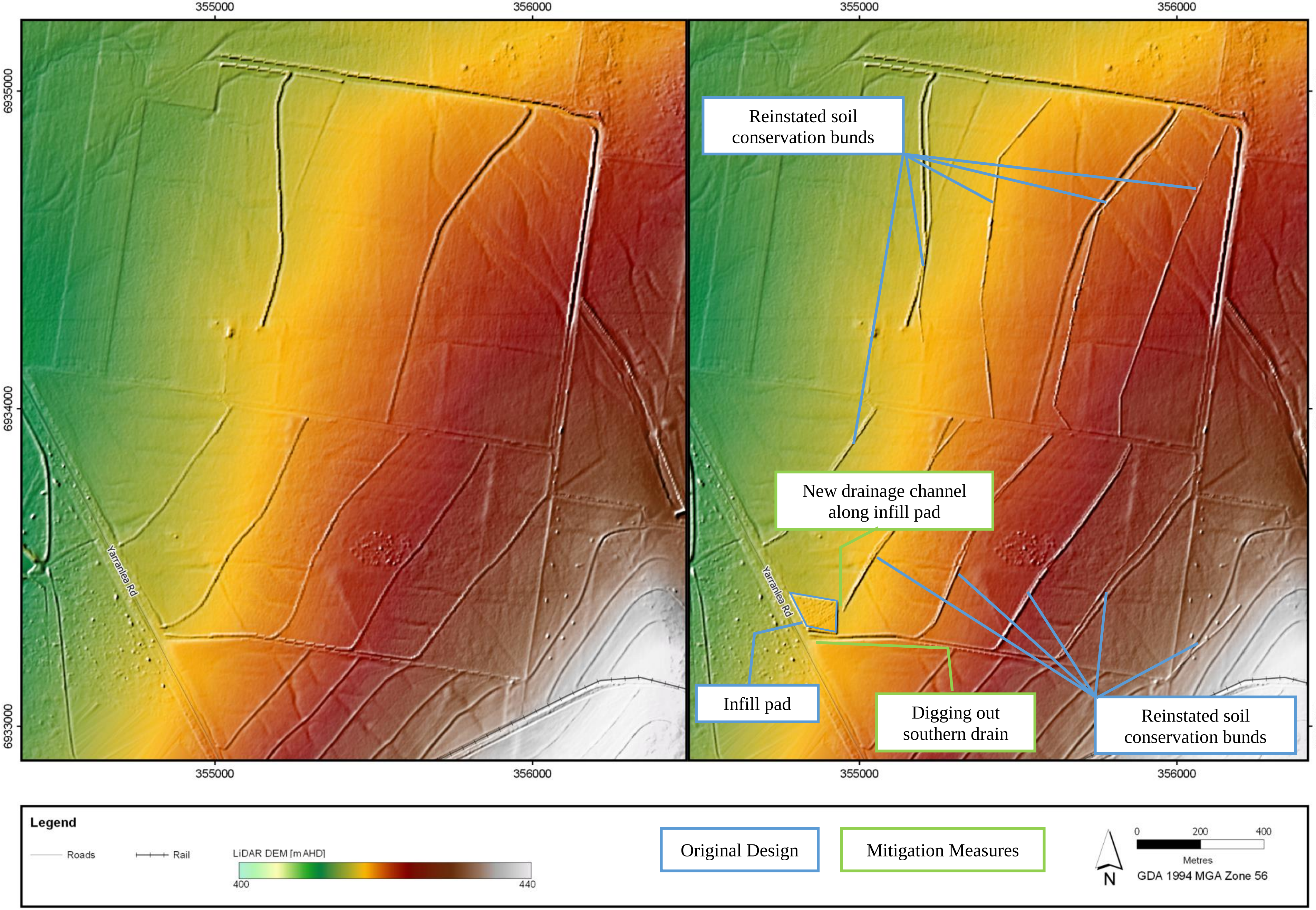
Title

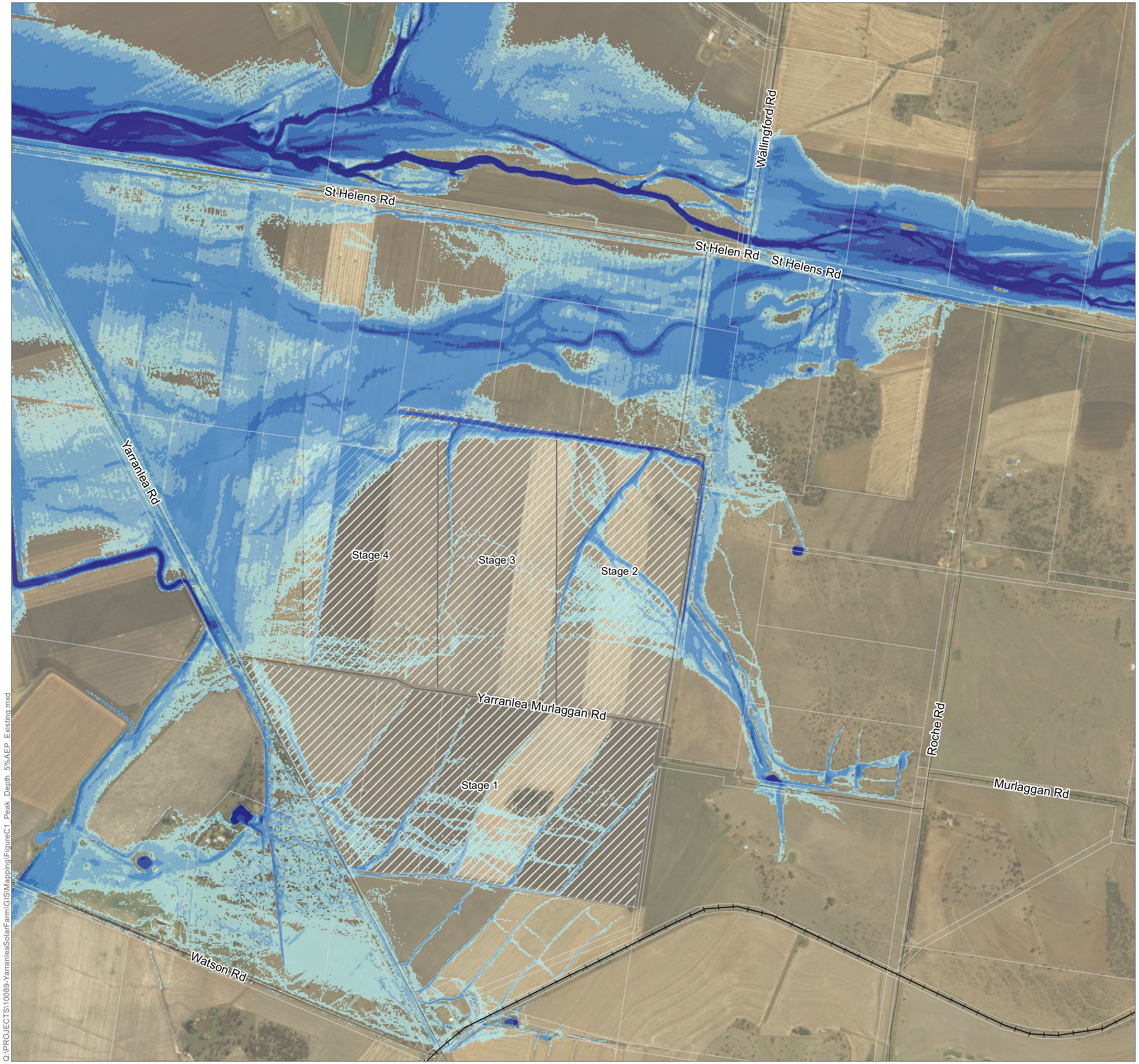
OVERALL STORMWATER MANAGEMENT PLAN

Drawn	Date	Chkd	Date
TJS	14.07.2016	NC	
Design	Date	Apprd	Date
TJS			
Scale	A1	Certif	Date
As indicated			
Project No. 15-282		Dwg. No. C06	Rev

23/08/2016 10:41:23 AM

Appendix B – Model Topography: Existing (Left) vs. Developed (Right)





solutions WATER MODELLING

LEGEND

Peak Depth [m]

- < 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure C.1 - Peak Depth
5% AEP Event
Existing Scenario

A3 scale:1:15,000
Projection: MGA Zone 56

0 125 250 500 m

Job No: 10089
Date: 17/11/2016

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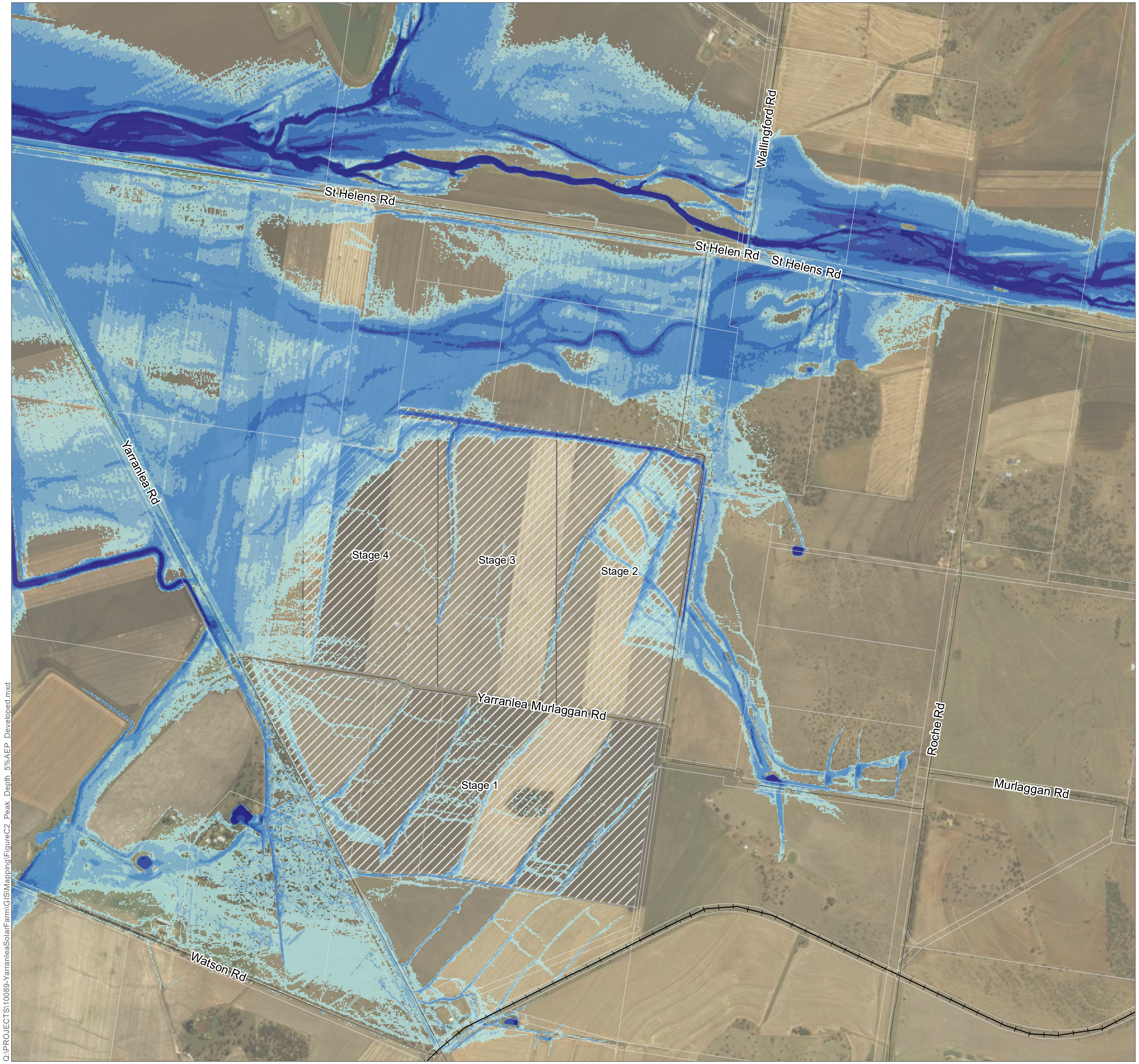

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solutions
WATER MODELLING

LEGEND

Peak Depth [m]

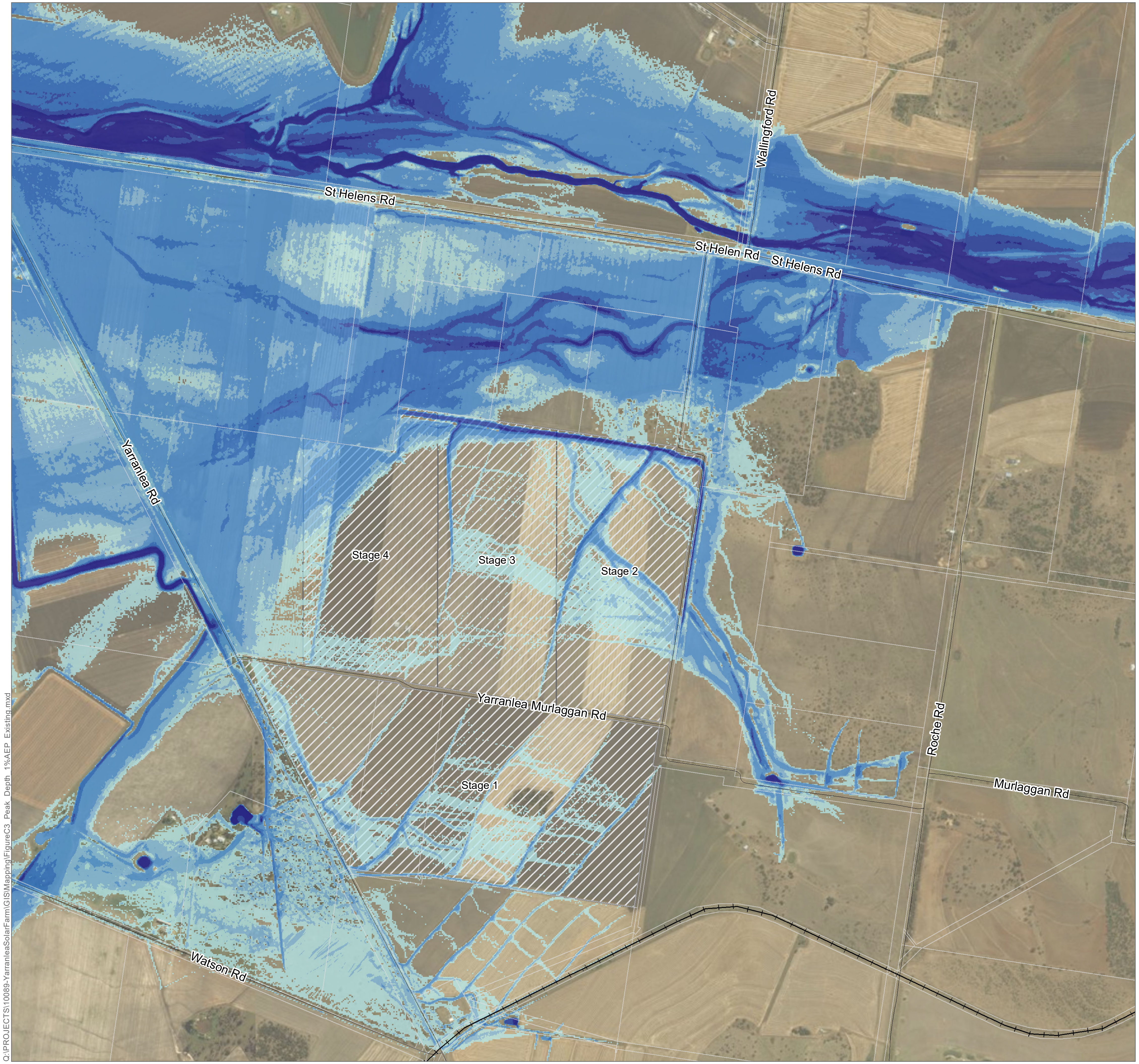
- < 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure C.2 - Peak Depth
5% AEP Event
Developed Scenario

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016



solutions WATER MODELLING

LEGEND

Peak Depth [m]

- < 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure C.3 - Peak Depth
1% AEP Event
Existing Scenario

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

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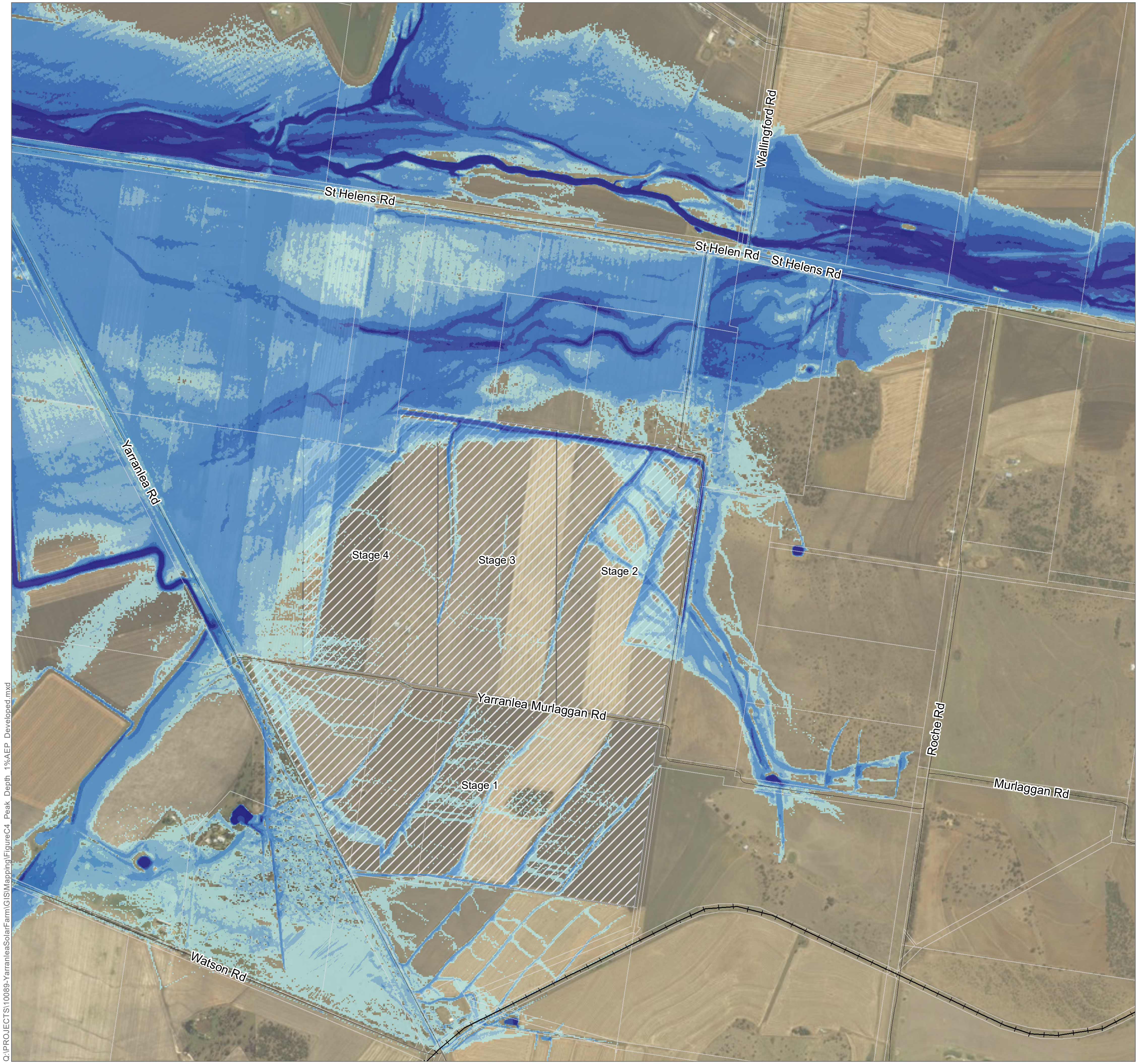


WATER MODELLING solutions

LEGEND

Peak Depth [m]

- < 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

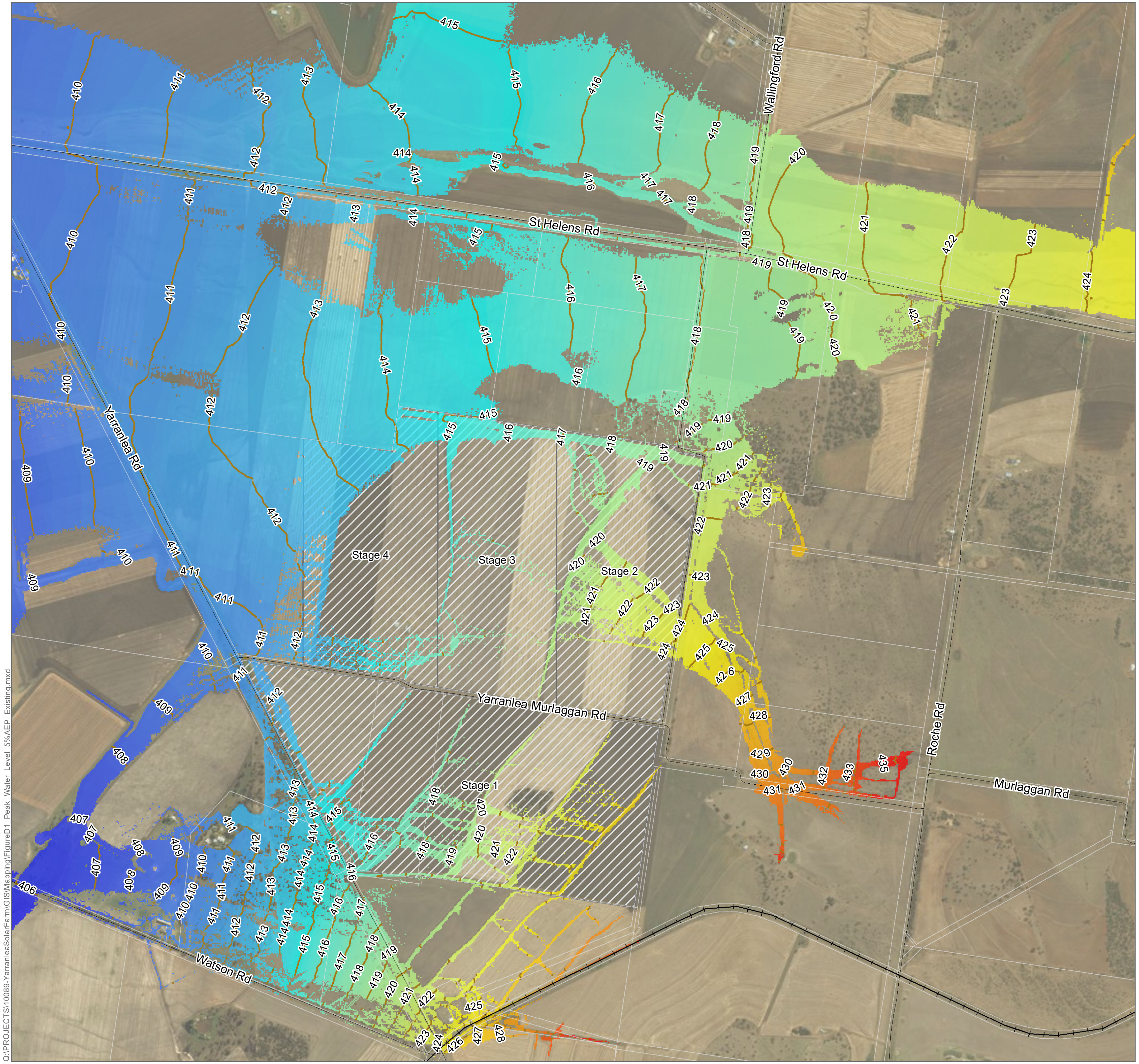
Figure C.4 - Peak Depth
1% AEP Event
Developed Scenario

A3 scale:1:15,000
Projection: MGA Zone 56

0 125 250 500 m

Job No: 10089
Date: 17/11/2016

WATER MODELLING solutions



LEGEND

Water Level [mAHD]

High : 435

Low : 405

Rail

Roads

Cadastre

Solar Farm

YARRANLEA SOLAR FARM

Figure D.1 - Peak Water Level
5% AEP Event
Existing Scenario

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

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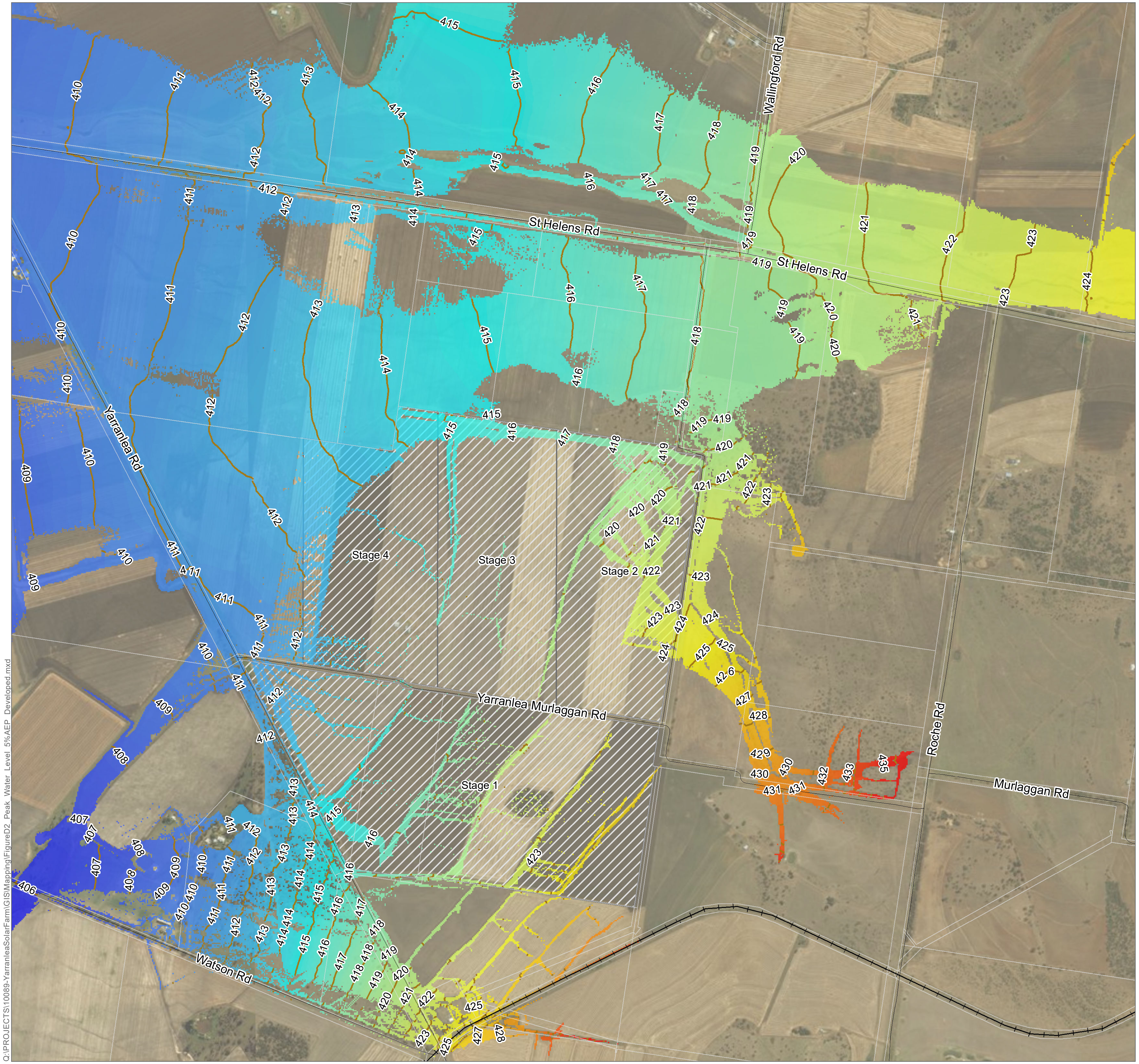


WATER MODELLING solutions

LEGEND

Water Level [mAHD]
High : 435
Low : 405

Rail
Roads
Cadastre
Solar Farm

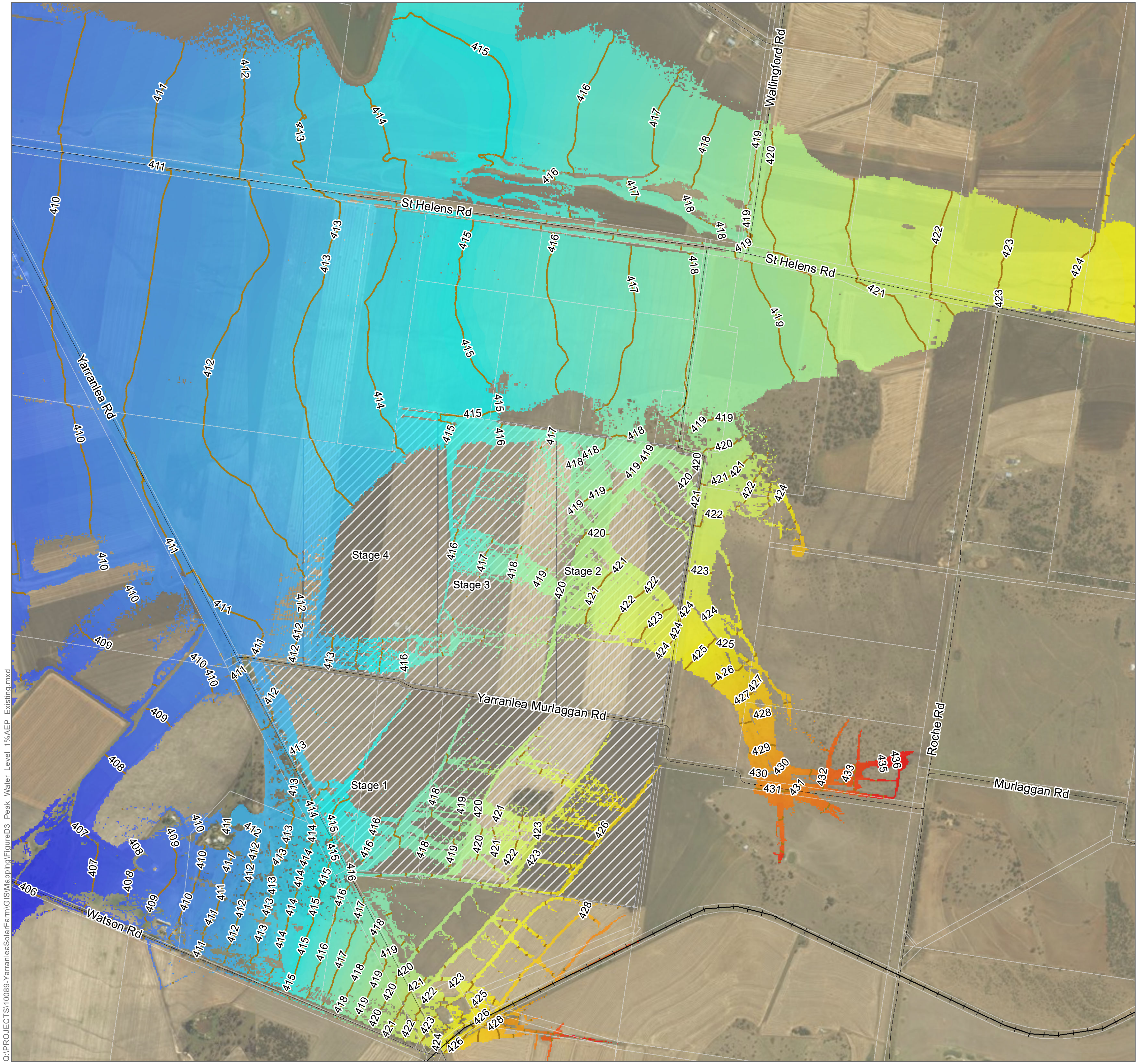
YARRANLEA SOLAR FARM

Figure D.2 - Peak Water Level
5% AEP Event
Developed Scenario

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

solutions WATER MODELLING



LEGEND

Water Level [mAHD]
High : 435
Low : 405

Rail
Roads
Cadastre
Solar Farm

YARRANLEA SOLAR FARM

Figure D.3 - Peak Water Level
1% AEP Event
Existing Scenario

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

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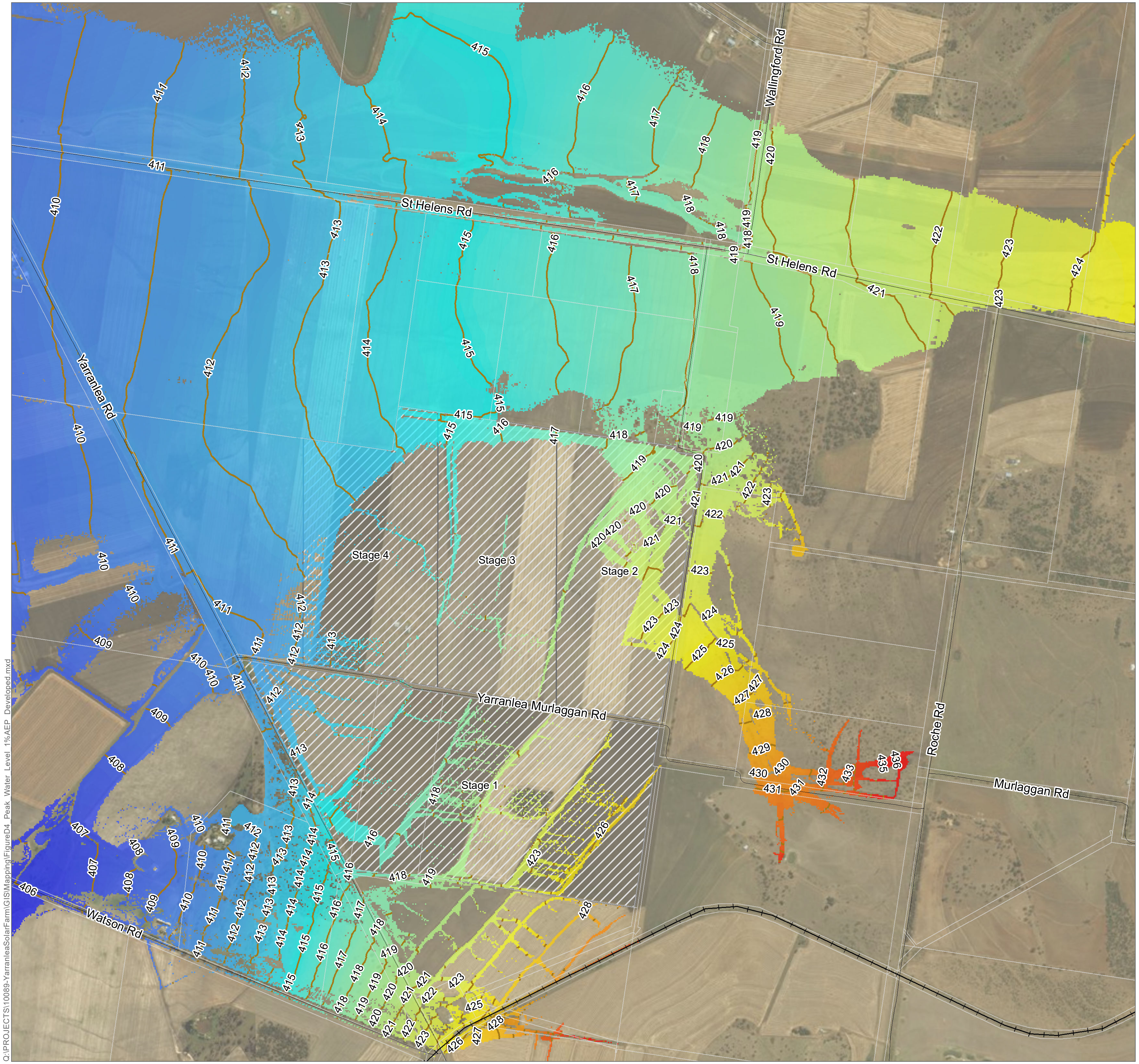

WATER MODELLING solutions

LEGEND

Water Level [mAHD]
High : 435
Low : 405

Rail
Roads
Cadastre
Solar Farm

YARRANLEA SOLAR FARM

Figure D.4 - Peak Water Level
1% AEP Event
Developed Scenario

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

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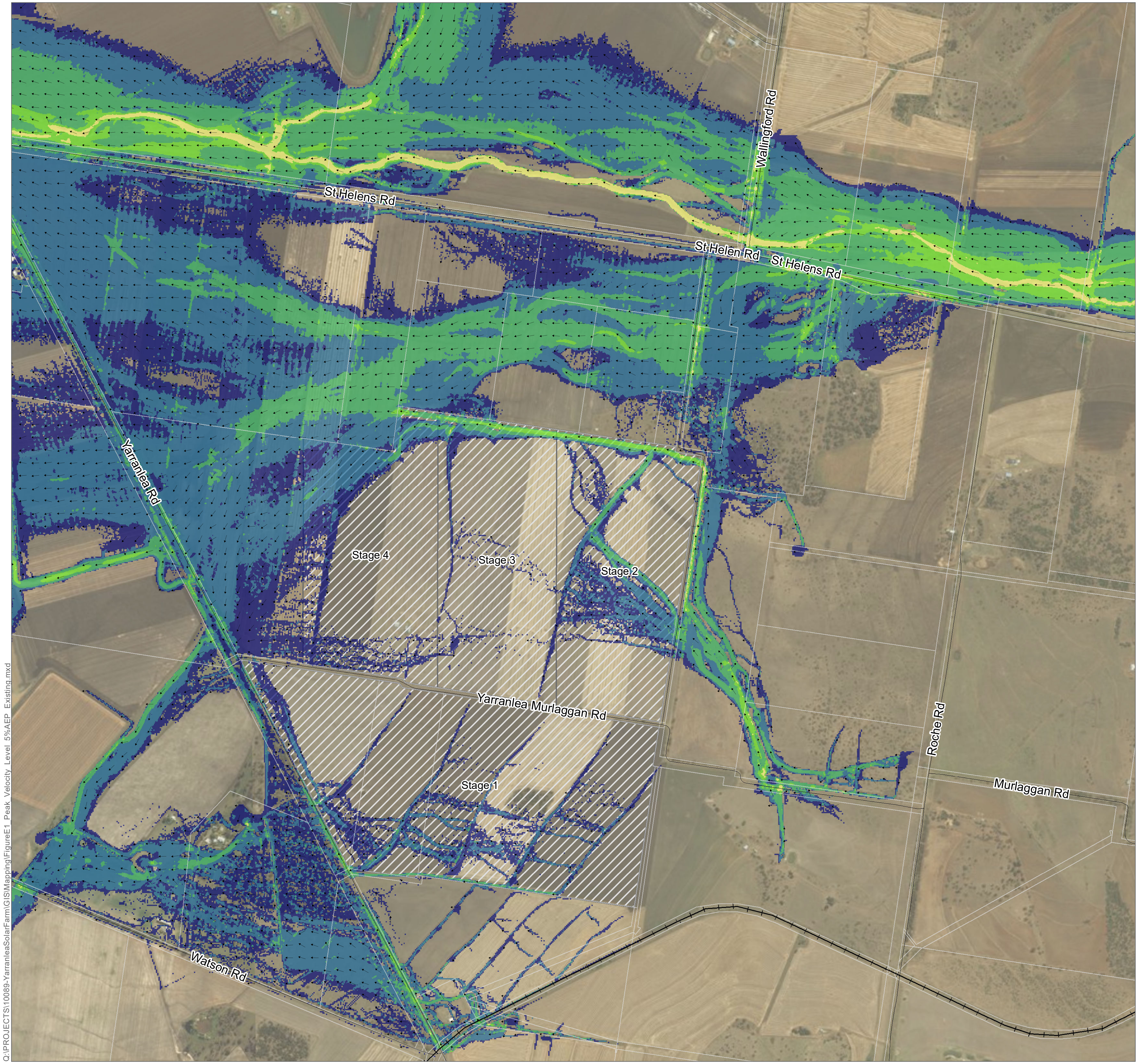

solutions
WATER MODELLING

LEGEND

Peak Velocity [m/s]

- < 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- > 1.50
- Flow Direction
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure E.1 - Peak Velocity
5% AEP Event
Existing Scenario

A3 scale:1:15,000
Projection: MGA Zone 56

0 125 250 500 m

Job No: 10089
Date: 17/11/2016

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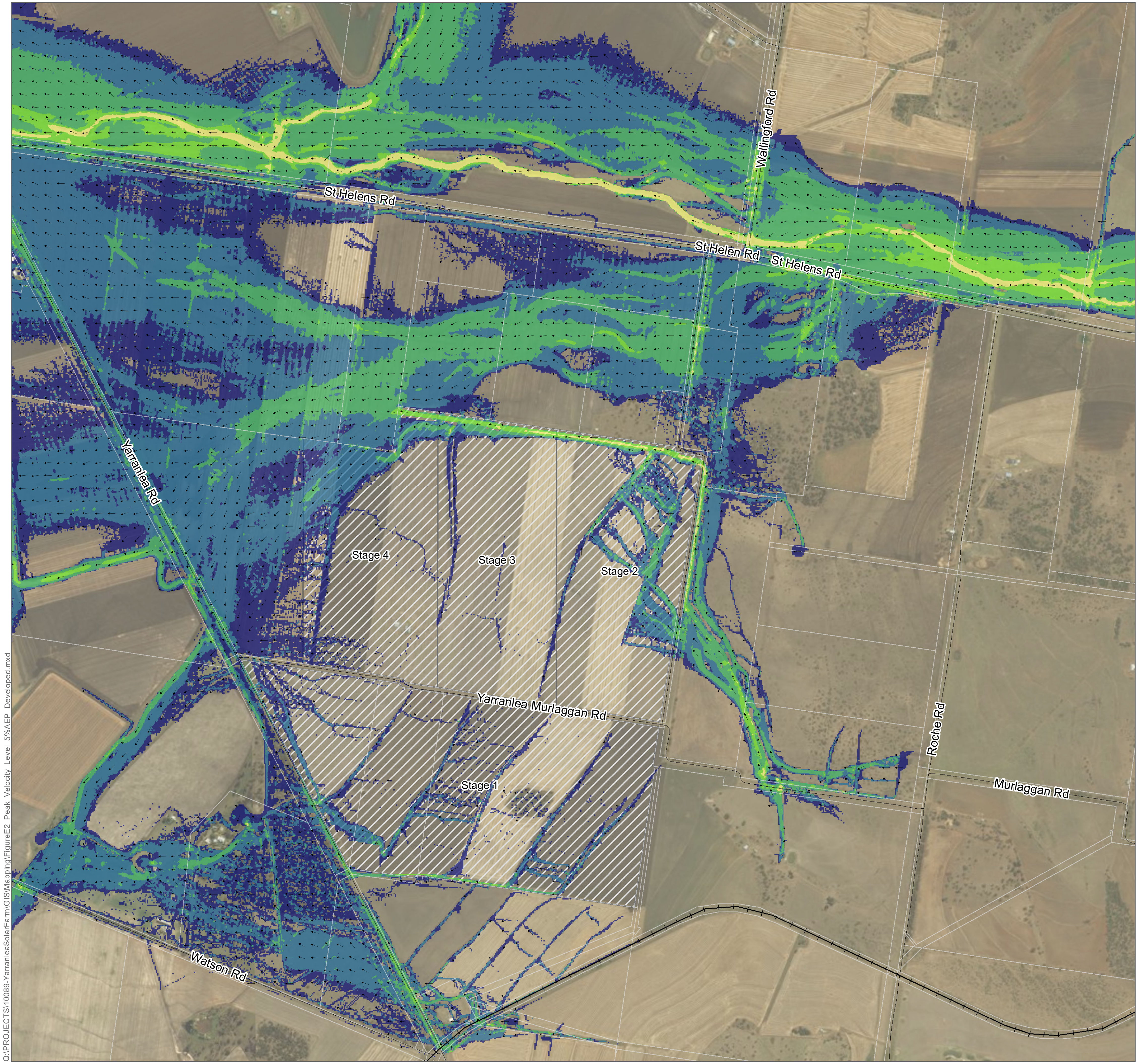


solutions
WATER MODELLING

LEGEND

Peak Velocity [m/s]

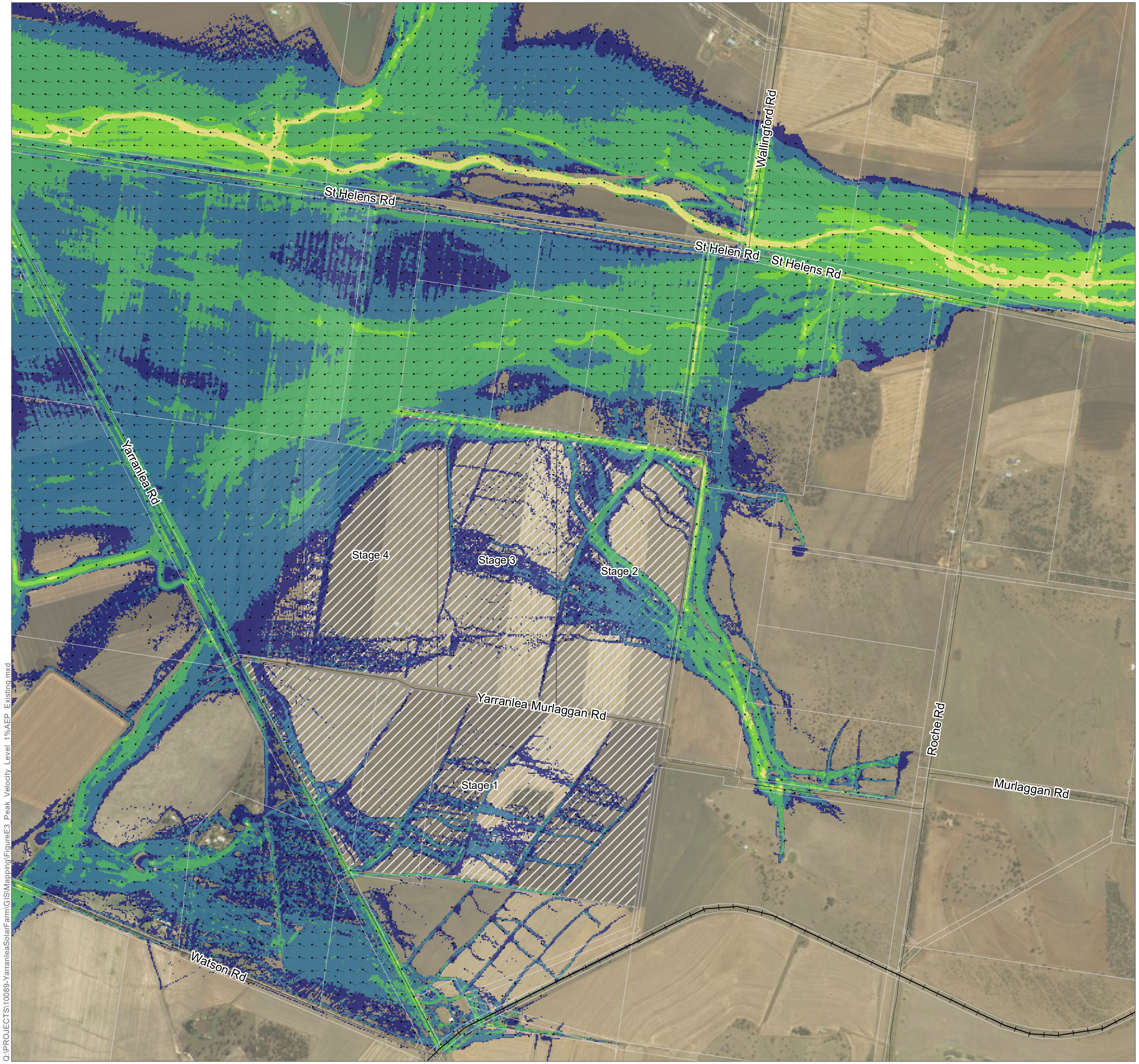
- < 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- > 1.50
- Flow Direction
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure E.2 - Peak Velocity
5% AEP Event
Developed Scenario

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016



WATER MODELLING solutions

LEGEND

Peak Velocity [m/s]

- < 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- > 1.50
- Flow Direction
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure E.3 - Peak Velocity
1% AEP Event
Existing Scenario

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

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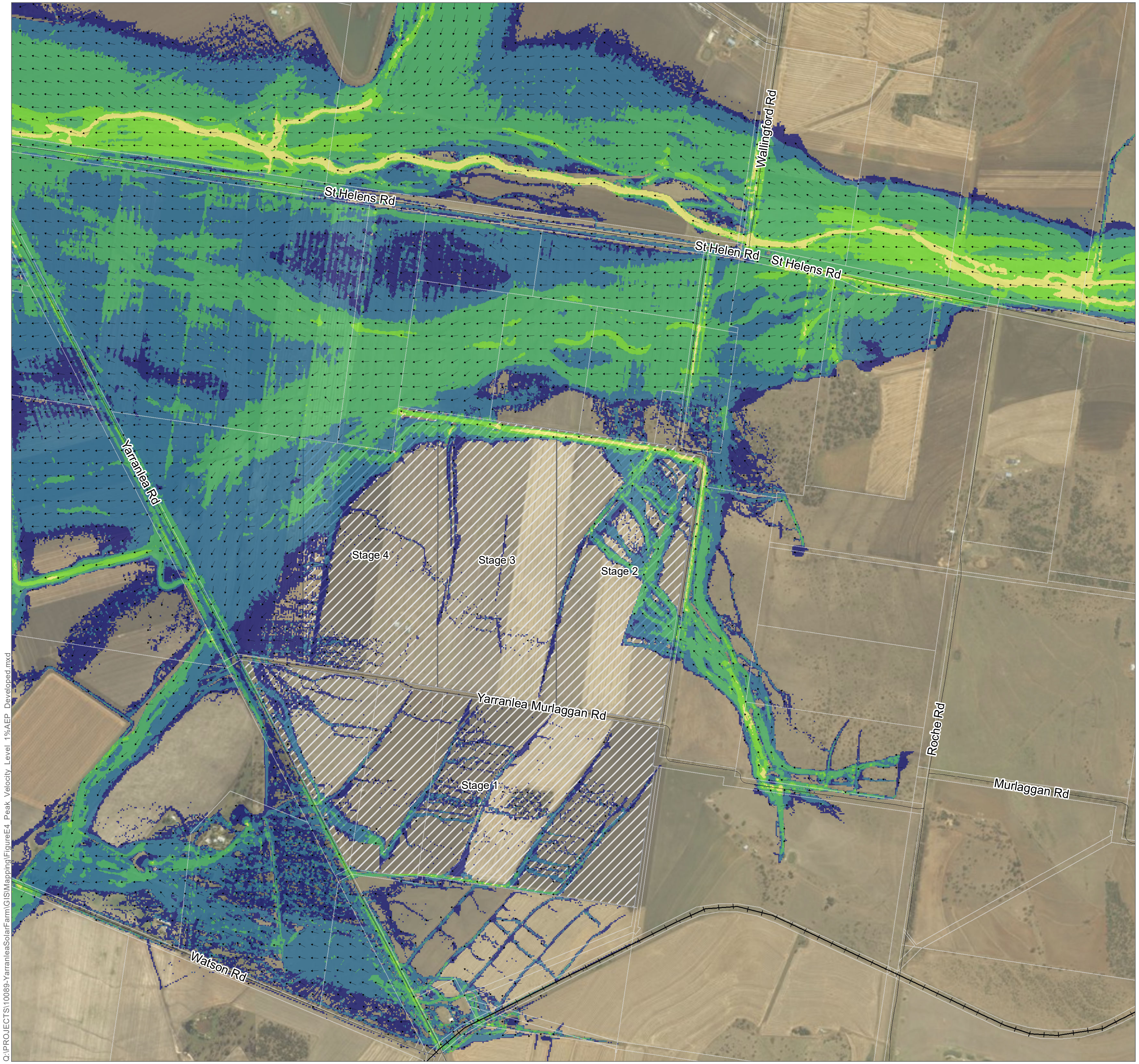

solutions
WATER MODELLING

LEGEND

Peak Velocity [m/s]

- < 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- > 1.50
- Flow Direction
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure E.4 - Peak Velocity
1% AEP Event
Developed Scenario

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

solutions
WATER MODELLING

LEGEND

Afflux [m] - Design minus Existing

- < -0.4
- -0.40 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.03
- -0.03 to 0.03
- 0.03 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.40
- > 0.4
- Was wet now dry
- Was dry now wet
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure F.1 - Afflux
5% AEP Event
1.5-Hour Storm Duration

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

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solutions WATER MODELLING

LEGEND

Afflux [m] - Design minus Existing

- < -0.4
- -0.40 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.03
- -0.03 to 0.03
- 0.03 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.40
- > 0.4
- Was wet now dry
- Was dry now wet
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure F.2 - Afflux
5% AEP Event
2-Hour Storm Duration

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

WATER MODELLING solutions

LEGEND

Afflux [m] - Design minus Existing

- < -0.4
- -0.40 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.03
- -0.03 to 0.03
- 0.03 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.40
- > 0.4
- Was wet now dry
- Was dry now wet
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure F.3 - Afflux
1% AEP Event
1.5-Hour Storm Duration

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

solutions WATER MODELLING

LEGEND

Afflux [m] - Design minus Existing

- < -0.4
- -0.40 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.03
- -0.03 to 0.03
- 0.03 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.40
- > 0.4
- Was wet now dry
- Was dry now wet
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure F.4 - Afflux
1% AEP Event
2-Hour Storm Duration

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

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solutions WATER MODELLING

LEGEND

Change in Velocity [m/s] - Design minus Existing

- < -0.50
- -0.50 to -0.25
- -0.25 to 0.25
- 0.25 to 0.50
- > 0.50
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure G.1 - Change in Velocity
5% AEP Event
1.5-Hour Storm Duration

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

WATER MODELLING solutions

LEGEND

Change in Velocity [m/s] - Design minus Existing

- < -0.50
- -0.50 to -0.25
- -0.25 to 0.25
- 0.25 to 0.50
- > 0.50
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure G.2 - Change in Velocity
5% AEP Event
2-Hour Storm Duration

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

Q:\PROJECTS\10089-YarranleaSolarFarm\GIS\Mapping\FigureG3_Change_in_Velocity_1%AEP_1p5Hour.mxd

solutions
WATER MODELLING

LEGEND

Change in Velocity [m/s] - Design minus Existing

- < -0.50
- -0.50 to -0.25
- -0.25 to 0.25
- 0.25 to 0.50
- > 0.50
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

Figure G.3 - Change in Velocity
1% AEP Event
1.5-Hour Storm Duration

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

solutions
WATER MODELLING

LEGEND

Change in Velocity [m/s] - Design minus Existing

- < -0.50
- -0.50 to -0.25
- -0.25 to 0.25
- 0.25 to 0.50
- > 0.50
- Rail
- Roads
- Cadastre
- Solar Farm

YARRANLEA SOLAR FARM

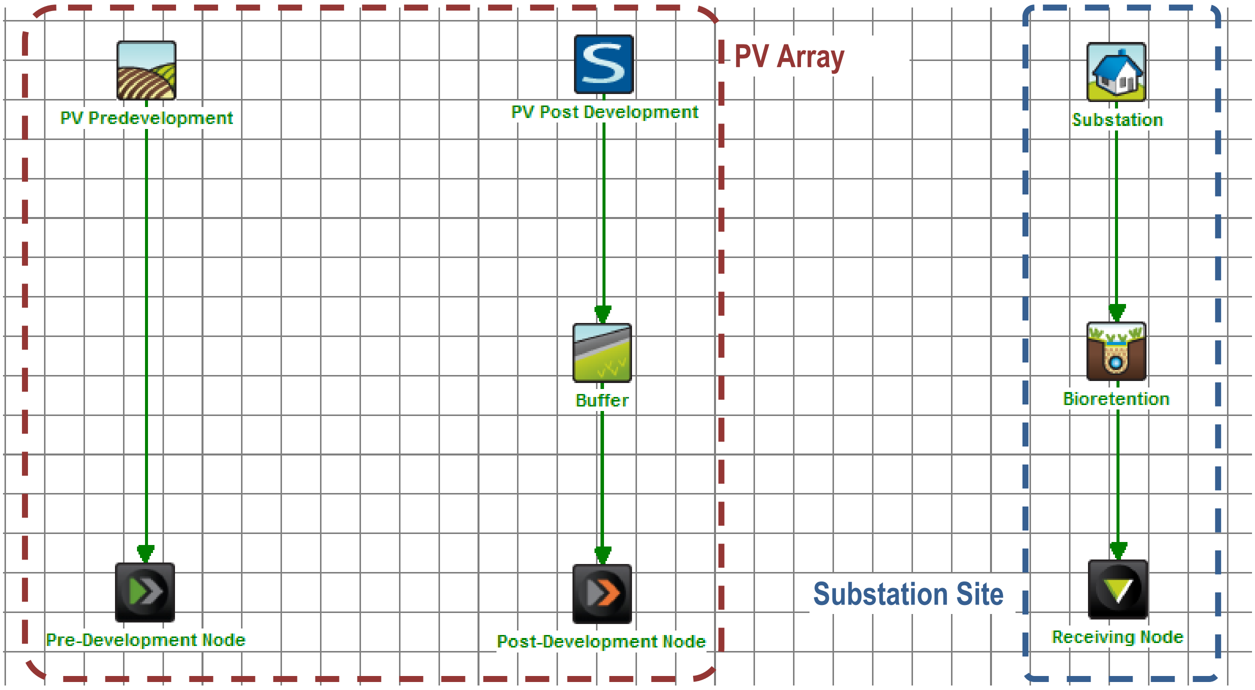
Figure G.4 - Change in Velocity
1% AEP Event
2-Hour Storm Duration

A3 scale:1:15,000
Projection: MGA Zone 56
0 125 250 500 m

Job No: 10089
Date: 17/11/2016

Appendix D – Music Output

Music Model



Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

Treatment Train Effectiveness

PV Array

	Sources		Residual Load		% Reduction	
	Pre	Post	Pre	Post	Pre	Post
Flow (ML/yr)	53	53	53	53	0	0
Total Suspended Solids (kg/yr)	20000	15800	20000	7910	0	49.9
Total Phosphorus (kg/yr)	21.9	16.7	21.9	11.7	0	29.9
Total Nitrogen (kg/yr)	121	133	121	112	0	15.8
Gross Pollutants (kg/yr)	156	156	156	156	0	0

☑ Include Pre-Development

Substation

	Sources	Residual Load	% Reduction
Flow (ML/yr)	2.74	2.43	11.3
Total Suspended Solids (kg/yr)	379	37.2	90.2
Total Phosphorus (kg/yr)	0.994	0.395	60.2
Total Nitrogen (kg/yr)	6.69	3.16	52.8
Gross Pollutants (kg/yr)	93.7	0	100

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

Appendix E – Bioretention Checklist

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

4.3 Inspection and maintenance checklist for bioretention systems

ASSET TYPE	Bioretention	ASSET ID
Location		
Date		
Date of last rainfall		Weather
Officer's name		

Bioretention plan

Insert diagram or plan of the asset showing key features e.g. locations of inlet, outlet, and overflow

Additional information	
Time taken to complete inspection or maintenance	
Photos of site (explanatory notes)	1. 2. 3. 4. 5. 6.
General comments and sketches	
Officer's signature	

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

What to look for	Performance Indicator (PI)	Condition rating*	Maintenance undertaken**	Additional work needed
SURROUNDS				
Damaged or removed structures e.g. traffic bollards	No damage that poses a risk to public safety or structural integrity			
INLET				
Erosion	Inlet is structurally sound and there is no evidence of erosion or subsidence/settlement			
Damaged or removed structures e.g. pit lids or grates	No damage that poses a risk to public safety or structural integrity			
Sediment, litter, or debris	No blockage			
COARSE SEDIMENT FOREBAY (IF PRESENT)				
Erosion	Minor erosion only that does not pose a risk to public safety or structural integrity and would not worsen if left unattended			
Sediment	Coarse sediment forebay <75% full and no litter			

*1 – PI met; 2–PI met after maintenance activity undertaken; 3 – Additional maintenance needed; 4 – Rectification may be needed; NI – not inspected; NA – not applicable

** Quantify where possible e.g. amount of sediment or litter removed

Level 2, 39 Sherwood Road
Toowong QLD 4066
mail@icubed.com.au
www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988

What to look for	Performance Indicator (PI)	Condition rating*	Maintenance undertaken**	Additional work needed
BATTER SLOPES AND BASE INVERT				
Erosion	Minor erosion only that does not pose a risk to public safety or structural integrity and would not worsen if left unattended			
Crust of fine sediment	No surface crusting			
Depressions or mounds	No surface depressions or mounds > 100 mm			
Hydraulic conductivity or permeability	Filter media is draining freely, whereby water is not ponded on the surface for more than 12 hours after rainfall and there is no obvious impermeable or clay-like surface on the filter media**			
Underdrains/clean out points	Clean out points not damaged and end caps securely in place			
Litter	Maximum 1 piece litter per 4 m^2			
Unusual odours, colours, or substances (e.g. oil and grease)	None detetcted			
Vegetation	Minimum 95% vegetation cover (minimal bare batches)			
	Plants healthy and free from disease			
	Average plant height > 500 mm			

*1 – PI met; 2–PI met after maintenance activity undertaken; 3 – Additional maintenance needed; 4 – Rectification may be needed; NI – not inspected; NA – not applicable

** Quantify where possible e.g. amount of sediment or litter removed

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Toowong QLD 4066
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www.icubed.com.au
P: 07 3870 8888
F: 07 3870 8988